

# Comparative study of different Tree species in controlling thermal comfort in Indore city

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## ABSTRACT

Thermal comfort generated by urban trees is as result of physical as well as physiological functions out of five common tree species studied *F. benghalensis* was found to be most effective providing coolness around them which ranges from (6.4-4.6°C) followed by *F. religiosa* (5.1-3.5 c) *Alstonia scholaris* was found to be least effective species with cooling efficiencies (3.5-5.6°C). The degree of cooling is found to be related with the canopy structure and leaf density.

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## INTRODUCTION

Trees and shrubs growing along roadside or in public parks are vital component of urban environment. Tree influences city climate chiefly by absorbing chiefly by radiant energy, atmospheric carbon dioxide and act as a major carbon sink. They also create microclimate under their crown in comparison to the outside ambient atmosphere (Dimoudi, and Nikolopoulou, (2003). It is a general experience that one usually experiences a significant coolness, under the shade of tree in public garden in comparison to the non-vegetated areas. The cooling generated by a tree is a result of physical as well as physiological functions of the trees. It largely depends on denseness of the crown, thickness of leaves and mainly on transpiration rates. The atmospheric parameters such as temperature, wind speed, relative humidity also influence the cooling generated by a tree under its shade (Akbari et al 1997). Lin and Lin 2010 reported in Taiwan temperature reduction under shade of trees from 0.64°C to 2.52°C.

However in our country such scientific work is very limited except an attempt to evaluate comparative study of common tropical tree species in controlling the microclimate (Pagare and Pawar 2013), recently Gupta et al 2018 made a comparative study of transpiration on the Cooling effect of forest tree species at Dehradun,. But to best of our knowledge no such work with reference to common urban trees species has not been work out. Looking to the parcity of research work in the field the present study was carried out to know the comparative cooling efficiency of five common urban trees.

## MATERIAL AND METHODS

To find out the cooling efficiencies of Five common trees, viz Mango (*Mangifera indica* L.), Neem (*Azadirachta indica* (A. Juss), Peepal (*Ficus religiosa* L.), Bargad (*Ficus benghalensis* L.), and saptarni (*Alstonia scholaris* (L.) R.Br.) were selected at different ten location of the city .

The Temperature humidity meter (HD- 203) was used for the temperature measurements, Temperature measurements were recorded in the Morning 8-10 am, afternoon 12-2 pm and evening 4-6 pm for alternate month on fair weather days. The data collection period spanned from Dec 2018 to Dec 2019. Temperature was measured at 1.5 m above the ground in the sunshine as well as under tree shades and at 2m, 4m, and 6m distance away from the base of the selected trees. The study was conducted in the following ten area of Indore city-

1 .Agriculture College 2. Alkapuri 3. Barfanidham 4. Bhavarkua 5. Chandan nagar  
6. Cloth market 7. Khajrana 8.Nanda nagar 9.Nehru nagar 10 Rajendra nagar.

The data present in the Table is an average of five sample reading

## RESULTS AND DISCUSSION

The cooling effect of the selected tree species varied across different months and with the distance from the base of the trees.

So in this study *F.benghalensis* is playing a major in maintaining outdoor thermal comfort followed by *F.religiosa* and *M.indica*

The lowering of temperature at ten selected location is presented in table 1.1-1.3, a perusal of this table clearly indicate that a reduction in average temperature as we go away from the canopy of the trees . A season wise variation in temperature under shade of different tree is very obvious. The summer days were comparatively hot as compared to rain and winter (fig 1.1). The maximum lowering in temperature was recorded for *F.benghalensis* winter to summer the values were (6.4°C-4.6°C) followed by *F. religiosa* 5.1°C to 3.5°C) minimum was found in *A.scholaris* here the values are here the reduction was only 3.15 to 2.1°C. As regarded the ambient air temperature in different location of Indore city in summer at bhavarkua (41.22) and alkapuri (41.36) we found very hot while Khajrana (34.8) and rajendra nagar (35.50) location were comparatively cool .one of the reason for higher ambient temperature might be very heavy traffic density at these traffic location.

The maximum cooling under *F.benghalensis* can be attributed to its dense canopy and thick leaves which may have reflected in coming solar radiation the reverse is true for *A.scholaris* were minimum cooling is found this can be accounted to sparse canopy structure branching pattern of the tree which allow more solar radiation at ground than other species such as *F. benghalensis* and *F. religiosa*

Recently Gupta et al 2018 has found reported similar finding regarding the cooling effect they have reported highest cooling on *Mangifera indica*. While in our work we find *F.benghalensis* to the most effective cooling species however *F.benghalensis* was not included in their work

