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EFFECT OF WINDBREAKS ON THE MICROCLIMATE OF THOMPSON SEEDLESS VINEYARD AT WEST NUBARIA, EGYPT

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Results of field experiments on the influence of Casuarina (*Casuarina equestifolia*) and Eucalyptus (*Eucalyptus camaldulensis*) windbreaks on microclimate elements; e.g wind velocity, air temperature, soil temperature and air relative humidity, of Thompson seedless vineyard during the two seasons of 1998 and 1999, are presented. It was observed that windbreaks of Casuarina and Eucalyptus reduced wind velocity (measured at 1.5 m above the ground surface) in the leeward side. The reduction of wind velocity as affected by windbreaks ranged from 5 to 31.5%, 8 to 28% and from 6 to 25%, 8 to 25% for Casuarina and Eucalyptus in the first and the second season, respectively. The air temperature of the protected vineyard were higher than in the open one, the increase in air temperature in the sheltered vineyard were in evidence between 50 to 100 m from Casuarina and Eucalyptus windbreaks. The air relative humidity was significantly higher in the protected vineyards compared to the open one. Soil temperatures in the sheltered vineyards by Casuarina and Eucalyptus were generally lower than in the open orchard depending upon month and season.

Keywords: windbreaks, microclimate, vineyards, eucalyptus, casuarina windbreaks, air temperature, soil temperature, relative humidity, wind speed.

Microclimate is the sum of many elements, most of which interact, and all of which can be modified by shelterbelts and windbreaks. The principal effect of shelter is to alter the pattern of mean wind velocity and turbulence, consequently, the air and soil temperatures, humidity can all be altered by shelter (McNaughton, 1988). The effect of windbreaks on field crops is based on the modification of the microclimate, mainly on the leeward side. Bagley and Gowen (1960) declared the effects of some small windbreaks on a certain micro meteorological elements. Wind speed was reduced from 50 to 70 % at a distance of eight times the height (8 *h*) of the windbreak. Moreover, the relative humidity was higher than in the open field.

Ujah and Adeoye (1984) reported that shelterbelts reduced wind velocity on the leeward side. Reduction in wind velocity ranged from 20 to 10 % at a distance of 20 and 150 m from the belt, respectively. Maximum air temperatures were 0.8 to 1.5 °C higher at 20 m from the belt on the leeward side than in the open field. Minimum temperatures were, however, of the same magnitudes in both the open and sheltered areas. The influence of shelterbelts on soil temperature was minimal. Maximum soil temperatures at 5-cm depth were 0.5 to 1.0 °C higher at the area close to the belt than in the open one.

Khalil (1982) reported that soil temperature at a depth of 20 cm in the protected area was lower than in the open one. This effect whether statistically significant or not depends on the month and the direction of windbreak. Jaworskii (1962) observed that 74% reduction in wind speed at a distance of 4 h from the lee side of a shelterbelt of 12.5-m height was recorded. This greatest reduction was defined for winds with an original speed of 3.8m/sec. Messing and Noureddine (1991) declared that the reduction of wind speed behind the artificial windbreaks varied between 30 and 60 % depending upon the distance from windbreaks. Among the biological windbreaks, Opuntia was the least effective, while a 60 % reduction in wind velocity was obtained at 4 h for Acacia and Casuarina windbreaks.

Heiligmann and Schneider (1975) recorded increase in daily maximum and minimum temperatures in the protected plots by 2.9 °C and 1.6 °C, respectively, compared to the open one. Meanwhile lower soil surface temperatures in the protected plots were detected. Enguange *et al.*(1996) reported that the construction of farmland shelter forests increased both annual average air temperature and ground temperature. Maki *et al.* (1994) found that Tamarix forest windbreaks alleviated the adverse effect of wind velocity and an excessive increase of air temperature near the windbreak due to the decrease of relative wind speed.

The present study was carried out at west Nubaria region of Egypt to investigate the role of Casuarina and Eucalyptus windbreaks on alteration of some microclimate elements e.g., wind speed, air temperature, air relative humidity and soil temperature of Thompson seedless vineyard as compared to those cultivated without protection by windbreaks.

MATERIALS AND METHODS

Two types of windbreaks were used, Casuarina (*Casuarina equestifolia*) and Eucalyptus *(Eucalyptus camaldulensis*), for the protection of 11 years old vineyard of Thompson seedless *(Vitis vinifera L.)* from wind damage and sandstorms in addition, there was the unsheltered vineyard for comparison (Fig. 1).

