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Effect of canopy management on yield and quality attributes of grafted "Flame Seedless" grapevines under overhead plastic covering and open field conditions

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ABSTRACT

The present investigation was conducted during the 2024 and 2025 seasons on eight-year-old Flame Seedless grapevines grafted onto 'Freedom' rootstock. The vines were grown either under a transparent plastic cover or in open-field conditions and subjected to canopy management practices involving the thinning of vegetative shoots and clusters. The number of vegetative shoots and clusters per vine were thinned to 40 or 50 shoots and 25 or 35 clusters, respectively. Results revealed that berry ripening in covered vines occurred 20 days earlier than in open-field vines. Both shoot length and leaf area significantly increased under the plastic cover. Covered vines also exhibited greater 100-berry weight and larger berry size compared with those grown open-fields. The combination of plastic covering with 40 shoots and 35 clusters produced the highest yield per vine, while the treatment of 50 shoots and 25 clusters resulted in the heaviest cluster weight and the largest berry size and length. Vines with 25 clusters recorded higher total soluble solids (TSS), whereas titratable acidity showed an opposite trend with increasing cluster number. Moreover, total anthocyanin content was enhanced under the plastic cover. From an economic perspective, the overhead plastic covering provided a considerable increase in net profit. Therefore, training Flame Seedless grapevines grafted on 'Freedom' rootstock under plastic cover with 50 shoots and 25 clusters per vine is recommended for achieving the best yield and fruit quality.

Keywords: Flame Seedless- Plastic cover- Canopy management- Cluster thinning- Berry quality.

INTRODUCTION

Flame Seedless grape is a well-known premium early table cultivar in Egypt that is prized for both domestic and international markets. This cultivar is distinguished by its exceptional sensory attributes, great yield, and early maturity. Additionally, because of its early maturation, it can be used to access the European Union market and prices are at their highest (Abd El-Wahab et al., 2025).

Table grapes are usually cultivated under plastic covers promote early production (Ergenoglu et al., 1999). Meanwhile, colored plastic films can either advance or delay grape ripening (Tarricone et al., 2017). Canopy management techniques can be useful to grapevines reproduction because they improve canopy structure and microclimate (Wang et al., 2019). Cluster thinning is achieved during a large range of grapevines phonological stages from bloom to veraison (Fanzone et al., 2011). Volschenk and Hunter (2021) observed that the highest yields were obtained by combining shoot positioning with defoliation or topping. Besides, total grape quality was increased by seasonal canopy management. Shoot thinning plus pre-flowering defoliation reduced yield and increased berry composition in a Mediterranean climate (Silvestroni et al., 2019). The highest TSS and the lowest acidity were observed either in leaf removal or its combination with shoot thinning plus shoot position treatments (Jogaiah et al., 2013). The primary role of canopy management that light environment of the renewal zone plays in the arrangement of shoots per node, clusters per shoot, cluster weight and primary bud-axis necrosis (dry., 2000).

The plastic covering is affixed on the vineyard at the end of winter. The maximum impact can be observed by covering the vineyard 50 days before natural vine bud break in open field (early and seedless grapes). However, starting from veraison, the harvest may be delayed by 3 months, without losing yield and berry properties. Besides, this date covering is particularly convenient for late seeded (Novello and Palma, 2008). Plastic covering of grapevines significantly encourage the dates of phonological stages and particularly ripening for 26-33 days according to cultivar as compared with the open-field ripening dates (Coban, 2004).

The use of plastic covering is method for the development of a more economically viable grape production system due to produce grapes in a safer way. Moreover, the reduction in the use of chemical pesticides attributed to the use of plastic covering, which enables more sustainable production with lower environmental risks. (Schwerz et al., 2023). The plastic cover had no effect on grape production. Meanwhile, the vines under plastic cover was greater the soluble solids content of berries than vines plastic screen. Besides, it was not discovered the incidence of downy mildew and reduction of fungicide number (Yamamoto et al., 2012). The vines under plastic cover lower incoming solar radiation and wind speed, changing air temperature and humidity (Palma et al., 2022). Plastic cover promotes yield increases and encourages production stability indolently of climate conditions in each season (Chavarria et al., 2009).

The ultimate goal of this research is to produce an early yield with high fruit quality attributes of Flame Seedless through overhead plastic covering and canopy management.

MATERIALS AND METHODES

The study was carried out during 2024 and 2025 seasons in a vineyard in El-Nobaria, El-Beheira governorate at 80 Km on Alexandria-Cairo desert road, Egypt (30°39'32.6"N 30°03'18.1"E). Eight years old Flame seedless rape Cv. grafted onto Freedom rootstock. The vines were grown in sandy soil, spaced at 2x3m, under a drip irrigation, spur pruned (4 buds/spure-60buds/vines) and supported by the Spanish Parron system. All grapevines were subjected to the same horticultural proceeding suggested by the Ministry of Agriculture and Land Reclamation (2014).

Ninety-six uniform vines were chosen each four vines acted as a replicate, and each three replicates were treated by one of the following treatments.

1. Plastic-covered vines with 40 shoots and 25 clusters
2. Plastic-covered vines with 40 shoots and 35 clusters
3. Plastic-covered vines with 50 shoots and 25 clusters
4. Plastic-covered vines with 50 shoots and 35 clusters
5. Open-field vines with 40 shoots and 25 clusters
6. Open-field vines with 40 shoots and 35 clusters
7. Open-field vines with 50 shoots and 25 clusters
8. Open-field vines with 50 shoots and 35 clusters

The vines were covered by plastic film after pruning (15 December), and the sheet was removed on 1st April. The plasticى cover was transparent white with a thickness of 100 microns, and it was thermally untreated. For shoot thinning, the number of shoots (40 and 50) was adjusted on 10 March for the covered vines and on 1st April for open field vines (pre-flowering), regarding to the cluster thinning, the number of clusters (25 and 35) was fixed on 15 March for the covered vines and on 10 April for open-field vines (pre- fruit set).

