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EFFECT OF PRUNING AND SKIFFING ON GROWTH AND PRODUCTIVITY OF DARJEELING TEA (*CAMELLIA SINENSIS* L.)

R. Kumar[1]*, J. S. Bisen[1], Mahipal Singh[1] and B. Bera[2]
[1]Darjeeling Tea Research and Development Centre, Tea Board of India, A.B. Path,
Kurseong – 734203, Dist- Darjeeling, (WB), India
[2]Director Research, Tea Board of India, 14, B.T.M. Sarani, Kolkata, (W.B.), India
rk.jayantdtrdc@yahoo.com

Abstract- 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. An investigation was initiated in Experimental Farm, Darjeeling Tea Research and Development Centre, Kurseong, Dist. Darjeeling at 1347 m a.m.s.l on old chinary tea bushes to evaluate the suitability of pruning cycles of varying durations and pruning skiffing sequence on yield and crop distribution. Shoot extension rate, active and banjhi shoot (shoots with restricted growth), net photosynthetic rate, leaf water potential, leaf area distribution and tea yield were measured. Active shoot density decreased with age, with the corresponding increase in banjhi shoot density. Net photosynthetic rate and leaf water potential were highest during the first year and then decreased subsequently in all pruning cycles. Leaf area index (LAI) increased up to 3rd year in 4 and 5 year pruning cycles after pruning and reduced thereafter. The maximum yield was observed in 5 year pruning cycle in 3rd year after pruning and then reduced with pruning age. The yield of all pruning cycle were lowest in first year after pruning which may be attributed to small bushes with few branches and lower LAI. The maximum yield was also observed when pruned in December followed by November which may be due to maximum accumulation of root starch in December.

Key words: Net photosynthetic rate, Pruning cycle, Pruning time, starch.

I. INTRODUCTION

Tea is a popular beverage made from the leaves of evergreen shrub or tree Camellia sinensis, family Theaceae. Under natural conditions, a tea plant grows to a small tree but it is configured into a bush by sequential pruning and other silvicultural practices, viz tipping, plucking and by harvesting the optimum vegetative produce. Pruning is one of the most important operations in tea plantation. To check the apical dominance and keep the bushes in vegetative stage and to divert the energy towards production of leaves, pruning is inevitable. It also leads to enhanced branching and hence a greater number of tender leaves. Plant height normally increases by 15-20 cm annually and leads to low productivity, as the plucking becomes more difficult. Hence in order to maintain tea bushes in a manageable condition for plucking and enhance production by increasing branching, pruning is essential. In South India a pruning cycle of four years is practiced [11]. Un-pruned tea plants produce more dormant buds than growing buds [10]. Therefore pruning prior to harvest greatly improves plant productivity. Pruning helps in forming a uniform plucking canopy. Pruning is followed in the succeeding years by skiffing. Combination of pruning and skiffing constitutes a pruning cycle. What would be the interval between one pruning to the next year, is a vital task which has a great role in yield status of tea plantation. Hence, selection of a suitable pruning cycle has a great role in yield status of tea plantation. In Darjeeling, tea there is lot of controversies about appropriate pruning cycle. In view of the same, an experimental field trial was proposed an old chinary tea bushes.

Pruning is the cutting of branches of a tea bush at pre-determined height and at a specified interval in order to reinvigorate and bring tea bushes within reach of the pluckers. Pruning rejuvenates the tea bush and brings it to growth of new pluckable shoots. Tipping is a method of breaking back the primary shoots developed after pruning to establish an even plucking table and bringing the field into production.

The most important manufacturing organs of the tea plant, In the presence of chlorophyll (green pigment in the leaves), carbon dioxide and water react to synthesis sugar in the process called photosynthesis, which is dependent upon light and temperature. If there is insufficient light photosynthesis will decrease. As leaves become older they become less efficient at photosynthesis. An efficient plant will manufacture more sugar than is needed for current growth and the excess sugar is converted into starch and stored in the root system. The stored starch is available at the time when new shoots are produced after pruning or when only old and inefficient leaves are present on the plant.

