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Influence of Organic, Inorganic and Combined based Fertilizers on Bush Physiology of Darjeeling tea (*camellia sinensis* L.)

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Abstract—*In the present investigation effect of the organic, inorganic and combined fertilizers on the photosynthetic activity and yield of Darjeeling tea cultivation was studied. Observations for physiological parameters like net photosynthetic rate and related parameter were recorded in three important seasons at the time of sunny day. The treatments were T1=Control, T2=Vermicompost (VC-100%), T3=Farmyard Manure (FYM -100%), T4=Chemical Fertilizers (CF–90:45:90:: N:P:K), T5=(VC 50%+CF 50%),T6=(FYM 50%+CF 50%), T7=(FYM 70%+CF 30%), T8=(VC 70%+CF 30%) and T9=(VC 50%+FYM 50). Highest photosynthetic rate (P_N) was observed with the application of 45: 22.5: 45 kg^{-ha} basal through Urea, RP and MOP+vermicompost 50% (T5), which was followed by 90: 45: 90 kg^{-ha} basal through Urea, RP and MOP (T4) but the lowest with the application of FYM @ 15 tones^{-ha} (T3). The maximum value of net photosynthetic rate (Pn) was recorded in T5 during rainy season, giving 42.0 percent increase over the control (T1), whereas in summer the lowest increase over the control (6.0 percent) was recorded with FYM 70%+CF 30% (T7). T5 recorded highest leaf water potential (ψ_L) than other treatments. In general; higher P_N coincided with higher ψ_L values. The maximum value of stomatal conductance (g_s) and transpiration rate (E) were recorded in T5 during rain. Chlorophyll content (Chl) was greater in combined fertilized plots (VC 50%+CF 50%). T5 showed maximum Chl and T1 recorded lowest. A positive correlation between Chl content and Pn existed in the present study. Highest yield was recorded in T5 and increased 45.71 percent over the controlT1. The combination of organic fertilizer along with inorganic fertilizer is beneficial for the photosynthetic activity and productivity of tea.*

Keywords: *Camellia sinensis, Chemical fertilizers, Chlorophyll, Organic fertilizers, made tea and Photosynthesis*

1. INTRODUCTION

Tea (Camellia sinensis L.) is a perennial small evergreen shrub belonging to the camellia genus of the Theaceae family. It is one of the most popular beverages of the world. Green tea, the favourite type consumed in Japan and China, has been increasingly used also in western countries in recent years. Planters usually apply urea for tea production, and apply organic manures for P, K and Mg nutrition. In fact, tea plants need large amounts of N, P, K, and Mg for growth. The deficiency of these nutrients could adversely affect the yield and quality [21]. Nutrient deficiency in soils and poor fertilization are two factors limiting the yield and quality of tea. Nitrogen is the part of DNA of plant and is major contributor towards the plant growth. Phosphorus is an important part of ATP and converts the light and energy into chemical energy during photosynthesis. Potash plays an important role in water retention by plant. It also regulates the opening and closing of stomata. Darjeeling tea plants experiences various types of climatic conditions in Darjeeling hills such as low temperature, low soil moisture in winter foggy climate, high humidity and low levels of solar radiation. For proper maintenance of the health of tea bushes and to obtain high yield, a balanced fertilization and manuring is necessary at certain intervals throughout the year. It is also vital to integrate the various factors relating to climate, soil, plant and cultivation for achieving the maximum return from the investment on fertilizers and productivity of the soil. Differences in photosynthetic characteristics are related to light environment, leaf anatomy, physiology and nutrient status of the leaves [14]. Fertilizer increased Pn both by enhancing Pn per unit area in healthy leaves and by increasing the proportion of sunlight intercepted by photo synthetically efficient leaves in tea [18]. [5] reported that Pn as well as physiological efficiencies of different nutrients increased with integrated nutrient management in Soybean. Positive correlations between leaf nitrogen content and P_N have been reported for tea [3].[15]emphasized that mineral nutrients affect the photosynthesis at all levels of plant structure, the photosynthesis has considerable influence on mineral nutrients uptake, distribution and utilization, and the photosynthesis should always be considered as only one factor among many others that are modified by changes of the mineral nutrition.

The most important elements present in organic fertilizers are nitrogen, phosphorus and potassium which influence vegetative and reproductive phase of plant growth. Compared to inorganic fertilizers the organic fertilizer having lowered the nutrient content, solubility, and nutrient release rate are typically low than inorganic fertilizers and therefore inorganic fertilizers are more preferred than organic fertilizers. Besides this application of organic manures not only produced the highest and sustainable crop yield, but also improved the soil fertility and productivity of land [19]. A combination of organic and inorganic sources of nutrients might be helpful to obtain a good return with good soil health for the subsequent crop yield [8]. The present study was undertaken to know the effect of combination of organic and inorganic fertilizers on photosynthesis efficiency and associated characteristics and yield of tea.

