

Effect of thermal time on shoot growth and development of low grown Tea [*Camellia sinensis* (L.) O. Kuntze] in Sri Lanka

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Introduction

Tea [*Camellia sinensis* (L.) O. Kuntze] is an important beverage crop in Sri Lanka and it is a sector where the country can take a lot of pride. The young, light green leaves, usually, the bud and the first two to three leaves are harvested for tea production. Study the shoot growth pattern of tea is an important element in tea physiology. It is difficult to predict leaf expansion and growth, based on calendar days, because leaf initiation and expansion are highly temperature dependent (Ritchie and Ne Smith, 1991). Because of the dependency on temperature, rate of shoot growth varies with elevation. Therefore, growing degree days based on actual temperature is a simple and accurate method to predict the occurrence of a certain developmental stage. Thus, thermal time can be used to predict the developmental stage of a leaf, extension of a tea shoot and Leaf Area (LA) expansion of shoot accurately.

This study was aimed to assess the variation in number of shoots at different developmental stages in the bush with thermal time, estimate shoot extension of a developing and harvestable tea shoot as a function of thermal time, estimate the Leaf Area (LA) of a developing and harvestable tea shoot as a function of thermal time and estimate the number of days taken to reach different leaf developmental stages of cultivar TRI 2025. This will provide an opportunity to estimate the shoot extension and Leaf Area (LA) expansion of harvestable tea shoot and it will help to adjust field management practices and to determine correct harvesting policies.

Materials and Methods

The field experiments were carried out at Field No 01, St. Joachim Estate, Tea Research Institute, Ratnapura, Sri Lanka (latitude : 6 40' N; longitude : 80 25'E) during mid of May to July 2014. Elevation of the study location is 29 m amsl and belongs to Agro ecological region of WL2. The soil group of the site belongs to Red Yellow Podzolic (Panabokke, 1996). The total rainfall was about 711 mm with a mean temperature of 28.5 °C during the experimental period. TRI 2025 was used as the planting material. Daily sunshine hours, rainfall, minimum maximum temperature was obtained from the meteorological station at St. Joachim Estate, Ratnapura. In addition, soil moisture was measured during the experimental period at weekly. Data analysis was done using MS-Excel and Minitab 16 software.

In the first experiment, field observations were made for TRI 2025 using 1m sample size of plucking table with ten bushes at homogeneous location. The numbers of shoots at different shoot developmental stages in the bush (i.e. buds, bud with fish leaf, bud with one normal leaf, bud with two normal leaves, bud with three normal leaves and banjies) were counted at seven days interval. The accumulation of Thermal Time (TT) over the growing period was calculated using equations developed by Robertson *et al.*, 2002. It was considered that T_{base} of 12.5 °C (Carr and Stephens, 1992), T_{opt} 22 °C (Amarathunga *et al.*, 1999) and T_{ce} 40 °C (Carr, 1972) for TRI 2025.

In the second experiment, with the appearance of each leaf, length of the shoot was measured at seven day intervals from randomly selected five axillary buds per bush that tagged immediately after plucking. The length of the new shoot was measured from the base of the shoot to the base of the bud. All measurements were taken until individual shoots reached their acceptable harvesting stage (bud with three normal leaves). Weather records obtained at experiment 01 were used in experiment 02.

In third experiment, Length (L) and width (W) of the individual leaves in a tea shoot (i.e. fish leaf, first, second, third normal leaf and bud) were measured at seven day intervals. Leaf length (L) was measured from lamina tip to the point of intersection of the lamina along the mid-rib, while leaf width (W) was measured from end to end between the widest lobes of the lamina perpendicular to the lamina mid-rib. The equation for TRI 2025 developed by (Jayasinghe *et al.*, 2013) was used in estimating the Leaf Area (LA) at each day. In addition to that, record the number of days it was taken to unfolding of each appendage from the date of tagging and time it was taken to reach a acceptable harvesting stage having bud with a three leaf stage.

