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Effect of Different Soil Moisture Conservation Practices on Evapotranspiration and Growth of Young Tea Plants

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Abstract: A field experiment was conducted to study the effect of different soil moisture conservation practices on evapotranspiration and growth of young tea (*Camellia sinensis* L.) plants. Treatments were: control (T_1), farmyard manure at 62 tons ha^{-1} (T_2), farmyard manure at 124 tons ha^{-1} (T_3), pine-needles at 12 tons ha^{-1} (T_4), pine-needles at 25 tons ha^{-1} (T_5) and tea inter-cropped with maize (T_6). Moisture content of the soil was determined upto 0.3 m depth by gravimetric method. Plant growth was recorded at 15-30 days intervals. Resulting values of evapo transpiration of young tea plants ranged from 0.50 mm day^{-1} for (T_5) to 4.77 mm day^{-1} for (T_2). Double dose of farmyard manure (T_3) caused 42% increase in plant height compared to control (T_1). One drawback of tea cultivation is that its first yield is delayed i.e. after 5 years, which could be compensated by inter-cropping.

Key words: Conservation practices, evapotranspiration, growth intercropping, soil moisture, *Camellia sinensis* L.

Introduction

Tea (*Camellia sinensis* L.) belongs to family Theaceae and is grown under varying agro-ecological conditions throughout the world. Being a water loving plant, tea requires high rainfall i.e., above 1000 mm annually evenly distribution over the growth period in addition to acidic soils for economic production (Anonymous, 2000).

The prospective tea growing areas in Pakistan are located in Hazara and Swat districts, which covers a latitude and longitude range of 34-36^{0}N and 72-75^{0}E, respectively. It has been estimated that 85% of the prospective area is in district Mansehra. In this district, the tea growing area lie in a sub-tropical zone with monsoon climate and a bimodal rainfall distribution with marked peaks in February/March and then in July/August. Thus, among the climatic features, soil moisture deficit is a major limiting factor for optimum growth of tea and all economic means for alleviating climatic constraints on tea growth needs to be attempted (Amin, 1998).

Improved soil moisture conservation techniques/ practices have been found to mitigate soil moisture stress in many water-scarce areas of the world. These practices include mulching, use of organic matter, chemical fertilizers and shading of crop to check or minimize direct evaporation from the soil surface and/or increase the water holding capacity of root zone. The practice of applying a layer of vegetable waste materials such as straw, hay or old grass, farmyard manure or plastic sheets onto the surface of the soil around trees and bushes has been prevalent for a long time in many parts of the world. These soil moisture conservation practices have very favorable effect on surface soil moisture conditions and consequently on the crops especially those with shallow root system. Thus, this practice has been widely used for many fruit trees, bushes and tropical plantations such as coffee and tea (Shaxon and Hall, 1968). In marginal rainfall areas, every drop of rain is important for the growth of tea plant. Use of mulches for water conservation are therefore, essential. Under favorable circumstances, soil fertility is improved by some of the soil moisture conservation practices i.e., application of farmyard manure and pine needles. In this process, a bed of humus is formed, which supports active micro-fauna, which actually speeds up the decomposition process and nutrients release to the crops. Tree growth and fruit production of apricot were significantly increased by both pre-plant compost application and mulching of the soil surface (Kotze and Joubert, 1992).

Due to its cheapness, tea is one of the most popular National beverages of Pakistan as well. The annual per capita consumption is 1.0 Kg. The annual import during 1999-00 had risen to 110,000 tons costing approximately

Rs.11.0 billions to the national exchequer (Anonymous, 2000). Thus with the current population growth rate demand will continue to increase with time that will result in heavy loss of foreign exchange to Pakistan. Therefore, it is the need of the time to make efforts for maximization of its production in the country to meet local demand as soon as possible.

This study was conducted to know about the consumptive use of water, which helps to determine the frequency and amount of irrigation water required for tea crop. Soil moisture conservation practices like application of pine needles and farmyard manure are essential to maintain existing soil moisture and for speed up the growth of tea plants. This is important to overcome water scarcity problem in area, thus saving water and labor.

