



Effect of Shoots and Clusters Density on Microclimatic Changes, Yield, and Fruit Quality of King Ruby Grapevines

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THE fruit quality of grapevines is a great importance for local consumption and export. Shoots and clusters thinning are substantial agricultural practices in grapevines to improve the berries quality. Herein, 10-years-old King Ruby grapevines were examined in two successive seasons. Four different levels of shoots number were applied (48, 42, 36, and 30, shoots/vine) with two different levels of clusters (30 and 24 clusters per vine). Results showed that the gradual decrease of shoots and clusters/vine improved vegetative growth parameters (shoot length and leaf surface area), total chlorophyll content, and microclimatic characteristics (light intensity, air temperature, and relative humidity); however, decreased yield/vine was observed. Consequently, enhanced chemical properties of berries (SSC, SSC/acid ratio total sugars, total anthocyanins, and total phenols) were obtained. In addition, an improved coefficient of wood ripening and total carbohydrates in canes was recorded. Moreover, the progressive increase in the number of shoots/vines in parallel with the decreased number of clusters/vine raised the cluster weight, cluster length, width, berry weight, length, and width. The thinning application of 30 shoots + 24 clusters per vine collectively achieved the significant highest values of vegetative growth, microclimatic parameters and berries quality, therefore, it could be recommended for application in King ruby vineyards under the Egyptian climatic.

Keywords: King Ruby grapevines, Shoots and Clusters density, Microclimate, Yield and Quality.

Introduction

Grapes (*Vitis vinifera* L.) is considered one of the most prominent fruit crops for consumption and export due to its high nutritious value, unique flavor, multipurpose applications and great money-related returns. It is also used to produce raisins, juices, drinks, jams, etc. Grapes are exceptionally digestible and have different medicinal properties (Kareem et al. 2022). Globally, the grapevine is ranked fifth among the top produced fruits next to bananas, watermelons, apples, and oranges with a total worldwide production of more than 77 million tons (FAOSTAT, 2021). In the last few years, the cultivated area of grapes in Egypt has grown rapidly in the last two decades

reached about 200,000 feddans producing about 1,800,000 tons according to the statistics of the Ministry of Agriculture (2020). King Ruby is one of the most distinguished cultivars of table grapes in the local and international markets due to its high fruitful. It's ripened late mid-season and produces dark red crisp fruit that is sweet and juicy and its high nutritious value and is beneficial in various ways (Al- Obeed et al., 2010 and Asmaa and Aboryia, 2020). Small berry size and poor coloration as well as high susceptibility to downy mildew severely are the most problem facing this cultivar which can cause a major loss in production and quality (Belal et al., 2016). The overload of clusters/berries and increased shoots density (shading) negatively impact the quality

characteristics of this cultivar, such as small berry size and poor coloration (El-Akad *et al.*, 2021). Therefore, determining the optimum number of shoots and clusters for this cultivar is a great importance to obtain desirable berries quality for both local consumption and export.

The excessive shading causes undesirable effects on developing grapes, including decreased sugar, color, phenolic, flavor and maturity (Downey *et al.*, 2006 and Ristic *et al.*, 2007) also, shading lead to decrease fruitfulness in the following season (Dry, 2000). Canopy management is a powerful factor that reduces excessive shading, directly enhancing berries quality, increasing diseases resistance, and photosynthetic efficiency of the grapevines (Somkuwar *et al.*, 2012 and Frioni *et al.*, 2017). The canopy management includes a range of practices on the vine shoots and clusters, leading to changes in the position or amount of leaves, shoots, and clusters (Dry, 2000). Among these techniques, shoots, and clusters thinning greatly impacts the source-sink relationship and the distribution of photo-assimilates between leaves and clusters (Mota *et al.*, 2010). Moreover, the optimized shoot spacing greatly enhances the canopy microclimate (Roberta *et al.*, 2020), light interception, leaf exposure and ventilation (Smart, 1992), and fruit composition (Reynolds *et al.*, 2005). In highly regulated production zones, this practice is also used as an alternate to cluster thinning to achieve the aim yield (Bernizzoni *et al.*, 2011). The vines responded to severe reduction in shoots number with an increase in leaf area and a higher cane weight while, yield compensated for the reduced bunch number from shoot thinned vines by increasing in bunch and berries weight (Roberta *et al.*, 2020).

