

ORNAMENTAL PLANTS AND CLIMATE CHANGE: CARBON DIOXIDE AND ATMOSPHERIC TEMPERATURE

E.M. Koriesh

Hort. Dept., Faculty of Agric., Suez Canal University, Ismailia, Egypt



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ABSTRACT: Virtually, one usually experiences a significant coolness around and under trees in comparison to open sunshine, with qualitative variations. This study was conducted to investigate the effect of irrigation with saline water (8000 and 16000 ppm) on some trees and their effect on transpiration rates, and the impact of these trees on reducing the atmospheric temperature and therefore their impact on climate change. The trees under study were used in the study: *Bauhinia variegata*, *Cassia fistula*, *Cassia nodosa*, *Eucalyptus camaldulensis*, *Ficus retusa* and *Khaya senegalensis*. In general, results indicated that, the atmosphere was cooler around *Cassia fistula* by reduction of atmospheric temperature by 6.5 °C (also, it produces odorous flowers) followed by *Eucalyptus camaldulensis* (5.3 °C). Reduction of temperature was correlated with high transpiration rate after irrigation with saline water after 2, 4 and 8 days of irrigation. It can be concluded that, using of saline water in irrigation of ornamental trees is efficient to induce the cooling effect in our gardens. Also, results showed the superiority of some trees in their efficiency in absorbing CO₂ and were in the following order: *Ficus religiosa* (87.65); *Bauhinia variegata* (83.76); *Cassia nodosa* (81.53); *Eucalyptus camaldulensis* (80.15); *Khaya senegalensis* (79.04); *Chorisia speciosa* (73.29); *Cassia fistula* (72.54); *Bombax malabaricum* (72.34); *Erythrina variegata* (71.82); *Ficus retusa* (71.33); *Ficus benghalensis* (67.20) and *Tipuana speciosa* (65.99).

Key words: saline water, carbon dioxide, transpiration, cooling effects, *Bauhinia variegata*, *Cassia fistula*, *Cassia nodosa*, *Eucalyptus camaldulensis*, *Ficus retusa* and *Khaya senegalensis*.

INTRODUCTION

The cooling effect of a tree is a result of physiological tasks of the tree. It depends on tree characters including shape, leaves type and number, besides, tree physiological functioning such as rate of transpiration. The cooling produced by trees varies with species due to variation in several anatomical, structural and physiological attributes of the species (Caemmerer and Baker, 2007). Therefore, cultivation of trees is usually practiced for controlling the urban

environment including cooling and air pollution abatement (Nowak, 2002).

Working with some tree species, Gupta *et al.* (2018) disclosed temperature reduction under shades of trees from 0.64 °C to 2.52 °C whereas Abdel-Aziz (2014) reported cooling under tree shades from 1 °C to 5 °C. They added that transpiration is one of the most significant physiological functions achieved by plants, which affects cooling effect of tree.

When solar energy impinges on the leaf, water emerges from its surface through transpiration taking the latent heat to convert it into water vapor. This leads to a rise in humidity of the atmosphere and reduction in temperature of the leaf. To evaporate 1 gram of water requires 600 calories (Jones, 2007). To encourage research on identification of ecologically more valuable species is of utmost importance to face the present challenges of global warming.

Urban trees do not have the suitable share of conventional water for irrigation, needing the use of high saline water from wells or blended with fresh water. Under salt stress results of Hasanuzzaman *et al.* (2017) displayed that transpiration was higher in old leaves than in the young one leaves. Ben-Gal *et al.* (2008) said that increased application of saline irrigation water led to increasing transpiration. Salt tolerant plants transpired more water than the sensitive variety under normal growth conditions. In contrary, Schröder *et al.* (2014) concluded that salinity causes osmotic imbalance, reduced water uptake and transpiration.

Thus, the present study was conducted to determine the transpiration rates and cooling effects of some urban trees at Ismailia when using fresh or saline water.

MATERIALS AND METHODS

This experiment was carried out at Suez Canal Region, through June, 2018 (average temperature between 34.8 and 19.5 °C and relative humidity 44% (Climate in Ismailia, Egypt, 2018), to evaluate the effect of exposure duration for some trees to saline irrigation-water on transpiration rate. Also, the effects of transpiration rate on cooling effect (°C) in the surrounding area for each tree.

Plant materials

Five Fresh branches (in 5 replicates) of the following trees: *Bauhinia variegata*, *Cassia fistula*, *Cassia nodosa*, *Eucalyptus camaldulensis*, *Ficus retusa*, *Ficus religiosa*, *Chorisia speciosa*, *Erythrina variegata*,

Tipuana speciosa and *Khaya senegalensis* were used. This experiment was conducted during 2018 summer season. Transpiration was calculated after Royal Society of Biology (2008).

