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Road Side Trees to Reduce Air Pollution Caused by Dust Particles

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ABSTRACT

The impact of dust particles on human health has become a major issue particularly among school children in Sri Lanka. Road side trees planted primarily for aesthetic purposes, provide coolness and shade, improve micro climate and reduce dust particles in air. However, there is little information on tree species for intercepting dust particles. Thus, the objective of this study is to identify potential tree species that could be used to reduce dust particles in urban areas. Six commonly used road side tree species, *Terminalia arjuna, Azadirecta indica, Tamarindus indicus, Khaya senegalensis, Thevetia Peruviana* and *Cassia* spp were selected for the study. Both quantitative and qualitative morphological characters which contribute effectively to mitigate dust particles were studied in all species. Based on the characters which contribute to a coarse texture and dense canopy, *T. arjuna* and *Cassia* spp can be recommended for road side planting to reduce air pollution caused by dust particles and also to obtain aesthetic benefits in landscaping.

KEYWORDS: Air pollution, Dust particles, Morphological characters, Road side trees

INTRODUCTION

Air pollution is one of the major environmental and health problems facing world today. Air pollution can be defined as any solid, liquid or gaseous substances present in the atmosphere in such concentrations that may tend to be injurious to human beings or other living creatures or plants or property or enjoyment (Purohit and Agrawal, 2006). Industrialization, urbanization, lack of awareness, increasing number of motor vehicles and badly maintained roads can be considered as the major causes of air pollution (Joshi and Chauhan, 2008). In Sri Lanka, Colombo Metropolitan Region was identified as an area of higher air pollution followed by Kandy town area, Galle, Kurunegala and Puttlaum (Anon, 2011).

Vehicle emission has been found to be a significant source of particulate contaminations (Matsumoto and Tanaka, 1996). Pollution caused by particulates is a serious health problem throughout the world, exacerbating a wide range of respiratory and vascular illnesses in urban area (Beckett *et al.*, 2000). Particulate matter is minute (10 µm and smaller) solid particles and liquid particles dispersed in the atmosphere. It includes dust, ash, soot, lint, pollen, spores, algal cells and many other suspended materials (Enger and Smith, 2004).

Diseases of the respiratory system ranked as the second leading cause of hospitalization in Sri Lanka (Senerath, 2003). Dockery *et al.*, (1989) reported positive associations between rates of chronic coughs, bronchitis and chest illness in school children and particulate pollution in the United State. It was revealed that a close relationship between air pollution in Colombo and acute childhood wheezing (Senanayake *et al.*, 1999).This is a serious matter especially among school children because most of the city schools are situated along very busy roads (Anon, 2012).

The abatement measures to reduce sources of particulate matter are generally costly, while natural sources are difficult or impossible to control. It is therefore becomes vital to explore alternatives to lower particle concentration in urban areas. The use of vegetation in filtering out particulates from the atmosphere has long been accepted and is common practice in some developed countries (Kulshreshtha *et al.*, 2008). Trees along roadsides establish primarily for aesthetic purposes, obtaining shade and coolness, attenuate noise, improve the micro-climate and effectively reduce particulate pollution (Varshney and Mithra, 1993).

Removal of air pollutants by plants from air is by three means, absorption, deposition and fallout from the leeward side of the vegetation (Prajapathi and Tripathi, 2008). Deposition of dust depends on the physical characteristics of particles and also the plant species (Harrison and Yin, 2000).

In Sri Lanka few studies were conducted to find out the relationship between the morphological characters and dust trapping efficiency of shrubs (Wijesinghe and Yakandawala, 2009; Kodikara and Yakandawala, 2010; Jayasinghe and Yakandawala, 2011). However, information on potential trees which can intercept dust particles efficiently is not available in Sri Lanka. Therefore, this study was conducted with the objective of identifying potential tree species with desirable morphological features that are capable of contributing positively for intercepting dust particles along road sides.

MATERIALS AND METHODS

Location

The study was conducted at the Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, during the period from January to May, 2013.

Collection of Materials

Six commonly found road side tree species, namely *Terminalia arjuna* (Kumbuk), *Azadirecta indica* (Kohomba), *Tamarindus indicus* (Siyambala), *Khaya senegalensis* (Khaya), *Thevetia peruviana* (Kaneru) and *Cassia* spp (Cassia) were selected for the study. The samples were collected along Wariyapola - Kurunegala main road between Wariyapola and Werapola. Five individual trees were selected randomly to represent a tree species and two mature twigs were selected from each individual. Then from each tree species, ten mature twigs were collected to measure quantitative and qualitative morphological characters as described by Wijesinghe and Yakandawala (2009).

