

GROWTH PERFORMANCE OF TEA (*CAMELLIA SINENSIS* L.) CULTIVARS AT NURSERY STAGE

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ABSTRACT

A study was conducted at National Tea and High Value Crops Research Institute, PARC, Shinkiari, Mansehra, Pakistan during 2010-11 to evaluate the growth performance of fourteen tea (*Camellia sinensis* L.) cultivars at the nursery stage and to screen out the best planting material having good establishment potential in the nursery. Data were collected on various plant growth parameters i.e. plant height (cm), number of leaves per plant, number of branches per plant, stem girth (cm), length of top 3rd leaf (cm), width of top 3rd leaf (cm), internodal distance between 2nd & 3rd leaf (cm), number of lateral roots per plant, root length (cm), fresh and dry weight of aerial plant parts (g), fresh and dry weight of roots (g) and fresh shoot-root weight ratio. It was found that the highest plant height (48.13 cm) was produced by cultivar Qi-men followed by Huangshan (47.58 cm), Turkish (46.18 cm) and Chuye (45.07 cm). Numbers of leaves per plant were maximum in Roupi (26.42), whereas P-3 recorded the highest number of branches per plant (1.98) followed by Roupi (1.81). Huangshan produced the highest fresh aerial plant weight (15.70 g), fresh root weight (11.22 g) and stem girth (1.85 cm). Number of lateral roots were highest in Chuye (6.27) while P-5 ranked first in root length (30.40 cm) among the evaluated tea cultivars. Marked significant variations were also recorded for length and width of 3rd leaf, internodal distance and fresh shoot-root ratio.

KEYWORDS: *Camellia sinensis*; cultivars; performance; agronomic characters; nursery; growth; Pakistan.

INTRODUCTION

Tea (*Camellia sinensis* L.) is one of the commercial crop globally due its large scale plantation, production, marketing, and consumption. Different regions favour different varieties of tea i.e. Black, Green, or Oolong and use different flavorings, such as milk, sugar or herbs. Tea is Pakistan's favorite hot beverage and in most segments of society, it has even attained the status

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of basic food. During 2010-11 Pakistan imported 127,316 tonnes of black tea costing Rs. 25.03 billion with the highest import from Kenya (55.01%) followed by India (17.13%) and Rwanda (5.69%), while green tea import was 3322 tons worth Rs.353 million mainly from Vietnam (64.38%) (10).

Systematic research and development activities on tea in Pakistan started with the establishment of National Tea Research Institute, Shinkiari in 1986. Tea germplasm was obtained from diverse sources mainly from China. Each germplasm has its own distinctive characteristics for nursery and field performance as well as for the quality attributes of brewed tea. It was necessary to characterize the available tea germplasm for their nursery performance for distinguishing the good and bad rooter as well as evaluating their growth potentials. Vegetative propagation in tea is of prime importance as the hybrid nature of all commercial tea and cross pollination prevent seed being true to type of its parents. Vegetative propagation greatly improved the possibilities of rapid multiplication of plants with high attributes for yield and quality (16). All the good hereditary characteristics of the parent tea bush can be fixed in the progeny by using internode cuttings from the selected parent bush for propagation (5). It is desirable that cuttings can be obtained from vigorously growing shoots which would perform better in the nursery. The most suitable type of cutting for propagation is the single node cutting consisting of a nodal leaf with an axillary bud and an internode of 2.5 to 3.8 cm in length. Due to different callusing and rooting ability the tea germplasm vary in their potential for the production of nursery plants (6, 7). Field conditions, eco-climatic system, inherent vigour and cultural operations influence the growth and development of tea plants. Similarly in the nursery also clones of tea species exhibit variations due to their inherent qualities, besides nutritional and hormonal factors (2). Incorporation of rooting trials with field trials in the selection process of superior clones is suggested (13). Variations were recorded in the growth attributes of nursery plants of 10 clones in Sri Lanka. The height of the plant and number of leaves produced was more in clone TK 48. The leaf area was higher in TRI-2003 and TRI-2005. More number of side shoots was seen in TRI-2003 and the girth of the stem was more in TRI-2003. Rooting of cuttings is influenced by the source and age of the plant and juvenile source always being more conducive to a high percentage of rooting (12). Variation in the rooting system in different clones may be due to genetic differences in endogenous auxin content (3). In mid-country wet zone of Sri Lanka, nursery plants raised from selected accessions from VP 80 and LVP 75 were evaluated. Growth attributes (plant height, number of branches, number of leaves, length and width of 3rd leaf, root length and root, stem and leaf fresh and dry weight) from 10 randomly

