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IMPACT OF PINCHING, LATERAL SHOOTS REMOVAL AND DEFOLIATION ON GROWTH, YIELD AND BUNCH QUALITY OF AUTUMN CRISP GRAPEVINES

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ABSTRACT: This inquiry was carried out for two consecutive seasons (2019 –2020) in a private vineyard located at El-Khatatba region, Monufyia Governorate, Egypt, to study the effect of pinching, lateral shoots removal and defoliation on growth, yield, and bunch quality of Autumn Crisp seedless grape. Seven treatments were carried out as follows: control, pinching the main shoots, lateral shoots removal, defoliation, pinching the main shoots + lateral shoots removal, pinching the main shoots + defoliation and lateral shoots removal + defoliation. Pinching the main shoots and lateral shoots removal treatments were applied just after fruit set stage, while basal defoliation treatment was applied at two weeks after fruit set stage. The results showed that all pinching, lateral shoots removal and defoliation treatments either alone or in combination among them had the best results in comparison with control in both seasons. In addition, pinching the main shoots + defoliation application achieved the best results in growth traits, carbohydrates %, nitrogen %, in canes, as well as improving the yield, physical and chemical characteristics of bunches and berries of Autumn Crisp grapevines in both seasons.

Key words: Grape, Autumn Crisp, pinching, lateral shoots removal, defoliation and carbohydrates.

INTRODUCTION

Grapes (*Vitis vinifera*, L.*)* are considered one of the most important and popular fruit crops in the world, especially in temperate, tropical, and subtropical regions. Berries are tasty both fresh and dried, and are also used to make jelly, juice, vinegar, and seed oil. In 2019, the global harvested area of viticulture was estimated at about 7 million ha, which produced about 77 million tons **(FAOSTAT, 2021)**.

Autumn Crisp (Sugra thirty-five; Sugra35; US Patent PP20, 491 P2) is desirable for its large, naturally occurring berries, superb sweetness at harvest (17°Brix), and great storage qualities. It has lovely milky pale green-yellow skin and big berry. The flesh has a high degree is very crisp, when biting into the berry, the skin is rarely noticeable and doesn't really affect how the berry tastes. Breeders describe the variety as being sweet with a characteristic crisp-juicy texture and a light Muscat scent. Grown in: California, Chile, Chile, Peru, Madrid, Portugal, Roma, South Africa Australia, and Brazil. The Sun world grape breeder responsible for the selection was Michael Striem. In 2012, saw the beginning of the first commercial manufacturing following an 11-year development period. The US Plant Patent for the cultivar and the registration for the name, Autumn Crisp seedless, belong to Sun World International, LLC, of California.In November 2009, the US plant patent was obtained.

Vegetative growth management or summer pruning practices or green pruning such as shoot pinching, shoot thinning, lateral removal, leaf defoliation, and yield thinning are used to modify the canopy for a particular objective of shoot thinning, yield level, or bunch exposure. Faulty, vegetative growth management can thin out a canopy or promote exposure, but it prevents the vine from reaching physiological balance; in order to quickly repair the problem and create the ideal microclimate for fruit development, vineyards with excessive canopy growth need more direct canopy management. **(Cartechini *et al.*, 1998)**

Shoot pinching is idea behind on the principle of the reduction of apical dominance, which encourages better balance more equitable distribution of

carbohydrates between sources and sinks **(Mota *et al.*, 2010).** Shoot pinching has a definite place as a key component of green pruning practices, it is mostly done to control growth, improve ventilation, and intercept light entering vegetative growth management; since this method was discovered to boost the shoots' carbohydrate content, which had an impact on the quality of the fruit, the yield, and the bud fertility of different grape variety, **Abd El-Wahab *et al.*, (1997), Ibrahim *et al.*, (2001), Lorenzo *et al.*, (2001) and Omar (2004**). **Reynolds *et al.* (2005**) reported that when shoots are removed the carbohydrate content of the vine reduced which, leads in a reduction in crop load and vegetative growth in the next season.