Salinity treatments:

Sodium chloride solution at concentrations of 0, 8000 and 16000 ppm were used. Transpiration rate per 1000 cm² green leaves after 2, 4 and 8 days was measured (Pawar, 2017).

Calculation the cooling effects:

- An estimate of the average tree size and average leaf area was carried out according to NParks Flora & Fauna Web (2019).
- Average number of leaves according to Czernia (2019).
- Transpiration rate according to Pawar (2017)
- Number of calories needed for evaporation of 1 g of water (about 600 calories) according to Behan (1992).
- Conversion of caloric value to C degrees according to Conversion of Measurement Units (2019).

Carbon dioxide absorption and calculations:

A suitable part was taken from each plant and placed in a glass container inside a handmade growth room with sufficient lighting. Carbon dioxide was injected from a liquid gas cylinder and measured. After 5, 10 and 15 minutes from the injection, the carbon dioxide concentration was measured. Leaves area of the plant part was calculated, and the amount of carbon dioxide absorbed was calculated per 1000 cm² of the leafy area for each plant. Carbon dioxide was measured by Indoor Air Quality Carbon Dioxide Meter Model 77535, Gainexpress Company.

Statistical Analysis:

All data were statistically analyzed as randomized complete blocks design (Bailey, 2008); using the MSTAT-C statistical package (Hasanuzzaman, 2008) and means

were compared by Duncan’s multiple range test $P \leq 0.05$ (Duncan, 1955).

RESULTS AND DISCUSSIONS

Effect of salinity levels on transpiration rate:

Table (1) shows that the use of saline water increased the transpiration rate in all trees under study. These results are consistent with the findings of Ben-Gal *et al.* (2008). It is evident in the same Figure that both *Eucalyptus* and *Cassia fistula* were the most transpiration plants at all treatments. In this respect, Taiz and Zeiger (2012) found that the plants differ in the parameters of

transpiration from each other.

The effect of trees on reducing the atmospheric temperature:

The results presented in Table (2) refer that *Cassia fistula* trees were the highest reducer of atmospheric temperature (6.517 °C) followed by *Eucalyptus* trees (5.343 °C). These findings among different trees may be related with the different size of the area occupied by the tree, number of leaves per tree and their transpiration rates.

Table (3) shows that trees differ in their efficiency of absorption or sequestration of carbon dioxide per 1,000 cm² plant leaves.

Table 1. Effect of saline irrigation-water levels on transpiration (cm³) after 2, 4 and 8 days of irrigation of some ornamental trees.

Plants	Salinity level (ppm)	Transpiration after 2 days for 1000 cm ²	Transpiration after 4 days for 1000 cm ²	Transpiration after 8 days for 1000 cm ²
<i>Bauhinia variegata</i>	0	11.0 d	25.5 c	22.3 h
	8000	9.1 de	25.5 c	23.8 h
	16000	5.6 ef	16.0 cd	23.4 h
<i>Cassia fistula</i>	0	29.2 b	55.6 b	29.0 gh
	8000	23.6 c	45.8 b	34.3 e-h
	16000	42.1 a	92.2 a	30.4 f-h
<i>Cassia nodosa</i>	0	7.4 d-f	15.7 cd	39.1 d-g
	8000	7.9 d-f	15.6 cd	41.6 d-g
	16000	7.9 d-f	16.6 cd	40.2 d-g
<i>Eucalyptus</i>	0	25.2 c	48.3 b	44.6 d-f
	8000	31.4 b	54.4 b	52.1 d
	16000	26.6 bc	47.7 b	47.9 de
<i>Ficus retusa</i>	0	5.9 ef	15.3 d	52.9 cd
	8000	4.6 f	10.7 d	85.7 b
	16000	8.6 de	16.2 cd	66.7 c
<i>Khaya senegalensis</i>	0	9.1 de	19.5 cd	106.6 a
	8000	7.3 d-f	14.3 d	144.9 a
	16000	9.0 de	16.7 cd	127.8 a

Means within a column having the same letter are not significantly different according to Duncan’s

Table 2. Effect of trees on reduction of the atmospheric temperature.

Plants	Cooling effect °C (based on transpiration of control treatments)
<i>Bauhinia variegata</i>	1.533
<i>Cassia fistula</i>	6.517
<i>Cassia nodosa</i>	4.527
<i>Eucalyptus camaldulensis</i>	5.343
<i>Ficus retusa</i>	4.123
<i>Khaya senegalensis</i>	3.896

Table 3. CO₂ absorption efficiency per 1000 cm² of tree leaves, arranged descendingly.

