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Effect of Plastic Covering and Rootstocks on Yield, Physical and Chemical Characteristics of Superior Grapevines (*Vitis vinifera* L.)

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ABSTRACT

The performance of Superior grapevines grafted onto three rootstocks namely SO4, Freedom and 1103 Paulsen cultivated under covered and uncovered conditions were evaluated during 2015 and 2016 seasons. Data obtained showed that grapevines under plastic cover recorded the highest leaf area, chlorophyll content in leaves and macroelement content in leaf petioles, in addition, it has a significant effect on yield and berry quality. Concerning the effect of rootstocks, the differences in productivity and grape quality between the tested rootstocks were significant and it was obvious that Freedom in comparison with 1103 Paulsen and SO4 significantly increased vines vegetative growth especially under protected cultivation.

INTRODUCTION

In Egypt, grapes are very important fruit crops. The planted area was about 192934 feddan producing 1596169 tons (Ministry of Agriculture statistics, 2015).The 'Superior seedless' cultivar is recognized as an important commercial grape cultivar and it's an early cultivar in the Egyptian market, therefore it has a great importance either for the local or international markets, which exported to European countries such as Germany, Holland and England.

Grafting is an effective technique used in viticulture for overcoming biotic and abiotic stresses (Walker *et al.*, 2014 and Jin *et al.,* 2016). Numerous reports have also proved that rootstocks greatly affect vine growth, yield, berry quality and phenological stages (Koundouras *et al.,* 2008 and Silva *et al.,* 2017). However, it should be noted that, rootstock is not appropriate for all cultivars as the proper one for one cultivar may not be the typical for another based on the specific association between stock and scion that influence the vine performance more than the stock or scion alone (Hartmann *et al.,* 2014). Further to this, this scion-rootstock association is extremely specific according to the compatibility of the combination and the adaptation with soil and climatic conditions (Vrsic *et al.,* 2015).Therefore, it's important to choose the most suitable rootstock to optimize the quality of berries.

There is another technique to improve berry clusters quality, vines could be covered with plastic film to protect plant leaves as well as clusters from unsuitable sun radiation, rain, wind, hail and frost, besides from diseases, pests or birds (Novello & de Palma 2008 and Du *et al.,*2015). Protected cultivation, using transparent plastic covering is now becoming a common practice in table grapes. It has been conducted to increase water use efficiency in grapevines by creating higher humidity and lowering transpiration as compared to open field conditions (Stanghellini, 2014 and Permanhani *et al.,* 2016). In addition, covering materials are practically used in grape production in order to have an early harvesting (Roberto *et al.,* 2011), increasing air temperature, will stimulates early bud break (Novello & de Palma 2008 and Suvocˇarev *et al.,* 2013).Contrarily, harvest could be delayed using protected cultivation, by decreasing light at the first stage of fruit ripening (Roberto *et al.,* 2011).

The aim of this study was to evaluate the effects of plastic covering and rootstocks on productivity and fruit quality of Superior grapevines.

MATERIALS AND METHODS

This investigation was carried out during 2015 and 2016 seasons. The experiment was conducted on 7 years old Superior cultivar grafted onto three grape rootstocks namely SO4 (*Vitis berlandieri* × *Vitis riparia* hybrids), Freedom (Couderc1613 × *Vitis champinii*) and 1103 Paulsen (*Vitis berlandieri* × *Vitis rupestris*) planted on sandy soil under drip irrigation system at 2 × 3 meters apart (2 m within and 3 m between rows) in a private farm (El – Egeizy vineyard) at El-Sadat, Minufiya governorate, Egypt. The vines were trained according to the "Parron" trellis system. Using cane pruning technique and leaving about 130 eyes / vine (on the basis of 10 canes / vine × 12 eyes/ cane + 5 renewal spurs / vine × 2 eyes/ spur).