Removal of lateral shoots is considered one of the most important green pruning in the grapevine. This project is related to canopy management practices and takes place after fruit set. The majority of the times, all lateral shoots that extend from the shoot's base to a bud above the last grape are cut off. In the grape zone, we do this to produce the optimal environment for the grapes' healthy growth. **(Ye *et al.*, 2022).**

Defoliation or leaf removal, this operation was historically defined as "the removal of some leaves from the fruiting area between fruit set and veraison" **(Smart, 1988**) with the overarching goal of obtaining a better bunch microclimate and decrease rot incidence in canopies that were too dense **(Gubler *et al.*, 2003).** Defoliation is a vegetative growth management that is known to impact berry quality and crop. Grape producers can adjust and lower canopy density using this method to increase fruit exposure, and, in general, to induce changes of the seasonal source–sink balance using the right technique at the right time **(Alessandrini *et al.*, 2018).** Defoliation is one of the most vegetative growth management operation as a result of its ease of use and adaptability for mechanisation **(Palliotti *et al.*, 2014a)**

The present's goal is to study was to evaluate the effects of pinching, lateral shoots removal and defoliation on growth, yield, and physicochemical characteristics of the Autumn Crisp seedless grapevines under Spanish baron system

MATERIALAND METHOD

This inquiry was carried out for two consecutive seasons (2019/2020) in a private vineyard located at El-Khatatba region, Monufyia Governorate, Egypt to study the impact of green pruning practices on the growth, yield and fruit quality of Autumn Crisp grapevines. The vines were six years old, grown in a sandy soil, spaced at 2 X 3 meters apart, irrigated by the drip irrigation system, and under standard practices commonly used. Vines were trained to quadrilateral cordon using Spanish baron system. During January of each experimental season, the selected vines were spur-pruned by leaving 8 spurs with 2 eyes on each cordon. The total load was 64 eyes. After first fruit set stage. The crop burden for all treatments was adjusted to 25 bunches per vine. In this study, seven treatments were utilised. They were all applied in three replicates, three vines per replicate, and on the same vines throughout the two study seasons. The treatments were arranged in a completely randomised blocks design. Sixty-three uniform vines were selected for this investigation uniform in vigor as possible. All the recommendations of the Ministry of Agriculture have been used to all the vines, such as Dormex spraying, fertilization, irrigation, diseases and pests resistant that usually used in this region. The trial period's climate had the following characteristics: average air temperature (16–31 °C), relative humidity (55–65%), and daily sunlight hours (11.8–12.9 h)

Seven treatments were applied as follows:

1- Control (untreated vines)

2- Pinching the main shoots

3- Lateral shoots removal

4- Defoliation

5- Pinching the main shoots + Lateral shoots removal

6- Pinching the main shoots + Defoliation

7- Lateral shoots removal + Defoliation

Pinching the main shoots was carried out at first fruit set stage by cutting off 2-3 cm from the tip of shoot. Lateral shoots removal treatment was applied just after fruit set stage. Basal defoliation was performed at two weeks after fruit set stage by removing leaves from the first four nodes from shoot base.

The subsequent parameters were measured to assess the tested treatments:

1- Yield and Physical properties of bunches and berries

At harvesting (time 12 weeks from the berries set) when SSC % in berry recorded about 16-17 % in control treatment **Sabry *et al.* (2009),** six bunches /vine were weighted and the average bunch weight was multiplied by number of bunches/ vine and hence average yield/ vine was calculated as(Kg), also, average bunch weight (g), average bunch dimensions (length and width) (cm), average 25 berry weight (g) and size (cm^3) and average berry dimensions (length and diameter) (mm) were measured.

2- Chemical properties of berries

The same bunches that were used to measure the physical characteristics of bunches and berries were used to measure the chemical characteristics of berries as follows: Soluble solids content (SSC %) by using a hand refractometer model Master T (ATAGO

Co., Ltd., Japan). Titratable acidity percentage (as g tartaric acid /100 ml juice) by titration against 0.1 N Na OH using phenolphthalein as described by **A.O.A.C. (2006).** Total sugars % was carried out according to the modified methods of **Sadasivam and Manickam (1996)** and Total carotenoids in skin of berries (mg/g F.W.) were determined as described by **Mackinny (1941).**

3- Measurements after harvest time: Internodes length (cm), shoot diameter (cm) and Trunk diameter (cm).

