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Increasing the opportunities of early grape production for exportation using some protection treatments in Egypt

Hamed Mohamed El-Saeed, Hussein Fawzy Abouziena, Mohamed Salama Abd Elwahed* and Zakaria Amin Ali

Department of Botany, National Research Centre, Dokki, Giza, Egypt, 12622

Abstract: For improving the early production and quality of Thompson grapes yield for export by modifying the climate, Thompson seedless grape were grown and covered under plastic greenhouses. The protection technique decreased plant leaf temperature and air temperature which became very suitable for growth. Plastic houses increased diffusion which resulted in decreasing transpiration. Photosynthetic Active Radiation over the plant was 960 and 1750 quantum as a result of plastic house and outdoors, respectively. The growth rate was increased under protection condition. In the 2nd season, under plastic house the relative humidity was increased by 49.8%, while light intensity was decreased by 30.2%, compared to outdoor. All protection treatments had no effect on bud break dormancy, during the 1st season, while in the 2nd season, enhanced the bud break (earlier 23 days) compared with outdoors. The protection treatments earliness the full bloom by about 39 days and caused both early fruit set and early harvest date (50%) by about 15 days, compared to outdoor. The whole period of development was shifted to 15 days or 5-7 and 10 days earlier as a result of plastic house or tunnels respectively than in uncovered vines, during the 1st and 2nd seasons, respectively. Protection treatments increased bunch, size, length, width and T.S.S of berry especially plastic house which increased the yield/vine by 20 % and 7.1 % and T.S.S (%) by 42.9 and 35.7% over the control, in the 1st and 2nd seasons, respectively. But these treatments decreased the acidity value.
Keywords: plastic house, tunnels, greenhouse, grape, early product, protection treatments, GA, IAA, TSS, elements.

Introduction

Grapes are the most widely cultivated horticulture crop all over the world. Grape is widely cultivated in Egypt and it came in the second order after citrus[1]. Most of the production is consumed locally. So, the use of protect cultivation techniques will evidently be more efficient in Egypt due to milder winter climate which will increase the possibility of export. There is considerable interest to growing grapes under protected cultivation for early maturation and out of season fruit. In several countries, i.e. Spain, Italy and Australia, the use of protected cultivation with efficient agro-management system resulted in earliness production.

Early maturity is the important factor in grape exportation in Egypt whereas most markets in the world lack grape fruit in the same period. Growing grapevines under plastic cover is not well understood, and could be a profitable management strategy for early maturation to increase the exportation chances for the Europe markets. Protected cultivation, which enables some control of wind velocity, moisture, temperature, mineral nutrients, light intensity, and atmospheric composition, has contributed to improving crop productivity in open fields. Protected cultivation is a unique and specialized form of agriculture[2]. They added that devices or technologies for protection (windbreaks, irrigation, soil mulches) or structures (greenhouses, tunnels, row covers) may be used with or without heat. The intent is to grow crops where otherwise they could not survive by modifying the natural environment to prolong the harvest period, often with earlier maturity, to increase yields, improve quality, enhance the stability of production, and make commodities available when there is no outdoor production. In fact, the most determinate factor in horticultural crop production is the climate[2]. The overall objective of protected cultivation is to modify the natural environment by practices or structures to achieve optimal productivity of crops by enhancing yields, improving quality, extending the effective harvest period and expanding production areas[2].

The use of a plastic cover to cultivate grapes created a micro-environment that was characterized by a decrease in the levels of solar radiation, an increase of the maximum temperatures and the persistence of higher saturation deficit levels[3,4].

Therefore the objectives of this study were an early production of Thompson grapes for export and improving the quality of early grapes by modifying the climate condition.

Materials and Methods

Experimental

Plan during the 1st season

Thompson seedless grape growing at Elnubaria Region, Beheira Governorate, Egypt, were covered under plastic greenhouses. The frame work of the greenhouses consisted of galvanized-iron-pipe arches. The cover was 200 micron thick polyethylene sheeting. Each greenhouse was double span 30 m long, 16 m wide and 5 m height with side ventilation. Moreover, plastic mulch, as well also tunnels technique (200 micron) and/or water tubes which absorb the sunrays and warm the grape roots during night were used.