Measurements data

- **Phenological dates**

All phenological dates were recorded during the growing seasons at specific intervals, including the dates of bud burst, full bloom, fruit set, veraison and ripening, periodically.

- **Vegetative growth aspects**

At growth cessation, such as shoot length (cm), number of leaves, and leaf area (cm²), were determined. As well as total leaf area/vine (m²), it was estimated by multiplying the average number of leaves/shoot by the average leaf area and then by the number of shoots per vine.

- **Yield**

Harvesting take place when total soluble solids (TSS) reached 17-18% according to Hamie *et al*. (2023). The total yield (kg) per vine was determined by multiplying number of clusters and average cluster weight.

- **Cluster physical attributes:**

Cluster weight (g), length and width (cm) were investigated

- **Berry physical attributes:**

100 berry weight (g) and size (ml), average berry length and diameter (mm) were investigated.

- **Berry chemical attributes:**

TSS% was determined using a refractometer (model ATC-1, Atago, Co., Tokyo, Japan). Total acidity % was determined by A.O.A.C. (1990). Total anthocyanin was determined as mg/100g F.W. (Husia et al., 1965).

Experimental design and statistical analysis

The analysis of variance was carried out according to Gomez and Gomez (1984) for a three factors with three replications arranged in a spilt-spilt plot design of three replications. The main plots represented the vines under plastic cover and open field, the shoots density were assigned to the sub plots, while the cluster density were allocated to the sub-subplots. Numerical data were transformed using square root transformation. Comparison of means was carried out using new LSD at 0.05 level (Steel and Torrie, 1980).

RESULTS

- **Phenological stages:**

Data in **Table (1)** and **Figure (1)** revealed that all phenological stages of Flame Seedless grapevines (budburst, full bloom, fruit set, veraison and grape maturity) were markedly affected by all conducted treatments in both seasons.

The range impact can be observed by the covered vines 16-20 days before the bud burst stage in open-field vines. The vines under plastic cover were earlier 12 days compared with open-field vines concerning the flowering stage. The peak effect can be reported by plastic cover 15 days before the fruit set stage in open-fields vines. Veraison stage was found to be earlier on the covered vines by about 25 days compared with the vines in open field conditions. Similarly, ripening in the vines under plastic covers, were 20 days earlier than open-field vines. Regarding the effect of shoot numbers, there were no significant differences between shoot numbers under plastic cover and open-field vines concerning all phenological stages. As for the effect of clusters number, the 25 clusters were earlier by 4-5 days, compared with the 35 clusters.

Table (1). Influence of shoots and clusters density on grafted Flame Seedless grapevines under overhead plastic covering and open field conditions on observed phenological dates in 2024 and 2025 seasons

Treatments	Phenological dates	Bud burst		Full bloom		Fruit set		Veraison		Ripening	
		2024	2025	2024	2025	2024	2025	2024	2025	2024	2025
Plastic covering	40 shoots+25 clusters	18-Jan	19-Jan	19-Feb	21-Feb	20-Mar	23-Mar	8-Apr	9-Apr	3-May	4-May
	40 shoots+35 clusters	19-Jan	20-Jan	21-Feb	23-Feb	21-Mar	24-Mar	11-Apr	12-Apr	8-May	8-May
	50 shoots+25 clusters	17-Jan	19-Jan	20-Feb	21-Feb	19-Mar	25-Mar	9-Apr	8-Apr	3-May	4-May
	50 shoots+35 clusters	19-Jan	20-Jan	22-Feb	21-Feb	20-Mar	25-Mar	11-Apr	11-Apr	8-May	9-May
Open field	40 shoots+25 clusters	7-Feb	4-Feb	3-Mar	5-Mar	3-Apr	7-Apr	3-May	4-May	23-May	23-May
	40 shoots+35 clusters	7-Feb	5-Feb	4-Mar	6-Mar	5-Apr	8-Apr	6-May	6-May	28-May	27-May
	50 shoots+25 clusters	6-Feb	4-Feb	4-Mar	5-Mar	3-Apr	8-Apr	3-May	3-May	23-May	23-May
	50 shoots+35 clusters	7-Feb	4-Feb	5-Mar	5-Mar	4-Apr	9-Apr	5-May	6-May	28-May	29-May

