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Effect of Cane Length and Number on Bud Behavior, Growth and Productivity in Red Globe and Black Monukka Grape Cultivars

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Abstract: A two-year trial was conducted during 2017 and 2018 experimental seasons to evaluate the effect of different cane numbers (8, 10, 12 and 15 canes) with a bud load (15, 12, 10 and 8 buds/cane) respectively on the bud behavior, vegetative growth and productivity of twelve-year-old Red globe and Black monukka grapevines. There were significant differences among the investigated treatments in relation to bud burst %, bud fertility %, fruitfulness coefficient, shoot diameter, leaf area, number of cluster per vine and yield. However, pruning Black Monukka at 8 canes x 15 bud/ cane treatment and 15 canes x 8 bud/ cane treatment for Red Globe were the superior in enhancing all parameters compared with the other investigated treatments during both seasons of study for both cultivars. Whereas, the balance between canopy density and sunlight penetration was ensured by allowing more light to reach the clusters, which creates an appropriate microclimate that improved the quality and productivity.

Key words: Cane bud load · Cane numbers · Sunlight intensity · Red Globe · Black Monukka grapevines · Vegetative growth · Yield and quality

INTRODUCTION

Winter pruning is considered one of the most important horticultural practices through which grape production can be increased. Pruning the vines for optimum cropping according to the vigor is the most reliable method to maintain the balance between growth and production. Each variety should carry a moderate number of canes, in order to maintain the uniform vigor throughout its life span.

The aims of pruning are to obtain vines in a convenient form to produce fruit of the target composition and regulate vegetative growth. Thus, pruning significantly influences the vine ability to grow and cropping [1].

Cane in some grape varieties may be fairly fruitful and differences in the degree of fruitfulness of buds along the length of the cane less marked than in other varieties whose buds are less fruitful near the base and show a sharp increase in fruitfulness towards the central part of the cane [2]. The choice of pruning method is largely affected by the fruitfulness characteristics of the vine variety [3]. However, controlling yield via pruning is an important way to increase grapes quality [4]. Cane length/ number of buds per cane affected significantly the bud behavior, yield and fruit quality of grapevine cultivars [5].

Black Monukka is a seedless grapevine cultivar with a perfect black color berries, good quality, pleasant flavor and texture characteristic [6]. Red Globe is one of the most promising table grape cultivars with exceptionally large seeded berries having an attractive pinkish red color [7].

Eynard and Gay [8] suggested that equilibrium of crop load versus vegetative development is important for production of quality fruits. In Egypt, the information concerning pruning of Red globe and Black monukka cultivars seems to be quite limited. However, cane pruning is adopted by grape growers with the purpose of obtaining the highest yield without taking into account the negative effect on size and quality of both bunches and berries. Therefore, some attempts were done in this aspect by several investigators on some deciduous fruits to determine the better cane lengths and bud load [9-12].

Moreover, shading has been identified as a major factor in reducing grapevine yields and fruit quality thus allowing more light penetration to enter the cluster area was reflected on enhancing coloration and improving yields and fruit quality [13].

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The ultimate target of this investigation is to determine the appropriate cane length and numbers on growth and yield of both Red globe and Black monukka cultivars, which can be recommended for each cultivar under cane pruning system.

MATERIALS AND METHODS

The present investigation has been carried out during the two successive growing seasons of 2017 and 2018 in a private vineyard at El-Sadat city located in Cairo-Alexandria Desert Road, Egypt, on 12 year-old " Red globe and Black monukka " grapevines, grown in a sandy soil and drip irrigated. Vines are spaced at (2.0 x 3.0) meters for both cultivars. Seventy-two uniform vines were chosen for this study, for "Red Globe and Black Monukka" (4 treatments x 3 replicates x 3 vines /replicate) arranged in a randomized design. All vines were carefully selected to be nearly uniform in vigor as possible and receiving regularly the same horticultural practices.

However, vines were trained according to the Spanish Parron system for both studied cultivars. During the first week of January for "Red globe and second week of February for Black monukka" cultivars were pruned in both seasons of study, to investigate the effect of different number of canes per vine on bud behavior, vegetative growth and yield quality and productivity of both grapevine cultivars. All treatments were adjusted to a total vine bud load of 120 buds per vine as follows:

- 8 canes x 15 bud/ cane
- 10 canes x 12 bud/ cane
- 12 canes x 10 bud/ cane
- 15 canes x 8 bud/ cane

Vines of the two experiments were subjected to the following estimation:

Sunlight Intensity %: Data of sunlight intensity was taken inside the vine canopy for each treatment and was recorded weekly during the growing period on three levels lower, middle and upper branches using "Scheduler Plant Stress Monitor", Standard Oil Engineered Materials Co., Ohio, USA.

