



## Research Article

# Morphological and Anatomical Studies of Tea Varieties and Clones Grown at Nthri, Shinkari, Mansehra, Pakistan

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**Abstract** | The primary knowledge gap and problem statement for all tea varieties and clones in my study field relate to their morphological and anatomical features. Tea belongs to family Theaceae and Camellaceae. The experiment was carried out for the morphological, anatomical studies of tea varieties and clones grown at National Tea and High Value Crops Research Institute, Shinkari Mansehra. The field experiments were conducted in Randomized Complete Block Design. Morphological and anatomical character of different tea varieties and clone were analyzed by standard techniques. Morphological character of various tea varieties and clones were recorded both qualitative and quantitative data such as stem colour, stem length, stem girth, number of leaves plant<sup>-1</sup>, leaf length, leaf width, leaf type, leaf apex, leaf base, leaf shape, distance between nodes, pedicel length, flower colour, and flower diameter. Tea samples were analyzed for anatomical parameters such as epidermis cells, mesophyll cells and epidermal anatomy of leaves. The stem length, stem girth, number of leaves plant<sup>-1</sup>, leaf width, leaf length, distance between node, pedicel length and flower in tea samples ranged between 9.66-71.80cm, 1.40-2.54cm, 7.66-15.66cm, 4.83-1.66cm, 11.50-3.86cm, 4.76-1.50cm, 2.03-1.06 and 4.56-2.66cm. In anatomical study transverse section of tea varieties and clone showed similar features in epidermis, mesophyll tissues and vascular bundles. Stomatal index of different tea varieties and clones was array from 33.9 to 45.4 respectively. Highest was mentioned in clone P-7 because high number of stomata found in lower epidermis.

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**Keywords** | Tea, Theaceae, NTHRI, Shinkari, Morphology character, Anatomical feature, Stomata, Transverses section



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## Introduction

Tea belongs to the family Theaceae and genus *Camellia*, which has 82 species. It grows in tropical and subtropical regions. The tea (*Camellia*

*sinensis* L.) plant basically originated in China, and drinking began in the 16<sup>th</sup> century. The tea plant is grown in tropical and subtropical areas. It is cultivated in 30 different countries around the world. Tea is the second most popular beverage in

the world after water (Akhlas *et al.*, 2003). Tea is the second most popular beverage in the world after water (Akhlas *et al.*, 2003). The plant is a medium-sized, evergreen shrub or tree having branches in common condition. The leaves are light green with a short pediculate, coriaceous, elliptical, alternate, and serrated margin. Having pearl-white flowers that are actinomorphic, 2.5–4 cm in diameter, and found singly or in clusters of two or six. Fruit is a flattened, smooth, rounded, trigonous capsule with one seed solitary in each, about the size of a small nut (Biswas, 2006). There are three different types of tea, i.e., green, black, and oblong, which depend on quality and chemical composition. The quality of tea (*Camellia sinensis* L.) is best for aroma, volatile compounds, taste, and colour (Cabrera *et al.*, 2006). Pakistan has a long tradition of tea drinking, which has become an integral part of social life. The quality and chemical composition of tea flush vary under varying climatic conditions (Madiha *et al.*, 2017). Some varieties have been grown at NTHRI Shinkari Mansehra according to their capacity and habitat on the basis of their physical characteristics. The value of tea is also affected by cultural practises, the environment, climatic conditions, and tea processing techniques (Waheed *et al.*, 2017). Tea crops has a medicinal and industrial value as well for different purposes. Morphology is a branch of biology that deals with study of external structure of plant body. In morphology both qualitative and quantitative characters are very importance like leaf shape, leaf length, stem girth and flower colour etc. (Gostin, 2011). Anatomy is also branch of science biology that explain the internal structure and source of identification of plant (Perxu *et al.*, 2009). Anatomy deals with interior cell and tissue of plant. Epidermal anatomy of plant includes stomata type, stomata length and epidermal shape etc. Epidermis character have been considered to be of great use in studying relationship between taxa and there are few descriptions of epidermal micromorphology but just limited number of species were included (Ao *et al.*, 2007).

