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Morphological Features and Landscaping Suitability of *Syzygium zeylanicum* (L.) DC. var. *lineare* Trees from the Belihuloya Region of Sri Lanka

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ABSTRACT

Purpose: *Syzygium zeylanicum (L.) DC. grows naturally in some of the Asian countries including Sri Lanka. In the Belihuloya region the S. zeylanicum trees are naturally grown with specific characteristics than the rest of the country and in other countries. It is scientifically identified as a different variety as S. zeylanicum (L.) DC. var. lineare (Wall.). There are no studies specifically focused on this tree in Sri Lanka. This study has focused on the studying morphological characters and suitability of S. zeylanicum var. lineare as a landscaping plant.*

Research Method: *Morphological characteristics of leaves, flowers, and fruits (pericarp thickness, seed diameter, width, length and weight of fruit) were recorded from randomly selected trees. Landscaping suitability was evaluated using measurements of shading under the tree canopy, the air pollution tolerance index of the plant and the general community perception.*

Findings: *Leaf (area, length, width, petiole length, internodal length, and leaf-veins-angle), flower (length and width of style, filament, floral cup and length of pedicel and anther) and fruit morphological parameters were significantly different among plants except for the width of anther, floral cup and fruit length. The average shading was 88.7%. Most of the surveyed persons preferred to grow the plants as a landscaping plant (47%). Twenty-six percent (26%) of the respondents indicated that it could be used as a good shade tree. Further, respondents identified fruit appearance, tiny leaves, and branching patterns are features that would give high landscaping value to the plant. The air pollution tolerance index was 9.72 in the control site and 9.32 in the polluted site.*

Research Limitations: *Selecting the same ageing plants for the study was difficult.*

Originality/ Value: *The plant can be used as a landscaping plant, mainly as a shade plant. The plant is sensitive in a polluted environment and can be used as an air pollution indicator.*

Keywords: *Air pollution tolerance index, Landscaping plant, Landscaping suitability, Morphological characters, Syzygium zeylanicum (L.) DC. var. lineare*

INTRODUCTION

Syzygium zeylanicum (L.) DC. is an evergreen tree species in the family Myrtaceae. It is widely distributed in many southern and eastern Asian countries including Sri Lanka (Anoop and Bindu, 2014) and is commonly known as '*Yakul maran'* in *Sinhala* language in Sri Lanka. The tree is naturally distributed in the dry, intermediate and wet zone coastal plains in Sri Lanka (Ashton, 2004). It has diverse uses, as a fruit plant, medicinal plant, timber plant, and being used to prepare a black dye (Fern, 2014). In Vietnam, the fresh leaves of this plant are

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eaten as food (Shilpa and Krishnakumar, 2015). The tree in Belihuloya region is with attractive leaf and branching patterns. The *S. zeylanicum* trees are naturally grown in Belihuloya region in high density with specific characteristics than the rest of the country and in other countries (D.S.A.Wijesundara, personal communication, March 20, 2020). It is scientifically identified as a different variety as *S. zeylanicum* (L.) DC. var. *lineare* (Wall.) (Ashton, 2004).

The specific features in *S. zeylanicum var. lineare* are mostly confined to the Belihuloya region specially leaf morphology and tree structure (personal observations). There is no any taxonomic or morphological study on *S. zeylanicum* var. *lineare* trees has been recorded. Every plant in nature must have unique morphological and anatomical traits. The growth of a certain plant species will be influenced by the surrounding environment, so there will be some morphological variations from one point to the next (Susetyarini, *et al*., 2019). Hence this morphological variation of *S. zeylanicum* var. *lineare* could be possible. Ecological variables and micro-geographical variations have a large role in determining genetic diversity among species (Reisch *et al*., 2003). Since the morphological traits of leaves, flowers, and fruits are the most crucial indicators for visually recognizing the plants, studying morphology is regarded as an important strategy to find the fastest way for researchers to characterize the species. As a result, the identification and classification of plant should be much easier in the end, especially in terms of naming species, families, and kingdoms (Susetyarini *et al.,* 2019). Hence it is important to study on the morphological features of this *S. zeylanicum* var. *lineare* tree.

Furthermore, designing conservation strategies requires studying morphological diversity and understanding how diversity is organized. It also aids in the resolution of taxonomic, phylogenetical, demographical, and ecological issues that are critical to conservation. Plant identification for varietal traits requires a basic understanding of morphological distinctions (Dissanayake *et al*., 2022).

Furthermore, nowadays, trees and other plants have high demand both locally and globally as landscaping plants. The visual comfort of a person can be positively influenced by a landscape, and a highly appealing landscape can have an impact on a person's psychology and behavior (Othman *et al*., 2015). There are reasons for choosing plants for the landscape. Plants provide aesthetic appeal and serve a specific function in the landscape, such as providing a screen, providing shade, blocking unwanted views, stabilizing a soil bank and providing the ability to adapt to poor soils (Schutzki, 2005). However, there is insufficient scientific literature on the aesthetic values of trees and their suitability for landscaping in Sri Lanka. However, there are no studies reported on *S. zeylanicum* var. *lineare* for its values as a landscaping plant in Sri Lanka.

Air pollution has been a conflicting global environmental issue for some time. Air pollution is intensifying each day as an outcome of industrialization and an increase in vehicular traffic (Gholami *et al*., 2016). Plants' responses to air pollution at biochemical and physiological levels can be assessed by analysis of factors that determine susceptibility and resistance. It has been shown that air pollution has an impact on total chlorophyll content, leaf extract pH, ascorbic acid content, and relative water content (Rai and Panda, 2013). Therefore, when selecting trees for landscaping, it is very important to consider the above factors to reduce air pollution. Therefore, the present study was undertaken with the objectives of morphological characterization and suitability of *S. zeylanicum* var. *lineare* trees from the Belihuloya region as a landscaping plant with particular attention to air pollution sensitivity.

MATERIALS AND METHODS

Location and Tree Selection

Twenty-four naturally grown *S. zeylanicum* var. *lineare* trees were randomly selected from the Belihuloya region of Sri Lanka for the experiment. An acronym was given to the selected trees for easy reference (from M1 to M26). The stem diameter of selected trees was 40 - 50 cm at 15 cm from ground level. The reason for this was due to branching start in some trees close to ground level.

To determine the air pollution tolerance index, trees were selected from two different sites in Belihuloya. One site was with continuous human disturbances such as with building construction and continuous vehicle movement in the Sabaragamuwa University premises. Here, the plants are frequently exposed to polluted gases emitted by vehicles. Therefore, the leaves of the plant have covered with a dusty layer. This site was considered as a polluted site. The other site which was considered as a natural site was situated in the jungle surrounded by forest trees and free from human activities. It is an undisturbed site 3km away from the polluted site. To determine APTI, five trees were selected from each site (Table 01).

Matured fresh leaves, ripened fruits, and bloomed flowers were collected from plants in the morning. Samples were carried to the laboratory in a cool box to record measurements.