By using the microprocessor of the apparatus, we calculate the average of canopy sunlight intensity in order to find the relationship between the different treatment and the amount of sunlight penetrating into the vine canopy.

Bud Behavior: Dormant buds per vine were observed weekly along the bursting period. Number of the burst buds and cluster/ vine were recorded then the percentage were calculated according to Bessis [14] during both seasons of study for both cultivars. Also, number of vegetative buds and number of fruitful buds were counted and the percentages were calculated in relation to the total number of the burst buds according the following equations:

$$\text{Bud burst (\%)} = \frac{\text{Number of burst buds}}{\text{Total number of buds}} x100$$

$$\text{Bud fertility (\%)} = \frac{\text{Number of clusters/vine}}{\text{Total number of buds}} x100$$

$$\text{Fruitfulness (\%)} = \frac{\text{Number of fruitful buds}}{\text{Number of burst buds}} x100$$

In addition, coefficient of fruitfulness was calculated by dividing the total number of clusters per vine over the total number of fruitful shoots per vine.

$$\text{Coefficient of fruitfulness} = \frac{\text{Total number of clusters / vine}}{\text{Total number of fruitful shoots / vine}}$$

Vegetative Growth: Ten vegetative shoots and ten fruitful shoots per vine were labeled and measured at growth cessation as follow:

- Shoot length (cm)
- Basal shoot diameter (mm)
- Number of leaves / shoot: taken from fruitful shoots
- The average leaf area (cm^2): the 6th and 7th leaf from shoot base were measured using a planimeter.
- Pruning weight in (kg): Pruning weight is an indicator of vegetative growth and vigor in grapevine and traditionally, it is manually determined.

Yield per Vine:

- Average yield per vine (kg)
- Average cluster weight (g)
- Average number of cluster/ vine
- Average berry volume (cm^3)

Chemical Characteristics: When clusters reached their full color and total soluble solids reached about 16-20, representative random samples of 15 clusters /treatment (5 cluster from each replicate) were collected according to [15].

The following determinations were carried out:

- Refractometric total soluble solids (TSS %)
- Titratable acidity as gram of tartaric acid per 100 ml of juice [16]
- TSS / acid ratio.
- Total anthocyanin in berry skin (mg/100g FW) using spectrocolourimeter at 250 µm according to Yilidz and Dikmen [17].
- Total chlorophyll content in leaf were measured at full bloom in the mature leaves of the sixth and seventh positions from the base by using the nondestructive Minolta chlorophyll meter model SPAD 502 (SPAD) is an acronym for soil plant analysis development [18].
- Total carbohydrates (%) in canes were taken at winter pruning (during the third week of January) and measured according to Smith *et al.* [19].

Statistical Analysis: All data obtained during two seasons of the present investigation were statistically analyzed using the analysis of variance method according to Snedecor and Cochran [20].

RESULTS AND DISCUSSIONS

Sunlight Intensity %: There is a relationship between light intensity and the number of inflorescences and flowers. Buds will produce more flowers if, in the previous season while they were being formed, more light was received by the bud and its adjacent leaves. The method used to prune and manage the shoots that grow is one of the major factors used to improve flower formation [21]. Data presented in Figure (1) shows the light intensity at the vines canopy as affected by various treatments significantly. The severity of shoot removal led to an increase in light intensity inside the canopy of the vines, through reducing the leaf number per vine as mentioned by Bedrech and Mostafa [22]. Thus, highest light intensity in the canopy was recorded by the treatment where the vine was pruned to 8 canes x 15 buds/cane for both cultivars and in both seasons. Pruning systems that do not give good light penetration can have the serious effects of inducing poor flower initiation and poor fruit set. In vines where very low light intensity occurs in the inflorescence zone, up to 100 percent of bunches can be affected and massive yield loss may occur.

Bud Behavior: Data in Tables (1) shows the bud behavior measurements expressed as bud burst (%), bud fertility (%), fruitfulness (%) and fruitfulness coefficient, in response to different cane numbers (8, 10, 12 and 15 canes) with a bud load (15, 12, 10 and 8 buds/cane) respectively for Red Globe and Black Monukka in both seasons as follow:

Bud Burst %: Data obtained in Tables (1) clearly shows that a significant gradual increase in bud burst percentage was accompanied with increasing the cane length and decreasing the cane numbers/ vine in Black Monukka in the first treatment (8 canes x 15 bud/ cane). These results in most cases are in partial agreement with those found by Al-Rawi and Al-Doori [9] indicated that the percentage of burst bud was increased by increasing the cane length in Deslains grapevine. Whereas, in Red Globe increasing the bud burst percentage was accompanied with decreasing the cane length and increasing the cane numbers / vine in the fourth treatment (15 canes x 8 bud/ cane) in both seasons. Similarly, Godara *et al.* [23] reported that severely pruned vines took lesser number of days for bud sprouting and flowering compared to lightly pruned ones in 'Beauty Seedless' grapes.

