Pak. J. Bot., 55(2): 739-748, 2023. DOI: http://dx.doi.org/10.30848/PJB2023-2(14)

EFFECTS OF DIFFERENT NUMBERS OF BUDS PER UNIT TRUNK CROSS-SECTION AREA ON GROWTH, YIELD AND QUALITY IN THE 'PRIMA' GRAPE (*VITIS VINIFERA* L.) CULTIVAR

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Abstract

In this study, the effects of varying numbers of winter buds left per trunk unit cross-section area were observed in the Prima grape variety. The treatments were determined by the trunk cross-section areas of vines as 2.0 bud.cm^{-2}, 2.5 bud.cm^{-2}, 3.0 bud.cm^{-2}, 3.5 bud.cm^{-2}, and 4.0 bud.cm^{-2}. The control vines were left as 20 buds for the initial 500 g of cane weight and 10 buds for every subsequent 500 g. The effects of the treatments on certain phenological and physiological characteristics, as well as vegetative development, grape yield, and quality, were researched in the vines. It was determined that the bud burst percentage and the coefficient of bud fertility in the vines were reduced as the number of buds increased (14-32 buds). There was no significant change between the treatments in terms of their numbers of water sprouts and shoots arising from secondary dormant buds. It was determined that the increase in the number of buds left on the vine caused an increase in the number of shoots up to a certain level, and this effect reduced shoot length and shoot diameter development. No significant difference was determined in leaf N, P, K contents or chlorophyll measurements. Grape yield was higher than 3.5 tons in the treatments of 3.0 buds, 3.5 buds, and 4.0 buds per cm^2. During the study, no significant difference was observed between the treatments in terms of cluster properties, berry properties (except for berry size), and berry color, or TSS and pH contents in juice. Increased numbers of buds in the study led to an increase in yield, without causing a significant loss in quality, except for the control treatment.

According to the results of this study, the recommended number of buds to be left per trunk unit cross-section area, in addition to yield and quality, crop load, which can be recommended with minimal need for summer pruning in terms of vegetative balance, is 3.0 bud.cm^{-2}.

Key words: Grapevine, Pruning, Trunk cross-section area, Yield, Quality.

Introduction

Grape is one among the most delicious, refreshing, and nourishing fruits in the world. It is one of the earliest fruits grown by man. Its berries are good sources of sugar, minerals (such as Ca, Mg, Fe), and vitamins (such as B1, B2, and C). The presence of a wide range of areas of use for grapes indicates its superiority over other fruit varieties (Senthilkumar *et al*., 2015; Okatan, 2020). Therefore, it has economic importance all over the world (Qui *et al*., 2019). According to 2020 data, viticulture is carried out on an area of 6950930 ha in the world, and 78,03 million tons of grapes are produced in total (Anon., 2022).

Turkey is an important country with an old and long-established tradition in terms of viticulture. It ranks 5th (400998 ha) in terms of vineyard areas and 6th (4208908 ton) in terms of grape production (Anon., 2022). The Mediterranean region ranks 2nd in Turkey in terms of grape production and vineyards. A significant portion of production in Mediterranean viticulture (79.1%) is allocated to table grape production (Turkstat, 2020). The production of grapes for early table consumption is becoming more popular in this region (Kamiloglu *et al*., 2011). Depending on this development, a new grape cultivar, 'Prima', is a cultivar with an economic propagation potential in terms of earliness.

In viticulture, the yield and quality characteristics of a grape variety which is desired to be grown must be superior (Wei *et al*., 2002). Grape growers are responsible for understanding the factors affecting vine physiology in the consideration of grape production and economic aspects together. The ability to determine the most economical and profitable pruning level is based on knowing the reactions given by a vine to different pruning practices (Steyn *et al*., 2016). Therefore, it is very important to study the management of optimal loads for different grape varieties (Lin *et al.*, 2018).

One of the most important objectives in growing is the maximization of economic benefit obtained from vineyards by observing the balance between growth and development and the parameters of product yield and quality (Celik, 2017). The priority for achieving this objective is winter pruning, which should be carried out for the next vegetation period. It is particularly important for table grape growers to prune approximately 85% to 90% of growth from the previous season. Leaving too many fruiting buds on the vine will produce numerous small, unattractive clusters (Zabadal, 2002).

There are several pruning methods to maximize fruit yield by balancing vegetative growth and without reducing vine strength (Senthilkumar *et al*., 2015). One of the important principles of vineyard growing is to leave a suitable number of buds in terms of vegetative and generative development by considering the effects of soil, rootstock, and maintenance conditions on the development of a variety along with planting distance and cultivation manner, based on the age of the vine. Leaving more buds during pruning does not always imply a linear increase in vine yield (Heazlewood *et al*., 2006). In contrast, an increase in pruning severity may imply loss in total growth and product, and increase in individual shoot strength (Senthilkumar *et al*., 2015).

The qualitative and quantitative performance levels of vines are impacted significantly by the number of buds left per vine. Pruning is a technique that regulates the balance among vegetative growth, fruit quality, and vine yield. It is important in terms of sustainable viticulture to adopt certain methods aimed at vine development in the determination of the number of buds to be left on vines. There are different ratios in terms of vine strength and crop load. The primary parameters among these ratios are yield/shoot weight, yield/leaf surface, and shoot weight/ leaf surface. These three ratios define the relationship between growth and yield, and they aim to measure vine strength (Steyn *et al*., 2016; Kahramanoglu *et al*., 2020).

Pruning formulas aim to guide commercial pruning practices by associating the size of a vine with the level of product that it can ripen. The number of buds to be left on vines during winter pruning (crop load or charge) can be determined based on the number of buds per vine, length on unit row (m), unit area (m^2), and unit pruning wood weight (g) (Çelik *et al*., 1998; Çelik, 2007; Çelik, 2017). In this sense, Gastol (2015) stated that the trunk cross-section area of vine is a good identifier that characterizes vineyards. The researcher found that the mean trunk growth had a good correlation with the mean yield and sugar production per vine, and trunk cross-section area was closely associated with the factors affecting photosynthesis activity.

The literature review in this study revealed no study in Turkey determining the number of buds according to the trunk cross-section area of vines. In this study, the effects of different numbers of winter buds left per trunk unit cross-section area on the phenological, physiological, and vegetative growth, grape yield, and grape quality of the Prima grape cultivar were investigated.

Material and Method

This study was conducted in the 2021-2022 vegetation period at the Horticulture Department of the Faculty of Agriculture at Mustafa Kemal University, on a vineyard land at an altitude of 88 m from sea level on the 36°26.566´N latitude and 36°18.096´ E longitude. A head treatment system, with pruning heads at certain intervals, was established on the Prima grape variety with a trunk height of 1.5 m, grafted on 1613 C rootstock planted at distances of 2.0 m X 1.5 m as row intervals in March 2017.