Morphological Characters

Leaf morphology: Measurements were taken from twenty trees. Four mature leaves of each of the five leaf branches that were randomly chosen from each tree were used to record measurements. All leaf branches were photographed using Infinix Hot 10 Play camera (13MP). By analyzing the images using ImageJ software (ImageJ 1.45s, USA), leaf area, leaf length, leaf width, petiole length, internodal length and angle between leaf midrib and leaf veins were measured.

Floral morphology: Floral morphological characters were recorded from five trees on which only flowers were available from selected trees during the study period. A dissecting microscope (Stemi 305, Carl Zeiss Microscopy, Germany) mounting with a digital camera was used to observe and photograph the ten randomly selected flowers from each tree. Calyx tube (floral cup/perianth) length, calyx tube width at the open end, style length, style width, filament length, filament width, anther length and anther width (Figure 01) and pedicel length of photographed flowers were measured using ZEN 2.3 lite Software.

Fruit morphology: Fruit morphological characters were recorded from five trees. During the experimental period, fruits were available only on a few trees due to erratic bearing which is a characteristic of fruit trees that do not produce fruits every year in every tree. Most trees remained without bearing fruits in one season (Dissanayake *et al*., 2022). Therefore, fruit samples from five different trees were selected for the study on fruit morphology.

Table 01: Acronyms of trees in polluted Site and in natural site

Acronyms of trees in polluted site	Acronyms of trees in natural site
M 2	M 1
M 4	M 22
M 11	M 24
M 12	M 25
M 13	M 26

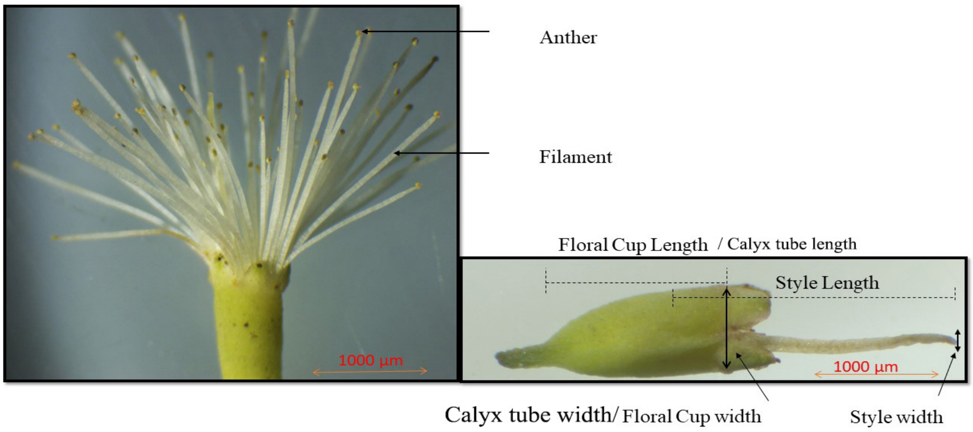


Figure 01: Floral morphology of *Syzygium zeylanicum lineare*

Randomly selected 20 ripen fruits from each tree were used for morphological study. A sharp laboratory knife was used to prepare cross-sections of ripened fruits. Cross sections of fruits were observed and photographed using a dissecting microscope (Stemi 305, Carl zeiss Microscopy, Germany) mounting with a digital camera. Pericarp thickness, seed diameter and fruit width (Figure 02) were measured by ZEN 2.3 lite Software. Fruit length and weight were measured using an vernier caliper and analytical balance (AR2140, Made in USA), respectively.

Structural characteristics of the Tree

As the tree structure, height of the tree, canopy height, canopy diameter, number of branches at the base and stem diameter were recorded from 23 trees. The height of the tree and canopy were measured using a clinometer (SILA, Made in Sweden) (Environment Protection Authority, 2013). Canopy diameter and stem diameter was measured using a measuring tape. The stem dimeter, measurement was taken at 15 cm of ground level due to many branches have developed in almost all trees close to the ground as separate stems. As there are many branches in the tree in similar size present close to ground level, the number of branches was also counted as part of the tree structure.

Community Perception of S. zeylanicum var. *lineare for Landscaping*

Subjective response data were collected from one hundred people through the distribution of questionnaires among the general community in the study area (Table 02). The questionnaire was prepared to obtain the awareness of the general community about *S. zeylanicum* var. *lineare* trees and their uses as landscaping plant. The information gathered were; general awareness about the usage of *S. zeylanicum* var. *lineare* trees, the preference for growing *S. zeylanicum* var. *lineare* as a landscaping plant, the preferred features of *S. zeylanicum* var. *lineare* as a landscaping plant, and the purposes to grow *S. zeylanicum* var. *lineare* in landscaping.

Shade Under the Canopy

Measurements were taken from twenty trees. Light intensity was measured at three places under the canopy of each tree and outside the canopy from the same levels using a lux meter (Brannan, Made in England). Light intensities were measured on sunny days three times from 11.00 a.m to1.00 p.m.

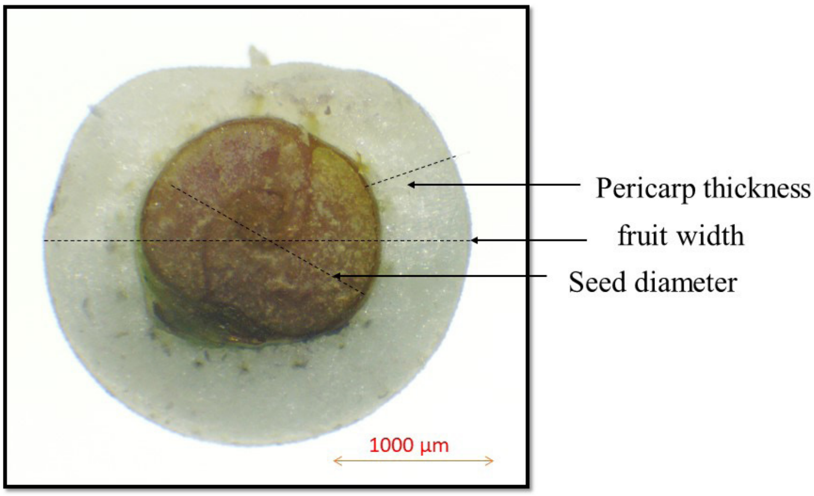


Figure 02: Cross section of ripen fruits of *Syzygium zeylanicum* var. *lineare*

Table 02: Components in the community perception survey form

	Make your selection
What is/are the use/uses	1. As a fruit plant 2. As a medicinal plant 3. For landscaping purposes 4. As a wood plant
Preferred features as landscaping plant	1. Appearance of fruit 2. Tiny leaves 3. Appearance of flower 4. Branching pattern 5. Form of plant canopy 6. Height of the plant canopy 7. Evergreen plant
Use as landscaping plant	1. As a wind barrier 2. As a focal point in the garden 3. As a shade plant 4. To increase aesthetic value in garden 5. As a screening plant 6. As a soil stabilizer 7. As a sound barrier