Fifty-four vines were chosen for this study, nearly uniform in vigor as possible, all the vines get the cultural management such as irrigation, fertilization, pest and diseases control that commonly performed in that district. Before 24 hours from spraying dormex, twenty-seven vines were covered with one layer of untreated plastic film (100-120 micron thick polyethylene) and a week after spraying dormex the sides of the plastic cover were shut down and the plastic cover removed before two weeks from harvest. While, the other twenty-seven vines remained uncovered. The experimental design was factorial experiment in randomized complete block design in a two factor arrangement since the first factor was covered or uncovered vines and the second factor was rootstock type, with three replicates each replicate consists of 3 vines.

Measurements at full bloom

1- Average leaf area (cm^2 / leaf)

Sample of four mature leaves from each treated vine (7^{th} leaf from the top of the growing shoot) were collected and used for measuring leaf area according to the equation of Montero *et al*., (2000):

$$\text{Leaf area } (cm^2 / leaf) = 0.587\ (L \times W)$$

Where, L= Length of leaf blade. W= Width of leaf blade.

2- Leaf chlorophyll pigments (mg / g fresh weight)

Chlorophyll pigments were extracted from the 7^{th} leaf of the shoot tip with methanol and traces of sodium carbonate, then estimated spectrophotometrically (T60 UV-visiblespectrophotometer, PG Instruments Limited, UK) as mentioned by Lichtenthaler and Wellburn (1985).

$$\text{Chlorophyll a} = 15.65\ A666 - 7.340\ A653$$

$$\text{Chlorophyll b} = 27.05\ A653 - 11.21\ A666$$

3- Chemical analysis of leaf petioles

Represented Samples of twelve petioles of leaves / replicate were collected from leaves opposite to basal clusters (Nijjar, 1985). Petioles were dried in oven at 70 °C until a constant weight and grinded to determine macroelements, 0.2 g of crude dried powder from each sample was wet digested using a mixture of concentrated sulphoric acid and perchloric acid, then heated until become clear solution (Peterburgski, 1968). After digestion the solution was totally transferred into 50 ml flask using distilled water to do determinations.

The modified Micro-kjeldahl apparatus was used to determine total nitrogen according to the method procedures in AOAC (1984).

Total phosphorus was also determined using Milton Roy spectronic 120 at wave length of 725 nm using Stannous Chloride Reduced Molybdophosphoric Blue Colors method in sulphoric system as mentioned by Jackson (1973).

Total Potassium was determined using Flamephotometer model Corning 400 according to the method described by Peterburgski (1968).

Measurements at harvest time

1- Yield (Kg/vine)

After harvest (covered vines at 28 and 27 May, uncovered vines at 12 and 10 June in 2015 and 2016, respectively) the yield in weight (kg) was determined by multiplying number of clusters / vine by the cluster average weight.

2- Cluster characteristics:

Sample of 9 clusters per treatment, each replicate consists of 3 clusters were harvested and transported to estimate physical and chemical characteristics of berries and clusters.

1- Average cluster weight (g):

It was determined by an electrical sensitive balance.

2- Berry diameter (mm): The average diameter of berries was measured by using a digital vernier caliper.

3- Total soluble solids (TSS%)

This was estimated as a percent in juice of fresh berries, a Carlsize hand refractometer was used in that respect.

4- Total acidity content (%)

It was estimated using titration of 5 ml clear juice against (0.1 N) NaOH after the addition of a little drops of phenolepthalene indicator. Acidity was expressed as gram of tartaric acid in 100 ml juice. The formula used was from AOAC (1984).

5- Total soluble solids / acid ratio

It was calculated by dividing the percentage of TSS on total acidity.

Statistical analysis:

Data obtained were statistically analyzed due to Analysis of Variance (ANOVA) in a complete randomized blocks design (Gomez and Gomez, 1984), using GenStat 11th Edition Package. The least significant differences (LSD) was used for comparing between the means according to Waller and Duncan (1969), at level of 5%.