The crop distribution in a year depends also on the pruning cycle and time which, in turn, is decided by the prevailing seasonal conditions. The objectives of this experiment were (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 and (3) to improve bush hygiene by removing pest and disease affected leaves and stems by fresh ones in old chinry tea plantation..

II. MATERIALS & METHODS

The study was conducted at the experimental farm of the Darjeeling Tea Research & Development Centre, Kurseong which is located at Lat. 26.9^0N, $88^0$12 E, altitude 1347 m during 2001 to 2011 on old chinary tea bushes, using 3 year (LP – UP/LOS – LS), 4 years (LP – UP/LOS – MS - LOS) and 5 years (LP – UP/LOS – LS - MS – LOS) pruning cycle. The topography comprised of moderate slopes (25-30%). The top-soil is about 45 cm in depth and the sub soil is stony. The soil is an Umbric Dystrochrept, moderately permeable and moderately well drained having sandy loam, texture.

Plants were subjected to water deficit from March to May and were without irrigation every year. The recommended dose of fertilizers i.e. N: P: K::90: 45: 90 Kg/ha through the mixture of Urea, Rock Phosphate and Muriate of potash were applied. Shoot extension rate, active and banjhi shoots (shoots with restricted growth), net photosynthetic rate and leaf water potential were measured. The harvested leaves comprised of young shoots, (normally two or three leaves) and a terminal bud, plucked at 7 days intervals (weekly) throughout the growth period. The fresh and dry weights, number of active and banjhi shoots were recorded from 100 gm of plucking green leaves and dry weight of made tea was taken.

III. MEASUREMENT TECHNIQUES

Photosynthesis was measured from the each plot using a portable photosynthetic system (Li 6200, Li – cor, Nebraska, USA) with a well mixed 390 cm^3 chamber as described [6]. This portable instrument has internal programmed to calculate physiological quantities from measurements of air and leaf temperatures, humidity and CO_2 concentrations. The humidity within the chamber was kept constant during the measurement period in order to get satisfactory results as observed by [5]. Dark-green healthy looking mature leaves at the surface of the canopy and fully exposed to incident sunlight were used for the observations. Such leaves are often referred to as 'maintenance' foliage. Three plants randomly selected from each plot, were assessed on every recording (486 reading). All measurements were made between 10 00 and 12 00 hours.

Leaf water potential (ψ_L) was measured simultaneously using a dew point hygrometer (model C-52 sample chamber connected to an HR 33T micro-voltmeter, Wescor Inc., Logan, USA) as described by [13]. Small circular leaf discs from the leaves on the opposite branches to those for Pn measurement were used for leaf water potential and ψ_L values were expressed as megapascals (-MPa).

From each plot, leaf samples were collected for measuring Leaf Area Index (LAI). Sample size was 1 square meter. Leaf area was measured from the field using a portable area meter (Li-3000A, Li – cor, Nebraska, USA) as described [7]. Leaf area index (LAI) is the total leaf area divided by the sample surface area. Following equation was used to calculate LAI.

$$LAI = \frac{\text{Total leaf area}}{\text{Sample surface area}}$$

IV. RESULTS AND DISCUSSION

There had been a tendency in Darjeeling hills to extend pruning cycle beyond its normal limit. As a result plucking had become problematic and the cost of plucking also increased. The result of past experiments on pruning cycle carried out by DTRDC, have been discussed to throw some light on the possible choice of pruning cycle. 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. The average annual yield of 10 years showed an increasing trend with increasing length of pruning cycle (Table 1 and Fig. 1). In 3 year cycle, a light skiff following an un-prune year was found to be desirable than to keep the bushes un-pruned successively for two years. It was felt that plucking became difficult in the second un-pruned year due to excessive banjhiness which reduced the yield where as a light skiff improved the shoot size and reduced the extent of banjhi formation. In 4 year and 5 year pruning cycles, with a medium skiff between two un-pruned years reduced this problem and contributed more yield than 3 year pruning cycles. The 5 year pruning cycle recorded the highest yield.