2. MATERIALS & METHODS

2.1 Experimental site and plant material

The study was conducted at the Darjeeling Tea Research & Development Centre, Kurseong (26.9^{0}N, 88^{0}12 E, altitude 1347 m) during 2011 to 2013. The topography comprised of moderate slopes (25-30%). The topsoil is about 45 cm in depth and the sub soil is stony. The soil is an Umbric Dystrochrept, moderately permeable and moderately well drained. Infiltration rate is 4 –6 cm h^{-1} measured by water hydrograph method in the field (unsaturated) conditions. The soil texture is sandy loam.

China-type mixed quality clones of commercial and scientific interest in the Darjeeling Hills were planted during the month of June, 2000 in the trial. The plots prepared were laid out in a randomized block design: T1=Control, T2=application of vermicompost (VC) (Nitrogen- 1.6%; phosphoric acid (P_2O_5)- 2.2%; Potash (K_2O)- 0.67%; Ca- 0.99% and Mg- 0.15%) @ 5.5 tones $^{-ha}$; T3=application of farmyard manure (FYM) (nitrogen- 0.6, phosphoric acid (P_2O_5)–0.17 and potash–0.5 percent) @ 15 tones^{-ha}; T4=Chemical Fertilizers 90: 40: 90 kg^{-ha} basal through Urea (nitrogen–46 percent), rock phosphate (RP) (P_2O_5–20 and sulphur–2.3 percent) and muriate of potash (MOP) (K_2O–50 and chlorine 47 percent); T5=(VC 50%+CF 50%),T6=(FYM 50%+CF 50%), T7=(FYM 70%+CF 30%), T8=(VC 70%+CF 30%) and T9=(VC 50%+FYM 50). Spacing for planting was 90 cm x 60 cm x 60 cm and the distance from hedge to hedge was 90 cm, row to row 60 cm, and plant to plant 60 cm. There were three replications per treatment. Each replication consists of 50 plants. The plants were not irrigated as this is the general practice in this region.

2.2 Measurement techniques

During 2011 to 2013, net photosynthetic rate (P_N), Photo synthetically active radiation (PAR), stomata conductance (g_s), transpiration (E), Intercellular CO2 conc. (Ci), Vapour pressure deficit (VPD) and WUE were monitored three times in a month at the beginning, middle and end of March- April, July- August, and December- January, using a portable photosynthetic system (Li 6200, Li -Cor, Nebraska, USA) with a well mixed 390 cm^3 chamber as described at the time of sunny day. This portable instrument has internal programmes to calculate physiological quantities from measurements of air and leaf temperatures, humidity and CO_2 concentrations. Assimilation rates are computed in this instrument by assuming linear rates of change in water vapour and CO_2 concentrations within the leaf chamber. All data points during a measurement period were fitted using linear regression techniques. Dark-green healthy looking mature leaves at the surface of the canopy and fully exposed to incident sunlight were used for the observations. Such leaves are often referred to as 'maintenance' foliage. Three plants randomly selected from each replicated plot were assessed on every recording (1458 reading). Efforts were made to ensure that measurements were taken only when there was no cloud cover. All measurements were made between 10 00 and 12 00 hours when the maximum values of P_N and other physiological parameters were recorded in the diurnal study [11]. Photosynthetically active radiation (PAR) and VPD were measured concurrently using the photosynthesis system three times in a month at the beginning, middle and end of the months. The intercellular CO_2 concentration (Ci) was computed in the Li-6200 using initial values of P_N, E, ambient CO_2 concentration, and leaf resistance. The water use efficiency (WUE) was calculated as the ratio of CO_2 assimilated to water transpired. The infrared gas analyzer had been recalibrated using compressed CO_2 gas immediately before the experimental work.

Leaf water potential (ψ_L) was measured simultaneously with P_N using a dew point hygrometer (model C-52 sample chamber connected to an HR 33T microvoltmeter, Wescor Inc., Logan, USA. Small circular leaf discs from the leaves on the opposite branches to those for P_N measurement were used and ψ_L values were expressed as megapascals (-Mpa).At monthly intervals, Chl of freshly harvested leaves collected from the opposite branches to those for P_N measurement was estimated according to the method described by [2], after extraction with 80% acetone in the dark and using the Hitachi (U 2000) double beam spectrophotometer.

