INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 5, No. 8, p. 237-243, 2014

RESEARCH PAPER OPEN ACCESS

Impact of pruning and plucking on induction of axillary buds in tea

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Key words: Buds, pruning, plucking, Qi-men and Indonesian.

http://dx.doi.org/10.12692/ijb/5.8.237-243 Article published on October 29, 2014

Abstract

Present study was designed to evaluate the effect of different strategies of pruning and plucking on induction of axillary buds in tea varieties (Qi-men and Indonesian). The tea bushes were pruned at three different levels i.e., deep, medium and top pruning from ground level and compared with control (un-pruned). Increase in plant height for Indonesian and Qi men varieties ranges from 24.987 to 26.314 cm, 27.731 to 28.831 cm, 29.889 to 31.354 cm and 10.532 to 18.190 cm for deep, medium, top pruned and un-pruned plants respectively. The difference was significant for both the varieties for all the levels/strategies of pruning. Similarly top pruned plant had significantly higher number of plucking points/axillary buds (291.95, 230.75) as compared to the medium (173.14, 138.84), deep pruned (101.83, 92.74) and un-pruned plants (95.14 and 90.00) for Qi-men and Indonesian varieties respectively. Moreover top pruning showed a significant increase in leaf fresh weight (57.647 and 46.421%) and leaf dry weight (42.029 and 73.00%) for Qi men and Indonesian respectively. Plucking methods used were fine and coarse plucking by hand and shear. Hand plucking (fine) had maximum plucking rounds of 11.08 as compared to hand plucking course i.e. 9.00 for both varieties. Maximum values for shear plucking fine was 7.92 as compared to shear plucking coarse having value of 7.75 for plucking rounds. Hand plucking (fine and coarse) showed higher growth rate of 117.4 cm and 91.32cm as compared to shear plucking (fine and coarse) i. e. 87.14 cm and 83.56 cm. While hand plucking (fine and coarse) produced less fresh harvest (1.40 kg and 4.2kg) as compared to shear plucking fine and coarse (5.3 kg and 6.9kg). It is concluded from the study that by adapting top pruning methods the maximum plant height, number of plucking points/number of axillary buds and yield can be obtained. Similarly hand plucking (fine) helps in new bud induction and increase growth and plucking rounds per season in both genotypes. On the basis of these results we recommend top pruning and hand plucking (fine) to get maximum yield in both the varieties

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Introduction

Tea (*Camellia spp*.) is an important perennial crop of dicotyledonous family *Theaceae* (Mondal, 2002). There are two major species of tea, a *Camellia sinensis* L. (small leaf) and *Camellia assamica* L. (broad leaf). *Camellia sinensis* is a slow growing shrub, 1-3 meter high with a number of stems arising from the ground. Leaves are thick, small, deep green and erect. The plant is hard and may grow in high altitudes where winters are cold (Sealy, 1958). *Camellia assamica* is a small tree, growing up to a height of 10-15 meters with a ramifying branch system and a distinct trunk. Due to high content of polyphenols in tender leaves, the crop harvest can be processed in black tea only (Wood & Barua, 1958).
Camellia sinensis beverages are claimed to be the most widely consumed fluid after water and gained further popularity as important "health drinks" due to their beneficial medicinal properties. Tea has been called an elixir of life and is commonly used as an antidote to mental fatigue. It contain thousands of bioactive ingredients contributed by two principal active polyphenols (doxorubicin and theanine), which are natural antioxidents and are responsible for their anticarcinogenic and mutagenic properties, as well as protective action against cardiovascular diseases (Namita *et al.,* 2012).

Tea serves as morning drink for two third of world population daily. The per capita consumption of tea is approximately 1 kg/annum. According to recent statistics, the world tea production reaches 2.8 million tons annually, 70% as black and 30% as green tea. On average about 2.5 million metric tons of tea are produced worldwide. However in Pakistan, on the average 3 billion cups of tea are drunk every day (Waheed *et al*., 2012). Pakistan is the third largest importer of tea after Russia and United Kingdom, because tea production is less than its demand. Beside the other environmental (biotic and abiotic) factors seed dormancy and apical dominance are the two major factors that reduce the crop yield. Generally tea plant are propagated both by sexual and asexual means and it takes about 4 to 12 years to produce seeds. Seeds propagation is a traditional method of tea growing. But seed has disadvantage of being genetically heterogeneous in respect of growth habit, yield potential and morphological characters. Moreover seed loses its viability rapidly with the passage of time and need to be planted immediately after picking. Most reliable method of tea multiplication is clonal propagation but the major problem in clonal propagation is of apical dominance because apical dominance controls bud growth in the vegetative developmental stages of many herbaceous plants and the juvenile stages of some trees (Cline, 2000).

