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Influence of conservation practices on soil moisture and growth performance of new tea [*Camellia sinensis* (L.)] plantation in Nilgiris

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ABSTRACT

An experiment under rainfed condition was conducted in the farmer's field in the Nilgiris, the North-Western part of Tamil Nadu for evaluating the influence of conservation practices on soil moisture and plant growth under new tea plantation. One year old B-6 tea clones were planted at double hedge spacing (135 x 75 x 75 cm) in two slopes (8-12 and 30-35%) with treatments viz., contour staggered trenches (CST) in the walking rows (space between pairs of tea rows), vegetative barrier (VB) of geranium in walking rows, CST and VB of geranium in alternate walking rows, CST with cover crop of beans as well as in control condition. Minimum runoff in CST with cover crop followed by CST and CST with VB in both the slopes proved the cause of CST either alone or in combination in reducing runoff. Runoff retention in the trenches attributed to higher soil moisture in CST (25.6%) and CST with cover crop (24.8%) followed by CST with VB (22.8%) in 8-12% slope with similar trend as well in 30-35% slope during non-monsoon period. Tea canopy followed a similar trend to that of soil moisture content with maximum (39.5%) in the CST with cover crop followed by CST (38.4%) and minimum in control just before the first harvest in 8-12% slope. The maximum plant height obtained in CST with cover crop followed by CST may be due to similar reason as in canopy development. Higher yield from all the conservation practices over control (3.8 t ha⁻¹) with maximum in CST with cover crop (4.7 t ha⁻¹) followed by CST (4.4 t ha⁻¹) in 8-12% slope was due to better growth resulting from higher soil moisture.

1. INTRODUCTION

In India, tea is grown over an area of 5.78 lakh ha mainly under rainfed sloping conditions (Madhu *et al.*, 2010) in the altitude ranging from 500 to 2500 m above msl with annual rainfall varying from 1150 to 6000 mm. In Tamil Nadu, tea is cultivated in an area of 0.47 lakh ha in the Nilgiris and stands first in terms of area (85%) and production (41%) in South India (Madhu and Sahoo, 2009). Growing of tea on sloping land without any soil and water conservation measures causes excess runoff, soil loss and land degradation especially in the initial years leading to decline in productivity. Soil loss could be as high as 28-40 t ha⁻¹yr⁻¹ in the absence of any vegetative canopy and soil

conservation measure (Chinnamani, 1977; Madhu and Tripathi, 1997). As a preventive measure, Soil and Water Conservation (SWC) practices have been most commonly developed under rainfed conditions with steep slope, excess runoff and soil loss, inadequate available soil moisture that limit the crop growth. These conservation practices are often not only used to reduce soil loss or manage runoff, but are often introduced to conserve soil moisture, improve productivity and the suitability of the land to cultivation (Kruger *et al.*, 1996). Various studies have revealed that in fruit crops like apple, aonla and sapota, mulching led to improved soil moisture status, growth, yield and quantity of these fruits and reduced weed growth (Jayant Kumar *et al.*, 1999; Shukla *et al.*, 2000).

Different soil and water conservation measures were effective in increasing soil moisture level and mulching was the best with 26.2% higher moisture over control during post monsoon period (Singh *et al.*, 2012).

Therefore, proper planning and implementation of SWC practices are very much needed in the initial period of plantation. The soil and water conservation measures in the initial period of plantation reduce the surface runoff, thereby reducing the soil loss, increasing available soil moisture and enhancing crop growth. Vegetative barrier, cover crop, CST and combination of mechanical measures with any biological measures are some of the conservation measures adopted for controlling surface runoff, soil loss and conserving soil moisture in the initial stages of tea plantation. The effect of conservation practices on soil moisture and plant growth in actual field condition in new tea plantation has not been well documented in the Nilgiris. In view of this, the experiment was carried out to study the influence of different conservation practices on soil moisture and plant growth in the initial stages of tea plantation under different slope ranges in Nilgiris.