According to the monthly climate data (January-December) from 2021, obtained from the meteorology station nearest to the trial area, the average temperature in the vegetation period (April-October) varied between 19.6 and 35.7°C, and the relative humidity varied between 31.0% and 61.1%, while 49.8 mm of the annual 371.6 mm of precipitation and 2060.1 hours of the annual 2809.1 hours of sunshine duration occurred within the vegetation period. The soil in the trial area was determined as clayey-loamy, non-saline, mildly alkaline, and calcareous, its organic matter content was almost medium, its phosphorus content was very high, and its potassium content was excessive.

During the trial, the number of buds per vine was determined according to the trunk cross-section area of the plants (cm^2/vine). For this purpose, the trunk circumferences of vines were measured at 30 cm above the grafting point (Motosugi *et al*., 2007). Plants that were uniform in terms of development were selected and marked. The trunk cross-section areas (cm^2) of the vines were calculated using their trunk circumference values. Different numbers of nodes (buds) were left for per unit trunk cross-section area in the study (Shalan, 2013). The total numbers of buds to be left were determined as 2.0 bud.cm^{-2}, 2.5 bud.cm^{-2}, 3.0 bud.cm^{-2}, 3.5 bud.cm^{-2}, and 4.0 bud.cm^{-2} in the treatments. The control vines were left with 20 buds for the initial 500 g of cane weight and 10 buds for every subsequent 500 g. Pruning was performed in the second half of February using the spur pruning method.

During the study, phenological observations, bud burst percentage, the coefficient of bud fertility, vegetative growth, pruning weight, grape yield and quality characteristics, the yield efficiency index (Gastol, 2015), the Ravaz index (Matthews, 2016), cluster characteristics, berry characteristics, and juice characteristics, as well as leaf element (N, P, K) contents, were analyzed to determine the effects of different treatments of number of buds per unit trunk cross-section area on vine development, yield, and quality. The N contents of leaf samples, which were washed, dried in a drying oven, (70°C, 48 hours), and ground in porcelain mortars, were determined according to the Kjeldahl method (Bremner, 1965). The K contents of the samples were determined by using a Flame-Atomic Absorption Spectrophotometer after they were dissolved in a MARS XPress (CEM Branded) microwave oven, and their P content was spectrophotometrically determined according to the method described by Barton (1948). During chlorophyll measurements, three readings (SPAD 502, Minolta Co. Ltd. Japan) were made, representing different directions, on leaves at the 10^{th} or 11^{th} nodes from the tip of the summer shoots. Berry surface temperature was measured between 9:30 am and 2:00 pm using an infrared thermometer (Spectrum IR thermometer) in 4 directions on a cluster in every vine at certain intervals beginning from the berry set period. Temperature (°C) and relative humidity (%) values were recorded in one-hour intervals during the day with measurement devices (datalogger) placed on the cluster areas of the vines in the control (20+10) vines and treatment vines with buds with the lowest and the highest trunk unit cross-section areas (respectively, 2-4 bud.cm^{-2}). These values were calculated daily and are given as weekly averages. Light intensity in the crown was measured on vines with a lux meter (Testo 540) at certain intervals beginning from the berry set period.

Statistical Analysis

This study was organized with a random parcel design. The trial was planned with three repetitions and 3 vines in every repetition. The statistical analyses were carried out by applying angular transformation to percentage values in characteristics that were represented proportionally. Data obtained as a result of the trial were subjected to analysis of variance (ANOVA) using the SAS package computer software, and Duncan's test was conducted at a 5% significance level in the identification of different groups.

Result and Discussion

Phenological observations: In the vines, bud burst occurred between 1 April and 4 April. The first bud burst was observed in the 2 bud.cm^{-2} treatment group, with a few days of difference among the treatments. Variety-specific color and taste formation in 50% to 60% of the clusters occurred in the last week of June (Table 1). The effects of increased bud load, which caused a delay of bud burst by several days in our study, were similar to the results obtained by Palma *et al*., (2000), Polat & Uzun (2007), and Senthilkumar *et al*., (2015).

Vegetative growth: Statistically significant differences were observed among the treatments in terms of bud burst ratio and the coefficient of bud fertility in the vines. The 2.0 bud.cm^{-2} treatment yielded the highest value, while the control treatment yielded the lowest value (Table 2). The results reported by Omar & Abdel-Kawi (2000) and Shalan (2013), indicating a decrease in the bud burst ratio depending on the increase in the number of buds, supported our findings. Studies conducted by Uyak *et al*., (2016) and Heazlewood *et al*., (2006), reporting that changes in bud load did not have a significant effect on bud burst, but an increase in the number of buds in vines reduced the number of clusters per bud, provided similar results to our findings.

Careful removal by hand was performed to determine the effects of different bud load levels in the vines on the number of water sprouts arising from the latent buds. This procedure kept the shoot numbers in the vines under control based on the treatments and prevented other measurement parameters from being affected. There was no significant difference among the total numbers of water sprouts in the measurements performed on different dates (Table 2). Kurtural *et al*., (2006) reported that the number of unwanted shoots was not significantly affected by treatments (except for the 2nd vineyard during the 1st year), and it varied from 10 to 13 during the first year and from 14 to 17 during the second year. The effects of bud numbers left with different pruning formulas on the numbers of unwanted shoots in vines as reported by Kurtural *et al*., (2006) and the similarity of the number of shoots comprising latent buds in our study were found to be interesting. Secondary shoots and inflorescences on the winter buds in the vines were counted before removal on 27 April. The number of secondary shoots varied from 2.78 to 4.56, and the number of inflorescences varied from 2.67 to 5.33 per vine (Table 2).

