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Comparative study on some morphological features of six selected and one standard clones of Bangladesh Tea [*Camellia sinensis* (L) O. Kuntze]

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Abstract

An attempt was made to study several parametric characteristics of stems and leaves of six selected and one standard clones of Bangladesh tea in order to identify and select superior clone in tea. Out of ten morphological characters, two characters of stem (stem circumference and height of the first branching position), five characters of 5^{th} leaf (leaf length, leaf breadth, leaf length/breadth ration, leaf size and leaf angle in degree) and three characters of pluckable shoots (internodal length, shoot density and yield of green leaf as well as made tea per hector) were considered qualitatively and quantitatively following IPGRI's guidelines with some minor adjustment and analyzed statistically. It was noticed that all clones were significantly different in respect of stem circumference, leaf length, leaf breadth, leaf length/breadth ratio, leaf size, leaf angle, internodal length of fish leaf to mother leaf, shoot density and yield. Considering different morphological and yield character MZ/39 was found most suitable followed by B2 × T1 and SDL/1 for commercial cultivation in Bangladesh.

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Introduction

Tea (*Camellia sinensis* (L.) O. Kuntze), which yields a non-alcoholic healthy beverage, is being cultivated in Bangladesh since 1854 though the first introduction was made in 1840 in Chittagong for experimental purpose with China plants from Calcutta Botanical Garden and some plants from Assam (Ahmed, 1963). Later on Bangladesh Tea Research Institute (BTRI) released a number of outstanding accessions from natural populations through breeding methods (Alam *et al.*, 2001). Since 1960, the Institute has initiated a project on collection of tea germplasm from abroad and efforts have been made since 1982 to intensify local collection (Rashid, 1983) by picking up the potentially valuable bushes from old sections of commercial tea and from old seed baries (orchards) due to uprooting. The vegetatively propagated plants from these collections are being added to the central germplasm collection. Therefore, the genetic resources of tea in BTRI are undoubtedly most important source of tea germplasm in Bangladesh. A large number of controlled hybridization was attempted and some of the progenies were also recommended for planting (Dutta *et al.,* 1998). The existing diversity will have to be preserved and characterized for future crop improvement programmes that constitute the fundamental support structure for the tea industry.

Leaf morphology has an important role in identifying taxa in which variation in floral structures is uninformative or in which flower specimens are infrequent owing to a limited flowering season, for example (Meade *et al.,* 2003). The use of morphological characters is cost-effective when compared to that of biochemical and molecular markers for preliminary characterization of many individuals to identify morphologically similar groups and for simple varietal identification of phenotypically distinguishable cultivars (Martinez *et al.,* 2003). In tea, morphological characters have been used to study genetic diversity (Wickramaratna, 1981 and Toyao *et al.,* 1999), variation (Gunasekara *et al.,* 2011; Piyasundara *et al.,* 2006; Su *et al.,* 2007), phylogeny and classification (Chen *et al.,* 2005; Vo, 2006; Piyasundara *et al.*2008; Peng *et al.,* 2009). Leaf features have been largely unexploited in taxonomic studies, resulting from a belief that they respond in a plastic manner to environmental factors. However, in *ex situ* gene banks, the plant materials are grown under similar environmental conditions and farming practices, making it possible to compare taxa.

Characterization of eleven released clones of BTRI on the basis of leaf morphology was described statistically by Sarwar *et al.* (2002). However, a few biometrical analysis or systematic work for identification of cultivars has been done (Shiblee *et al.,* 1994). Therefore, the present investigation was undertaken to study the variations in morphological characteristics of leaves and bushes of six selected clones against one standard clone BT2.

Materials and methods

Plant materials

Six test clones coded as MZ/39, E/4, D/13, B2×T1, BR2/97, SDL/1 and one standard clone BT2 were included in this study. The morphological description of the test clones and the standard clone used as control are given below:

BT2 (Control): Orthotropic, not densely branched, comparatively loose frame, but effective branches, very well and uniform flushing behaviour, moderately floriferous. Leaf texture fairly thick and soft, semi-dark green. Apex less pointed, lamina considerably equal width in mid region, serration uniform and semi-erect and Assam-China hybrid type.