selected plants were recorded at the 8th month (4). Results of the study on performance of tea clones in the nursery through vegetative propagation in Darjeeling revealed that the clone T-78 performed best in respect of shoot length (60.22 cm), shoot volume (30.89 cm), number of leaves (39.78) and branches per plant (7.33), respectively as compared to other clones. Root length was higher (35.44 cm) at clone B-668 (9). Three clones of tea (TRI 2027, TRI 3041 and TRI 4049) selected for testing the nursery performance showed that higher dry shoot weight, dry root weight and lowest shoot:root ratio was recorded by TRI 4049 followed by TRI 2027 (15). A larger canopy with greater leaf area has the ability for producing more carbohydrates or dry matter. It also enhances growth of plant and level of root starch reserves, the presence of a vigorous root system with a lower shoot:root ratio is a good indication of drought tolerance (8).

Improved tea cultivars Huangshan have leaf length of 10.60-11.80cm and leaf width of 4.20-5.00 cm while Jiukeng have the leaf length of 10.40-12.10 cm and leaf width of 4.00-4.50 cm (1). Because of the importance of rooting ability for successful establishment of clones, cuttings obtained from mother bushes are also tested for their rooting efficiency at the nursery stage (14).

Present study was carried out to evaluate the performance of tea cultivars and their growth potential to be propagated vegetatively (through single nodal cuttings at nursery stage under the climatic conditions of Shinkhari, Mansehra, Pakistan.

MATERIALS AND METHODS

Fourteen tea genotypes were evaluated for their growth performance at nursery stage in National Tea and High Value Crops Research Institute (NTHRI), Shinkhari, Mansehra, Pakistan during 2010-11. The institute is located at 1000 meter from sea level. The area lies between latitudes 34° 20' and 34° 30' North and longitude 73° 5' and 73° 20'. Cultivars Qi-men, Roupi, Chuye, Huangshan, Indonesian, Turkish and Clone Aa-117 were obtained from NTHRI tea garden and P-3, P-5, P-9, P-12 and P-44 were collected from Unilever Tea Research Station, Ahcrian Mansehra while Jiukeng and High grown Sri Lankan were obtained from NTHRI Experimental Tea garden at Devly, Mansehra. Experiment was laid out in RCBD with three replications. Single nodal cuttings consisting of a single mother leaf were prepared from healthy and actively growing shoots of 6-8 months and inserted in the soil filled polythene tubes during the second week of September, 2010. The pH value of soil was 5.90. One hundred and twenty cuttings of each genotype

were planted per replication. The tubes planted with cuttings were covered under plastic sheets during winter season and were arranged under the tunnels of 9 feet height and covered with stretched green color nylon net providing 80 percent partial shade to protect them against cold injury during winter season and direct sunlight during hot weather. All the recommended management practices were performed uniformly for each germplasm. Data were recorded for following parameters.

1. Plant height (cm),
2. Number of leaves per plant,
3. Number of branches per plant,
4. Stem girth (cm),
5. Length and width of top 3rd leaf (cm),
6. Internode length b/w 2nd & 3rd leaf (cm),
7. Number of lateral roots per plant,
8. Root length (cm),
9. Fresh and dry weight of aerial plant parts (g),
10. Fresh and dry weight of roots (g) and
11. Fresh shoot-root weight ratio

The data were analyzed statistically by using Fisher analysis of variance techniques with the help of computer software MSTAT-C. Duncan's New Multiple Range Test was used to determine the differences among means for different plant growth parameters.

RESULTS AND DISCUSSION

Plant height (cm)

The data (Table 1) showed that plant height was significantly different among the tea cultivars and was recorded highest in Qi-men (48.13 cm) followed by Huangshan, Turkish, Chuye, Clone Aa-117 and Roupi, with plant height of 47.58, 46.18, 45.07, 43.15 and 42.73 cm, respectively. Minimum plant height (23.87 cm) was produced by P-12. The differences in plant height may be due to the genetic variability in genotypes. Shanmugarajah (12) also recorded variations in the height of nursery plants of 10 clones in Sri Lanka.