Leaf morphology and anatomy have always played an important role in plant taxonomy and identification of taxa (Parnell and Meade, 2003).

The present trial was carried out to find-out morphological characters and anatomical features of different lines and varieties tea.

## Materials and Methods

### *Experimental site and plant material*

During 2021-2022 at National Tea and high Value Crops Research Institute, Shinkari, Mansehra (KPK), morphological, physicochemical and other activities were conducted. The plant material was collected from National Tea and High Value Crops Research Institute, Shinkari, Mansehra.

### *Experimental design and treatment combination*

Three replications of a randomised complete block design were used to set up the experiment.

### *Climatic factor of NTHRI, Shinkari*

The tea crop grows in Shinkari's climate, which is ideal.

### *Collection of tea varieties and clones from NTHRI*

There some tea varieties and clones grown at National Tea and High Crops Research Institute, Shinkari, Mansehra, such as Qi-Men, Sri-Lanka, Roupi, Chuye, Japanese, Indonesian, Turkish, Jue king, P-3, P-5, P-7, P-8 and P-9 were selected for experimentation. Tea samples were collected from National Tea and high value crops Shinkari, Mansehra, Pakistan. The sample was washed, dried under the sun, crushed, and powdered with an electric grinder. All these samples were used for anatomical and morphologic studies.

### *Research work in laboratory of NTHRI, Shinkari*

The study was conducted in two phases: the morphological aspect was the first, and the anatomical, physical, and chemical variations in several tea varieties and clones grown at NTHRI Shinkari, Mansehra, were the second. Main portion of experiment was conducted in open field while another part was carried out in laboratory of NTHRI, shinkari and Hazara University Mansehra.

### *Investigation of morphological characteristics*

Morphological characters of different tea varieties and clones according to standard method of Ashrad *et al.* (2002) were recorded. Morphological data, both qualitative and quantitative characters such as leaf length, leaf width, leaf colour, leaf margin, leaf shape, stem colour, stem girth, flower colour, flower diameter etc. were analysed in field.

### *Protocol used for anatomical studies*

Anatomical studies of leaves and stem (tea plant)

were used by the protocol [Poornima et al. \(2009\)](#) with slight modification.

### *Transverse section of tea leaves*

**Apparatus/equipment:** Some material were used for transverse section of tea leaves such as beaker, glass slide, watch glass, cover slip, dropper, needle, blade, slide box, nail polish, heat Lamp, Forceps, Staining, light microscope and photography, potatoes, paper tape, permanent marker, brush.

### *Preservation*

The plant material (tea leaf) were preserved in three solvents for about 48 hours to study the anatomical parameters. The composition of preservative as follows:

- Ethyl Alcohol (C<sub>2</sub>H<sub>5</sub>OH) = 10ml
- Acetic acid (CH<sub>3</sub>COOH) = 10ml
- Formalin (HCHO)= 10ml

### *Section cutting*

Transverse section of leaves were taken following the procedure of [Poornima et al. \(2009\)](#). To observe the anatomical feature of tea leaf thin transverse sections were made with the help of sharp blade. During section cutting both blade and section was kept in water. The section was removed from razor with help of brush and place onto the slide. Transverse sections were prepared in large number and only thin section was select and stained. After making permanent slide, it seen under microscopic and photograph and micrometry.

### *Morphological attributes*

Qualitative parameters: Qualitative parameter are those which cannot be measured and countable. Data was recorded on various parameter such as:

- Leaf colour: Fresh and mature leaves colour was recorded.
- Leaf shape: Shape of first leaf was observed and noted.
- Leaf margin: Leaf margins were observed as well as recorded.
- Leaf base and apex: Leave base and apex was observed as well as recorded.
- Stem colour and type: Stem colour and surface was also observed.
- Flower colour: Flower colour were observed.