MZ/39: Ortho-plagotropic, compact bush, densely branched with heavy girth and floriferous. Patina is quite glossy, leaves are semi-dark green, medium in size, texture is fairly thick and hard, prominent long apex, serration uniform, leaf blade is slightly wavy and leaf pose is semi-erect and moderately embossed.

E/4: Plagiotropic, loose frame, not very compact but having effective plucking points and poorly floriferous. Leaves are medium in size, light green, quite glossy, leaf texture thin and soft, semi-erect leaf pose, apex is less prominent, long lamina, slightly boat shape, serration uniform and venation is less prominent.

D/13: Plagiotropic, compact plucking table, fairly dense plucking points, heavy girth with good branching behaviour and poorly floriferous. Patina is glossy, leaves are light green, broad in size, texture is thick, soft and leathery, and apex is less prominent, leaf pose semi horizontal.

B2×T1: Biclonal progeny of BT2 and TV1. Ortho-plagiotropic, compact bush with dense plucking points, very uniform flushing behaviour. Patina is quite glossy, dark green foliage, texture is thick and hardy, erect leaf pose, apex is prominent, uniformly dentate serration and venation is fairly prominent.

BR2/97: Orthotropic, fairly compact bush, good branching, fair growth and quite hardy. Patina quite glossy, texture is fairly thick, dark green foliage, blades are wavy with prominent apex, serration is uniform but dent bluntish, leaves are long with erect pose.

SDL/1: Typically plagiotropic, very compact bush and profuse branch, highly plucking density. Patina is glossy, light green foliage, semi erect leaf pose, leaves are small in size and texture is thin and soft. Apex is less prominent; serration is less uniform and venation is fairly prominent.

Methods

The experiment was laid out in Randomized Block Design with three replications having 120 cm × 60 cm in the field of BTRI experimental farm. There were thirty plants per plot. Following quantitative and qualitative characters were investigated from the currently harvested tea trees following IPGRI's guide line (IPGRI, 1997) with some minor adjustments.

Stem circumference

The stem circumference was measured in cm at 10 cm above ground level.

Height of the first branching position

The height of the first branching position was measured in cm from ground level to the first branching position.

The characteristics of the 5^{th} leaf

The 5^{th} leaves counted from the bud were exploited by the following characteristics:

The leaf length (cm)

The leaf length was measured in metric scale from the leaf base to the tip.

The leaf breadth (cm)

The leaf breadth was measured at the widest position of the lamina in cm.

The leaf length/breadth ratio

The leaf length/breadth ratio was measured by calculated from the data of the leaf length and breadth.

The leaf size (cm^2)

The leaf size was calculated by multiplying leaf length and breadth.

The leaf angle (degrees)

The angle formed between the branches and the lamina and it was measured in degree.

The length of internodes

Internodal length was measured in the well developed shoots which were about to be plucked. Shoot components were designated from maintenance foliage to scale leaf (MF><SL) as first order, scale leaf to fish leaf (SL><FL) as second order, fish leaf to mother leaf (FL><ML) as third order, mother leaf to 3^{rd} leaf (ML><3L) as fourth order, 3^{rd} leaf to 2^{nd} leaf (3L><2L) as fifth order, 2^{nd} leaf to 1^{st} leaf (2L><1L) as sixth order and 1^{st} leaf to bud (1L><Bud) as seventh order. Each order was measured with metric scale.

Shoot density

Numbers of pluckable shoots of each bush were counted by 60cm × 60cm quadrate method. Data was taken two months interval from April to November.

Yield of green leaf (gm/plant) and made tea production (kg/ha)

Pluckable shoots were picked up on weekly basis during the cropping season. Yield data were recorded for each year and also over the years starting from the first year after planting the plants in the trial plot. The yield was expressed as mean yield of green leaf gm per plant and presented separately for immature (1^{st}-5^{th}) and mature (6^{th}-7^{th} year) stage. The made tea per hectare was also calculated on the basis of 23% recovery from green leaf and 13,888 plants per hectare at 120 cm × 60 cm spacing.