**Table 1.1 Species wise temperatures °C, and cooling under trees in winter**

S.NO.	Location	<i>Alstonia scholaris</i>	<i>Azadirachta indica</i>	<i>Ficus benghalensis</i>	<i>Ficus religiosa</i>	<i>Mangifera indica</i>
	Air Temperature	27.5±0.12	29±0.11	29.9±0.11	29.5±0.12	29.7±0.11
1	Temperature under Shade in Agriculture College	25.3 ± 0.1	24.3± 0.09	23.46 ± 0.13	24.21 ± 0.1	24.68 ± 0.11
	Cooling	2.14	3.64	4.54	4.14	4.34
	Air Temperature	33.5±0.13	32.5±0.13	32.5±0.12	33.5±0.13	32.5±0.11
2	Temperature under Shade in Alkapuri	30.95± 0.09	28.6± 0.08	27.39 ± 0.08	29.05 ± 0.07	28.75 ± 0.13
	Cooling	2.55	3.9	5.11	4.45	3.75
	Air Temperature	26.04±0.13	25.87±0.14	26.25±0.13	25.99±0.13	26.33±0.11
3	Temperature under Shade in Barfanidham	23.09± 0.15	22.37 ± 0.08	20.35 ± 0.12	21.19 ± 0.09	21.83 ± 0.1
	Cooling	2.95	3.5	5.9	4.8	4.5
	Air Temperature	28.4±0.11	29.06±0.12	28.95±0.013	28.7±0.12	29.03±0.13
4	Temperature under Shade in Bhavarkua	25.3± 0.13	24.16 ± 0.13	22.55 ± 0.15	23.6 ± 0.14	24.13 ± 0.13
	Cooling	3.1	4.9	6.4	5.1	4.9
	Air Temperature	0.14	28.56±0.14	28.01±0.14	28.14±0.11	27.84±0.14
5	Temperature under Shade in	24.27 ± 0.11	23.66 ± 0.1	22.51 ± 0.13	23.6 ± 0.14	23.34 ± 0.12

	Chandan Nagar					
	Cooling	2.8	4.9	5.5	4.9	4.5
	Air Temperature	30.15±0.12	31.13±0.13	29.79±0.12	±0.13	30.1±0.13
6	Temperature under Shade in Cloth Market	27.05± 0.13	26.33 ± 0.09	24.69 ± 0.11	25.6 ± 0.14	25.8 ± 0.13
	Cooling	3.1	4.8	5.1	4.7	4.3
	Air Temperature	27±0.13	27.41±0.14	24.28±0.13	25.8±0.14	25.81±0.14
7	Temperature under Shade in Khajrana	23.8 ± 0.17	22.71 ± 0.1	19.08 ± 0.12	20.9 ± 0.14	21.31 ± 0.11
	Cooling	3.2	4.7	5.2	4.9	4.5
	Air Temperature	27.77±0.13	28.73±0.13	28.49±0.12	27.93±0.14	27.53±0.13
8	Temperature under Shade in Nanada Nagar	24.27± 0.13	23.83 ± 0.13	22.99 ± 0.14	23.23 ± 0.16	23.23 ± 0.14
	Cooling	3.5	4.9	5.5	4.7	4.3
	Air Temperature	26.15±0.14	28.89±0.11	29.93±0.13	29.2±0.13	28.59±0.11
9	Temperature under Shade in Nehru Nagar	26.15± 0.15	25.39 ± 0.1	25.03 ± 0.13	25.1 ± 0.16	24.69 ± 0.13
	Cooling	3.2.	3.5	4.9	4.1	3.9
	Air Temperature	25.47±0.12	23.97±0.11	24.71±0.13	23.61±0.13	22.5±0.12
10	Temperature under Shade in Rajendra Nagar	21.97± 0.11	19.87 ± 0.11	18.81 ± 0.1	19.11 ± 0.11	18.7 ± 0.11
	Cooling	3.5	4.1	5.9	4.5	3.8

\*Average of five reading under the tree at 2,4 and 6m away from the tree.

**Table 1.2 Species wise temperatures °C, cooling under trees in summer**

<u>S.NO.</u>	Location	<i>Alstonia scholaris</i>	<i>Azadirachta indica</i>	<i>Ficus benghalensis</i>	<i>Ficus religiosa</i>	<i>Mangifera indica</i>
	Air Temperature	37.25 ± 0.13	37.45±0.14	38.23±0.14	38.71±0.11	39.1±0.11
1	Temperature under Shade in Agriculture College	35.75 ± 0.13	34.95 ± 0.13	33.73 ± 0.11	34.91 ± 0.13	35.61 ± 0.11
	Cooling	1.5	2.5	4.5	3.8	3.5
	Air Temperature	41.36 ± 0.12	42.31±0.12	42.54±0.14	42.35±0.12	42.36±0.12
2	Temperature under Shade in Alkapuri	39.56 ± 0.13	38.91 ± 0.12	37.74 ± 0.12	38.85 ± 0.12	39.26 ± 0.12
	Cooling	1.8	3.4	4.8	3.5	3.1
	Air Temperature	38.03±0.12	40.24±0.13	39.25±0.11	39.9±0.11	39.87±0.13
3	Temperature under Shade in Barfanidham	36.13 ± 0.12	36.94 ± 0.14	34.75 ± 0.12	36 ± 0.12	36.37 ± 0.11
	Cooling	1.9	3.3	4.5	3.9	3.5
	Air Temperature	41.22± 0.11	41.32±0.14	41.72±0.13	42.37±0.14	41.91±0.11