4- Measurements at dormancy time

At winter pruning time in the second week of January during the two years (2019 and 2020), the following morphological and chemical properties of canes were carried out as follow: Pruning wood weight (g), Total carbohydrates in canes(C) (%) were estimated according to **Schaffer and Hartman (1921),** Total Nitrogen in canes **(N)** was estimated by the microkieldahl method according to **Cottenie *et al.* (1982)** and C/N ratio was estimated

Statistical analysis

The outcomes were statistically analysed using **Snedecor and Chocran (1980)**. Using the new LSD values at 5% level to compare the differences among various treatments.

RESULTS AND DISCUSSION

1- Yield and physical properties of bunches

The response of used treatments (pinching the main Shoots, lateral shoots removal and defoliation) either alone or combined on both yield and physical characteristics of bunches during 2019 and 2020 seasons are cleared in Table (1). More clearly, all treatments either individually or combined between of them gave the significant increases in yield, bunch weight, bunch length, and bunch width as compared to control (untreated vines). As for individual treatments, it can be noticed that the pinching the main shoots application (T2) used in this study was the most effective than the others in both seasons. Further observing the results, it can be noticed that the combined treatments used in this study were the most effective than the individual treatments, especially the application of Pinching the main shoots + defoliation (T6) followed by the application of Pinching the main shoots + Lateral shoots removal (T5), which showed the highest significant values in yield, bunch weight, bunch length, and bunch width as compared to others applications (untreated vines) and non-significant between of them. It has been previously shown that the combined application between pinching the main shoots + defoliation) can result in an improvement in fruit production in terms of quality and yield, which could be attributed to a higher concentration of phytohormones and photosynthates in vines**.** This canopy management technique is easily mechanized, and the target is a canopy area geographically removed from the fruiting region, therefore the problem of cluster damage is solved, **Palliotti *et al.*, 2014a**. Moreover, **Uyak *et al.* (2016)** reported that pinching the main shoot enhanced weight of cluster of "Erciş" grapevine. **Abd El-Wadoud (2015)** reported that, all summer pruning treatments as lick pinching and defoliation resulted in significantly increase in bunch length and width of "Melissa" grapevines. These data are agree to the mentioned by (**Reynolds *et al.*, 1994; Morris *et al.*, 2004; Ghada, 2015 and El-Boray *et al.*, 2018)**.

Table (1). Effect of pinching the main shoots, lateral shoots removal and defoliation on yield and physical properties of bunch of Autumn Crisp grapevines during 2019 and 2020 seasons

Treatments / Characteristics		Yield/vine (Kg)		Cluster weight (g)		Cluster length (cm)		Cluster width (cm)	
		2019	2020	2019	2020	2019	2020	2019	2020
T1	Control (untreated vines)	13.00	14.04	520.3	561.66	25.3	26.3	14.6	15.5
T2	Pinching the main shoots	16.29	16.95	651.6	678.33	27.3	27.6	16	16.3
T3	Lateral shoots removal	14.04	14.4	561.6	576	25.6	26.3	15.3	16
T4	Defoliation	15.41	15.41	616.6	616.6	26	26.6	15.3	16
T5	Pinching the main shoots + Lateral shoots removal	17.08	17.91	683.3	716.6	27.6	28.6	17.3	18.6
T6	Pinching the main shoots + Defoliation	17.91	18.83	716.6	753.3	28.33	28.6	18.6	18.7
T7	Lateral shoots removal + Defoliation	16.66	17.91	666.6	716.6	27.3	26.6	16.3	16.3
New L.S.D at 5%		1.25	0.958	50.26	38.35	1.21	1.10	0.85	0.74

2- Physical properties of berries

As regard to physical properties of berries, data in Table (2) show that the physical properties of berries that including average 25 berry weight, average 25 berry size, berry length and diameter significantly increased with all used treatments either alone or combined between of them as compared to control in both seasons. As for individual treatments, it can be noticed that pinching the main shoots treatment (T2) was the most effective than the others individual treatments in both seasons, and the descending order was as follow: pinching the main shoots>defoliation >lateral shoots removal. The combined treatments were the best favorable in increasing these parameters than the individual applications, especially pinching the main shoots + defoliation (T6) treatment, which improved these parameters.