During the flowering period, the doors and sides of the greenhouses were kept open,for about two weeks until most berries had set, to keep maximum temperatures below 30°C and thus prevent flower shatter. After berry set and until grapes were ripe, greenhouses were ventilated-

to prevent temperature from rising above 40°C. The polyethylene was turn off greenhouses

to prevent temperature from rising above 40°C. The polyethylene was turn off greenhouses in July-August.

Cultural practices i.e. pruning, application of fertilizers, irrigation and Dormex application were carried out for covered and non- covered vines. Moreover ,grapes received four gibberellin sprays as described in Table (1).

Data recorded:

1. Maximum-minimum temperatures and relative humidity were recorded daily for covered and non - covered vines (Table 2).
2. Some physiological and chemical determinations were recorded:-

Some physiological parameters in plants (plant leaf temperature, diffusion, transpiration, photosynthetic active radiation over and under the plant as well as chlorophyll measurements). Chlorophyll index of leaf was measured by SPAD-502 (Minolta, Japan).

Photosynthetic Capacity

Date of bud-burst and beginning of flowering

2.1. % bud-burst.
2.2. Nutrient Status: Macro (N, P, K, Ca and Mg) and micro (Zn, Mn and Fe) elements content for leaf petiole were determined[5]. Nitrogen (%) was determined by the modified micro-Kjeldahl method[6]. Phosphorus (%) was determined using the Olsen method, and potassium (%) with flame photometer method[7]. Potassium, magnesium and calcium were determined using flame photometer. Micronutrients (Fe, Mn, Zn) were measured by atomic absorption technique[8].
2.3. T.S.S were recorded to determine the suitable harvest time.

2.4. Number and weight of bunch/vine.
2.5. Number and weight of bunch/vine.
2.6. The percentage of grape prepared for export until 10 June in the 1st season.

3. **Some metrological data** as well as some physiological parameters were recorded: Relative humidity %, air temperature, plant leaf temperature, diffusion, transpiration,

Photosynthetic Active Radiation (PAR) over and under the plant and chlorophyll were recorded in the vineyard and in the plastic houses. Meteorological data as well as physiological parameters were determined by using Li-Cor 1600 steady state pororneter.

During the 2nd season

Low tunnels were constructed on 8 January. These tunnels were large enough to do the cultural practices. The plastic cover was100 micron thick polyethylene sheeting. Moreover, the effect of plastic houses which constructed during the season on the growth and yield is still under study during this season to investigate its effect on the quantity and quality of yield for this season. Samples were taken to determine the buds fertility and hormonal content.

For determination of the endogenous hormones activity, the plant (leaves) was frozen in liquid nitrogen immediately after sampling at-20°C till extraction. The procedure of indoles was similar to the described method[9]. However, the extraction procedure of GA was similar to that described method[10].

Titratable acidity measured as % citric acid of fresh mango juice was determined by titrating the sample to pH 8.2 with 0.1 N sodium hydroxide (NaOH), as described[11]. Total Soluble Solids (T.S.S.) was measured by a Kruss hand refractometer model HRN-32.

Three replicates were carried out. Each replicate contains three cultivated lines each of 36 trees.

The recorded data were subjected to standard ana1ysis of variance procedure and the values of L.S.D. are obtained whenever the calculated 'F' values are significant at 5% level.

Results and Discussion

Metarological and physiological parameters

Relative humidity %, air temperature, plant leaf temperature, diffusion, transpiration, Photosynthetic Active Radiation (PAR) over and under the plant and chlorophyll parameters were recorded in the vineyard and in the plastic houses (Tables 2, 3).