Air Pollution Tolerance Index (APTI)

Air Pollution Tolerance Index (APTI) value was calculated according to Singh and Rao (1983), which is given below.

$$\mathrm{APTI} = \frac{[A(T + P) + R]}{10}$$

Where, A = Ascorbic acid content (mg / g FW), T = Total Chlorophyll content (mg / g FW), P = Leaf extract pH, R = Relative water content (%),

Relative water content (RWC) in Leaves: RWC in leaves was determined according to Rajakaruna and Masakorala (2019). One gram of fresh leaves (wf) was measured using an analytical balance (AR2140, Made in USA). After leaves were immersed in deionized water overnight, their turgid weight (wt) was measured. Then samples were kept in the oven at 75°C till constant weight (wd). Following equation was used to calculate relative water content.

$$\mathrm{RWC} = \frac{Wf - Wd}{Wt - Wd} \times 100$$

pH of leaf extracts: Fresh leaf material of 0.5 g was ground and homogenized in 50 mL of deionized water, and pH was measured by using a calibrated pH meter (HQ40d, made in USA) (Rajakaruna and Masakorala, 2019).

Ascorbic acid (AA) content: AA content was determined by using the Indophenol dye redox titration method (Dissanayake and Wekumbura, 2020). Two grams (2 g) of fresh leaves were taken and crushed with 10 mL of 3% Meta phosphoric acid in mortar and pistol in cool condition. The mixture was filtered by using the suction pump with Whatman No: 01 filter paper. Using 2, 6-Dchloroindophenol dye solution (DCIP), 6mL of filtered extract was titrated. The end point reading was taken at a stable light pink color that appeared in the solution.

Determination of total chlorophyll content (Chl): One gram (1g) of fresh leaf material was measured and macerated well with 80% acetone. After five minutes the mixture was filtered by using Whatman No: 01 filter paper. Filtrates were centrifuged at 2795 x g centrifugal force for five minutes. Two milliliters (2 mL) of supernatant were taken to cuvette and measured the absorbance at 663 nm (A663) and 645 nm (A645) using spectrophotometer (GENESYS 10S UV-Vis, USA) (Arnon, 1949).

Data Analysis

Data were analyzed using one way analysis of variance (ANOVA) with the statistical analysis system in the online version. Means were separated using Duncan's multiple range test (DMRT) at $P < 0.05$. The Microsoft excel (2010) computer software package was used to prepare all the graphs. IBM SPSS statistical software was used to analyse questionnaire data.

RESULTS AND DISCUSSION

Leaf Morphology

Leaf area: The average leaf area of all selected trees of *S. zeylanicum* var. *lineare* was 5.16 (±0.26) cm^2 (Fig.03). The lowest average leaf area was recorded in the M8 tree (3. 41(±0.12) cm^2) (Fig.03 and Fig.04) and it was significantly lower than the rest of the trees expect M6, M9, M10, M11, M22 and M23 trees, whereas the highest value was recorded from M7 (7.49(±0.61) cm^2) and it was significantly higher than the rest of the plants except M2, M5, and M14. This showed that the leaf area of *S. zeylanicum* var. *lineare* in the Belihuloya region varies from 3.41cm^2 to 7.49cm^2. This leaf area is comparatively very low than that of other areas of Sri Lanka and other regions of the world (Ashton, 2004; Sasidharan *et al*., 2022).

Leaf length: The average leaf length of *S. zeylanicum* var. *lineare* trees was 5.92(±0.15) cm (Fig.05). The lowest average leaf length (4.94(±0.56) cm) was recorded in the M6 tree, and it was significantly lower than M1, M2, M3, M5, M7, M14, M15, M17 and M20. The highest average leaf length was recorded from M7 (7.30(±0.27) cm) and it was significantly higher than the rest of the plant except for M5, M15 and M20. The leaf length of other records was also within the range (Ashton, 2004; Sasidharan *et al*., 2022).

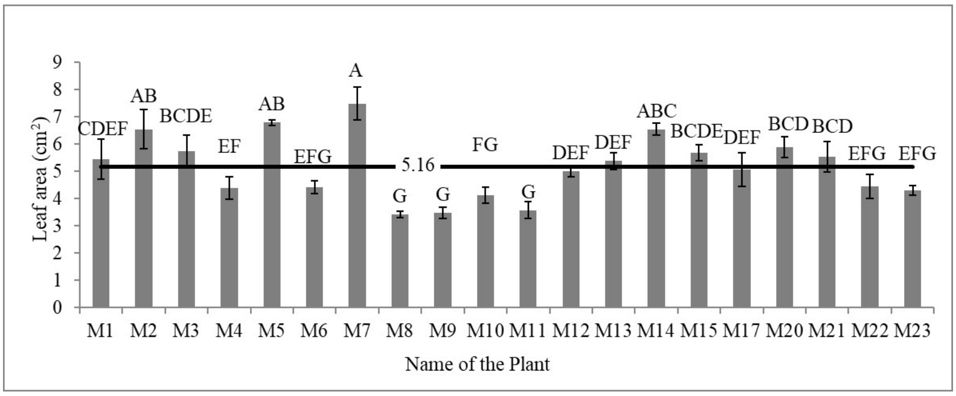
Leaf width: Average leaf width from Belihuloya region was recorded as 1.02(±0.03) cm (Fig.06). The highest leaf width was from the M2 tree (1.27(±0.11) cm). It was significantly higher than the rest of the trees except M3, M5, M7 and M14. The lowest leaf width (0.75(±0.02) cm) was recorded in the M9 and it was significantly lower than the rest of the trees except for M8, M10, M11, and M22.

Leaf lengths/ Leaf width ratio: Average Leaf length/Leaf width ratio of *S. zeylanicum* var. *lineare* was recorded as 5.88(±0.16) (Fig.07). The highest ratio was recorded from M8 (7.15(±0.16)) and it was significantly higher than the rest of the trees except for M9, M11, M17 and M22. The lowest ratio was recorded from M6 (4.72(±0.46)) and it was significantly lower than the rest of the tree except M1, M2, M3, M13, M14, M21 and M23. Leaf length/width ratio in certain extent represents and gives an idea about leaf shape (Dissanayake *et al.*, 2022). These leaves of the plants show a lanceolate shape.

Petiole length: Average petiole length from Belihuloya region was recorded as 0.55(±0.02) cm (Fig.08). Significantly longer petiole length (0.76(±0.04) cm) was found in M5 tree and it was significantly higher than the rest of the trees except M2, M7 and M13. The lowest petiole length was recorded from M22 (0.4(±0.02) cm). However, this was not significantly lower than other trees except M2, M3, M4, M5, M7, M11 and M13.

Internodal length: Average internodal length of total plants was 1.66(±0.06) cm (Fig.09). The highest internodal length was recorded in M5 tree (2.34(±0.08) cm) and it was significantly higher than the rest of the plant expect for M1, M7 and M17 plants. The lowest internodal length was recorded from M14 tree (1.21(±0.08) cm) and it was significantly lower than M1, M3, M4, M5, M7, M8, M9 and M17.