The mean annual yield was recorded only 587.6 kg/ha and varied with pruning cycle. The maximum yield was when pruned in 1st week of December followed by November and last week of September (Table 1). During the growing season from spring to summer (March to August), photosynthates are supplied to the growing shoots by all the leaves of maintenance foliage. By end October, the lower layer of leaves send photosynthates downwards to the roots and the upper layer continues to support the top growth. But with the fall of ambient temperature in November, all the layers send photosynthates downwards to the roots which accumulate as starch. [2], after estimating the root starch of all TV clones, advocated pruning between end December and early January which supports the present study that the maximum yield was from plots pruned during 1st week of December followed by November pruned plots. The starch accumulation increased gradually from October and reached the peak in December. The quantity of starch reserve was highest around 16.0% in December and lowest in September (Figure 6) as it was observed by [9]. Considering the highest accumulation of starch during December, the pruning operation can be safely done in December.

In general, total as well as summer season percent crop increased in four and five year cycles than three year cycle (Fig. 2). The maximum number of active shoots per unit weight of green leaves was recorded in the first year in all pruning cycles and it declined progressively with the age. An opposite trend was observed for banji shoots. It was observed that leaf area index (LAI) 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 cycles (Fig. 7).

Maximum photosynthetic rate and leaf water potential in all pruning cycles were observed after the first year of pruning, and decreased thereafter with pruning age (Fig. 3 & 5). During the first year after pruning canopy illumination was highest. With the accumulation of more leaves with aging, proportional sunlight leaf area gradually decreased, reducing the canopy photosynthetic efficiency [12]. Maximum leaf water potential (ψ_L) was recorded (Fig. 5) in rainy season (non-stress period) followed by summer season (stress). Leaf water potential of the pruned plants is constantly higher than the un-pruned tea bushes.

Darjeeling plantation is dominated by cultivars of China type which perform better than cultivars of Assam and Cambod types under the extreme climatic conditions of Darjeeling. Moreover, China hybrids exhibit higher plant water status than Assam and Cambod clones under soil moisture deficit [3]. 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 [1].

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 un-prune/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.

Maximum yield was observed in the 3rd year after pruning and then reduced with pruning age (Fig. 4). In the pruning cycles, 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 (LAI). Tea bushes expanded and produced more productive shoots during the 2nd and 3rd years of pruning. Productivity trend was started to decrease after the 3rd year of pruning. This may be due to lower, leaf photosynthesis, leaf water potential, and decreased number of active and increased number of banjhi shoots. Overall yield increased when light skiffing was carried out at the 3rd year of pruning. Light skiffing of the maintenance foliage results in quick recovery and increased yield. New shoots are developed from the young woods from a larger area which forms plucking table of a bush. Because of improper bush management like hard plucking, results in rapid decline in yield, a form of light skiffing is necessitated in order to maintain normal pruning cycle or to extend pruning cycle length [4].

The maximum yield has been recorded in 5 year pruning cycle followed by 4 year pruning cycle and their difference was significant. The yield 3 year pruning cycle and 4 year pruning cycle were at par and difference was not significant. The 5 year pruning cycle was the best of all pruning cycle.

The maximum yield was recorded when the bushes pruned during 1st week of December followed by November (Table 1) and their difference was statistically significant. The pruning in November and September yielded almost the same because December is the best time of pruning of tea at Darjeeling hill. Non-significant difference was observed in the interaction of pruning cycle and pruning time. Thus these two factors are independent.