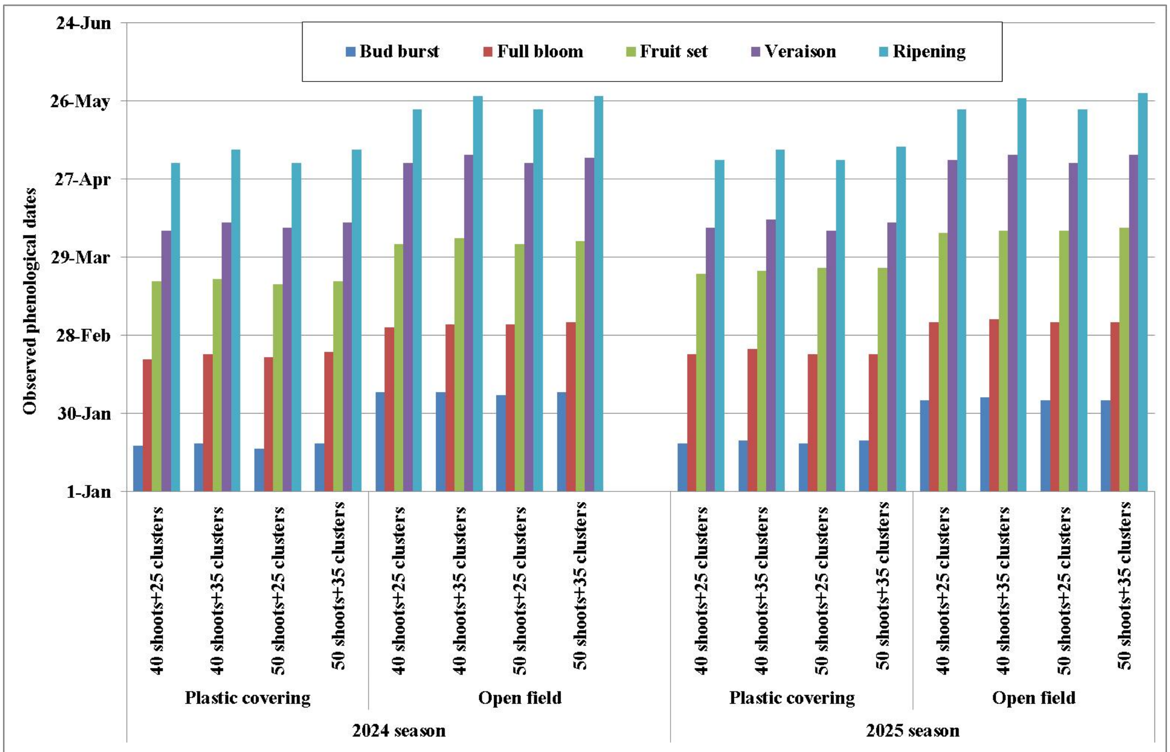

Figure (1). Influence of shoots and clusters density on grafted Flame Seedless grapevines under overhead plastic covering and open field conditions on observed phenological dates in 2024 and 2025 seasons

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- **Vegetative growth aspects**

It is obvious from the data in **Table (2)** that all vegetative growth traits including shoot length, number of leaves and leaf area of Flame Seedless grape cultivar were significantly influenced by all the conducted treatments in both seasons of the study.

Shoot length

Regarding to the covering impact, shoot length was significantly increased in the covered vines as compared with open-field vines in both seasons. In contrast, concerning the shoot numbers effect, it was noticeable that there were no significant differences between 40 and 50 shoots in both seasons.

With respect to the cluster numbers impact, the vines with 25 clusters had a remarkably higher shoot length than the vines with 35 clusters in both seasons. However, there were no significant differences among all the interactions.

Leaf numbers

With respect to cluster numbers impact, number of leaves was remarkably higher in the vines with 25 clusters compared to those with 35 clusters in both seasons. On the other hand, number of leaves was not considerably affected by the other factors and interactions.

Leaf area

Regarding to the covering impact, vines under plastic cover had a considerably higher leaf area either per shoot or per vine than open-field vines in both seasons. Relating to shoot numbers effect, there were significant differences between the vines with 40 shoots and the vines with 50 shoots in both seasons. As for cluster numbers impact, the vines leaf area with 25 clusters as compared with the vines with 35 clusters considerably increased either per shoot or per vine in both seasons. Meanwhile, there were no considerable differences among all the interactions.

Table (2). Influence of shoots and clusters density on grafted Flame Seedless grapevines under overhead plastic covering and open field conditions on vegetative growth aspects in 2024 and 2025 seasons

Factors of treatments			Shoot length (cm) 2024	Shoot length (cm) 2025	Number of leaves 2024	Number of leaves 2025	Leaf area/shoot (cm^2) 2024	Leaf area/shoot (cm^2) 2025	Leaf area/vine (m^2) 2024	Leaf area/vine (m^2) 2025
(A): Covering	A1 (Plastic covering)		84.49	84.34	16.41	15.89	160.4	159.8	7.78	7.51
	A2 (Open field)		83.09	83.07	15.33	15.32	156.2	156.6	7.09	7.10
new L.S.D. (A)=			0.94	0.62	N.S	N.S	2.35	2.71	0.43	0.38
(B): Shoots density	B1 (40 shoots)		83.50	83.68	15.74	15.57	164.0	163.2	7.62	7.51
	B2 (50 shoots)		84.07	83.73	16.00	15.64	152.7	153.2	7.24	7.09
new L.S.D. (B)=			N.S	N.S	N.S	N.S	3.77	3.36	0.27	0.21
(C): Clusters density	C1 (25 clusters)		84.66	84.50	17.14	16.82	159.7	159.4	6.84	6.70
	C2 (35 clusters)		82.91	82.92	14.60	14.39	157.0	156.9	8.02	7.90
new L.S.D. (C)=			1.10	1.35	0.42	1.06	1.45	1.67	1.19	1.03
(AXB): Interaction	Plastic covering	40 shoots	83.98	84.18	16.32	15.97	165.3	164.4	7.98	7.76
		50 shoots	85.00	84.50	16.50	15.80	155.5	155.2	7.57	7.26
	Open field	40 shoots	83.03	83.18	15.15	15.16	162.6	162.0	7.27	7.27
		50 shoots	83.15	82.97	15.50	15.48	149.8	151.2	6.90	6.92
new L.S.D. (AXB)=			N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
(AXC): Interaction	Plastic covering	25 clusters	85.00	84.85	17.82	17.15	162.2	161.4	7.22	6.92
		35 clusters	83.98	83.83	15.00	14.63	158.7	158.2	8.33	8.10
	Open field	25 clusters	84.33	84.14	16.45	16.49	157.2	157.5	6.47	6.49
		35 clusters	81.85	82.01	14.20	14.15	155.3	155.7	7.71	7.71
new L.S.D. (AXC)=			N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
(BXC): Interaction	40 shoots	25 clusters	84.51	84.35	17.12	16.81	165.5	164.7	7.09	6.92
		35 clusters	82.50	83.01	14.35	14.33	162.4	161.7	8.16	8.11
	50 shoots	25 clusters	84.82	84.64	17.15	16.83	153.8	154.2	6.60	6.48
		35 clusters	83.33	82.83	14.85	14.45	151.5	152.2	7.88	7.70
new L.S.D. (BXC)=			N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
(AXBXC): Interaction	Plastic covering, 40 shoots	25 clusters	84.65	84.70	17.64	17.29	167.0	166.7	7.36	7.21
		35 clusters	83.30	83.65	15.00	14.65	163.6	162.0	8.59	8.31
	Plastic covering, 50 shoots	25 clusters	85.35	85.00	18.00	17.00	157.3	156.0	7.08	6.63
		35 clusters	84.65	84.00	15.00	14.60	153.7	154.3	8.07	7.88
	Open field, 40 shoots	25 clusters	84.36	84.00	16.60	16.32	164.0	162.6	6.81	6.63
		35 clusters	81.70	82.36	13.70	14.00	161.2	161.3	7.73	7.90
	Open field, 50 shoots	25 clusters	84.29	84.28	16.30	16.65	150.3	152.3	6.12	6.34
		35 clusters	82.00	81.65	14.70	14.30	149.3	150.0	7.68	7.51
new L.S.D. (AXBXC)=			N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