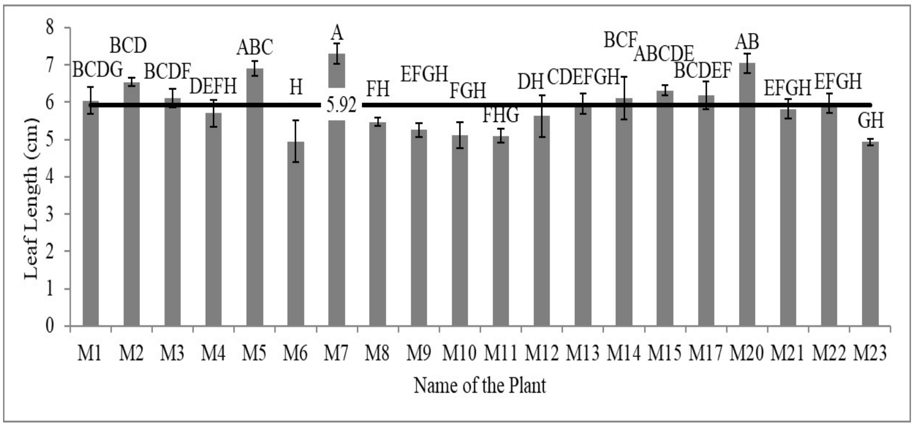
Angle between leaf midrib and leaf vein: Average leaf vein angle of total trees was 49.6(±0.91)^0 (Fig.10) and the highest angle was recorded from M9 tree (58.13(±2.87)^0). It was significantly higher than the rest of the trees except for M5, M6, M7, M8 and M21. The lowest angle was recorded from M1 plant (43.52(±2.44)^0) and it was significantly lower than M5, M6, M7, M8, M9 and M21 and M17.



(Vertical bars represent mean ± SE (n = 20). Means that do not share a letter are significantly different. Solid line across the graph shows mean leaf area of all plants, CV=17.64)

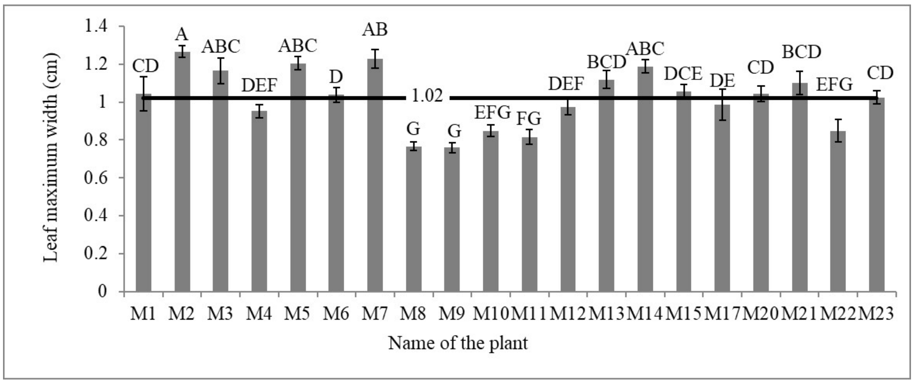
Figure 03: **Leaf area of *Syzygium zeylanicum* trees**

Figure 04: ***Syzygium zeylanicum* leaves with the highest and smallest leaf area from M8 and M7 Plants, respectively**



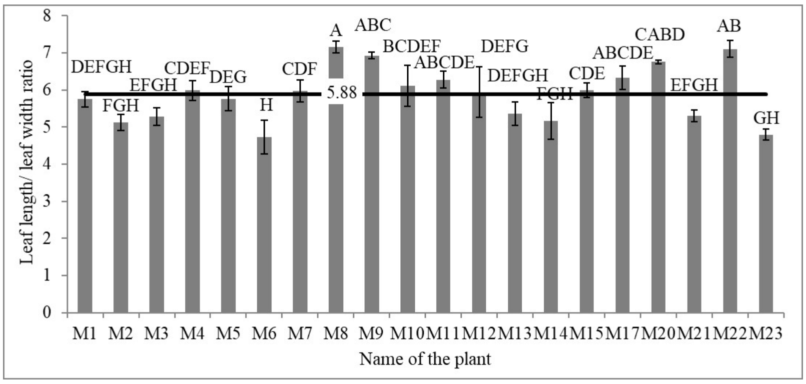
(Vertical bars represent mean ± SE (n = 20). Means that do not share a letter are significantly different. Solid line across the graph shows mean leaf length of all plants, CV= 12.15)

Figure 05: **Leaf length of *Syzygium zeylanicum* trees**



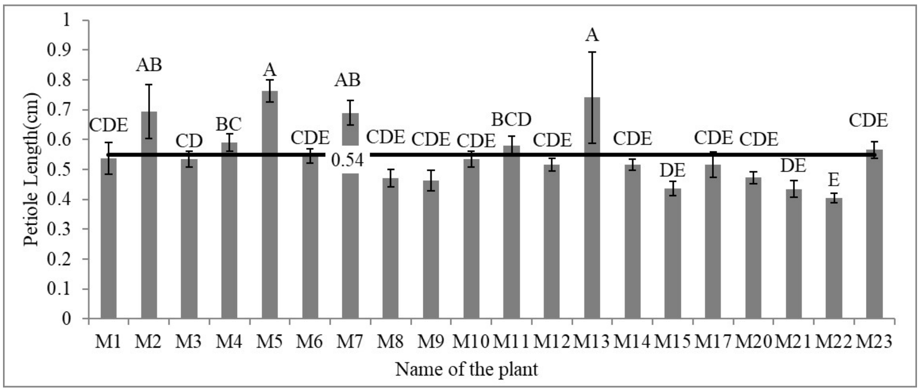
(Vertical bars represent mean ± SE (n = 20). Means that do not share a letter are significantly different. Solid line across the graph shows mean leaf maximum width of all plants, CV=11.24)

Figure 06: **Leaf Width of *Syzygium zeylanicum* trees**



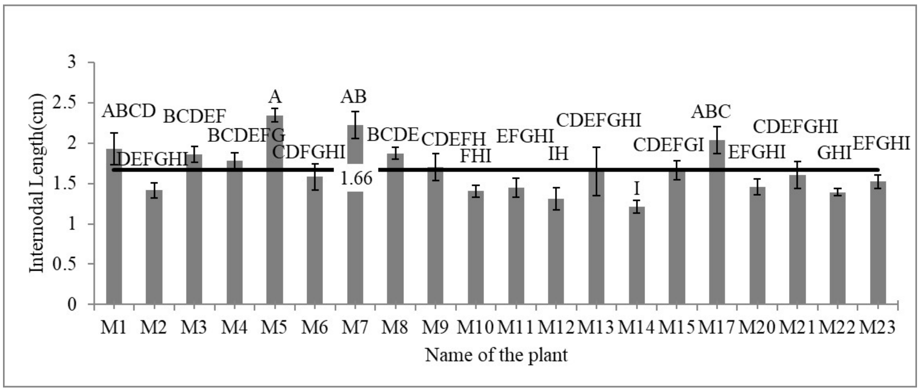
(Vertical bars represent mean ± SE (n = 20). Means that do not share a letter are significantly different. Solid line across the graph shows mean Leaf lengths/ Leaf width ratio of all plants, CV=12.17)