The experimental plot comprised of three parts of the cultivated vineyards; vines protected by Casuarina, vines protected by Eucalyptus and the unsheltered vines. Casuarina and Eucalyptus windbreaks were 12 years old and orientated at the west- east direction. Casuarina tree belts were alternatively planted in double line in a distance of 1 m between the two lines and 1 m between trunks of the same line. Tree height reached about 11-m. Trunk diameter was about 23 cm at 1 m from soil surface. Tree belts of Casuarina extended to 200m with a porosity of about 45 %. Eucalyptus tree belts were also alternatively planted in a double line, 12 m-height and of about 30-cm trunk diameter at 1m from soil surface. Spacing between trunks of the same line was 2-m. Tree belts of Eucalyptus extended to 200 m on the same line of Casuarina and far from it by 300 m with a porosity of 55 %. The vine rows were extended from north-south direction. Vines were Y shaped trained.

Data of environmental factors such as wind speed, soil temperature, air temperature and air relative humidity were recorded during March, May and August during the two seasons 1998 and 1999. The recording points for measuring wind speed and soil temperature were located at a distances of 10 and 30 m from the windbreaks (windward side) and 0, 10, 30, 60, 90, 120 and 150 m (at the leeward side of windbreaks), the distances of 0, 50, 100 and 150m from tree bases were chosen for the measurements of air temperatures and air relative humidity. Wind speed was measured at 1.5 m above ground surface by hand anemometer. Air temperatures and air relative humidity were measured by recording hygro-thermometers. Soil temperatures were measured by digital soil thermometer (Gilson Company, INC, model 39658-J). Mean of climate data is presented in table (1).

The experiment was arranged in split plot design with three replicates that all over nominated distance. The main plots were assigned to the three shelter conditions and subplots for the distances from windbreaks. Analysis of variance was computed for various treatments using the LSD 0.05 for mean separation (Snedecor and Cochran, 1980).

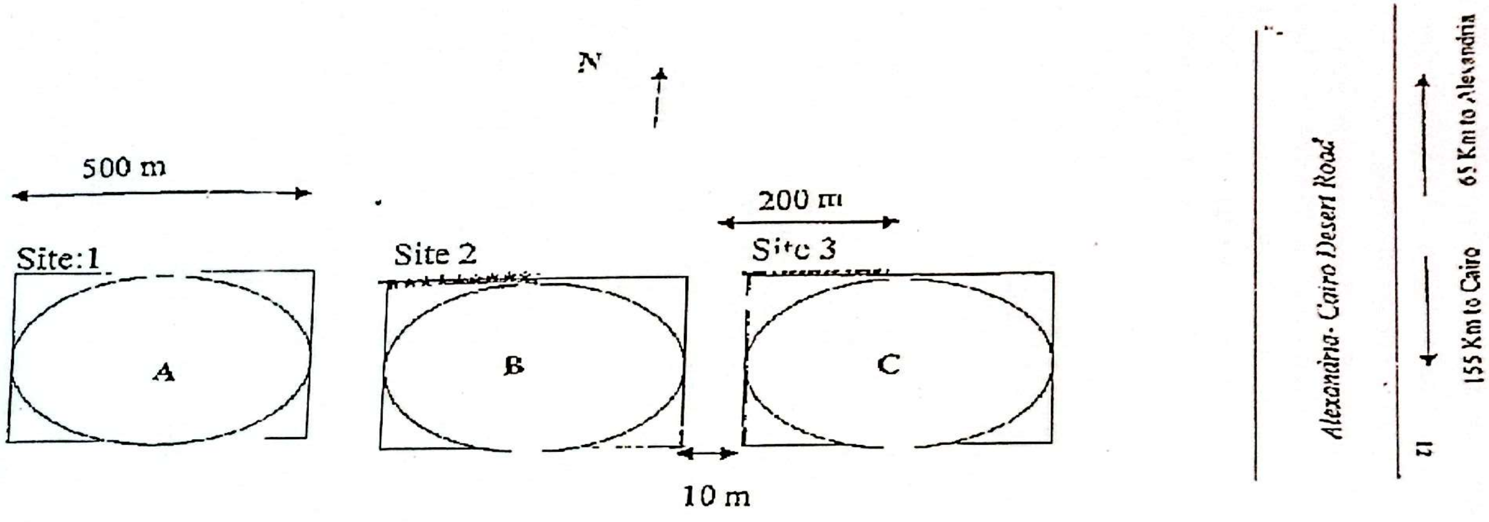
RESULTS AND DISCUSSION

Microclimate

Some elements of microclimate were measured such as wind speed, soil temperature, air relative humidity in addition to air temperatures to investigate the effects of shelter conditions on the previous components.