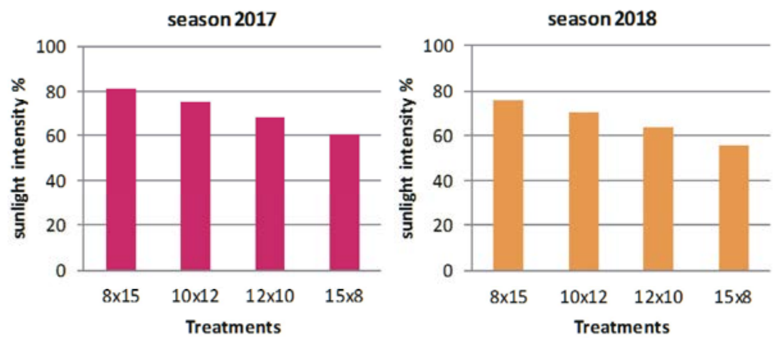
Bud Fertility: Concerning the effect of the different factors involved in this study i.e., cane number/vine and cane length, on the percentage of vegetative buds in relation to the total number of burst buds, data obtained in Tables (1) clearly show that pruning Red Globe, which has fertile basal buds, to 8 canes x 15 buds/vine, produced the least vegetative bud percentage during both seasons. Followed in an increasing order by 10 canes x 12 bud/ cane, 12 canes x 10 bud/ cane and the least highest was 15 canes x 8 bud/ cane. Piras *et al.* [24] stated that 'Red Globe' had fertilities greater than 1.0 bunches/shoot as of the fifth bud of the cane.

On the other hand, pruning Black Monukka to 8 canes x 15 buds/vine, produced the highest vegetative bud percentage during both seasons. Followed in a decreasing order by 10 canes x 12 bud/ cane, 12 canes x 10 bud/ cane and the least was 15 canes x 8 bud/ cane as its terminal buds of the cane (9th to 12th buds) are the most fertile ones [25].

Moreover, the present results are in harmony with those mentioned by Huglin and Schneider [26] who revealed that the bud fertility was in in negative correlation with the cane numbers for Red Globe whereas Fawzi [5] found that it was with a positive correlation with the cane length left after pruning for Black Monukka.

Fruitfulness %: Buds are said to be fruitful if they have at least one developing cluster, but many buds have two or more clusters, so bud fruitfulness is often expressed as the average number of clusters per shoot.

Red Globe



Black Monukka

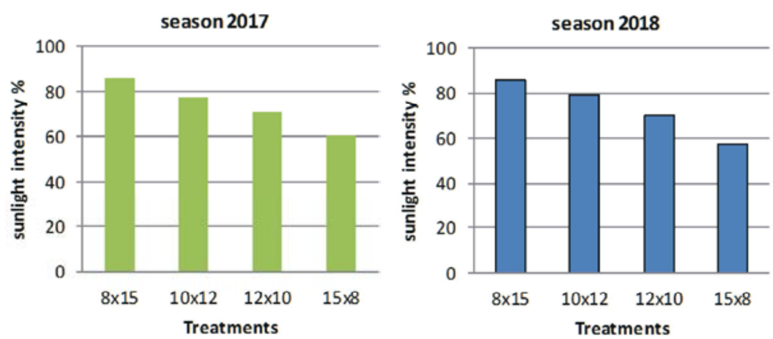


Fig. 1: Different treatments as affected by sun light intensity in Red Globe and Black Monukka grapevines in 2017 and 2018

*Treatments

- 8 canes x 15 bud/ cane
- 10 canes x 12 bud/ cane
- 12 canes x 10 bud/ cane
- 15 canes x 8 bud/ cane

Table 1: Effect of cane length and number on bud behavior in Red Globe and Black Monukka grapevines in 2017 and 2018