Figure 07: **Leaf length: Leaf width ratio of *Syzygium zeylanicum* trees**



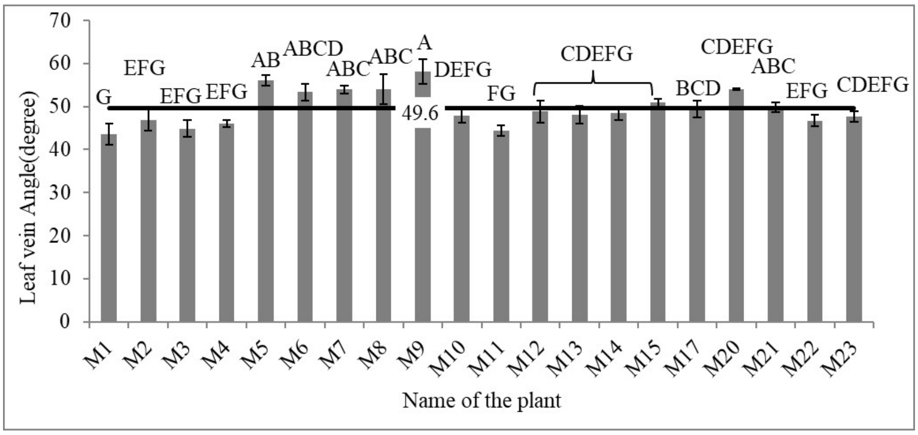
(Vertical bars represent mean ± SE (n = 20). Means that do not share a letter are significantly different. Solid line across the graph shows mean petiole length of all plants, CV=18.4)

Figure 08: Petiole length of *Syzygium zeylanicum* trees



(Vertical bars represent mean ± SE (n = 20). Means that do not share a letter are significantly different. Solid line across the graph shows means internodal length of all plants, CV=18.54)

Figure 09: Internodal length of *Syzygium zeylanicum* trees



(Vertical bars represent mean ± SE (n = 20). Means that do not share a letter are significantly different. Solid line across the graph shows mean angle between leaf midrib and leaf vein of all plants, CV=8.12)

Figure 10: Angle between leaf midrib and leaf vein of *Syzygium zeylanicum* trees

Floral Morphology

Floral morphology of the *S. zeylanicum* var. *lineare* trees is presented in Table 03. Nine (9) traits out of 10 traits, such as pedicel length (1.93±0.12mm), calix tube length (4.2±0.10mm), filament length (5.33±0.26mm), filament width (0.17±0.01mm), anther length (0.24±0.02mm), anther width (0.32±0.03mm), style length (7.23±0.42mm) and style width (0.41±0.03mm) showed significant differences among selected trees but not the calix tube width (2.01±0.05mm). This seems that tree to tree variation is high among the selected trees, but coefficient variation (CV) is lesser than 20 and lesser than 10 in floral cup length and in floral cup width. This implied that there was no significant variation of floral morphology among the population in the Belihuloya area. As there are no any detailed studies about the floral structure of *S. zeylanicum* var. *lineare* trees, values recorded in this study on floral morphology can be used as reference values. According to Ashton (2004) in flora of Ceylon volume II, only two floral characters are considered such as calyx tube length x width (5vmm x 3 mm) and stamen length (7 mm) of *S. zeylanicum* . In our study on *S. zeylanicum* var. *lineare*, those values were smaller than previously recorded in *S. zeylanicum* such as calyx tube length x width (4.2±0.10 mm x 2.01±0.05 mm) and stamens length (filament length 5.33±0.26 mm) (Ashton, 2004).

Fruit Morphology

Pericarp thickness, fruit width, seed diameter and fruit weight were also significantly different among all trees. However, the length of fruit is not significantly different among plants (Table 04). The average pericarp thickness recorded was 1.35±0.22 mm. It varied from 1.47±0.02 mm to 1.24±0.05 mm. This was a very thin layer of pericarp which does not attract consumers for commercial use as a fruit crop. The average fruit length (7.54±0.15 mm) and width (7.55±0.25 mm) are almost similar in dimensions. This showed that the fruit is almost globular in shape (globose to subglobose).

Table 03: Floral morphological characters of *Syzygium zeylanicum* (n=5).

Trees selected (with accession number)	Pedicel length (mm)	Floral cup length (mm)	Floral cup width (mm)	Filament length (mm)	Filament width (mm)	Anther length (mm)	Anther width (mm)	Style length (mm)	Style width (mm)
M2	1.95±0.15 AB	4.41±0.18 A	1.83±0.13 A	4.60±0.40 B	0.15±0.01 B	0.24±0.026 AB	0.29±0.02 A	7.22±0.26 B	0.33±0.02 B
M4	2.07±0.16 AB	4.39±0.12 A	1.98±0.05 A	5.05±0.2 AB	0.15±0.01 B	0.28±0.03 AB	0.30±0.02 A	7.30±0.20 B	0.35±0.01 B
M6	1.55±0.07 C	4.28±0.15 A	2.14±0.04 A	5.78±0.24 A	0.19±0.01 A	0.29±0.01A	0.40±0.01 B	8.72±0.23 A	0.5±0.01 A
M21	1.80±0.16 BC	3.85±0.09 B	2.09±0.03 A	5.13±0.22 AB	0.18±0.01 A	0.19±0.02B	0.25±0.02 A	6.66±0.4 B	0.36±0.03 B
M24	2.29±0.16. A	4.08±0.13 AB	1.99±0.07 A	6.07±0.22 A	0.18±0.01 A	0.18±0.01B	0.35±0.09 AB	8.74 ±0.26 A	0.52±0.01 A
Mean	1.93±0.12	4.2±0.10	2.01±0.05	5.33±0.26	0.17±0.01	0.24±0.02	0.32±0.03	7.23±0.42	0.41±0.03
CV	14.53	5.54	5.89	11.09	10.26	19.98	17.64	11.5	16.33

Note: Data were presented as mean ± SE. Values with similar letters are not significantly different in one column. CV =Coefficient of Variance.

Table 04: Fruit morphology of *Syzygium zeylanicum* (n=5).

