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Determination of crop evapotranspiration of tea (*Thea sinensis*) using weighing lysimeter for the Nilgiris

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ABSTRACT

A long term experiment (1996-2001) was conducted for determining crop evapotranspiration (ET_c) of tea *(Thea sinensis)* using weighing type lysimeter at the Central Soil and Water Conservation Research and Training Institute-Research Centre (CSWCRTI-RC), Research Farm, Udhagamandalm, Tamil Nadu, India. Based on the weekly average crop evapotranspiration for the entire period of observation, the different growth stages were observed and classified as initial season, mid season and late season for increasing growth rate, constant growth rate and declining growth rate, respectively. The average crop evapotranspiration for the corresponding s was 2.77, 3.31 and 2.27 mm/day, respectively. The maximum ET_c was observed during mid season followed by initial and late seasons.

***Key words**:* Evapotranspiration, tea, and lysimeter

Tea (*Thea Sinensis*) is grown in India over an area of 1.34 lakh ha in the four states of Assam, Tamil Nadu, Kerala, and Karnataka. In South India, tea is being cultivated on hill slopes in an area of 0.55 lakh ha (41 % of total area under tea). In Tamil Nadu, major tea plantation area occurs in the district of Nilgiris which constitutes about 85 per cent of total area under tea. Tea is grown well in areas where annual rainfall varies from 1150 to 6000 mm. In Nilgiris tea is cultivated in areas having well distributed annual rainfall of about 1500 mm/year. The effect of precipitation is more manifested by its influence on soil moisture status inducing vegetative growth and yield of green tea leaves. Therefore distribution of rainfall over the year is more vital than the total amount of rainfall. Daily mean relative humidity should be around 80 per cent most of the time and it should never be less than 40 per cent for better growth and yield of tea.

There are two distinct peak harvesting periods in South India, i.e., pre-monsoon and post South-West monsoon. The variation in crop yield distribution ranges from minimum of 7.8 per cent to maximum of 13.1 per cent of total annual yield in different months of a year (Murthy, 1992). The reason for variation in yield distribution is mainly due to changes in temperature and development of large soil-water deficit during dry period. The yield and quality of tea suffers due to the variation in the quantity of water applied and improper irrigation scheduling. The water requirement of crops varies substantially during the growing period mainly due to variation in crop canopy and climatic conditions (Doorenbos and Pruitt, 1977). Irrigation scheduling and management depends upon the accurate estimation of evapotranspiration. Evapotranspiration and crop coefficient of tea under different irrigation levels have been estimated by Dabral and Rao (1997) for hills of North-Eastern region of India. However, direct measurement of crop evapotranspiration (ET_c) is difficult and data on ET_c are commonly not available (Sikka and Ramasastri, 1987). Therefore, this paper presents the crop evapotranspiration (ET_c) of tea for assessing water requirement for different growing season of the year.

MATERIAL AND METHODS

About the experimental area

The experiment was conducted in a weighing type lysimeter at the Research Farm of CSWCRTI, Research Center, Udhagamandalam, Tamil Nadu, India, situated at a latitude of $11^0$242 N, longitude of $76^0$412 E and elevation of 2218 m above mean sea level. The area receives an average annual rainfall of 1200 mm with most of the rainfall concentrated during the South-West monsoon (June-August) and North-East monsoon (September-December). During the remaining period, there is occasional rainfall with very unevenly distributed. The mean monthly maximum and minimum temperatures are 22.1^0 C and 8.5^0 C occurring in the months of April and January, respectively.