Table (1) Different timing of hormone spraying at Elnubaria region

Treatment	1st Flowering spray*	2nd Flowering spray	1st Enlargement spray**	2nd Enlargement spray
Control	10 April	15 April	3 May	10 May
Low tunnels	30 March	5 April	13 April	20 April
Low tunnels + Mulch	30 March	5 April	13 April	20 April
Low tunnels + Mulch + Water tubes	27 March	3 April	13 April	20 April
Plastic house***	25 March	30 Mars	10 April	17 April

*The 1st flowering spray was at the beginning of flowering stage.
**The 1st enlargement spray was when the diameter of fruit became 5- 7mm.
***PE house: this practice established by the farmers as a simple protected house to earliness production.

Table (2) Effect of protection treatments on some meteorological data* as well as some physiological parameters of grape at June. (1st season) at Elnubaria

Parameters	Plastic house	Outdoors	LSD at 5 %
Relative Humidity %	30.5	25.6	1.2
Air temperature (°C)	31.8	33.0	0.8
Plant leaf temperature (°C)	30.7	32.0	0.6
Diffusion	16.6	1.45	4.8
Transpiration	0.99	17.20	3.8
Photosynthetic Active Radiation (PAR) over plant (quantum)	960	1750	15
Photosynthetic Active Radiation (PAR) under plant (quantum)	33	88	8
Chlorophyll index**	33.5	41.7	2.4

* Metarological data as well as physiological parameters were determined by using Li-Cor 1600 steady state pororneter. **This was determined using Minolta Chlorophyll Meter SPAD- 502

Table 3. Effect of protection treatments on some meteorological data as well as some physiological parameters of grape at May (2nd season) at Elnubaria

Parameters	Plastic house*	Outdoors	LSD at 5 %
Relative Humidity %	32.2	21.5	2.7
Air temperature (°C)	31.4	32.1	NS
Plant leaf temperature (°C)	31.0	32.0	NS
Light intensity (Lux)	28368	40543	2536

*PE house: this practice established by the farmers as a simple protected house to earliness production.

Under the plastic houses conditions, relative humidity was increased compared with control. The increment was not high. Protection technique decreased air temperature which became very suitable for growth. Also, protection treatments decreased plant leaf temperature. Moreover, diffusion was increased as a result of plastic houses. This increment of diffusion resulted in decreasing transpiration. Photosynthetic Active Radiation (PAR) over the plant was 960 and 1750 quantum as a result of plastic house and outdoors, respectively. The same trend was observed for PAR under plant. Chlorophyll in out of doors was higher than that under plastic house conditions (Table 2). Inside the plastic greenhouse, the radiation-use efficiency is sometimes higher than outside [3, 12].

In the 2nd season, the relative humidity under plastic house was increased by 49.8%, while light intensity was decreased by 30.2%, compared to outdoor (Table 3).

Photosynthetic Capacity

Table 4: Effect of different protection treatments on the photosynthetic capacity after 30 days from protection at Elnubaria

Treatments	Apparatus reading (SPAD)*
Outdoors	26.0
Low tunnels	26.9
Low tunnels + Mulch	30.7
Low tunnels + Mulch + Water tubes	32.4
Plastic House	28.9
LSD at 5%	1.12

*This was determined using Minolta Chlorophyll Meter SPAD- 502

Photosynthetic capacity was determined as shown in Table (4). These data indicated that different covered treatments significantly increased photosynthetic capacity compared with those non covered, except only with low tunnels. This increment may be due to leaves area/plant increase. The process of photosynthesis provided the raw materials (reduced organic compounds and oxygen) for new mechanism of energy release, the aerobic respiration of organic cell constituents. The molecules elaborated by photosynthesis were at one and the same time the starting molecules (precursor molecules) for the synthesis of other organic molecules essential to life. The acceleration and accumulation of these products may increase the yield and resulted in early grape production.