RESULTS AND DISCUSSION

The results of the experiment are presented and discussed as following:

Effect of covering, rootstocks and their interaction on leaf area and leaf total chlorophyll content:

Data in Table 1 show that covered vines gave a significant increase on leaf area and leaf total chlorophyll content in both seasons of study when compared with uncovered vines. Among rootstocks, the concerned results pointed to Freedom rootstock as the super ones in that respect, the tested scion on it determined the highest values of leaf area and leaf total chlorophyll content in both seasons of study followed by 1103 Paulsen rootstock. These results are agreed with the results of de Souza *et al.* (2015), who found larger leaf area and also chlorophyll content of leaf for cv. 'Syrah' vines grafted onto 1103 paulsen rootstock grown under protected cultivation.

Table 1. Effect of covering, rootstocks and their interaction on leaf area (cm^2 / leaf) and leaf total chlorophyll content (mg / g fresh weight) of Superior grapevines during 2015 and 2016 seasons.

	Leaf area (cm^2 / leaf)		Total chlorophyll (mg / g fresh weight)	
	2015	2016	2015	2016
Coverage (A)				
Covered	132.86	131.66	6.65	6.53
Uncovered	99.40	102.42	1.65	1.55
F test (A)	*	*	*	*
Rootstock (B)				
SO4	109.63	110.41	3.96	3.86
Freedom	124.20	123.34	4.38	4.23
1103 Paulsen	114.56	117.37	4.11	4.02
LSD (B) at 5%	2.41	3.37	0.11	0.03
Interaction (A×B)				
Covered				
SO4	126.63	125.58	6.47	6.34
Freedom	139.23	136.10	6.85	6.67
1103 Paulsen	132.73	133.30	6.61	6.57
Uncovered				
SO4	92.64	95.24	1.44	1.37
Freedom	109.16	110.58	1.91	1.78
1103 Paulsen	96.39	101.43	1.60	1.48
LSD (A×B) at 5%	3.41	4.77	0.16	0.05

Data in the same Table show that leaf area was significantly increased in the first season only in case of covered Superior/ Freedom combination, the values were (139.23 and 136.10 cm^2 / leaf) in 2015 and 2016 seasons, respectively, whereas data for leaf total chlorophyll content were significantly increased in both seasons of study (6.85 and 6.67 mg / g fresh weight)) in 2015 and 2016 seasons, respectively. On the other hand, the lowest values were in leaves of uncovered Superior/ SO4 combination with values of (92.64 and 95.24 cm^2 / leaf), (1.44 and 1.37 mg / g fresh weight) in both seasons of study, respectively.

These results were approved by changes in leaf anatomy and increased chlorophyll content of grapevines under plastic cover as showed by Chavarria *et al.*, (2012), who found that the photosynthetic possibility of vines is not affected by solar radiation limitation caused by plastic cover due to anatomical modification in leaves. Grapevines under plastic cover tend to have leaves with larger area, since the suitable conditions (light and water) led to increasing leaf area (Chavarria *et al.,* 2008). The chlorophyll concentration in leaves is considered as an indicator of the photosynthetic activity of plants (Taiz and Zeiger, 2004). Higher differences found between covered and uncovered vines may be due to an easier stomatal opening under plastic covering since transpiration process is restricted under low solar radiation and wind speed

(Cardoso *et al.,* 2008; Chavarria *et al.,* 2009). In addition, rootstocks influence scion in terms of leaf gas exchange, water uptake/transport, and vigour (Galbignani *et al.,* 2016) and this can be due to xylem hydraulic function. Good growth would be correlated by larger hydraulic conductance of the all root system (Gambetta *et al.,* 2012). These results are also confirmed with those obtained by Bica *et al.,* (2000) who confirmed the higher significant effect of rootstock on chlorophyll content, stomatal conductance and leaf area based on the data of the lower values of stomatal conductance, chlorophyll content and photosynthesis in 'Chardonnay' vines grafted onto SO4 than those grafted onto 1103 Paulsen. As for leaf area, Aly *et al.*, (2015) found that grafted Superior seedless grapevines on Freedom, 1103 Paulsen and salt Greek rootstocks are Superior in this respect and enhanced of Leaf area during the two studied seasons.