Materials and Methods

The present study was conducted at the National Tea Research Institute, Shinkiari, district Mansehra from July to October 1999. In this study, two years old nursery young tea plants were transplanted in the field when plenty of monsoon water was available. There were six treatments and each treatment consisted of 9 plants with 48 cm row to row and 24 cm plant to plant distance. Where as the plot size consisted of 144 cm in length and 72 cm in width. Treatments were: control (T_1), farmyard manure at 62 tons ha^{-1} (T_2), farmyard manure at 124 tons ha^{-1} (T_3), pine-needles at 12 tons ha^{-1} (T_4), pine-needles at 25 tons ha^{-1} (T_5) and tea inter-cropped with maize (T_6). All agronomic practices were kept uniform with the application of recommended dose of fertilizers (Ammonium sulphate 225 Kg ha^{-1}, potassium 15 Kg and DAP 25 Kg ha^{-1}) were applied. The experiment was laid out in randomized complete block design. Experimental field had a clay loam soil. General trend of pH and K in (Table 1) decreasing from 0-15 to 15-30 cm soil depth and in case of No_3-N, P, Zn, Cu and Fe were increasing from 0-15 to 15-30 cm soil depth. Evapotranspiration was determined by soil moisture depletion method as described by James (1993). Gravimetric method was used to estimate the soil moisture content at 105 °C till the constant weight. Soil samples were also collected before each irrigation. Soil samples were taken at 0-15 and 15-30 cm depths from each sub-plot (treatment). Moisture content of soil on weight basis was calculated and than it is converted on volume basis as describe by James (1993). Irrigation to the experimental fields was carried out on demand basis i.e., at 50% depletion of available moisture in the root zone to bring the soil moisture back to field capacity, which was established in the field by fully wetted the soil to at least 30 cm below the proposed maximum sampling depth, and it was covered with a sheet of polythene to reduce evaporative losses. Soil samples were taken at different depths after every 24 hours until the moisture contents at successive samplings agreed to within 1% at each depth. Height of each plant was determined by measuring tape and average height was calculated for each plot. It was taken at 15-30 days interval. The yield of inter-cropped maize was determined at the time of harvesting of maize crop, which included weight of grain, stalk and total biomass. Data were subjected to statistical analyses (Sher Mohammad Chaudhry, 1996), by using F- test to detect the significance of treatment affect and LSD was used as a test of significance.

Results and Discussion

Evapotranspiration showed a variable trend from July 20 to September 20 and after that it gradually decreased till October 30, 1999 (Table 2).

Minimum ETa of 0.50 mm day^{-1} was found for T_5 (double dose of pine-needles) at 30 October 1999 and maximum in T_2 (4.77 mm day^{-1}) at 20 August, which is 90 % higher than minimum value (Fig. 1). Average study period ETa 2.73 mm day^{-1} was observed maximum for T_4, while minimum 2.52 mm day^{-1} in T_5,

Maximum ETa for T_2 could be because of application of single dose of pine needles, which contained high moisture content than other treatments. The minimum value of ETa of T_5 may be due to low soil temperature. This shows that pine-needles can be used efficiently in conserving soil moisture content. The analysis of variance indicates that there is no significant effect of different soil moisture conservation treatments on

Table 1: Physio-chemical properties of soil at National Tea Research Institute (Mansehra)

Depth of soil (cm)	Chemical properties of soil (mg kg^{-1})							Soil texture	Bulk density (g cm^{-3})	Fc% by Vol.	Wp% by Vol.
	pH	NO_3-N	P	K	Zn	Cu	Fe				
0-15	5.9	1.5	0.7	80	0.5	12	66	Sandyloam	1.25	36	18
15-30	5.5	6.6	0.9	59	2.6	18.4	109				

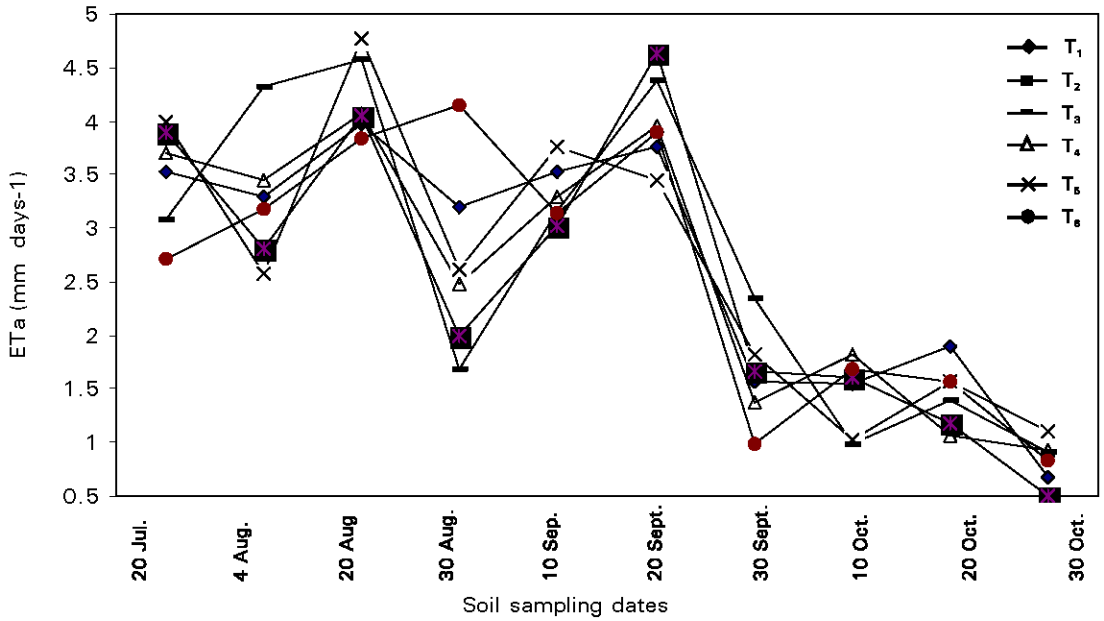

Fig. 1: Evapotransiration of young tea plants under different soil moisture onservation treatments