2. MATERIALS AND METHODS

Study Area

The experiment was conducted in the farmer's field representing the most commonly practiced slopes (8-12 and 30-35%) for tea in Nilgiris district (11°26'40" N and 76°45'58" E, 2150 m amsl) of Tamil Nadu. The climate is temperate to sub-tropical with long term average annual rainfall of 1276 mm distributed over South-West and North-East monsoons. The mean monthly maximum and minimum temperatures are 22.1 and 8.5°C occurring in the months of April and January, respectively with average annual temperature of 15.0°C. Daily mean relative humidity is about 76% most of the time, which is favorable for tea in the region.

Soil at the experiment site is deep and well drained with granular structure and low in clay content with more coarse sand, very coarse sand and gravel content. The soil is acidic with pH in the range of 4.39 to 4.71, EC of 0.22 to 0.24 dS m⁻¹ and Cation Exchange Capacity (CEC) ranging from 12.3 to 14.2C mole (p⁺) kg⁻¹. The available nitrogen ranges between 166.8 to 255.3 kg ha⁻¹, phosphorus between 51.1 to 79.5 kg ha⁻¹ and potassium between 178.9 to 319.15 kg ha⁻¹.

The experiment was laid out in a Randomized Block Design with four replications in 20 plots to accommodate four conservation practices with one control. One year old B-6 tea clones were planted before the onset of North-East monsoon during the month of September in humid climate and moist soil for better establishment of young tea plants at double hedge spacing (135 x 75 x 75 cm) with row to row spacing of 65 cm. Four conservation practices viz., CST in

each walking rows (space between two hedge rows), VB of geranium in each walking rows at plant to plant and row to row (P-P and R-R) spacing of 30 cm, CST and VB of geranium in alternate walking rows, CST with cover crop of beans were taken for experiment (Table 1).

Planting Technique

Double hedge planting (135 x 75 x 75 cm) along the contour line accommodating 13,200 plants ha⁻¹ was followed by using a triangular frame of equal length (0.75 m each side) for laying out the double hedge rows and spacing between plants. Points are marked at each corner of the frame and then it is inverted at the forward toe (Point C) and kept along the line AC to mark the point B again on already marked contour line. Then it is inverted at point B along the line BC, the point A is marked and the entire process is repeated with marking by pegs followed by planting holes and plantation (Fig.1 and Fig. 2). Planting hole of adequate size (30 cm dia and 45 cm depth) was made for better establishment of young plants.

Table: 1
Treatment details with specification of the conservation measures

Treatments	Specification
T ₁ : CST in each walking rows	180 x 30 x 45 cm (L x W x D)
T ₂ : VB in each walking rows	Two rows of geranium at P-P and R-R spacing of 30 cm
T ₃ : CST and VB in alternate walking rows	Trenches of 180 x 30 x 45 cm (L x W x D) alternate with two rows of VB of geranium at P-P and R-R spacing of 30 cm.
T ₄ : CST with cover crop	Trenches of 180 x 30 x 45 cm (L x W x D) with beans as a cover crop in the space between the double hedge rows.
T ₅ : Control	No conservation measures

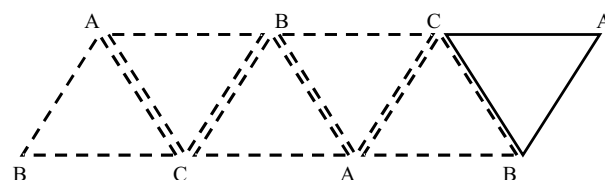


Fig. 1. Triangular frame for double hedge layout

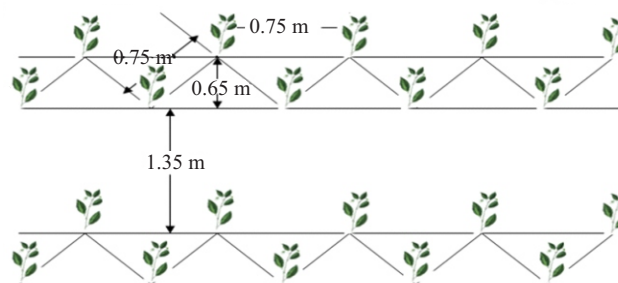


Fig. 2. Layout for tea plantation

Rainfall, Runoff and Soil Moisture

The multi-slot divisor installed at the down end of every treatment was used for runoff monitoring by measuring the runoff depth collected in each compartment in the stilling tank as well as in the collecting tank. The soil loss was estimated from sample volume of 500 ml runoff water collected from each runoff tank after stirring to determine the silt content. Events wise runoff and soil loss analysis was made and expressed in mm and $t\ ha^{-1}yr^{-1}$, respectively.