Number of leaves per plant

Marked variations were observed in number of leaves per plant among the various tea cultivars (Table 1). Maximum number of leaves per plant (26.42) was recorded in cultivar Roupi followed by P-3, Huangshan, Jiukeng, P-44,

P-5, P-12, P-9, Chuye, Qi-men, Clone Aa-117, Turkish, H.G. Sri Lankan and Indonesian with 26.27, 23.40, 20.13, 19.53, 19.13, 17.93, 17.87, 16.69, 16.33, 14.87, 14.47, 10.80 and 8.83 leaves per plant, respectively. Mrityunjay *et. al.* (10) reported that eight tea clones evaluated for nursery performance differed considerably for leaves per plant which ranged from 15.33 to 39.78. The higher number of leaves per plant in Roupi and P-3 may be due to high number of branches and plant height.

Number of branches per plant

Number of branches per plant ranged from 0.29 (Turkish) to 1.98 (P-3) (Table 1). The differences for number of branches per plant in Qi-men, Indonesian, Turkish, High Grown Sri Lankan and Clone Aa-117 were non-significant. Chuye, Huangshan, Jiukeng, P-5, P-12 and P-44 also showed non-significant differences for number of branches per plant. Difference in branching behavior of various tea germplasm is due to specific growth habit characterized for each germplasm. Mrityunjay *et. al.* (8) reported that the number of branches per plant of clones showed noteworthy difference and ranged from 2.22 to 7.33.

Length of top 3rd leaf (cm)

Significant variations were recorded for length of top 3rd leaf and it was found that Indonesian gave the longest top 3rd leaves (10.63 cm) followed by Huangshan, Qi-men, Turkish and Clone Aa-117 with the production of 10.32, 10.22, 10.15 and 10.07 cm long top 3rd leaf, respectively (Table 1). Minimum length of top 3rd leaf was found in P-3 (7.55 cm), P-12 (8.37 cm), P-44 (8.50 cm) and H.G. Sri Lankan (8.53). These results are in line with the findings of Tea Research Institute, Chinese Academy of Agricultural Sciences (1) which showed that 10.60-11.80 cm leaf length in Huangshan and 10.40-12.10 cm long leaf in Jiukeng.

Width of top 3rd leaf (cm)

Leaves of tea germplasm varied significantly in their width and ranged from 3.27 cm (P-3) to 4.73 cm in Indonesian (Table 1). Data indicated that out of 14 tea germplasm 11 have the leaf width between 3.00 and 4.00 cm while the top 3rd leaf width in Indonesian, Huangshan and Clone Aa-117 was 4.73, 4.21 and 4.07 cm, respectively. Tea Research Institute, Chinese Academy of Agricultural Sciences (1) also recorded 4.20-5.00 cm leaf width in Huangshan and 4.00-4.50 cm wide leaf in Jiukeng.

Table 1. Growth performance of tea cultivars at nursery stage.

Cultivars	Plant height (cm)	No. of leaves/plant	No. of branches/plant	Length of top 3 rd leaf (cm)	Width of top 3 rd leaf (cm)	Internode length b/w top 2 nd & 3 rd leaf (cm)	Stem girth (cm)
Qi-men	48.13a	16.33abcd	0.39d	10.22a	3.93bc	3.91a	1.80ab
Roupi	42.73a	26.42a	1.81a	8.90ab	3.60bc	2.66b	1.63abc
Chuye	45.07a	16.69abcd	1.07bc	9.75ab	3.68bc	3.80a	1.82a
Huangshan	47.58a	23.40abc	1.22bc	10.32a	4.21ab	3.65ab	1.85a
Indonesian	24.80b	8.73d	0.40d	10.63a	4.73a	3.13ab	1.47abc
Turkish	46.18a	14.47cd	0.29d	10.15a	3.70bc	3.85a	1.37c
Jiukeng	42.38a	20.13abc	1.31b	9.97a	3.85bc	3.78a	1.55abc
H.G. Srilankan	28.23b	10.80d	0.30d	8.53ab	3.28c	3.41ab	1.28c
Clone Aa-117	43.15a	14.87bcd	0.34d	10.07a	4.07abc	3.46ab	1.53abc
P-3	41.23a	26.27ab	1.98a	7.55b	3.27c	3.18ab	1.40bc
P-5	41.75a	19.13abcd	1.26bc	9.67ab	3.47bc	3.06ab	1.62abc
P-9	42.07a	17.87abcd	1.01bc	9.90a	3.77bc	3.76a	1.35c
P-12	23.87b	17.93abcd	1.06bc	8.37ab	3.38bc	2.60b	1.45abc
P-44	36.63ab	19.53abcd	0.97c	8.50ab	3.45bc	3.43ab	1.25c
LSD at α 0.05	12.01	9.82	0.29	2.00	0.72	0.91	0.41

Any two means not sharing a common letter differ significantly from each other at 5% probability.

