Mysore J. Agric. Sci., 59 (1) : 13-21 (2025)

Ultra High Density (UHD) Planting Method for Modification of Canopy Architecture in Tea to Suit for Mechanical Harvesting

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Received : October 2024
Accepted : October 2024

Abstract

South Indian tea industry is facing the problems of acute shortage of workers and increasing cost of production for the last two decades. In order to overcome these two issues, mechanization is the only option available for the South Indian tea industry. UPASI Tea Research Institute has evaluated different makes and models of tea harvesting machines and as per the recommendation of the Institute, many tea growers have already using these harvesters. But the existing low yielding old seedling tea fields were planted many years ago following the traditional planting style are not suitable for the recently introduced tea harvesting machines. There is a mismatch of the tea canopy (harvesting surface) and the length of the blade of the tea harvester. The traditional planting methods are also not suitable for the recently developed wheel mounted tea harvesters. Therefore, a new ultra high density (UHD) planting method is developed with modified training of young tea and multi-stage tipping to suit for mechanical harvesting.

Keywords : Apical dominance of tea, Multi-stage tipping, Replanting of tea, Training of young tea, Wheel mounted harvester

Tea is cultivated in India with an area of 6,19,773 ha in the states of Assam, West Bengal, Tamil Nadu, Kerala and Karnataka and annual production of 1367 million kg in 2023 (Anonymous, 2024). Among the various cultivation practices, harvesting is the major operation accounting to 70 per cent of the total cost of production (Sharma *et al*., 1981). For the last twenty years, shortage of workers is reported by all the tea growers in south India followed by increasing worker wages. As a result, the tea growers are not able to harvest the tea crop on time as per the recommended harvesting interval leading to deterioration in the quality of tea (Ilango *et al*., 2001). Therefore, in order to overcome the issue of worker shortage and to reduce the cost of production, mechanization is the only option available for the south Indian tea industry (Ilango *et al*., 2013).

Many of the cultivation practices such as pruning, lane cutting and harvesting are already mechanized in south India as per the recommendation of UPASI Tea Research Institute (Satyanarayana and Sharma, 1994). However, while implementing different makes and models of machineries especially for harvesting, unless the tea field is modified to suit for mechanical harvesting, expected output of the harvesting machines cannot be achieved. Therefore, in order to implement mechanical harvesting in tea modifications of tea canopy architecture is necessary (Ilango *et al*., 2013).

Productivity of tea in south India is stagnating around 2000 kg made tea/ha/year due to the low yielding senile 'Assam' / 'China' seedling populations. These old 'Assam' / 'China' seedling tea populations are

more than 80 - 100 years of age (Chandra Mouli and Sharma, 1993). Over the years, vacancies have been created in the old seedling tea due to unfavourable climate conditions leading to reduction in the plant population. In order to improve the productivity and quality of tea, replanting of the old seedling tea fields with high yielding superior quality clones is recommended (Ilango, 2007). Spacing and nutrient management are the two basic agronomic practices, which influences the yield potential of cultivated crops (Janhabi Sabar *et al*., 2024). While replanting, in order to implement mechanical harvesting, a new planting design to modify the tea canopy architecture suitable for mechanical harvesting has to be followed. Most of the tea growing companies are using the two men operated harvesting machines with a blade length of 1.2 m as per the recommendation of the UPASI Scientific Department (Ilango *et al*., 2013). A few start-up companies also have initiated to develop indigenous wheel mounted tea harvesters with the financial support from various schemes of Government of India. Indigenously developed wheel mounted tea harvesting machine runs on a caterpillar wheel and the length of the harvesting blade is 1.8 m. In order to develop a tea canopy to suit for the harvesting machines, a new planting design is developed. Modification of planting design to suit for mechanization is studied in other crops like Mulberry (Bharathi and Basavaiah, 2022). Further, to the new ultra-high-density planting method, a modified method of training of young tea and modified multi-stage tipping method is studied and reported.

