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Bush Physiology, Growth Analysis and Productivity of Darjeeling Tea (*Camellia sinensis* L) Plantation

R. Kumar*, Mahipal Singh and B. Bera[1]

ABSTRACT: *Tea plant manufactures more sugar than is needed for growth. The excess sugar is converted into starch and stored mainly in the roots. The starch is utilized to generate energy when new shoots are produced after pruning or when the rate of photosynthesis declines at night. The maximum seasonal photosynthetic rate (Pn) was observed during autumn followed by winter and summer seasons irrespective of the clones. Vapour Pressure Deficit (VPD) was highest in April and very high in other summer months, pre-monsoon (April) when atmosphere was dry and plants were suffering from moisture stress. Leaf water potential was lowest in summer and higher in rains. The decrease in stomatal conductance and transpiration were more pronounced in general during moisture stress period. Stomata normally close in response to increasing VPD. Pruning cycle is one of the most important operations in tea with a primary objective to replace the old set of maintenance foliage by a fresh one, so that tea bushes remain healthy and continue to provide succulent shoots to manufacture quality tea. Responses to different aspects of climate change can be both positive and negative. The yield increases due to increasing atmospheric* CO_2 *concentration* (C_a) *were augmented by increasing ambient temperature (Ta) at high altitudes. However, at low altitudes, yield gains of higher* C_a *were pulled back because the rising Ta pushed the already high Ta in to the DTRDC, Kurseong for most of the key physiological processes that determine yield. The climate change scenarios specified by different Global Circulation Models also showed increased yields at higher altitudes, but reduced yields at lower altitudes in future.*

Key words*: Climate, fertilization, pruning, photosynthesis, productivity, tea bush*

INTRODUCTION

Tea is one of the most sought after refreshing drinks in the world. Tea is a heritage non-alcoholic beverage of the world. It is one of the economically important small, evergreen woody plantation crop predominantly grown in the humid tropical and subtropical regions. Tea trees are very adaptable meaning that they can grow in wide range of locations. This does not mean that the quality of tea leaves grown in different areas is comparable. Tea leaves with the most desired qualities are generally grown in areas which have a relatively high level of humidity. Humidity is a relevant factor as it moderates the temperature of a region. Dry regions tend to heat up and cool down reasonably fast, whereas regions which are wetter tend to heat up and cool down more slowly. Darjeeling tea plantation experiences various types of adverse climatic conditions in the Darjeeling hills such as low temperature, low soil moisture in winter season, foggy climate, and high humidity including receiving low levels of solar radiation. A moderate and stable climate is essential for tea leaves to grow uniformly and contain the maximum amount of nutrients.

Tea plants are often mentioned as belonging to three distinctive types, viz Assam, China, and Cambod. According to a recent classification, there are three taxa of cultivated tea, corresponding to the three geographical regions of South East Asia, namely Assam, China and Indo-China. The first two are distinct varieties, *assamica* and *sinensis*, while the third form is known as southern or Cambod form. They are "light leaf" and "dark leaf" Assam varieties. The commercially grown tea plant, as we know it today, is highly heterogeneous. It is not uncommon to find tea plants with varying leaf angles, leaf pose, leaf size, pubescence, and colouration. Two main varieties (subspecies) of *C. sinensis* are used for tea production.

* Darjeeling Tea Research & Development Centre, Tea Board of India, A.B. Path, Kurseong – 734203, Dist. – Darjeeling (W.B.), India

[1] Tea Board of India, 14, B. T. M. Sarani, Kolkata- 700001 (W.B.), India, *E-mail: rk.jayantdtrdc@yahoo.com*

Within these main varieties, there are thou-sands of cultivars and clones. Origin, distribution and botanical features of tea plant; soil and climatic requirements; propagation technique; land preparation and planting; management of young tea; management of mature tea plantation; manuring and fertilization; shade management; irrigation drainage; integrated pest management; chemical composition of tea shoots; tea processing technology for Darjeeling (green and black) tea; sorting, grading, packing and storage of tea product. Before 1970s, the spacing of 120 cm × 75 cm to 120 cm × 60 cm depending on topography, and a population range of 11,000 to 14,000/ ha and three and four year pruning cycles were the conventional recommendations. As in many other tea growing countries, long term trial results have led now a day to spacing from 120 cm × 75 cm to 90 cm × 60 cm with a population load of 15,500 to 18,000. In Darjeeling now a days: The spacing for planting was 90 cm x 60 cm x 60 cm and the distance from hedge to hedge was 90 cm, row to row 60 cm, and plant to plant 60 cm with a population load of 17, 000 to 18, 000 plants per hectare.