### *Quantitative parameters*

Quantitative parameter are those which can measurable. Following quantitative parameter were

recorded.

- Leaf width and length (cm): Leaf width and length was measured by using graduated scales
- Shoot length (cm): Stem lengths were measured with help of scale and noted.
- Distance between nodes (cm): Internode distance were measured by using graduated scale and observed.
- Stem thickness: Stem thickness was measured by Vernier caliper and data was noted in centimeter
- Pedicel length (cm): Pedicel of length was measured with help of scale and was noted in centimeter
- Flower diameter (cm): Flower diameter were also measured by using graduated scale.

### *Anatomical attributes*

- No of stomata per plant: The number of per plant were count in the specific area through compound microscopic.
- Stomatal index: The stomata index were determine by the specific formula are given below
- Stomatal Index =  $S / (E + S) \times 100$
- Stomata length and width: The stomata length of tea varieties and clones were determine in specific area through measured by compound microscopic.
- Number epidermal cell: The number of epidermal cell were measured in specific area through microscopic.
- Epidermis length and width : The epidermis length of tea varieties and clone were measured in specific site through microspic

### *Statistical software*

Data were analysed using statistical software 10.1 for morphological data. Table were design in MS. Word 2013 version. Anatomical data of means values were analysed in MS. Excel.

## **Results and Discussion**

### *Morphological characteristics*

Morphological data of several tea varieties and clone was based on their leaf, stem and flower character but differed from variety to variety. Both qualitative and quantitative boundary of morphology data of different tea varieties and clone were recorded.

### *Qualitative characters of morphological data*

The qualitative characters of morphological data of various tea varieties and clones are shown in [Table 1](#). Stem colour was observed green and dark green in

various tea varieties and clones. Leaf base was acute in all tea varieties and clones. The leaf apex were recorded acuminate in Turkish, Sir Lanka, clone P-3, clone P-5, and clone P-9 whereas other tea samples were having acute leaf apex. Leaf margin were observed serrulate in clone P-8, P-7, P-3, Turkish, Sir Lanka and Qi-men variety. Flower colour was reported pearl white in all tea varieties and clones.

*Quantitative parameters of morphological data*

Quantitative parameters of different tea varieties

and clones were varying from one to other and data was reported in Table 2.

*Stem length (cm)*

Data regarded stem length is present in (Table 2). Analysis of variance showed non-significant variation in stem length and ranged from 9.66 to 17.66 (unit?). The maximum stem girth was observed in Sir Lanka (17.80cm) variety but in case of minimum stem length was found in Clone P-7 (9.66cm).

**Table 1:** *Qualitative characters of morphological data of tea varieties and clones.*

| Varieties/ <i>Camellia sinensis</i> L | Qualitative character |           |           |                    |               |             |               |
|---------------------------------------|-----------------------|-----------|-----------|--------------------|---------------|-------------|---------------|
|                                       | Stem colour           | Leaf base | Leaf apex | Leaf shape         | Leaf position | Leaf margin | Flower colour |
| Roupi                                 | Light green           | Acute     | Acute     | Elliptical         | Alternate     | Serrate     | Pearl white   |
| Qi-men                                | Light green           | Acute     | Acute     | Ovate              | Alternate     | Serrulate   | Pearl white   |
| Chuye                                 | Dark green            | Acute     | Acute     | Elliptical         | Alternate     | Serrate     | Pearl white   |
| Jue king                              | Dark green            | Acute     | Acute     | Elliptical         | Alternate     | Serrate     | Pearl white   |
| Japanese                              | Dark green            | Acute     | Acute     | Narrow elliptical  | Alternate     | Serrate     | Pearl white   |
| Turkish                               | Dark green            | Acute     | Acuminate | Elliptical         | Alternate     | Serrulate   | Pearl white   |
| Sir lanka                             | Light green           | Acute     | Acuminate | Ovate              | Alternate     | Serrulate   | Pearl white   |
| Indonesian                            | Light green           | Acute     | Acute     | Broadly elliptical | Alternate     | Serrate     | Pearl white   |
| <b>Tea clones</b>                     |                       |           |           |                    |               |             |               |
| P-3                                   | Dark green            | Acute     | Acuminate | Elliptical         | Alternate     | Serrulate   | Pearl white   |
| P-5                                   | Dark green            | Acute     | Acuminate | Elliptical         | Alternate     | Serrate     | Pearl white   |
| P-7                                   | Dark green            | Acute     | Acute     | Ovate              | Alternate     | Serrulate   | Pearl white   |
| P-8                                   | Dark green            | Acute     | Acute     | Elliptical         | Alternate     | Serrulate   | Pearl white   |
| P-9                                   | Dark green            | Acute     | Acuminate | Elliptical         | Alternate     | Serrate     | Pearl white   |