Pinching the main shoots, lateral shoots removal and defoliation lead to enhance in photosynthetic activity of leaves consequentially increased carbohydrate accumulation surely reflected on improving physical properties of berries.

Defoliation and pinching treatments enhanced photosynthetic activity and encourage translocation of assimilates from leaves towards berries **(Winkler, 1965).** When done early in berry development (before or before fruit set), defoliation in the cluster zone can enhance the sunshine exposure of grape clusters, which can stimulate the production of secondary metabolites in the berry. In agreement with **Poni *et al.* (2006)** this study indicated that post flowering defoliation appears to be quite effective as an earlier removal when the aim is also to achieve some control over fruit size. In this respect, **Abd El-Wahab *et al.* (1997)** on "King Ruby" and **Sabbatini *et al.* (2015)** reported that, green pruning practices were effective in enhancing berries physical characters of "Niagara" grapevines. Our results were in agree with those of **Fawzi *et al.* (2010)** on "Crimson seedless", **Roberto *et al.* (2017)** on "Thompson seedless" Also**, Khamis *et al.* (2017) El-Boray *et al*., 2018; Belal *et al*., 2019 and Bassiony, 2020).**

Table (2). Effect of pinching the main shoots, lateral shoots removal and defoliation on physical properties of berries of Autumn Crisp grapevines during 2019 and 2020 seasons

Characteristics / Treatments		25 berry weight (g)		25 berry size (cm^3)		Berry length (mm)		Berry diameter (mm)	
		2019	2020	2019	2020	2019	2020	2019	2020
T1	**Control (untreated vines)**	168.6	174	144.6	150	24.3	26	19.3	20.3
T2	**Pinching the main shoots**	178.3	187.3	154.6	159	26.6	27.6	19.6	20.9
T3	**Lateral shoots removal**	175.6	182	154.3	155.6	25.3	26.3	19.3	20.3
T4	**Defoliation**	176.6	185	154.6	156.6	25.6	27.3	19.6	20.6
T5	**Pinching the main shoots + Lateral shoots removal**	191.6	194.67	163.3	164.6	28.3	29.3	21	22.3
T6	**Pinching the main shoots + Defoliation**	193.3	196.67	165.3	166.6	29	29.6	22.6	23
T7	**Lateral shoots removal + Defoliation**	187.6	191	155.66	160.3	27.6	28	20.6	21.3
New L.S.D at 5%		**7.57**	**11.24**	**1.88**	**2.55**	**1.42**	**1.15**	**1.61**	**0.94**

3- Chemical properties of berries

The effect of used treatments such as pinching the main Shoots, lateral shoots removal and defoliation either alone or combined on the chemical properties of berries during 2019 and 2020 seasons are showed in Table (3). Data show that the chemical properties of berries were significantly improved by all applications as compared to the control. Non-significant deference was noticed between the individual treatments of SSC in the both season.

More obviously, the results demonstrated that all treatments combined afforded significant increases in SSC**,** Total sugars%, and total carotenoids of berries and reduced titratable acidity compared to the control in both seasons. Also, the combined treatments remarkably enhanced these parameters in both seasons than the individual treatments, and the

greatest increase was detected from the berries treated with pinching the main shoots + defoliation (T6).

Summer pruning is a viticulture technique helps to improve the microclimate of vine canopy, improves ripening and controls the incidence of diseases **(Di Lorenzo *et al.*, 2001).**

Excessive total soluble solids accumulation has been linked to several other factors: an increase of CO2 in the atmosphere that leads to a higher canopy photosynthetic potential as a result of using summer pruning treatments **(Ainsworth and Rogers, 2007)**.

Pinching the main shoots, lateral shoots removal and defoliation lead to enhance in photosynthetic activity of leaves consequentially increased carbohydrate accumulation surely reflected on improving chemical properties in berries. Phenolics, anthocyanins, carotenoids, and tannins are some of these flavonoids. It has also been demonstrated that fragrance components are increased by fruit contact in aromatic white grape variety. These findings are in harmony with (**Morris *et al.*, 2004; Ghada, 2015 and El-Boray *et al.*, 2018) t**hey ensured that some shoots removal shoots improved chemical properties in the berries.