	Red Globe							
	2017				2018			
Treatments	Bud burst %	Bud fertility %	Fruitfulness %	Coefficient of fruitfulness	Bud burst %	Bud fertility %	Fruitfulness %	Coefficient of fruitfulness
8 canes x 15 bud/ cane	63.4	30.3	28.3	1.64	64.2	31.6	29.6	1.76
10 canes x 12 bud/ cane	68.2	33.4	31.2	1.55	66.1	33.5	33.7	1.50
12 canes x 10 bud/ cane	71.6	36.7	37.8	1.32	70.5	35.2	41.0	1.38
15 canes x 8 bud/ cane	76.3	39.1	45.8	1.20	77.9	40.7	47.2	1.18
New LSD at 5%	2.3	1.6	2.3	0.10	1.6	1.1	3.0	0.16
	Black Monukka							
8 canes x 15 bud/ cane	78.3	40.2	49.1	1.32	75.6	41.0	48.2	1.29
10 canes x 12 bud/ cane	72.9	37.6	41.6	1.37	71.2	37.5	39.5	1.44
12 canes x 10 bud/ cane	69.6	35.8	36.0	1.51	68.0	34.6	35.1	1.58
15 canes x 8 bud/ cane	65.1	32.6	28.3	1.81	64.3	33.1	27.7	1.73
New LSD at 5%	2.2	1.9	4.2	0.03	2.1	1.1	3.9	0.05

Data in Table (1) showed the percentage of fruitfulness as affected by the number and the length of canes/vine. It was clear that the fruitfulness percentage is inversely proportional with the number of canes/vine in Red Globe, whereas, it is directly proportional with the cane length and thus the number of buds/shoot in the Black Monukka in both seasons. Accordingly, we find that leaving 15 canes x 8 buds/vine/cane for Red Globe and 8 canes x 15 buds/vine is significantly increased the fruitfulness.

The obtained results are referred to the fact that during bud development, the tissue within the bud can form either a tendril or a cluster during the process of differentiation. Whether they form tendrils or clusters depends heavily on the light environment and C/N ratio of the previous season. Exposure of the buds to more sunlight (Fig. 1) increases fruitfulness and shading or low light intensity reduces it because the developing bud forms tendrils instead of cluster. It was mentioned before in a detailed study of several varieties that bud fruitfulness generally increases with increasing shoot light exposure with at least one-third to one-half of the available sun [27].

Coefficient of Fruitfulness: The effect of cane length (No. of buds/cane) and number on fruitfulness coefficient data in Tables (1), displayed that treatments significantly affected the fruitfulness coefficient throughout the two seasons of study, the first for "Black Monukka" resulted in a gradual increase in fruitfulness coefficient value and significantly exhibited with increasing the number of buds/cane. This trend could be supported by the findings of Pondev [11] who reported that increasing both buds load/vine and fruiting units length (number of buds per cane) exhibited a higher significant fruitfulness coefficient number of cluster per vine and yield.

In "Red Globe", the highest fruiting coefficient recorded was obtained from increasing the number of shoots per vine and lowering the number of buds per cane. These results in this aspect are in harmony with those obtained by Rizk [28] and Abd El-Wahab [29] who found that the load of 6 buds/ cane excreted the highest fruitfulness coefficient, while the load of 15 buds/cane possessed the lowest fruitfulness coefficient in Crimson seedless.

Vegetative Growth

Shoot Length (cm): It is obvious from the data in Table (2) that the first treatment 15 canes x 8 buds/ cane, has the tallest shoots in "Red Globe" this result may be attributed to the specific numbers of buds left per vine. Whereas 8 canes x 15 buds/ cane for "Black Monukka" gave the highest results. Recent research has suggested that shoot numbers/vine, controlled at pruning, is a critical component in the shoot length and the recommended shoot density is ranged between about 12 to 15 shoots/vine [30].

If shoots are too dense, light in the fruiting zone is reduced, leading to reduced fruit quantity and quality. Another critical interaction is that shoot number per vine affects shoot length when the numbers of buds are fixed. Moreover, incorrect vine shape often results in uneven shoot length which will result in uneven ripening of grapes [31].

Basal Shoot Diameter (cm.): As a general trend decreasing the number of canes and increasing the cane length in Black Monukka and increasing the number of canes and decreasing the cane length in Red Globe recorded the highest values as shown in Table (2). Meanwhile the other treatment appeared to be less effective than the above mentioned ones.

Shading and its impact on bud fruitfulness is the reason why it is important to select well-exposed, moderate diameter canes for retention at pruning. Cane diameter is a good indicator of shoot vigor. Both low-vigor (small diameter) and high-vigor (large diameter) canes tend to have lower bud fruitfulness [32].