On the other hand, clusters thinning is a common management technique executed by grape growers to control the production amount to be within the limits of the natural load and improve clusters quality (Fawzi & Abd El-Moniem 2003, Nuzzo, 2004 and Belal *et al.*, 2016). In addition, thinning of clusters or berries determines the clusters' size, directly promoting their ripening, sugar contents, and anthocyanins (El-Salhy *et al.*, 2010, Vicente & Yuste, 2015 and Belal *et al.*, 2016). Cluster thinning also affects the availability of stored food material required to grow developing cluster after the fruit thinning. Thinning of clusters technique varies based on the cultivar and sunshine and temperature and nutrient supply (Cheema *et al.*, 2003, Poni, 2003;

and El-Salhy *et al.*, 2010). Clusters thinning could be essential or recommended in vineyards with overload and/or under adverse climate conditions. It can help achieve the desired maturity status if done early enough before harvest (Radwan, and Masood, 2017). The reduction of crop modifies the source-sink ratio and can facilitate the advancement of ripening (Pallioti *et al.*, 2000). Rising number of clusters on the vine could be reduce berry dimensions and SSC% (Somkuwar and Ramteke, 2010), on the other hand decrease load of clusters per vine could be decreasing yield, but lead to increase berry weight, SSC/ acidity ratio (Ezzahouani & Williams, 2003 and Mancha *et al.*, 2021), anthocyanins content (Pastore *et al.*, 2011), phenolic content (Gil *et al.*, 2013) as well as, increased vegetative growth vigor (Kavoosi *et al.*, 2009). Removal some of shoots and clusters is a practice used to enhance the chemical characteristics of grape berries by controlling the relationship between leaf area and clusters (Dayer *et al.*, 2013). Cluster thinning and cluster zone leaf removal leads to changes in the fruit microenvironment. In addition to, enhance fruit ripening, fruit uniformity and chemical composition (Frioni *et al.* 2017). Cluster thinning and shoot topping resulted in the best yield, cluster and berries quality (Bassiony 2020). The thinning severity affects the leaf photosynthesis, physiological parameters, total soluble solids, titratable acidity and pH (Cataldo *et al.*, 2021).

The present investigation purposed to study the influence of shoots and clusters density through their respective thinning practices on the production, microclimatic changes, and quality of clusters and berries of King Ruby grapevines.

Materials and Methods

Plant materials and experimental design

Two successive seasons (2019 & 2020) on King Ruby grapevines were conducted in El-Waha vineyard of El-Khatatba region, Minufyia Governorate, Egypt. In sandy soil, ten-year-old vines were chosen, spaced at 2 X 3 meters, irrigated by the drip irrigation system, and trellised by the Spanish Parron system. Vines were trained to quadrilateral cordons. During the second week of January of each experimental season, the studied vines were spur-pruned by leaving 7 spurs with 2 eyes on each cordon; the total load was 56 eyes per vine. Four different shoots density were applied (48, 42, 36, and 30, shoots/vine) with two different levels of cluster thinning (30 and 24 clusters per vine). (48 shoots with 30 clusters

per vine represents the vineyard program). Shoots were thinned at the beginning of vegetative growth when shoots reached about 15–20 cm in length (Bernizzoni et al., 2011). Clusters thinning to adjust number of clusters per vine were performed after the fruit set (Ola, 2016). Seventy-two vines were regularly selected for this investigation in vigor as much as possible. All grapevines were given the same cultural administration recommended by the ministry of agriculture, such as fertilization, irrigation, disease, and pest management. The investigation included eight treatments coordinated in a complete randomized blocks design, each treatment replicated 3 times, and included 3 vines/replicate (Table 1).

Vegetative growth parameters and total chlorophyll content in the leaves

Vegetative growth parameters were taken from non-fruiting shoots two weeks after fruit set to determine: Average shoots length (cm) and number of leaves. Moreover, the leaf surface area (cm²) was measured two weeks after fruit set at the 6th and 7th leaf from the top of the developing shoot according to the following equation; Leaf surface area = 0.587 (L x W); Where, L= length of the leaf blade; W= width of the leaf blade (Montero et al., 2000). The leaves which were used to measurement leaf surface area was used to determined total chlorophyll content in the leaves (mg/g F.W.), which 0.1 g fresh leaf sample was

taken for extraction by 20 ml methanol for 24 hr under laboratory temperature and were measured by spectrophotometer under wave length 650 and 665 nm. (Mackinny, 1941) according to the following equation. Total chlorophyll=25.5 OD⁶⁵⁰ + 4.0 OD⁶⁶⁵ where OD= Optical Density.

Microclimatic data measurement

The microclimatic parameters for vines canopy, including light intensity (watt/m²), air temperature (°C), and relative humidity (%), were recorded weekly at the cluster's zone during the growing period from veraison stage to the harvest stage (Ghada, 2015). The Scheduler Plant Stress Monitor (Model R/O Consultant- Standard Oil Company, U.S.A) was used to measure the microclimatic parameters.