In the Darjeeling Hills, flushing of the tea crop starts at the end of March and after a sequence of production of normal leaves in April the shoot goes dormant for a short period during May. Thereafter, harvesting of the tea crop continues until September, declines considerably towards the end of October and then ceases during November until flushing starts again at the end of March. Shoots (two leaves and a terminal bud) were harvested at weekly intervals between March and November (Twenty-six cycles per year) from all the plots. The total fresh mass of the shoots from each plot was weighed at each harvest and converted to the made tea equivalent using a constant value of 0.22 **[1]**.The volumetric water content of the soil was determined gravimetrically in three replicates at two depths viz. 0 –15 cm and 15–30 cm.

3. RESULT AND DISCUSSION

3.1 Physiological characteristics

The integrated effects of vermicompost, Farmyard manure and chemical fertilizers on photosynthetic efficiency and yield of Darjeeling tea have been tabularized along with statistical data. Significant difference in all the combinations of treatments was observed as compared to control. The highest P_N (11.64 µ mol $m^{-2}s^{-1}$) was recorded with application of VC 50% (@ 2.75 tones+CF 50% (45: 22.5: 45 kg^{-ha} basal through Urea, RP and MOP (T5), which was followed by 90: 45: 90 kg^{-ha} basal through Urea, RP and MOP (11.21 µ mol $m^{-2}s^{-1}$) (T4) but the lowest with the application of FYM @ 15 $tones^{-ha}$(8.79 µ mol $m^{-2}s^{-1}$) (T3) (Table 1). The maximum value of P_N (12.45 µ mol $m^{-2}s^{-1}$) was recorded in T5 during rain, giving 42.0 percent increase over the control (T1), whereas in summer the lowest increase over the control (6.0 percent) was recorded with FYM @ 15 $tones^{-ha}$ (T3).

Table 1: Influence of combination of fertilization on net photosynthetic rate (P_N-µ $molm^{-2}$ s^{-1}) on Darjeeling tea in three important seasons at sunny weather (Mean of three years)

Treatments	Seasons: Summer	Rainy	Winter	Mean
T1	7.37	8.75	8.46	8.19
T2	8.03	9.87	8.99	8.96
T3	7.78	9.63	8.77	8.79
T4	9.00	11.99	11.57	11.21
T5	9.08	12.45	11.95	11.64
T6	9.24	10.71	10.73	10.33
T7	7.95	9.96	9.74	9.21
T8	8.53	10.59	11.29	10.14
T9	9.08	11.19	11.10	10.45
Se	0.23	0.29	0.40	0.25
CD at 5 %	0.69	0.88	1.13	0.75

Note: (T1=Control, T2=VC (100%), T3=FYM (100%), T4=C F (90:45:90::N:P:K), T5=VC 50%+CF 50%, T6=FYM 50%+CF 50%, T7=FYM 70%+CF 30%, T8=VC 70%+CF 30%, T9=VC 50%+FYM 50%)

In Southern Highlands of Tanzania, [18] reported that fertilizer (combined with irrigation) at an annual application @ 225 kg N^{-ha} caused increase in P_N than the unfertilized and application of nitrogen @ 225 kg $^{-ha}$ treatment plots. When the atmosphere was dry during pre-monsoon (March-April) and plants were suffering from moisture stress till the end of May, the lower rate of P_N was recorded in all treatments and that may be due to low humidity or moisture stress. There is abundant evidence in the literature that P_N is inhibited by water stress [10]. With the onset of the monsoon rain in June, the plants were able to recover fully from the water stress and an increase in the water contents of the leaves. The increased water content helps in maintaining the turgidity of the assimilatory cells and the proper hydration of their protoplasm. In summer, higher temperature prevailed but P_N was lowest in summer rather than winter. Low temperature accompanied by low soil moisture reduced P_N in winter than rain. In summer, when PAR increased from lower intensity 650 µ mol $m^{-2}s^{-1}$ (during rain) to about 1050 µ mol $m^{-2}s^{-1}$(Fig. 1), the value of P_N in all treatments were lowest than rain. In rains, humidity and soil moisture were highest, PAR recorded 400-1100 µ mol $m^{-2}s^{-1}$ and P_N was also highest (12.45 µ mol $m^{-2}s^{-1}$).