Number of Leaves/Shoot: Leaf number per vine is an important characteristic affecting yield of grapevines. Table (2) shows the effect of different treatments on the average leaf number per vine for both cultivars in both seasons. It is obvious from the recorded data that there are significant differences among treatments. The highest values were obtained from the treatment of 8 canes x 15 buds/cane for the "Black Monukka" and 15 canes x 8 buds/cane for the "Red Globe". However, if shoots are too short they will not have enough leaf area to ripen the clusters on the shoot thus increasing the number of shoot as in Red Globe will compensate the number or leaves lost during shoot thinning. However, if shoot number is too few for vine capacity then shoot length must be too long, with excessive leaf area per shoot and encouraging lateral leaf development in the fruiting zone as in the case of Black Monukka. The working definition of a balanced shoot is that it has a sufficient amount of leaves, given that the leaves are well exposed to sunlight, to ripen two clusters completely [31].

Leaf Area (cm^2): With respect to the specific effect of cane length and the Number of buds/ cane, it was quite clear from data in Table (2) that 8 canes x 15 bud/ cane in “Black Monukka” and 15 canes x 8 bud/ cane in “Red Globe” treatments recorded the highest leaf area than the other treatments during the two seasons of study. In “Red Globe” these results are in conformity with the results obtained by Gaser *et al.* [33] who displayed that increasing the cane length decreased the current season's leaf area/shoot and then this may be attributed to the competition between the shoots in the treatments of long canes.

Table 2: Effect of cane length and number on vegetative growth in Red Globe and Black Monukka grapevines in 2017 and 2018

	Red Globe									
	2017					2018				
Treatments	Shoot length (cm)	Shoot diameter (cm)	No. of leaves /shoot	Leaf area (cm^2)	Weight of pruning (kg)	Shoot length (cm)	Shoot diameter (cm)	No. of leaves /vine	Leaf area (cm^2)	Weight of pruning (kg)
8 canes x 15 bud/ cane	99.2	0.83	26.2	86.00	3.94	105.3	0.76	26.5	87.35	3.46
10 canes x 12 bud/ cane	107.5	0.88	25.1	87.63	4.42	110.2	0.82	25.7	90.23	4.43
12 canes x 10 bud/ cane	115.6	0.92	23.6	91.77	4.71	121.0	0.90	24.2	91.89	4.71
15 canes x 8 bud/ cane	120.1	0.96	22.0	99.34	4.90	127.8	0.95	22.1	98.45	4.77
New LSD at 5%	2.23	0.02	0.8	1.01	0.20	2.04	0.02	0.6	1.54	0.32
	Black Monukka									
8 canes x 15 bud/ cane	189.5	1.01	32.1	183.17	5.65	187.2	0.97	31.5	187.26	5.81
10 canes x 12 bud/ cane	175.3	0.98	29.8	169.34	5.37	180.6	0.90	29.6	172.53	5.32
12 canes x 10 bud/ cane	158.6	0.94	24.5	162.38	4.93	162.7	0.85	25.3	164.89	4.89
15 canes x 8 bud/ cane	152.4	0.90	20.5	152.82	4.68	155.3	0.83	21.7	158.92	4.72
New LSD at 5%	1.70	0.01	1.4	3.21	0.31	1.98	0.01	1.1	3.42	0.35

In “Black Monukka” these results were similar to those obtained from Zamboni *et al.* [34] who stated that vines with high number of nodes developed a larger total leaf area compared to those having lower node number but had the same total leaf area/fruit yield ratio.

Pruning Weight in (Kg): Pruning weight is an important indicator used to appraise biomass production, carbon storage cycle, vigor and vine balance [35, 36].

All treatments were found to affect the characteristics of vegetative growth parameters in both seasons for the two cultivars under study as mentioned in Table (2). The weight of pruning highest values were detected in case of vines treated with 8 canes x 15 buds/cane for the "Black Monukka" and 15 canes x 8 buds/cane for the "Red Globe". Pruning the vines for optimum cropping according to the vigor is the most reliable method to maintain balance between growth and production. The vine should carry moderate number of canes in order to maintain the uniform vigor throughout its life span. So, canopy, vigor and productivity can be balanced through pruning levels. According to Smart and Robinson [35], pruning weight is proportional to leaf area carried on the shoots in the previous growing season. The ratio of yield to pruning weight gives a good indication of balance between fruit and vegetative growth.

Yield

Average Yield/Vine (Kg): Data in Table (3) shows the average yield per vine as affected by cane numbers and length in all treatments. Generally, increases in yield tend to result from increases in cluster numbers per vine. It is cleared that in the case of Red globe, as bud fertility along the cane was increased from the base to the middle and decreased again toward the tip, the highest yield was obtained when the vines were pruned to 15 canes x 8 buds/vine. However, increases in yield were simply due to the addition of more shoots per vine [37].