Lysimeter

A weighing type lysimeter with the tank size of 1.2 m 1.2 m × 1 m (Length × Breadth × Depth) supported by a weighing bridge with sensitivity of 200 gms (0.14 mm of water depth), installed in the research farm of the center was used for the study. Details about the design dimensions of lysimeter are taken from Bhardwaj (1983). The square shape of the lysimeter was preferred over the circular one keeping in view of the requirement of the crop geometry. B-6 clone

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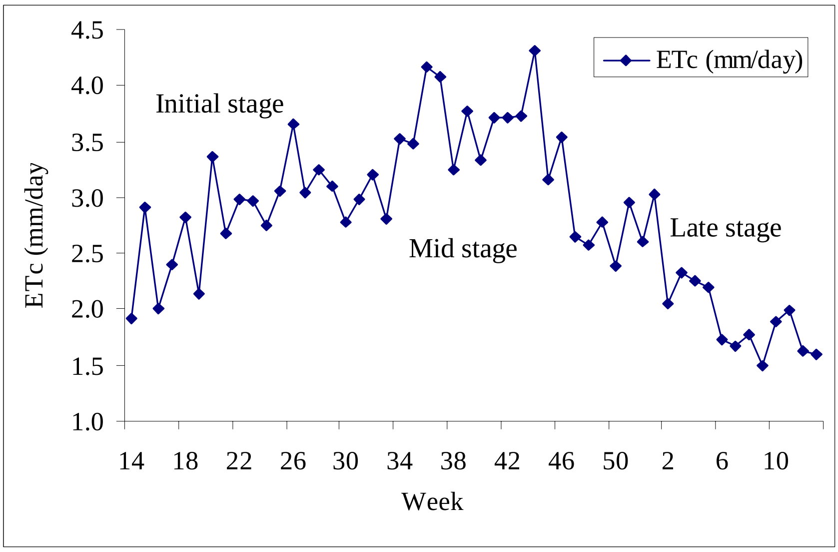

Fig.1: Weekly average crop evapotranspiration in different growth stages

variety of tea (around 12 months old plants) was transplanted in and around (18 m x 18 m) the lysimeter at a spacing of 75 cm x 75 cm in order to maintain similar micro-climatic conditions following the recommended agronomic practices. All the cultural operations were carried out, including harvesting of tea, at the same time in the tank as well as outside the tank in the adjacent field.

Suitable arrangements were made to measure the deep percolation loss, surface runoff and change in soil moisture content. The surface runoff was measured through the holes made into the side wall of the tank at surface level and connected to the measuring container by flexible pipe. Similar arrangement were made at the bottom of the tank and connected to the measuring container by flexible pipe for measuring the deep percolation loss. Regular recording of rainfall, change in weight of lysimeter tank, measurement of runoff and deep percolation losses from the tank were made on daily basis at 0830 hrs (ISI) for computing daily crop evapotranspiration following the simple water budgeting technique.

ET_c = Rainfall - Runoff - Deep percolation loss – Change in weight.

The average area available for each tea plant was 0.48 sq. meter inside the lysimeter against 0.75 sq. meter as per the standard spacing followed in the region. Three tea clones were planted in lysimeter in order to fit the standard spacing between the rows and plants. The lateral growth of roots were restricted to 1.44 sq. meter only due to the side walls of the lysimeter tank. Therefore ETc was determined based on the lysimeter data and adjusted to actual area required for each tea plants as per the standard spacing.

RESULTS AND DISCUSSION

Crop evapotranspiration

The daily rainfall, runoff, deep percolation loss and change in weight of lysimeter were measured for the entire period of observation. The crop evapotranspiration (ET_c) is determined using the water balance equation as stated earlier using the weighing type lysimeter. The year wise annual rainfall, computed values of ET_c along with adjusted to actual area and ratio of adjusted ET_c to open pan evaporation (OPE) are given in Table 1. It is clearly shows that the total crop evapotranspiration increases over the years with growth and development of tea plants. The ratio of crop evapotranspiration to open pan evaporation also increases over the years other than first two years. In the initial two years there was slow establishment of crop, which was the main cause of the variation. In the first year high ET_c was due to relatively higher soil moisture content in the profile and less canopy, causing more soil surface exposed to soil evaporation rather than transpiration. When the crop is established with full canopy, this ratio tends to be lesser. In general, an increasing trend of ET_c and increased leaf area index could be seen with time. However, year to year variation in ET_c could be attributed to amount and distribution of rainfall, profile soil moisture content and other climatic variables.