**Table 2:** *Quantitative character of morphological data of tea varieties and clones (Mean value of stem height, stem girth, leaf length, leaf width, pedicel length, flower diameter of tea varieties and clones).*

| Varieties  | Stem length (cm) | Stem girth (cm) | Number of leaves/plant | Leaf length (cm) | Leaf width (cm) | Distance between nodes (cm) | Pedicel length (cm) | Flower diameter (cm) |
|------------|------------------|-----------------|------------------------|------------------|-----------------|-----------------------------|---------------------|----------------------|
| Roupi      | 16.16a           | 1.68cd          | 15.66a                 | 6.46b            | 2.43bc          | 3.36bc                      | 1.20bc              | 4.00a                |
| Qi-men     | 14.13ab          | 2.54a           | 14.33ab                | 6.80b            | 2.66bc          | 2.16de                      | 1.10c               | 4.46a                |
| Chuye      | 15.66ab          | 1.80bcd         | 11.33abcd              | 6.70b            | 2.30bcd         | 1.73de                      | 1.56abc             | 4.06a                |
| Jue king   | 12.33            | 1.92bcd         | 13.33abc               | 7.60b            | 2.73bc          | 1.83de                      | 1.60abc             | 3.66ab               |
| Japanese   | 17.66a           | 1.86bcd         | 9.66bcd                | 7.13b            | 2.70bc          | 3.56bc                      | 1.76ab              | 4.56a                |
| Turkish    | 16.33a           | 1.58cd          | 8.66cd                 | 6.50b            | 2.93b           | 3.80ab                      | 1.66abc             | 4.43a                |
| Sir Lanka  | 17.80a           | 2.27ab          | 12.33abcd              | 3.86c            | 1.66d           | 2.73cd                      | 1.76ab              | 3.83a                |
| Indonesian | 14.33ab          | 2.54a           | 7.66d                  | 11.50a           | 4.83a           | 4.76a                       | 1.63abc             | 2.66b                |
| P-3        | 15.33ab          | 1.77bcd         | 13.33abc               | 5.53bc           | 2.06cd          | 1.50e                       | 1.23bc              | 3.60ab               |
| P-5        | 13.66ab          | 1.40d           | 9.33cd                 | 7.16b            | 2.26bcd         | 2.16de                      | 2.03a               | 4.23a                |
| P-7        | 9.66b            | 1.75bcd         | 14.66a                 | 5.63bc           | 2.16cd          | 2.66cd                      | 1.63abc             | 3.46ab               |
| P-8        | 13.33ab          | 2.04abc         | 12.66abc               | 7.23b            | 2.66bc          | 1.86de                      | 1.53abc             | 3.46ab               |
| P-9        | 11.66ab          | 1.52cd          | 11.00abcd              | 6.73b            | 2.26bcd         | 1.80de                      | 1.06c               | 3.50ab               |
| LSD Value  | 6.4345           | 0.5823          | 4.8158                 | 2.0845           | 0.7510          | 1.0632                      | 0.6494              | 1.1357               |

Note: each value is a mean of three replications.