Similar finding was mentioned by Harikanth *et al.* [38] who stated that the maximum number of clusters/vine was observed when all the canes pruned to 6 bud level in Red Globe.

On the other hand, in Black Monukka, data shows that the best results were obtained from the first treatment 8 canes x 15 buds/vine with decreasing effect along the three other treatments respectively. In this line, Fawzi, [5] found in a study on Superior grape cultivar that pruning by leaving 6 or 7 canes with 14 or 12 buds / cane resulted in a higher yield and better fruits quality. In addition, total yield / vine tended to increase either as average number of clusters/ vine or average weight of clusters/ vine. Also, Bhujbal [39] stated that in grape cv. Thompson Seedless, when the vines were pruned to 4, 6, 8 and 10 buds per cane keeping 16 canes per vine, the maximum bunch weight recorded were 8 buds per cane level.

Average Cluster Weight (g): The recorded data in Table (3) showed the average cluster weight as affected by all treatments for both cultivars. Data obtained from the first treatment in Black Monukka was the highest of all followed by the other treatments. This may be attributed to the effect of lower number of shoots, which is related to the activation of photosynthesis inside the canopy of the vine through increasing light penetration that is accompanied by an increase in sugars in the berries, raising its osmotic pressure and attraction force of water, leading to an improve in physical properties of berries and clusters as well [40].

Table 3: Effect of cane length and number on yield in Red Globe and Black Monukka grapevines in 2017 and 2018

	Red Globe							
	2017				2018			
Treatments	Yield/ vine (Kg)	Cluster weight (g)	No. clusters / vine	Berry volume (cm^3)	Yield /vine (Kg)	Cluster weight (g)	No. clusters / vine	Berry volume (cm^3)
8 canes x 15 bud/ cane	10.1	616.6	16.5	5.75	10.4	621.6	16.8	5.55
10 canes x 12 bud/ cane	11.9	676.9	17.7	6.05	12.0	685.5	17.6	5.95
12 canes x 10 bud/ cane	13.1	703.3	18.6	7.25	13.7	745.6	18.5	7.34
15 canes x 8 bud/ cane	15.0	743.4	20.2	8.86	15.9	783.8	20.4	8.09
New LSD at 5%	1.3	22.7	1.2	1.02	1.3	25.2	1.2	0.99
	Black Monukka							
8 canes x 15 bud/ cane	21.7	801.3	27.2	23.3	20.9	797.3	26.3	6.88
10 canes x 12 bud/ cane	18.7	740.8	25.3	18.6	18.5	752.6	24.6	5.85
12 canes x 10 bud/ cane	15.5	691.2	22.5	14.8	15.6	687.4	22.8	5.14
15 canes x 8 bud/ cane	13.3	645.0	20.7	11.9	13.6	649.1	21.1	4.18
New LSD at 5%	1.4	26.9	1.2	1.03	1.5	26.8	1.3	0.87

These results are in accordance with those obtained by Reynolds *et al.* [41] who showed that berry weight and thus cluster weight decreased with increasing shoot density.

On the other hand, the last treatment, 15 canes x 8 buds was superior for the Red Globe cultivar. Similarly, kumar and Tomer [42] retained 60 buds on each vine in 'Himrod' grape and revealed that 5 buds with 12 canes pruning gave the maximum bunch weight as compared to 6 buds with 10 canes, which means that cluster weight increased as the number of buds is decreased and the number of canes is increased.

Average Number of Clusters/Vine: It is clear from the data in Table (3) that the average number of clusters increased by increasing the cane length and decreasing the cane number as in the first treatment in Black Monukka. The results in this respect are in harmony with Gaser *et al.* [33] on Red Globe who displayed that vines with long pruning resulted in a higher significant number of clusters in comparison with short pruning.

Contrarily, in Red Globe, the highest value was obtained from the last treatment as increasing the cane length and decreasing the cane number led to a decrease in the number of clusters/vine. This result is convenient with those of Avenant [43] who revealed that in cv. Festival Seedless, the average number of bunches/vine increased linearly as cane density increased from 4 to 12 canes.

Average Berry Volume (cm^3): There are significant differences in berry volume between the different treatments (Table 3). Grape berries exposed to high radiation levels, as in Black Monukka, were smaller for the 8 canes x15 buds treatment, these results are in harmony with those of Bergqvist *et al*. [44] and Deloire and Hunter [45].