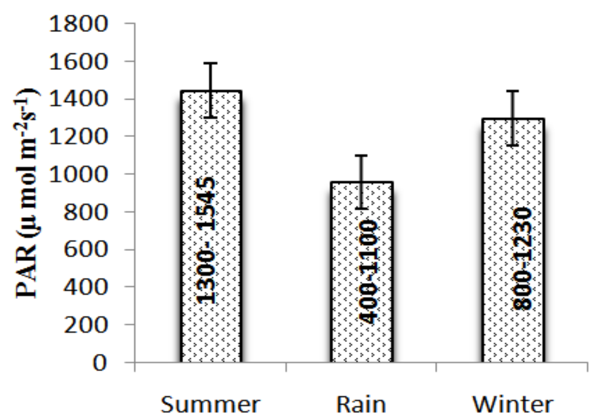


Fig. 1: Seasonal changes of photosyntheticaly active radiation (PAR) during the study. Vertical bars indicate standard error of means. (Data are the average of each season for 2011-2013)

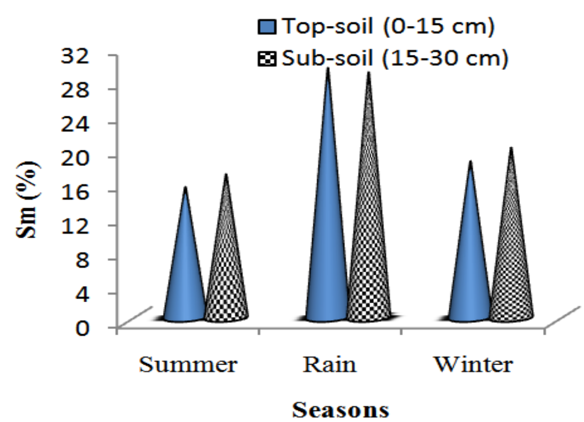


Fig. 2: Voluemetric water content (Sm) of treatment plots during the study at DTRDC, Kurseong (Data are average of each season during 2011 to 2013

Table 2: Influence of combination of fertilization on Transpiration (*E* - m molm^{-2} s^{-1})) on Darjeeling tea in three important seasons (Mean of three years).

Treatments	Seasons			Mean
	Summer	Rainy	Winter	
T1	2.61	5.25	2.03	3.29
T2	3.02	5.77	2.52	3.77
T3	3.91	5.16	2.58	3.88
T4	3.63	6.44	3.02	4.36
T5	3.12	6.62	3.46	4.40
T6	3.34	6.86	2.53	4.24
T7	2.07	6.15	2.34	3.52
T8	3.48	4.90	3.48	3.95
T9	3.87	6.37	3.48	4.57
Se	0.07	0.12	0.06	0.34
CD at 5 %	0.22	0.35	0.18	1.02

Table 3: Influence of combination of fertilization on Stomatal conductance (gs–(molm^{-2} s^{-1}) on Darjeeling tea in three important seasons (Mean of three years).

Treatments	Seasons			Mean
	Summer	Rainy	Winter	
T1	0.07	0.23	0.10	0.13
T2	0.10	0.26	0.13	0.16
T3	0.09	0.27	0.13	0.16
T4	0.10	0.30	0.17	0.19
T5	0.11	0.33	0.17	0.20
T6	0.10	0.27	0.14	0.19
T7	0.08	0.24	0.13	0.15
T8	0.09	0.25	0.18	0.17
T9	0.11	0.29	0.17	0.19
Se	0.01	0.02	0.01	0.01
CD at 5 %	0.01	0.03	0.03	0.04

Table 4: Influence of combination of fertilization on Water use efficiency (WUE- µ mol mmol^{-1}) on Darjeeling tea in three important seasons (Mean of three years).

Treatments	Seasons			Mean
	Summer	Rainy	Winter	
T1	2.94	1.79	4.16	2.96
T2	2.67	1.71	3.56	2.64
T3	2.02	1.86	3.48	2.45
T4	2.49	1.86	3.83	2.72
T5	2.91	1.88	3.47	2.74
T6	2.77	1.56	4.23	2.85
T7	3.52	1.62	4.16	3.10
T8	2.45	2.16	3.24	2.62
T9	2.33	1.77	3.22	2.44
Se	0.10	0.07	0.15	0.21
CD at 5 %	0.31	0.21	0.46	0.65

Table 5: Influence of combination of fertilization on Intercellular CO2 conc. (Ci - ppm) on Darjeeling tea in three important seasons (Mean of three years).