Internode length b/w 2nd and 3rd leaf (cm)

Like other growth parameters the length of internode between the top 2nd and 3rd leaf among tea cultivars was significantly different (Table 1). The highest internodal length (3.91 cm) was recorded in Qi-men followed by Turkish (3.85 cm), Chuye (3.80 cm), Jiukeng (3.78 cm), P-9 (3.76 cm), Huangshan (3.65 cm) and Clone Aa-117 (3.46 cm). Minimum internodal length was found in P-12 (2.60 cm). George and Sherrington (4) reported that clones of tea species exhibit variations due to their inherent qualities.

Stem girth (cm)

The data (Table 1) revealed that significant differences were observed for stem girth in tea germplasm. The cultivars were ranked as Huangshan, Chuye, Qi-men, Roupi, P-5, Jiukeng and Clone Aa-117 with the production of 1.85, 1.82, 1.80, 1.63, 1.62, 1.55 and 1.53 cm stem girth respectively. The stem girth in other genotypes was P-44 (1.25 cm), H.G. Srilankan (1.28 cm), P-9 (1.35 cm), Turkish (1.37 cm), P-12 (1.45 cm) and Indonesian (1.47 cm). Shanmugarajah (12) also recorded differences in stem girth of tea clones at nursery stage.

Number of lateral roots per plant

The tea cultivars significantly varied in their root production potentials. Number of lateral roots ranged from 3.73 (H.G. Sri Lankan) to 6.27 (Chuye).

The difference among the clone genotypes (Clone Aa-117, P-3, P-5, P-9 and P-44) was not significant (Table-2) while the other genotypes showed significant differences. Following the Chuye, the other germplasm ranked in the order of number of roots per plant are Turkish (6.20), Qi-men (6.13), Huangshan (5.87), P-12 (5.73) and P-3 (5.47). Sharma (13) also reported that rooting of cuttings is influenced by the source and age of the plant.

Root length (cm)

Root length for various tea cultivars showed significant differences (Table 2) and it was found highest in P-5 (30.40 cm) followed by Roupi (29.40 cm), Jiukeng (28.75 cm), Qi-men (27.35 cm), Huangshan (25.69 cm), P-44 (24.85 cm), P-3 (24.37 cm), P-9 (22.13 cm), P-12 (21.90 cm) and Clone Aa-117 (20.20 cm). Minimum root length (17.73 cm) was recorded in Turkish. The difference among H.G. Sri Lankan, Indonesian and Chuye were non-significant for root length of 19.05, 19.70 and 19.90 cm, respectively. Kathiravetpillia and Kulasegaram (8) also reported that due to different callusing and rooting ability the tea germplasm vary in their potential for the production of nursery plants. Samartin *et al.* (11) reported that variation in the rooting system in different tea clones may be due to genetic differences in endogenous auxin content.

Table 2. Growth performance of tea cultivars at the nursery stage.

Cultivars	No. of lateral roots/plant	Root length (cm)	Fresh aerial plant weight (g)	Dry aerial plant weight (g)	Fresh root weight (g)	Dry root weight (g)	Fresh shoot-root weight ratio
Qi-men	6.13a	27.35abcd	13.68ab	5.65abc	6.33b	2.72cd	2.14ab
Roupi	4.20bc	29.40ab	14.17ab	5.80ab	10.08a	4.37ab	1.44b
Chuye	6.27a	19.90ef	11.12abc	5.02abcd	5.57b	2.57cd	1.99ab
Huangshan	5.87ab	25.69abcde	15.70a	6.98a	11.22a	4.90a	1.43b
Indonesian	4.80abc	19.70ef	6.03c	2.28e	4.48b	1.83cd	1.33b
Turkish	6.20a	17.73f	8.75bc	3.55bcde	5.17b	2.27cd	1.69ab
Jiukeng	4.60abc	28.75abc	10.98abc	4.78abcde	5.72b	2.73cd	1.98ab
H.G. Sri Lankan	3.73c	19.05ef	6.17c	2.58de	3.33b	1.32d	1.90ab
Clone Aa-117	4.93abc	20.20def	10.07abc	4.40bcde	6.37b	3.17bc	1.56b
P-3	5.47abc	24.37abcdef	11.55abc	4.88abcd	5.43b	2.20cd	2.12ab
P-5	5.07abc	30.40a	10.73abc	4.43abcde	6.05b	2.33cd	1.76ab
P-9	4.67abc	22.13bcdef	10.23abc	4.13bcde	3.97b	1.72cd	2.55a
P-12	5.73ab	21.90cdef	7.40c	3.18cde	3.93b	1.83cd	2.02ab
P-44	5.40abc	24.85abcdef	9.95abc	4.08bcde	6.33b	2.65cd	1.58b
LSD at α 0.05	1.82	7.35	6.21	2.57	3.27	1.56	0.87