The principle axiom for requirements is the fact that the lighter the cut during pruning, the more is the yield and vice versa. Moreover, continuous high treatment also congestion at the top, apart from a general decline in productivity and resultant will crop loss. Although the earlier practice was to go for annual pruning to stimulate growth, it caused a major stagnation in yield level. When this situation was overcome by the introduction of selective un-pruning between pruned years as in un-pruned tea, the level of yield was generally high. This essentially was the rationale behind the introduction of the so called longer pruning cycle with a combination of pruned and un-pruned years. But keeping tea continuously un-pruned (with appropriate height reduction) had it own drawbacks, because this led to the formation of large knots on the branches accompanied by general thickening and reduction of number of pruning sticks, and severe congestion at the top. The physiological basis for this complex morphological change is not known, except perhaps that more of the dry matter goes into the stems [8] but the net effect is a serious decline in yield. However, as pointed out earlier, long term productivity of the plants their intrinsic abilities to yield should be overriding importance. The rule of thumb in selecting the form of skiffing is the quantum of possible yield increase very light prune tea; this would be in the reason of the 10 to 15 percent with deep skiff, 15 to 20 percent with medium skiff, 20 to 25 percent with light skiff and if tea is kept un-pruned the possible yield increase would be in the region of 30 to 35 percent over pruned tea. It is important that these apparent gains over light pruned tea are neither cumulative nor continuous.

The second important consideration in selecting a pruning cycle is the pattern of crop distribution. Unlike the tea growing areas close to the equator, crop distribution in North-East India being somewhat erratic the only way to get more of early equality crop is to go for skiffing and perhaps to an extent un-pruned tea as well. The crop distribution under different forms of pruning and skiffing (Fig 4) suggests that a varying measure of early crop is possible by differential pruning but the best results come only from a realistic combination of different forms of pruning and skiffing.

V. CONCLUSION

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. Overall results suggested that yield increases in 5 year pruning cycle and reaches to a maximum in the 3rd year of two pruning. 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. It is suggested that in Darjeeling hills the pruning cycle of tea should be of 5 year pruning and December as pruning time.

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REFERENCES

[1] Barman, T. S., Baruah, U. and Sarma, A. K. (1992). Physiological importance of maintenance leaves in tea. Proc. 31st Tock. Conf., pp 42-9.

[2] Barman, T. S., Saikia, J. K. and Pathak, S. K. (1998). Starch reserve and growth of tea. *Two and Bud*, **45**:14-8.

[3] Handique, A. C. and Manivel, L. (1986). Shoot water potential in tea. II, Screening Tocklai cultivars for drought tolerance. *Two Bud*, **33**:39-42.

[4] Kulasegaram, S., Kathiravetpillai A. and Shanmugarajah V. (1988). Approaches to higher tea productivity through proper bush management. Sri Lankan *J. of Tea Science* conference Issue (19-21, January 1988), Colombo, Sri Lanka. Pp 157- 161.

[5] Leuning, R. and Sands, P. 1989. Theory and practice of a portable photosynthesis instrument. *Plant. Cell and Environment* **15**: 669-678.

[6] Li-Cor Inc. 1987. Li-6200 Portable Photosynthesis System, Instruction Manual.Li- Cor, Lincoln, NE, USA.

[7] Li-Cor Inc. 1987. Li-3000A Portable Leaf Area Meter, Instruction Manual.Li- Cor, Lincoln, NE, USA.
[8] Magambo, M. J. S., Waithaka, K., 1985. The effect of pruning at different heights on yield, dry matte production and partitioning clonal tea (Camellia sinensis) in Kenya. *Expl. Agric*., **21**: 67-72.
[9] Saikia, J. K., Rai, S., Barua, R. K., Pathak, S. K. and Barman, T. S. (2007). Physiology of pruning in Darjeeling tea (*Camellia sinensis* L.). *Two and a Bud* **54**: 29-34.
[10] Satyanarayana, N., sreedhar, C., Cox, S. and Sharma, V.S. (1994). Response of tea pruning height. *J Plantation Crop* **22**, 81-6.
[11] Sharma, V.S. (1997). Harvest in tea. *Planters Chronicle* **82**, 261-6.
[12] Squire, G. R. (1985). Ten years of tea physiology. *Tea*. **6** (2), 43-48.
[13] Wescor Inc.1988. HR-33T micro-voltmeter, Instruction Manual. Wescor Inc., Logan, Utah, USA.