Results and Discussion

Experiment 01

Distribution of shoot generations in plucking table with cumulative thermal time from May to July 2014 is shown in figure 01.

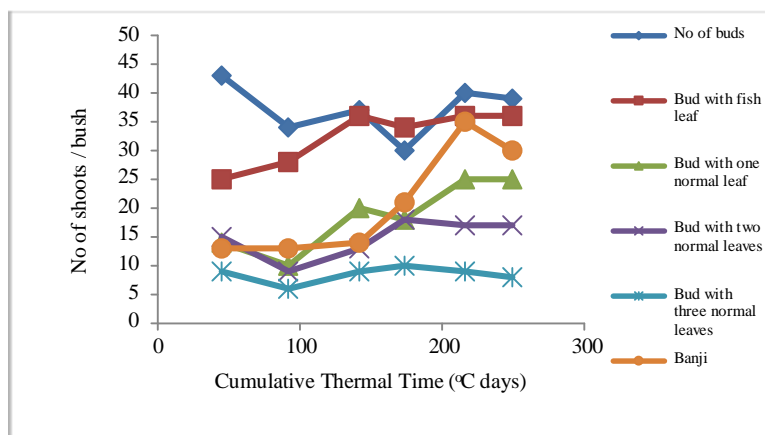


Figure 01: Distribution of shoot generations in plucking table with cumulative thermal time (°C days) from May to July 2014.

According to the Pearson's correlation coefficient (r), there was a positive correlation between the number of shoots having bud with fish leaf ($r = 0.912$), bud with one normal leaf ($r = 0.820$), bud with two normal leaves ($r = 0.688$), bud with three normal leaves ($r = 0.502$), number of shoots having banji ($r = 0.799$) and total number of shoots ($r = 0.848$) per bush and the cumulative thermal time at 5 % probability level. According to the results average temperature, rainfall, daily sunshine hours and soil moisture were not significantly affect to the numbers of shoots at different developmental stages on the bush during the period at 5 % probability level.

Experiment 02

Mean shoot length of the tea shoot in relation to cumulative thermal time from May to July 2014 is shown in figure 02.

According to the Pearson's correlation coefficient (r), there was a positive correlation between the mean shoot length ($r = 0.842$) and the cumulative thermal time at 5 % probability level. According to the results, average temperature ($P = 0.549$), rainfall ($P = 0.532$), daily sunshine hours ($P = 0.128$) and soil moisture ($P = 0.599$) were not significantly affect to the length of the developing and harvestable tea shoot during the period at 5 % probability level.

According to the regression analysis, there was a very close relationship between the shoot length and the cumulative thermal time ($R = 0.956$). Figure 02 showed that, growing bud needs to accumulate 249.56 °C days to attain to the harvestable size having length of 112.34 mm.

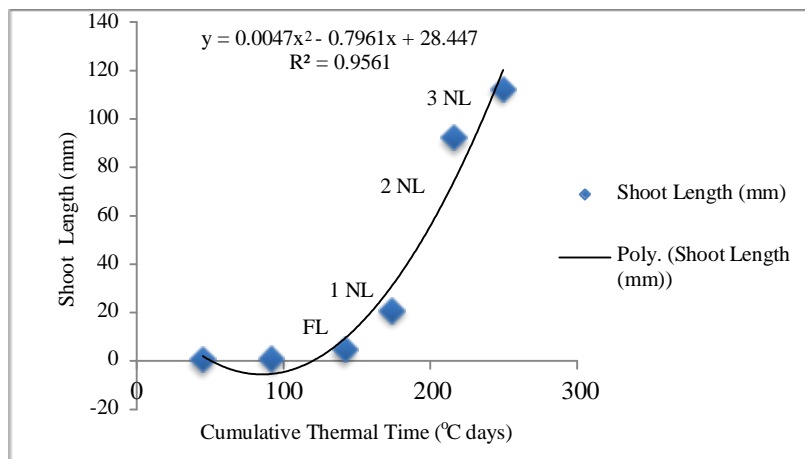


Figure 02: Mean shoot length (mm) of the tea shoot with cumulative thermal time from May to July 2014, note: FL – Fish Leaf 1NL – First Normal Leaf 2NL – Second Normal Leaf 3NL – Third Normal Leaf

Experiment 03

Total Leaf Area (LA) expansion of a tea shoot in relation to cumulative thermal time from May to July 2014 is shown in figure 03.