The most desired teas generally come from estates at high elevation. The reason for this can be explained by a process called orographic lift. In short, at higher altitudes air pressure is lower which cools down the air. In turn, the ability of air to hold water decreases with temperature. Thus as air rises, it expands and cools down, which causes clouds to form resulting in rain or snow. The wind facing side of the mountain tends to receive a high amount of rain while the leeward side of the mountain tends to be relatively dry. Since the tea tree is a water loving plant, tea estates are generally located on the wind facing side of mountains. In addition to the weather benefits associated with growing tea trees at higher altitudes, teas which are grown at high elevations also grow slower. This gives the tea plant additional time to develop more complex aromas and flavours. Growth of the tea plant is dependent on many factors comprising of those that are inherent in the plant it and those exerted on the tea crop by nature such as soil and climatic conditions, pest and diseases, and man through crop husbandry and cultural practices. The main nutrient elements removed from a tea plantation through harvested tea are nitrogen (N), phosphorus (P), and potassium (K) and this attributed to the inevitable removal of the young shoots [13]. Pruning is seen as an important management practice in tea in the production of leaves for the manufacture of black tea [32]. These studies were intended to create an understanding of the basis of tea response to various environmental factors.

ENVIRONMENTAL FACTORS

The study was conducted at the Darjeeling Tea Research & Development Centre, Kurseong (26.9^{0}N, 88^{0}12 E, altitude 1347 m). The topography comprised of moderate slopes (25- 45%). The topsoil is about 45 cm in depth and the sub soil is stony. The Centre is located in the lower Himalayas. Owing to the Sub-tropical situation, the year comprises a summer season (March to mid. May), rain (Mid. May to August), autumn (September and November) and winter season (December to February). Towards the beginning of December frost can occur and sometimes in January the ground becomes extremely cold and the temperature goes down to 5 ^{0}C. Although there can be occasional falls of snow in January and February and air temperatures fall below freezing point, no snowfall was experienced during the study.

Mean maximum air temperature ranges from around 16 ^{0}C in February to 24 ^{0}C in July; a mean minimum temperature of 4.5 ^{0}C was recorded in January [16]. A rapid increase of temperature takes place during March and April owing to the warmer air from the plains. In May, the southerly winds reach the hills and because increased precipitation which is at times are very high. November to February are almost rainless and the light showers which fall in December and March occur when shallow depressions are passing eastward over the plaint. Based on the agro-climatic conditions, the month of April is considered as pre-monsoon, June to August as monsoon, October to December as post monsoon and January to February as winter. Further, December to April could be considered as a moisture-stress period. The minimum ambient temperature for shoot extension and development varies from clone to clone in the range 8 - 15 ^{0}C [29]. The rapid decline in yield in Darjeeling during October and then a cessation during November until the end of March indicates that low temperature is one of the major climatic variables limiting yield. Low temperature is also the vital factor causing low yields in the cold season in Malawi [30]. In Darjeeling, the extension growth stops at monthly mean maximum and minimum temperatures of 18 ^{0}C and 10 ^{0}C respectively in November and it start flushing at the end of March when maximum and minimum temperatures exceed 20 ^{0}C and 12 ^{0}C respectively. In Kenya, the monthly mean maximum and minimum temperatures rarely exceed 24 ^{0}C and 11 ^{0}C respectively at any time of the year, but the tea plants flush throughout the year and produce annual yields of the same order as plants in many warmer regions [3].

The study was conducted by [11] that the growth performance in terms of percentage of increment of stem diameter (SD) was highest during June to August which may be due to favourable climatic conditions such as ambient temperature (Ta - 21 to 23 ^{0}C), relative humidity (RH- 94 to 96 %), and high soil moisture (Sm – 31 to 35 %) also prevailed during the period. Lowest SD noticed in April was probably due to low Sm and high VPD. A positive correlation was observed between SD and precipitation, soil temperature and RH indicate that Tea require high rainfall and high humidity for its growth. Positive correlation existed with Ta indicated that the growth of tea in this region is associated with an increase in the levels Ta [11].