Table1. Effect of different pruning times on yield of made tea (Kg ha^{-1})

Pruning cycles	Pruning months			Mean yield (Kg ha^{-1})
	Sep.	Nov.	Dec.	
3 year	506.2	521.2	546.1	524.5
4 year	560.8	579.8	608.4	583.0
5 year	626.3	638.9	701.0	655.4
Mean	564.4	580.0	618.5	**587.6**
Pruning cycle:- CD. at 1% = 79.305 **Pruning Time: -** CD. at 5% = 32.017 **Pruning cycle and Pruning Time: -** CD. at 5% Non-significant				

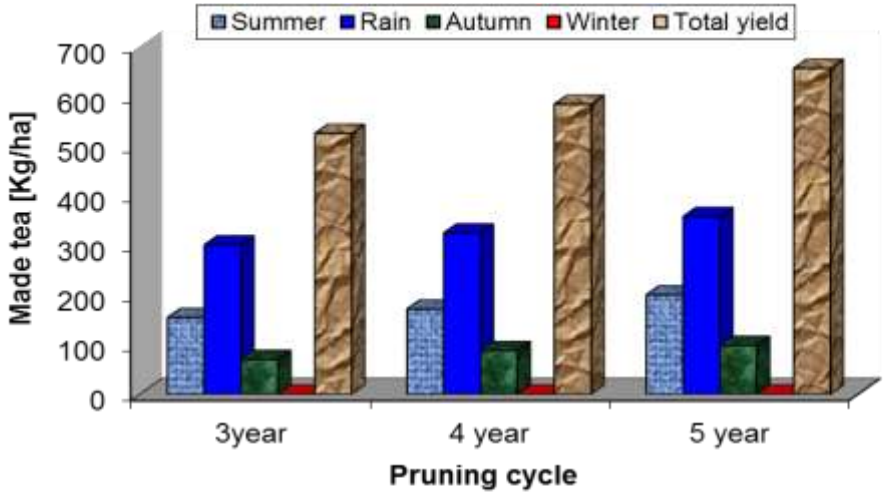

Fig. 1. Seasonally crop distribution under three, four and five year pruning cycle (average of 10 years).

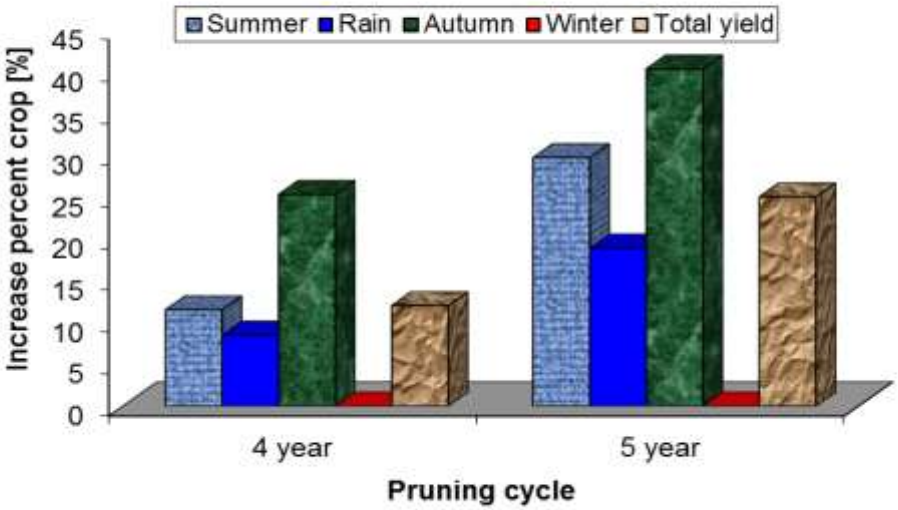

Fig. 2 . Seasonlly percentage increase of four and five year over three year pruning cycle (average of 10