- **Yield and cluster physical attributes**

Data in **Table (3)** revealed that yield and cluster physical attributes i.e. cluster weight, length and width of Flame Seedless grapevines were significantly affected by all conducted treatments in both seasons.

Yield

Regarding covering impact, the covered vines were considerably higher yield than open field vines. Concerning shoot numbers effect, there were significant difference between the vines with 40 and 50 shoots in both seasons. With respect to clusters number impact, the vines with 35 clusters were considerably higher yield than vines with 25 clusters in both seasons. With respect to the interaction between covering and shoots number effect; yield was significantly affected by the vines under cover with 40 shoots as compared with open-field vines with 50 shoots in both seasons. For the interaction between shoots number and clusters number impact, the vines with 50 shoots and 35 clusters had the highest yield, while vines with 40 shoots and 25 clusters gave the lowest value in the first season. The vines under plastic cover with 40 shoots and 35 clusters had the significantly highest yield. Meanwhile, open-field vines with 50 shoots and 25 clusters gave the considerably lowest value in both seasons. On the other hand, there were no significant differences among the other interactions.

Cluster weight

With respect to covering impact, the covered vines had remarkably greater cluster weight than open-field vines. Concerning shoot numbers effect, cluster weight was remarkably increased by the vines with 50 shoots as compared with the vines with 40 shoots in the first season. Concerning clusters number effect, the vines with 25 clusters had considerably greater cluster weight than the vines with 35 clusters in both seasons. The interaction covering and shoot numbers impact, there were significant difference between the covered vines with 50 shoots and open field vines with 40 shoots in both seasons. The interaction between covering and cluster numbers, the vines under cover with 25 clusters had the greatest cluster weight whereas open-field vines with 35 clusters recorded the lowest value in both seasons. Three-way interaction, in both seasons, the covered vines with 50 shoots and 25 clusters recorded remarkably the greatest cluster weight. However, open field vines with 40 shoots and 35 clusters gave considerably the lowest value. Cluster weight was not significantly affected by the rest factors and interactions.

Cluster length

Regarding covering impact, cluster length significantly increased in the vines under plastic cover compared with open-field vines in both seasons. Concerning the shoot numbers effect, the vines with 50 shoots had greater cluster length than the vines with 40 shoots in both seasons. With respect to cluster numbers impact, there was significant difference between the vines with 25 clusters and the vines with 35 clusters in both seasons. The interaction between covering and shoot numbers impact, the covered vines with 50 shoots had the greatest cluster length whereas open field vines with 40 shoots recorded the lowest value in the first season. The interaction between covering and clusters number impact, the covered vines with 25 clusters had the highest cluster length while open-field vines with 35 clusters gave the lowest value in both seasons. In the first season, the vines under plastic film with 50 shoots and 25 clusters had the significantly highest cluster length whereas open-field vines with 40 shoots and 35 clusters gave considerably the lowest values. Cluster length has no remarkable influence by the remaining interactions.

Table (3). Influence of shoots and clusters density on grafted Flame Seedless grapevines under overhead plastic covering and open field conditions on yield/vine and cluster physical attributes in 2024 and 2025 seasons