Soil moisture content was monitored during post monsoon period of the experiment. This was estimated gravimetrically from each treatment with three replications by collecting soil samples using auger at 20, 40 and 60 cm soil depths after the monsoon at regular monthly intervals to quantify the soil moisture content and growth parameters. Growth parameter of tea namely plant height and canopy were recorded from all the treatments with replications by randomly selecting five plants for each plots at every three months till the first harvest (September 2008 to June 2009). After the harvesting started, the yield of green tea leaves was recorded from every treatment with replications. Statistical analysis was carried out for runoff and growth parameters using WASP 2 developed by ICAR Research Complex for Goa.

3. RESULTS AND DISCUSSION

Rainfall and Runoff

The total annual rainfall received during the year 2008 and 2009 are 986 and 1212 mm, respectively. The runoff in the first year is less than the second year in all the treatments under both the slopes (8-12 and 30-35%) due to the less annual rainfall. However, the runoff percent in the second year is less than first year showing the establishment and impact of conservation measures in the hills over time. A minimum runoff of 112.2 mm was found in CST with cover crop of beans from 8-12% slope followed by CST (118.1 mm) against the maximum runoff of 213.1 mm in control. The runoff from all treatments found significantly different from control. Similar trend in runoff was also observed in the slope of 30-35% with minimum of 136.4 mm in CST with cover crop of beans followed by CST (152.1 mm) against the maximum of 252.4 mm in control. Runoff reduction from control to treated plots was higher in 30-35% slope than the respective reduction in 8-12% slope showing better efficiency of the conservation measures in the higher slope. A similar result of runoff reduction was also found by Badhe and Magar (2004) from the trapezoidal shaped staggered trenches under hilly terrain in lateritic soils of Konkan region of Maharashtra.

Soil Moisture

The soil moisture content at 20, 40 and 60 cm depths were monitored from all the treatments under both the slope ranges at periodical intervals after the cessation of

monsoon till the onset of the next monsoon. The average soil moisture content during the non- monsoon period at 20 cm depth varied from a minimum of 19.4% in VB to a maximum of 25.1% in CST followed by CST with cover crop of beans (23.3%) at 8-12% slope (Fig. 3). The moisture content are at par between control and VB showing the minimum effect of VB in retaining soil moisture within 20 cm depth of the soil. The soil moisture content at 40 cm depth varied from maximum of 26.9% in CST with cover crop to a minimum of 19.8% in control with intermediate values in the remaining treatments. However, the close values of soil moisture contents between CST and CST with cover crop followed by CST alternate with VB at 40 cm depth shows the effect of CST either alone or with combination in influencing the soil moisture. Similar trend in soil moisture among all the treatments at 60 cm depth with maximum in CST followed by CST with cover crop beans were also observed.

The average soil moisture content among the treatments at a depth of 20 cm varied between 18.6% in control to maximum of 24.1% in CST followed by CST with cover crop under 30-35% slope (Fig. 4). The close values of soil moisture content between the CST with cover crop (22.8%) and CST alternate with VB (21.9%) may be due to the effect of CST in both as explained earlier. The effect of the CST were very well realized at the soil depth of 40 cm with maximum soil moisture content in CST (26.3%) followed by CST with cover crop (25.4%). This higher soil