Material and Methods

Replanting of the Old Seedling Tea Field

One hectare of old 'Assam' seedlings tea field in Valparai, Coimbatore district, Tamil Nadu was identified for replanting due to its low yield of 1500 kg/made tea/hectare/year. The field was located on a flat terrain suitable for mechanical harvesting. In the month of March 2019, the field was uprooted with a JCB machine (Plate 1) and in the month of April and May the field was levelled followed by lining and pitting was done as per the new UHD planting design (Plate 2). The indigenously developed wheel mounted

Plate 1 : JCB machine uprooting the old seedling tea field

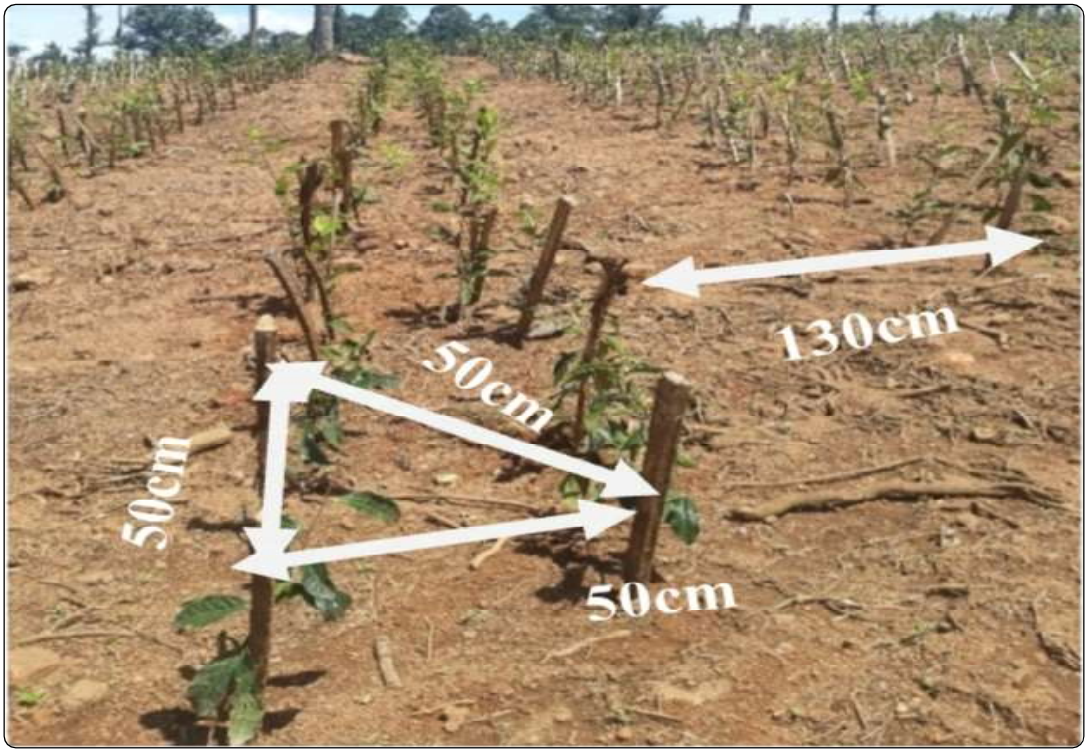

Plate 2 : Planting aspacement 130 x 50 x 50 x 50 cm

Plate 3 : Wheel mounted harvesting machine

tea harvester had a distance of 1.8 m between the two caterpillar wheels. The length of the harvesting blade is 1.8 m and the width of the caterpillar wheel (track width) is 20 cm. The new UHD planting design is developed to suit the distance between the two caterpillar wheels and the length of the blade and the track width of the wheel mounted tea harvester (Plate 3).

The new UHD planting design is 130 x 50 x 50 x 50 cm *i.e.*, 130 cm is the distance between the two double hedges, 50 cm is the distance between plant-to-plant distance in the same row, 50 cm is the distance between two rows (Plate 2). As per the new planting design, the total number of plants that can be accommodated in one hectare is 23000 plants. The new planting design is compared with the currently followed double hedge system of planting with a plant population of 13000 plants per ha following a spacing of 135 x 75 x 75 x 75 cm (Plate 4).

