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Changes the Microclimate Using Some Protection Treatments for Early Grape Production in South of Egypt

Hamed Mohamed El-Saeed, M.S. Abd Elwahed*, H.F. Abouziena and E.R. El-Desoki

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

Abstract: The microclimate play an important role in early, late and total crop production. For improving the early production and quality of Thompson grapes yield in Minia region, South of Egypt 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 factors for growth. Plastic houses increased diffusion which resulted in decreasing transpiration. In the 2^{nd} season, under plastic house the relative humidity was increased by 50.5%, while light intensity was decreased by 43.0%, compared to outdoor. 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, which was related to increase plat growth regulators. In the 2^{nd} season, bud break was earlier by 27 days under protection treatments, while in the 1^{st} season all protection treatments had no effect on bud break dormancy, compared with outdoors. In the 1^{st} season, the protection treatments resulted in earliness the fruit set and the full bloom by 10-15 days and the whole period of development was shortened 5-15 days, compared to outdoor. While in the 2^{nd} season, the bud break, full bloom, fruit set, harvest date (50%) and the whole period of development were earlier by 27, 35, 35, 25 and 10 days, respectively, as a result of plastic house or tunnels than in uncovered vines. Protection treatments increased bunch, size length and width of bunch and T.S.S of berry, especially plastic house, which increased the yield/vine by 20.6 % in the 1^{st} season, while T.S.S (%) of berry was increased 36.0% and decreased by 12.5% in the 1^{st} and 2^{nd} seasons, respectively, compared to the control. On the other hand, plastic house treatment decreased the acidity value in the 1^{st} season, but increased it by 20 % in the 2^{nd} season.
Keywords: grape, plastic house, tunnels, early product, protection treatments, elements.

Introduction

Early maturity is the important factor in grape exportation in Egypt whereas the most world markets lack grape fruits in the same period. 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. 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 foreign markets. 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[2].

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[3]. 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. The most determinate factor in horticultural crop production is the climate[3]. 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].

Compared to open field production, protected production led to 15-18 days earliness. The cluster weight, cluster width, and cluster length of cultivars did not vary between the different production treatments. Total soluble solids (TSS) and pH values of both of the production types were similar[4]. For 'Yalova incisi' and 'Cardinal' cultivars, the yield in open field production was higher than that in the protected cultivation. In the protected cultivation, the effect of production sites on shoot development was greater than that in the open field[4].

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[5,6].

Therefore, the objective of this study was to obtain an early production of Thompson grapes for export and improving the quality of early grapes by modifying the climate condition under Minia Governorate condition.

2. Materials and Methods

2.1. Experimental

2.1.1. Plan during the 1st season

Thompson seedless grape growing at Minia Governorate, South of 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 as 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 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).

Table 1. Different timing of hormone spraying at Minia 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 March	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.

2.2. Data recorded:

2.2.1. Maximum-minimum temperatures and relative humidity were recorded daily for covered and non - covered vines (Table 2).

2.2.2. 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).

2.2.3. Photosynthetic Capacity

2.2.4. Date of bud-burst and beginning of flowering

2.2.4.1. Bud-burst (%).

2.2.4.2. Nutrient Status: Macro (N, P, K, Ca and Mg) and micro (Zn, Mn and Fe) elements content for leaf petiole were determined [7]. Nitrogen (%) was determined by the modified micro-Kjeldahl method [8]. Phosphorus (%) was determined using the Olsen method and potassium (%) with flame photometer method [9]. Potassium, magnesium and calcium were determined using flame photometer. Micronutrients (Fe, Mn and Zn) were measured by atomic absorption technique [10].

2.2.4.3. T.S.S were recorded to determine the suitable harvest time.

2.2.4.4. Number and weight of bunch/vine.

2.2.4.5. Number and weight of bunch/vine.

2.2.4.6. The percentage of grape prepared for export until 10 June in the 1st season.

2.2.5. 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.