Treatments	Seasons			Mean
	Summer	Rainy	Winter	
T1	201.37	297.37	231.60	243.45
T2	176.60	262.80	228.87	222.76
T3	197.17	281.00	230.37	236.18
T4	176.30	234.37	214.63	208.43
T5	132.03	219.77	210.80	187.53
T6	191.73	266.37	211.03	223.04
T7	161.10	261.63	208.87	210.53
T8	193.97	260.23	226.97	227.06
T9	188.67	242.97	208.10	213.25
Se	6.41	2.93	4.17	7.24
CD at 5 %	19.45	8.89	12.65	21.95

Table 6: Influence of combination of fertilization on Leaf water potential (ψ_L -MPa) on Darjeeling tea in three important seasons (Mean value of three years)

Treatments	Seasons			Mean
	Summer	Rainy	Winter	
T1	-3.52	-1.83	-3.16	-2.84
T2	-3.08	-1.53	-2.94	-2.52
T3	-3.28	-1.71	-3.02	-2.67
T4	-2.74	-1.49	-2.59	-2.27
T5	-2.63	-1.44	-2.51	-2.19
T6	-3.30	-1.83	-2.92	-2.68
T7	-2.85	-1.75	-3.01	-2.54
T8	-3.13	-1.55	-3.06	-2.58
T9	-2.80	-1.54	-2.95	-2.43
Se	0.17	0.09	0.10	0.08
CD at 5%	0.53	0.30	0.32	0.24

Table 7: Influence of combination of fertilization on Vapour pressure deficit (VPD) on Darjeeling tea in three important seasons (Mean of three years).

Treatments	Seasons			Mean
	Summer	Rainy	Winter	
T1	3.386	1.847	1.793	2.342
T2	3.785	2.106	1.925	2.605
T3	3.852	1.804	2.028	2.561
T4	3.696	2.399	1.839	2.645
T5	3.904	2.440	2.060	2.801
T6	3.313	2.030	1.904	2.416
T7	3.322	2.200	1.819	2.447
T8	3.664	1.860	2.038	2.521
T9	3.630	2.368	2.055	2.684
Se	0.08	0.05	0.06	0.06
CD at 5 %	0.49	0.46	0.58	0.51

Among the treatments, T1 showed lowest ψ_L while T5 recorded highest in all seasons (Table 6). The highest ψ_L was obtained in rains and PN was also high. There is a positive correlation observed between PN and ψ_L (Fig. 5). Among the seasons, ψ_L was lowest in summer and highest in rains. T5 recorded higher *E* than other treatments (Table 2). Transpiration rate was lowest in summer season and higher in rain, though the PAR reached minimum but the temperature, Soil moisture and RH were reasonably high. Similar finding has been reported in tea [13]. [4]also reported a sharp decline of *E* with reduced soil moisture in Assam tea plantation. In general, the decrease in g_s was more pronounced in moisture stress period (Table 3). The maximum value of g_s (0.33 mol $m^{-2}s^{-1}$) was recorded in rain in T5, giving 43 percent increase over the control, whereas the lowest increase (14 percent) over the control was recorded in summer with application of FYM 70%(10.5 tones^{-ha})+CF 30% (27:13.5:27 kg^{-ha} basal through Urea, RP and MOP (T7) (Table 3). The decrease in g_s and *E* were more pronounced in summer when both soil and atmospheric moisture was low and demand for water was high. Thus, there was depression in P_N under transient water stress in summer. In different treatments, maximum WUE was associated with relatively lower $\psi_{L,}$ lower *E* and lower g_s(Table 6, 2 & 3). Maximum WUE was recorded in winter (4.23 µ mol/ mmol^{-1}) and minimum in rainy season (1.56 µ mol mmol^{-1})(Table 4). The maximum value of Ci (243.45 ppm) was recorded in unfertilized treatment (T1) and lowest (187.53ppm) in T5**(**Table 5). Among the seasons, Ci was lowest in summer (132.03 ppm) and highest in rain (297.37 ppm). The volumetric water content of both top and sub-soils decreased gradually from winter and declined rapidly during summer (Fig. 2). The maximum value of P_N (12.45 µ mol $m^{-2}s^{-1}$) was recorded up to a VPD of 2.4 kPa (T5); thereafter Pn declined slowly. In the present study, reduction in g_s with higher VPD values was observed. Similar finding has been reported in tea ([20]. Chl content was greater in fertilized plots than unfertilized control (T1). Chl was recorded highest during rain and lowest in summer (moisture stress period) in all treatments (Fig. 3). T5 showed maximum Chl and T1 recorded lowest. A positive correlation between Chl content and P_N existed in the present study (Fig. 5) which is in conformity with the findings of [17] and [13]. The chlorophyll is the most important plant pigment playing a vital role in determining the photosynthetic efficiency and productivity of the plant. The Chl content in leaves vary with the day length, irradiance and radiation quality, temperature and nutrient status of the soil. In the present study, totalChl content was highest during Rain and lowest in summer (moisture stress period) (Figure3). Decline in Chl due to water stress has also been reported in tea [16].