Effect of covering, rootstocks and their interaction on N, P and K (%) content in leaf petioles:

The concerned results in Table 2 show that covering Superior grapevines gave a highest significant increase in N, P and K content in leaf petioles during the two seasons of study. As for rootstocks, data in the same Table pointed to Freedom as the most effective rootstock causing the highest N, P and K content in leaves of the tested scion. Considering the interaction, results in the same Table revealed that under covering conditions the highest significant N, P and K values were measured in the leaves of vines that were grafted on the Freedom rootstock (2.03 & 2.09 N%, 0.311 & 0.301 P%, 2.29 & 2.33 K%) in 2015 and 2016 seasons, respectively. The next degree in that respect was to 1103 Paulsen rootstock. Otherwise, the lower degree appeared with uncovered Superior on SO4 rootstock, since the scion leaf petioles onto it tabulated the lowest values of N, P and K in both seasons of study.

Table 2. Effect of covering, rootstocks and their interaction on N, P and K (%) content in leaf petioles of Superior grapevines during 2015 and 2016 seasons.

	N (%)		P (%)		K (%)	
	2015	2016	2015	2016	2015	2016
Coverage (A)						
Covered	1.83	1.88	0.293	0.282	2.09	2.14
Uncovered	1.17	1.27	0.234	0.220	1.48	1.57
F test (A)	*	*	*	*	*	*
Rootstock (B)						
SO4	1.29	1.39	0.243	0.233	1.57	1.65
Freedom	1.71	1.78	0.283	0.272	1.99	2.06
1103 Paulsen	1.50	1.57	0.265	0.248	1.78	1.86
LSD (B) at 5%	0.04	0.04	0.005	0.007	0.05	0.05
Interaction (A×B)						
Covered						
SO4	1.63	1.69	0.275	0.263	1.89	1.94
Freedom	2.03	2.09	0.311	0.301	2.29	2.33
1103 Paulsen	1.83	1.87	0.293	0.283	2.08	2.15
Uncovered						
SO4	0.95	1.09	0.212	0.202	1.26	1.36
Freedom	1.38	1.47	0.254	0.242	1.69	1.79
1103 Paulsen	1.17	1.26	0.236	0.214	1.48	1.56
LSD (A×B) at 5%	0.06	0.06	0.007	0.010	0.07	0.07

These findings are in harmony with those reported by Ibacache and Sierra (2009), who indicated that N, P and K content in Superior leaves were greatly affected by rootstock and it was markedly higher with Freedom rootstock when compared with 1103 Paulsen and SO4 rootstocks. Concerning total nitrogen, Aly *et al.*, (2015) found that grafted Superior grapevines on Freedom and 1103 Paulsen rootstocks gave the highest values of total nitrogen content in leaves. Under plastic house conditions, Abd Elwahed *et al.*, (2015) pointed that K (%) and P (%) in leaf petioles of Thompson seedless grapevines reached its maximum value under plastic house condition compared with other treatments.

Little is known about the particular mechanisms used by grape rootstocks to absorb nutrients. In this regard, Anderson *et al.*, (2001) showed that rootstocks had significant effect on concentrations of N and NO_3 according to investigations carried out on 14 rootstocks combined with 3 scions. Additionally, Grant and Matthews (1996) revealed that rootstocks differ in their ability of soil-P utilization including P transport from roots to the cane and performance of P utilization by scion. Regarding K uptake and utilization, several reports suggested that K uptake and utilization depends on the genetic origin of the rootstock (Avenant *et al.*, 1997; Wolpert *et al.*, 2005).

Smart *et al.,* (2005) pointed out that absorption was related to the increased density of root hairs as a response to the deficiency of a nutrient; or as Siminis and Stavrakakis (2008), who reported that absorption is related to the increased capacity of the roots to assimilate specific nutrients. In all cases, more study is required to understand the influence of the root system in mineral absorption (Nikolaou *et al.,* 2000).