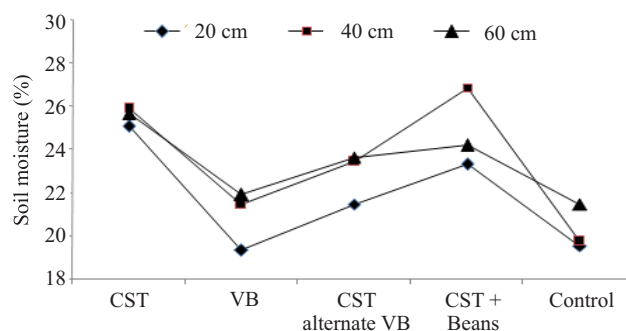


Fig. 3. Soil moisture under conservation practices in 8-12% slope

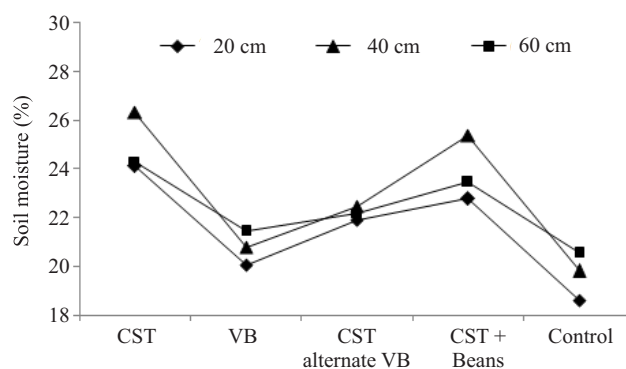


Fig. 4. Soil moisture under conservation practices in 30-35% slope

moisture content can be attributed to less runoff due to retention in the trenches followed by absorption in the soil profile within the root zone. Similar trend in soil moisture content with less difference among the treatments were also observed at 60 cm of soil depth. Similar results of moisture conservation and higher moisture availability in the soil profile have been reported by Singh *et al.* (2005) and Regar *et al.* (2009) due to conservation measures.

Plant Growth

The plant growth parameters *viz.*, canopy and height of tea under different conservation measures from both the slope groups were monitored after first year of plantation (during 2008-09) at every three months to assess the impact of conservation practices on growth. Variation in tea canopy among the treatments was insignificant during the extent of monsoon may be due to enough soil moisture availability of irrespective of treatment effect in the slope of 8-12%. In post monsoon, the variation in canopy due to treatment effect was realized. In June, the maximum canopy (39.5%) was observed in the CST with cover crop of beans followed by CST (38.4%) with minimum in control (Fig. 5). This may be due to the direct effect of higher soil moisture content resulting from conservation practices as explained earlier assuming the other factors remaining same among the treatments. Canopy (%) development among all treatments also found significantly different from control at

5% level of significance [$LSD (0.05) = 1.79$]. Unlike the observations made in the slope of 8-12%, there is significant variation in tea canopy between the control and treatments are observed from the beginning in 30-35% slope (Fig. 6). However, less variation among treatments during monsoon was widened afterwards owing to wider variation in soil moisture content in the plant root zone. But, maximum canopy of 35.5% was observed in CST followed by CST (32.5%) with cover crop in 30-35% slope may be due to the cultivation of cover crop of beans affecting the growth.

The difference in plant height among the treatments are not clearly visible during monsoon and immediately after may be due to enough available soil moisture irrespective of treatment effects as the case in canopy development in the slope of 8-12%. There is increase in height over time and during June 2009, maximum height (58.3 cm) was observed in CST with beans followed by CST (55.2 cm) against the minimum of 45.5 cm in control with intermediate growth in CST with VB (53.6 cm) and VB (51.1) (Table 2). The maximum height obtained in CST with beans may be due to higher soil moisture content as the case in canopy development as well as of the effect of the residual nutrients applied during the cultivation beans. From the statistical analysis, the tea height from all treatments found significantly different from control other than the treatment with VB at 5% level of significance ($LSD 0.05 = 6.72$). Similar trend in tea height among the treatments including