In the month of June 2019, three tea clones *viz.,* TRF 4, UPASI 9 and TRI 2043 were planted

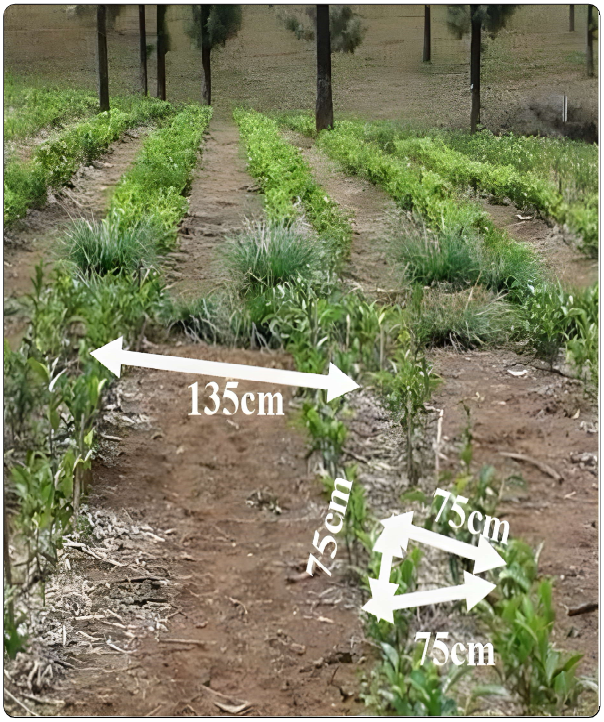

Plate 4 : Planting aspacement 135 x 75 x 75 x 75

separately in the field following the recommended practices (Ilango, 2007). During the last week of July 2019, all the young tea plants were trained by the modified training of young tea and tipping methods. For comparison the existing / current recommendation of training of young tea, tipping methods were followed as per the procedure (Satyanarayana and Sharma, 1991).

Experimental plot-1 : Modified Training of Young Tea and Tipping Methods

During the last week of August 2019, leader stem of the young tea plants was cut at 10 cm from the ground using secateure. The lateral branches were allowed to grow and first tipping was carried out in February, 2020 at 25 cm from the ground. After first tipping, the lateral branches were again allowed to grow and second tipping was carried out in March, 2020 at 30 cm. The same procedure was repeated for third tipping in June, 2020 at 35 cm, fourth tipping in July, 2020 at 42.5 cm and fifth tipping in August, 2020 at 50 cm (Plate 5).

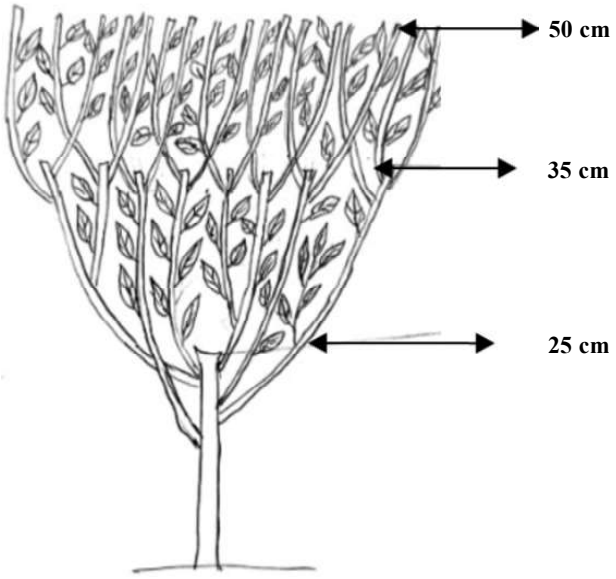

Plate 5 : Current practice of two-stage tipping

Experimental plot-2 : Current Recommendation of Training of Young Tea and Tipping Methods

In the month of October, 2019 the leader stem of the young tea plants was cut at 25 cm from the ground using secateure. The lateral branches were allowed to grow and first tipping was carried out at 35 cm in the month of April, 2020 and the lateral branches were allowed to grow. The lateral branches were cut at 50 cm in July, 2020 as per the procedure (Sharma *et al*., 1982) (Plate 6).