According to the Pearson's correlation coefficient (r), there was a positive correlation ($r = 0.810$) between the total leaf expansion of a harvestable tea shoot and the cumulative thermal time at 5% probability level. According to the results, average temperature ($P = 0.463$), rainfall ($P = 0.553$), daily sunshine hours ($P = 0.074$), soil moisture ($P = 0.652$) were not significantly affect to the Total Leaf Area (LA) expansion of the developing and harvestable tea shoot during the period at 5 % probability level.

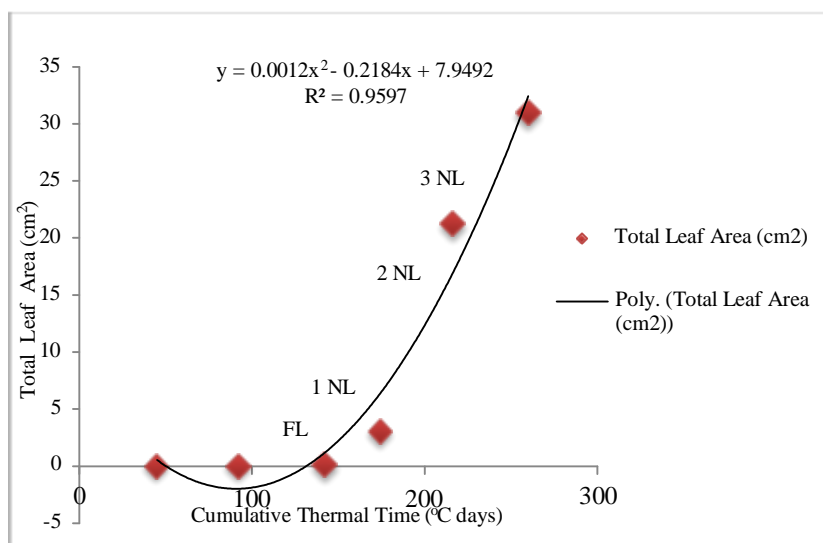


Figure 03: Total Leaf Area (LA) expansion of a tea shoot in relation to cumulative thermal time from May to July 2014, note: FL – Fish Leaf 1NL – First Normal Leaf 2NL – Second Normal Leaf 3NL – Third Normal Leaf

According to the regression analysis, there was a very close relationship between the Total Leaf Area expansion of developing and harvestable tea shoot with cumulative thermal time ($R = 0.959$).

Conclusions

Leaf initiation, shoot extension and leaf expansion can be predicted using calendar days but it varies with the temperature and other environmental factors. Growing degree days based on actual temperature is a simple and accurate method to predict the occurrence of a certain developmental stage. After the bud break, growing tea bud required 24, 28, 32 and 35 days to produce fish leaf, the first normal leaf, second normal leaf and third normal leaf, respectively and bud break was occurred after 18 days from the date of tagging. In terms of degree days 153.82, 173.69, 197.28 and 216.17 $^{\circ}\text{C}$ days were required to initiate, fish leaf, the first, second and the third normal leaf respectively, after the removal of apical dominance by plucking. To attain a harvestable tea shoot (bud with three normal leaves) of cultivar TRI 2025 required with accumulation of 249.56 $^{\circ}\text{C}$ days (at mean temperature 28.5 $^{\circ}\text{C}$ and base temperature 12.5 $^{\circ}\text{C}$). Length of the tea shoot having almost 112 mm in 41 days required to become pluckable size in low country region.

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