Phenological behavior of *cv.* Thompson seedless:

Table 5. Phenological behavior of *cv.* Thomposon seedless under protection in the 1st season at Elnubaria

Treatments	Bud break	Full bloom	Fruit set	Harvest date (50%)	Total days
Outdoors	Feburary1	April 10	April 15	June 30	150
Plastic house	Feburary1	March 30	April 5	June 25	145
Plastic house + Mulching	Feburary1	March 30	April 5	June 25	145
Plastic house + Mulching+ heating	Feburary1	March 28	April 5	June 20	140
Plastic house	Feburary1	March 25	March30	June 15	135

Data presented in Table (5) indicate the effect of protection treatments on Phenological behavior of *cv*. Thompson seedless at El-Nobaria.

It is clear that all protection treatments had no effect on bud break dormancy, during the 1st season. The data of bud break was 1st February.

During the 2nd season, protection treatments enhanced the bud break compared with outdoors. Bud break under protection treatments was 8th January (earlier 23 days), while it was 1st February as a result of non covered vines. On the other hand, protection treatments had great effect on the date of full bloom. The date of full bloom under protection treatments was 10th April as a result of non covered vines and 25-30 March (earlier by 15-10 days) for protection treatments during the 1st season. In the second season, the date of full bloom under outdoors conditions was (April 15-20), while it was 7-10 March under plastic house, *i.e.* the protection treatments earliness the full bloom by about 39 days compared to outdoors.

Concerning the effect of protection treatments on fruit set, it is clear from Table 5 that these treatments had great effect on this character. These treatments caused early fruit set. The date of fruit set was 30th March and 15th April for plastic house and outdoors respectively during the 1st season. Also, protection treatments caused early harvest date (50%) especially plastic house. However, harvest date (50%) was June 15th and June 30 for plastic house and outdoors treatments, respectively.

Table 6. Phenological behavior of *cv.* Thomposon seedless under protection treatment in the 2nd season at Elnubaria

Treatments	Bud break	Full bloom	Fruit set	Harvest date (50%)	Total days
Outdoors	Feburary1	April 15-20	April 20-25	June 26-Joulay 2	156
Plastic house	January 8	March 7-10	March 12-15	June 6- June 11	155-160

The phenological behavior of Thompson seedless grape vine under protection treatments during the second season are shown in Table (6). It is clear that during the second season protection treatments (plastic house or tunnels) had great effect on all phenological behavior compared with out of doors. Protection treatments caused an earlier bud break, full bloom, fruit set and harvest date (50%). There is no difference between the effect of plastic house and tunnels (Table, 6). Worthy mentioned that, in most cases, the total time of crop development from bud break to maturation was altered in *cv.* Thompson seedless due to protection treatments. The whole period of development was shifted to 15 days or 5-7 days earlier as a result of plastic house or tunnels respectively than in uncovered vines, during the 1st season. On the other hand, the whole period of development was shifted to 10 days earlier as a result of protection treatments during the 2nd season (Table 6).

Shoot growth rate (cm/day)

Data in Table (7) indicated that the growth rate (cm/day) increased under plastic house or tunnels condition. This effect may be due to the increment of air temperature which accelerate the growth. At the beginning the rate of shoot growth was higher under tunnels compared with plastic house conditions then the opposite direction was appeared because the condition of growth, air temperature and relative humidity was suitable under plastic house compared with tunnels, which effect on biosynthesis of endogenous hormone as a result to growth conditions.

Table 7. Effect of plastic house and tunnels on the shoot growth rate (cm/day)

Treatments	Dates			
	1st February	15th February	1st March	15th March
Control	0.00	0.20	0.47	1.50
Tunnels	0.28	1.80	2.20	2.70
Plastic house	0.28	1.50	2.70	3.00

Table 8. Effect of different protection treatments on the leaves macro- and micro- nutrient status at Elnubaria

Treatments	N	P	K	Mg	Ca	Zn	Mn	Fe
	%					ppm		
Outdoors	2.14	0.90	2.40	0.26	0.32	18.75	22.00	19.00
Low tunnels	1.52	1.06	2.31	0.29	0.32	16.25	22.25	10.25
Low tunnels + Mulch	2.05	1.11	3.26	0.30	0.31	8.00	13.50	8.500
Low tunnels + Mulch + Water tubes	1.84	1.11	2.99	0.34	0.33	19.25	24.00	21.50
Plastic House	1.48	1.12	4.20	0.35	0.30	12.75	20.75	12.25
LSD at 5%	**0.26**	**0.08**	**0.36**	**NS**	**NS**	**NS**	**NS**	**NS**