On the other hand, in Red globe temperature differences also explain why berry response to sunlight varied due to cluster position within the canopy, berries response to sunlight varied based on cluster location within the canopy. Moderately exposed clusters inside the canopy do not received direct sunlight [44] as a results, high vigor obtained from the 15 canes x8 buds/cane treatment gave the highest values in berry size as mentioned by Hulands *et al.* [46] who found that light intensities occurring during the development of grape berries are known to have persistent effects on their growth and ripening processes and also induce sunburn.

Chemical Characteristics of Berries, Leaves and Shoots

Total Soluble Solids (TSS %): There are significant differences in TSS between the different treatments (Table 4). Increasing fruit exposure to light penetration has been linked to enhanced accumulation of soluble solids [13, 47, 48] as shown in the results of the first treatment 8 canes x 15 buds/vine in Black Monukka.

In Red Globe, 15 canes x 8 buds/vine recorded the highest levels of TSS% which means that TSS% was negatively correlated with number of buds per cane Singhrot *et al.* [49].

However, Balakrishnan and Rao [50] revealed that in grape variety Muscat Hamburg, when the vines were pruned to 4, 6, 8 and 10 buds per cane keeping 14 canes per vine, the maximum total soluble solids recorded were 4 buds per cane level.

Table 4 Effect of cane length and number on chemical characteristics in Red Globe and Black Monukka grapevines in 2017 and 2018

	Red Globe							
	2017				2018			
Treatments	TSS %	Acidity %	TSS/acid ratio	Anthocyanin (mg/100g FW)	TSS %	Acidity %	TSS/acid ratio	Anthocyanin (mg/100g FW)
8 canes x 15 bud/ cane	17.5	1.9	9.2	31.8	17.2	1.7	10.1	33.7
10 canes x 12 bud/ cane	18.0	1.5	12.0	34.0	17.9	1.6	11.1	34.8
12 canes x 10 bud/ cane	18.7	1.5	12.4	35.6	18.3	1.4	13.0	36.6
15 canes x 8 bud/ cane	19.0	1.3	14.6	37.2	19.1	1.3	14.6	37.4
New LSD at 5%	0.37	0.15	0.2	1.3	0.23	0.10	0.2	1.6
	Black Monukka							
8 canes x 15 bud/ cane	20.0	0.9	22.2	44.2	19.8	1.1	18.0	43.1
10 canes x 12 bud/ cane	18.9	1.4	13.5	41.3	18.8	1.3	14.4	41.0
12 canes x 10 bud/ cane	18.5	1.4	13.2	40.5	17.6	1.4	12.5	40.3
15 canes x 8 bud/ cane	17.8	1.6	11.1	39.2	17.1	1.5	11.4	38.7
New LSD at 5%	0.32	0.39	0.2	2.3	0.28	0.48	0.5	1.9

Titratable Acidity: An opposite trend was observed for acidity in Table (4). Data revealed that in Red Globe acidity was significantly affected by different cane length in both seasons and the highest significant values was attained from vines pruned with cane length of 8 canes x 15 buds/cane. These results coincided with those of Gaser *et al.* [33] who reveal that vines with long pruning showed a significant increase in total acidity content of the berry juice in comparison with short pruning.

Clusters of Black Monukka in the first treatment exposed to more sunlight, displayed lower acidity as a consequence of higher temperatures, this is consistent with the work of Jackson and Lombard [51] who suggest that Shade, whether natural or artificial, nearly always reduces sugar levels and usually increases acidity. Also Spayd *et al.* [52] found that pH was higher in grapes under western exposure.

TSS / Acid Ratio: As for the effect of cane numbers and length/vine, it is clear from data at Table (4) that TSS/acid ratio were significantly increased in response to more shoot removal given by the first treatment whereas, gradual increase in the number of canes resulted in the lowest values.

Total Anthocyanin in Berry Skin: Data in Table (4) revealed that cane numbers and length/vine, affected the accumulation of anthocyanin in both cultivars berry skin. Maximum anthocyanin content was gained by the first treatment in both seasons for 'Black Monukka as it received the highest amount of sunlight than the other treatments. In a similar trial, Jackson and Lombard [51] found that a shaded microclimate reduces color and reduces sugar levels, which are usually interpreted as delayed maturity.

Morrison and Noble [48], ensured that anthocyanin was lower in fruits that developed in shade. Moreover, the rates of berry growth and sugar accumulation were slower in fruits from vines with shaded leaves. In contrarily, for 'Red Globe' highest values were obtaind from the short pruned shoots and increasing the number of shoots per vine as vines with short pruning a significant reduction in anthocyanin content in berry skin than vines with long pruning [33].