Yield, cluster, and berry physical characteristics

The total number of clusters per vine was recorded at harvest time when soluble solids content (SSC %) of berries juice attained to 16-17 %. A representative sample of six clusters/ vine was weighted, and the average cluster weight was multiplied by the number of clusters /vine. Hence, average yield/vine (Kg) was calculated, and yield/ feddan (ton) was calculated by multiplying yield/ vine in the total number of vines/feddan (700 vines). Also, average cluster weight (g), the weight of 100 berries (g), cluster length and width (cm), berry length and diameter (cm) were calculated.

TABLE 1. The thinning treatments used in the present study

Treatment	Thinning application*
T1	48 Shoots + 30 clusters/ vine
T2	48 Shoots + 24 clusters/ vine
T3	42 Shoots + 30 clusters/ vine
T4	42 Shoots + 24 clusters/ vine
T5	36 Shoots + 30 clusters/ vine
T6	36 Shoots + 24 clusters/ vine
T7	30 Shoots + 30 clusters/ vine
T8	30 Shoots + 24 clusters/ vine

*The shown values indicate the number of shoots and clusters that have been left.

Chemical properties of berries

The chemical properties of berries were determined in the used clusters to determine yield and physical characteristics. Soluble solids content (SSC %) was measured using a hand refractometer model Master T (ATAGO Co., Ltd., Tokyo, Japan). Titratable acidity percentage was measured by titration against 0.1 N NaOH and expressed as g tartaric acid/100 ml juice) as described by AOAC, (2006) then the SSC/acid ratio was also calculated. Total sugars (%) were measured according to the method described by Sadasivam and Manickam, (1996). Furthermore, total anthocyanin of the berries skin (mg/100g F.W.) was determined according to Husia *et al.*, (1965) which, samples of 0.5 g of berry skin were softly detached from the flesh using a sharp blade and added to 30 mL of acidified methanol (HCl 1% + methanol 99%), and left in the dark for 48 h then evaluated by spectrophotometer at 520 nm. Total phenols (mg/100g F.W) was extracted from berries using 80% ethanol method and determined using Spectrophotometer on wave length 650nm according to Malick and Singh (1980).

At dormant season's parameters

Before winter pruning, twelve shoots for each replicate were selected to measure the coefficient of ripening wood by dividing the length of the matured part by the total length of the shoot as stated by Rizk and Rizk, (1994). The total carbohydrates in canes was estimated at winter pruning time which, samples of 0.2 g from fine powder of dried canes were taken from the middle part of canes and were extracted with 15 ml HCL (1.0 N) for 6 hrs. and was estimated as (g /100 g D.W) on the method described by Hodge and Hofreiter (1962). Pruning wood weight at the winter pruning period was determined, and the data were recorded as Kg/vine.

Statistical Analysis

All data were examined for the influence of treatments on the recorded parameters by the one-way analysis of variance (ANOVA) technique. Treatments means were detached and compared using the New LSD value at 5% level according to the method described by Snedecor and Cochran (1980).

Results

Vegetative growth parameters and total chlorophyll content in the leaves

We observed that decreasing the number of shoots and clusters/vine causes a significant increase in shoot length, shoot diameter, leaf surface area, and total chlorophyll in leaves (Table 2). The minimum density (30 shoots + 24 clusters/vine) and maximum thinning (48 shoots + 30 clusters/vine) achieved the highest and lowest significant values, respectively of shoot length, the number of leaves per shoot, leaf surface area for leaf, and total chlorophyll in leaves in both seasons (Table 2). These results suggest an inverse relationship between density and vegetative growth of the King Ruby grapevine. Also, our results showed insignificant differences between the vines thinned at (48 shoots+24 clusters/ vine) and (42 shoots+ 30 clusters/vine) on shoot length, the number of leaves/shoots, and leaf surface area (Table 2). Similarly, there were non-significant differences between the vines thinned at (36 shoots+24 clusters/ vine) and those thinned at (30 shoots +30 clusters/vine) on the number of leaves/shoot in both seasons (Table 2).

Microclimate data

That microclimate data of the vine's canopy, such as light intensity, air temperature, and relative humidity, were affected by all the shoots thinning treatments in both seasons (Table 3). The vines removal at 30 shoots + 24 or 30 clusters/ vine produced the highest significant light intensity, air temperature, and relative humidity compared with other treatments in both seasons (Table 3). By comparison, the vines thinned at 24 or 30 clusters/vine under different shoots retentions showed insignificant differences on light intensity and air temperature in both seasons (Table 3), suggesting the shoots number but not cluster density as the main factor affecting the microclimate data. Consistently, the decreasing number of shoots from 48 to 36 shoots/vine under different clusters retentions was accompanied by increasing light intensity, air temperature, and relative humidity inside the vines (Table 3), suggesting an inverse relationship between shoots number and the microclimate data.