Statistical analysis

The data of all morphological and yield characters were compiled and analyzed statistically following statistical technique (Gomez & Gomez, 1984).

Results and discussion

Estimation of the characteristics of bush

It reveals from the Table 1 that there were significant variations among all test clones in stem circumference while there is no significant variation in respect of 1^{st} branching position among the test clones.

Table 1. Variation in two parametric characteristics of bush.

Character	Clones							LSD	
	MZ/39	**E/4**	**D/13**	**B2×T1**	**Br2/97**	**SDL/1**	**BT2**	**at 5%**	**at 1%**
Stem circumfere-nce (cm)	21.33 (1.12)	18.53 (0.80)	17.75 (0.54)	18.17 (1.07)	21.57 (1.57)	19.06 (0.94)	15.90 (0.26)	1.56	2.19
1^{st} branching position from ground level	8.80 (4.84)	8.33 (1.53)	13.73 (0.46)	8.31 (0.98)	9.77 (1.84)	11.37 (1.24)	10.38 (1.59)	NS	-

NS – not significant; The numbers in the parenthesis are standard deviation values.

Age of the studied accessions and the yearly pruning methods obviously influence the stem circumference as well as stem height. The stem circumference of MZ/39 was the highest among the test clone while BT2 was lowest. Vo *et al.* (2005) also opined that stem characteristics were strongly controlled by the cultivation techniques applied to the farm; therefore, these characteristics were mainly used to describe the studied tea plants.

Estimation of characteristics of the 5^{th} leaf

There were statistically significant differences among the clones for every parametric characteristic measured for the 5^{th} leaf (Table 2). Br2/97 produced the longest leaf and BT2 had the shortest while D/13 produced the widest leaf and BT2 the narrowest. The variations in the different clones might be due to the genetic make-up of the clones.

Majority of the clones had similar values for L/B ratio. The leaves of E/4 had the highest L/B ratio and D/13 possessed lower value. The highest L/B ratio indicates that the leaf is long and narrow with an elliptic shape and lowest L/B ratio indicates the leaf is wide relative to its length with lanceolate shape. Leaves having lower L/B ratio indicates that they are somewhat broader than E/4 and are obovate in shape includes MZ/39, B2×T1, Br2/97, SDL and BT2. On the basis of the L/B ratio of leaves of the clones would be grouped into three distinct groups- elliptic, lanceolate and obovate. However, it was reported that the leaf length was found to be of less important in distinguishing some Sri Lankan tea clones (Wickramaratne, 1981). Sarwar *et. al.* (2002) studied on parametric and non-parametric characteristics of eleven BTRI released clones and observed that it was not usually possible to recognize clones on the basis of single character but rather a combination of characters was required. There were significant differences among the clones in leaf size. D/13 and Br2/97 possessed the largest leaves whole BT2 had the smallest leaves and SDL/1, B2×T1, E/4 and MZ/39 had medium leaf size.

Table 2. Leaf characteristics of studied clones.

Character	Clones							LSD	
	MZ/39	E/4	D/13	B2×T1	Br2/97	SDL/1	BT2	at 5%	at 1%
Length (cm)	14.39 (0.65)	13.67 (0.42)	14.67 (0.47)	12.07 (1.13)	15.94 (1.36)	12.69 (1.20)	10.63 (0.59)	1.69	2.38
Breadth (cm)	4.85 (0.05)	4.08 (0.08)	6.10 (0.43)	4.88 (0.49)	5.12 (0.54)	4.30 (0.34)	3.78 (0.24)	0.65	0.91
Length-Breath ratio (L/B)	2.95 (0.10)	3.34 (0.06)	2.40 (0.14)	2.47 (0.02)	3.11 (0.07)	2.94 (0.06)	2.80 (0.04)	0.132	0.186
Leaf-size (L×B)	69.90 (3.88)	55.84 (2.69)	89.55 (8.23)	59.36 (11.11)	82.11 (15.44)	54.91 (9.21)	40.30 (4.79)	17.14	24.04
Angle (0°)	60.69 (1.02)	70.14 (5.96)	51.57 (9.05)	43.33 (6.00)	27.92 (6.29)	55.41 (4.39)	38.87 (5.35)	9.65	13.53
Leaf shape	Obov-ate	Elip-tic	Lance-olate	Obov-ate	Obov-ate	Obov-ate	Obov-ate	-	-
Leaf pose	Oligo-phile	Plano-phile	Oligo-phile	Erecto-phile	Erecto-phile	Oligo-phile	Erecto-phile	-	-

The numbers in the parenthesis are standard deviation values.