The effects of different crop loads per trunk cross-section area on the number and development of summer shoots are given in Table 3. The highest number of summer shoots in the vines were achieved in the 4 bud.cm^{-2} and control treatments, while the lowest number was achieved in the 2 bud.cm^{-2} treatment. The lowest values of shoot length and diameter growth were achieved in the 4 bud.cm^{-2} and control treatments, which were statistically similar, while the highest value was identified in the 2 bud.cm^{-2} treatment. The effects of the treatments on the node numbers of shoots were found to be insignificant. The decrease in the total number of shoots per vine in our study was in parallel with the increase in pruning severity reported by Kurtural *et al*., (2006) and Uyak *et al*., (2016), the increase in shoot growth based on the number of reduced shoots on vines reported by Shiranal *et al*., (2020), and the decrease in shoot diameter development based on increased number of buds reported by Somkuwar *et al*., (2012), Shalan (2013), Senthilkumar *et al*., (2015), Uyak *et al*., (2016), and Bassiony (2020). Leaf area is an important parameter that affects vine performance. Too large leaf area values encourage shading and reduce fruit quality and sometimes bud yield. Too small leaf area values per unit fruit delay ripening and shrink vine size (Bates *et al*., 2011). Based on the increase in the number of winter buds left on vines, the main leaf sizes of the summer shoots and the lateral leaf sizes shrank in general. However, this effect of the treatments on leaf sizes was not found to be statistically significant. The main leaf size were between 186.92 and 218.30 cm^2, while the lateral leaf sizes were between 64.69 and 75.46 cm^2. The main leaf areas of the vines showed statistically significant differences based on the treatments. As a matter of fact, the 4.0 bud.cm^{-2} treatment was found to have the highest (15.34 m^2/vine) leaf area, while the 2.0 bud.cm^{-2} treatment was found to have the lowest (10.39 m^2/vine) leaf area (Table 3). Shalan (2013) identified the mean leaf area as the highest in the 2 bud.cm^{-2} treatment (120.47 to 122.55 cm^2) and the lowest in the 5 bud.cm^{-2} treatment (82.12 to 84.86 cm^2), while Bassiony (2020) identified the highest value at a 20-bud load level (142.5 to 146.1 cm^2) and the lowest value in the control (111.2 to 110.4 cm^2). The main leaf size in the 'Thompson Seedless' variety was determined to be the maximum at a 30-shoot density (241.75 cm^2) and the minimum at a 40-shoot density (136.17 cm^2) (Chougule, 2004). If our findings are compared to results in the literature reporting that an increase in the number of buds in vines reduces leaf size (Chougule, 2004; Shalan, 2013; Bassiony, 2020), this effect was mild. This was caused by the fact that the bud load intervals in our study were not wide enough to affect leaf size. Brandon *et al*., (2012) reported that a decrease in pruning severity caused a linear increase in the leaf area per vine and the number of leaf layers. Results indicating that an increased bud load causes an increase in vine leaf area, as reported in the literature, were in parallel with our findings (Brandon *et al*., 2012; Somkuwar *et al*., 2012; Teker *et al*., 2018).

Upon the measurements of the trunk areas of vines after harvest and during the dormancy period, no statistically significant difference was identified between bud load levels based on the treatments. A proportional increase of 21.76% to 33.27% after harvest and another at 39.21% to 60.28% during the dormancy period were observed in trunk development in comparison to the values obtained at the beginning of the trial (Table 4). It may be stated that different bud loads applied on vines with similar trunk cross-section areas (6.85 to 7.15 cm^2) did not create an adequate effect as a result of the one-year development period in our study. This was also due to the excessive trunk lengths of the vines. During the study, the highest pruning weight was obtained in the 3.5 bud.cm^{-2} treatment, which was followed by the 2.0, 2.5, and 4.0 bud.cm^{-2} treatments. The mean cane pruning weight was the highest in the 2.0 bud.cm^{-2} treatment, which was followed by the 2.5, 3.5, 3.0, and 4.0 bud.cm^{-2} treatments. These two parameters, belonging to the dormancy period, were found to be the lowest in the control treatment (Table 4). Somkuwar *et al*., (2012), who reported that pruning weight per vine in the dormancy period was a significant parameter in the prediction of shoot growth density, and therefore, leaf density, stated that different numbers of shoots in the vine did not have a significant effect on pruning weight. In some cases, scarcity in the number of shoots in a vine can be compensated by an increased vegetative strength in the shoots. Bassiony (2020) achieved the highest pruning weight in the 15+20 and 15+30 treatments and the lowest pruning weight value in the control treatment among the values of the controls (90 bud/vine), 15 bud/vine +20, +30, and +40 buds (for every 1 kg pruning weight) pruning treatments in the Flame Seedless variety. It is considered that *V. vinifera* vines are balanced in pruning weight between 0.7 and 1.5 kg (Senthilkumar *et al*., 2015; Teker and Altindisli, 2021). It is seen that the pruning weight values achieved in our study (except for 3.5 bud.cm^{-2}) were close to the range achieved by Senthilkumar *et al*., (2015) (0.62 kg/vine-2.39 kg/vine), but they exceeded the specified balanced pruning weight value. It is seen in the studies mentioned above that results achieved in pruning weight have not been in parallel with the increase in the number of buds left in the vine. This situation can be partially explained by the root-shoot development principle in severe pruning practices as reported by Jackson (2001). The calculation of the mean cane pruning weight is a beneficial indicator in the determination of shoot strength (Senthilkumar *et al*., 2015). This parameter, called the development strength (Growth strength, Vigor), is obtained by comparing the pruning weight to the number of shoots (Bahar *et al*., 2018). According to reports in the literature, the reason for the mean cane pruning weight to be significantly above average in our findings was that procedures such as pinching or topping were not performed on the summer shoots. This was because it was aimed to determine the exact effects of different numbers of buds on summer shoot development in the vines and the pruning weight.

Table 1. The effect of different bud load levels on bud burst, full bloom, veraison, and maturity (day.month).

Treatments	Bud burst	Full bloom	Veraison	Maturity
2,0 bud.cm^{-2}	01.Apr	07.May	13.Jun	26.Jun
2,5 bud.cm^{-2}	02.Apr	07.May	14.Jun	26.Jun
3,0 bud.cm^{-2}	03.Apr	07.May	14.Jun	26.Jun
3,5 bud.cm^{-2}	02.Apr	07.May	14.Jun	26.Jun
4,0 bud.cm^{-2}	04.Apr	07.May	16.Jun	26.Jun
Control	03.Apr	07.May	15.Jun	26.Jun

Table 2. The effect of different bud load levels on bud burst percentage and coefficient of bud fertility, the numbers of water sprout, the numbers of cluster and shoot consisting of secondary buds.

Treatments	Bud burst percentage (%)	Coefficient of bud fertility (n)	Water sprout (n)	Secondary shoot number (n)	Cluster number on secondary shoot (n)
2,0 bud.cm^{-2}	87,76 (69,53) a	1,94 a	13,67	3,33	5,00
2,5 bud.cm^{-2}	81,50 (64,55) ab	1,86 ab	13,53	3,66	5,33
3,0 bud.cm^{-2}	82,22 (65,09) ab	1,70 abc	14,13	3,67	4,33
3,5 bud.cm^{-2}	75,73 (60,75) bc	1,74 ab	14,00	4,22	4,66
4,0 bud.cm^{-2}	79,85 (63,63) ab	1,66 bc	13,13	4,56	5,00
Control	70,78 (57,29) c	1,48 c	12,20	2,78	2,67
P[1]	0.0122	0.0202	ns	ns	ns

[1]Statistical significance value according to P:Variance analysis ($p<0.05$), ns: Not significant

Table 3. The effect of different bud load levels on shoot number, shoot length, shoot diameter, node number of shoots, main leaf size, lateral leaf size and main leaf area/vine.