Factors of treatments				Yield/tree (kg)		Cluster weight (g)		Cluster length (cm)		Cluster width (cm)	
				2024	2025	2024	2025	2024	2025	2024	2025
(A): Covering	A1 (Plastic covering)			16.94	16.99	570.00	567.50	19.00	19.05	11.23	11.25
	A2 (Open field)			15.89	15.85	535.00	529.16	18.64	18.67	10.35	10.35
new L.S.D. (A)=				0.40	0.78	16.43	23.51	0.12	0.16	0.31	0.07
(B): Shoots density	B1 (40 shoots)			16.26	16.28	547.50	545.83	18.74	18.79	10.74	10.74
	B2 (50 shoots)			16.58	16.56	557.50	550.83	18.91	18.93	10.84	10.86
new L.S.D. (B)=				0.22	0.20	6.54	N.S	0.08	0.12	0.05	0.11
(C): Clusters density	C1 (25 clusters)			14.28	14.34	571.66	568.33	19.22	19.27	11.16	11.21
	C2 (35 clusters)			18.56	18.50	533.33	528.33	18.42	18.46	10.42	10.39
new L.S.D. (C)=				0.20	0.30	8.37	9.98	0.11	0.19	0.17	0.12
(AXB): Interaction	Plastic covering	40 shoots		16.53	16.66	556.66	556.66	18.85	18.95	11.08	11.11
		50 shoots		17.36	17.33	583.33	578.33	19.16	19.15	11.38	11.40
	Open field	40 shoots		15.98	15.90	538.33	535.00	18.63	18.63	10.40	10.36
		50 shoots		15.81	15.80	531.66	523.33	18.65	18.72	10.30	10.33
new L.S.D. (AXB)=				0.30	0.27	9.25	17.61	0.08	N.S	0.08	0.15
(AXC): Interaction	Plastic covering	25 clusters		14.82	14.98	595.00	593.33	19.56	19.58	11.72	11.80
		35 clusters		19.07	19.01	545.00	541.66	18.45	18.52	10.75	10.71
	Open field	25 clusters		13.74	13.70	548.33	543.33	18.88	18.95	10.60	10.63
		35 clusters		18.05	18.00	521.66	515.00	18.40	18.40	10.10	10.06
new L.S.D. (AXC)=				N.S	N.S	11.84	14.12	0.14	0.26	0.34	0.17
(BXC): Interaction	40 shoots	25 clusters		14.24	14.28	568.33	566.66	19.16	19.20	11.13	11.16
		35 clusters		18.28	18.28	526.66	525.00	18.32	18.38	10.35	10.31
	50 shoots	25 clusters		14.32	14.40	575.00	570.00	19.28	19.33	11.18	11.27
		35 clusters		18.84	18.73	540.00	531.66	18.53	18.53	10.50	10.46
new L.S.D. (BXC)=				0.29	N.S	N.S	N.S	N.S	N.S	N.S	N.S
(AXBXC): Interaction	Plastic covering	40 shoots	25 clusters	14.41	14.55	576.66	576.66	19.36	19.40	11.53	11.56
			35 clusters	18.65	18.76	536.66	536.66	18.33	18.50	10.63	10.66
		50 shoots	25 clusters	15.23	15.40	613.33	610.00	19.76	19.76	11.90	12.03
			35 clusters	19.48	19.25	553.33	546.66	18.56	18.53	10.86	10.76
	Open field	40 shoots	25 clusters	14.06	14.00	560.00	556.66	18.96	19.00	10.73	10.76
			35 clusters	17.90	17.80	516.66	513.33	18.30	18.26	10.06	9.96
		50 shoots	25 clusters	13.41	13.40	536.66	530.00	18.80	18.90	10.46	10.50
			35 clusters	18.20	18.20	526.66	516.66	18.50	18.53	10.13	10.16
new L.S.D. (AXBXC)=				0.41	0.60	16.75	19.97	0.21	N.S	N.S	0.25

Cluster width:

Regarding covering impact, the vines under plastic cover had significantly higher cluster width than those of open-field conditions. Concerning shoot numbers effect, cluster width was considerably increased by the vines with 50 shoots compared to vines with 40 shoots in both seasons. With respect to cluster numbers effect, there was a significant difference between the vines with 25 and 35 clusters in both seasons. As for the interaction between covering and shoots number, the covered vines with 50 shoots had the greatest cluster width while open-field vines with 50 shoots had the lowest value in both seasons. The interaction between covering and clusters number impact, the covered vines with 25 clusters gave the highest cluster width whereas open field vines recorded the lowest value in both seasons. In the three-way interaction, the covered vines with 50 shoots and 25 clusters had the greatest cluster width while the vines in open-field with 40 shoots and 35 clusters gave the lowest values in the second season. Cluster width was not considerably influenced by the other interactions.

- **Berry physical attributes**

As shown in **Table (4)** all berry physical attributes including weight and size of 100 berries as well as average berry length and diameter of Flame Seedless grapevines were significantly influenced by all treatments applied in both seasons.

Weight of 100 berries

With respect to covering impact, weight of 100 berries was markedly increased in the covered vines compared with open-field vines in both seasons. Concerning shoot numbers effect, the vines with 50 shoots were considerably higher than the vines with 40 shoots in both seasons. Regarding clusters number impact, there were significant differences between the vines with 25 clusters and the vines with 35 clusters in both seasons. The interaction between the covering vines and shoot numbers impact, showed that the covered vines with 50 shoots gave the highest weight of 100 berries while the open-field vines recorded the lowest value in both seasons. As for the interaction between covering and cluster numbers impact, the covered vines with 25 clusters were greater than the remaining other treatments in the first season. In the three-way interaction, covered vines with 50 shoots and 25 clusters had the greatest weight of 100 berries while open-field vines with 40 shoots and 35 clusters showed this in the first season. There were no remarkable differences among the remaining factors and interactions.

Size of 100 berries

Regarding covering impact, size of 100 berries was remarkably increased by the covered vines compared with the open-field vines in both seasons. Concerning shoot numbers effect, size of 100 berries was not significantly affected by shoot numbers in both seasons. With respect to clusters number impact, the vines with 25 clusters were considerably higher than the vines with 35 clusters in both seasons. The interaction between the covering vines and shoot numbers, the covered vines with 50 shoots were considerably greater than the other treatments in the first season. In three-way interaction, covered vines with 50 shoots and 25 clusters recorded the highest size of 100 berries whereas open-field vines with 40 shoots and 35 clusters gave the lowest values in the first season. Meanwhile, size of 100 berries was not significantly affected by the remaining factors and interactions.

Table (4). Influence of shoots and clusters density on grafted Flame Seedless grapevines under overhead plastic covering and open field conditions on berry physical attributes in 2024 and 2025 seasons