The possible solution to remove the apical dominance are pruning and plucking. Pruning is the cutting of branches of a tea bush at a pre-determined height and at a specified interval in order to reinvigorate and bring tea bushes within reach of the pluckers. Pruning leads to enhanced branching and hence a greater number of tender leaves (Ravichandran, 2004). Un-pruned tea plants produce more dormant buds than growing buds. Therefore, pruning prior to harvest has been considered to have great effects on plant productivity and quality because pruning shapes the plant so as to encourage a fresh supply of new shoots and ultimately increase yields (Bonheure, 1990). Similarly removal of young tea shoots having two to three leaves and soft dormant shoots (banjhi) is known as plucking. There are two major types of plucking i.e., fine plucking and coarse plucking. Harvesting 2 leaves or less and a bud are called fine plucking. While harvesting more than three leaves and a bud is called coarse plucking (Zeiss and Braber, 2001).

Though pruning and plucking can remove apical dominance but incorrect pruning and plucking methods lead to yield and quality decline. Keeping in view the importance of pruning and plucking, in present study an attempt has been made to evaluate the impact of different pruning and plucking strategies on yield two tea varieties to recommend the best method to ensure the yield.

Materials and methods

The experiments were conducted at National Tea and High Values Crops Research Institute (NTHRI), Shinkiari, Mansehra, Khyber Pakhtunkhawa (KP) during October 2012 to May 2013.

Plant Material

Ten years old tea varieties of *Camellia sinensis (*Qi-men) and *Camellia assamica* (Indonesian) were selected and tagged. Initial data was obtained after pruning at three levels i.e., deep pruning (35.0 cm), medium pruning (55.0 cm) and top pruning (65.5 cm) from ground level.

Experimental Design and Layout in Field

The experiment was laid out in Randomized Complete Block Design with eight Treatments viz; T1 = Control (un-pruned), T 2 = Deep pruning, T 3 = Medium pruning, T4 = Top pruning, T5 = Hand plucking (Fine), T6 = Hand plucking (Coarse), T7 = Shear plucking (Fine) and T8 = Shear plucking (Coarse) having four Replications, comprising total 1600 cuttings i.e. 5 rows per replication and 10 cuttings / row. Row to row and plant-to-plant distance was 10 cm respectively with following treatments.

Cultural practices were kept uniformly both in the field and nursery. Mature tea bushes were applied nitrogen (N) 225 kg/h in two split doses. The other cultural practices were kept constant in nursery i.e. Irrigation, spraying, weeding, and providing shade whenever needed. The data was collected on regular basis of one month interval.

Results

Plant Height

The data pertaining plant height is presented in Table-1. Analysis of variance showed significant difference among the three levels of pruning i.e., control, top pruning, medium pruning and deep pruing. The maximum increase (31.354 cm) in plant height was observed in Qi-men for top pruning followed by Indonesian (29.889 cm), while minimum plant height (10.532 cm) and (18.19 cm) were found in Indonesian and Qi-men respectively for control. Data showed non-significant difference between top pruning and medium pruning, while significant difference among control, top pruning and deep pruning. For both varieties maximum increase in plant height was found in top pruning followed by medium pruning while minimum plant height was found in control.

Table 1. Effect of pruning strategies on plant height, fresh leaf productivity, dry leaf productivity and no of plucking point/axillary buds/ plucking round.

	Pruning Levels (cm)	Qi-men	Indonesian	Critical Value%
Plant height	T1	18.190	10.532	5.60
	T2	31.354	29.889	5.03
	T3	28.831	27.731	6.65
	T4	26.314	24.987	6.42
Fresh leaf productivity	T1	49.26	240.22	10.23
	T2	85.48	517.92	33.53
	T3	82.90	398.42	30.05
	T4	57.76	333.60	35.67
Dry leaf productivity	T1	29.20	154.93	10.23
	T2	69.44	211.46	33.53
	T3	53.52	201.29	30.05
	T4	26.80	157.84	35.67
No of plucking point/ axillary buds	T1	95.14	90.00	10.23
	T2	291.95	230.75	33.53
	T3	173.14	138.84	30.05
	T4	101.83	92.74	35.67

T1 = Control (un-pruned), T 2 = Deep pruning, T 3 = Medium pruning, T4 = Top pruning, T5 = Hand plucking (Fine), T6 = Hand plucking (Coarse), T7 = Shear plucking (Fine), T8 = Shear plucking (Coarse).