4	Temperature under Shade in Bhavarkua	39.12 ± 0.16	37.52 ± 0.11	36.42 ± 0.12	37.57 ± 0.13	38.41 ± 0.13
	Cooling	2.1	3.8	5.3	4.8	3.5
	Air Temperature	39±0.12	39.8±0.15	40.34±0.12	41.37±0.12	40.51±0.12
5	Temperature under Shade in Chandan Nagar	37.4 ± 0.1	36.3 ± 0.13	35.24 ± 0.12	36.67 ± 0.1	36.71 ± 0.11
	Cooling	1.6	3.5	5.1	4.7	3.8
	Air Temperature	34.03±0.13	35.15±0.11	34.98±0.12	35.82±0.13	35.7±0.12
6	Temperature under Shade in Cloth Market	32.23 ± 0.13	31.95 ± 0.14	30.08 ± 0.13	31.92 ± 0.14	32.3 ± 0.31
	Cooling	1.8	3.2	4.9	3.9	3.4
	Air Temperature	32.2 ± 0.14	31.95±0.12	30.08 ± 0.13	31.92 ± 0.11	32.3±0.12
7	Temperature under Shade in Khajrana	33.41 ± 0.13	33.15 ± 0.12	31.4 ± 0.12	32.89 ± 0.11	33.04 ± 0.13
	Cooling	1.4	3.5	4.6	3.5	3.8
	Air Temperature	34.81±0.12	36.65±0.12	36±0.11	36.39±0.14	36.84±0.13
8	Temperature under Shade in Nanada Nagar	34.8 ± 0.11	33.94 ± 0.11	32.81 ± 0.13	34.36 ± 0.1	34.16 ± 0.12
	Cooling	1.9	3.8	5.1	3.8	3.9
	Air Temperature	39.01±0.11	39.56±0.14	40.07±0.14	39.18±0.11	40.21±0.14

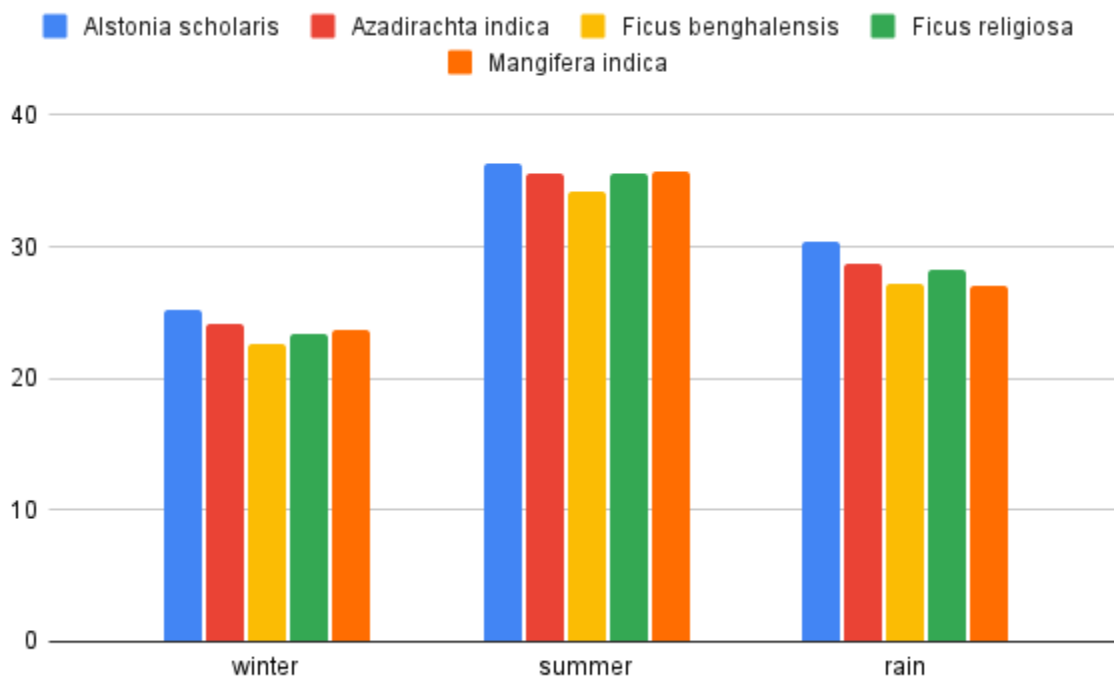
\*Average of five reading under the tree at 2, 4 and 6m away from the tree.