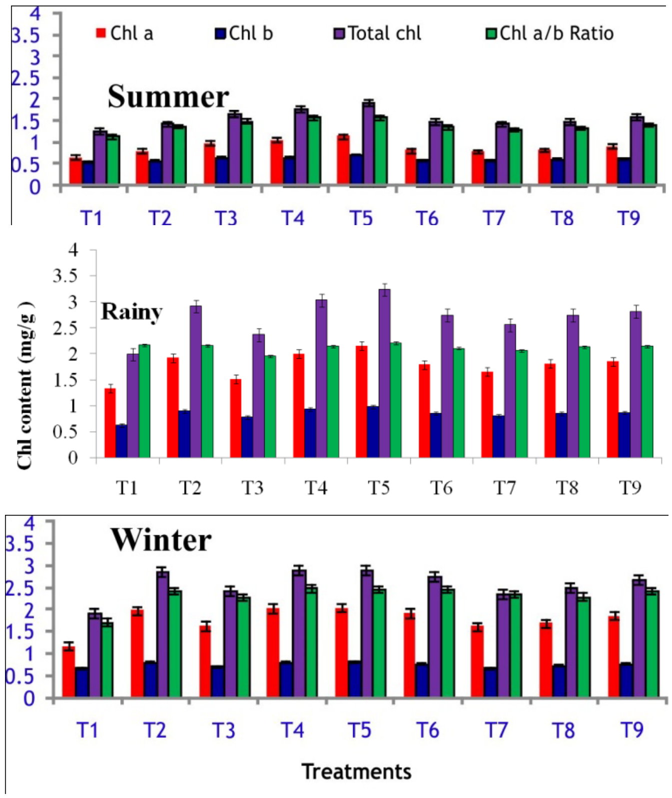


Fig. 3: Influence of fertilization on chlorophyll content (Chl -mg/g fresh wt. of green leaf) during the year 2011 to 2013 (Mean value of three years). Vertical bars indicate standard error of means

3.2 Photosynthesis and yield

The highest mean annual yield was 670.18 kg ha-1 recorded in T5 which showed an increase of 45.70 percent by applying with application of VC 50% (@ 2.75 tones+CF 50% (45: 22.5: 45 kg-ha basal through Urea, RP and MOP over the control T1 (459.92 kg ha-1. There were no significant differences in yield in T7 (589.97 kg ha-1) and T8 (601.87 kg ha-1) but these were higher than T3 (571.54 kg ha-1) and T2 (575.75 kg ha-1) (Fig. 4). The three year's yield trend of an experiment on the efficacy of split and basal application of organic, inorganic and combined fertilizers in the optimization of tea yield conducted in Darjeeling hills revealed that Combinedorganic and inorganic fertilizers dose (during April/May) of VC 50% (@ 2.75 tones+CF 50% (45: 22.5: 45 kg-ha gives highest return (Fig. 4).

There were also differences in the distribution of seasonal yield. Highest yield and PN in all treatments were recorded in rains. Moderate yield was recorded in April despite low soil moisture and a high rate of evaporation from the soil surface, but high air temperature, high sunshine hours and day length (more than 12 h) occurred in April. No yield was recorded during winter and moisture-stress period from second week of November until end of March. The day length of Kurseong was observed below 11 h during November and December and then gradually increased till August (13 h) [11].

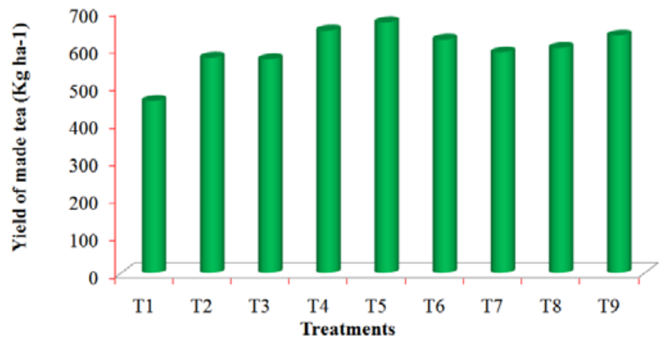


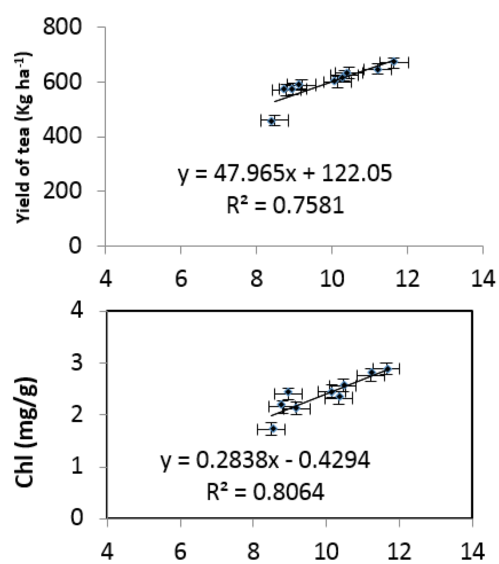
Fig. 4: Influence of fertilization on the yield of made tea during the year 2011 to 2013 (Mean of three years). Se=15.41, CD at 5%=46.74.