Trees selected (with accession number)	Pericarp thickness (mm)	Fruit length(mm)	Fruit width(mm)	Seed diameter(mm)	Fruit weight(g)
M2	1.24±0.05 B	7.88±0.1 A	7.76±0.17 AB	5.44±0.15 A	0.22±0.01 C
M5	1.41± 0.06 A	8.07±0.1 A	7.98±0.34 A	4.53±0.37 B	0.26±0.01 B
M7	1.39±0.05 A	7.62±0.1 A	7.23±0.16 BC	4.16±0.11 B	0.20±0.01 CD
M8	1.26±0.051 B	7.50±0.1 A	8.05±0.1 A	5.56±0.11 A	0.31±0.01 A
M23	1.47±0.02 A	6.65±0.1 A	6.75±0.08 C	4.31±0.29 B	0.19±0.01 D
Mean	1.35±0.22	7.54±0.15	7.55±0.25	4.80±0.29	0.23±0.02
CV	16.82	9.18	13.07	24.95	21.13

Note: Data were presented as mean ± SE. Values with similar letters are not significantly different in one column. CV = Coefficient of Variance

The average seed diameter was 4.80±0.29 mm. This varied from 5.56±0.11 mm to 4.16±0.11 mm. This showed that comparative to the fruit size, seed size is higher to consider as commercial interest fruit crop. The average fruit weight was 0.23±0.02 g. It is varying from 0.19±0.02 g to 0.31±0.01 g.

As the coefficient of variations was almost lower than 25, the tree-to-tree variation of morphology of *S. zeylanicum* var. *lineare* was not implied that those trees were different forms or varieties. This could be the effect of surrounding micro climate such as soil condition, space between tress, exposure to wind condition in the area.

Structure of the Tree

The average values of all tree structure parameters are present in Table 05. According to our observation average tree height of *S. zeylanicum* var. *lineare* was 4.82m from ground level to the tip of the canopy. It however, varies from 2.6 m to 7.2 m. This is a medium size tree, which is more convenient to manage in any home or office garden. The average canopy height was 3.50 m. Canopy height also varies from 1.6 m to 5.8 m. The ground clearance of the tree was very small (average 1.36 m) and sometimes canopy reaches to the ground level. Hence in landscape applications, the removal of lower branches is recommended to provide ample space at ground level. Further, as the tree has many branches from the ground level, it is difficult to distinguish the main stem most of the time. At least two branches arise from the base. Tree canopy is also well spread with an 8.24 m diameter in average.

Community Perception of S. zeylanicum* var. *lineare for Landscaping

Awareness of usage of S. zeylanicum var. lineare: As a usage, most people are aware of *S. zeylanicum* var. *lineare* as a fruit plant (81.4%), though it is not commercially recognized as a fruit crop (Fig. 11 A). Only 34.3% of people have identified the tree as a landscaping plant. Meanwhile, 33.3% identified the *S. zeylanicum* var. *lineare* as a medicinal plant. Due to the *S. zeylanicum* var. *lineare* being a naturalized tree, most people do not have the intention of having this tree in the home garden. That could be the reason for receiving lower rating than the usage as a fruit crops.

Table 05: Structural characteristics of the *Syzygium zeylanicum* tree

	Height of the tree (m)	Canopy height (m)	Height to the canopy from ground (m)	Number of branches from base of main stem	Stem Diameter (cm)	Canopy Diameter (m)
Average	4.82	3.46	1.36	4.21	52.21	8.24
Maximum	7.20	5.80	2.42	11.00	79.62	11.83
Minimum	2.60	1.60	0.20	2.00	25.47	5.35

Perception on S. zeylanicum var. *lineare as a landscaping plant:* When asked about usage in landscaping, 76.5% of the respondents preferred to grow plants as landscaping plants (Fig.11 B). Only 4.9% of respondents do not prefer to grow *S. zeylanicum* var. *lineare* trees as landscaping plants, and 18.6% of respondents have no idea whether they prefer to grow plants as landscaping plants.

Preferred features of S. zeylanicum var. *lineare as Landscaping Plant:* More than 50% of the respondents selected the appearance of the fruit, tiny leaves, and branching patterns of the plant as their preferred features of *S. zeylanicum* var. *lineare* as a landscaping plant (57.8%, 55.9%, and 52.9% respectively) (Fig. 11 C). Other features such as the appearance of flowers, the form of the plant canopy, the height of the plant, and its evergreen nature also received more than 30% of preference as a landscaping plant. With those many preferred features, we can strongly recommend *S. zeylanicum* var. *lineare* as a most suitable eye-catching tree for landscaping with respect to the view of the general community. This implied that *S. zeylanicum* var. *lineare* trees would give more aesthetic value to the garden.

Uses of S. zeylanicum var. *lineare tree as landscaping plant:* When concerning the functions of growing *S. zeylanicum* var. *lineare* as landscaping plant, most people, 70%, identified it as a shade plant (Fig. 11 D). A percentage of forty-nine (49%) respondents identified the aesthetic value of the tree. Other uses were also identified, but in less frequency. It could be used as a wind barrier, a screening plant and a soil stabilizer. This implies that the general community has a considerable understanding of the value of the function of a tree in a garden. Shading and esthetic aspects are more promising uses of a tree in the garden. Through planting of *S. zeylanicum* var. *lineare* in a garden, people can get the expected value to the garden as a landscaping plant.

Shade Level Under Canopy

The average shade under the canopy of *S. zeylanicum* var. *lineare* trees was 88.7% (Fig.12). The highest percentage indicated by M17 tree (95.6%). The lowest percentage indicated by M23 tree (67.15%). According to Caldera and Perera, (2018), when 8%-27% of the solar radiation penetrates across the tree canopy, its values show high shade to moderate shade level of under canopy. The Plant Area Index (PAI) of the plant is effective to reduce light penetration and provide shade under the canopy. This shows that *S. zeylanicum* var. *lineare* is providing high shade under the canopy and can be used in landscaping as a shade plant.