Factors of treatments				100 berry weight		100 berry size (ml)		Berry length (mm)		Berry diameter (mm)	
				2024	2025	2024	2025	2024	2025	2024	2025
(A): Covering	A1 (Plastic covering)			452.50	449.08	460.00	455.77	19.75	20.08	15.00	15.25
	A2 (Open field)			423.33	419.18	435.83	436.66	17.58	17.33	14.25	14.50
new L.S.D. (A)=				3.58	16.43	7.17	15.62	0.71	0.62	N.S	N.S
(B): Shoots density	B1 (40 shoots)			434.16	428.26	445.83	442.50	18.33	18.41	14.58	14.83
	B2 (50 shoots)			441.66	440.00	450.00	449.93	19.00	19.00	14.66	14.91
new L.S.D. (B)=				4.00	9.53	N.S	N.S	N.S	N.S	N.S	N.S
(C): Clusters density	C1 (25 clusters)			445.83	442.51	456.66	451.58	20.08	20.25	15.25	15.58
	C2 (35 clusters)			430.00	425.75	439.17	440.85	17.25	17.16	14.00	14.16
new L.S.D. (C)=				5.43	9.01	6.07	9.01	0.60	0.79	0.76	0.47
(AXB): Interaction	Plastic covering	40 shoots		445.00	438.17	453.33	446.68	19.33	19.66	14.66	14.83
		50 shoots		460.00	460.00	466.67	464.85	20.16	20.50	15.33	15.66
	Open field	40 shoots		423.33	418.35	438.33	438.33	17.33	17.16	14.50	14.83
		50 shoots		423.33	420.00	433.33	435.00	17.83	17.50	14.00	14.16
new L.S.D. (AXB)=				5.66	13.48	6.53	N.S	N.S	N.S	0.65	N.S
(AXC): Interaction	Plastic covering	25 clusters		463.33	456.67	470.00	461.50	21.66	22.00	15.50	15.83
		35 clusters		441.66	441.50	450.00	450.03	17.83	18.16	14.50	14.66
	Open field	25 clusters		428.33	428.35	443.33	441.65	18.50	18.50	15.00	15.33
		35 clusters		418.33	410.00	428.33	431.68	16.66	16.16	13.50	13.66
new L.S.D. (AXC)=				7.68	N.S	N.S	N.S	0.83	N.S	N.S	N.S
(BXC): Interaction	40 shoots	25 clusters		443.33	435.02	453.33	448.33	20.00	19.83	15.16	15.50
		35 clusters		425.00	421.50	438.33	436.68	16.66	17.00	14.00	14.16
	50 shoots	25 clusters		448.33	450.00	460.00	454.83	20.16	20.66	15.33	15.66
		35 clusters		435.00	430.00	440.00	445.03	17.83	17.33	14.00	14.16
new L.S.D. (BXC)=				N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
(AXBXC): Interaction	Plastic covering	40 shoots	25 clusters	453.33	443.33	456.66	450.00	21.00	21.00	15.00	15.32
			35 clusters	436.66	433.00	450.00	443.36	17.66	18.33	14.33	14.30
		50 shoots	25 clusters	473.33	470.00	483.33	473.00	22.33	23.00	16.00	16.35
			35 clusters	446.66	450.00	450.00	456.70	18.00	18.00	14.65	15.00
	Open field	40 shoots	25 clusters	433.33	426.70	450.00	446.65	19.00	18.66	15.33	15.66
			35 clusters	413.33	410.00	426.66	430.00	15.66	15.66	13.70	14.00
		50 shoots	25 clusters	423.33	430.00	436.66	436.65	18.00	18.33	14.68	15.00
			35 clusters	423.33	410.00	430.00	433.35	17.66	16.66	13.29	13.33
new L.S.D. (AXBXC)=				10.87	N.S	12.15	N.S	1.19	1.58	N,S	N.S

Berry length

Concerning covering impact, berry length was markedly increased by the vines under cover as compared with the outdoor vines in both seasons. Regarding shoots number effect, there were no significant difference between the vines with 40 and 50 shoots in both seasons. With respect to clusters number impact, the vines with 25 clusters were significantly higher berry length than the vines with 35 clusters in both seasons. The interaction between the covering and clusters number impact, the vines plus 25 clusters had the greatest berry length whereas the vines with 35 clusters gave the lowest value in the first season. In both seasons, the vines under cover with 50 shoots and 25 clusters recorded the remarkably berry length but the open field vines gave the considerably lowest value. There were no considerable differences among the rest and interactions.

Berry diameter

Regarding covering and shoots number impact, berry diameter was not remarkably influenced by covering impact alone and shoots number alone in both seasons. With respect to clusters number impact, the vines with 25 clusters were considerably higher berry diameter than the vines with 35 clusters in both seasons. The interaction between covering and shoots number impact, the covered vines with 50 shoots recorded the considerably greatest berry diameter while the outdoor vines with 50 shoots gave the lowest value in the first season. Berry diameter was not significantly affected by the others factors and interactions.

- **Berry chemical attributes**

Data in **Table (5)** revealed that berry chemical attributes i.e. TSS, total acidity and total anthocyanin of Flame Seedless grapevines were markedly affected by all conducted treatments in both seasons.

Total soluble solids (TSS)

With respect to covering and shoots number impacts, total soluble solids was not remarkably influenced by the covering impact alone or shoots number alone in both seasons. Concerning clusters number impact, the vines with 25 clusters were significantly higher TSS than the vines with 35 clusters in both seasons. There were no significant differences among all the interactions.

Total acidity

Regarding covering and shoots number impacts, there were no considerable differences between the cover and open-field vines or 40 and 50 shoots concerning acidity. Vines with 35 clusters had the significantly higher acidity than the vines with 25 clusters in both season. Total acidity was not remarkably influenced by all the interactions.

Total anthocyanin

Concerning covering impact, anthocyanin level was highly significant increased by the covered vines as compared with open field vines. With respect to clusters number impact, the vines with 25 clusters were very considerable higher anthocyanin concentration than the vines with 35 clusters in both seasons. The interaction between covering and clusters number impact, the covered vines with 25 clusters were markedly greater anthocyanin than the vines with 35 clusters in both seasons. The covered vines with 40 shoots and 25 clusters recorded the greatest anthocyanin level, while the outdoor vines with 50 shoots and 35 clusters had the lowest concentration in the first season. There were no remarkable differences among the rest factors and the interactions.