Total Chlorophyll Content in Leaves (mg/ml): As shown in Figure (2) for Black Monukka, there are significant differences in leaf pigments content treatment. Regarding the effect of cane length and number, the highest significant values was attained from vines pruned with cane length of 8 canes x 15 buds/cane in Black Monukka followed by vines pruned with cane length of 12 buds. The results in this respect are in harmony with Kappel and Flore [53], as well as Marini and Marini [54], who found similar results, where chlorophyll concentrations in sun-exposed leaves were higher than ones in more shaded conditions.

Data of Red Globe revealed that different cane length and numbers significantly affected leaf content of total chlorophyll in both seasons. Highest significant values of these contents were attributed to vines pruned with cane length of 15 canes x 8 buds/ cane followed by vines pruned with cane length of 12 canes x 10 buds/ cane buds.

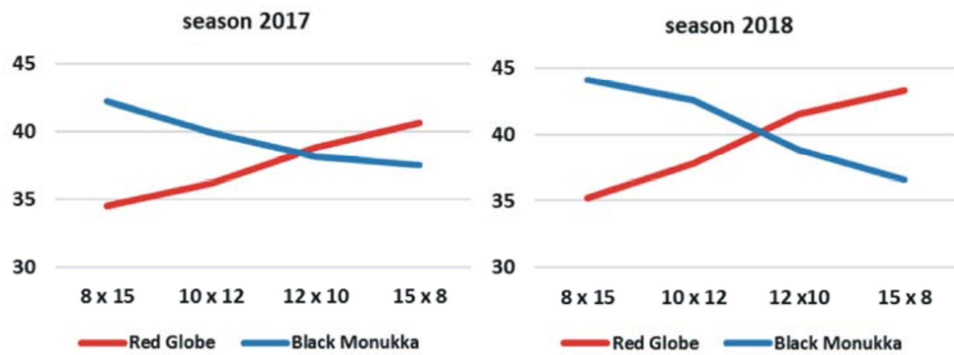


Fig. 2: Effect of cane length and number on total chlorophyll content in Red Globe and Black Monukka grapevines in 2017 and 2018

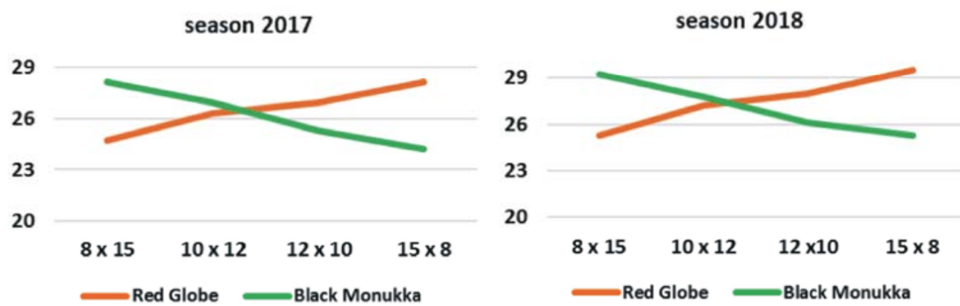


Fig. 3: Effect of cane length and number on total carbohydrate % in Red Globe and Black Monukka grapevines in 2017 and 2018

These results were similar to those obtained from Abd El-Ghany [55] on Flame Seedless and Gaser *et al.* [33] on Red Globe, who declared that vines with long pruning units had decreased leaf contents of total chlorophyll in comparison with short pruning units.

Total Carbohydrates %: Data presented in Figure (3) showed that cane content of total carbohydrates were significantly affected by different cane length and numbers for both cultivars in both seasons. Highest significant values of these contents were attributed to vines pruned with cane length of 15 buds/ cane x 8 canes for Black Monukka and 8 buds/ cane x 15 canes for Red Globe. In Black Monukka, similar findings were obtained in 'Italian Riesling' grapevines where vines with minimum number of shoots stored the maximum amount of carbohydrates in the canes [56].

In Red Globe these results coincided with those Abbas *et al.* [56] on Flame Seedless and Gaser *et al.* [33] on Red Globe, who demonstrated that vines with long pruning units had decreased cane content of total carbohydrates in comparison with short ones.

In conclusion, cane length and number is one of the important cultural operations in grape production and standardized the pruning severity for any grape varieties is of utmost importance for obtaining optimum yield and quality. However, Black Monukka 8 canes x 15 bud/ cane treatment was the superior in enhancing all parameters and 15 canes x 8 bud/ cane treatment for Red Globe compared with the other investigated treatments during both seasons of study for both cultivars

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