Wind speed

In the first season, the maximum means wind speed were recorded during May and the values were 3.18, 2.75 and 2.41 m/sec, for the open vineyards, the protected vineyards by Eucalyptus and protected vineyards by Casuarina, respectively. Wind speed records ranged from 1.50 to 3.20 m/sec,



...... Places of Casuarina windbreak (site 3)
* * * places of Eucalyptus windbreak (site 2)
site 1 is the unsheltered vineyard

- The round shapes A, B and C within squares are the areas for field crops cultivation and irrigated by Pivots.
- Sites 1, 2 and 3 are the study fields, cultivated with vineyard and irrigated by drip irrigation system.
- Every square represent an area of 41.5 hectare and sites , 2 and 3 which look like a triangle represent 7 feddan for each Hectare = 2.4 feddan.

Fig. (1). Diagram of the study area at Nubaria region (Nile Company for Agriculture)

2.00 to 3.20 m/sec and from 1.00 to 1.60 m/sec, during March, May and August respectively. (Fig 2; 1A, 1B, 1C).

TABLE (1). Mean climate data of observation area (from Nozha* meteorological station).

	Air temperature ˚C		Wind speed m/sec.		Relative humidity %	
	1998	1999	1998	1999	1998	1999
March	14.60	16.83	2.92	3.48	65.33	66.20
April	19.67	18.87	3.79	3.15	64.00	64.33
May	21.75	22.37	3.18	3.29	65.67	64.33
June	23.83	25.10	2.45	4.27	66.67	69.00
July	26.57	26.53	2.47	3.60	70.66	71.33
August	28.17	27.70	1.57	3.26	72.00	67.63
September	26.70	25.33	1.34	4.17	63.33	69.20
Mean	**23.04**	**23.25**	**2.5**	**3.60**	**66.81**	**67.43**

* Nozha station is the nearest meteorological station to the field of study and far from it by about 60-km.

In the second season, maximum mean wind speed were recorded during May with values of 3.56, 3.00 and 2.85 m/sec. in the open vineyard, vineyards sheltered by Eucalyptus and vineyards sheltered by Casuarina, respectively. Wind speed records ranged from 1.50 to 3.00 m/sec, 2.10 to 3.60 m/sec and from 1.50 to 2.85 m/sec during March, May and August respectively, (Fig 3; 1A, 1B, 1C). From the results obtained, it is evident that Casuarina windbreak was the most effective in the reduction of wind speed compared to the Eucalyptus windbreaks. The effect of the shelters on the reduction of wind speed extended up to 120 and 90 m for Casuarina and Eucalyptus windbreaks, respectively. It is well known that wind speed starts to decrease slightly in front of Casuarina and Eucalyptus windbreaks then passes over the crown with very low speed, the greatest part of wind passes through the crown which acts as a filter and causes a high reduction in wind speed. This reduction extended to a certain distance depending upon crown density and tree height. Generally the rate of wind reduction by windbreaks depends on primary wind speed, angle between wind direction and windbreaks and porosity of the windbreak. This trend is in harmony with those obtained by Bagely and Gowen (1960), Ujah and Adeoye (1984), Messing and Noureddine (1991) and Maki *et al.* (1994).