EFFECT OF MICRO-ENVIRONMENT

Tea plants apparently adapt to the changing environment and with stand adverse climatic conditions. Analysis of seasonal variations in gas exchange property may be useful in constructing models of plant growth. Therefore the studies were done to find out the changes in photosynthetic parameters of tea leaves responding to diurnal and seasonal changes in climate. The highest value of photosynthetic rate (Pn) were recorded at 10:00 h to 13:00 h in autumn and summer, winter and rainy season [9]. The midday depression in Pn was evident in summer, autumn and winter seasons. The midday depression of Pn during the study may be a reflection of stomatal closure rather than photoinhibition as the tea leaf in Darjeeling did not show any photoinhibition on exposure to a high photosynthetic photon flux density (PPFD- 1450 μ mol $m^{-2}s^{-1}$) at an optimal temperature. During summer, Pn was noticed at lower rate than autumn and winter. The lower rate of Pn recorded in summer when atmosphere was dry and plant were suffering from moisture stress [9], [7] and [1]. The chlorophyll pigments play a vital role in Pn which in turn determines the productivity. Total chlorophyll content was found highest in autumn followed by rainy, winter and summer seasons [8]. Therefore, you can see the trend of the physiological parameters from the table 1.

The study was conducted at the experimental farm of this centre Kurseong during 2010-11. Maximum leaf water potential was noticed during rainy season followed by autumn, winter and summer season. The early morning hours showed higher leaf water potential (ψ_L) in the all seasons. A gradual reduction of ψ_L till 12:00 was observed in winter. In general, ψ_L was low at noon during all season (Table 1). Higher value of leaf water potential was associated with low PPFD, higher atmospheric temperature, soil moisture and relative humidity during rainy season. The minimum ψ_L was observed in summer; PPFD has increased from lower intensity to a saturation level (about 1350 μ mol $m^{-2}s^{-1}$) by 10:00

Table 1
Diurnal pattern of physiological parameters i.e. photosynthetic photon flux density (PPFD), net photosynthetic rate (Pn), stomatal conductance (gs), transpiration rate (E), intercellular CO2 conc. and leaf water potential (ψ_L) in Darjeeling tea plantation. Mean of 12 months.

Time (hrs.)	*PPFD (μ mol $m^{-2}s^{-1}$)*	*Pn (μ mol $m^{-2}s^{-1}$)*	*gs (mol $m^{-2}s^{-1}$)*	*E (m mol $m^{-2}s^{-1}$)*	*Ci (ppm)*	$\psi_{L(-Mpa)}$
6:00	61.8	2.4	0.23	1.4	316.7	-1.1
7:00	91.5	3.9	0.14	1.6	292.0	-1.1
8:00	185.9	6.3	0.12	1.7	238.9	-1.5
9:00	688.7	9.7	0.13	2.2	193.5	-1.8
10:00	1357.0	10.5	0.13	2.6	172.8	-1.9
11:00	1351.0	10.9	0.11	2.8	153.8	-2.1
12:00	1392.0	12.8	0.18	3.3	148.8	-2.9
13:00	1157.0	10.3	0.10	1.9	159.6	-2.8
14:00	1213.9	9.9	0.12	2.5	174.7	-2.2
15:00	816.5	8.8	0.17	2.8	229.5	-2.0
16:00	96.6	3.3	0.08	1.2	278.2	-2.0
17:00	2.9	0.5	0.03	0.4	354.1	-1.6
18:00	0.0	0.0	0.01	0.2	377.9	-1.3
CD at 5%	43.58	0.73	0.04	0.33	11.95	0.44

to 12:00 as compared to rainy season which was less than 380 μ mol $m^{-2}s^{-1}$. The clones, T135 showed higher ψ_L followed by AV2, P312 and T383 [17]. The data showed that the leaf water potential could be a potential indicator of drought sensitivity in tea clones. Vapour pressure deficit value of 2.5 kPa appears to be a critical value at which the leaf water potential drops below -1.0 Mpa for drought sensitive plants but stays above -1.0 Mpa for plants that are not sensitive to drought [17].

The volumetric water content of both top and sub-soils decreased gradually from winter and declined rapidly during summer (Figure 1). Transpiration rate was lowest in summer season and higher in rain, though the PPFD reached minimum but the temperature, Sm (Soil moisture), wind velocity and RH were reasonably high.