Any two means not sharing a common letter differ significantly from each other at 5% probability.

Weight of fresh aerial plant parts (g)

Fresh weight of aerial parts of plant was significantly different among the tea cultivars and the top five cultivars in respect of fresh aerial plant weight are

Huangshan (15.70 g), Roupi (14.17 g), Qi-men (13.68 g), P-3 (11.55 g) and Chuye (11.12 g). As these germplasm produced more plant height, number of leaves per plant, therefore the highest fresh weight of aerial plant part may be due to maximum biomass production in these cultivars. Kaufmann (9) also reported that a larger plant size with greater leaf area has the ability for producing more carbohydrates or dry matter. Cultivar Indonesian, H.G. Srilankan, P-12, Turkish and P-44 gave the less fresh weight of aerial part of plant (Table 2).

Dry aerial plant weight (g)

The data (Table 2) showed that similar to the fresh weight of aerial plant part, dry weight was also highest in Huangshan (6.98 g), Roupi (5.80 g), Qi-men (5.65 g), Chuye (5.02 g) and P-3 (4.88 g). Dry weight of the plant depicted that how efficiently the plant has absorbed the water and minerals and used them to produce the biomass with assimilation. Similarly the cultivars Indonesian (2.28 g), High Grown Sri Lankan (2.58 g), P-12 (3.18 g), Turkish (3.55 g) and P-44 (4.08 g) recorded the less dry weight of aerial plant parts as in the case of fresh weight. Wijeratne and Premathunga (15) recorded differences in shoot dry weight of three tea clones at nursery stage.

Fresh root weight (g)

Fresh weight of root was significantly different among the tea cultivars (Table 2) and it was found highest in Huangshan (11.22 g) followed by Roupi (10.08 g), Clone Aa-117 (6.37), Qi-men (9.33), P-44 (6.33 g), P-5 (6.05 g), Jiukeng (5.72 g), Chuye (5.57 g), P-3 (5.45 g) and Turkish (5.17 g). Minimum fresh root weight (3.33 g) was recorded in H. G. Srilankan. Fresh root weight correlates with root length and number of lateral roots per plants. Kaufmann (7) reported that a larger canopy with greater leaf area has the ability to produce more carbohydrates or dry matter. It also enhances growth of the plant and level of root starch reserves.

Dry root weight (g)

It was recorded that likes fresh weight the dry weight of root was also highest in Huangshan (4.90 g), Roupi (4.37 g), Clone Aa-117 (3.17 g), Jiukeng (2.73 g), Qi-men (2.72 g), P-44 (2.65 g) and Chuye (2.57 g). Likewise the germplasm H. G. Srilankan (1.32 g), P-9 (1.72 g), Indonesian (1.83 g) and P-12 (1.8 g) produced the less dry weight of roots per plant as exhibited in fresh root weight per plant. Wijeratne and Premathunga (15) reported differences in root dry weight of three tea clones at nursery stage.

Fresh shoot-root weight ratio

Significant variations were observed in fresh shoot-root weight ratio (Table 2). Indonesian recorded the lowest shoot-root weight ratio (1.33), followed by Huangshan (1.43) and Roupi (1.44).

P-9 with 2.55 shoot-root weight ratio ranked significantly highest followed by Qi-men (2.14), P-3 (2.12), P-12 (2.02), Chuye (1.99) and Jiukeng (1.98). Kaufmann (9) reported that presence of vigorous root system with a lower shoot:root ratio is a good indication of drought tolerance.

CONCLUSION

The study concludes that among the 14 tea cultivars evaluated for their nursery performance, the 5 cultivars namely Qi-men, Huangshan, Turkish, Chuye and Roupi recorded more growth as compared to other cultivars under the climatic conditions of Shinkiari, Mansehra, Pakistan.

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