The seasonal yield distribution varies primarily as a result of seasonal changes in temperature and the development of soil moisture stress during the dry season. Kericho in Kenya has the most even yield distribution with only a relatively small drop in production during dry season. By contrast Mufindi, Tanzania and Mulanje, Malawi showed marked seasonal variations in yield distribution. In Mulanje for instance, about 80 % of the annual yield from non-irrigated tea may be harvested during the five months from December to April (water surplus period) [6]. However, in Darjeeling 50 % of the annual crop is produced in the wet season (June to August). A proportion of the carbon fixed by photosynthesis is used in maintenance respiration, and the remainder is then available for partitioning into shoot or root growth or into storage reserves [18]. The highest yield was obtained in rains and PN was also high. There is a positive correlation observed between PN and yield (Fig. 5). The temperature, relative humidity and soil moisture were high during June to August. Relative air humidity of 80–90 % is favorable for growth of tea plant but shoot growth is inhibited and adversely affected if it is below 50 % and 40 % respectively [12]. The concept of increasing crop productivity by use of nutrients seems to have reached a plateau but improvement in photosynthetic performance seems to have considerable scope of improving crop yield [7]. It was reported that the photosynthetic basis for increasing harvested yield involves light interception and conversion by foliage into photosynthetic products and then the partitioning of photo assimilates to the harvested economic sinks [9].

Continued use of organic fertilizers results in increased soil organic matter, reduced erosion, better water infiltration and aeration, higher soil biological activity as the materials decompose in soil, and increased yields after the year of application (residual effects). Proper handling of organic fertilizers enhances their quality and effectiveness. For example, with the exception of green manures, there is significant crop response if organic fertilizers are combined with N-based mineral fertilizers or other N-rich organic minerals. Mineral fertilizers on the other hand immediately supply nutrients needed by crops. Basal fertilizers contain elements required for good crop establishment and early growth while top-dressing can be done through split applications depending on visible hunger signs and/or moisture availability. In risky environments, spot application of small amounts of N fertilizers improves fertilizer effectiveness. The best response to fertilizer use is obtained if the soil has a high inherent fertility level (high organic matter status). Building inherent fertility requires practices such as retaining crop residues on the field.

4. CONCLUSION

The results indicate that the highest P_N recorded was in the T5 treatment which gives 45.71 percent higher production of made tea over unfertilized control. Combination of Vermicompost and Chemical fertilizers in treatment T5 (VC 50%+CF 50%) were found to be the best combination observed for the increase in leaf chlorophyll content, photosynthetic activities and ultimate yield of young tea plant as compared to other treatments. Significant differences were observed for various parameters studied irrespective of treatments at 5% level of significant. Combined application of organic and inorganic proved to be superior might be due to growth promoting effect of organic sources of nutrients.



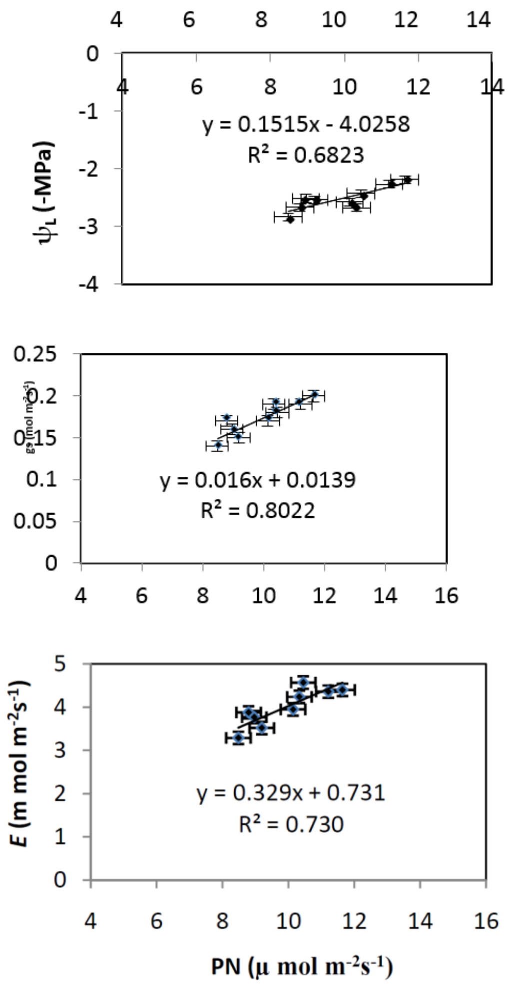


Fig. 5: Relation between photosynthis (PN) and Transpiration (E); PN and gs; PN and ψL; PN and Chl content; PN and made tea yield. Vertical bars indicate standard error of means.