It reveals from Table 2 that there were significant variations in leaf angle. The highest angle between the leaf and the branches in the test clone E/4 and can be categorized as Planophilie (>70°). The lowest angle between the branches in the test clones Br2/97, BT2, & B2×T1 can be categorized as Ereectophile (50°). On the other hand, test clones MZ/39, D/13 and SDL/1 showed the medium degree of angle and can be categorized into Oligophile (50°-70°). The angle of inclination facilitates trapping of light energy thereby promoting photosynthesis as the lamina is fully exposed to the sunlight. Leaves act as natural spore traps where the Planopliles enhance the deposition of inoculums and there by promoting disease incidence (Gregory, 1971). Higher susceptibility of 'Assam' type clones to foliar disease and pest can be attributed to its leaf angle.

Estimation of the length of internodes

It reveals from the Table 3 that the internodal length increased gradually from maintenance foliage to 3rd leaf and declined in second and first leaves. Among the test clones no significant variation in internodal length was observed except in scale leaf to fish leaf. Ponmurugan *et al.* (2000) did not find any significant differences in intermodal lengths of six elite tea clones.

Table 3. Internodal length according to order (cm).

Order (cm)	Clone							LSD	
	MZ/39	**E/4**	**D/13**	**B2×T1**	**Br2/97**	**SDL/1**	**BT2**	**at 5%**	**at 1%**
MF><SL	2.258 (0.14)	2.327 (0.82)	1.550 (0.23)	1.491 (0.52)	2.233 (0.43)	1.739 (0.82)	1.900 (0.37)	NS	-
SL><FL	2.494 (0.52)	3.013 (0.34)	1.847 (0.22)	2.133 (0.24)	2.532 (0.52)	2.141 (0.36)	2.653 (0.29)	0.549	NS
FL><ML	3.327 (0.35)	3.968 (1.13)	3.720 (0.39)	3.436 (0.09)	4.290 (1.01)	3.200 (0.48)	4.013 (1.06)	NS	-
ML><3L	4.005 (0.29)	4.593 (0.81)	4.680 (0.18)	3.480 (0.55)	5.018 (0.83)	4.525 (0.56)	4.225 (0.19)	NS	-
3L><2L	3.299 (0.40)	3.197 (0.65)	3.393 (0.29)	2.694 (0.49)	3.091 (0.36)	3.133 (0.81)	2.757 (0.70)	NS	-
2L><1L	1.772 (0.55)	1.438 (0.14)	1.580 (0.07)	1.239 (0.12)	1.531 (0.14)	1.441 (0.40)	1.168 (0.19)	NS	-
1L><Bud	0.483 (0.09)	0.438 (0.07)	0.520 (0.05)	0.388 (0.02)	0.476 (0.04)	0.408 (0.03)	0.433 (0.04)	NS	-

NS – Not Significant; The numbers in the parenthesis are standard deviation values.

In general, in the proportion of leaf and internode in tea shoot will influence recovery percentage and quality of made tea.

Estimation of shoot density

It reveals from Table 4 that the shoot density of the test clones SDL/1, MZ/39 and B2×T1 was significantly higher than the control BT2. It also appears all these three test clones performed the best shoot density from the month of June to November. Only MZ/39 and SDL have got more dense shoots in the month of April might be due to early recovery from pruning. On the other hand, in June-July shoot density of all test clones decreased in order to heavy rainfall excepting test clone SDL/1. It may be the unique genetic character of SDL/1.

Yield of green leaf (gm/plant) and made tea production (kg/ha)

The mean yields data i.e. green leaf harvested per plant during each cropping season at the immature stage of plant (up to 5th year) are presented in Table 5.

Table 4. Shoot density at monthly interval.