Leaf fresh weight

Among the different levels of pruning top pruned plant bushes produced high leaf productivity for both varieties i.e., Qi-men and Indonesian as compared to the control, medium pruning and deep pruning. Leaf fresh weight productivity for top pruning was maximum (517.92g) in Indonesian followed by medium pruning (398.42 g) and deep pruning (336.60 g) while in Qi-men leaf fresh weight was 85.48 g, 82.90 g, 57.76g and 49.26g for top pruning, medium pruning, deep pruning and control respectively. The analysis of variance showed significant difference among the pruning levels in Indonesian, while there was non-significant difference in Qi-men for all the pruning levels Table-1).

Table 2. Effect of plucking (hand and shear) on growth rate, fresh weight and plucking round/axillary buds for Qi-men and Indonesian.

Treatment	Growth Rate (cm)	Fresh Weight (kg)	Plucking Round
T5	117.4	1.40	11.08
T 6	91.32	4.2	9.00
T7	87.14	5.3	7.92
T8	83.56	6.9	7.75
LSD 0.05	1.06	0.03	0.65

Leaf dry weight

The results regarding leaf dry weight productivity are presented in Table-1. The table showed that Indonesian had maximum dry weight of 211.46 g in top pruning, followed by medium pruning (201.29g) , deep pruning (157.84 g) and control (154.93g) while in Qi-men leaf dry weight was 69.44 g , 53.52 g, 29.20 g and 26.80 g in top pruning, medium pruning, control and deep pruning respectively. Non-significant difference exists among the top and medium pruning levels while significant difference exist among the top pruning, deep pruning and control. Similarly significant difference exists among the genotypes.

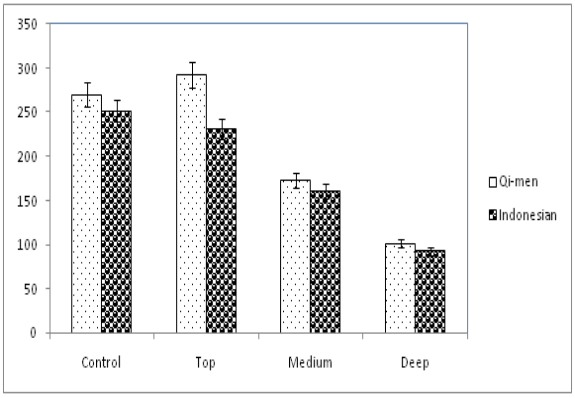

Fig. 1. Effect of different levels of pruning on plant canopy.

Number of plucking points / axillary bud density

Data regarding the number of plucking points/axillary buds is presented in Table-1. The table showed that the maximum (291.95) and 230.75 number of plucking points/axillary buds were observed in Qi-men and Indonesian for top pruning. While minimum number of plucking points (90.00) was observed in Indonesian in control. Analysis of variance showed significant difference among the top pruning, medium pruning, deep pruning and control while non-significant difference exists among the deep pruning and control. A significant difference between the numbers of plucking points in the two varieties was observed for top pruning while non-significant for medium pruning, deep pruning and control.

Plucking methods

The results regarding to plucking methods are presented in the Table-2. Analysis of variance showed that plucking rounds/ axillary buds for hand plucking (fine) i.e., 11.08 and hand plucking (coarse) i.e., 9.00 were greater as compared to shear plucking (fine) i.e., 7.92 and shear plucking (coarse) i.e., 7.75. Hand plucking (fine) produced less fresh harvest (1.40 kg) as compared to shear plucking (fine) i.e., 5.3 kg. Similarly fresh weight harvest (Table-2) for hand plucking (coarse) i.e., 4.2 kg was less as compared to shear plucking (coarse) i.e., 5.3 kg, while growth rate

for hand plucking (fine) i.e., 117.4cm and hand plucking (coarse) i.e., 91.32cm was greater as compared to shear plucking (fine) i.e., 87.14 cm and shear plucking (coarse) i.e., 83.56cm.