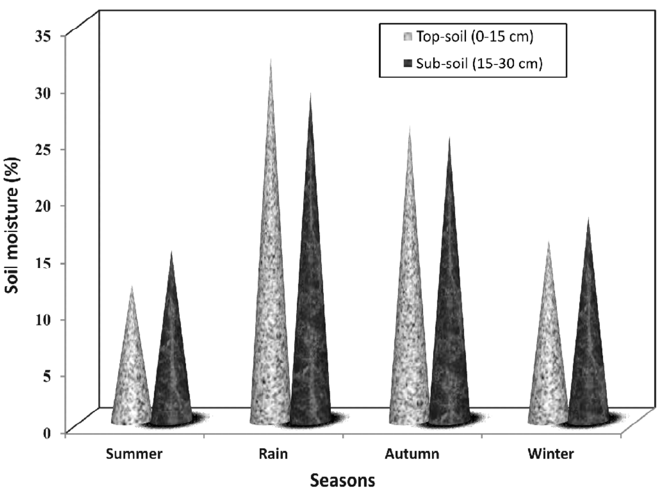


Figure 1: Voluemetric water content (Sm %) of Experimental farm at DTRDC, Kurseong (Data are average of 15 years)

EFFECTS OF CANOPY COVER

The leaves in the lower layers of mature bushes hardly receive any light. These old leaves may be depending on translocation photosynthates. The study was conducted to find out the influence of the climatic variable on physiological characteristics of released tea clones i.e. T78, B157, AV2 and old china tea bush planted in Darjeeling. Highest value of photosynthetic rate (Pn), transpiration rate (E), stomatal conductance (gs) were noticed in canopy depth 0-10cm and lowest in <30cm. The photosynthetic activities were observed in the mid elevation. The rising ambient temperature triggers a variety of changes in the atmosphere leading to modified rainfall patterns, evapotranspiration rates and Vapour pressure deficit [18]. Different clones also differed in canopy characteristics and shoot density distribution on the plucking table [4]. Response to different aspects of climate change can be both positive and negative. The yield was increase due to increasing atmosphere CO2 concentrations (Ca) were augmented by increasing Ta at high altitude. The climate change scenarios specified by different Global circulation models also showed increased yield at higher altitudes, but reduced yields at lower altitudes in future.

PHOTOSYNTHETIC RATE AND OTHER RELATED PARAMETERS

The study was conducted to investigate the impact of climatic variables on physiological and biochemical characteristics and crop productivity of three contrasting clones. Soil and atmospheric droughts influenced the photosynthetic rate (Pn) and other related parameters, and biochemical variables. Low PPFD and low sunshine hours were important limiting factors for Pn. Temperature and irradiance never reach a sufficiently high level in Darjeeling hills (High elevation) to have a detrimental effect on Pn. Quantum of Chlorophyll, total free amino acid (TFFA), free proline FP), ascorbic acid (AA) and epicuticular was (EW) could be used as screening parameters for selecting clone for drought tolerance [10].

The other studies were done to find out the seasonal effect of environment on physiological and biochemical characteristics of released ten tea clones and also to see the performance of South Indian clones [viz. T235, B-157, B-777, MB-6, T-78, TtV1, RR-17/144, Athrey, Pandian and Springfield (China seed jat)] planted in Darjeeling, and to determine the correlation between variables of gas exchange, stem diameter increment and yield of young tea clone grown in a subtropical environment. Among the clones, MB-6 and B157 assimilated significantly higher amount of CO_2 than any other clones. Although humidity (96%) and soil moisture (35%) had a positive influence on Pn, low PPFD and sunshine hours (less than 2.0 h day^{-1}) affected Pn activity. The limiting factor for Pn was probably the low sunshine hours. The value of Pn was higher when PPFD increased from 950 μ $molm^{-2}s^{-1}$ (winter) to 1350 μ $molm^{-2}s^{-1}$ (autumn). Lowest PPFD was noticed during rainy season which in turn affected the Pn. Among the clones, TtV1 showed lower values of ψ_L while MB-6 recorded highest in all seasons. Lower values of gs observed in summer and winter. The highest value of g_s was recorded in rainy season. The decrease in stomatal conductance and transpiration was pronounced in summer when both atmospheric and soil moisture were low and demand for water was more. Among the clones, MB-6 showed average value in all seasons. Transpiration in general increased with increase in leaf temperature [14]. Total chlorophyll content was found highest in rainy season and lower in summer [10] [34]. Among the clones, MB-6 and B157 had higher amounted of chlorophylls followed by others clones. Influence of environmental factors on total Chl content was evident and results substantiate the earlier findings [25]. [10] & [26] were reported that the chlorophyll content was positively correlated with photosynthetic rate in the case of clones and found negative correlation existed between Chl content and yield.