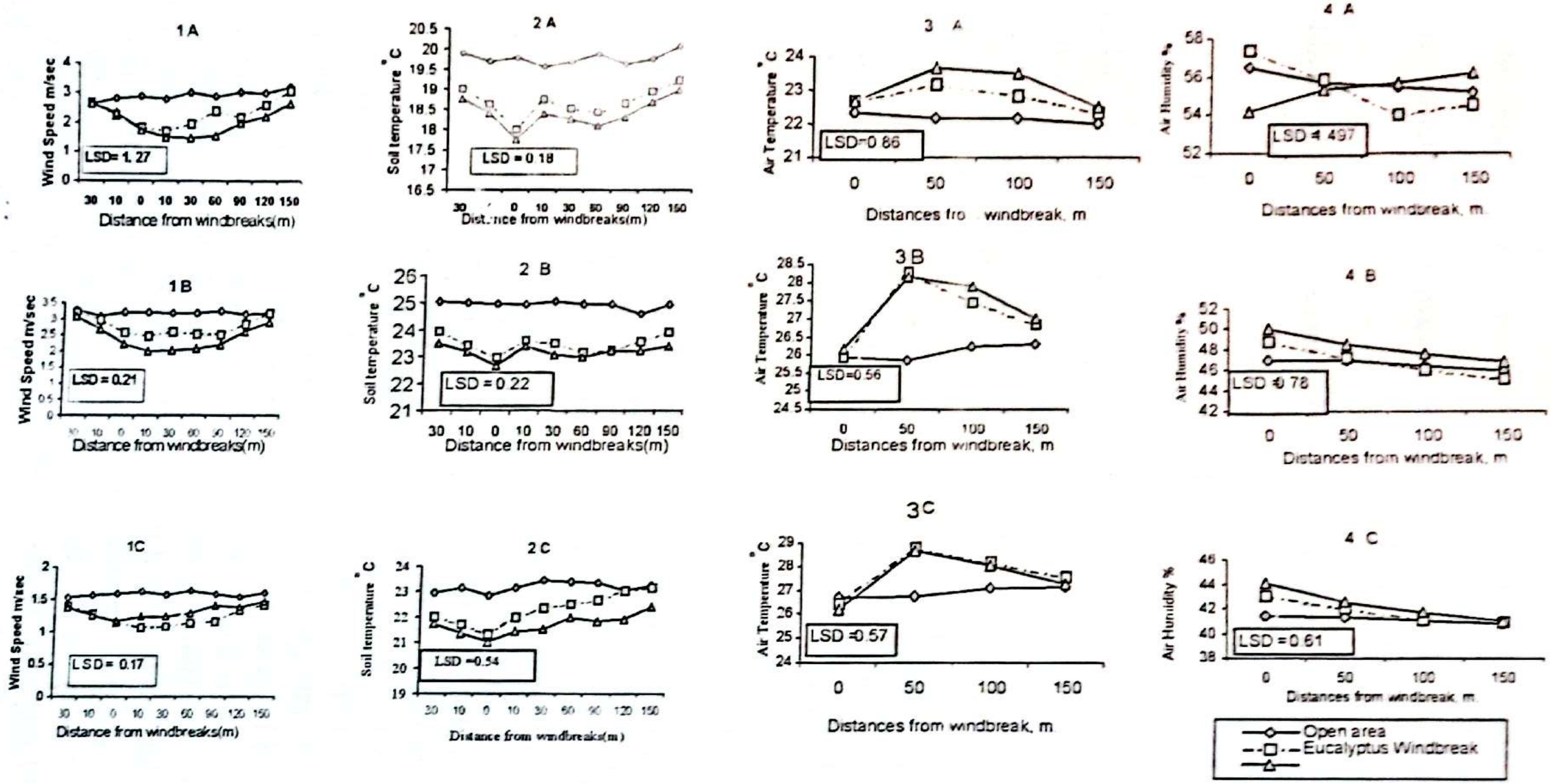


Fig (2). Effect of windbreaks on wind speed m/sec., soil temperature °C, air temperature °C and air humidity % within a Thompson seedless vineyard at west Nubaria region, 1998. A: March, B: May, C: August. 1: Wind speed, 2: Soil temperature, 3: Air temperature, 4: Air humidity.

