DETERMINATION OF SOIL RESPIRATION IN A HIGH GROWN AND A LOW GROWN TEA GROWING ENVIRONMENTS OF SRI LANKA

T. L. Wijeratne*[1] and G. C. K. Bandara[2]
[1]*Tea Research Institute of Sri Lanka*
[2]*Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka*
**Corresponding author (email: thushari.wijeratne@gmail.com)*

Introduction

Soil respiration is referred to as release of carbon dioxide (CO_2) from soil due to the production of CO_2 by roots and soil organisms and to a lesser extent to chemical oxidation of carbon compounds [1]. Soil respiration is an important function in terrestrial ecosystems as it helps to global carbon cycling and affects climate change. In addition, soil carbon is the backbone of soil organic matter which is crucial for maintaining soil quality and production through maintaining many physical and chemical properties.

Climate change is a hot topic today which affects all living beings. Therefore there is a growing global concern of developing mitigation and adaptation strategies in all the countries. Determining the soil respiration values or the CO_2 efflux is important under this context. The total global emission of CO_2 from soil is recognized as one of the largest fluxes in the global carbon cycle and small changes in the magnitude of soil respiration could have a large effect on the concentration of CO_2 in the atmosphere [2].

Tea (*Camellia sinensis* L. O. Kuntz) being one of the most important plantation crops grown in a vast extent of Sri Lanka, it is of utmost importance to get an idea about the carbon emissions and sequestrations of the tea lands to remain as a sustainable industry. The tea sector contributes a lot for the Sri Lankan economy in terms of export earnings and its contribution for the gross domestic product (GDP) in Sri Lanka is nearly 1%. Therefore determining the soil respiration and carbon sequestration would have immense benefits in future. The carbon sequestration potential of tea lands have been reported in literature [3]. However the possible soil respiration levels in tea lands have not yet reported.

There are three main tea growing regions in Sri Lanka namely, high grown, medium grown and low grown. The taste, flavor and aroma of teas from each region are influenced by the conditions particular to those regions and so as the carbon sequestration and emissions too. Since tea is cultivated on a large extent of lands in Sri Lanka, it is important to study and quantify the soil respiration values of the same and understand its relationships with the soil moisture availability and the organic matter content etc. in order to take precautionary measures to mitigate the impacts of climate change.

Both high grown (UC) and low grown (LC) tea production collectively accounted for 85% of the total tea production in Sri Lanka during the year 2015. Hence, in view of the above facts a preliminary study was planned with the objectives to compare the soil respiration in UC and LC which are the two extreme tea growing regions of Sri Lanka and also to study the relationships of soil respiration with soil moisture content and soil organic matter content.

Materials and methods

The research was conducted in the Tea Research Institute (TRI) of Sri Lanka in 2014. UC and LC tea growing regions were selected in order to determine the soil respiration in two extreme sites of tea growing areas. St. Coombs Estate, Talawakelle (1382 m amsl altitude, 19.2 ^{o}C average temperature) and St. Joachim Estate, Ratnapura (29 m amsl altitude, 27.8 ^{o}C average temperature) were selected to represent UC and LC tea growing areas respectively. The experiment was conducted covering both the wet weather as well as the dry weather periods and also seedling tea (8000 bushes/ha) and vegetatively propagated (VP) tea lands (12500 bushes/ha) in both UC as well as in LC tea growing regions.

Soil respiration (SR) was measured using Anderson method from experimental sites according to stratified random sampling technique taking the tea growing region as the main strata. CO_2 traps (alkali traps) prepared by pipetting 20 ml of 1.0 N NaOH into glass jars were placed on the soil surface of the selected sites using tripods. The metal cylinders were placed immediately over the alkali traps, and the edges were pressed up to about 2 cm into the surface of soil. After exposure of these traps for 24 hours, jars were removed and excess amounts of $BaCl_2$ solution was added and they were covered with lids immediately to prevent dissolution of extra CO_2 from the atmosphere. Then samples were taken to the laboratory for analysis (Controls for this experiment were almost similar but soil was completely covered with thick polythene). There after soil samples were collected using soil augers along the active root zone depth of the tea plants, i.e. up to a depth of 0-45 cm for the measurement of soil moisture content (MC) and organic carbon content (OC). Soil moisture content was measured gravimetrically and organic carbon content was measured using Walkley-Black method. The relationships of soil respiration with the soil moisture content and organic carbon content were developed using regression analysis. Data were analyzed using SAS software package version 9.1.

Results and discussion

The soil respiration was significantly higher in UC than LC ($p<0.05$). The differences in weather and the higher organic carbon content in UC than LC must be the main reasons behind this observation (Data were not shown).