Table 2: Results of evapotranspiration under different soil moisture conservation practices

Soil sampling dates	Evapotranspiration (mm day^{-1})					
	T_1	T_2	T_3	T_4	T_5	T_6
20 Jul	3.52	3.99	3.08	3.71	3.90	2.72
4 Aug	3.30	2.57	4.32	3.44	2.81	3.18
20 Aug	3.98	4.77	4.57	4.06	4.06	3.84
30 Aug	3.19	2.62	1.69	2.48	2.00	4.14
10 Sept	3.53	3.75	3.16	3.30	3.02	3.13
20 Sept	3.76	3.45	4.38	3.95	4.64	3.90
30 Sept	1.57	1.81	2.35	1.38	1.66	0.99
10 Oct	1.55	1.03	0.99	1.82	1.61	1.69
20 Oct	1.90	1.57	1.40	1.06	1.18	1.57
30 Oct	0.68	1.10	0.90	0.92	0.50	0.83

Table 3: Effect of different soil moisture conservation practices on plant height

Days after transplantation	Plant height (cm)						LSD (0.05)	Pr>F
	T_1	T_2	T_3	T_4	T_5	T_6		
0	29.27	30.52	30.43	31.19	31.28	27.51	3.58	0.26
30	30.57	32.67	32.59	33.32	33.89	29.17	3.75	0.12
60	31.21	34.03	33.81	34.08	34.92	29.96	4.08	0.12
75	31.55	34.51	34.46	34.94	35.37	30.51	4.22	0.12
90	32.35	35.61	35.80	36.16	36.60	31.27	4.09	0.06
105	32.74	36.13	36.42	36.78	37.22	31.67	4.05	0.04
120	32.82	36.27	36.59	36.19	37.38	31.73	4.08	0.04
Difference (Max-Min)	03.55	05.75	06.16	05.71	06.10	03.22		

Table 4: Yield of grain, stalks and biomass(Kg ha^{-1}) of inter-cropped maize

Replications	Grain	Stalk	Biomass
R_1	1251	1601	4658
R_2	1055	1062	3290
R_3	1384	902	3418
R_4	2156	988	5194
Mean	1461	1138	4140

evapotranspiration of young tea plants. Evapotranspiration values reported by Willatt (1973) were higher than the present study. The reason for obtaining the lower values may be due to the difference in the climatic conditions of the research area and young tea plants, having very small canopy.

Plant height: Plant height of T_2, T_3, T_4 and T_5 were higher than T_1 and T_6 (Table 3).

The maximum plant height under T_3 (6.16 cm) may be due to conservation of high moisture content and more organic matter was available due to farmyard manure decomposition, which speeded up the plant growth. The minimum plant height of T_1 (3.55 cm) may be due to less availability of moisture content in the soil and high rate of evapotranspiration under natural condition. This indicate that double dose of farmyard manure (T_3) can used effectively for tea plant growth. The analysis of variance indicated that there is significant effect of different soil moisture conservation treatments on height of young tea plants. These results seems to be in accordance with Kotze and Joubert (1992) and Nath and Sarma (1992) that mulching improved organic matter and speeded up growth of the plants.

Yield of inter-cropped maize: The average yield of inter-cropped maize indicates that grain yield was 1461 kg ha^{-1} (Table 4) whereas average grain yield of maize crop in the area according to average yield of NWFP (1997-98) is 1525 kg ha^{-1} which is 4% greater then that of inter-cropping maize yield. This may be due to attack of predators (birds), not application of fertilizers, insecticides (under control condition) and scarcity of water as two crops were committing for the same water.

Stalk yield of inter-cropped maize shows that average value was 1138 kg ha^{-1} (Table 4) whereas average yield of the maize stalk in the area according to local farmers' interview was 1205 kg ha^{-1} that is 6% greater than that of inter-cropped maize data.

Average biomass of maize was 4140 kg ha^{-1} whereas average total biomass of maize in the area is 4687 kg ha^{-1}, which is 12% greater than inter-cropped data. During the initial period of tea plant growth (when there is no yield to tea available) the farmers could inter-crop maize and can get some income.

There is no significant effect of different soil moisture conservation treatments on evapotranspiration. However, pine-needles at a rate of 25 tons ha^{-1} can be used efficiently in conserving soil moisture.

Farmyard manure at a rate of 124 tons ha^{-1} was found to be the best for optimum tea plant growthDuring the initial period of tea plant growth when tea is not available, farmers can inter-crop maize to get some income.

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