2.1.2. During the 2nd season

Low tunnels were constructed on 8 January. These tunnels were large enough to do the cultural practices. The plastic cover was 100 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 [11]. However, the extraction procedure of GA was similar to that described method [12].

Titratable acidity was determined by titrating the sample to pH 8.2 with 0.1 N sodium hydroxide (NaOH), as described [13]. 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. were obtained whenever the calculated 'F' values are significant at 5% level.

3. Results and Discussion

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

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 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 Minia region

LSD (0.05)	Outdoors	Plastic house	Parameters
3.2	20.4	30.7	Relative Humidity %
1.9	36.8	34.6	Air temperature (°C)
2.0	36.6	34.4	Plant leaf temperature (°C)
2536	39597	22576	Light intensity (Lux)

*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 under plastic house conditions (Table 2). Inside the plastic greenhouse, the radiation-use efficiency is sometimes higher than outside[4, 13].

In the 2nd season, the relative humidity under plastic house was increased by 50.5%, while light intensity was decreased by 43.0%, compared to outdoor (Table 3). Similar trend was recorded in the north of Egypt [2].

3.2. Photosynthetic Capacity

Photosynthetic capacity was determined as shown in Table (4). These data indicated that the 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.

Table 4. Effect of different protection treatments on the photosynthetic capacity after 30 days from protection at Minia region

Treatments	Apparatus reading (SPAD)*
Outdoors	25.7
Low tunnels	26.8
Low tunnels + Mulch	30.4
Low tunnels + Mulch + Water tubes	35.6
Plastic House	41.6
LSD at 5%	**2.8**

*This was determined using Minolta Chlorophyll Meter SPAD- 502

3.3. Phenological behavior of cv. Thompson seedless

The effect of protection treatments on Phenological behavior of *cv*. Thompson seedless at Minea region are shown in Table (5). It is clear that no changes in bud break dormancy, during the 1st season due to the all protection treatments. But the data of bud break was 5th February, *i. e.* its earlier by 4 days compared to that under north of Egypt [2] and this may be attributed to the variation in the ambient temperature between the two regions (36.8 °C and 34.6 °C at south and 32.1 °C and 31.4 °C at north of Egypt in the outdoor and under plastic house, respectively. In another study it was found that protected production led to 15-18 days earliness [4].

In the 1st season, the protection treatments resulted in earliness early fruit set and the full bloom by about 10-15 days and caused full bloom and the whole period of development was shortened by about 5-15 days, compared to outdoor. While in the 2nd season, the bud break, full bloom, fruit set, harvest date (50%) and the whole period of development were earlier by 27, 35, 35, 25 and 10 days as a result of plastic house or tunnels than in uncovered vines, respectively (Tables 5 & 6).

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

Treatments	Bud break	Full bloom	Fruit set	Harvest date (50%)	Total days
Outdoors	Feb.5	April 10	April 15	June 25	140
Low tunnels	Feb.5	March 30	April 5	June 20	135
Low tunnels + Mulch	Feb.5	March 30	April 5	June 20	135
Low tunnels + Mulch + Water tubes	Feb.5	March 28	April 5	June 18	133
Plastic house	Feb.5	March 25	March 30	June 10	125

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

Treatments	Bud break	Full bloom	Fruit set	Harvest date (50%)	Total days
Outdoors	Feb.1	April 15-20	April 20-25	June 30-July 5	150-155
Tunnels	Jan.5	March 0-15	March 5-20	June 5-10	140-145
Plastic house	Jan.5	March 0-15	March 5-20	June 5-10	140-145

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). Similar finding was reported at Nuobaria region, North of Egypt [2].

3.4. Shoot growth rate (cm/day)

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

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 accelerates 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.