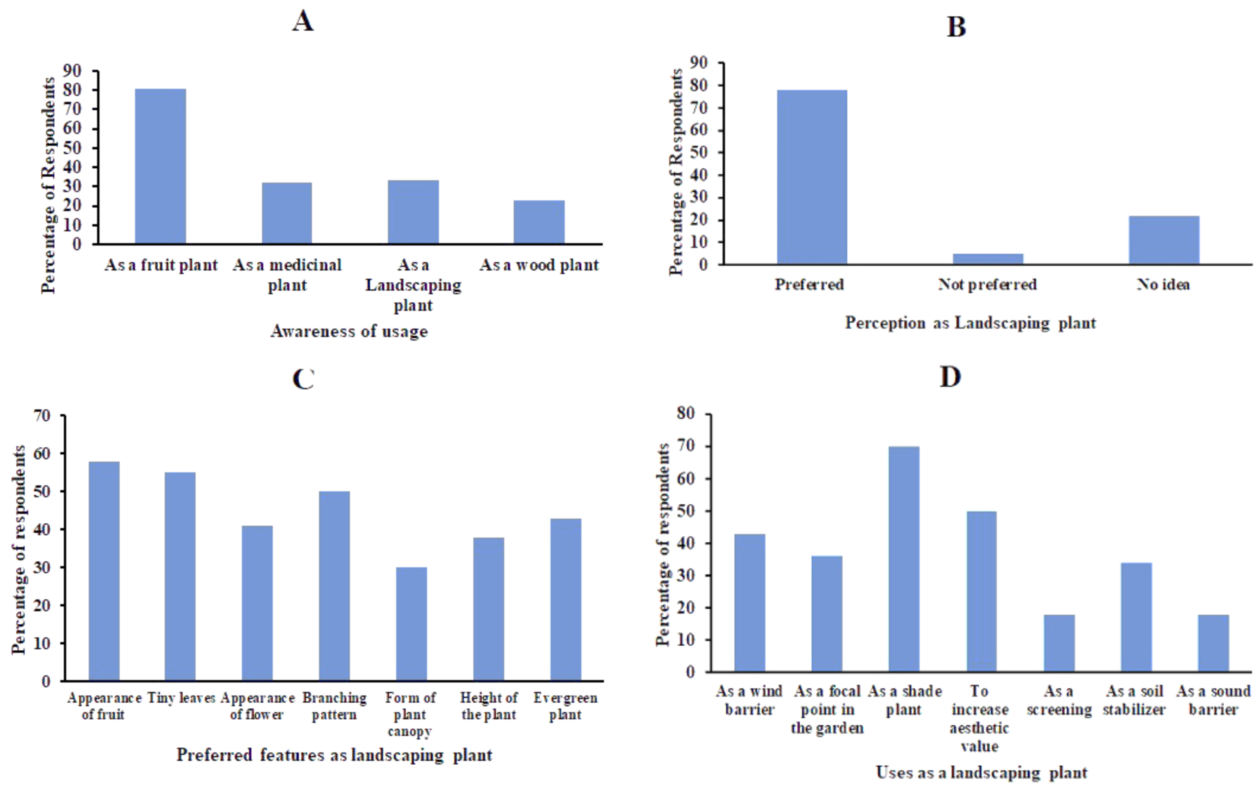
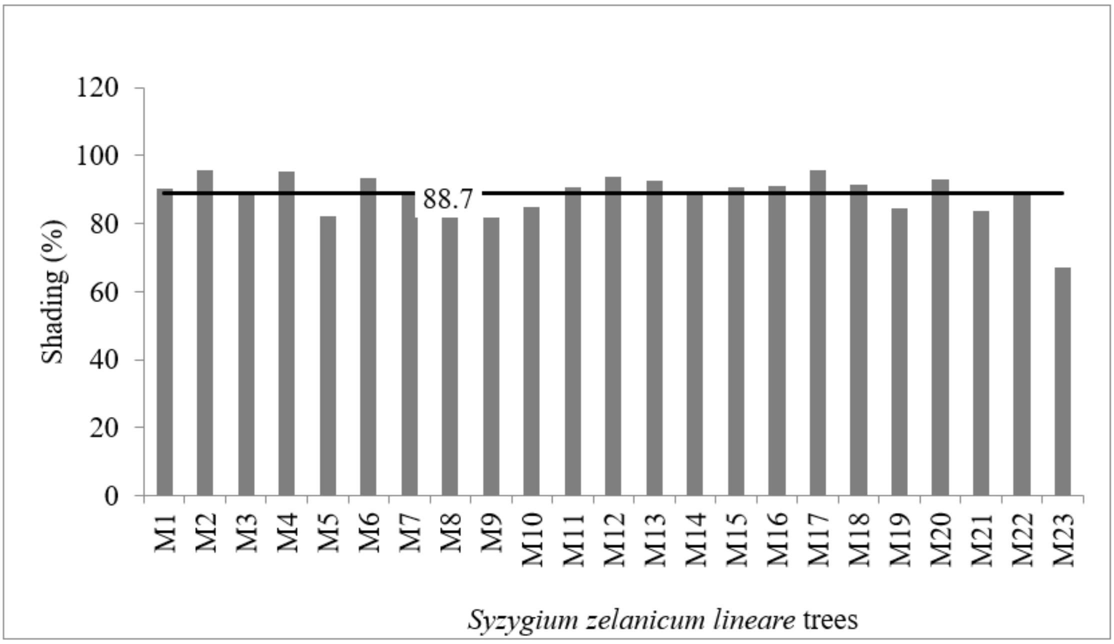


Figure 11: **Views and Perception on *Syzygium zeylanicum lineare* plant as a landscaping plant. A: Awareness of usage of *S. zeylanicum* var. *lineare* trees, B: Perception on *S. zeylanicum* var. *lineare* as a landscaping plant, C: Preferred features of *S. zeylanicum* var. *lineare* as Landscaping Plant, D: Uses of *S. zeylanicum* var. *lineare* tree as landscaping plant**



(Solid line across the graph shows average reduction percentage of light under canopy of all plants.)

Figure 12: **Shading under canopy of *S. zeylanicum* var. *lineare* trees**

Air Pollution Tolerance Index (APTI) of S. zeylanicum* var. *lineare

The tested parameters in this study have been used for the evaluation of *S. zeylanicum* var. *lineare* plants' tolerance to air pollution.

Relative water content (RWC): According to the results, there was a significant difference ($P < 0.05$) in relative water content between both sites (Figure 13). The RWC of plants in the polluted site was lower (93.26%) in comparison to the control site (97.26%). The average percentage reduction of the relative water content of trees in polluted site than control site was 4.11%.

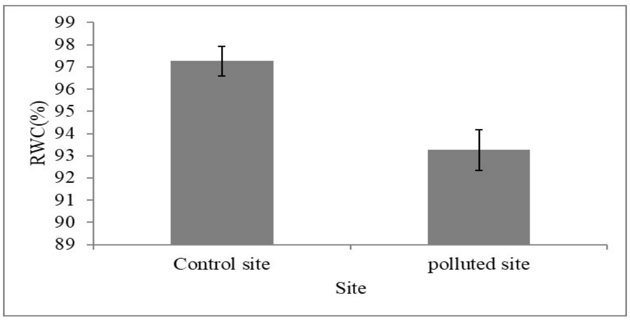
High water content in plants is highly supportive to maintain its physiological balance under stressful conditions, such as exposure to air pollution (Innes and Haron, 2000; Gholami *et al*., 2016). The lower the reduction in relative water content, the higher the above-mentioned physiological balance. Air pollution is a reason for higher transpiration rates (Rai and Panda, 2013). Further, air pollution increases cell permeability and it includes water loss along with dissolved nutrients (Rai, 2016). Plants are tolerant to polluted air if they can maintain higher relative water contents even in polluted air.

Ascorbic acid content (AA): Results show that the AA content in the polluted site has exceeded that of the control site (Fig. 14). The AA of plants in the polluted site was 17.2 X 10^{-5} mg/g FW and the AA of plants in the control site was 9.62 X 10^{-5} mg/g FW. The average percentage increments of ascorbic acid content in polluted site in comparison with control site was 72.6%.

As a defense mechanism to tolerate the stress caused by air pollution, plants show higher production of ascorbic acid. Therefore, ascorbic acid content in plants can be introduced as a very sensitive parameter for air pollution (Rajakaruna and Masakorala, 2019). Plant species with high content of ascorbic acid are considered to be tolerant to air pollutants (Gholami *et al*., 2016).