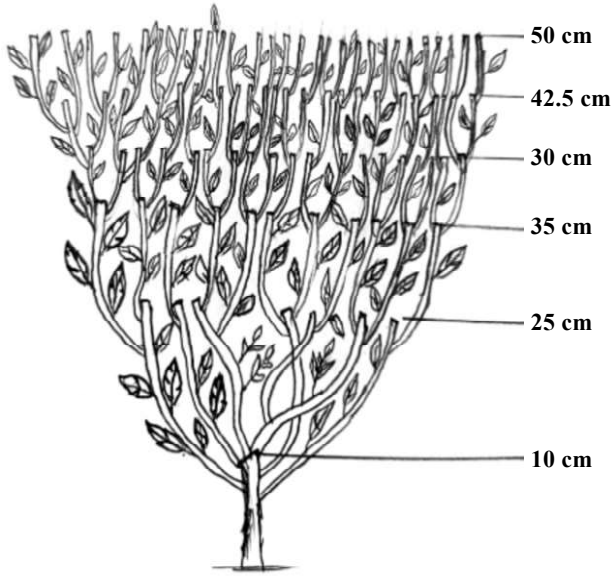

Plate 6 : Modified method of multi-stage tipping

Observations on the number of branches after each time of tipping was recorded both in the modified training of young tea and tipping methods and conventional training of young tea and tipping methods. Canopy width and plant height were also recorded after completing training of young tea and tipping methods.

The data recorded on various parameters were subjected to statistical analysis of variance (ANOVA) with Microsoft excel stat software using the critical difference (CD) at 5 per cent probability level as the test criterion and for comparison.

Results and Discussion

Difference in growth parameters of young tea plants after cutting the leader stem at different heights were observed and presented in Table 1 and Fig. 1. In all the three clones, height of the young tea plants was significantly maximum after cutting the leader stem at 25 cm as per the current practice when compared to cutting the leader stem at a low height of 10 cm (Table 1). When the apical dominance of the young tea plants was arrested by cutting the leader stem at 10 cm closer to the ground level induced more number of primary, secondary and tertiary branches than the plants cut at 25 cm from the ground level as per the current recommendation. Number of lateral branches increased by 1.69 fold after cutting the leader stem at 10 cm as compared to the current practice of cutting the leader stem at 25 cm from the ground (Table 1). Removal of apical dominance by cutting the leader stem closer to the ground level (at 10 cm) induced more number of lateral branches. Among the three different clones, the clone TRF 4 is more suited to the UHD planting method for modifying the canopy architecture to suit for mechanical harvesting. The mechanism of response to cutting the leader stem is hormonal in nature. The downwards flow of auxin from the growing tip of shoots control the bud development. When the top portion of the leader stem is cut, the downward flow of auxin is arrested which enables to increases the number of lateral buds to sprout just below the cut-end and subsequently induce branching. Perhaps this would be the reason for the significantly higher number of lateral branches as reported after cutting the leader stem as well as after pruning (Mohan and Singh, 1991).

Growth parameters of the young tea plants after cutting the leader stem at 10 cm followed by multi-stage tipping as well as cutting the leader stem at 25 cm followed by two-stage tipping as per the current practice were monitored. Significant increase in the number of branches was observed after tipping the young tea plants multiple times as compared to the current practice of two-stage tipping (Table 2). Tipping the young tea plants multiple times induced more number of lateral branches than tipping twice and the increase in number of branches is 1.5 fold higher (Table 2).