*Stem girth (cm)*

Statistical analysis of data showed significant variation in stem girth at different tea varieties and clones (Table 2). The data varied from 1.40 cm-2.54 cm. Maximum stem girth was observed in Qi-men and Indonesian (2.54cm) and minimum stem girth were recorded in P-5 (1.40cm).

*Number of leaves plant<sup>-1</sup>*

Number of leaves per plant of each tea varieties and clones were ranged from 15.66 to 7.66 (Table 2). Maximum increase (15.66 cm) in number of leaves was observed in Roupi variety while minimum decrease in number of leaves was recorded in Indonesian variety (7.66cm).

*Leaf width (cm)*

Data of leaf width were ranged from 1.66 to 4.83 cm (Table 2). Statistical analysis of data showed highly significant variation in leaf width at different tea assortment and clone. The highest leaf width was observed in Indonesian (4.83cm) whereas minimum leaf width were found in Sir Lanka (1.66cm).

*Leaf length (cm)*

Length of different tea varieties and clones was were ranged from 11.50cm to 3.86cm (Table 2). Highest leaf length was reported in Indonesian (11.50cm) while lowest leaf length were showed in Sir Lanka tea variety (3.86cm).

*Distance between nodes (cm)*

Analysis for distance between nodes showed highly significant variation at various tea assortment and clones (Table 2). The data range from 1.50cm to 4.76cm. Highest (4.76) distance between nodes was recorded in Indonesian variety but in case of lowest (1.50cm) distance between node was found in clone P-3.

*Pedicle length (cm)*

The pedicle length varied form 1.06 cm to 2.03cm (Table 2). Maximum pedicle length was noted in Clone P-5 (2.03 cm) while minimum value was (1.06) recorded in clone P-9. Analysis of variance showed significant variation at various tea assortment and clones.

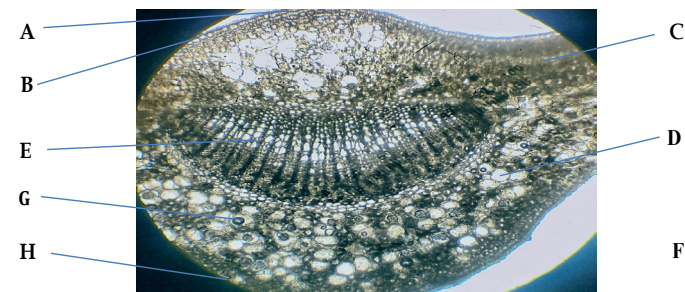
*Flower diameter (cm)*

The flower diameter varied from 2.66cm to 4.56 cm (Table 2). Highest flowers diameter was present in

Japanese (4.56 cm) tea variety whereas lowest flower diameter was observed in Indonesian (2.66cm) tea variety.

*Anatomical studies of tea leaves*

The transverse section of tea varieties and clones showed the following features in Figure 1.



**Figure 1:** Transverses section of various part of tea leaf: A: cuticle, B: Upper epidermis, C: Palisade parenchyma, D: Spongy parenchyma, E: Vascular bundle, F: Lower epidermis, G: Parenchyma, H: stoma.

*Stomata index of tea varieties and clones*

Stomata number, number of epidermis cell was measured in all tea varieties and clones and data was recorded taken by specific formula. Results of stomata index was shown in the Table 3.

**Table 3:** Stomatal index of tea leaves.

| S.No | Varieties and clones | Stomatal index = $S/(E + S) \times 100$ |
|------|----------------------|---|
| 1.   | Roupi                | 33.3                                    |
| 2.   | Qi- men              | 45.4                                    |
| 3.   | Chuye                | 42.8                                    |
| 4.   | Jue king             | 35.7                                    |
| 5.   | Japanese             | 42.8                                    |
| 6.   | Turkish              | 40.2                                    |
| 7.   | Sir lanka            | 36.5                                    |
| 8.   | Indonesian           | 40                                      |
| 9.   | P-3                  | 38.0                                    |
| 10.  | P-5                  | 33.9                                    |
| 11.  | P-7                  | 47.5                                    |
| 12.  | P-8                  | 37.9                                    |

*Epidermal anatomy*

Anatomy of epidermis of different tea varieties and clones was carried out i.e., upper and lower surface. (Figures 2 and 3).