Treatments	Shoot number (n)	Shoot length (cm)	Shoot diameter (mm)	Node number of shoot (n)	Main leaf size (cm^2)	Lateral leaf size (cm^2)	Main leaf area (m^2/vine)
2,0 bud.cm^{-2}	12,00 d	301,89 a	11,32 a	39,72	218,30	75,46	10,39 c
2,5 bud.cm^{-2}	14,11 cd	282,39 ab	10,38 ab	38,78	211,10	70,27	11,52 bc
3,0 bud.cm^{-2}	16,89 bc	282,50 ab	10,28 ab	38,72	200,37	67,44	13,18 abc
3,5 bud.cm^{-2}	18,56 b	245,83 bc	10,01 ab	36,33	207,88	66,09	13,95 ab
4,0 bud.cm^{-2}	22,78 a	213,33 c	9,14 b	33,50	200,09	66,63	15,34 a
Control	22,78 a	223,89 c	9,02 b	34,61	186,92	64,69	14,78 ab
P[1]	<.0001	0.0023	0.0219	ns	ns	ns	0.0289

[1]Statistical significance value according to P:Variance analysis ($p<0.05$), ns: Not significant

Table 4. The effect of different bud load levels on trunk area and growth rate, pruning weight and mean cane pruning weight.

Treatments	Trunk area (cm^2)		Trunk growth rate (%)		Pruning weight (g/vine)	Mean cane pruning weight (g)
	Post-harvest	Dormant	Post-harvest	Dormant		
2,0 bud.cm^{-2}	9,13	11,02	32,93 (34,81)	60,28 (51,01)	2387,22 ab	197,54 a
2,5 bud.cm^{-2}	8,99	10,68	29,53 (32,72)	54,48 (47,62)	2352,80 ab	167,61 ab
3,0 bud.cm^{-2}	8,40	9,61	21,76 (27,78)	39,21 (38,77)	1961,67 bc	116,52 cd
3,5 bud.cm^{-2}	9,27	11,04	33,27 (35,20)	58,87 (50,15)	2709,44 a	149,57 bc
4,0 bud.cm^{-2}	9,06	10,86	27,03 (31,18)	52,10 (46,21)	2158,33 ab	94,54 de
Control	8,47	9,88	23,65 (29,08)	44,75 (41,97)	1583,89 c	69,21 e
P[1]	ns	ns	ns	ns	0.0100	<.0001

[1]Statistical significance value according to P:Variance analysis ($p<0.05$), ns: Not significant

Table 5. The effect of different bud load levels on yield parameters.

Treatments	Cluster number per vine (n)	Grape yield per vine (g)	Grape yield in decare (ton)	Yield efficiency index	Ravaz index
2,0 bud.cm^{-2}	26,39 c	8540,17 c	2,846 c	812,23 c	3,62 b
2,5 bud.cm^{-2}	32,00 bc	8834,33 c	2,945 c	872,27 bc	3,76 b
3,0 bud.cm^{-2}	35,06 b	11017,17 ab	3,672 ab	1185,40 a	5,60 a
3,5 bud.cm^{-2}	42,56 a	11280,00 ab	3,759 ab	1059,73 ab	4,19 b
4,0 bud.cm^{-2}	47,33 a	12237,11 a	4,079 a	1173,90 a	5,72 a
Control	46,11 a	9563,22 bc	3,187 bc	1047,23 ab	6,16 a
P[1]	<0.0001	0.0019	0.0019	0.0107	0.0005

[1]Statistical significance value according to P:Variance analysis ($p<0.05$), NS.: Not Significant

Grape yield characteristics: The highest numbers of clusters were achieved in the 3.5 bud.cm^{-2}, control, and 4.0 bud.cm^{-2} treatments, which were statistically in the same group. The lowest number of clusters per vine was achieved in the 2.0 bud.cm^{-2} treatment at 26.39. While the highest grape yield per vine was achieved in the 4.0 bud.cm^{-2} treatment at 12237.11 g, the lowest yield was achieved in the 2.0 bud.cm^{-2} and 2.5 bud.cm^{-2} treatments. In terms of product per decare, the highest yield was achieved in the 4.0 bud.cm^{-2} treatment (4.0 tons), while the lowest yield was achieved in the 2.0 bud.cm^{-2} and 2.5 bud.cm^{-2} treatments (respectively, 2.8 tons and 2.9 tons). While the treatments with the highest values of the yield efficiency index, which is the ratio of grape yield per vine (g) to trunk cross-section area (cm^2), were 3.0 bud.cm^{-2} and 4.0 bud.cm^{-2}, the lowest value was achieved in the 2.0 bud.cm^{-2} treatment. The treatments were statistically divided into two groups according to the Ravaz index. Accordingly, the 3.0, 4.0 bud.cm^{-2}, and control treatments were found to have the highest index values, while other treatments displayed the lowest index values (Table 5). Khalil *et al*., (2018) found that an increase in pruning severity led to a decrease in grape yield. Balbaba and Tangolar (2018) observed a significant increase in the number of clusters and vine yield (except for 2014) in their 20+15 treatment in comparison to their 20+5 and 20+10 treatments in their 3-year study. Shiranal *et al*., (2020) reported a significant increase in total fruit weights in wine varieties, the shoot numbers of which were arranged, due to an increase in the number of clusters. The highest grape yield (14.91 kg/vine) in the control treatment was followed by the treatments where 40 and 33 shoots were left (13.46 kg and 13.02 kg/vine), respectively, and the lowest yield was obtained in vines with 25 shoots (11.83 kg). According to the values obtained in our study, with the exception of our control treatment, the increasing trend in the number of clusters, grape yield of vines, and grape yield per decare due to the increased number of buds in the vine, was similar to those provided in the literature. The ratio of yield to pruning weight is a good indicator of the balance between fruit and vegetative growth (Senthilkumar *et al*., 2015). The Ravaz index is a commonly used measurement method for both researchers and growers in the assessment of success of vineyard management practices (Bates *et al*., 2011). The most appropriate level for a vine with medium strength is a 5:10 g yield/pruning weight ratio (Senthilkumar *et al*., 2015). The 3-4 bud.cm^{-2} and control treatments in our study were able to reach the 5-7 range determined by Vasconcelos & Castagnoli (2000) for balanced vines. In our study, minimal intervention was made on summer shoot growth to vegetatively determine the effectiveness of the treatments applications. Thus, it was considered that an arrangement could be made based on the extent of intervention in shoot development, and labor costs could be evaluated according to bud loads in vines. Therefore, the other treatments yielded low Ravaz index values.

Table 6. The effect of different bud load levels on cluster characteristics.