TABLE 2. Effect of shoots and clusters density on shoot length, number of leaves per shoot, leaf surface area, and total chlorophyll content in leaves of King ruby grapevines during 2019 and 2020 years

Treatments	Shoot length (cm)		Number of leaves per shoot		Leaf surface area (cm ²)		Total chlorophyll content (mg\gf.w)	
	2019	2020	2019	2020	2019	2020	2019	2020
T1 48 Shoots +30 clusters/ vine	134	140	18	19	75	80	10.5	11.6
T2 48 Shoots+24 clusters/ vine	139	148	19.3	19.7	80	85	11.4	12.7
T3 42 Shoots +30 clusters/ vine	143	153	19.7	20.3	83.3	87.3	12.5	13.6
T4 42 Shoots +24 clusters/ vine	149	157.3	21.3	21.5	87.3	92	13.6	14.9
T5 36 Shoots + 30 clusters/ vine	157	164	22	22	93.7	97.7	14.4	16.4
T6 36 Shoots +24 clusters/ vine	163	174.6	23.3	23.7	101.3	108	16.7	17.1
T7 30 Shoots+ 30 clusters/ vine	175	185	24	24.7	108.3	114.3	18.7	19.03
T8 30 Shoots+24 clusters/ vine	181.7	195	25	26	114.7	120	19.4	20.03
New L. S. D. at 5%	5.1	5.5	1.4	1.1	4.6	3.2	0.65	0.89

TABLE 3. Effect of shoots and clusters density on light intensity, air temperature and relative humidity of King Ruby grapevines during 2019 and 2020 years

Treatments	Light intensity (watt/m ²)		Air temperature (°C)		Relative humidity (%)	
	2019	2020	2019	2020	2019	2020
T1 48 Shoots +30 clusters/ vine	54.3	54.7	24.7	24.3	55.3	54.8
T2 48 Shoots+24 clusters/ vine	55.0	55.3	25.0	24.7	56.1	55.5
T3 42 Shoots +30 clusters/ vine	57.0	57.0	26.0	25.3	57.0	56.7
T4 42 Shoots +24 clusters/ vine	57.3	57.7	26.3	25.7	57.5	57.3
T5 36 Shoots +30 clusters/ vine	58.7	59.7	27.0	26.6	58.6	58.7
T6 36 Shoots +24 clusters/ vine	59.3	60.3	27.3	27.0	59.0	59.3
T7 30 Shoots+ 30 clusters/ vine	60.7	62.3	28.3	27.7	60.2	60.5
T8 30 Shoots+24 clusters/ vine	61.3	63.0	28.6	28.0	60.8	60.9
New L.S.D	1.1	0.91	1.22	1.11	0.7	0.5

Yield and physical properties of clusters and berries

Our results indicate that yield/vine and yield/feddan significantly differed in response to shoots and clusters density treatments (Tables 4). Yield/vine and yield/feddan were positively related to the number of shoots and clusters per vine. A gradual reduce in the number of shoots and clusters per vine were accompanied by a gradual reduce in yield/vine and yield/feddan and vice versa (Tables 4). The highest significant values of yield/vine (19.10 and 20.34 kg) and yield/feddan (13.37 and 14.23 ton) were registered when the number of shoots and clusters/vine were (48 shoots+30 clusters/ vine) followed by the vines were removal at (42 shoots+30 clusters/ vine), then the vines which were (36 shoots+30 clusters/vine) then the vines which were (30 shoots+30 clusters/ vine), but insignificant differences between of them. In contrast, the lowest significant values of yield/vine (15.71 and 17.29 kg) and yield/feddan (11.0 and 12.11 ton) were registered when the number of shoots and clusters per vine were (30 shoots+24 clusters/ vine) during the two seasons, respectively (Table 4). These results suggest a linear relationship between clusters density and yield, which is logically expected.