*Qualitative characters*

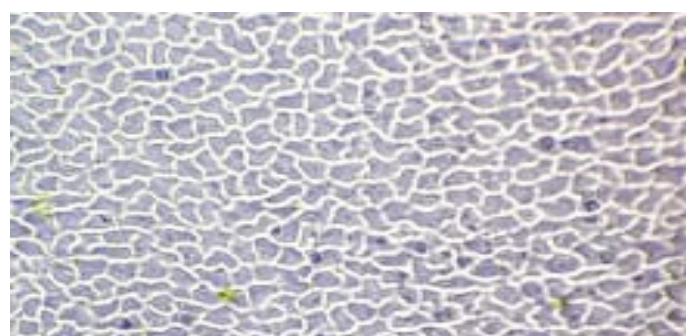
The epidermis cell of tea varieties and clones are triangular, sinuos and repand. Trichome and stomata are also present in lower epidermis but present in upper epidermis both tea varieties and clones.

**Table 4:** Epidermal anatomy of tea leaves based on qualitative character qualitative character of tea varieties and clone.

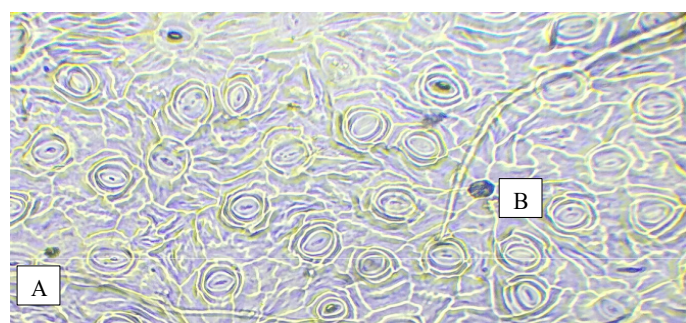
| Qualitative character of tea varieties and clone |        |       |          |          |                               |           |            |     |     |     |     |     |
|--|--------|-------|----------|----------|-------------------------------|-----------|------------|-----|-----|-----|-----|-----|
| Roupi  | Qi-men | Chuye | Jue king | Japanese | Turkish                       | Sir lanka | Indonesian | p-3 | P-5 | P-7 | P-8 | P-9 |
| Shape of epidermis cell                          |        |       |          |          | Triangular, sinuose or repand |           |            |     |     |     |     |     |
| Layer of epidermis                               |        |       |          |          | Single layer                  |           |            |     |     |     |     |     |
| Epidermis cell margin                            |        |       |          |          | Smooth                        |           |            |     |     |     |     |     |
| Absent and present of trichome                   |        |       |          |          | Present ( lower surface)      |           |            |     |     |     |     |     |
| Type of Trichome                                 |        |       |          |          | Non-granular/unbranched       |           |            |     |     |     |     |     |
| Stomata types                                    |        |       |          |          | Anomocytic                    |           |            |     |     |     |     |     |
| Shape of guard cell                              |        |       |          |          | Bean shape                    |           |            |     |     |     |     |     |