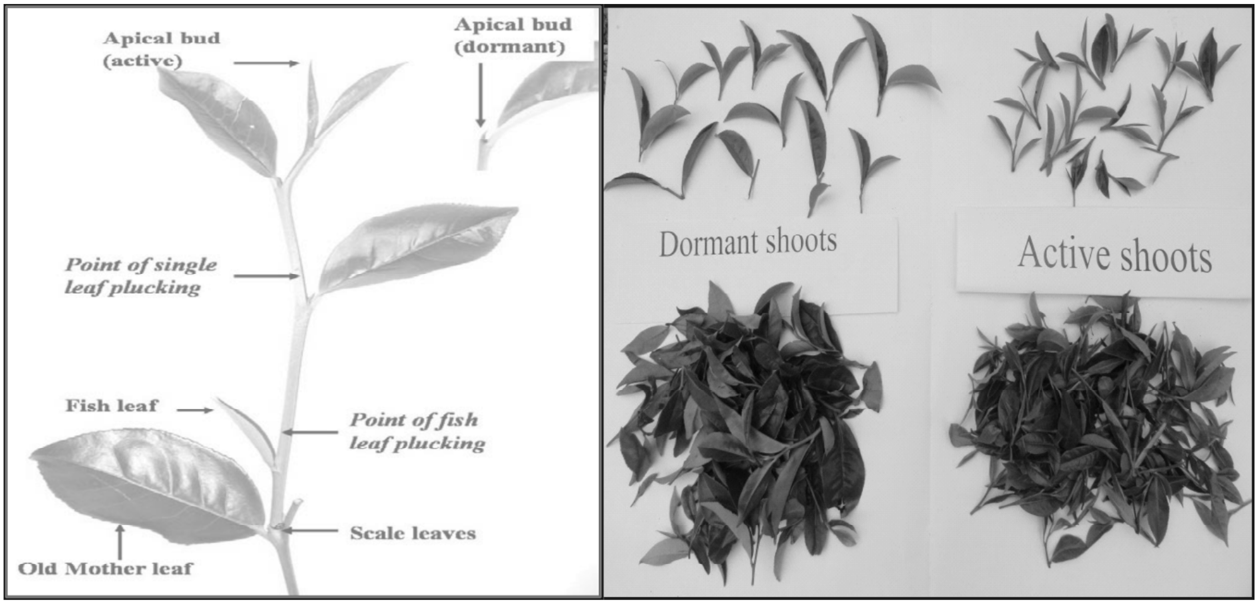
EFFECTS OF FERTILIZATION

The study was done to know the effect of fertilization on photosynthesis and associated characteristics and yield of young tea. The four year's yield trend of an experiment on the efficacy of split and basal application of organic and inorganic fertilizers in the optimization of tea yield conducted in Darjeeling hills revealed that single basal dose (during April/May) of CAN: DAP: MOP @ 60: 30: 60: gives highest return [16]. In this low temperature hilly acidic tea soils the microbes responsible for the mineralisation of Ammoniacal- Nitrogen to Nitrate-Nitrogen is low. Hence it has been suggested that the highest yield for CAN – treated plots was perhaps primarily because of the immediate availability of Nitrate – Nitrogen from CAN (12.5% nitrate and Ammoniacal nitrogen each) which other Nitrogenous fertilizers lacked in viz., Urea and Ammonium Sulphate which contains only the Ammoniacal form of Nitrogen.

The study was undertaken to know the effect of combination of organic and inorganic fertilizers on photosynthesis efficiency and associated characteristics and yield of tea. The highest photosynthetic rate, Stomatal conductance and Leaf water potential were recorded with the application of vermicompost (VC) 50% @ 2.75 tones + Chemical fertilizers (CF) 50% (45:22.5:45 kg^{-ha} basal through Urea, Rock phosphate and muriate of potash, which was followed by 90:45:90 kg^{-ha} basal through Urea, Rock phosphate and muriate of potash [19]. When the atmosphere was dry during the pre-monsoon and plants were suffering from moisture stress till the end of May, the lower rate of Pn was recorded in all treatments and that may be due to low humidity or moisture stress. There is abundant evidence in the literature that Pn is inhibited by water stress [8]. The made tea was highest by the applying with combined application of Vermicompost 50% and Chemical fertilizer 50% which showed an increase 46 percent. The three years yield trend of experiment on the efficacy of split and basal application of organic, inorganic and combined fertilizers in the optimization of the yield conducted in Darjeeling hills revealed that Combined organic and inorganic fertilizers dose (during April/May) of vermicompost 50% @ 2.75 tones + chemical fertilizers 50 % (45:22.5:45 kg^{-ha} gives highest return [19].