Furthermore, data showed that a decreasing number of clusters from 30 to 24 clusters/vine under different shoots retention treatments was accompanied by increasing cluster weight, 100 berries weight, cluster length and width, in addition to berry length and diameter (Table 4 and 5). Among all the treatments, the density of (48 shoots+24 clusters/ vine) significantly achieved the highest values of cluster weight (724 and 782 g) and 100 berries weight (428 and 451 g) in both seasons, respectively (Table 4). By contrast, the vines thinned at (30 shoots+30 clusters/vine) recorded the significant lowest values for cluster weight (620 and 660 g) and 100 berries weights (332 and 367 g) in both seasons, respectively (Table 4). Collectively, these results suggest an inverse relationship between clusters density and physical characteristics. Also, data showed that, when the number of shoots and clusters per vine was left on the vine at (48 shoots+24 clusters/ vine), cluster length and width, berry length and diameter recorded the significant highest values as compared with other applications followed by the vines which were thinned at (42 shoots+24 clusters/ vine) and non-significant differences between of them, while the vines which were removal at (30 shoots+30 clusters/ vine) recorded

the significant lowest values in this regard. Also, data revealed insignificant differences between the vines thinned at (36 shoots+24 clusters/ vine) and (42 shoots+24 clusters/ vine) on cluster length and width and berry length and diameter in both seasons (Table 5).

Chemical properties of berries

The data showed that soluble solids content (SSC), SSC/acid ratio, total sugars, total anthocyanins and total phenols of berries were significantly enhanced by thinning at 30 shoots+24 clusters/ vine (T8) compared to other treatments in both seasons (Table 6). Moreover, this treatment (T8) recorded the significant lowest total acidity values (Table 6). On the other hand, the vines density of (48 shoots+30 clusters/ vine) recorded the lowest significant soluble solids content, total sugars, total anthocyanins, total phenols, and the significant highest acidity (%) values (Table 6). These results suggest that the gradual increase of the shoots number/vine from 30 to 48 and the number of clusters/vine from 24 to 30 negatively affected the berries quality and vice versa.

At dormant season's parameters

The results revealed that coefficient of ripening wood, total carbohydrates in cans and pruning wood weight of King Ruby grapevines during the winter period were significantly affected by different applications (Table 7). The vines thinned at (30 shoots+24 clusters/vine) effectively enhanced the coefficient of ripening wood (0.90 and 0.92) and total carbohydrates in canes (34.82 and 35.58 g/100g D.W) as compared to other treatments in the 2019 and 2020 seasons, respectively (Table 7). By contrast, the vines thinned at (48 shoots+30 clusters/ vine) recorded the significant lowest values of coefficient of ripening wood (0.71 and 0.71) and total carbohydrates in canes (19.43 and 20.19 g/100g D.W) in both seasons, receptivity (Table 7). Notably, decreasing the number of shoots/vine from 48 to 30 and increasing the number of clusters/vine from 24 to 30 reduced the pruning wood weight (Table 7). The vines retained with 48 shoots+24 clusters/ vine recorded the significant highest pruning wood weight (4.35 and 4.5 kg) as compared with other applications in both seasons (Table 7). In comparison, the vines retained with 30 shoots+30 or 24 clusters/ vine recorded the significant lowest pruning wood weight during both seasons (Table 7). Our results indicated that the lower the shoots and clusters number/vine, coefficient of ripening wood and total carbohydrates in cans was the better.

TABLE 4. Effect of shoots and clusters density on yield/ vine, yield/ fadden, cluster weight, and 100 berry weight of King ruby grapevines during 2019 and 2020 years

Treatments	Yield/vine (kg)		Yield /Fadden (Ton)		Cluster weight (g)		100 berry weight (g)	
	2019	2020	2019	2020	2019	2020	2019	2020
T1 48 Shoots +30 clusters/ vine	19.10	20.34	13.37	14.23	637	678	366	388
T2 48 Shoots+24 clusters/ vine	17.36	18.76	12.15	13.14	724	782	428	451
T3 42 Shoots +30 clusters/ vine	18.95	20.20	13.26	14.14	632	673	368	378
T4 42 Shoots +24 clusters/ vine	16.76	18.00	11.73	12.61	698	750	408	431
T5 36 Shoots + 30 clusters/ vine	18.90	19.95	13.23	13.96	630	665	360	380
T6 36 Shoots +24 clusters/ vine	16.42	17.74	11.49	12.42	684	739	403	415
T7 30 Shoots+ 30 clusters/ vine	18.61	19.81	13.02	13.87	620	660	332	367
T8 30 Shoots+24 clusters/ vine	15.71	17.29	11.0	12.11	655	721	376	412
New L. S. D. at 5%	1.17	0.73	0.82	0.51	45	26	23.0	10.0

TABLE 5. Effect of shoots and clusters density on cluster and berry physical properties of King ruby grapevines during 2019 and 2020 years