Treatments	Cluster weight (g)	Cluster width (cm)	Cluster lenght (cm)	Cluster size (cm^2)	Berry homogeneity in cluster (%)
2,0 bud.cm^{-2}	417,66	12,46	19,04	237,28	79,82 (63,52)
2,5 bud.cm^{-2}	406,00	11,91	19,41	230,94	79,71 (63,41)
3,0 bud.cm^{-2}	412,37	12,00	20,25	243,32	77,79 (62,04)
3,5 bud.cm^{-2}	371,67	11,69	20,41	238,95	73,60 (59,15)
4,0 bud.cm^{-2}	352,82	11,94	18,91	225,99	77,73 (61,85
Control	336,87	11,40	19,14	217,80	78,82 (62,49)
P[1]	ns	ns	ns	ns	ns

[1]Statistical significance value according to P:Variance analysis ($p<0.05$), ns: Not significant

Table 7. The effect of different bud load levels on berry characteristics.

Treatments	100 berry weight (g)	Berry length (mm)	Berry width (mm)	Berry size (mm^2)	L	a	b	H	CIRG
2,0 bud.cm^{-2}	581,98	22,40	19,78	443,18 a	24,10	1,74	1,22	33,08	5,63
2,5 bud.cm^{-2}	572,53	21,86	19,67	430,09 ab	23,88	1,97	1,14	29,93	5,77
3,0 bud.cm^{-2}	589,75	22,51	19,90	448,07 a	23,86	2,06	1,13	26,81	5,92
3,5 bud.cm^{-2}	551,19	21,46	19,10	409,68 b	24,44	1,73	1,50	33,32	5,57
4,0 bud.cm^{-2}	562,31	21,95	19,45	426,99 ab	24,85	2,27	1,80	31,28	5,45
Control	559,88	21,99	19,42	427,28 ab	24,03	1,94	1,07	25,53	5,94
P[1]	ns	ns	ns	0.0496	ns	ns	ns	ns	ns

[1]Statistical significance value according to P:Variance analysis ($p<0.05$), ns: Not significant

Grape quality characteristics: It was determined that the effects of different bud loads on cluster weight, cluster widths, cluster lengths, cluster sizes, and berry homogeneity in the clusters were not statistically significant (Table 6). The effects of different bud load levels on Chambourcin vines (Kurtural *et al.*, 2006), Pinot Noir vines (Heazlewood *et al.*, 2006), Trakya İlkeren vines (Polat & Uzun, 2007), and Early Cardinal vines (Balbaba & Tangolar, 2018) on cluster weight were not found significant in previous studies. Khalil *et al.*, (2018) found that the effects of different numbers of buds (96, 128, 160 buds) were the highest in the samples with 128 buds in the Sahebi variety. Shalan (2013) reported that their 2 bud.cm^{-2} treatment increased the cluster weight in comparison to their 5 bud.cm^{-2} treatment in the Flame Seedless variety in both years of their study. The conclusion of Shalan (2013), indicating that a reduction in the numbers of buds increased the cluster weight, was not observed in our study. Our findings were generally in parallel with the results of the provided literature. It was determined that different bud load levels did not impact the 100-berry weight, berry length, or berry width. However, this effect, which was not observed on the berry length and berry width, was reflected on the berry size (width x length), while the highest value was identified in the 3.0 bud.cm^{-2} and 2.0 bud.cm^{-2} treatments, and the lowest value was identified in the 3.5 bud.cm^{-2} treatment (Table 7). The results reported by Balbaba and Tangolar (2018) and Polat & Uzun (2007), indicating that the effects of different bud loads on 100-berry weights were not significant, were found to be fully supporting our findings, while the results of the study by Kurtural *et al.*, (2006) were found to be partially supporting ours. The effects of the numbers of buds on berry weight, reported by Khalil *et al.*, (2018), yielded a result similar to the effect on berry size in our study. No significant change was observed in berry color. The L (23.86-24.85), a (1.73-2.27), b (1.07-1.80), and H (25.53-33.32) values were found to be similar between the treatments (Table 7). The results of Sayman & Akın (2015), who reported that the control, 25 bud/vine, and 30 bud/vine treatments did not create a statistically significant difference in L, a, and b values indicating berry color, were in parallel with our findings. The CIRG value that was determined between 5.45 and 5.94 based on the treatments in our study indicated that grape berry color is was Red-Black according to the OIV descriptor list (Carreño *et al.*, 1996).

The TSS content values were between 12.87% and 14.57% in the treatments in our study, and no statistically significant difference was observed. The pH values were between 3.55 and 3.68. Acidity content was found to be the highest in the 3 bud.cm^{-2} and 4 bud.cm^{-2} treatments. The control, 2 bud.cm^{-2}, and 2.5 bud.cm^{-2} treatments yielded the lowest (0.72%) acidity value. The maturity index reached the highest value in the 2.0 and 2.5 bud.cm^{-2} treatments, while the lowest value was obtained from the 4.0 bud.cm^{-2} treatment (Table 8). The results of Balbaba & Tangolar (2018), indicating that different numbers of buds did not affect TSS and pH (three years), and Kurtural *et al.*, (2006), indicating that different numbers of buds did not affect TSS and pH (first year, in two vineyards), supported the findings of our study. Differently from the studies of Balbaba & Tangolar (2018) and Polat & Uzun (2007), the results of our study, indicating that acidity increased while the maturity index value decreased upon an increase in the bud load, were similar to the results of Shalan (2013).

Table 8. The effect of different bud load levels on juice characteristics.

Treatments	TSS (%)	pH	Acidity (%)	Maturity index
2,0 bud.cm^{-2}	14,57	3,62	0,72 b	20,29 a
2,5 bud.cm^{-2}	14,17	3,68	0,72 b	19,99 a
3,0 bud.cm^{-2}	13,60	3,56	0,83 a	16,43 bc
3,5 bud.cm^{-2}	14,10	3,62	0,77 ab	18,36 abc
4,0 bud.cm^{-2}	12,87	3,55	0,82 a	15,66 c
Control	13,77	3,62	0,72 b	19,29 ab
P[1]	ns	ns	0.0206	0.0214

[1]Statistical significance value according to P:Variance analysis (p<0.05), ns: Not significant

Table 9. The effect of different bud load levels on chlorophyll content.

Treatments	Chlorophyll content (SPAD)			
	01 Jun	15 Jun	25 Jun	Mean
2,0 bud.cm^{-2}	26,20	25,38	28,67	26,70
2,5 bud.cm^{-2}	27,08	25,54	28,65	27,10
3,0 bud.cm^{-2}	25,87	25,59	29,22	26,90
3,5 bud.cm^{-2}	26,67	24,86	29,77	27,10
4,0 bud.cm^{-2}	26,95	25,90	30,36	27,73
Control	26,11	27,12	31,05	28,10
P[1]	ns	ns	ns	ns

[1]Statistical significance value according to P:Variance analysis (p<0.05), ns: Not significant

Table 10. The effect of different bud load levels on light intensity and berry surface temperature.

