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Investigation of Natural Air Conditioning through Tropical Avenue Trees

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Abstract-The present study gives an idea on effect of trees on temperature, relative humidity and light intensity. There was an increase in temperature with corresponding increase in distance from the base of trees. There was 1-2º C difference found from 0-6 meter distance away from the base under different tree species. Whereas the relative humidity decreases with corresponding increase in distance .The difference in temperature away from the base of tree was more pronounced in *F.benghalensis* and *F.religosa* than *E.camaldulensis*. This was 8-9º C lower as compared to vegetation free ground. The study emphasizes the role of tree in controlling the micro-climate of holkar science college campus Indore. Maximum shade was observed under *F.benghalensis*and minimum at *E. camaldulensis*.The average light cut off was three times more by *F.benghalensis* than *E. camaldulensis* out of five test species .The *Ficus species* were found more effective than other .The study suggest plantation of *Ficus species* in urban areas to feel comfort in summer months.

Keywords- Micro-Climate, Temperature, Relative Humidity, Light Intensity, Air Conditioning

I. INTRODUCTION

The main benefits of vegetation in hot climates are reduced solar radiation and lower air temperature due to shading and evapo-transpiration. Trees reduced amount of sunlight reaching soil and crops through shading and the extent of reduction varies according to crown dimension, tree phenology and leaf density (Breman and Kessler, 1995).Trees offer a cooling effect outside a building that is equal to 5 average air conditioners (Santamouris, 2001).Trees are the most effective vegetation element for the reducing overheating in urban areas. Open spaces types and in particular those with a high percentage cover of trees and water surface were the coolest areas in the city. An increase of trees canopy cover by 10% can reduced surface temperature on average by 1.4º C during day time on a hot summer day. In semi-arid Kenya, the temperature below surface were at least 5-9°C lower than in open grassland , both at beginning of the growing season and when grass cover was at a maximum.(Besley et al., 1989). However such studies are not available in our country. The present paper discusses the comparative effectiveness of five trees with reference to cooling from the base of the trees up to their canopy and surrounding areas.

II. MATERIALS AND METHODS

Indore is a historical city situated on the banks of rivers Khan and Saraswati, is the largest city of Madhya Pradesh. It is almost centrally located on the fertile Malwa Plateau at latitude 220 43’ North and longitude 760 42’ East and is the nerve centre of the economic activities of the state. According to the census conducted in 2011, the population of the city of Indore is 1,960,631. The density of population is 9,718 km^2. The city covers a total area of 3,898 sq km.
Five common trees species viz. *A.indica*, *E.camaldulensis, F. benghalensis, F. religiosa* and *M .indica* growing in college campus were selected for this study to know their comparative efficacy in controlling the micro-climate. To study the micro-climate of the college campus, temperature, relative humidity, and light intensity were monitored from the base i.e. 0 to 6 meters away from tree.

Ambient air temperature and Relative humidity was determined using a digital temperature and Humidity Indicator indosaw OSAW industrial product private limited ambala cantt. Haryana India. The probe was put at the standard height of 1.5 m. for air temperature at horizontal distances from the base of tree.

Light is an also important parameter in determining the micro climate it was determined using a Lux meter model LT luton AB 61221 made in Taiwan.

III. RESULTS AND DISCUSSION

Variation in temperature and relative humidity with increasing distance from the base of tree for different tree

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species are presented in table 1-5.There was an increase in temperature with corresponding increase in distance from the base of tree. Whereas relative humidity decreases as the distance increases. The average temperature and relative humidity was 32.5, 33.4, 33.8 and 16.5, 15.6, 15.1 respectively at 0, 4, and 6 meter distance. Thus temperature and relative humidity showed a negative correlation. The average temperature near the tree was comparatively 8-9 (°C) less as compared to the temperature recorded at vegetation free area. This study is in support with Owen et al., (1998) and Carlson and Arthur (2000). They studied the effect of land coverage changes on surface temperature. Through developing and analyzing land coverage parameters using remote sensed data, Carlson and Arthur (2000) found that temperature became higher, as vegetation grew smaller due to the urbanization. According to Eliasson (2000) air temperature was significantly lower inside park as compared to the surrounding built areas and in transition zone outside the park.