3.5. Nutrient Status

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

Treatments	N	P	K	Mg	Ca	Zn	Mn	Fe
	%					ppm		
Outdoors	1.93	1.18	2.17	0.63	0.17	27.75	14.50	51.25
Low tunnels	1.06	1.04	2.65	0.60	0.13	25.50	15.50	130.50
Low tunnels + Mulch	1.40	1.21	2.65	0.91	0.17	49.25	23.25	59.50
Low tunnels + Mulch + Water tubes	1.87	1.08	1.97	0.91	0.21	44.25	19.00	163.20
Plastic House	1.61	1.06	2.30	0.70	0.17	28.00	16.50	44.25
LSD at 5%	**0.22**	**0.09**	**0.19**	**0.10**	**0.03**	**6.13**	**1.78**	**46.27**

Data presented in Table (8) show that P (%), K (%) and Mg (%) as well as Zn (ppm) and Mn (ppm) reached its maximum value under Low tunnels + Mulch condition compared with other treatments. While, all protection treatments decreased N (%) compared with outdoors. This decrement was 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, Fe (ppm) reached its maximum value under low tunnels + mulch + water tubes treatment.

3.6. Chlorophyll and TSS

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

Treatments	TSS %	Chlorophyll (SPAD)
Plastic house	11.5	34.5
Tunnels	10.4	27.3
Outdoors	5.6	26.2
LSD at 5%	**0.9**	**1.7**

*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 second seasons. The results indicate that protection treatments increased both chlorophyll (SPAD) and TSS %, especially the plastic house protection which gave 30.2 and 105.4 % over than open field, respectively. So, the increment of chlorophyll increased photosynthesis which had good effect on fruiting quality and quantity.

3.7. Endogenous hormonal content

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

Stage	IAA		GA		ABA	
	Indoors	**Outdoors**	**Indoors**	**Outdoors**	**Indoors**	**Outdoors**
Flowering	120	245	765	118	1829	2372
Fruiting	26	514	986	289	180	885

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 [15].

3.8. Bud fertility (%)

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

Treatments	Positions of the eyes on the cane												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Aver.**
Control	20	40	60	40	40	80	80	80	40	40	40	20	50
Tunnels	20	40	60	60	60	80	80	60	80	80	80	20	60
Plastic house	00	15	25	40	50	60	60	70	60	50	60	25	43

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 8, 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.

3.9. Performance and fruit quality of cv. Thompson seedless

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 significantly increased the yield/vine (26%) and insignificant increase (3.3%) 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 were harvested when they reach optimum maturity. The variation between T.S.S. is depending on the variety [16-20].

In the 1st season, the maximum values of bunch and berry size was obtained as a result of plastic house treatment, while the other protection treatments decreased these both characters if compared with outdoor (Table 12). Also plastic house gave the best results for berry length and width (best quality). These results are in agreement with reference [16] whom reported that warm summer temperatures favours grape production. Also, warm weather is conducive to high wine quality in *V. vinifera* [17].

High temperatures (≥26°C) were associated with good production, probably because warm temperatures are required for flower bud initiation and development [18].

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

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	June25	450	3.0	1.9	1.5	12.5	1.00
Polyethylene (PE)	9.5	June20	360	2.2	1.8	1.4	14.0	0.80
PE+ Mulching	9.0	June20	420	2.7	1.7	1.5	13.5	0.80
PE+ Mulch +Heating	10.5	June18	420	2.7	2.0	1.5	15.0	0.75
PE house*	12.6	June10	500	3.5	2.3	1.7	17.0	0.60
LSD at 5%	1.9		38	0.7	0.3	NS	2.1	0.19

*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 Minia region

Treatments	Vine (kg)	Harvest 50% (date)	Bunch Size (g)	Berry Size(g)	Berry length (cm)	Berry Width(cm)	TSS (%)	Acidity (%)
Outdoors	9.0	30/6-5/7	420	2.5	1.7	1.5	16	0.75
Plastic house	9.3	June5-10	450	2.9	1.8	1.6	14	0.90
LSD at 5%	0.1		17	0.3	0.1	0.1	1	0.09

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 36.0% in the 1st season, but significantly decreased it by 12.5% compared to outdoor in the 2nd seasons. it is known that there is a positive correlation between this parameter and the time of harvest [19,20], while no significant relationship was observed between yield and TSS [21]. 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 [22]. 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 in the first season (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 [5].

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