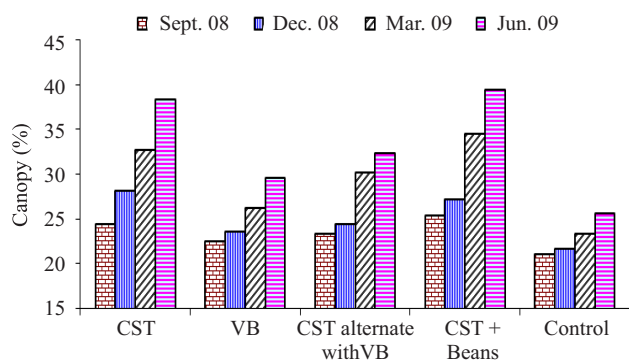


Fig. 5. Canopy (%) under different conservation measures in 8-12% slope

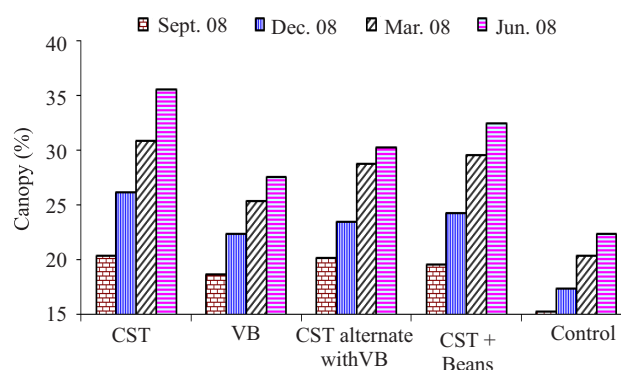


Fig. 6. Canopy (%) under different conservation measures in 30-35% slope

Table: 2
Plant height under different conservation practices

Month	Treatment				
	CST	VB (Geranium)	CST alternate with VB	CST + Beans	Control
Plant height (cm) in 8-12% slope					
September,08	34.2	32.3	32.8	34.2	31.1
December,08	41.4	38.7	41.0	39.7	36.3
March,09	48.7	44.6	47.5	51.5	45.9
June,09	55.2	51.1	53.6	58.3	45.5
Plant height (cm) in 30-35% slope					
September,08	31.3	32.2	32.2	32.3	30.2
December,08	39.9	38.2	38.8	40.1	36.3
March,09	51.5	46.1	47.4	50.3	42.2
June,09	58.9	51.7	52.6	56.4	48.3

control was also observed in the slope of 30-35% up to December, 2008 due to similar reasons explained earlier. However, in the next two observations during March and June 2009, the difference became prominent with maximum height (58.9 cm) in CST followed by CST with beans (56.4 cm) and minimum height of 48.3 cm in control during June. In this case, the plant height is better in CST as compared to the CST with cover crop of beans may be due to the existing steeper slope resulting in human interference while cultivating the cover crop. Earlier studies by Mane *et al.* (2009) reported on the performance of different conservation measures in cashew plantation and found significant effect of stone bund followed by CCT over control on growth of cashew. Kumar *et al.* (2008) also found similar result of conservation practices significantly influencing the plant height.

Yield

Tea starts producing potential yield from sixth year onwards of plantation. However, during the experiment, the harvesting was done periodically in every alternate month after two years of plantation from all the treatments under both the slopes. It was found that, higher yield from all the conservation practices over control (3.8 t ha^{-1}) with maximum in CST with cover crop of beans (4.7 t ha^{-1}) followed by CST (4.4 t ha^{-1}) in 8-12% slope due to better growth resulting from higher soil moisture. The yield data are found statistically significant at 5% level of significance. However, there is no significance difference in yield between CST with cover crop of beans and CST, among CST alternate with VB, VB alone and control. Maximum yield of 4.6 t ha^{-1} obtained in CST followed by CST with cover crop (4.5 t ha^{-1}) with statistically insignificant at 5% level in 30-35% slope. But, all the treatments are found significantly different from control.

4. CONCLUSIONS

CST either alone or in combination with vegetative measure is highly accountable in reducing runoff in the tea plantation fields under steep slopes of Nilgiris. The reduction in runoff percent in the subsequent years also proved the increased effect of establishment of conservation practices over time. Runoff retention in the trenches followed by absorption in the soil profile attributed to higher soil moisture in CST and CST with cover crop followed by CST with VB in both the slopes during non- monsoon period resulted in better canopy and plant growth. Higher yield from all the conservation practices over control (3.8 t ha^{-1}) with maximum in CST with cover crop (4.7 t ha^{-1}) followed by CST (4.4 t ha^{-1}) in 8-12% slope due to better growth resulting from higher soil moisture.

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