The lowering temperature and increased relative humidity in area covered by trees and shrubs can be assigned to more shading and evapo-transpiration. Toudert and mayer (2005) have also found similar result. More the temperature less the relative humidity (Fig. 1-5) as observed in present study was also reported earlier (Souch and Souch, 1993) in study conducted in Bloomington Indiana. They reported 27 -33% greater humidity under tree than at the open site. The difference in temperature away from base of the tree is more pronounced in *F.benghalensis* and *F. religiosa* than other *tree* species. As for as relative humidity is concerned the value were highest for *F. religiosa* and *F. benghalensis* as compared to *A.indica* and *E.camaldulensis.*

In the college campus, the maximum light intensity was recorded under *E. camaldulensis* the values were 6205.4 lux, 9300.1 lux, and 10444 lux respectively at 0, 4, and 6 meter away from the base of the tree (Table 6-9). In *F. religiosa* the value were 2654 lux, 6302 lux and 7852.9lux respectively at 0, 4, and 6 meter away from the base of the tree. In *A. indica* the value were 3544.7 lux , 5447.2 lux, and 5948.7 lux respectively at 0, 4, and 6 meter away from the base of the tree . In *M. indica* the value were 2140.7 lux , 5183 lux , and 6779.8 lux respectively at 0, 4, and 6 meter away from the base of the tree .In *F. benghalensis* the value were 1956.8 lux, 2774 lux ,and 4327.5 lux respectively at 0, 4, and 6 meter away from the base of the tree. A clear species wise variation in the light intensity reduction has been observed. On the basis of amount of light intensity from the base of tree the plant species can be arranged in decreasing order as follows-

E. camaldulensis > *F. religiosa* > *A. indica* > *M. indica* > *F. benghalensis*

The decrease in the light intensity under different tree species is result of interception of solar radiation mainly through the leaves. The light intensity appears to be related with the canopy cover and foliar density. More the cover of the tree less the amount of light reached to the ground (Fig.-6). The increase in light intensity at different distance can also be interpreted to the thinning of canopy cover and type of tree species. Akbari et al., (2001) have reported that tree canopy creates shade by its foliage geometry. Crown of trees that is created by branches leaves and twigs can provide shade and reduce wind speed. The shade cast by trees can reduce glare and block the diffuse light from the sky and surrounding surfaces, there by altering the heat exchange between the building and its surroundings. During the day, tree shading also reduces heat gain in buildings by reducing the surface temperature of the surroundings. The species wise variation can be attributed to the canopy cover more number of branches leaf size and orientation of the leaves. Obviously the canopy of *F. benghalensis* was denser as compared to *E. camaldulensis*. This is confirmed by the amount of light reaching at the base of tree in *E. camaldulensis* (6205 lux) and at the base of *F. benghalensis*(1956 lux) .

On the basis of present investigations it can be concluded that the *Ficus* species found more effective in cooling and creating comfort zone in the surrounding than other species .The study suggest plantation of *Ficus species* in urban areas to feel comfort in summer months. The study provides empirical data on the effectiveness of different planting strategies.

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REFERENCES

[1] Akbari, h.; pomerantz, m.; taha, h, cool surfaces and shade trees to reduce energy use and improve air quality in urban areas**.** Solar Energy, Tampa, **70**, n. **3**, pp. **295-310 (2001)**.

[2] Ali-toudert, f.; Mayer, h., Thermal comfort in urban streets with trees under hot summer conditions. In: PLEA 2005 – Passive and Low Energy Architecture, 2005, Beirut. Proceedings PLEA 2005 – Passive and Low Energy Architecture, Beirut: PLEA International, (**699-704**), **(2005).**

[3] Belsky, A.J., Amundson, R.G., Duxbury, J.M., Riha, S.J., Ali, A.R. & Mwonga, S.M. The effects of trees on their physical, chemical, and biological environments in a semi-arid savanna in Kenya. *Journal of* Applied Ecology, **26: 1005–1024**, (**1989.**).

[4] Breman, H. & Kessler, J.J. Woody plants in agro-ecosystems of semi-arid regions, with an emphasis on the Sahelian countries. Berlin, Springer Verlag. **340**, **(1995)**.

[5] Souch, C.A. and Souch, C.1993. The effect of trees on summertime below canopy urban climates: a case study, Bloomington Indiana. J. arboric.**19(5):303-312),** (**1993**).

[6] Carlson, T. N. and Arthur, S. T., the Impact of Land Use – Land Cover Changes due to Urbanization on Surface Microclimate and Hydrology: a Satellite Perspective, *Global and Planetary Change*, **25:49-65**, **(2000)**.