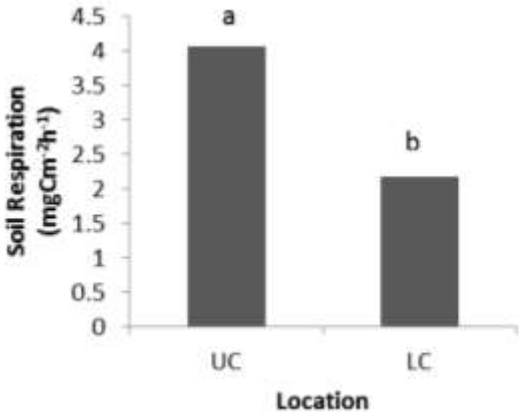

Figure 1. Variation of soil respiration in high grown (UC) and low grown (LC) tea growing regions (means with the same letter are not significantly different at α = 0.05)

Soil moisture is one of the most important environmental factor controlling the soil respiration [4]. The soil respiration was much higher in wet condition than dry condition. Wet condition is favorable for microbes as well as for plant roots for their metabolic activities. This increased metabolic activity of microbes and plant roots may have resulted the observed high soil respiration values during wet conditions than in dry conditions. In contrast in dry condition, water is a limiting factor. Therefore microbial activity and root activity were reduced. Hence, soil respiration was very low under dry conditions.

Table 1. Summary of the relationships developed with the Soil Respiration

Variable	R^2	Intercept	Parameter estimate
MC (n= 12)	61.88% (P<0.0001)	-4.30 (P=0.0180)	0.61 (P<0.0001)
OC (n=12)	23% (P=0.0002)	6.12 (P=0.0001)	1.70 (P=0.0002)

Accordingly the derived relationships are given below.

$$SR = 0.61\ MC - 4.3$$ **Equation 1**

$$SR = 1.70\ OC + 6.12$$ **Equation 2**

Where SR = Soil respiration
MC = Soil moisture content
OC = Soil organic carbon content

The relationship between soil moisture content and soil respiration was highly significant (p<0.0001). The Equation 1 explains 61.88 % of the relationship between the soil respiration and the soil moisture content and associates about 38.12 % error. Parameter estimated value for the gradient was 0.61. That means when moisture content is increased by one unit, the respective soil respiration value will be increased by 0.61 unit when the other factors affecting soil respiration are not considered except for moisture content. It further indicates that the soil moisture content and soil respiration have a positive relationship at the moisture level range that the experiment was conducted. However the soil water content can also exceed the ideal conditions for soil respiration where extremely high water contents can prevent CO_2 production through soil respiration in soils by limiting the aeration for the microbes to respire, i.e. by filling both the micro pores as well as macro pores in soil creating unfavorable, anaerobic condition. However in this experiment it was not possible to observe this relationship as the soil moisture content was not increased that much.

The relationship between soil organic carbon and soil respiration showed a significant (P=0.0002) relationship when the other factors controlling soil respiration are not taken into account except for soil organic carbon content (Equation 2). However the lower R^2 value (23.0%) indicates a higher error associated with the derived relationship.

Since the soil respiration depends on many factors as described in [5] the relationship was developed for soil respiration with the soil moisture and organic carbon content in the soil and the summary is given in the Table 2.

Table 2. Descriptive summary of the relationship of soil respiration with the moisture content and the organic carbon content

Parameters	**Values**
R^2	63.66%
P value	P<0.0001
Intercept	-5.0 (P=0.0074)
Parameter Estimate (MC)	0.72 (P<0.0001)
Parameter Estimate (OC)	-0.69 (P=0.1199)

The model used to predict the relationship of soil respiration with the soil moisture and soil organic carbon content was highly significant (p<0.0001). However the estimated parameter for the soil organic carbon content was not significant. Added to that the increase of the R^2 value due to the addition of this variable is 1.78 % which is quite lower compared to the partial R^2 of the soil moisture (61.88 %). The main reason may be the presence of multicollinearity where the effect of the soil organic carbon is also confounded in the effect of soil moisture. Therefore the step wise procedure had finally removed the variable organic carbon content in the relationship with the soil respiration. Therefore the resultant final relationship of soil respiration and the factors tested is exactly the same to the Equation 1 described previously.

Conclusions

The soil respiration was much higher in UC than LC. Soil respiration was significantly higher in wet condition than dry condition too. Relationship of the soil respiration with factors tested is that the soil respiration is having a positive relationship with the soil moisture content and the relationship between soil respiration and organic carbon content was complex and negligible.

References

[1] J.L. Loyd and J.A. Taylor, "On the temperature dependence of soil respiration." Functional Ecology, vol. 8, pp. 315-323 1994.

[2] W. H. Schlesinger and J. A. Andrews. "Soil respiration and the global carbon cycle." Biogeochemistry, 2000. vol. 48, pp. 7-20.

[3] T.L. Wijeratne, W.A.J.M. De Costa and M.A. Wijeratne. "Carbon sequestration potential of tea plantations of Sri Lanka," in Proc. 228th Experiment and Extension Forum of the Tea Research Institute of Sri Lanka, 2014, p. 31 - 40.

[4] E.A. Davidson *et al.,* "Effects of soil water content on soil respiration in forests and cattle pastures of eastern Amazonia." Biogeochemistry, 2000. vol. 48, pp. 53–69.

[5] P.E. Wiseman and J.R. Seiler, "Soil CO2 efflux across four age classes of plantation loblolly pine (Pinustaeda L.) on the Virginia Piedmont." Forest Ecology and Management, 2004. vol. 192, pp. 297–311.