Quantitative Morphological Characters

From each selected twig, petiole length and internodal distance were measured by visual observations. Three mature leaves were used from each twig to measure leaf width and length (visual observations). An eye piece graticule was used to measure hair length under the light microscope and hair density was measured using compound microscope (Table 1).

Qualitative Morphological Characters

The qualitative characters were recorded as described by Hickey and King (2000). Leaf arrangement, margin, orientation, folding and prominent venation of leaves were observed by visual observations. Hairs on petiole, stem, leaf margin, hair type and cell arrangement of hairs were studied under the compound microscope (Table 2).

Data Analysis

Data were subjected to ANOVA analysis with the help of Statistical Analysis System (SAS). Mean comparison was performed using Least Significant Difference (LSD) test to examine whether the difference among variables were significant at 5% probability level.

RESULTS

Quantitative Morphological Characters

The internodal distance varied from 1.86 cm to 5.59 cm. Significantly shorter internodal distance was recorded in *T. peruviana* followed by *K. senegalensis, T. arjuna* and *A. indica.* When consider the petiole length, it varied from 0.37 cm to 13.52 cm. Significantly shorter petiole lengths were recorded in *T. peruviana, T. arjuna and T. indicus.* The longest petiole length was recorded in *K. senegalensis.*

Leaf length varied from 8.54 cm to 29.11 cm. *Kahaya senegalensis* recorded significantly higher leaf length followed by *Cassia* spp, *A. indica* and *T. arjuna.* Leaf width varied from 1.04 cm to 22.66 cm while *K. senegalensis* recorded significantly higher leaf width followed by *A. indica, Cassia* spp and *T. arjuna.* Leaf hairs were present on upper surface only in *T. arjuna* and *A. indica* while on lower surface in *T. arjuna, A. indica* and *Cassia* spp. Where in *T. arjuna* hair densities were significantly high compared to other species. Length of leaf hairs varied from 0.70 mm to 0.95 mm and *Cassia* spp recorded significantly longer leaf hairs.

Qualitative Morphological Characters

Spiral leaf arrangement observed in *T. peruviana, Cassia* spp, *A. indica* and *K. senegalensis. Tamarindus indicus* possesses alternate leaf arrangement while *T. arjuna* possesses opposite leaf arrangement. All species possess semi erect leaf orientation except *K. senegalensis* and *T. peruviana. Tamarindus indicus, Cassia* spp, *T. peruviana* and *K. senegalensis* possess entire leaf margin while *A. indica* recorded serrate leaf margin. *Terminalia arjuna* showed crenate leaf margin. All species possess carinate leaf folding. Prominent venation was recorded in all species except in *T. indicus* and *T. peruviana.* Out of species studied, *T. arjuna, Cassia* spp and *A. indica* possess hairs in their leaves.

When consider the hair types of the species, *A. indica, Cassia* spp *and T. arjuna* possess unicellular solitary hairs. However, *T. arjuna, T. indicus* and *Cassia* spp showed hairs on stem, petiole and leaf margin except other species. It was interesting to note that, *T. indicus* possesses hairs only one side of the leaf margin. *Cassia* spp possesses hairs only in lower leaf surface while *A. indica* recorded hairs on midrib.

Table1. Quantitative morphological characters examined during the study

Tree species	Morphological character						
	Internodal Distance (cm)	Petiole length (cm)	Leaf length (cm)	Leaf width (cm)	Leaf upper surface hair density	Leaf lower surface hair density	Average hair length (mm)
CS	5.59^{a}	7.17^{b}	19.33^{b}	13.25^{c}	-	4.87^{b}	0.95^{a}
TA	4.50^{bc}	0.77^{c}	15.68^{c}	5.75^{d}	5.37^{a}	20.17^{a}	0.70^{b}
TI	4.77^{b}	1.00^{c}	8.54^{e}	3.23^{e}	-	-	-
AI	4.49^{bc}	6.33^{b}	17.87^{bc}	14.70^{b}	2.43^{b}	3.00^{c}	0.72^{b}
TP	1.86^{d}	0.37^{c}	12.42^{d}	1.04^{f}	-	-	-
KS	3.90^{c}	13.52^{a}	29.11^{a}	22.66^{a}	-	-	-

Means in a column with the same letters are not significantly different at the 0.05 level. Cassia spp - (CS), Terminalia arjuna - (TA), Tamarindus indicus - (TI), Azadirecta indica - (AI), Thevetia peruviana- (TP), Kahaya senegalensis- (KS)

Table2. Qualitative morphological characters examined during the study

Leaf character	Tree species					
	CS	TA	TI	AI	TP	KS
Arrangement	S	O	A	S	S	S
Margin	E	C	E	S	E	E
Orientation	SE	SE	SE	SE	E	H
Folding	C	C	C	C	C	C
Prominent venation	+	+	-	+	-	+
Leaf hair type	S	S	-	S	-	-
Hairs cell arrangement	Uni	Uni	-	Uni	-	-
Hairs on petiole	+	+	+	-	-	-
Hairs on stem	+	+	+	-	-	-
Hairs on leaf margin	+	+	+	-	-	-