Table – 1

Variation in temperature and relative humidity at horizontal distance from the base of tree the *Azidirachta indica.*

March 11:00-2:00pm	**Ambient air temperature (°C)**	**Relative humidity (%)**	**0 meter**		**4 meter**		**6 meter**	
Date			**Temp. (°C)**	**RH (%)**	**Temp. (°C)**	**RH (%)**	**Temp. (°C)**	**RH (%)**
7	40.5±0.2	10.4±1.0	32±0.1	12.6±0.2	32.3±0.1	11.3±0.1	32.6±0.06	11.7±0.2
12	41.7±0.3	11.5±1.2	33.9±0.1	16.1±0.3	34.9±0.1	15.5±0.1	35.4±0.1	15.2±0.7
13	38.8±0.3	13.8±0.6	30.6±0.2	18.8±0.4	32.2±0.02	17.7±0.5	32.2±0.1	16.1±0.3
14	40.9±0.2	10.7±0.3	33.9±0.1	15.1±0.3	33.9±0.1	14.9±1.1	34.8±0.1	14.1±0.1
20	38.6±0.1	13.8±0.3	30.6±0.3	23.9±0.5	32.3±0.1	22.4±0.3	32.2±0	22.2±0.1
21	40.8±0.4	9.2±0.2	34.4±0.1	13±0.1	35.2±0	12.0±0.5	35.9±0.1	11.4±0.1
average	40.2	11.5	32.5	16.5	33.4	15.6	33.8	15.1

Table – 2

Variation in temperature and relative humidity at horizontal distance from the base of tree the *Eucalyptus camaldulensis*

March *1:00-3:00 pm*	**Ambient air temperature (°C)**	**Relative humidity (%)**	**0 meter**		**4 meter**		**6 meter**	
Date			**Temp.(°C)**	**RH (%)**	**Temp.(°C)**	**RH(%)**	**Temp.(°C)**	**RH(%)**
4	41.0±0.2	10.0±0.3	32.1±0.1	9.5±0.1	32.7±0.1	9.3±0.4	32.5±0.1	9.7±0.5
11	39.7±0.2	10.6±02	35.8±0.1	13.5±0.6	37.6±0.1	13.0±0.3	38.5±0.1	12.5±0.3
14	41.4±0.3	9.7±0.3	34.0±0.1	15±0.5	33.6±0.1	15.7±0.5	34.4±0.1	15.4±0.3
20	40.2±0.4	14.2±0.7	37.8±0.1	18.4±0.1	38.9±0.1	16.6±0.2	37.8±0.1	17.3±0.7
21	40.0±0.2	9.8±0.7	35.3±0.1	13.3±1.0	37.3±0.06	11.2±0.6	37.8±0.1	9.9±0.2
22	40.4±0.3	9.8±0.5	36.3±0.1	14.5±0.1	37.3±0.2	13.6±0.1	38.3±0.1	13.6±0.1
30	40.1±0.4	14.0±0.4	32.0±0.1	22.8±0.2	34.3±0.2	20.6±0.2	34.5±0.06	20.2±0.4
Average	40.4	11.2	34.7	15.2	35.9	14.2	36.2	14.0

Table-3

Variation in temperature and relative humidity at horizontal distance from the base of tree the *Ficus bengalensis.*

March *12:00-2:00 pm*	**Ambient air temperature (°C)**	**Relative humidity (%)**	**0 meter**		**4 meter**		**6 meter**	
Date			**Temp. (°C)**	**RH (%)**	**Temp. (°C)**	**RH (%)**	**Temp. (°C)**	**RH (%)**
7	40.6±0.2	11.0±0.6	31.5±0.1	12.5±0.2	31.8±0.1	13.4±0.2	32.5±0.1	11.7±0.3
12	40.4±0.2	11.9±0.3	33.1±0.1	17.6±0.4	34.5±0.1	16.2±0.2	34±0.2	17±0.7
14	38.1±0.3	16.9±0.4	26.9±0.1	35.4±0.7	28.0±0.3	31.5±0.1	27.9±0.7	30.8±0.1
20	39.8±0.1	16.9±0.6	30±0.2	29.8±0.3	32.9±0.2	26.6±0.2	34.8±0.1	23.5±0.1
21	40.2±0.3	10.7±0.4	31.3±0.1	17.1±0.2	34.2±0.1	15.3±0.1	34.4±0.1	14.4±0.2
30	39.5±0.2	15.2±0.5	30.7±0.1	25.7±0.4	31.9±0.1	25.2±0.1	33.5±0.1	22.4±0.2
Average	39.7	13.7	30.5	23.0	32.2	21.3	32.8	19.9

Table-4

Variation in temperature and relative humidity at horizontal distance from the base of tree the *Ficus religiosa* .