Treatments	Cluster length (cm)		Cluster width (cm)		Berry length (mm)		Berry diameter (mm)	
	2019	2020	2019	2020	2019	2020	2019	2020
T1 48 Shoots +30 clusters/ vine	28.0	30.0	19.0	19.0	17.0	18.7	16.0	16.3
T2 48 Shoots+24 clusters/ vine	33.0	33.0	21.7	22.0	21.3	22.0	19.3	20.0
T3 42 Shoots +30 clusters/ vine	28.0	28.7	18.3	19.3	18.0	18.7	17.0	17.33
T4 42 Shoots +24 clusters/ vine	31.7	32.0	20.3	21.0	19.7	20.7	19.0	20.0
T5 36 Shoots +30 clusters/ vine	27.0	27.3	17.0	18.3	17.0	17.7	16.0	16.2
T6 36 Shoots +24 clusters/ vine	30.3	30.7	20.0	20.7	19.7	21.0	17.3	19.0
T7 30 Shoots+ 30 clusters/ vine	25.3	26.7	17.3	18.3	16.3	17.0	15.0	16.3
T8 30 Shoots+24 clusters/ vine	29.0	31.0	19.0	20.3	20.0	20.3	17.3	18.0
New L. S. D. at 5%	1.9	1.5	1.5	1.2	1.5	1.3	1.5	1.6

TABLE 6. Effect of shoots and clusters density on chemical properties of berries during 2019 and 2020 years

Treatments	SSC (%)		Acidity (%)		SSC/Acid ratio (%)		Total Sugars (%)		Total Anthocyanins (mg /100g F.W)		Total phenols mg/100g (F.W)		
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	
T1	48 Shoots +30 clusters/ vine	16.5	17.0	0.74	0.68	22.5	25.0	15.27	15.76	29.34	30.4	51.46	50.90
T2	48 Shoots+24 clusters/ vine	16.9	17.5	0.68	0.65	25.10	26.9	15.92	16.36	31.52	32.5	56.33	56.6
T3	42 Shoots +30 clusters/ vine	17.6	18.0	0.65	0.62	27.3	29.05	16.3	16.69	32.7	33.8	59.11	59.35
T4	42 Shoots +24 clusters/ vine	18.5	18.8	0.62	0.59	29.8	31.7	16.9	17.23	34.88	35.82	64.68	65.03
T5	36 Shoots +30 clusters/ vine	19.2	19.2	0.60	0.55	32.0	34.7	17.3	17.47	36.28	37.02	67.58	69.18
T6	36 Shoots +24 clusters/ vine	19.9	19.8	0.55	0.5	36.5	39.6	17.86	18.0	38.32	38.94	72.80	73.30
T7	30 Shoots+ 30 clusters/ vine	20.0	20.3	0.51	0.48	39.5	42.10	18.2	18.38	39.86	40.32	75.81	77.23
T8	30 Shoots+24 clusters/ vine	20.6	21.1	0.46	0.44	44.8	47.6	18.84	18.96	41.84	42.18	80.62	82.76
New L. S. D. at 5%		0.34	0.49	0.04	0.03	1.9	2.1	0.21	0.21	0.20	0.22	0.67	0.25

TABLE 7. Effect of shoots and clusters density on coefficient of ripening wood, total carbohydrates, and pruning weight of King ruby grapevines during 2019 and 2020 years

Treatments	Coefficient of ripening wood		Total carbohydrates (g/100g D.W)		Pruning wood weight (Kg)		
	2019	2020	2019	2020	2019	2020	
T1	Shoots +30 clusters/ vine 48	0.71	0.71	19.43	20.19	4.10	4.33
T2	Shoots+24 clusters/ vine 48	0.74	0.75	21.93	23.19	4.35	4.50
T3	Shoots +30 clusters/ vine 42	0.75	0.77	23.76	24.7	3.50	3.61
T4	Shoots +24 clusters/ vine 42	0.79	0.80	26.48	28.0	3.65	3.81
T5	Shoots + 30 clusters/ vine 36	0.81	0.82	27.92	29.07	3.25	3.43
T6	Shoots +24 clusters/ vine 36	0.85	0.86	30.36	31.25	3.32	3.50
T7	Shoots+ 30 clusters/ vine 30	0.86	0.88	31.94	32.56	3.00	3.12
T8	Shoots+24 clusters/ vine 30	0.90	0.92	34.82	35.58	3.10	3.20
New L. S. D. at 5%		0.01	0.01	0.19	0.18	0.11	0.09