Table (5). Influence of shoots and clusters density on grafted Flame Seedless grapevines under overhead plastic covering and open field conditions on berry chemical attributes in 2024 and 2025 seasons

Factors of treatments			TSS (%) 2024	TSS (%) 2025	Total acidity (%) 2024	Total acidity (%) 2025	Total anthocyanin (mg/100gF.W.) 2024	Total anthocyanin (mg/100gF.W.) 2025
(A): Covering	A1 (Plastic covering)		17.58	17.75	0.55	0.55	41.33	42.39
	A2 (Open field)		17.66	17.91	0.56	0.55	32.42	33.55
new L.S.D. (A)=			N.S	N.S	N.S	N.S	1.31	1.61
(B): Shoots density	B1 (40 shoots)		17.50	18.00	0.56	0.55	36.81	37.88
	B2 (50 shoots)		17.75	17.66	0.55	0.55	36.93	38.07
new L.S.D. (B)=			N.S	N.S	N.S	N.S	N.S	N.S
(C): Clusters density	C1 (25 clusters)		18.08	18.16	0.54	0.54	39.89	41.12
	C2 (35 clusters)		17.16	17.50	0.56	0.56	33.86	34.83
new L.S.D. (C)=			0.19	0.66	0.01	0.02	0.89	1.31
(AXB): Interaction	Plastic covering	40 shoots	17.50	18.00	0.55	0.55	41.33	42.49
		50 shoots	17.66	17.50	0.54	0.55	41.00	42.30
	Open field	40 shoots	17.50	18.00	0.56	0.55	32.29	33.27
		50 shoots	17.83	17.83	0.56	0.55	32.54	33.83
new L.S.D. (AXB)=			N.S	N.S	N.S	N.S	N.S	N.S
(AXC): Interaction	Plastic covering	25 clusters	18.00	18.20	0.53	0.54	44.96	46.09
		35 clusters	17.16	17.36	0.56	0.56	37.69	38.70
	Open field	25 clusters	18.10	18.15	0.55	0.55	34.81	36.14
		35 clusters	17.20	17.70	0.57	0.56	30.02	30.96
new L.S.D. (AXC)=			N.S	N.S	N.S	N.S	1.26	N.S
(BXC): Interaction	40 shoots	25 clusters	18.00	18.35	0.54	0.54	39.90	41.34
		35 clusters	17.00	17.65	0.57	0.56	33.72	34.42
	50 shoots	25 clusters	18.15	18.00	0.54	0.54	39.88	40.90
		35 clusters	17.30	17.35	0.56	0.55	33.99	35.23
new L.S.D. (BXC)=			N.S	N.S	N.S	N.S	N.S	N.S
(AXBXC): Interaction	Plastic covering 40 shoots	25 clusters	18.00	18.30	0.54	0.53	45.51	47.03
		35 clusters	17.00	17.60	0.57	0.57	37.15	37.96
	Plastic covering 50 shoots	25 clusters	18.00	18.00	0.53	0.54	44.41	45.15
		35 clusters	17.37	17.00	0.55	0.55	38.24	39.44
	Open field 40 shoots	25 clusters	18.10	18.36	0.55	0.55	34.29	35.65
		35 clusters	17.00	17.70	0.57	0.56	30.29	30.89
	Open field 50 shoots	25 clusters	18.30	18.00	0.55	0.55	35.34	36.64
		35 clusters	17.35	17.60	0.57	0.56	29.75	31.03
new L.S.D. (AXBXC)=			N.S	N.S	N.S	N.S	4.37	N.S

Economic feasibility of the overhead plastic covering compared with the open-field vines

As shown in **Table (6)**, it is obvious that although the overhead plastic covering had the highest cost compared to the open-field in both seasons, economically, the net profit from using the overhead plastic covering was notably greater.

Table (6). Cost and net profit/Feddan between overhead plastic covering and open field conditions on grafted Flame Seedless grapevines in 2024 and 2025 seasons

Per Feddan	Overhead plastic covering	Open field	Overhead plastic covering	Open field
	2024 season		2025 season	
Cost of covering (L.E.)	50000	---	51000	---
Cost of cultural practices (L.E.)	40000	40000	45000	45000
Total cost (L.E.)	90000	40000	96000	45000
Increase of the total cost over open field (L.E.)	50000	---	51000	---
Yield (Kg)	11858	11893	11123	11095
Kg (L.E.)	50	20	55	22
Yield (L.E.)	592900	237860	611765	244090
Price of increase in yield over open field (L.E.)	355040	---	367675	---
The net profit (L.E.)	502900	197860	515765	199090
The net profit over open field (L.E.)	305040	---	316675	---

DISSCUSION

The position of the removed shoot leaves along with shoot shortening, distinctly influences fruit set, the number of berries per cluster, berry fresh weight and composition at harvest. However, the influence on cluster compactness was restricted mainly because photosynthetic and morphological factors vigorously associated with the cultivar (Mataffo et al., 2023). Ferree et al. (2003) observed that none indicated clear effect of thinning timing on yield. However, all timings thinning increased TSS and decreased acidity. Anthocyanin and phenolics in berries increased regardless of cluster thinning timing (Gatti et al., 2012). Koblet (1996) found that, if the lateral shoots were consistently removed during the season, the main-shoot leaves responded by increasing their photosynthetic rates during the remaining of the season and by a delay in aging. Moreover, one or zero grape clusters after either early or late cluster thinning, no considerable impact of crop load could be observed on leaf gas exchange. However, there was an obvious direction towards greater photosynthetic rates in the check vines during the whole season.

Silverstone et al. (2019) observed that shoot thinning alone decreased canopy vigour while it failed to reduce yield or increase fruit quality. However, shoot thinning plus pre-flowering defoliation reduced yield and enhanced berry components in a Mediterranean climate. The tested treatments (early defoliation, cluster thinning 30%, cluster thinning 50%, cluster cutting 30% and cluster cutting 50%) increased both TSS improved the nutritional quality of both the grape and the grape (Scaglione et al., 2012).

Canopy management led to a much more balanced penetration of sunlight into the cluster zone-here, shoot positioning played a big role. Airflow through the canopy was greatest when partial defoliation, in combination with suckering and shoot positioning was applied these practices had the greatest effect on microclimate and appearance. These practices reduced Botrytis and increased yield and total grape quality. Covering improved the growing degree-days accumulation and progressed bud break by 12-20 days. The ripening (14 Brix) was accelerated by 8-22 days. This is attributed to different radiometric characteristics under different colored covering plastic films (Tarricone et al., 2017).