Effect of covering, rootstocks and their interaction on yield, cluster weight and berry diameter:

Data in Table 3 indicate that covered vines gave a significant increase of yield/vine, cluster weight and berry diameter in both seasons of study. These results are in harmony with those of (Abd Elwahed *et al.,* 2015 and de Souza *et al.*, 2015), who reported that under protected cultivation grapevines showed the highest yield and cluster weight. From the same Table it was cleared that the rootstock Freedom had a significant effect on yield/vine, cluster weight and berry diameter of Superior vines compared with SO4 since the later one provided lower yield/vine, cluster weight and berry diameter, such results are in agreement with those of Bica *et al.,* (2000), who reported that the effect of rootstock was significantly higher on quantum yield of 'Chardonnay' vines and those grafted onto SO4 showed lower quantum yield than those grafted onto 1103 Paulsen. In the same line, Cus (2004) found that with the cv. Cabernet Sauvignon the yield was higher on 1103 Paulsen followed by SO4 in the second season. Regardless of the type of scions, 1103 Paulsen, 'Freedom' and 'salt Greek' rootstocks increased yield (Aly *et al.,* 2015). In addition, Satisha *et al.,* (2010) reported that most of the fruit quality components showed very little response to the rootstock treatment with the exception of berry diameter, since higher berry diameter and berry weight were recorded on Dog Ridge rootstocks.

Data in the same Table revealed that in both seasons, there was a significant effect of plastic cover and rootstock interaction treatment on yield/vine, cluster weight and berry diameter. Covered Superior/Freedom combination significantly gave the highest values in that respect in both seasons of study. The effect of rootstocks on the yield was also the subject of several studies carried out by Bica *et al.* (2000) and Ollat *et al.* (2003). The results of these studies suggest that rootstocks differ in the root distribution patterns and the total root numbers, both of which influence the yield (Morano and Kliewer, 1994).

Table 3. Effect of covering, rootstocks and their interaction on yield (Kg/vine), cluster weight (g) and berry diameter (mm) of Superior grapevines during 2015 and 2016 seasons.

	Yield (Kg/vine)		Cluster weight (g)		Berry diameter(mm)	
	2015	2016	2015	2016	2015	2016
Coverage (A)						
Covered	17.46	17.79	538.90	555.41	19.59	19.73
Uncovered	16.12	16.21	495.20	498.22	17.44	17.43
F test (A)	*	*	*	*	*	*
Rootstock (B)						
SO4	14.72	14.69	437.70	438.34	17.51	17.54
Freedom	18.56	19.08	593.90	616.94	19.47	19.48
1103 Paulsen	17.09	17.22	519.60	525.17	18.56	18.72
LSD (B) at 5%	0.31	0.39	9.83	3.80	0.283	0.379
Interaction (A×B)						
Covered						
SO4	15.22	15.25	449.00	453.00	18.41	18.40
Freedom	19.01	19.76	620.00	658.78	20.84	20.99
1103 Paulsen	18.07	18.36	547.80	554.44	19.52	19.79
Uncovered						
SO4	14.21	14.12	426.30	423.67	16.61	16.68
Freedom	18.04	18.40	567.90	575.11	18.10	17.96
1103 Paulsen	16.11	16.09	491.30	495.89	17.61	17.64
LSD (A×B) at 5%	0.44	0.55	13.90	5.36	0.400	0.536

Effect of covering, rootstocks and their interaction on TSS, acidity and TSS/acid ratio in berry juice:

Data in Table 4 show that covering vines significantly increased the percentage of total soluble solids and TSS/acid ratio and decreased total acidity in berry juice in both seasons of study. Among all rootstock varieties, Freedom rootstock gave the highest TSS% and TSS/acid ratio in berry juice, and the lowest acidity % in the first and second seasons, but no significant differences were found between Freedom and 1103 Paulsen rootstock in case of total acidity in berry juice. In addition, the highest values of acidity and the lowest values of TSS/acid ratio were recorded with SO4 rootstock, similar results were found in the berries of 'Summer Black' vines grafted on SO4 rootstock (Jin *et al.,* 2016).