**Table 5:** Quantitative characters of tea leaf based on the epidermal anatomy.

| Varieties and clones | Qualitative character        |                  |                 |                     |                |               |
|----------------------|------------------------------|------------------|-----------------|---------------------|----------------|---------------|
|                      | No. of epidermal Cells /area | Epidermal length | Epidermal width | No of stomata/ area | Stomata length | Stomata width |
| Roupi                | 100                          | 15 µm            | 12 µm           | 50                  | 15µm           | 13µm          |
| Qi- men              | 120                          | 16µm             | 14µm            | 95                  | 13µm           | 14µm          |
| Chuye                | 110                          | 20 µm            | 17 µm           | 85                  | 14µm           | 14µm          |
| Jue king             | 160                          | 15 µm            | 22 µm           | 89                  | 14µm           | 16µm          |
| Japanese             | 200                          | 22µm             | 13µm            | 150                 | 13µm           | 15µm          |
| Turkish              | 89                           | 12µm             | 16µm            | 60                  | 16µm           | 14µm          |
| Sir lanka            | 78                           | 13µm             | 15µm            | 45                  | 13µm           | 13µm          |
| Indonesian           | 105                          | 17 µm            | 18 µm           | 70                  | 17µm           | 14µm          |
| P-3                  | 130                          | 10 µm            | 20 µm           | 80                  | 15µm           | 13µm          |
| P-5                  | 150                          | 19 µm            | 12 µm           | 77                  | 15µm           | 14 µm         |
| P-7                  | 210                          | 40 µm            | 20 µm           | 190                 | 14µm           | 12µm          |
| P-8                  | 90                           | 11 µm            | 15 µm           | 55                  | 12µm           | 14µm          |
| P-9                  | 144                          | 13µm             | 15µm            | 102                 | 15µm           | 14µm          |



**Figure 2:** Upper epidermis of tea sample.



**Figure 3:** Lower epidermis cell of tea sample: A, Stomata; B, trichome.

Trichome may be non-granular and type of stomata are anomocytic in all tea varieties and clones. The shape of guard cells are bean like. All these qualitative characters were shown in Table 4.

*Quantitative characters*

In the leaves of different tea samples varied from stomata length and width. The number of stomata and number of epidermis cell per area is also determined in Table 5. All readings were taken on 10 X magnification of microscope. These results were presented in Table 5.

*Morphological characteristics of tea samples*

Morphological analyses both qualitative and quantitative character were examined in various tea varieties and clones. Qualitative character of all tea varieties and clones showed minor differences to each other. The stem colour, type and surface in all tea varieties and clone were observed light green

colour and minute hair present as well as woody and erect. Leaf base was recorded acute in all tea varieties and clone but there was no difference. Leaf apex of some tea sample was recorded acuminate in Turkish and Sir Lanka, P-5, P-3, P-9 while acute leaf apex were found in other tea varieties and clone. Leaf margin were found serrulate in tea varieties and clone of Qi-men, Turkish, Sir Lanka, P-3, P-7 and P-8 whereas serrate margin were observed in few tea varieties and clone. These results are similar with finding of Luo *et al.* (2004) who reported that light green and dark leaves type only depend upon leaves colour and high serration margin depend on leaf margin. Elliptical shape of leaves were found in Roupi, Chuye, Jue king, Turkish (varieties), P-3, P-5, P-8 and P-9 (clone) while ovate leaf shape were found Qi-men, Sir lanka (varieties), P-3 (clone) etc. These result also dissimilarities with pervious work of Jala (2011) who observed that some shape of leaves of become Lanceolate and some morphological parameter in wishdone flower (*Torenia fourmerie*). Data of stem length, stem girth, leaf width, leaf length, internodes distance, pedicel length and flower diameter were found to be in the range from 9.66 - 17.66, 1.40-2.54, 1.62-4.83, 1.50-4.76, 1.06-2.03 and 2.66-4.56cm respectively. Highest stem length were found in Sir Lanka variety (11.80) and lowest in clone of P-7. Present work showed dissimilar with previous work of Wei *et al.* (2005) who observed that stem length range from 5.6 cm to 13.2 cm. Maximum stem girth data were indicated in Indonesian and Qi-men variety but least were observed in clone P-5). Present results agree with pervious work of Shanmugarajah (1986) who studied that at nursery stage tea clone differ in stem girth. Peak leaf length (11.50) and width (4.83) were showed in Indonesian variety while lowest value were reported in Sir Lanka (3.86cm, 1.66cm). Our results showed dissimilarities with previous work of Jin *et al.* (2005) that leaf length in *Camellia sinensis* L. varied from 3.2 to 6.4 cm. leaf length and width ratio is dependent upon the length and width of leaf. Highest length of pedicel and flower were found in clone P-5 (2.03cm), Japanese (4.56cm) variety whereas lowest value were recorded in clone P-9 (1.66cm) and Indonesian variety (2.66). Lowest distance between nodes (1.50cm) were shown in Clone P-3 and highest internodes distance were in Indonesian variety (4.76cm). Current study showed resemblance with result of pervious work of Sha and Guo (2005) who found that distance between