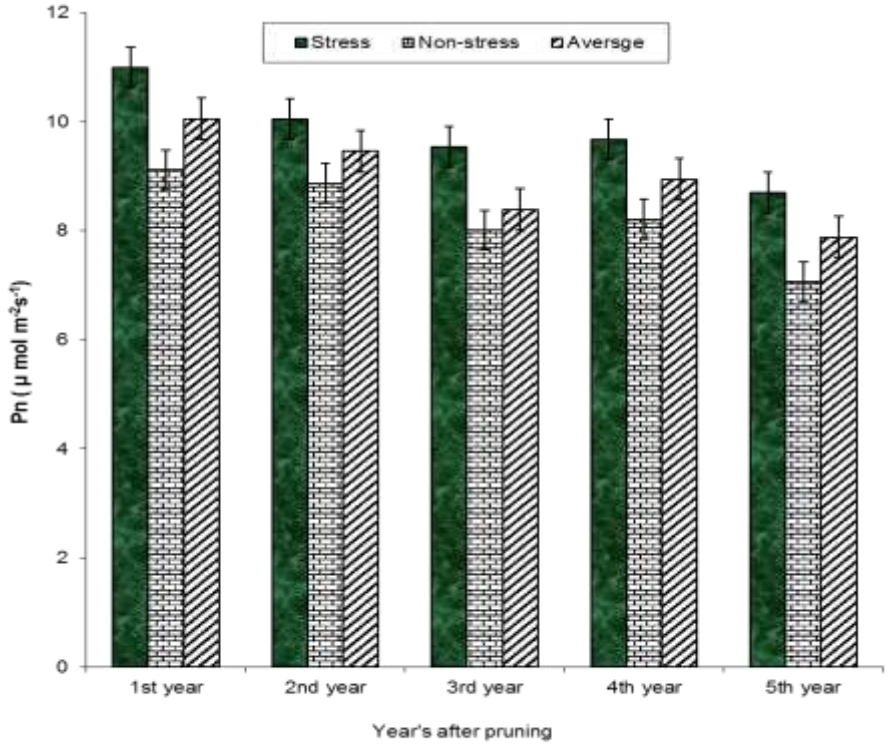

Fig. 3. Leaf net photosynthetic rate (Pn) of old chinary tea at different years after pruning. Vertical bars indicate standard error of means.

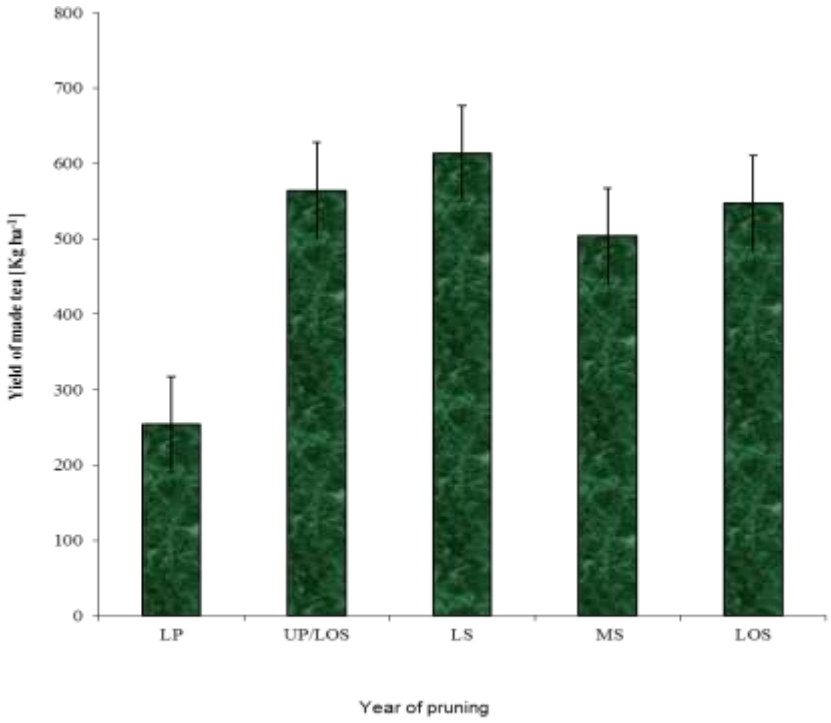

Fig. 4. Yield of made tea at different year's after pruning of old chinary tea. Vertical bars indicate standard error of means. (LP- Light pruning, UP- Un-prune, LS - Light skiffing, MS - Medium skiffing and LOS - Levelling of skiffing)