Treatments	Light intensity (lux)				Berry surface temperature (°C)			
	2 Jun	14 Jun	25 Jun	Mean	2 Jun	14 Jun	25 Jun	Mean
2,0 bud.cm^{-2}	3667,73 a	2285,33 a	2554,27 a	2835,76 a	28,97	31,77	33,40	31,40
2,5 bud.cm^{-2}	2461,43 b	1651,28 b	1603,90 b	1883,33 b	28,20	31,63	32,83	30,90
3,0 bud.cm^{-2}	2681,63 b	1409,90 bc	1264,80 bc	1785,47 b	28,27	31,17	32,70	30,70
3,5 bud.cm^{-2}	2513,20 b	1546,27 bc	1379,50 bc	1813,53 b	28,13	30,53	32,17	30,30
4,0 bud.cm^{-2}	1843,90 c	1032,23 c	932,63 c	1269,57 c	28,10	30,60	32,23	30,33
Control	3018,20 b	1520,06 bc	1369,93 bc	1969,40 b	29,33	31,77	33,00	31,37
P[1]	0.0006	0.0036	0.0002	<.0001	ns	ns	ns	ns

[1]Statistical significance value according to P:Variance analysis (p<0.05), ns: Not significant

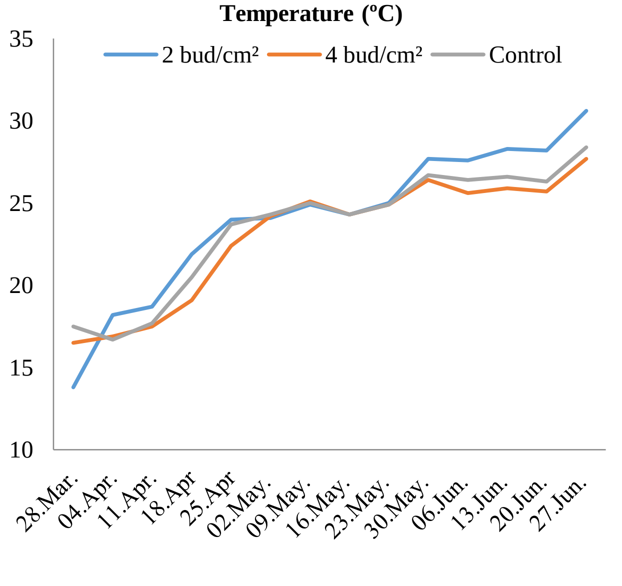

Fig. 1. Weekly intra-canopy temperature change in control, 2 bud/cm^2, 4 bud/cm^2 applications.

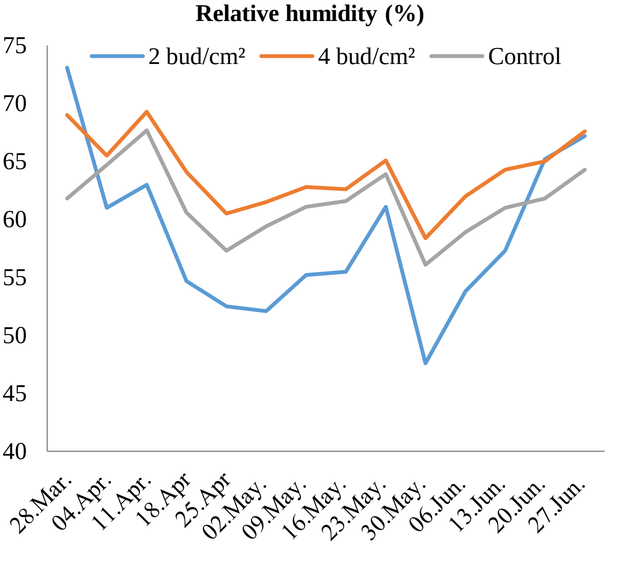

Fig. 2. Weekly intra-canopy relative humidity change in control, 2 bud/cm^2, 4 bud/cm^2 applications.

Physiological characteristics: Different bud load applications per unit trunk cross-section area have statistically similar effects on leaf blade nitrogen, phosphorus, and potassium contents during the full bloom period (data not shown). An increase in bud load in the Superior Seedless variety (increase from 72 to 96) caused a decrease in the N and K contents of leaf petioles (Samra *et al*., 2006), while an increase in the number of buds left per cm^2 in trunk cross-section area in the Flame Seedless variety caused a decrease in N, P, and K contents (Shalan, 2013). An increase in the number of shoots per vine in the Thompson Seedless variety caused an increase in the N, P, and K contents of petioles (Senthilkumar *et al*., 2015). The effects of the treatments in our study on leaf blade N, P, and K contents were not statistically significant as opposed to the studies of Samra *et al*., (2006), Shalan (2013), or Senthilkumar *et al*., (2015). Chlorophyll is an important pigment that ensures the absorption of light, constituting the primary stage of photosynthetic reactions in plant growth, at different wavelengths (Li *et al*., 2018). A positive correlation was reported between yield per vine and photosynthetic speed and leaf area per vine (Senthilkumar *et al*., 2015). In this study, no statistically significant difference was observed between the treatments during the leaf chlorophyll measurements performed at different times in the grapes (pre-veraison, veraison, and harvest). The chlorophyll contents were found to be close (26.70-28.10) according to the average period values of the treatments (Table 9). Hamid *et al*., (2015) reported that there was no significant difference in leaf chlorophyll contents in vines pruned from 32-42-52-60 buds in the Autumn Royal variety. Our findings indicated that chlorophyll contents were not affected by different bud load levels, similar to the study by Hamid *et al*., (2015).

Canopy microclimate: The weekly temperature and relative humidity values of the control and treatment groups are given respectively in Figs. 1 & 2. It was observed that intra-canopy temperature values were higher in the 2 $bud.cm^{-2}$ treatment, and this difference reached the highest value (approximately 3ºC) between veraison and harvest in comparison to the 4 $bud.cm^{-2}$ treatment. It was seen that intra-canopy relative humidity values were the lowest during the process of post-bud burst, almost until the harvest time in the 2 $bud.cm^{-2}$ treatment, unlike temperature. The purpose of a canopy microclimate in most commercial vineyards is to maximize the penetration of light inside the canopy and minimize internal shading. The potential light penetration inside the canopy may vary according to vine leaf area and growth in vineyards (Bates *et al*., 2011). Light may have a positive impact on the quality of the harvested product. The quality of clusters that are exposed to sunlight vary depending on temperature or light quality (Bahar *et al*., 2018). The light intensity measurement values in the cluster area were found to differ significantly based on the different bud load treatments in our study. In general, while the intensity of light, measured pre-veraison, was higher, a decrease was identified in light intensity towards the maturity time. Light intensity decreased in line with the increase in the number of buds left per unit trunk cross-section area (Table 10). As a consequence of an overall evaluation, it was seen that the measurements in the cluster area were below the light balance point. Shading in a cluster reduces the concentration of phenolic substances. Other effects of light are less notable than temperature. In general, low light causes berry size, pH, and TSS to decrease and total acidity to increase (Ağaoğlu, 2002). The berry surface temperatures in the grape clusters within the vine canopy were observed to be a few degrees higher in following measurement times. However, no statistically significant difference occurred in terms of both measurements at different times and average temperature values (Table 10).