Tea plant (*Camellia sinensis*) grows as a tree in nature. In order to harvest the young tea leaves at periodic

Table 1

Difference in growth parameters of young tea as influenced by cutting the leader stem at 10 cm and 25 cm from the ground (mean of all clones)

Treatments (Methods of training of young tea)	Plant height (cm)	Number of branches / plant			
		Primary	Secondary	Tertiary	Total
Cutting the leader stem at 10 cm	36.2	6.9	11.3	15.2	33.4
Cutting the leader stem at 25 cm as per current practice	53.9	3.1	6.7	9.9	19.7
S. Em ±	0.63	0.33	0.39	0.60	0.97
CD @ 5%	1.32	0.71	0.92	1.15	2.04

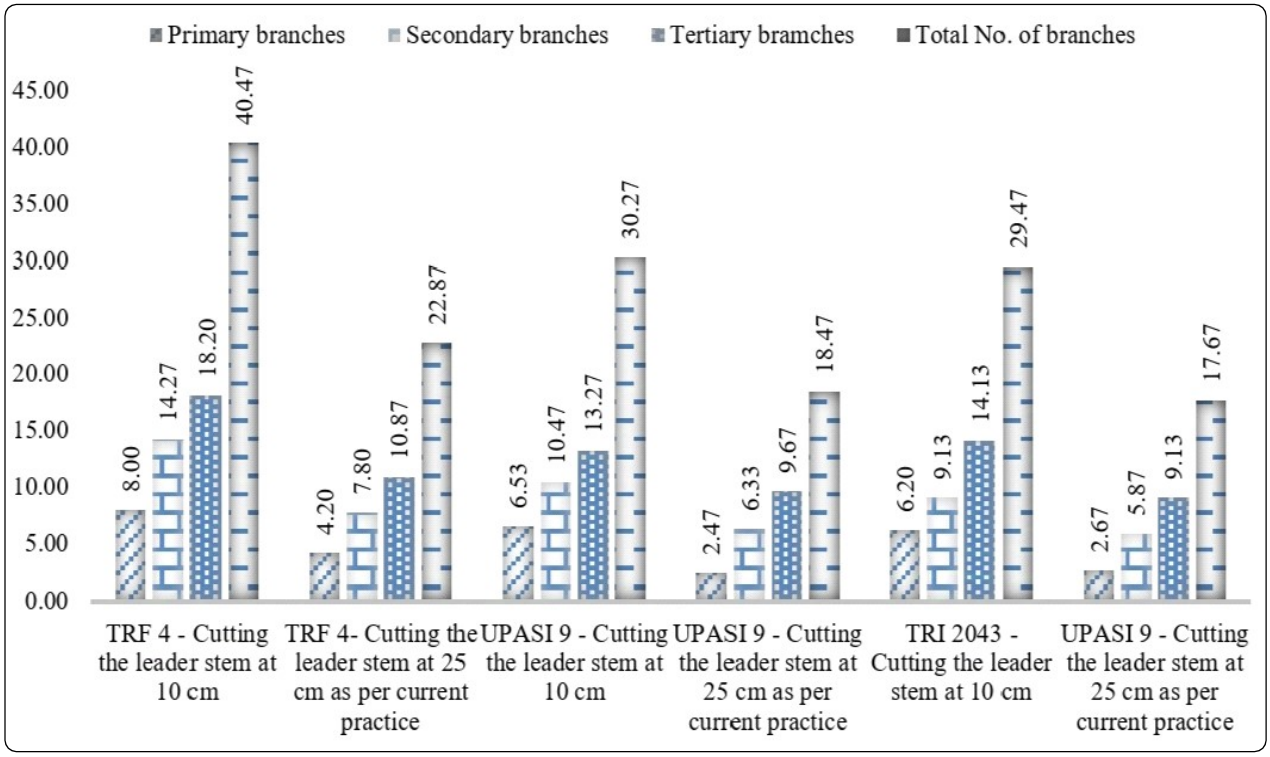

Fig. 1 : Response of young tea plants to two different training methods at the end of one year from planting

TABLE 2

Difference in growth parameters of young tea as influenced by cutting the lateral branches at 25 cm, 30 cm, 35 cm, 42.5 cm and 50 cm from the ground (Mean of all clones)