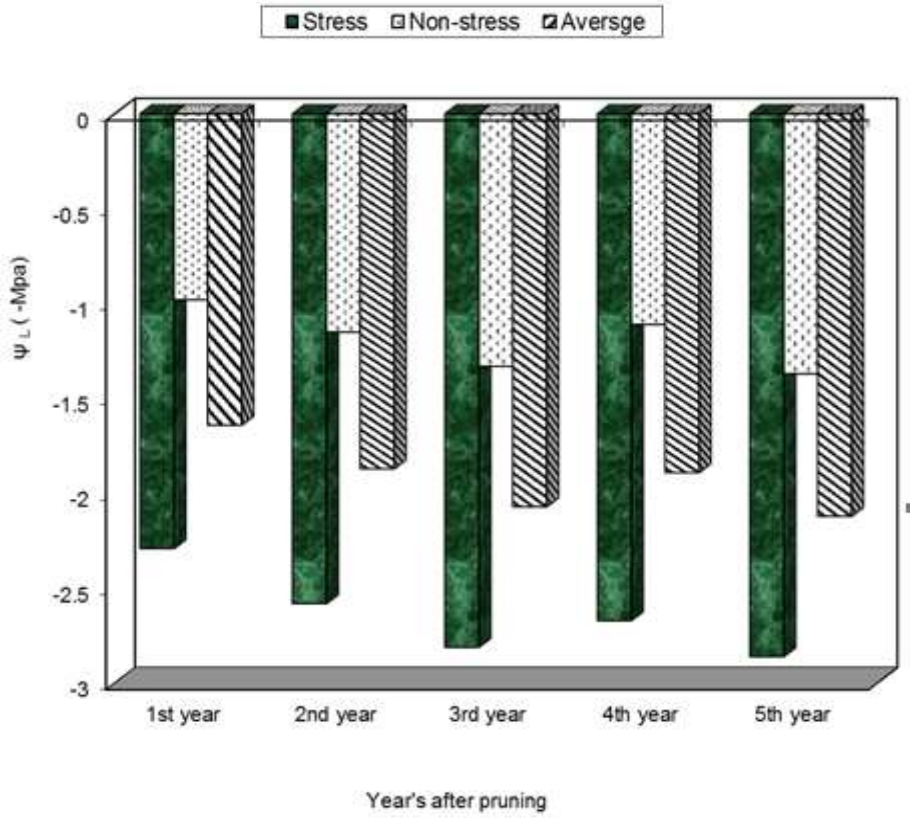

Fig. 5. Leaf water potential (Ψ_L) of old chinary tea at different years after pruning (Five year s pruning cycle).