Conclusion

The conversion of yield and quality into adequate economic income depends on crop load (number of buds), recognized as an important and primary cultural parameter in grape production. In this sense, the effects of treatments with varying numbers of winter buds left per unit of trunk cross-section area, were examined to determine the number of buds to be left on vines based on trunk growth.

Different numbers of buds did not have a distinctive effect on phenological periods in the Prima grape cultivar, which could be considered as very early in terms of maturity in the area where the study was conducted. It was determined that the bud burst percentages and the coefficients of bud fertility in the treatments were reduced by the increasing number of buds (14-32 bud/vine). The difference in the total number of shoots, growing on old parts of the vines, was limited to 2. It was considered that removing these shoots would not cause a significant load between the treatments. However, this value was found to be high for the vines with low numbers of buds in proportion to the number of winter buds left on the vines. There was no significant change in the numbers of secondary shoots and total numbers of inflorescences on these shoots in the winter buds left on the vines. In this sense, it was considered that disbudding practices could be completed in a similar duration and at a similar cost during the vegetation period in vines with different numbers of buds in the study. It was determined that the increase in the number of buds left on the vines caused an increase in the number of shoots to a certain extent, and this effect reduced shoot length and shoot diameter growth. In terms of these characteristics, the number of buds left in the 4 $bud.cm^{-2}$ treatment in our study can be accepted as a limit. This is because there was no increase in the number of shoots although more buds were left in the control treatment. Different bud loads did not cause any significant difference in trunk development in the treatments. No significant difference was determined in leaf N, P, K contents and chlorophyll measurements. The intra-canopy light and temperature values during the period near maturity were found to be significantly higher in the 2 $bud.cm^{-2}$ treatment. It was considered that this situation could have an effect on shoot growth and fruit maturity. The numbers of clusters were found to be high also in the control and 3.5 $bud.cm^{-2}$ treatments besides the 4 $bud.cm^{-2}$ treatment with the highest main leaf area/vine values. However, the increase in leaf area and number of clusters was not reflected on grape yield per vine and decare in the control treatment. The treatments with a grape yield above 3.5 tons were found to be interesting. No significant difference was observed between the treatments in the study in terms of cluster characteristics, berry characteristics (except for berry size), berry color, TSS in juice, or pH content. The 3 bud.cm^{-2} treatment, with a yield above 3.5 ton/da, was prominent in terms of berry size. In the 4 bud.cm^{-2} treatment, the juice acidity content was high, and the maturity index value was low. Product maturation was quicker in the vines on which fewer buds were left (2.0-2.5 bud.cm^{-2}).

It was considered that the increased number of buds in the study might have led to an increase in yield, a slowdown in the course of grape maturity, and a delay in harvest time, without causing a significant loss of quality. In this regard, market price and the decisions of growers are important in terms of treatment selection. It is considered that the recommended crop load (number of buds), which might require minimal summer pruning in terms of vegetative balance, besides yield and quality, is 3.0 bud.cm^{-2} among the treatments tested in this study in terms of the number of buds to be left per unit trunk cross-section area.

Acknowledgements

This study was supported by the Scientific Research Projects Coordination Unit, Hatay Mustafa Kemal University (Project No: 21.YL.012).

References

Ağaoğlu, Y.S. 2002. Asma fizyolojisi. Kavaklıdere Eğitim Yayınları, No: 5, 445s Ankara.

Anonymous. 2022. Food and agriculture organization of the united nations, https://www.fao.org/faostat/en/#data/QI.

Bahar, E., I. Korkutal and H. Öner. 2018. Bağcılıkta terroir unsurları. *Bahçe*, 47(2): 57-70.

Balbaba, N. and S. Tangolar. 2018. Early Cardinal üzüm çeşidinde farklı terbiye şekilleri ile göz yükünün verim ve kalite özellikleri ile taç mikroklimasına etkisi. *Ç.Ü Fen ve Mühendislik Bilimleri Dergisi*, 35(1): 129-138.

Barton, C.J. 1948. Photometric analysis on phosphate rock. *Ind. Anal. Eng. Chem.*, 20: 1068-1073.

Bassiony, S.S. 2020. Effect of bud load levels and summer pruning on vine vigor and productivity of "Flame Seedless" (*Vitis vinifera* L.) grapevines. *J. Plant Prod.*, 11(4): 301-310.

Bates, T., B. Grochalsky and S. Nuske. 2011. Automating measurements of canopy and fruit to map crop load in commercial vineyards. appellation cornell. *Research News from Cornell's Viticulture and Enology Program Research Focus*, 4: 1-6 p

Brandon, S., D.D. Archbold and S.K. Kurtural. 2012. Effects of balanced pruning severity on traminette (*Vitis* spp.) in a warm climate. *Amer. J. Enol. Vitic.*, 63(2): 284-290.

Bremner, J.M. 1965. Total nitrogen. In: *Methods of soil analysis.* (Ed.): Black, C.A.. Part 2. *Agron.*, 9: 1149-1178.

Carreño, J., A. Martínez, L. Almela and J.A. Fernández-López. 1996. Measuring the color of table grapes. *Color Res. & Appl.*, 21(1): 50-54.

Çelik, H. 2017. Bağlarda taç yönetimi-kış budamaları. *Turk. Dergisi*, 24: 32-42 s.

Çelik, H., Y.S. Ağaoğlu, Y. Fidan, B. Marasalı and G. Söylemezoğlu. 1998. Genel bağcılık. *Sun Fidan A.Ş. Mesleki Kitaplar Serisi*: 1, 253, Ankara.

Çelik, S. 2007. Bağcılık (Ampeloloji). *N.K.Ü. Ziraat Fak., Bahçe Bitkileri Bölümü*, Tekirdağ, 428s.

Chougule, R.A. 2004. Studies on sub-cane pruning and cycocel application in relation to the canopy management in grapes. *M.Sc., Thesis submitted to MPKV*, Rahuri

Gąstoł, M. 2015. Vineyard performance and fruit quality of some ınterspecific grapevine cultivars in cool climate conditions. *Folia Hort.*, 27(1): 21-31.

Hamid, A., N. Samah, I. Nasr and H.M. Korkar. 2015. Effect of vine bud load on bud behavior, yield, and cluster characteristics of Autumn Royal Seedless grapevines. *Arab Uni. J. Agri. Sci.*, 23(1): 51-60.

Heazlewood, J. E., S. Wilson, R.J. Clark and A.J. Gracie. 2006. Pruning effects on pinot noir vines in Tasmania (Australia). *Vitis*, 45(4): 165-171.

Jackson, D. 2001. Monographs in cool climate viticulture-1. pruning and training. *Daphne Brasell Associates and Lincoln University Press*. 68 p.