Nutrient Status:

Data presented in Table (8) show that K (%) and P (%) reached its maximum value under plastic house condition compared with other treatments. While, all protection treatments decreased N (%) compared with outdoors. This decrement was no significant. This decrement may be due to increment of growth under protection systems or/and using nitrogen in built new growth. On the other hand, it is clear from Table (8), that protected treatments had now clear trend on Mg (%), Ca% as well as Fe (ppm), Mn (ppm), and Zn (ppm).

Chlorophyll and TSS

Table 9. Effect of different protection treatments on the chlorophyll and TSS% of grape berry in 25th May in the first and second seasons

Treatments	TSS %	Chlorophyll (SPAD)
	1st season	
Outdoors	5	22.5
Low tunnels	6	23.0
Low tunnels + Mulch	8	24.1
Low tunnels + Mulch + Water tubes	10	24.7
Plastic house*	13	33.1
Treatments	**2nd season**	
Plastic house	11.5	32.6
Tunnels	9.8	22.0
Outdoors	4.2	20.0

*PE house: this practice established by the farmers as a simple protected house to earliness production.

Table (9) shows the effect of different protection treatments on chlorophyll (SPAD) and T.S.S % of the first and second seasons. The results indicate that protection treatments increased both chlorophyll (SPAD) and TSS % in both seasons, especially the plastic house protection which gave 160 and 174 % over than open field, in the first and second seasons, respectively. So, the increment of chlorophyll increased photosynthesis which had good effect on fruiting quality and quantity.

Endogenous hormonal content

Data in Table (10) show that GA content increased as a result of protection treatments compared with vines cultivated in outdoors. So, the vegetative growth under protection cultivation was more than outdoors because of increasing GA. While IAA and ABA values were decrease to a great extent under protection treatments. This effect may be due to the night temperature, whereas ABA content was decreased and IAA increased. This shows that both endogenous hormones biosynthesis are related to temperature conditions that reflect on the production of grape plant[13].

Table 10. Endogenous hormones as affected by protected cultivation during flowering and fruiting stages in grape plants at Elnubaria

Stage	IAA		GA		ABA	
	Indoors	Outdoors	Indoors	Outdoors	Indoors	Outdoors
Flowering	391	2289	640	125	1980	2423
Fruiting	230	918	126	27	432	6286

Table 11. Bud fertility % of Thompson seedless grapevine under plastic house and tunnels at Elnubaria

Treatments	Positions of the eyes on the cane												
	1	2	3	4	5	6	7	8	9	10	11	12	Aver.
Control	15	35	20	45	65	75	75	60	45	45	50	40	47.0
Tunnels	40	40	60	60	80	80	80	80	60	60	60	50	62.5
Plastic house	5	25	50	70	50	75	70	75	50	70	70	25	50.0

Bud fertility (%)

The result of this character is very important to determine the pruning practice. Generally, it is clear from data in Table (11) that the bud fertility (%) increased from bud number 4 and reached its maximum value in the bud number 10, and then it began to decrease after bud number 11. Under plastic house condition, the bud fertility (%) of the bottom buds was less than under other treatments.

The training system which is Y system or/and the biggest growth and the increment the leaf area in plastic house which resulted in decreasing the bud fertility especially the bottom buds. To prevent this we can eliminate the leaves and lateral branches besides using growth retardants. These processes make a suitable condition to expose buds to light.