Interval (two months)	Clones							LSD	
	MZ/39	E/4	D/13	B2×T1	Br2/97	SDL/1	BT2	at 5%	at 1%
April-May	82.93 (43.97)	32.43 (3.31)	35.70 (6.33)	40.03 (6.01)	36.67 (8.09)	45.83 (5.78)	39.07 (5.22)	NS	-
June-July	49.07 (12.34)	27.03 (2.21)	24.23 (2.73)	61.17 (6.11)	28.97 (5.35)	73.07 (11.90)	46.93 (7.02)	13.16	18.45
Aug.-Sep.	57.53 (8.39)	33.80 (4.76)	30.33 (4.05)	48.87 (12.28)	37.33 (7.18)	65.50 (11.93)	36.67 (2.08)	14.73	20.65
Oct.-Nov.	65.00 (11.89)	40.83 (5.12)	34.03 (2.11)	74.73 (7.38)	50.83 (0.86)	74.73 (16.77)	63.53 (7.37)	15.99	22.42

NS – Not Significant; The numbers in the parenthesis are standard deviation values.

Table 5. Yield of fresh leaves (gm/plant) at immature stage.

Year with pruning operation	Clones							LSD	
	MZ/39	E/4	D/13	B2×T1	Br2/97	SDL/1	BT2	at 5%	at 1%
1st (Decet.)	192.34 (36.98)	63.93 (2.33)	112.14 (5.26)	112.33 (28.81)	106.80 (31.12)	130.44 (37.44)	122.25 (26.33)	44.97	63.05
2nd (Pruned)	448.50 (91.04)	146.23 (27.07)	219.52 (26.22)	286.67 (66.71)	202.40 (51.18)	293.44 (119.53)	320.01 (55.43)	117.01	164.05
3rd (Skiff)	581.43 (150.49)	278.73 (43.73)	439.37 (39.14)	541.22 (142.47)	263.53 (51.31)	461.11 (173.41)	455.95 (65.11)	188.87	NS
4th (Pruned)	482.97 (88.00)	283.60 (52.86)	364.83 (17.20)	536.63 (115.36)	350.53 (60.37)	354.80 (99.27)	394.27 (31.77)	128.12	NS
5th (Skiff)	938.73 (157.02)	452.44 (50.77)	646.02 (83.44)	801.11 (175.52)	534.55 (78.82)	666.24 (116.27)	629.55 (44.89)	116.79	163.74

NS- Not significant; Decet. = Decentering; The numbers in the parenthesis are standard deviation values.

It reveals from Table 5 that the test clone MZ/39 was significantly high yielder in comparison to the control BT2 while test clones B2×T1 and SDL/1 were comparable with the control in respect of yield. Rests of the clones were lower yielder excepting D/13 and E/4 in 5th year. Made tea production per hectare of all the clones studied were estimated and presented in Fig. 1.

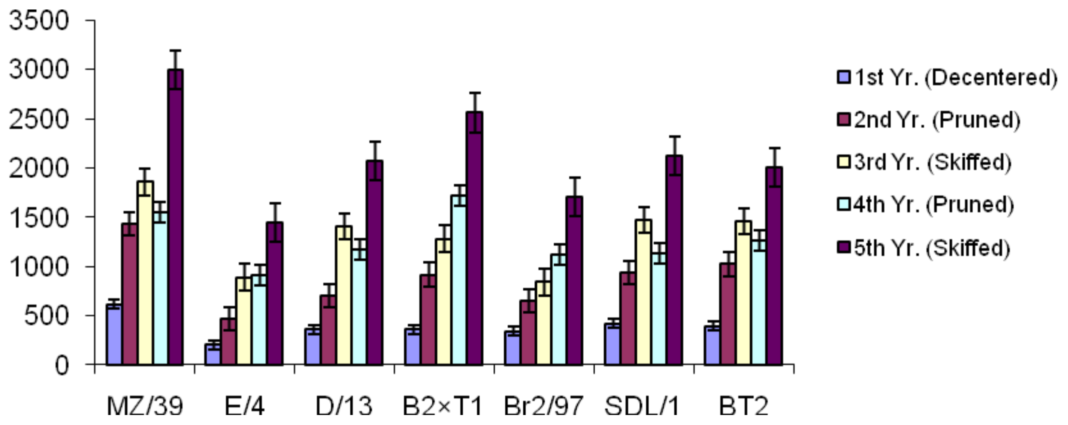

Fig.1. Estimated production of made tea (kg/ha) during immature stage.