Plants	Efficiency of reducing CO ₂ % after 5 min	Efficiency of reducing CO ₂ % after 10 min	Efficiency of reducing CO ₂ % after 15 min
<i>Ficus religiosa</i>	87.6	92.1	92.6
<i>Bauhinia variegata</i>	83.7	89.0	94.3
<i>Cassia nodosa</i>	81.5	85.2	88.7
<i>Eucalyptus camaldulensis</i>	80.2	85.7	91.1
<i>khaya senegalensis</i>	79.0	89.3	92.2
<i>Chorisia speciosa</i>	73.3	90.3	95.9
<i>Cassia fistula</i>	72.5	81.8	91.1
<i>Bombax malabaricum</i>	72.3	82.7	93.2
<i>Erythrina variegata</i>	71.8	88.1	89.8
<i>Ficus retusa</i>	71.3	78.9	86.5
<i>Ficus benghalensis</i>	67.2	85.7	87.5
<i>Tipuana speciose</i>	65.9	84.7	86.3

Also, *Ficus religiosa* trees were the most efficient for the unit of area of leaves, followed by *Bauhinia variegata*. On the other hand, *Ficus retusa* trees, which are grown in large quantities in the Egyptian environment, are not the most efficient, and this requires a review of their cultivation in the Egyptian environment in general or in Ismailia in particular. The difference in trees' absorption of carbon dioxide corresponds to the results of Nowak (2002), Nowak *et al.* (2013) and Nowak *et al.* (2014).

Conclusion:

Saline water can be used for irrigation of the ornamental trees in gardens to reduce the ambient temperature and heat islands. Saline water may increase the transpiration rate of trees. *Cassia fistula* and *Eucalyptus camaldulensis* are suitable trees in cooling effect of Ismailia Governorate gardens.

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نباتات الزينة وتغير المناخ: ثاني أكسيد الكربون ودرجة الحرارة في الغلاف الجوي

عيد محمد قریش

قسم البساتين، كلية الزراعة، جامعة قناة السويس، الإسماعيلية، مصر

يعتبر النتح في الأشجار أحد الوسائل التي تستخدمها النباتات لتنظيم درجة الحرارة في الأوراق، وعادة ما يشعر الإنسان برودة حول أو تحت الأشجار مقارنة بأشعة الشمس المفتوحة، مع وجود اختلافات نوعية بين الأشجار. أجريت هذه الدراسة في مدينة الإسماعيلية بمصر بهدف التعرف على آثار استخدام المياه عالية الملوحة (٨٠٠٠ و ١٦٠٠٠ جزء في المليون) لبعض الأشجار وتأثيرها على معدلات النتح، وتأثير هذه الأشجار على تقليل درجة الحرارة للتغلب على مشكلة تغير المناخ. تم استخدام الأشجار التالية في الدراسة: خف الجمل، الخيار شمير، كاسيا نودوزا، الكافور العادي كامالدولينسيس، الفيكس ريتوزا والماهوجني الأفريقي. أوضحت النتائج ان يكون الطقس أكثر برودة بشكل عام حول الخيار شمير حيث انخفضت درجة الحرارة بمقدار ٦,٥ درجة يليها الكافور بمقدار ٥,٣ درجة . هذا الانخفاض في درجة الحرارة ارتبط بمعدلات نتح عالية عند استخدام الماء المالح بعد ٢ و ٤ و ٨ ايام من الري .

ويمكن التوصية بان استخدام الماء المالح في رى نباتات الزينة في الحدائق العامة وسيلة فعالة في خفض درجات الحرارة. أظهرت النتائج تفوق بعض الأشجار في كفاءتها في التخلص من ثاني أكسيد الكربون بالترتيب التالي: الأعلى الفيكس لسان العصفور (٨٧,٦٥٪) ثم خف الجمل (٧٣,٧٦%) ثم كاسيا نودوزا (٨١,٥٣%) ثم الكافور كمالديولنس (٨٠,١٥%) ثم الكايا (٧٩,٠٤%) ثم الكوريزيا (٧٣,٢٩%) ثم الكاسيا فستيوولا (٧٢,٥٤%) ثم البومباكس (٧٢,٣٤%) ثم الإرتريينا (٧١,٨١%) ثم الفيكس نتدا (٧١,٣٣%) ثم التين البنغالي (٦٧,٢٠%) وفي النهاية الأقل كفاءة أشجار أبو المكارم (٦٥,٩٩%).