nodes range from 1.7 cm to 6.6 cm, respectively.

#### *Anatomical studies of tea samples*

The cross section of different tea varieties and clones were showed the presence of cuticle, upper epidermis, mesophyll cell, vascular bundle and lower epidermis in Figure 1. Lower epidermis larger than upper epidermis. Lu *et al.* (2008) who reported single layer of epidermis in *Camellia rhytidophylla*.

Stomata index of different tea varieties and clones were found in Table 3 and range from 33.3 to 45.4, respectively. Anatomical features of different tea varieties and clones were found similar in leaf epidermal anatomy such as epidermis shape, stomata types, trichome shape and guard cell shape. Epidermal anatomy were observed both qualitative and quantitative character but quantitative feature were differ in all tea sample and clone. In qualitative character, the epidermal shape of tea leaves were showed triangular, sinuous and repand whereas shape of stomata and guard cell were observed anomocytic and bean shape in tea sample (Table 4). The type of trichomes were found non granular or unbranched in some tea varieties and clone. These results are similar with pervious work of Perveen *et al.* (2007) who recorded that stomata type is anomocytic. In Epidermal anatomy, the major important in taxonomy and classification are stomata character but it's no easy to observe similar in same. Present work were dissimilar with previous work of Chengqi *et al.* (2002) who observed that stomata type in all tea varieties is anioscytic and paracytic (Table 4). Stomata length of different tea and clone were range from 13 to 17  $\mu\text{m}$ . The stomata width of tea sample were varied between 12 to 16  $\mu\text{m}$ . Number of epidermis cell more than number of stomata. Number of stomata and number of epidermis were found numerous in all tea varieties and clone but randomly count in area.

#### Conclusions and Recommendations

In present study morphological analysis of both qualitative and quantitative characters of various tea varieties and clones were done. Morphology characteristics is initial step of tea varieties and clones because each parameter was different such stem colour, type, surface, leaf shape, leaf apex and base etc. Anatomical studied are more essential than morphological characteristics. Transverse section

of tea varieties and clones showed similar feature in cuticle, lower and upper epidermis, mesophyll tissue and vascular bundle but major different in stomata index and epidermal anatomy were found. In my point of view Indonesian tea variety is very essential in future because it leave was board and great important in medicine. Therefore, present study was helpful for students in future and provide important source for the identification of research plant as well as beneficial for medicinal purposes.

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### Novelty Statement

As far as our knowledge, this kind of research has been carried out for the first time on tea crops after the climate change in the area. The research presents novel ideas about morphology and anatomy of the tea which will tell us about the characterization of morphological variability, it will allow breeders to identify varieties with desirable characteristics for future research and will improve the quality of tea.

### Author's Contribution

**Danish Kamal:** Designed the experiment, managed, collected and analysed the data.

**Muhammad Abbass Khan:** Technical guidance at each and every step of the research process.

**Ghulam Mujtaba-Shah:** Technically review the whole paper.

**Naveed Ahmed:** Helped in data collection and data analysis.

**Maryam Iqbal:** Designed the experiment, managed, collected and analyzed te data.

**Basharat Hussain Shah:** Technical guidance regarding layout of the experiment.

**Imtiaz Ahmed:** Helped in draft improvement and English language of the manuscript.

### Conflict of interest

The authors have declared no conflict of interest.

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0047-6

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