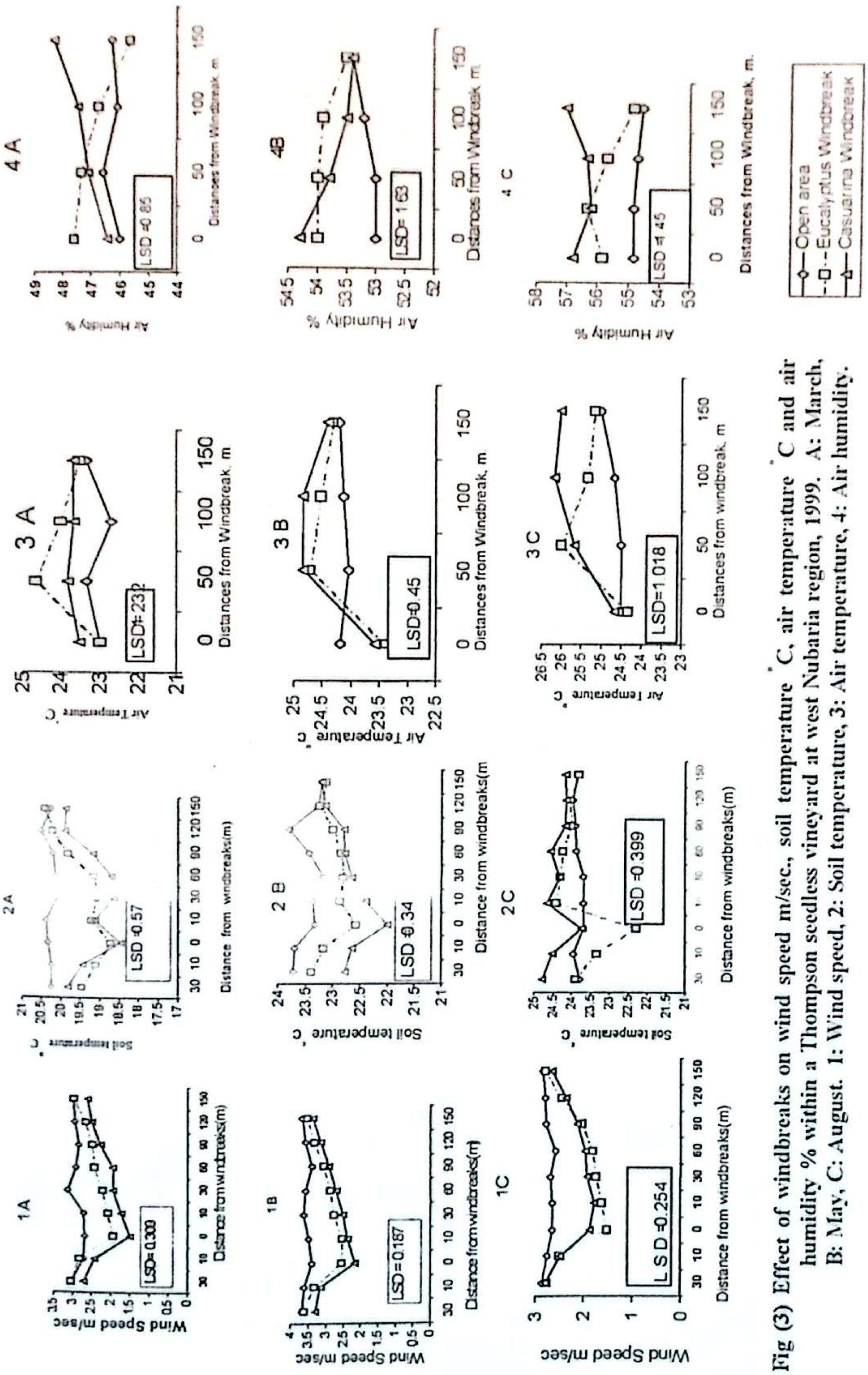


Fig (3) Effect of windbreaks on wind speed m/sec., soil temperature °C, air temperature °C and air humidity % within a Thompson seedless vineyard at west Nubaria region, 1999. A: March, B: May, C: August. 1: Wind speed, 2: Soil temperature, 3: Air temperature, 4: Air humidity.

Soil temperature

It was observed that soil temperature in the sheltered vineyard by Casuarina and Eucalyptus was significantly lower than in the unsheltered vineyard. This was obvious during most of measuring months (Figs. 2 and 3; 2A, 2B, 2C). The lowest soil temperature was recorded under Casuarina and Eucalyptus at tree bases (at 0 m) and increased gradually with the distances from windbreaks. Soil temperature values in sheltered vines by Casuarina were the lowest all over distances up to 120 m, followed by values of soil temperatures of sheltered vines by Eucalyptus. Although, in the year of 1999 during August, the lowest values were obtained in the open area on the lee ward side. Generally the decrease of soil temperature within sheltered vineyards may be due to higher water content of the soil which raises the heat capacity of the soil, hence more energy is required to heat it. This trend is in harmony with previous findings obtained by Heiligmann and Schneider (1975) and Khalil (1982).

Air temperature

Results of the two seasons on air temperature showed that during most of measuring months, air temperature within the sheltered vineyards was higher significantly compared to the unprotected vines (Figs. 2 and 3; 3A, 3B, 3C).

The maximum means of air temperature were observed within the sheltered vines at a distance from 50 to 100 m from Casuarina and Eucalyptus tree bases. The increase in air temperature within the sheltered vines may be attributable to the reduction of the vertical diffusion and turbulent mixing of air. This trend in general is in accordance with those stated by Marshall (1967), Ujah and Adeoye (1984) and Maki *et al.* (1994).