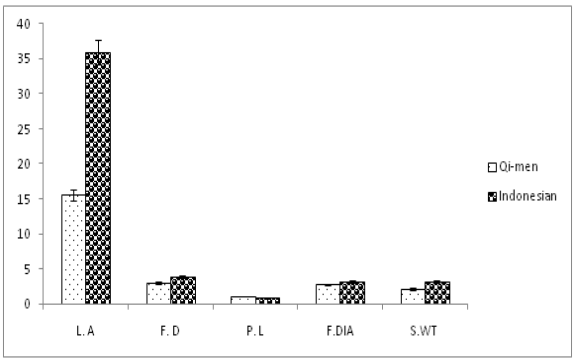

Fig. 2. Leaf area (L.A), flower diameter (F.D), pedicel length (P.L), fruit diameter (FRT. D) and seed weight (S.W).

Plant canopy

Results for plant canopy are presented in Fig. 1. According to statistical analysis of variance top pruning showed a maximum value (291.95 cm^2) of plant canopy in Qi-men followed by Indonesian (230.75 cm^2). The minimum value of plant canopy (92.74 cm^2) was found in deep pruning in Indonesian, followed by 101.83cm^2 in Qi-men. Non-significant difference exists among top pruning and control while significant difference exists among top pruning, medium pruning and deep pruning (Fig.1). The Fig.1 showed that significant difference in plant canopy exists among the genotypes i.e., Qi-men and Indonesian in top pruning while non-significant difference exists among the genotypes for control, medium pruning and deep pruning.

Leaf area, flower diameter, Pedicel length, Fruit diameter and Seed weight per fruit

The data pertaining to leaf area is presented in Fig.2 which showed that Indonesian had maximum leaf area of 35.956cm^2 followed by Qi-men i.e., 15.562cm^2. The difference in leaf area for both the genotypes is highly significant (Fig. 2). Similarly Indonesian has the maximum flower diameter of 3.8320 cm, followed by Qi-men i.e., 3.0320 cm (Fig. 2). On the other hand results in the table Fig.2 also showed that the maximum value for pedicel length was observed in Qi-men i.e., 1.0660 cm, followed by Indonesian i.e., 0.7900 cm. Whereas maximum fruit diameter (3.1155 cm) and seed weight (3.1750 g) was observed in Indonesian followed by Qi-men having fruit diameter of (2.7505 cm and seed weight of 2.1250 g respectively. There is significant l difference between the leaf area, flowers diameter, pedicel length, fruit diameter and seed weight of both the varieties.

Discussion

Tea is an important perennial crop of dicotyledonous family *Theaceae* that is propagated by seed as well as vegetatively through cutting. It is self-sterile and cross pollinated crop. It is an ever green tree that would attain a height of 12 meters if left un-harvested and un-pruned. Axillary buds in tea are very important as they produce new flush i.e., a bud and two leaves. Present research was initiated to evaluate effect of different strategies of pruning and plucking on induction of axillary buds in different tea varieties to select the best tea bushes with all agronomic character and high yield (Wood & Barua, 1958).

The criterion was to apply three different pruning (deep pruning, medium pruning and top pruning) and plucking methods i.e., fine and coarse plucking by hand and shear for selection of best tea bushes that sprout earlier and had best yield. The results show that increase in plant height is maximum for top pruned plant followed by medium pruned plant bushes, while the minimum height was observed by deep pruned and un-pruned plants. Analysis of variance showed that Qi-men has maximum height in all the pruning levels while Indonesian has minimum plant height for the three levels of pruning. Our results support the findings of Hamid *et al.,* (2000) who reported that narrow leaved genotypes had greater plant height as compared to the broad leaved genotypes.

Productivity in tea is mainly related to the production of dry matter. Table-1 indicated that the genotype has significant differences for leaf fresh and dry weight. Indonesian had greater leaf fresh weight (517.92 g) and dry weight (211.46 g) productivity as compared to Qi-men in which leaf fresh weight productivity is 90.44g

and dry weight is (69.44g). It is because narrow leaves have less leaf area thus have less fresh and dry weight. Similar results have been found by Waheed *et al.*, (2002) who have reported that narrow leaved group have high number of leaves but less fresh and dry leaf weight. Kumar *et al.,* (1993) reported that clones with high yield of green leaf do not necessarily project the high content of dry matter since clonal variation exists in portioning of dry matter.