Parameters	Number of branches / plant				Bush height (cm)	Width of a double hedge (cm)
	Primary	Secondary	Tertiary	Total		
Two- stage tipping as per current practice	5.4	24.9	71.1	101.3	75.0	114.4
Cutting the leader stem at 10 cm followed by three-stage tipping	6.5	29.5	83.4	119.3	77.8	130.3
Cutting the leader stem at 10 cm followed by four-stage tipping	8.0	35.0	96.5	139.5	82.2	147.2
Cutting the leader stem at 10 cm followed by five-stage tipping	10.6	39.4	102.7	152.7	86.7	161.5
S. Em ±	0.59	1.08	0.99	0.61	0.85	1.98
CD @ 5%	1.28	2.36	2.16	1.32	1.86	4.31

short intervals, growth of the single stemmed tall growing tea plant is modified into a bush. It has been reported that well developed primary frame with more number of lateral branches is important to achieve high productivity throughout the life of the tea plant (Sharma *et al*., 1992). The structure and development of the primary frame and the lateral branches can be modified through the various methods of training of young tea (Sharma *et al*., 1992). If the young tea plants are not properly trained by arresting the apical

dominance to induce more number of lateral branch systems, the young tea plants develop only a primary frame having fewer, lanky branches and poor spread (Sharma *et al*., 1992). In the modified method of training of young tea and multi stage tipping method, many lateral branches could be developed and the spread of the canopy is also more. Due to more number of lateral branches after multi stage tipping, canopy width of the tea plants in the UHD double hedge also increased up to 160.5 cm when compared to the current practice of two-stage tipping. Tea canopy width in the modified UHD planting method after removing the apical dominance by cutting the leader stem at 10 cm followed by multi-stage tipping increased by 1.41 fold when compared to the current practice (Table 2).

With rising input costs, High Density Planting is a way of increasing efficiency of agriculture inputs. The main advantage of high density planting is that it is one of the most effective measures to increase early quality production with best use of land resources increasing the returns per unit area significantly. Harvesting and crop management become easier due to dwarf size of the crop and enables mechanization. Moreover, High Density Planting is highly amenable to modern input application techniques such as drip irrigation, fertigation, mechanization etc. as compared to traditional system (Singh, 2018).

Among the three different clones, the clone TRF 4 responded better to the modified method of removal of apical dominance by cutting the leader stem closer to the ground level (at 10 cm) by producing more number of lateral branches when compared to the other two clones UPASI 9 and TRI 2043 (Fig. 2).

In both the experimental plots, the wheel mounted harvesting machine and hand held two men operated machine was operated and the operational efficiency was monitored. In the experimental plot under the currently recommended planting style with the existing practices of training of young tea and two-stage tipping, many protruding side branches had to be cut and removed for the operation of the