Relative humidity

In the first season, during May and August air relative humidity was higher within vines protected by Casuarina windbreaks than in both of vines protected by Eucalyptus and the open area. The effect of windbreaks extended to 150m. The highest value of relative humidity was obtained at 0 m beneath the trees of Eucalyptus windbreak. In the second season, during August the highest values of relative humidity were obtained in vines protected by Casuarina, it recorded 56.8 and 57 % at 0 and 150 m, respectively. Generally during the two seasons, it was observed that the relative humidity was higher within the sheltered vineyard. Generally, the records of humidity were the highest in the vicinity of shelter and it decreased gradually with the distance from shelterbelt canopy (Figs. 2 and 3; 4A, 4B, 4C). The increase of humidity within a sheltered vineyard may be due to the reduction of wind speed, which in turn result in increasing of humidity around plants owing to the evapo-transpiration although it is lower during a lower wind speed. The results are in agreement with those stated by Bagely and Gowen (1960), Enguang *et al.* (1996) and Khalil (1982).

CONCLUSION

The results obtained indicate that the protected vineyard showed a reduction of wind speed in the leeward of windbreaks. The reduction extended to 120 and 90 m from Casuarina and Eucalyptus, respectively. Soil temperature in the protected vineyards was significantly lower than in the unprotected vines. Generally, air temperature was significantly higher in the sheltered vines compared to the unsheltered vines. The increase in air temperature within the sheltered vineyard was in evidence between 50 to 100 m in the leeward of windbreaks. Moreover, the humidity was higher within the sheltered vineyards and the highest records observed in the vicinity of trees canopy.

From the previous mentioned results it can be concluded that Casuarina windbreaks are most effective compared to Eucalyptus windbreaks in the protection of vines from wind damage. Also, it is clear that the extent of leeward protection is directly proportional to the height of windbreak, so it is necessary to construct a replicated parallel windbreaks every 120-m of Casuarina windbreak and every 90-m of Eucalyptus.

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تأثير مصدات الرياح على العناصر المناخية الصغرى لكرمات العنب البناتى بغرب النوبارية، مصر

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تم تنفيذ هذا البحث في عامي ١٩٩٨، ١٩٩٩ لدراسة تأثير مصدات رياح (الكازوارينا والكافور) على بعض العناصر المناخية الصغرى مثل سرعة الرياح ودرجة حرارة التربة والهواء وكذلك الرطوبة النسبية للهواء وذلك حول كرمات العنب وعلى مسافات مختلفة من مصدات الرياح. وتشير أهم النتائج إلى ما يلي:

١. أدى وجود مصدات رياح كل من الكازوارينا والكافور إلى الحد من سرعة الرياح داخل البستان وحول كرمات العنب فى الجانب الخلفي من المصد حيث تراوحت نسبة خفض سرعة الرياح بين ٥ – ٣١،٥ % ، ٨ – ٢٨ % ; ٦ – ٢٥ % ، ٨ – ٢٥ % وذلك بواسطة مصدى الكازوارينا والكافور في الموسمين الأول والثاني على التوالي.
٢. درجة حرارة الهواء حول الكرمات المحمية كان أعلى منها في حالة الكرمات غير المحمية وكانت الزيادة في درجات الحرارة واضحة في المسافة ما بين ٥٠ إلى ١٠٠ متر من الجانب الخلفي من مصدى الكازوارينا والكافور.
٣. الرطوبة النسبية للهواء كانت أعلى معنويا حول كرمات العنب المحمية .
٤. درجات حرارة التربة في المناطق المحمية بمصدى الكازوارينا والكافور كانت أقل بصفة عامة عن درجات حرارة التربة للبستان الغير محمى.
٥. أوضحت النتائج أن مصد الكازوارينا أفضل من مصد الكافور في توفير الحماية لكرمات العنب حيث امتد تأثيره إلى ١٢٠ متر من المصد.
٦. وجد أن مساحة كرمات العنب المحمية من أضرار الرياح تتناسب مباشرة مع طول المصد، لذا فمن الضروري إعادة زراعة مصدات متوازية وموازية للمصد الأساسي وذلك كل ١٢ضعف لارتفاع المصد في حالة الكازوارينا وذلك منذ بداية زراعة المحاصيل المراد حمايتها.