From the same Table, it was observed that covering Superior vines grafted onto Freedom rootstock significantly increased the percentage of total soluble solids and TSS/acid ratio in berry juice with values (18.11 & 18.44 % and 22.80 & 23.59) in 2015 and 2016 seasons, respectively. Also, covered vines on Freedom and 1103 Paulsen decreased total acidity in berry juice in both seasons of study. The obtained results are in agreement with those reported by de Souza *et al.* (2015), they found that the lowest grape quality was observed from uncovered vines. This treatment showed the lowest total soluble solids and the highest acidity as compared to covered vines. In the same line, Abd Elwahed *et al.* (2015) reported that plastic house treatment increased TSS% and decreased acidity in berry juice of Thompson seedless grapevines.

Table 4. Effect of covering, rootstocks and their interaction on TSS (%), acidity (%) and TSS/acid ratio in berry juice of Superior grapevines during 2015 and 2016 seasons.

	TSS (%)		Acidity (%)		TSS/acid ratio	
	2015	2016	2015	2016	2015	2016
Coverage (A)						
Covered	17.15	17.30	0.829	0.831	20.80	21.01
Uncovered	16.12	15.91	0.878	0.879	18.50	18.22
F test (A)	*	*	*	*	*	*
Rootstock (B)						
SO4	16.24	16.14	0.940	0.943	17.31	17.21
Freedom	17.61	17.72	0.816	0.814	21.62	21.85
1103 Paulsen	16.06	15.94	0.805	0.808	20.02	19.79
LSD (B) at 5%	0.30	0.36	0.027	0.043	0.77	1.09
Interaction (A×B)						
Covered						
SO4	16.78	16.67	0.903	0.913	18.57	18.36
Freedom	18.11	18.44	0.795	0.783	22.80	23.59
1103 Paulsen	16.56	16.78	0.790	0.798	21.04	21.09
Uncovered						
SO4	15.70	15.61	0.978	0.973	16.06	16.05
Freedom	17.11	17.00	0.838	0.845	20.44	20.11
1103 Paulsen	15.56	15.11	0.820	0.818	19.00	18.50
LSD (A×B) at 5%	0.43	0.51	0.038	0.061	1.09	1.55

CONCLUSION

From the mentioned results, it could be concluded that, Superior grape cultivar gave the highest and earliest yield as well as better berry physical and chemical properties when grafted onto Freedom rootstock under covering with plastic film at El-Sadat district.

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تأثير التغطية بالبلاستيك والأصول على المحصول والخصائص الفيزيائية والكيميائية لكرمات العنب صنف السبريور

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أجريت هذه الدراسة خلال موسمي ٢٠١٥ و ٢٠١٦بمزرعة خاصة(العجيزى) بمدينة السادات – محافظة المنوفية على كرمات عنب صنف السبربور عمرها ٧ أعوام منزرعة فى تربة رملية على مسافة ٢ × ٣ م وتروى بنظام الرى بالتنقيط ومطعومة على ثلاث أصول وهىSO4 وفريدم وبولسن ، وقد استهدف هذا البحث دراسة تأثير التغطية بالبلاستيك وكذلك الأصول على المحصول وجودة الثمار ، وقد أظهرت نتائج الدراسة أن العنب السبريور تحت ظروف التغطية بالبلاستيك سجل أكبر مساحة ورقية وأعلى محتوى من الكلوروفيل فى الأوراق وكذلك أعلى محتوى من العناصر الكبرى فى أعناق الأوراق بالاضافة الى التأثير المعنوى على المحصول وجودة الثمار، وبالنسبة لتأثير الأصول فقد أظهرت النتائج أن السبريور المطعوم على أصل الفريدم أدى الى زيادة النمو الخضرى والمحصول وجودة الثمار مقارنة بباقى الأصول تحت ظروف التغطية بالبلاستيك