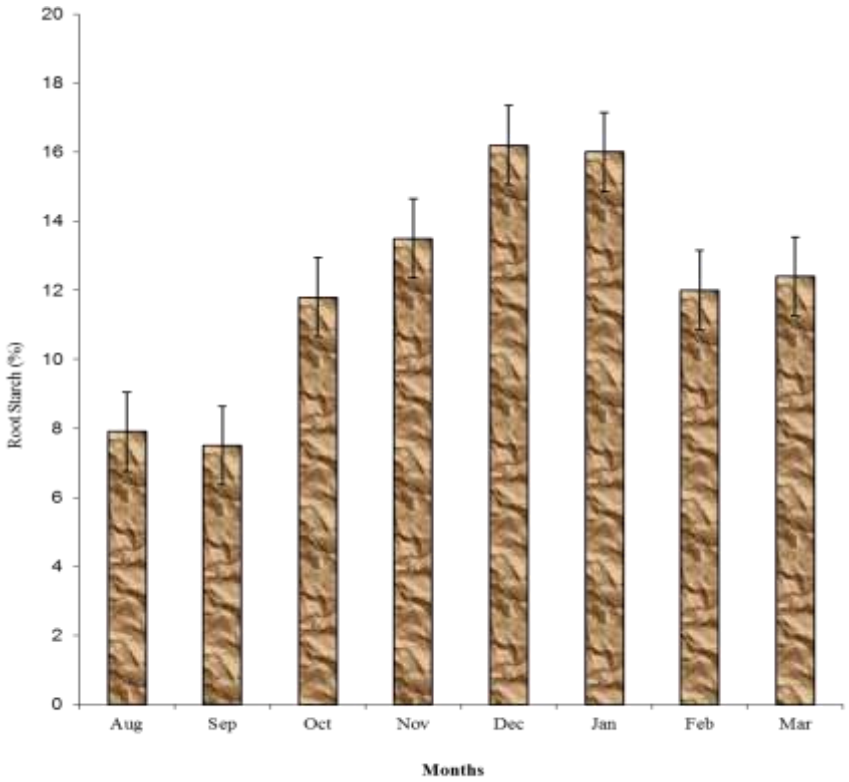

Fig. 6. Percentage of root starch reserves of old Chinary tea at mid elevation. Vertical bars indicate standard error of means.

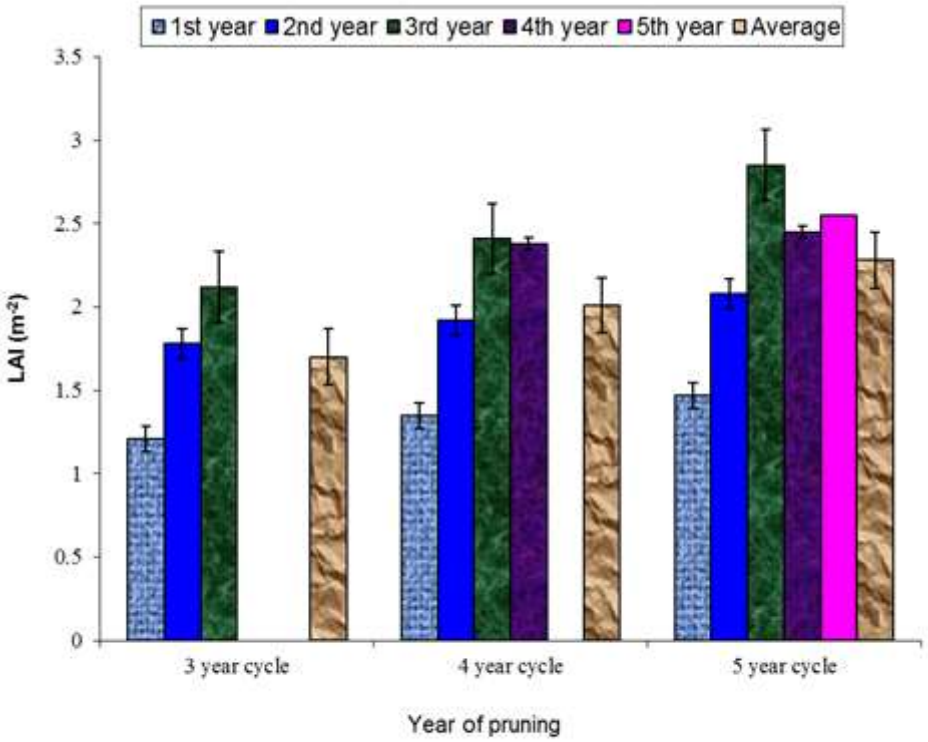

Fig. 7. Leaf Area Index (LAI) of old chinary tea at different years after pruning (Average of 10 years). Vertical bars indicate standard error of means.