March 10:00-1:00pm	**Ambient air temperature (°C)**	**Relative humidity (%)**	**0 meter**		**4 meter**		**6 meter**	
Date			**Temp. (°C)**	**RH (%)**	**Temp. (°C)**	**RH (%)**	**Temp. (°C)**	**RH (%)**
1	39.4±0.2	17.8±0.5	23.8±0.1	33.6±0.4	25.5±0.1	32.4±0.3	26.3±0.4	30.5±0.3
4	40.4±0.3	6.9±0.4	31.3±0.1	11.2±0.2	32.4±0.1	11.7±0.1	31.9±0.1	11.9±0.4
5	40.8±0.2	7.0±0.5	31.9±0.1	11.3±0.9	32.4±0.1	10.8±0.5	32.8±0.1	10.3±0.1
7	40.8±0.3	7.9±0.6	31.9±0.2	12.7±0.5	32.6±0	12.2±0.4	32.7±0.1	12±0.1
9	38.3±0.2	11.0±0.5	28.4±0.1	24.1±0.6	31.2±0.1	18.6±0.3	31.7±0.1	19.4±0.3
11	38.0±0.05	11.0±0.5	30.2±0.1	25.5±0.4	31.8±0.1	20.3±0.1	33.0±0	18.4±0.3
12	39.8±0.2	12.4±0.7	32.0±0.1	19.9±0.7	34.5±0.1	16.3±0.1	35.2±0.2	13.7±0.9
14	37.9±0.1	11.5±0.7	29.4±0.1	23.3±0.2	31.2±0.1	18±0.7	32.5±0.1	18.6±0.6
20	37.2±0.2	17.8±0.4	27.5±0.5	35.3±0.2	29.6±0.2	29.0±0.6	31.8±0.1	27.1±0.3
21	39.4±0.3	10.1±0.4	30.2±0.1	19.4±0.2	32.9±0.06	15.7±0.1	34.0±0.1	15.7±0.3
30	38.8±0.2	18.5±0.5	29.5±0.1	28.0±1.4	31.1±0.1	16.6±0.4	32.5±0.1	23.2±0.1
average	39.1	11.9	29.6	22.2	31.3	18.3	32.2	18.2

Table -5

Variation in temperature and relative humidity at horizontal distance from the base of tree the *Mangifera indica* .

March 10:00-2:00am	**Ambient air temperature (°C)**	**Relative humidity (%)**	**0 meter**		**4 meter**		**6 meter**	
Date			**Temp. (°C)**	**RH (%)**	**Temp. (°C)**	**RH (%)**	**Temp. (°C)**	**RH (%)**
1	39.8±0.2	17.6±0.5	26.3±0.1	26.2±0.1	26.5±0.06	27.8±0.1	26.3±0.4	30.5±1.3
4	40.1±0.2	18.3±0.6	29.7±0.1	15.7±0.2	30.2±0	14.1±0	30.3±0.1	15.7±0.3
5	38.6±0.3	13.1±0.6	30.0±0.1	17.6±0.4	30.7±0.1	14.3±0.1	30.9±0.1	14.1±0.7
7	38.9±0.1	13.2±0.4	30.3±0.1	13.5±0.1	30.4±0.2	12.9±0.1	30.8±0.1	13.5±0.1
12	38.2±0.4	13.3±0.5	31.2±0.1	22.3±0.2	32.8±0.1	20.4±0.1	33.8±0.1	19.2±0.7
14	39.8±0.2	11.6±0.6	32.0±0.1	17.7±0.5	32.8±0.1	17±0.7	34.4±0.1	15±0.4
20	40.7±0.1	10.5±0.3	33.8±0.1	24.5±0.6	34.7±0.1	22.7±0.5	36.6±0.06	20.1±0.4
21	37.2±0.2	12.5±0.4	28.9±0.1	26.6±0.2	30.4±0	20.1±0.4	30.7±0.1	19.0±0.5
30	38.1±0.3	19.5±0.4	28.9±0.1	30.8±0.1	29.8±0.1	29.1±0.2	29.6±0.2	29.3±0.5
Average	39.0	14.3	30.1	21.6	30.9	19.8	31.4	19.6