Previous studies have shown that minimizing the possibility for grape sugar accumulation by lowering the leaf area to fruit weight ratio can affect berry quality **(El-Boray *et al.*, 2018; Belal *et al.*, 2019; Bassiony, 2020.**

Table (3). Effect of pinching the main shoots, lateral shoots removal and defoliation on chemical properties of berries of Autumn Crisp grapevines during 2019 and 2020 seasons

Characteristics / Treatments		SSC (%)		Titratable acidity (%)		Total sugars (%)		Total carotenoids (mg/g FW)	
		2019	2020	2019	2020	2019	2020	2019	2020
T1	**Control (untreated vines)**	16.6	16	0.93	0.91	9.6	10.3	3.1	3.5
T2	**Pinching the main shoots**	16.8	17.3	0.66	0.63	10.4	11.2	4	4.3
T3	**Lateral shoots removal**	16.6	17	0.9	0.83	10	11.0	3.7	4.2
T4	**Defoliation**	17	17.3	0.66	0.63	10.8	11.2	4.2	4.6
T5	**Pinching the main shoots + Lateral shoots removal**	19.3	19.6	0.6	0.53	12.5	12.7	4.7	5
T6	**Pinching the main shoots + Defoliation**	19.6	20	0.53	0.5	12.78	13	5.6	6.1
T7	**Lateral shoots removal + Defoliation**	18.6	19	0.66	0.6	12.13	12.3	5.1	5.7
New L.S.D at 5%		1.21	0.59	0.092	0.076	0.80	0.46	0.54	0.36

4- After harvest time parameters

Results of growth parameters after harvest time parameters such as internode length shoot diameter, and trunk thickness, which are considered the indicators of vine vigor for Autumn Crisp grapevines are presented in Table (4), data show that all used treatments such as pinching the main Shoots, lateral shoots removal and defoliation either alone or combined of them positively influenced on the growth parameters such as internode length and shoot diameter, and trunk thickness compared to the control in both seasons. As for individual treatments, the descending order was as follow: pinching the main shoots>defoliation >lateral shoots removal. The combined treatments improved these parameters than using each treatment individually alone. The best treatments in this respect was using pinching the main shoots + defoliation (T6) followed by pinching the main shoots + lateral shoots removal (T5) followed by lateral shoots removal + defoliation (T7).

Woody structures such as trunks and shoot act as sources for early season growth and development, as they contain stores of carbohydrates, amino acids and proteins, which are remobilized in summer to promote vine development prior to the emergence of fresh leaves and to export energy during the growing season (**Holzapfel *et al.*, 2006). Abd El-Wadoud (2015)** concluded that vine vigor parameters as the

shoot diameter and weight of pruning were significantly increased as a result of pinching and defoliation in "Melissa" grapes. Moreover, **Di Lorenzo *et al*. (2001)** reported that pinching the main shoots and head suckering with maintaining lateral shoots treatments showed the premier growth characters of "Nerod'Avola" grape. These results are in agreement with those mentioned that **(Marini, 1985 and Ikinci, 2014)** who found that summer pruning increased shoot diameter and trunk enlargement.

Table (4). Effect of pinching the main shoots, lateral shoots removal and defoliation on internode length, shoot diameter, and trunk thickness of Autumn Crisp grapevines during 2019 and 2020 seasons

Characteristics / Treatments		Internode length(cm)		Shoot diameter (cm)		Trunk thickness (cm)	
		2019	2020	2019	2020	2019	2020
T1	Control (untreated vines)	7.07	7.11	0.91	1.01	5.57	6.21
T2	Pinching the main shoots	7.77	7.95	1.21	1.48	6.27	7.05
T3	Lateral shoots removal	7.17	7.22	0.98	1.26	5.67	6.32
T4	Defoliation	7.31	7.35	1.17	1.30	5.81	6.45
T5	Pinching the main shoots + Lateral shoots removal	7.82	7.85	1.59	1.78	6.58	7.12
T6	Pinching the main shoots + Defoliation	8.08	8.17	1.61	1.82	6.59	7.27
T7	Lateral shoots removal + Defoliation	7.56	7.60	1.23	1.47	6.06	6.7
New L.S.D at 5%		0.451	0.4005	0.306	0.289	0.2707	0.228