EFFECT OF PLUCKING

The study was done to optimum a suitable plucking interval for old chinary tea plantation of Kurseong (Mid elevation) in terms of yield of quality. Sorter plucking intervals was higher production compared to extended intervals during the study [12]. [5], was reported that china clone, which had shorter leaf period given highest yield in 5 day rounds. [6], were noticed that a short round gave the highest yield from seedling and clonal tea. Harvest from shorter plucking interval would consist of a large majority of active shoots of 1+ bud and 2+ bud. Quality of the tea was almost same in 4, 5 and 6 day intervals. Free growing bushes produced more dry matter than plucked bushes, and the extra dry matter was mainly in the woody parts, especially the frame. Plucking affected both total dry matter production and partitioning in the bushes. Indeed plucking changed the way tea partitioned in the following ways: (1) tea bushes produced more dry matter when not plucked because they formed more woody tissues, which in turn required more assimilates for secondary thickening in addition to new tissue formation; (2) plucking changed the way dry matter was partitioned by allocating more assimilated to new tissue formation instead of formation of secondary thickening of old branches; (3) the plucked bushes under the existing management and cultural practices may be capable of achieving higher annual harvest index than so far reported, if favourable growing conditions prevailed for a longer period [23]. The study indicates that yield and quality can be improved by reducing the intervals between successive plucking rounds. After producing the fish leaf, the terminal bud produces normal flush leaves are 1L+ b (one leaves and a bud), 2L+ b (Two leaves and a bud) and 3L+ b (Three leaves and a bud). The dormant bud banjhi is a few millimeters long tiny bud usually covered by leaf hairs. It could be easily differentiated from an active terminal bud as the former is very small compared to the latter.



Photographs: Normal flush leaves and dormant shoots & active shoots.

SHOOT GROWTH

The study was done to examine the relation between climates and shoot growth in china type popular Darjeeling tea clones i.e. B157, AV2, T78, T135, T383, B777, P312 and Nanda Devi. This study revealed an exponential increase in the growth of shoots, different patterns of fish leaves compared with full leaves, indications of activity in banjhi buds at a very early stage and cessation of leaf growth at a point when the leaves were ready for harvesting. The difference in total shoot population densities between clones were every marked. Clones AV2, P312 and seed stock Nanda Devi had lower shoot numbers than T135, B157 and B77. Clone AV2 had 50 to 400 shoots m^{-2} and seed stock Nanda Devi had rarely crossed 400 shoots m^{-2} [15].

The results indicated highest shoot growth rate and population density in clone T135 and minimum in P312. The maximum shoot growth rates were observed in April, July and August in clones T135, B157 and B77. Shoot growth rates in clones T135, B157 and B777 increased from 5 to 40 mm $week^{-1}$ in March

Photo: Experimental field and counting of shoots.

to April and between 35 and 65 mm week^{-1} during the rainy season from June to August. Maximum yield was noticed in T135 in the 3rd year after pruning and then reduced with pruning age. However, in B157 and B777, yield increased up to 4th year. Tea bushes expanded and produced more productive shoots during the 2nd and 3rd years of pruning. Yield reduction was mainly associated with the reduction of shoot number per unit area, size of the shoot, photosynthetic rate, proportional sunlight, leaf area and percentage of active shoots. The drought tolerant clones produced more dormant shoots than drought susceptible clones. The Clones T135, T78 and B157 produced less dormant shoots than AV2 and B777 [15].

EFFECT OF PRUNING, PRUNING TIME AND PRUNING CYCLE

Pruning is the cutting of branches of a tea bush at predetermined height and at a specified interval in order to reinvigorate and bring tea bushes within reach of pluckers. The study was done (1) to determine the most appropriate pruning cycle and pruning time, (2) to keep the bushes continuously under vegetative phase of growth as growing shoots are the harvestable part in tea, (3) to improve bush hygiene by removing pest and disease affected leaves and stems by fresh ones in old chinary tea plantation. The study was also done that the starch accumulation increased gradually from October and reached the peak in December. The quantity of starch reserve was highest in December and lowest in September [20]. It was also noticed by [27].