Discussion

Shoots and clusters thinning are substantial agricultural practices in grapevines to improve the berries quality. Shoot thinning had the strongest positive influence on vegetative growth parameters mentioned in Table 2. The positive influence of the shoot thinning on improving vegetative growth parameters such as shoot length and leaf area can be explained through the following information, shoot removal increases the physiological activity of the remaining leaves in the photosynthesis process and increase carbohydrates photosynthesis, which increases root intensity (Hunter and Le Roux, 1992), causing to an significant increase in nutrient absorption and transmission a lot of carbohydrates to vegetative organs (Hunter and Visser, 1990) also, shoots thinning lead to reducing the competition between the shoots for nutrients and water that might have resulted in this effect, which is generally observed in the vineyards (Somkuwar et al., 2012), the positive impact of cluster thinning in improving total chlorophyll in leaves could be due to enhancing the nutritional condition of the retained organs and increase the concentration of Mg element, which involved in the formation of chlorophyll molecular as stated by Weaver, (1976) also, who reported that early cluster thinning without removing leaves raised leaf chlorophyll content. The same results of the present work were obtained by (Ghada, 2015, Ola, 2016 and El-Boray et al., 2018)

Yield/vine and yield/feddan (Table 4) were positively related to the number of shoots and clusters per vine. A gradual increase in the number of shoots and clusters per vine were accompanied by a gradual increase in yield/vine and yield/feddan and vice versa. Our data are in agreement with those obtained by Patricia, and Maria (2016) who found that yield was higher in vines were retained with (84 shoots/vine) as compared with vines were retained with (63 and 74 shoots/vine), also the vines retained with (74 and 64 bunches/vines) gave higher yield as compared with vines retained with (52 and 42 bunch/vines), also bunch and berry weight was higher in treatments retained with (84 shoots+52 bunches /vines) as compared with vines retained with (74 shoots+74 bunches/vines) of 'Sugraone' and 'Thompson Seedless' grapevines Sun et al., (2011) reported that shoot thinning reduced yield per vine and cluster number per vine, but increased berry weight. Also, Preszler et al. (2013) proved that

yield per vine and hectare was reduced about 58% by cluster thinning.

The improvement of physical properties of clusters and berries (Table 4 and 5) could be due to decreasing number of clusters per vine which allowed to allocation a large amount of photosynthesis products and reserves of nutrients and water to each of the remaining clusters (Naor and Gal, 2002). Reduce the cluster number per vine without changing the number of leaves or shoots lead to reduce the competition between the clusters on essential materials which lead to improve physical properties of clusters and berries (Radwan and Masood, 2017). Also, Asmaa and Aboryia, (2020) indicated that all cluster thinning applications increased average cluster weight, berry weight and diameter of Ruby Seedless grapevines

The positive results of shoots thinning treatments on enhancing microclimate characteristics and chemical properties of berries (Table 3 and 6) can be explained through the following fact; shoot thinning improves canopy density, reduces shading and leaf layer number, thereby increasing proportion of canopy gaps, and the penetration of sunlight and ventilation inside the canopy (Kliwer et al., 1988 and Ghada, 2015). Previous studies showed that the impacts of light on fruit composition are entrusted on the degree of berry exposure and the resulting temperature (Haselgrove et al., 2000 and Bergqvist et al., 2001). The moderate exposure to sunlight lead to enhance in grape composition, the increases in temperature caused to accelerate the rate of metabolic processes in the plant, with subsequent acceleration in the development and metabolite accumulate (Downey et al., 2006). Sun et al. (2012) reported that anthocyanin content is highly dependent on the amount of solar radiation, both in the vegetative canopy and directly in the clusters. Shoot thinning permits the light to infiltrate the canopy of the vines and increase in the photosynthetic efficiency of the leaves and allows air circulation raising and light intensity inside the canopy as shown in (Table 3), consequently increases of carbohydrate accumulation in of the remained shoots and leaves and translocation of more carbohydrates to berries which, reflects on the enhancement of chemical properties of berries (Hunter and Le Roux, 1992 and Ghada, 2015). Also, cluster thinning is a method of the production regulation, with thinning number of cluster or one part of the clusters, the production

per leaf area will be lower hereby the quality will be improved in terms of increasing sugars and anthocyanin contents as well as total soluble solids and decreasing total acidity (Fazekas, et al., 2012, Belal et al., 2016 and Asmaa & Aboryia, 2020). Moreover, the increment in total carbohydrate content of canes as results of removing some shoots lead to enhance in rates of wood ripping, there is a positive relationship between the accumulation of carbohydrates in the cans and the rates of wood ripping (Winkler 1965). Naor and Gal (2002) cleared that pruning wood weight increased when the vines were thinned at (one cluster/ shoot) as compared with (two cluster/ shoot) of 'Sauvignon blanc' grapevines. In plants that have high shoot density, high vigor leads to excessive lateral growth, competing with fruits for carbohydrates (Keller, 2010), consequently total carbohydrates in cans is decreased.