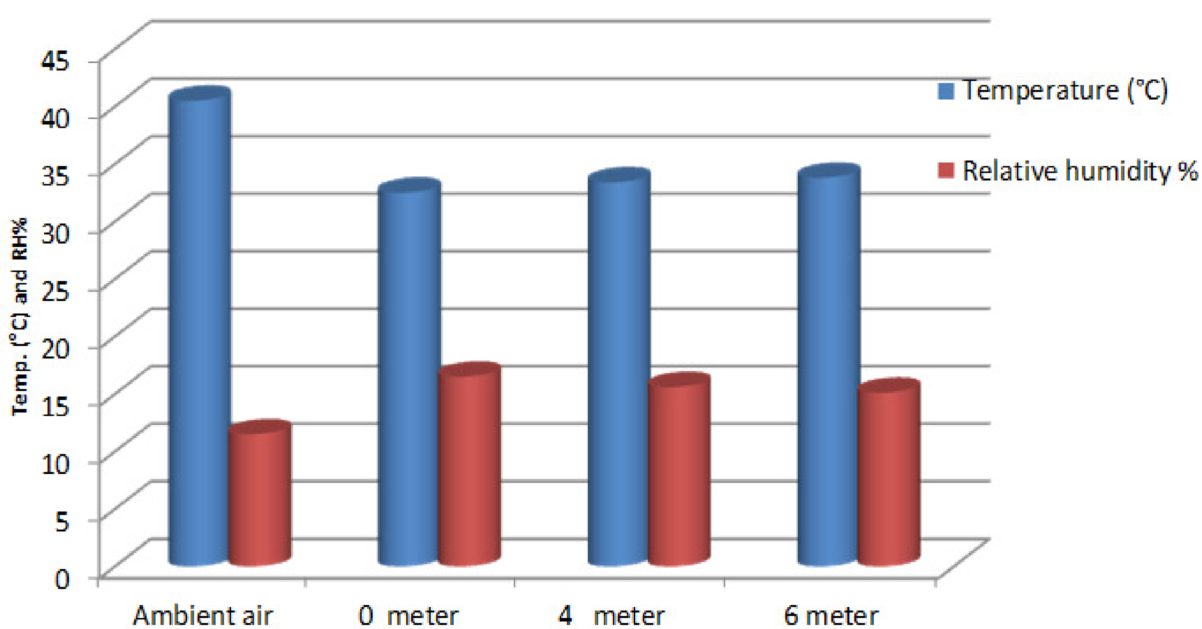

Fig 1 Variation in temperature and relative humidity from the base of the *Azidirachta indica* in the month of March