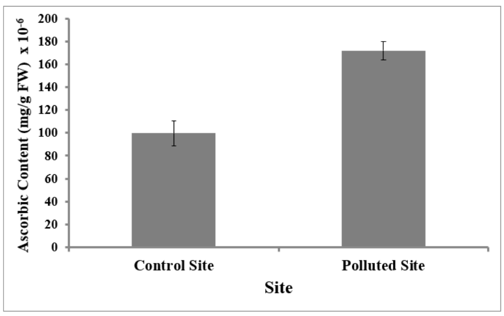
When pH increases in the plant, the ascorbic acid content of the plant also increases, and it occurs as vice versa (Rajakaruna and Masakorala, 2019). Furthermore, ascorbic acid content within a plant is more or less pH controlled. According to Ogunkunle *et al*. (2015), ascorbic acid is a natural detoxicant of air pollutants. It is also a molecule that scavenges free radicals that inhibit enzymes and is a catalyst for various physiological and biochemical processes (Gupta *et al*., 2016).

pH of leaf extracts: According to the results (Figure 15), there was a significant difference ($P < 0.05$) between the pH of leaf extracts in both sites. The pH of plants in the polluted site has been lower in comparison with the control site. The pH of plants in the polluted site was 5.09 and the pH of plants in the control site was 5.59. The average percentage reduction in pH of tree leaf extracts was 8.90 %. Gholami *et al*. (2016) reported that a high level of pH in a plant improves its resistance to air pollution and low level of pH in a plant is sensitive to air pollution. The burnt fossil fuels release acidic Sulfur Oxide and Nitric Oxide gases that also make the leaf sap acidic (Leghari *et al*., 2011). This could be the reason for reducing their pH in the polluted area.



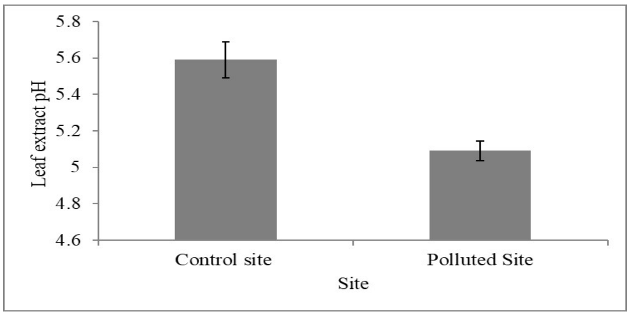
(Vertical bars represent mean ± SE (n = 10)

Figure 13: Relative water content of trees



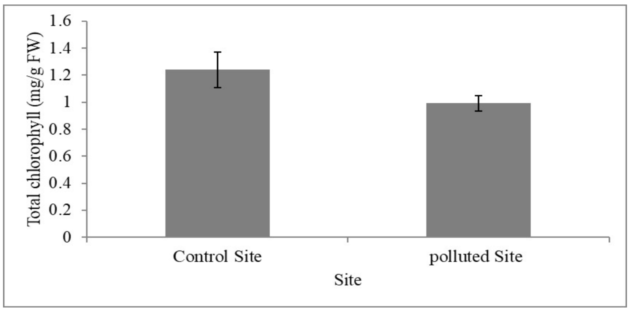
(Vertical bars represent mean ± SE (n = 10)

Figure 14: Ascorbic acid content of trees



(Vertical bars represent mean ± SE (n = 10)

Figure 15: pH of leaf extracts of trees



(Vertical bars represent mean ± SE (n = 10)

Figure 16: Total chlorophyll content of trees

Total chlorophyll content: Total chlorophyll content in the polluted site has been lower in comparison to the control site (Fig. 16). The total chlorophyll content of plants in the polluted site was 0.9921 mg/g FW and the total chlorophyll content of plants in the control site was 1.2411 mg/g FW. The average percentage reduction of total chlorophyll content of leaf extracts of trees was 20.05%. The chlorophyll content decreases with increasing pollutant levels because certain pollutants generally reduce the total chlorophyll content (Rajakaruna and Masakorala, 2019). However, the total chlorophyll content of leaf extracts in both locations did not differ significantly ($P< 0.05$). According to Gholami *et al*.(2016), plants might have developed mechanisms to maintain their chlorophyll content at a stable level.

The photosynthetic activity of the plant is indicated by the total chlorophyll content, and it determines the growth and development of plants. Plant chlorophyll content loss is a common indicator of poor air quality. Degradation of chlorophyll content in plants is caused by oxidation, reduction and bleaching, and inhibition of chlorophyll molecule biosynthesis by plant functional groups and pollutants (Rai, 2016). Tolerant plant species can have enhanced chlorophyll content at polluted sites as a defense mechanism under stressful conditions. (Rai and Panda, 2013).

Air Pollution Tolerance Index (APTI): The air pollution tolerance index in polluted sites was 9.32 and the air pollution tolerance index in control sites was 9.72. Both sites also showed low values. According to Padmavathi *et al*. (2013), *S. zeylanicum* var. *lineare* trees are sensitive to polluted air, and sensitive plant species can be utilized as bio indicators for air pollution levels, whereas tolerant plant species can be employed as pollution sinks (Leghari *et al*., 2011). Within these results *S. zeylanicum* var. *lineare* trees can be considered as an effective bio indicator.

The use of these four different metrics separately has shown contradictory results for the same species and according to Ogunkunle *et al*. (2015), these parameters individually may not provide a clear picture of pollution-induced alterations within plants. APTI, on the other hand, reflects a considerably more generalized output of all four factors. As a result, it is a useful tool for combining the data of all the observed parameters (Rajakaruna and Masakorala, 2019).

CONCLUSION

The morphological characteristics of the leaf (Leaf area, leaf length and leaf width, petiole length, internodal length and angle between leaf midrib and leaf veins), flowers (length of calyx tube, style, filament, anther, pedicel and width of style and filament), and fruit (pericarp thickness, fruit width, seed diameter and fruit weight) of *S. zeylanicum* trees in the Belihuloya region are diverse, except for the width of the anther and floral cup and length of fruit. As the coefficient of variations was almost lower than 25, the tree-to-tree variation of the morphology of *S. zeylanicum* var. *lineare* was not implied that those trees were different forms or varieties. This could be the effect of the surrounding micro-climate such as soil condition, space between tress, and being prone to wind conditions in the area.

According to respondents' feedback on the community perception survey, the *S. zeylanicum* var. *lineare* can be used as a landscaping plant, especially as a shade tree, and as a tree with aesthetic value. Moreover, other features such as branching pattern, small leaf size also contributed to the attractiveness of *S. zeylanicum* var. *lineare* trees as landscaping plant. When considering all above description, *S. zeylanicum* var. *lineare* has promising eye-catching features as a landscaping plant in the Belihuloya area of Sri Lanka. Further, the Air Pollution Tolerance Index showed that *S. zeylanicum* var. *lineare* is not tolerant in a polluted environment and it can be used as an air pollution indicator while using in landscaping.

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