Performance and fruit quality of *cv.* Thompson seedless:

Table 12. The effect of polyethylene covering on the performance and fruit quality of cv. Thompson seedless in the 1st season at Elnubaria

Treatments	Vine (kg)	Harvest 50% (date)	Bunch Size (g)	Berry Size (g)	Berry length (cm)	Berry width (cm)	TSS (%) June10	Acidity (%) June10
Outdoors	10.0	June30	420	2.5	1.7	1.45	11.2	1.1
Polyethylene (PE)	8.5	June25	350	2.4	1.6	1.45	13.0	0.8
PE+ Mulching	9.5	June25	430	2.7	1.7	1.5	13.5	0.8
PE+ Mulch +Heating	9.0	June20	480	2.9	1.8	1.55	14.0	0.8
PE house*	12.0	June15	520	3.8	2.2	1.75	16.0	0.7

*PE house: this practice established by the farmers as a simple protected house to earliness production.

Table 13. The effect of polyethylene covering on the performance and fruit quality of cv. Thompson seedless in the second season at Elnubaria

Treatments	Vine (kg)	Harvest 50% (date)	Bunch size (g)	Berry size (g)	Berry length (cm)	Berry width (cm)	TSS (%)	Acidity (%)
Outdoors	6.5	June 26 – July 2	358	2.1	1.6	1.40	14	0.90
Plastic house	7.1	June 6- June 11	428	2.8	1.8	1.55	19	0.65

Data in Tables (12 and 13) indicate the effect of protection on the performance and fruit quality of *cv.* Thompson seedless yield/vine (kg), bunch size, berry size, berry length, berry width, T.S.S. % and acidity %, during the two seasons. It is clear that these criteria were increased under plastic house compared with other treatments. This treatment gave yield/vine 20 % and 7.1 % over the control in the 1st and 2nd seasons, respectively. The other protection treatments insignificant decrease the yield/vine (Kg), compared to uncovered (Table 12). Grapes harvested when they reach optimum maturity. This varies between16-18 T.S.S. depending on the Variety.

Protection treatments increased bunch size and berry size except low tunnels which decreased these both characters. The maximum values of bunch and berry size was obtained as a result of plastic house. Also plastic house gave the best results for berry length and width (best quality). These results are in agreement with reference[14] whom reported that warm summer temperatures favours grape production. Also, warm weather is conducive to high wine quality in *V. vinifera*[15]. High temperatures (≥26°C) were associated with good production, probably because warm temperatures are required for flower bud initiation and development [16] .

Concerning the effect of different protection treatments on TSS (%) and acidity (%), it is clear from data in Tables (12 and 13) that protection treatments increased T.S.S. (%) especially plastic house protection which gave 42.9 and 35.7% over the control, in the 1st and 2nd seasons, respectively. it is known that there is a positive correlation between this parameter and the time of harvest [17,18], while no significant relationship was observed between yield and TSS[19]. So protection treatments ripen fruit earlier than vine grown outdoors. Highly significant positive correlations were found between TSS and harvest date in the three mango cultivars tested[20]. On the other hand protection treatments decreased acidity values (%) especially plastic house treatment. So there is a negative correlation between T.S.S. (%) and acid (%).

The effect of protection treatments on the performance and fruit quality during the second season are shown in Table 13. It was indicated that the number of days between blooming and harvesting was also highly variable, where protection treatments caused earlier harvest compared with outdoors. Protection treatments increased bunch size, size, length, width and T.S.S of berry especially plastic house. But these treatments decreased the acidity value (Tables 12 and 13). These increments may be due to the use of a plastic cover to cultivate grapes created a micro-environment that was characterized by a decrease in the levels of solar radiation, an increase of the maximum temperatures and the persistence of higher saturation deficit levels[3].

Additional cost and return of one kg of grapes produced

From comparing the cost of plastic house and tunnels (data not shown), we can say that tunnels are very useful for farmers than plastic house. These tunnels must be constructed after the vines get its cold requirements. Also the height and width of these tunnels must be suitable to do every agricultural practices and plastic must be far from vine parts and do not touch them.

Conclusion

From comparing the cost of plastic house and tunnels, we can say that tunnels are very useful for farmers than plastic house. These tunnels must be constructed after the vines get its cold requirements. Also the height and width of these tunnels must be suitable to do every agricultural practices and plastic must be far from vine parts and do not touch them.

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