The obtained results are in accordance with those found by many of investigators who reported that thinning of shoots and clusters improved vegetative growth parameters, microclimate characteristics, and physical and chemical characteristics of cluster and berries on many grape cultivars; Naor et al. (2002) on 'Sauvignon blanc' grape; Abd El-Baki (2003) on King Ruby grape; Bernizzoni, et al. (2011) on Barbera grape; Fanzone et al. (2011) on Malbec grape; Pastore et al. (2011) on Sangiovese grape; Sun et al. (2011) on Marechal Foch grape; Somkuwar et al. (2012) on Tas-A-Ganesh grapes; Avizcuri-Inac et al., (2013) on Baga grape; Katja, et al. (2013) on Sauvignon Blanc grape; Somkuwar et al., (2014) on Tas-A-Ganesh grape; Ghada, (2015) on Red Globe grapevines; Belal, et al. (2016) of King Ruby Grape; Patricia and Maria, (2016) on Thompson Seedless grape; Ola (2016) on Red Globe Grape; Frioni et al. (2017) on Cabernet franc grape; Radwan and Masood (2017) on Ruby seedless grape; El-Boray, et al., (2018) on "Superior" grape, Silva, (2018) on Baga grape; Roberta et al. (2020) on Semillon grapes and Asmaa and Aboryia (2020) of Ruby Seedless grape.

Conclusion and Future Perspectives

The gradual decrease in the number of shoots and clusters per vine despite decreased yield/vine but improved vegetative growth parameters, total chlorophyll content in the leaves, and microclimate characteristics (light intensity, air temperature and relative humidity).

Consequently, we observed improved chemical properties of berries such as (SSC, SSC/acid ratio total sugars, total anthocyanins and total phenols) in addition, coefficient of wood ripening and total carbohydrates in cans. The application of 30 shoots+24 clusters per vine recorded the highest significant values on vegetative growth parameters, microclimate characteristics and chemical properties of berries, which is recommended for application in King Ruby vineyards under the Egyptian climatic.

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Conflicts of interest

The author declares that there are no conflicts of interest related to the publication of this study.

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تأثير كثافة الأفرع والعناقيد على بيانات المناخ الدقيق والمحصول وجودة الثمار لعنب الكنج روبي

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- أجريت هذه الدراسة خلال موسمي ٢٠١٩ و ٢٠٢٠ في مزرعة خاصة بقريه الواحة مركز الخطاطبة - محافظة المنوفية على كرمات عنب الكنج روبي عمرها ١٠ سنوات ومنزعة في تربة رملية وتروى بنظام الري بالتنقيط ومرباه بالطريقة الكرونية وتحت نظام التدعيم البارون.

- كان الهدف من هذه الدراسة هو تحديد العدد الأمثل للأفرع والعناقيد لصنف عنب الكنج روبي والذي يتميز بالخصوبة العالية وذلك من أجل تحسين صفات الجودة للعناقيد والحبات.

- حيث تم استخدام أربعة مستويات مختلفة من معاملات خف الأفرع (٣٠ & ٣٦ & ٤٢ & ٤٨ فرع / كرمة) مع مستويين مختلفين من خف العناقيد (٢٤ & ٣٠) عنقود / كرمة حيث تم خف الأفرع في بداية مرحلة النمو الخضري عند وصول طول النموات من ١٥-٢٠ سم أما عملية خف العناقيد لضبط عدد العناقيد لكل كرمة فقد أجريت بعد تمام العقد.

- وقد أظهرت النتائج أن النقص التدريجي في عدد الأفرع والعناقيد على الرغم من أنه قلل محصول الكرمة والفدان ولكنه أدى الى زيادة وتحسن في قياسات النمو الخضري مثل طول الأفرع والمساحة الورقية وكذلك الكلوروفيل الكلي في الأوراق وتحسين الظروف المناخية داخل الكرمة وقد انعكس ذلك على تحسين الصفات الكيماوية في الحبات مثل نسبة المواد الصلبة الذائبة والسكريات الكلية وصبغة الأنثوثيانين والفينولات الكلية وأيضاً معامل نضج الخشب والكربوهيدرات الكلية في القصبات.

- كما أن زيادة عدد الأفرع مع نقص عدد العناقيد لكل كرمة أدى الى زيادة وتحسن في الصفات الطبيعية للعنقود والحبات مثل وزن وطول وعرض العنقود وكذلك وزن وطول وعرض الحبات وأيضاً وزن خشب التقليم - وقد أعطت معاملة (٣٠ فرع + ٢٤ عنقود / كرمة) أفضل النتائج في تحسين قياسات النمو الخضري والظروف المناخية داخل الكرمة و صفات الجودة للحبات والتي يوصى بتطبيقها في مزارع عنب الكنج روبي .

الكلمات الدالة : عنب الكنج روبي- كثافة الأفرع والعناقيد - بيانات المناخ- المحصول - صفات الجودة