5- Dormant season parameters

Data in Table (5) show that all used treatments such as pinching the main shoots, lateral shoots removal and defoliation either alone or combined between of them gave the maximum significant values in total carbohydrates (C) %, nitrogen (N) %, in canes and pruning wood weight as compared to the control. the combined treatments were the most effective than the individual treatments especially pinching the main shoots + defoliation (T6) and pinching the main shoots + lateral shoots removal (T5) treatments, which showed the highest significant values in total carbohydrates (C) %, nitrogen (N) %, in canes and pruning wood weight as compared to the other treatments.

Regarding C/N ratio in canes, data in Table (5) showed that pinching the main shoots + lateral shoots removal (T5) significantly increased C/N ratio in canes compared with the other treatments during both seasons.

Defoliation typically alters the direction of glucose translocation, which changes the content of the fruit (**Parker *et al.*, 2015a)**. Furthermore, the increment in total carbohydrate content and C/N ratio of canes as results of removing some shoots and defoliation may be attributed to enhance the light rays that received by the leaves into the vines, leading to enhance the photosynthesis activity of the leaves and therefore increase the accumulation of carbohydrates in cans **Kliewer (1981).** Also, the increment in total nitrogen (N) in canes as results application of shoots removal could be due to fewer remaining shoots (cans) on vine and increase their absorption of nutrients, especially nitrogen. Also **Abd El-Razek *et al.* (2010)** found that the excrescent of leave thinning may be decreased accumulation of carbohydrates in cans shoot tipping enhancement by removing a portion of the shoot tip, energy is moved from the side shoot to the main shoot, which exports photosynthetic energy to the main shoot, as well as laterals that grow on the main shoot **(Abd El-Ghany *et al*., 2005).**

These data are in line with these obtained by **Ghada (2015)**and **El-Boray *et al.* (2018)** they reported that carbohydrates content in the canes significant increased by applications of shoots removal.

Finally, other compounds of the fruits may be affected by the green pruning practices of pinching the main shoots; lateral shoots removal, defoliation, of the vines. This possibility opens up the opportunity for future studies directed to greater detailing of the contents of these constituents in the grapes as a means of adjusting canopy management for the assessment of the quality of the grapes.

Table (5). Effect of pinching the main shoots, lateral shoots removal and defoliation on total carbohydrates, total nitrogen in the canes and C/N ratio, and pruning wood weight of Autumn Crisp grapevines during 2019 and 2020 seasons

Characteristics / Treatments		Total carbohydrates (g/100gm DW)		N (%)		C/N ratio		Pruning wood weight (g)	
		2019	2020	2019	2020	2019	2020	2019	2020
T1	Control (untreated vines)	31.32	31.54	0.87	0.90	36.59	35.04	2440	2516
T2	Pinching the main shoots	32.55	33.50	0.88	0.92	35.84	36.69	2916	2970
T3	Lateral shoots removal	33.34	33.84	0.99	0.99	33.44	34.14	2503	2590
T4	Defoliation	34.35	34.78	0.98	0.99	34.87	34.89	3066	3100
T5	Pinching the main shoots + Lateral shoots removal	38.55	40.46	1.01	1.02	37.91	39.56	2793	2900
T6	Pinching the main shoots + Defoliation	39.1	39.90	1.04	1.06	37.30	37.56	3100	3233
T7	Lateral shoots removal + Defoliation	34.21	34.56	0.96	0.99	35.52	37.06	2916	2970
New L.S.D at 5%		2.34	1.97	0.07	0.06	3.96	2.71	160.53	249.30

Conclusion

Conclusively, the results of this investigation demonstrated that (pinching the main shoots + defoliation) treatment gave the optimum results for increasing carbohydrates (C) %, nitrogen (N) %, in canes and improving yield, the physical and chemical properties of bunches and berries, Therefore, it is recommended to use this application for Autumn Crisp grapevines vineyards**.**

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RESEARCH ARTICLE

Impact of pinching, lateral shoots removal and defoliation on growth, yield and bunch quality of Autumn Crisp grapevines

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