Leaf arrangement : Alternate – A, Opposite – O, Spiral – S ; Margin : Crenate – C, Entire – E ; Orientation: Semi erect – SE, Horizontal- H; Folding: Carinate – C, Flat- F ; Prominent venation : present +, Absent -; Leaf hair type: Cluster- C, Solitary - S; Hairs cell arrangement: Unicellular- Uni, Multi cellular- Multi; Hairs on petiole: present +, Absent - ; Hairs on stem: present +, Absent - ; Hairs on leaf margin: present +, Absent -

DISCUSSION

Ability of a plant to intercept particles depends on its external microscopic and macroscopic morphological features which include internodal distance, petiole length, leaf folding, shape of leaf margin, hair type, hair length, hair density, leaf venation, leaf arrangement, leaf orientation, hairs on stem and petiole (Yunus *et al.*, 1985; Prajapathi and Tripathi, 2008; Wijesinghe and Yakandawala, 2009; Kodikara and Yakandawala, 2010; Jayasinghe and Yakandawala, 2011). Most of these Morphological features are collectively contribute to dense canopy and coarse texture of leaves that are very important factors for mitigating dust particles in air. According to Prajapathi and Tripathi (2008) shorter internodal distance, shorter petiole and high surface area have direct contribution to particle interception. When considering dust retention ability, petiole length is a very important character compared to others, especially for leaves with smooth texture. Small petioles reduce movement of leaves in wind thus, it increases dust accumulation in the leaves (Prajapathi and Tripathi, 2008). When considering the leaf arrangements apart from opposite, all other leaf arrangement types minimize the space in between and therefore give a complete cover. Further, leaf margins apart from entire, contributes to increase surface area that give positive contribution to dust accumulation. Considering the leaf orientation either horizontal or semi erect position reduces the inter-space among the adjacent leaves contributing to a dense cover. All these features help to increase the canopy density of a plant species.

Apart from density of the canopy, coarse texture of the leaf lamina is effective in trapping particles in air (Ingold, 1971). Presence of hairs and prominent veins on leaves positively contribute to the texture of leaves. The density, length and type of hairs influence over the coarse texture and there by the particulate interception ability. These microscopic structures can increase the effective surface area of leaves and trap particulates between them (Yunus *et al.*, 1985).

Terminalia arjuna and *Cassia* spp have a significant potential to intercept particles in air compared to other species because they possess desirable morphological features which contribute to the density of their canopy and coarse texture of leaves. *Terminalia arjuna* has shorter petiole length and semi erect leaf orientation that contribute towards a dense canopy while crenate leaf margin increases the effective surface area available to trap particles. Whereas the presence of hairs on both leaf surfaces, longer hairs and prominent venation contribute towards a coarse leaf texture. Further, hairs can be observed in petioles, stem and leaf margin which increase efficiency of particle interception ability. In *Cassia* spp, spiral leaf arrangement, semi erect leaf orientation and carinate leaf folding contribute towards a dense canopy. Whereas the presence of hairs on leaf lower surface, particularly longer hairs and prominent venation contribute towards a coarse leaf texture.

Though *Azadirecta indica* has high leaf length and width with coarse leaf texture it does not possesses a dense canopy due to its significantly long petioles and internodes. Though *K. senegalensis* has high leaf length and width it does not produce dense canopy due to its significantly long petioles, internodes and horizontal leaf orientation. In addition, it possesses smooth textured leaves due to the absence of leaf hairs.

Thevetia peruviana has shorter internodal distance and petiole length compared to other species. However, leaf width and length are significantly low. In addition, hairs absent on both surfaces of the leaves. Therefore, particle interception ability is low. In *Tamarindus indicus*, erect leaf orientation, low leaf length and width and long internodes contribute towards sparsely canopy though it has shorter petioles. Further, it has no hairs on leaf lower and upper surfaces.

Based on the present study, *T. arjuna* and *Cassia* spp can be recommended as potential tree species to intercept dust particles along road sides. In addition, *Cassia* spp has attractive yellow colour flowers and *T. arjuna* has brownish pink colour bark that are aesthetically valuable in landscaping.

CONCLUSION

Out of six road side species studied, *T. arjuna* and *Cassia* spp have dense canopy and coarse textured leaves which contribute positively for capturing dust particles from air. Therefore, *T. arjuna* and *Cassia* spp can be recommended to plant along road sides to obtain health benefits together with functional benefits and aesthetic aspects.

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