The vines under open field were higher acidity than the covered vines. Yield per vine improved under plastic cover but not at considerable level. Cluster, berry and pruning wood mass increased by plastic cover as compared with open field (Novello et al.,2000). Besides, berry weight and sugars were increased by yellow plastic film and Trifolim (cover crop) soil management due to different radiometric properties, preserving clusters from adverse weather conditions(rain-hail-wind) and reduce damage of the berries from diseases particularly in organic farms

(Tarricone et al., 2017). Shoot length under plastic covering were always longer than those of controls while yield and fruit quality were not significantly affected by plastic covers (Coban, 2004).

Plastic covering accelerates all phonological stages. Besides, it leads to abiotic stress increased soluble sugar, total phenols and proline content in vine leaves. However, there were no considerable differences between the covered vines and open field vines regarding cluster weight, small berries, TSS% and titratable acidity%. Besides, Average cluster, berry weight and their size were reduced under plastic cover. Meanwhile, uniformity in berry size and colour and total shoot length were not remarkably affected by cover and open-field systems and the preserved cultivation was more economic than open field system (Ergenoglu et al., 1999).

The covering of the vineyard leads to decrease air temperature and increase air humidity at grape cluster zone. The reducing of the air temperature is as result of the modify of the net radiation (Rana et al., 2004). There were no significant differences between cover and open field systems concerning productivity, the number branches and its fertility (Holcman et al., 2019).

Balanced cluster thinning improved photosynthetic rate, stomata communication and carbon assimilation to clusters as compared with the check treatment and high clusters thinning application. This considerable reduce in assimilation rate and carbon distribution to fruit under high clusters thinning can be explored by the result that low sink activity (yield decreasing by high clusters thinning) of the fruit probable improved feedback inhibition particularly in the afternoon (Yue et al., 2022 and Edson et al.,1995).

Many investigations observed an improve in anthocyanin and not convert of TSS under cluster thinning. This suggested that the effects of cluster thinning on overall composition of grape are not inevitably related to the effects on TSS (Wang et al., 2018 and Nuzzo et al., 2006). Besides, high blue light under plastic covering increased the anthocyanin content by enhancing enzyme activities (Cheng et al., 2015)

CONCLUSION

From the foregoing results, the study revealed that overhead plastic covering combined with balanced canopy management markedly improved the performance of Flame Seedless grapevines grafted onto 'Freedom' rootstock. Plastic covering advanced all phenological stages and enhanced vegetative growth, berry size, and anthocyanin accumulation compared with open-field vines. Among the treatments, vines under plastic cover with 50 shoots and 25 clusters achieved the best balance between yield and fruit quality, showing higher total soluble solids and lower acidity. Economically, this treatment also provided the greatest net profit. Therefore, it is recommended as the most effective practice for early, high quality, and profitable Flame Seedless production in El-Nobaria conditions.

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الملخص العربى

تأثير إدارة المسطح الخضرى على المحصول وصفات الجودة لكرمات عنب "الفليم سيدلس" المطعومة تحت ظروف التغطية بالبلاستيك والحقل المفتوح

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أجريت هذه الدراسة خلال موسمي 2024 و2025 على كرمات عنب الفليم سيدلس بعمر ثماني سنوات مطعومة على أصل فريديم. الكرمات مزروعة إما تحت غطاء بلاستيك شفاف أو في الحقل المفتوح. تم خف الأفرع إلي (40 و 50 فرع) وعدد العناقيد إلي (25 و 35 عنقود).

أظهرت النتائج أن التبكير في النضج للكرمات تحت ظروف التغطية سجلت بما يقرب 20 يوم مقارنة بالكرمات النامية تحت ظروف الحقل المفتوح كما اتضح أن كلا من طول الفرع والمساحة الورقية زادت معنويا بالكرمات المغطاة فى كلا الموسمين. كما سجلت الكرمات المغطاة أعلى معنويا فى حجم 100 حبة عن كرمات الحقل المفتوح.

الكرمات المغطاة عند 40 فرع و35 عنقود كانت الأعلى معنويا فى كمية المحصول فى كلا الموسمين. علاوة على ذلك الكرمات تحت التغطية بالبلاستيك مع 50 فرع و25 عنقود سجلت الأعلى وزن عنقود معنويا. النباتات تحت التغطية عند 25 عنقود والأعلى وزن 100 حبة معنويا فى الموسم الأول فقط. سجلت الكرمات المغطاة مع 50 فرع و25 عنقود الأعلى قيم حجم 100 حبة وطول الحبة. هناك اختلافات معنوية بين الكرمات عند 25 عنقود والكرمات عند 35 عنقود فيما يتعلق بالمواد الصلبة الذائبة فى كلا الموسمين. بالنسبة للحموضة الاتجاه انعكس فى كلا الموسمين فيما يتعلق بتأثير عدد العناقيد، بينما لا يوجد هناك اختلافات معنوية بين العوامل الاخرى فيما يخص المواد الصلبة الذائبة والحموضة فى كلا الموسمين. كما ازداد الانثوسيانين الكلى زيادة معنويا بالكرمات النامية تحت ظروف التغطية. وتشير الدراسة الإقتصادية إلى أن كرمات عنب الفيلم سيدلس النامية تحت ظروف التغطية قد أعطت أعلى عائد إقتصادى مقارنة بالكرمات النامية تحت ظروف الحقل المفتوح، لذا يمكن التوصية بأن الكرمات المغطاة عند 50 فرع و25 عنقود كانت المعاملة الأفضل للعنب الفليم سيدلس المطعوم على اصل الفريديم لتحقيق أفضل إنتاجية وأعلي جودة للعناقيد.