Considering the highest accumulation of starch during December, the pruning operation can be safely done in December. In ten (10) years of study, pruning cycles of 3 year (LP – UP/LOS – LS), 4 year (LP – UP/LOS – MS - LOS) and 5 year (LP- UP - LS – MS – LOS) completed 3, 2 $^1/_2$ and 2 cycles respectively.

Photograph: Starting bud brake in the plots of Light pruning (LP), Medium skiffing (MS), Light skiffing (LS) and Levelling of skiffing.

The length of pruning cycle also depends on the elevation. The growth rate is generally slower at high elevation and thereby tea can be kept on a comparatively longer pruning cycle than at low elevations. It would ensure proper thickening of the primaries which is very essential for a good light prune. A five year pruning cycle with china hybrid tea at mid elevation, introducing Deep skiff/Medium skiff after two year of UP/LOS and leaving the bushes LS/LOS again in the last year of the pruning cycle was found desirable. Medium skiff in the fourth year of the cycle helped to minimize the problem of excessive banjhiness and in improving the shoot size considerably. The maximum yield was noticed in 5 year pruning cycle followed by 4 year pruning cycle and their difference was significant [20]. The yield 3 year pruning cycle and 4 year pruning cycle were at par and difference was not significant. Overall results suggested that yield increases in 5 year pruning cycle and reaches to a maximum in the 3rd year of two pruning. [33], was reported that the same trend of less yield in the first year, with yield increasing in the subsequent second and third years. It has also been shown that during the first year of the pruning cycle, yield are generally low, because bushes have to recover from the prune before plucking can resume and because it takes time for shoot numbers to build up [31]. Thereafter, a gradual decline in yield with pruning was observed. Yield reduction was mainly associated with the reduction of shoot number per unit area, size of the shoot (reduced inter-nodal length and leaf size), photosynthesis rate, proportional sunlight leaf area, leaf water potential and percentage of active shoot number in all pruning cycles.

Tea yields started to decrease after four harvest years following pruning. Therefore, after 3rd or 4th year of pruning yield starts to gradually decline and this leads to another pruning operation [28]. Skiffing is normally light pruning and involves removal of the green wood at about 15 cm above the pruning height

Photograph: Light pruning (LP) section

and has been found to prolong the pruning cycle in Sri Lanka [24]. [22], was pointed out that pruning has a direct effect on regrowth and recommended that it should be tried at field scale on cultivated bush tea to assess the vigour of growth, productivity and quality. A five year pruning cycle is better than a four and three year cycle. However, a six year pruning cycle may also be tried at mid to high elevation. It is suggested that in Darjeeling hills the pruning cycle of tea should be of 5 year pruning cycle. [21], was noticed that the pruning of tea under the climatic conditions of Darjeeling hill should be carried out in the dormant period. Mid November to December month for Deep/Light pruning and January month for Skiffing are the most suitable times for the pruning of tea plantations to get high productivity. The study was indicating that the pruning should be done when the root starch will be high.

LEAF AREA INDEX

The leaf area index (LAI) is an important parameter in the productivity of tea. It was observed that leaf area index was highest in the 5 year pruning cycle and minimum in 3 year pruning cycle. Leaf area in the upper layers of the canopy was higher in 3rd year of pruning in all pruning cycle [20]. In the pruning cycle, yield was comparatively lower in the first year after pruning which may be attributed to small bushes with few branches and lower leaf area index. The low yield of Darjeeling tea may be because of continuous fine plucking which reduces the sink activities in totality limiting the upward movement of assimilates. Leaf area index (LAI) has a positive correlation with yield. Higher the LAI more is the total carbon uptake for carbohydrate production [2].

CONCLUSIONS

Various studies have been conducted to determine the effect of cultural practices such as minerals nutrition on the tea growth and productivity. The current review serves as a foundation towards a study to investigate the effects of nitrogen fertilization, timing of nitrogen fertilization, effect of shoot growth, plucking, pruning, Micro-environmental factor and physiological parameters on the yield and quality of Darjeeling tea plantation. Pruning and pruning time have a significant positive effect on tea yield indicating yield increase when the proper pruning cycle is followed. As a strong relationship between tea yield and leaf area index (LAI). LAI can be used as a predictor of tea yield. The current study gives us an idea that such effects could be analysed and monitored of Darjeeling tea Industry.

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