Results on number of plucking points/axillary buds showed that top pruned plant had greater number of plucking point/axillary buds 291.95 in Qi-men followed by 230.75 in Indonesian (Table-1). In Control, maximum numbers of plucking points/axillary buds are 95.14 and 90.00 in Qi-men and Indonesian respectively. It is clear from the results (Table-1) that plucking points/axillary buds increased in top pruned plants. No significant difference exists among top pruning and medium pruning while significant difference exists among top pruning, deep pruning and control. Hamid *et al.,* (2000) also revealed that top pruning significantly increased the number of plucking points, fresh and dry wt. of leaves. Waheed *et al.*, (2001) have reported that greater the amount of pruned material to the individual bush more is the plucking points and bush canopy results in more yields.

The results regarding to plucking methods showed that hand plucking (fine) had maximum plucking rounds of 11.08 as compared to hand plucking course i.e. 9.00 for both varieties. Similarly maximum values for shear plucking fine was 7.92 as compared to shear plucking coarse having value of 7.75 for plucking rounds. Hand plucking (fine and coarse) showed higher growth rate of 117.4 cm and 91.32cm as compared to shear plucking (fine and coarse) i. e. 87.14 cm and 83.56 cm. Hand plucking produced less fresh harvest and the other parameters as compared to shear plucking except plucking rounds perhaps due to more injuries to new shoots/ plucking buds with the shear. The other reason may be that new sprouted shoots could not be saved with shear and was damaged as compare to hand plucking. Watson (1986) reported that short round i.e., higher performance of plucking generally results in higher yield than longer rounds. Removal of tender apices of shoots by plucking removes the apical dominance which suppresses the growth of their axillary buds. Generally, the axillary bud immediately below the point of plucking is the first to produce a new shoot. Some buds produce two fish leaves; the smaller one just above the scale leaves is termed small *fish* leaf or *janum* (Arunachalam, 1995) and the other as big fish leaf. After producing the fish leaf, the terminal bud produces normal flush leaves. The rate of growth of the axillary bud is very slow until it commences the production of normal leaves (Wijeratne *et al.,* 2002).
Results on plant canopy is showed in Fig 1, which revealed that among the three level of pruning maximum plant canopy was found in top pruned plants i.e., 291.95cm^2 in Qi-men, followed by i.e., 230.75cm^2 in Indonesian. The minimum plant canopy was found in deep pruned plant bushes i.e., 92.74cm^2 in Indonesian. Similar results were also shown by Waheed *et al.*, (2001) who reported that greater the amount of pruned material to the individual bush more is the plucking points and bush canopy will result in more yield.

Results in Fig. 2, for leaf area showed significant difference at 5% probability among the genotypes, Indonesian showed the maximum leaf area of 35.956cm^2 as compared to Qi-men (15.562 cm^2) it's because of genotypic variation. This is in confirmation to the study of Banerjee (1987) who reported that broad leaf varieties have greater leaf area as compare to narrow leaf varieties.

Results for flower diameter in Fig. 2, showed that the studied genotype were significantly different at 5% level of probability. Indonesian had the maximum flower diameter of 3.8320 cm, followed by Qi-men i.e., 3.0320 cm. While Qi-men had longest pedicel length of 1.0660 cm than Indonesian (0.7900 cm). Smith and Baura (2002) also reported the same results. Similarly maximum fruit diameter was found in Indonesian i.e., 3.1155 cm, while in Qi-men fruit diameter was 2.7505 cm. Results on seed weight per

fruit in Fig. 2 showed there was significant difference at 5% of probability. It indicates that maximum seed weight per fruit was showed by Indonesian (3.1750g) while Qi-men has less seed weight per fruit (2.1250 g), it might be due to the genetic differences.

It is concluded from the study that by adapting top pruning methods the maximum plant height, number of plucking points/number of axillary buds and yield can be obtained. Similarly hand plucking (fine) helps in new bud induction and increase growth and plucking rounds per season in both genotypes. On the basis of these results we recommend top pruning and hand plucking (fine) to get maximum yield in both the genotypes/varieties.

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