**Table 1.3 Species wise temperatures °C, cooling under trees in Rain**

S.NO	Location	<i>Alstonia scholaris</i>	<i>Azadirachta indica</i>	<i>Ficus benghalensis</i>	<i>Ficus religiosa</i>	<i>Mangifera indica</i>
	Air Temperature	33.37±.12	32.5±0.14	35.08±0.11	34.35	32.58±0.132
1	Temperature under Shade in Agriculture College	30.87 ± 0.11	29.4 ± 0.11	29.58 ± 0.13	29.45 ± 0.1	29.08 ± 0.11
	Cooling	2.5	3.1	5.5	4.9	3.5
	Air Temperature	32.73±0.11	30.84±0.11	33.13±0.12	0.11	30.71±0.13
2	Temperature under Shade in Alkapuri	29.93 ± 0.13	27.34 ± 0.13	27.33 ± 0.15	28.18 ± 0.11	27.01 ± 0.13
	Cooling	2.8	3.5	5.8	4.7	3.7
	Air Temperature	30.85±0.13	33.44±0.13	31.75±0.13	31.98±0.14	30.39±0.11
3	Temperature under Shade in Barfanidham	28.25 ± 0.12	29.84 ± 0.12	26.05 ± 0.15	27.18 ± 0.12	26.59 ± 0.13
	Cooling	2.6	3.6	5.7	4.8	3.8
	Air Temperature	33.4±0.14	31.98±0.13	33.56±0.14	32.44±0.13	30.92±0.12
4	Temperature under Shade in Bhavarkua	30.9 ± 0.17	28.48 ± 0.14	28.06 ± 0.15	27.84 ± 0.13	27.52 ± 0.16
	Cooling	2.5	3.5	5.5	4.6	3.4
	Air Temperature	33.9±0.13	31.08±0.11	33.56±0.13	32.37±0.13	31.02±0.14
5	Temperature under Shade in Chandan Nagar	31 ± 0.16	27.48 ± 0.14	27.96 ± 0.16	27.5 ± 0.13	27.52 ± 0.16
	Cooling	2.9	3.6	5.6	4.87	3.5

	Air Temperature	33.7±0.11	32.3±0.12	33.36±0.11	33±0.13	30.92±0.13
6	Temperature under Shade in Cloth Market	30.9 ± 0.17	28.5 ± 0.14	28.06 ± 0.15	28.5 ± 0.13	27.52 ± 0.16
	Cooling	2.8	3.8	5.3	4.5	3.4
	Air Temperature	34.3±0.1	32.1±0.14	31.46±0.14	33.71±0.11	31.22±0.14
7	Temperature under Shade in Khajrana	31.9 ± 0.17	28.5 ± 0.14	26.06 ± 0.15	29.01 ± 0.13	27.52 ± 0.16
	Cooling	2.4	3.6	5.4	4.7	3.7
	Air Temperature	31.45±0.14	33.37±0.13	32.48±0.15	32.11±0.13	30.27±0.14
8	Temperature under Shade in Nanada Nagar	28.65 ± 0.14	29.67 ± 0.13	26.88 ± 0.17	28.01 ± 0.14	26.47 ± 0.11
	Cooling	2.8	3.7	5.6	4.1	3.8
	Air Temperature	33.85±0.13	33.29±0.12	31.77±0.13	34.01±0.14	29.96±0.12
9	Temperature under Shade in Nehru Nagar	31.15 ± 0.16	29.79 ± 0.13	26.37 ± 0.13	29.51 ± 0.14	26.26 ± 0.15
	Cooling	2.7	3.5	5.4	4.5	3.7
	Air Temperature	32.6±0.12	31.86±0.13	29.98±0.12	33.06±0.12	27.86±0.11
10	Temperature under Shade in Rajendra Nagar	30.1 ± 0.18	28.56 ± 0.15	24.78 ± 0.16	28.46 ± 0.17	24.26 ± 0.13
	Cooling	2.5	3.3	5.2	4.6	3.6

\*Average of five reading under the tree at 2,4 and 6m away from the tree.



Graph 1.1 showing average temperature of all the three season at ten sampling stations under trees

## CONCLUSION

Trees interact with its ambient environment through exchange of energy and material leaves the chief organ of trees intercept the solar radiation and their by attain a certain temperature. Transpirational cooling result in lowering of ambient air temperature under trees. In present study out of five tree species *F.benghalensis* was found to be the most effective tree species in cooling the surrounding area followed by *F.religiosa* , while *A.scholaris* was noted to be least effective in providing thermal comfort. So plantation of *A.scholaris* cannot be recommended for thermal comfort as well as it is also allergic to people.

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