The average weekly ET_c of tea varied from 1.5 mm day^{-1} (9th meteorological week during the late growing season) to 4.3 mm day^{-1} (44th meteorological week during the peak

Table 1: Year wise water balance components of tea

Year	Total Rain fall (mm)	Total ET_c* (mm)	Open pan Evaporation (mm)	ETC/OPE
1997	1260.9	988.1 (632.4)	694.4	1.42 (0.91)
1998	1176.3	925.9 (592.6)	1054.9	0.90 (0.56)
1999	953.0	937.0 (599.7)	1135.4	0.83 (0.53)
2000	1653.9	1033.7 (661.6)	1042.2	0.99 (0.63)
2001	1065.6	1020.9 (653.4)	1012.0	1.01 (0.65)

* Figures in parenthesis is the computed ET_c based on lysimetric data

growing period of mid season). From the Fig.1, it is evident that the initial season (*i.e.*, the increasing ET_c) starts from mid April (14th meteorological week) and continues up to second week of July (27th meteorological week). For this period ET_c varies from 1.92 mm day^{-1} to 3.67 mm day^{-1} and average ET_c is 2.77 mm day^{-1}. Then from the third week of July up to first week of November there is a constant growth rate with average ET_c of 3.31 mm day^{-1}. This period is considered as mid season where the ET_c varies from 2.78 mm day^{-1} to 4.3 mm day^{-1}. From second week of November to mid April there is a declining trend in ET_c with the average ET_c of 2.27 mm day^{-1}. During this period, the ET_c varies from 1.48 mm day^{-1} to 3.16 mm day^{-1}.

This type of behavior in ETc may be expected because of trend in development of crop canopy, multiple harvesting of tea leaves, variation in amount of rainfall in different season and difference in energy absorption characteristics which in turn depends upon the changes in temperature, humidity, sunshine hours and wind speed. The rainfall spreads all over the three season of the year *viz.*, December –April (winter with summer and pre-monsoon rains), May–August (South-West monsoon) and September-November (North-East monsoon) with most of the rainfall concentrated during the South-West and North-East monsoons. The initial season gets some pre-monsoon rain followed by South-West monsoon where the plants get adequate water coupled with increase in temperature which is most congenial for plant growth resulting in increasing growth rate. This increasing growth rate continues till the plant gets its optimum water requirement. Then towards the third week of July, the mid season starts when the growth rate becomes almost constant. This is due to better soil moisture availability as compared to the crop water requirement. Maximum ET_c was observed during this season as compared to other two seasons. In the late season, the rainfall becomes inadequate, which leads to soil moisture stress that results in declining growth rate, and thus the evapotranspiration as well as crop coefficient goes on decreasing. It was reported that there is a linear relationship between growth rate of tea and mean air temperature (25^{0}C to 17^{0}C) and growth rate becomes very slow at temperature below 12-13^{0}C (Squire, 1979). This is one of the reasons for decrease in crop evapotranspiration during the late season since mean air temperature during this period remains mostly below 12-13^{0}C in the Nilgiris.

CONCLUSION

The average crop eavpotranspiration value for initial season, mid season and late season same are found to be 2.77, 3.31 and 2.27 mm day^{-1}, respectively. The different growth trends obtained are increasing growth rate (in the initial season which starts from mid April up to second week of July), constant growth rate (in mid season which starts from third week of July and continues up to first week of November) and decreasing growth rate (in the late season which spans from second week of November up to mid April). The ET_c is maximum during the mid season, which happens to be grand growth period, followed by initial season and late season. In general, mid season is the maximum yield contributing period in this region where as the initial and late seasons are the lean periods. Therefore to optimize the yield during the initial and late season, additional irrigation should be provided based the water requirement of the crop.

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