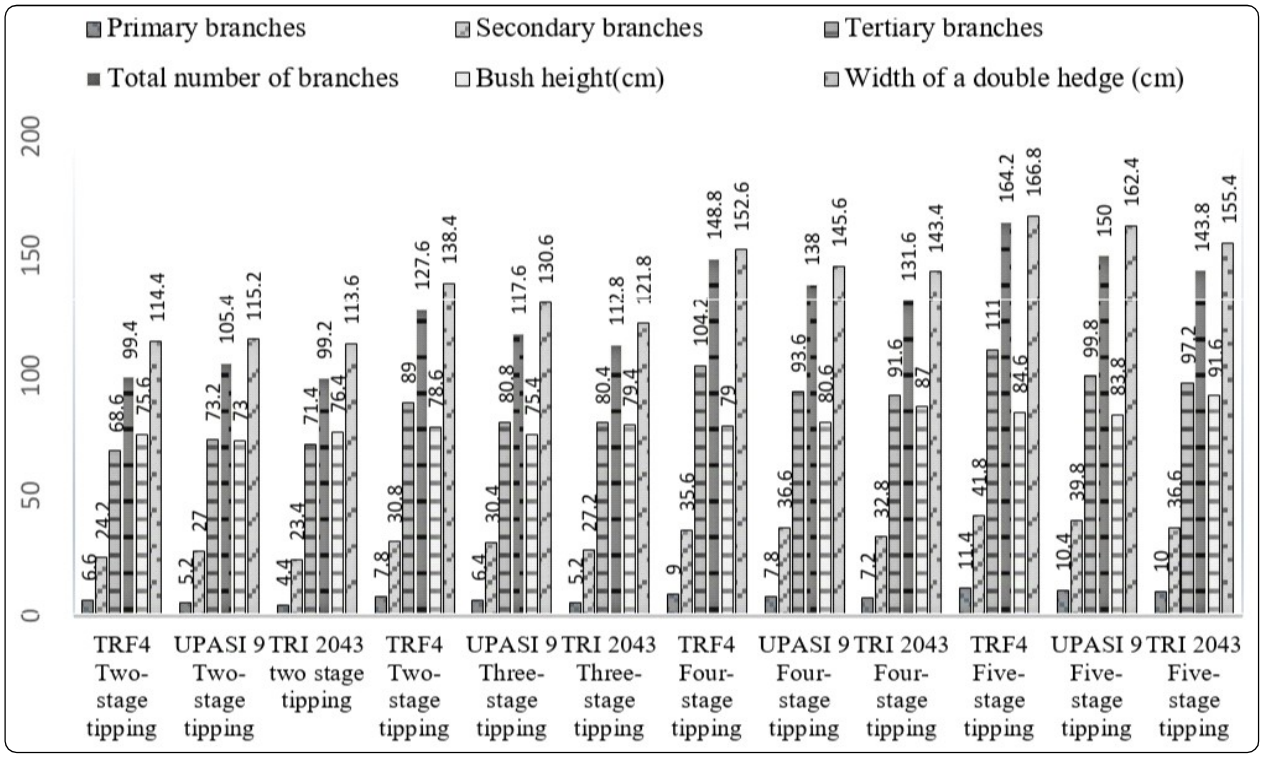

Fig. 2 : Difference in growth parameters of young tea plants influenced by methods of tipping

wheel mounted harvester. Besides, the width of the canopy in the currently recommended plating style of 135 x 75 x 75 x 75 cm and trained by two stage tipping reached up to 114.4 cm only (Fig. 2). The existing practice of planting method and training of young tea and two-stage tipping method was not suitable to the easy and smooth operation of the wheel mounted harvester. Due to the mismatch of the canopy width (harvesting surface in a double hedge) and the blade of the tea harvesting machine, the wheel mounted tea harvester had to be operated twice to cover the full harvesting surface of the tea bushes resulting in wastage of fuel and time.

Canopy width of the double hedge due to the modified method of UHD planting style of 130 x 50 x 50 x 50 cm, followed by the new method of training of young tea (cutting the leader stem at 10 cm followed by multi-stage tipping) reached 161 cm at the end of the fourth year from planting. In the experimental plots under new UHD planting design with modified training of young tea and multi-stage tipping method, the wheel mounted harvester could be early operated with a speed of 30 m covering 60 to 70 bushes /minute without any hindrance due to the protruding branches. The blade in the harvester also fully covered the entire canopy (harvesting surface) area of the tea bushes. UHD system gives 20 to 30 per cent higher yield on an average under rainfed condition in other crops. It has been reported that in tea 18 years is the payback period for replanting programme of the uneconomical old tea fields following the conventional planting system. Whereas, UHD system in tea is the fastest way of reducing the gestation period (Senthil *et al*., 2004). It not only ensures high crop but also makes the crop ready for mechanical harvesting (Desai, 2021; Ahmed & Kaur 2022 and Prasad *et al*., 2023). The newly developed UHD planting style with modified method of training of young tea and multi-stage tipping method is recommended to be followed in all the replanted tea fields for the smooth operational efficiency of the tea harvesters and to achieve a high worker productivity and also to overcome the worker shortage.

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