Kahramanoğlu, İ., S. Usanmaz, T. Alas, V. Okatan and C. Wan. 2020. Combined effect of hot water dipping and *Cistus creticus* L. leaf extracts on the storage quality of fresh Valencia oranges. *Folia Hort.*, 32(2): 337-350.

Kamiloğlu, Ö., A.A. Polat and C. Durgaç. 2011. Comparison of open field and protected cultivation of five early table grape cultivars under mediterranean conditions. *Turk. J. Agric. For.*, 35: 491-499.

Khalil, A., N. Nazir and R. Bhat. 2018. Influence of bud load and micronutrients on pomological traits and economics of grape cv. Sahebi. *Int. J. Adv. Res. Sci. & Eng.*, 7(4): 865-872.

Kurtural, S.K., I.E. Dami and B.H. Taylor. 2006. Effects of pruning and cluster thinning on yield and fruit composition of Chambourcin' Grapevines. *Hort. Technol.*, 16(2): 233-240.

Li, Y., N. He, J. Hou, L. Xu, C. Liu, J. Zhang and X. Wu. 2018. Factors influencing leaf chlorophyll content in natural forests at the biome scale. *Front. Ecol. & Evol.*, 6: 64.

Lin, Y., C. Jiang, Y. Guo, L. Li, Z. Liu, Z. Lin, X. Li, G. Yue, Q. Fu, W. Li J. Zheng, Y. Dou and X. Gou. 2018. Relationship between 2-phenylethanol content and differential expression of L-amino acid decarboxylases (AADC) in (*Vitis vinifera*) vidal wine grape at different loads. *Pak. J. Bot.*, 50(2): 661-666.

Matthews, M.A. 2016. Terroir and other myths of winegrowing. *University of California Press*. 289 p.

Motosugi, H., Y. Yamamoto, T. Naruo and D. Yamaguchi. 2007. Growth and fruit quality of 'kyoho'grapevines grafted on autotetraploid rootstocks. *J. Japanese Soc. for Hort. Sci.*, 76(4): 271-278.

Okatan, V. 2020. Antioxidant properties and phenolic profile of the most widely appreciated cultivated berry species: A comparative study. *Folia Hort.*, 32(1): 79-85.

Omar, A.H. and A. Abdel-Kawi. 2000. Optimal bud load for Thompson Seedless grapevines. *J. Agri. Sci. Mansoura Univ.*, 25(9): 5769-5777.

Palma, L.D., V. Novello and L. Tarricone. 2000. Blind buds, fruitfulness and balance between vegetative and reproductive growth of grape cv. Victoria as related to bud load and pruning system during vine canopy establishment. *Rivista di Frutticoltura e di Ortofloricoltura*, 62(3): 69-74.

Polat, I. and I. Uzun. 2007. Plastik serada yetiştirilen trakya ilkeren üzüm çeşidinde farklı terbiye sistemi ve asma şarjı uygulamalarının erkencilik, verim ve kalite faktörleri üzerine etkileri. *Akdeniz Üniversitesi Ziraat Fakültesi Dergisi*, 20(2):289-300.

Qui, Z., G. Chen and D. Qui. 2019. Pruning and dormancy breaking make two sustanible grape cropping productions in a protected environment possible without overlap in a single year. *Peer J.,* 412: 1-19.

Samra, N.R., M. El-Kady, M.H. Rizk and A.S. Soliman. 2006. Effect of pruning severity on bud behaviour, vegetative growth, yield and some bunch characteristics of Superior Seedless grape. *J. Agric. Mansoura Univ. Sci.,* 9: 5845-5858.

Sayman, M. and A. Akın. 2015. Razakı üzüm çeşidinde farklı seviyede şarj (ürün yükü) ve hümik madde uygulamalarının verim ve verim unsurları üzerine etkileri. *ÇOMÜ Zir. Fak. Derg.,* 3(2): 1-8.

Senthilkumar, S., R.M. Vijayakumar, K. Soorianathasundaram and D.D. Devi. 2015. Effect of pruning severity on vegetative, physiological, yield and quality attributes in grape (*Vitis vinifera* L.)–A review. *Curr. Agri. Res. J.,* 3(1): 42-54.

Shalan, A.M. 2013. Performance of *Vitis vinifera* cultivar Flame Seedless grapevines under different node load per centimeter square of trunk cross-sectional area. *Asian J. Crop Sci.,* 5(2): 139-152.

Shiranal, R., K. Hipparagi, S.N. Patil, D.L. Rudresh, M. Awati, G. Raghavendra and S. Pattepur. 2020. ınfluence of cane regulation on growth, yield and quality of wine grapes (*Vitis vinifera* L.). *Int. J. Curr. Microbiol. App. Sci.,* 9(2): 440-446.

Somkuwar, R.G., P.B. Taware, D.D. Bondage and S. Nawale. 2012. Influence of shoot density on leaf area, yield and quality of tas-a-ganesh grapes (*Vitis vinifera* L.) grafted on Dog Ridge rootstock. *IRJPS, 3*: 94-99.

Steyn, J., J. Aleixandre Tudo and J.L. Aleixandre Benavent. 2016. Grapevine vigour and within vineyard variability: A Review. *Int. J. Sci. & Eng. Res.,* 7(2):1056-1065.

Teker, T. and A. Altindisli. 2021. Excessive Pruning Levels in Young Grapevines (*Vitis vinifera* L. cv. Sultan 7) Cause Water Loss in Seedless Cluster Berries. *Int. J. Fruit Sci*., 21: 1, 979-992

Teker, T., O. Soltekin and A. Altindişli. 2018. Effects of extreme bud load and leaf removal treatments on leaf water potential, stomatal conductance and ripening of'Sultana'(*Vitis vinifera* L.). *In XXX International Horticultural Congress IHC2018: International Symposium on Viticulture: Primary Production and Processing*. pp. 205-212.

Turkstat, 2020. Türkiye bitkisel üretim istatistikleri. *http://www.tuik.gov.tr*

Uyak, C., A. Doğan and S. Delikanlıoğlu. 2016. Effects of pruning ıntensity on grape yield and quality of Ercis grape cultivar (*Vitis vinifera* L.). *Res. J. Agri. Sci.,* 9(1): 45-47.

Vasconcelos, M.C. and S. Castagnoli. 2000. Leaf canopy structure and vine performance. *Amer. J. Enol. & Viti.,* 51(4): 390-396.

Wei, X., S.R. Sykes and P.R. Clingeleffer. 2002. An investigation to estimategenetic parameters in CSIRO's table grape breeding program. 2. Quality characteristics. *Euphytica,* 128(3): 343-351.

Zabadal, T.J. 2002. Growing table grapes in a temperate climate. *Michigan State University Extension*, 44 p.

(Received for publication 15 June 2022)