It appears from the above graphical presentation that the estimated per hectare production of made tea for test clone MZ/39 was significantly higher in 1st to 5th year while test clone B2×T1 yielded higher than the control in 3rd to 5th year. On the other hand, SDL/1 showed higher yield in 3rd and 5th year while D/13 yielded higher than control in 5th year only. Among the all test clones MZ/39 showed the best performances followed by B2×T1 in respect of per hectare production. Yield performance of the test clones under trial along with the control BT2 during the mature stage of plants (6th year onward) are presented in Table 6.

Table 6. Yield of fresh leaves (gm/plant) during mature stage.

Year with pruning operation	Clones							LSD	
	MZ/39	E/4	D/13	B2×T1	Br2/97	SDL/1	BT2	at 5%	at 1%
6th (LP)	809.29 (71.56)	424.56 (26.99)	566.51 (38.66)	842.77 (199.88)	354.30 (269.82)	712.41 (40.02)	663.86 (90.21)	229.51	NS
7th (DSK)	986.97 (57.31)	549.09 (72.05)	725.37 (30.30)	863.33 (164.32)	603.56 (34.10)	845.59 (87.84)	800.20 (102.83)	163.09	228.67

NS- Not significant; LP = Light prune, DSK = Deep skiff; The numbers in the parenthesis are standard deviation values.

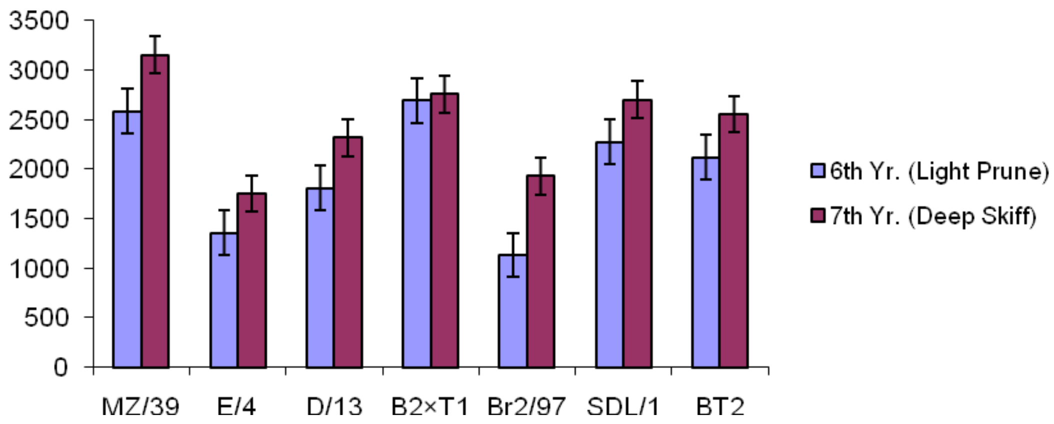

Fig. 2. Estimated production of made tea (kg/ha) during mature stage.

Table 6 shows that the yield of the test clones MZ/39, B2×T1 and SDL/1 were significantly higher than the control while rests of the test clones yielded low. Made tea production per hectare were calculated for each year and presented in Fig. 2. It appears from Figure 2 that production in per hectare of test clones- MZ/39, B2×T1 and SDL exceeded the yield record of the control BT2 in most of the years while rest of the clones yielded lower than the control.

Conclusion

Seven tea genotypes were studied considering ten quantative characters as parameters in this study. The results obtained in this study reveal the presence of wide spread and significant variation among the genotypes in respect of these characters. Among all the test clones MZ/39 followed by B2×T1 and SDL/1 showed the best performance in respect of all characters and these particular three cultivars may be selected as new clones in future. The information generated from this study can be used to broadly sort out the tea germplasm to facilitate its utilization in future breeding programme.

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