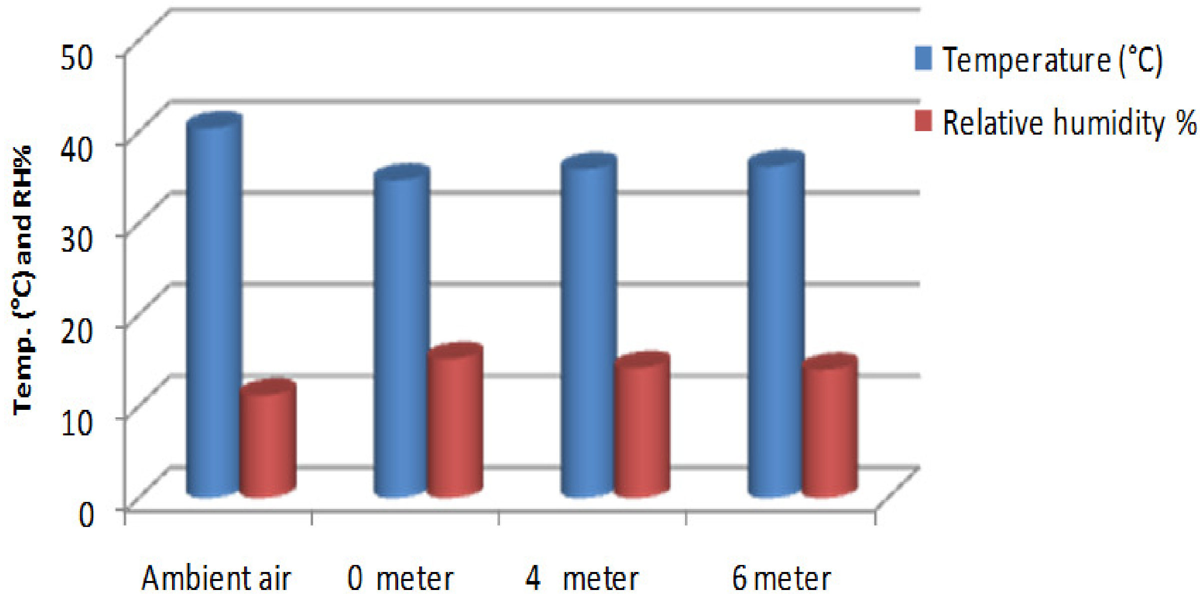

Fig 2 Variation in temperature and relative humidity from the base of the *Eucalyptus camaldulensis* in the month of March

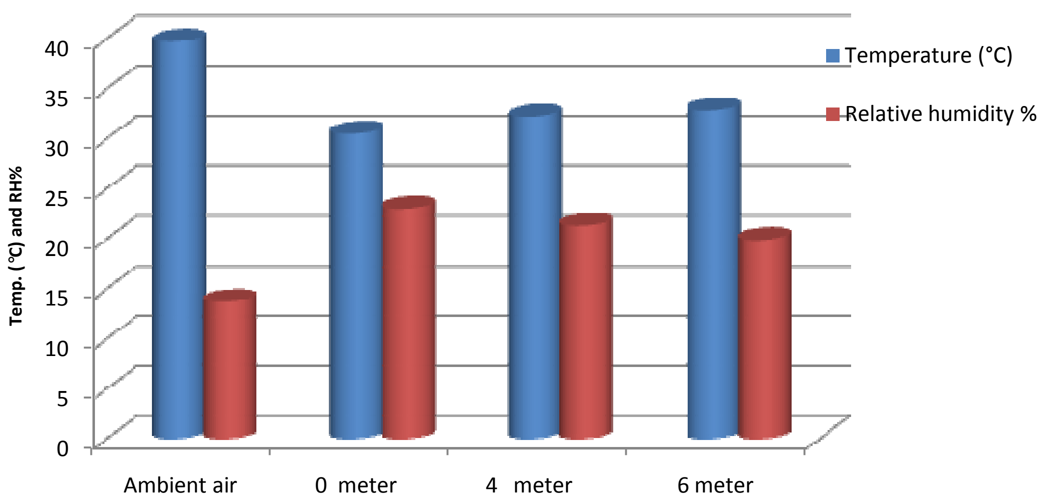

Fig 3 Variation in temperature and relative humidity from the base of the *Ficus bengalensis* in the month of March

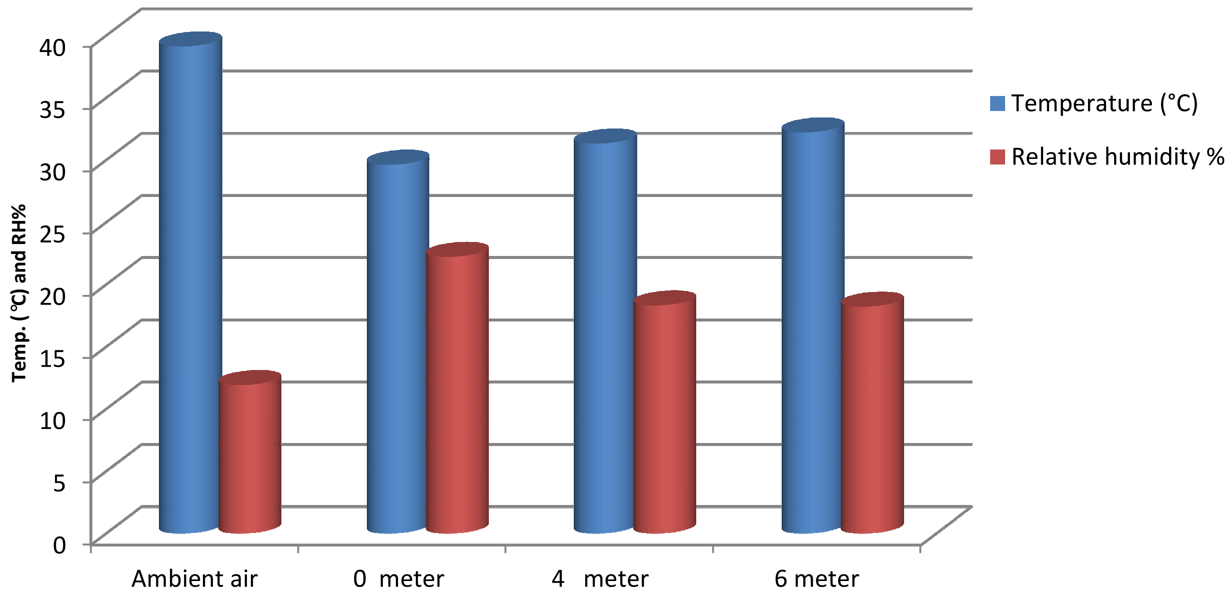

Fig 4 Variation in temperature and relative humidity from the base of the *Ficus religiosa* in the month of March

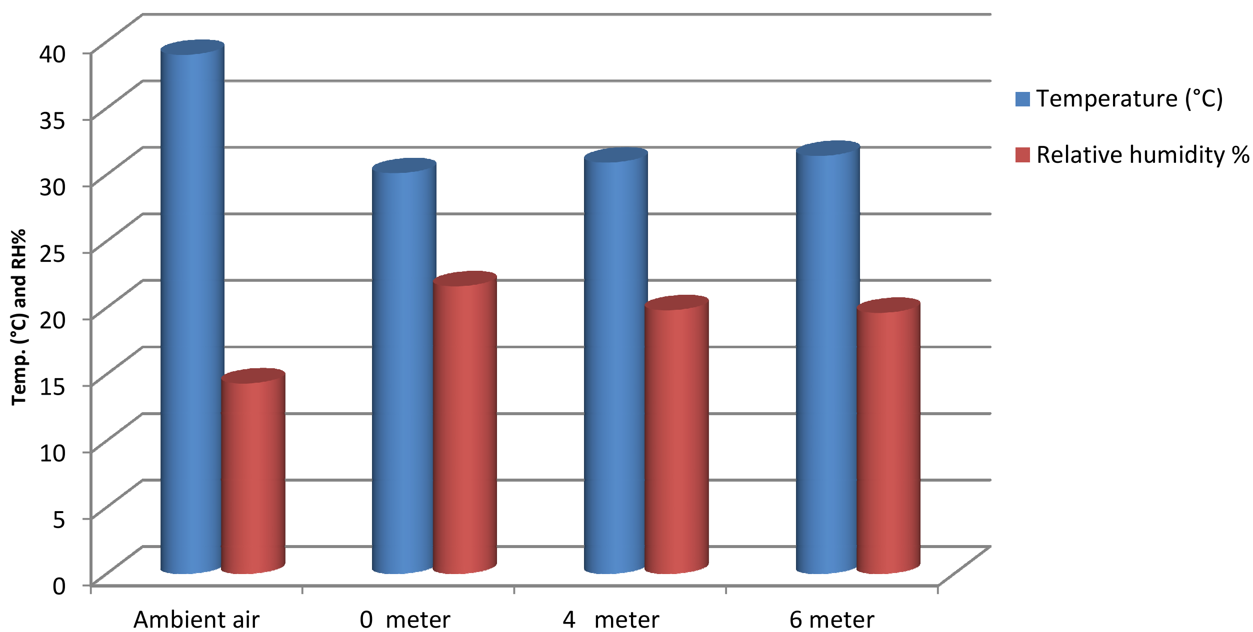

Fig 5 Variation in temperature and relative humidity from the base of the *Mangifera indica* in the month of March

Table- 6

Variation in light intensity (lux) from the base of tree in *Azidirachta indica*

March ***11:00-2:00 pm***	**0 meter**	**4 meter**	**6 meter**
7	2650±0.5	3533±1.0	3566±1.5
12	3033±0.5	5800±1.0	6666±1.5
13	4366±0	6766±1.5	7743±1.0
14	2966±0.5	3566±1.5	4233±1.0
20	4066±0.3	7200±0	7300±1.0
21	2766±0.3	4166±0	4400±1.0
30	4966±0.3	7100±1.0	7733±1.0
Average	3544.7	5447.2	5948.7

Table-7

Variation in light intensity (lux) from the base of treethe *Eucalyptus camaldulensis* **.**

March ***1:00-3:00 pm***	**0 meter**	**4 meter**	**6 meter**
4	3933±0	4990±1.0	5400±1.0
11	4843±1.0	9576±1.0	11100±1.0
14	4143±1.0	7233±1.0	6666±1.5
20	10043±1.0	13633±1.5	16113±1.0
21	4443±1.0	7556±1.5	7900±2.0
22	12733±0	16200±1.5	19266±2.0
30	3300±1.0	5913±1.5	6643±2.0
Average	6205.4	9300.1	10444

Table -8

Variation in light intensity (lux) from the base of tree the *Ficus bengalensis.*

March 12:00-2:00 pm	**0 meter**	**4 meter**	**6 meter**
7	1100±0	1186±1.0	1590±1.0
12	3166±0	3123±1.0	3123±1.5
14	1300±0	1590±1.0	1900±1.0
20	2866±0.5	4056±1.0	10600±1.0
21	1676±0.5	3366±0.5	4866±1.5
30	1633±0	3323±0.5	3886±1.0
Average	1956.8	2774	4327.5

Table -9

Variation in light intensity (lux) from the base of tree the*Ficus religiosa.*

March10:00-1:00 pm.	**0 meter**	**4 meter**	**6 meter**
1	1423±0	2576±1.0	5920±1.5
4	2403±0	2710±1.0	2586±2.0
5	2663±0.5	4376±1.0	4103±1.5
7	2563±0.5	3776±1.0	4576±1.5
9	1976±0.5	6233±1.0	8100±1.0
11	2300±0	5633±1.5	6066±1.5
12	3733±1.0	8933±1.0	13366±1.0
14	2676±0	6276±1.0	9066±1.0
20	3700±1.0	12466±1.0	13633±1.0
21	3000±1.0	8533±1.0	9933±1.0
30	2766±1.0	7810±1.0	9033±1.0
Average	2654	6302	7852.9

Table-10

Variation in light intensity (lux) from the base of tree the *Mangifera indica.*

March 10: 00-12:00AM.	**0 meter**	**4 meter**	**6 meter**
1	1630±0	3660±1.0	5920±1.5
4	1606±0.5	3016±1.0	4843±1.5
5	1240±1.0	3873±1.0	5733±1.0
7	1706±0.5	3596±1.0	4673±1.5
12	3666±0	7433±1.0	9333±1.0
14	2053±0.5	7066±1.5	8300±1.0
20	4953±0.5	14896±1.0	15700±1.0
21	2510±0.5	4620±1.0	6786±1.0
30	2043±0	3676±1.0	6500±1.0
Average	2140.7	5183.6	6779.8

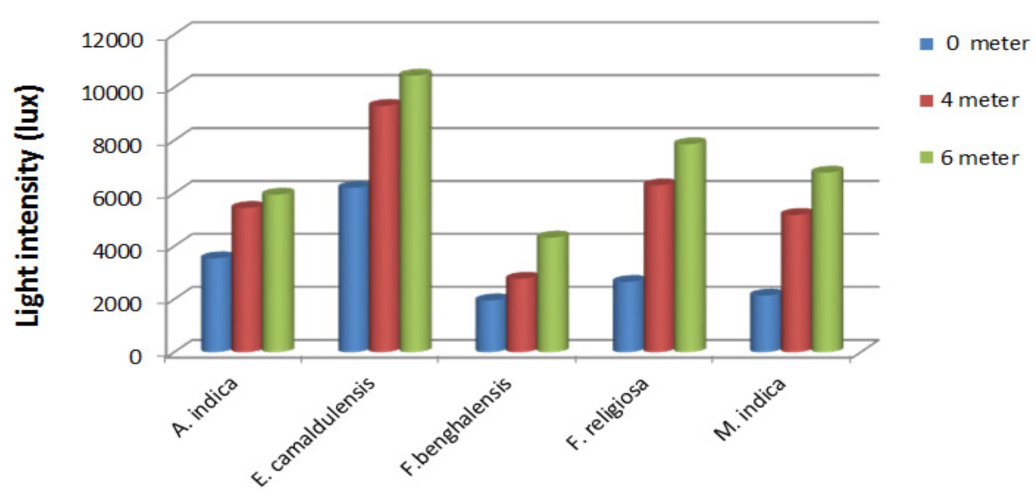

Fig 6 Variation in light intensity (lux) from the base of tree species