5. ACKNOWLEDGEMENTS

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REFERENCES

[1] Anonymous "Tea Encyclopaedia", Tea Research Association, Jorhat, Assam, India, Serial no. **K185**, 1–4(1988).

[2] Arnon, D. I., "Copper enzyme in isolated chloroplast",Polyphenol oxidase in Beta vulgaris; *Plant Physiol.,***24**: 115 (1949).

[3] Aoki, S., "Varietals differences and effects of nitrogen fertilization on decline of photosynthetic rate in over wintered tea leaves", *Japanese. J. crop Sci*., **56**: 252–256 (1987).

[4] Barbora, A.C.,"Gas exchange in tea (*Camellia sinensis* L.) under water stress",*Two and a Bud***41**: 19-24 (1994).

[5] Bisht, J.K. and Chandel, A. S.,"Effect of integrated nutrient management on leaf-area index, photosynthetic rate and agronomic and physiological efficiencies of soybean (*Glycine max*)",*I. J. Agron*., **36**: 129–132 (1991).

[6] Carr, M. K. V. and Stephens, W.,"Climate, weather and the yield of tea; in Tea: cultivation and consumption", (eds) K C Willson and M N Clifford (London, Chapman & Hall) pp. 97–135 (1992).

[7] Das, V. S. R. and Readdy, A. R., "Photosynthetic productivity in field crops–A Review", Pl.*Physiol. & Bichem*. 15(1): 1-17 (1988).

[8] Deshnukh, S. S., Chaudhari, V. S., Narkhede, S. D., Jadhav, R. N and Attarde, S. B.,"Effect of three different composts on the growth rate of Wheat (Triticum aestivum)", International *Journal of Plant Sciences*, 6(1): 22-26 (2010).

[9] Gifford, R. M., Thorne, J. H., Hitz, W. D. and Giaquinta, R. T.,"Light interception and conversion",*Science* 225: 801 (1984).

[10] Ghosh Hajra, N and Kumar, R.,"Seasonal variation in photosynthesis and productivity of young tea", *Expl. Agric.,***35**: 71–85 (1999).

[11] Ghosh Hajra, N and Kumar, R., "Diurnal seasonal variation in gas exchange property of tea leaves", *J. Plant Biol.,***29**: 169–173 (2002).

[12] Huang, S.,"Meteorology of the tea plant in China: A review", *Agric. For Meteorol.,***47**: 19-30 (1989).

[13] Kumar, R. and Bera, B.,"Seasonal response of photosynthetic characteristics and productivity of young Darjeeling tea clone to organic and inorganic fertilization", *Journal of Crop and Weed*, 9(2):142-153 (2013).

[14] Natr, L., "Influence of mineral nutrition on photosynthesis of higher plants", Photosynthetica **6**: 80- 99 (1972).

[15] Natr, L., "Mineral nutrients: a ubiquitous factor for photosynthesis", *Photosynthetica*. **27 (3)**: 271-294 (1992).

[16] Rajasekar, R., Cox, S. and Satyanarayana, N., "Evaluation of certain morphological and physiological factors in tea (*Camellia sinensis*) cultivars under water stress", *J. Plant. Crops.,***18 (Suppl.)** : 83-89 (1991).

[17] Raj Kumar, R., Jayakumar, D and Marimuthu, S., "Relation between chlorophyll content and photosynthetic rate in tea",*UPASI Tea Res. Found Newsl***., 10**:2-3 (2000).

[18] Smith, B. G., Stephens, W Burgess, P. J. and Carr, M. K. V.,"Effects of light, temperature, irrigation and fertilizer on photosynthetic rate in tea (Camellia sinensis)", *Experimental Agriculture***29**: 291-306 (1993).

[19] Sanwal, S. K., Lakminarayana, K., Yadav, R. K., Rai, N., Yadav, D. S and Mousumi, B.,"Effect of organic manures on soil fertility, growth physiology, yield and quality of turmeric",Indian J. Hot., 64(4): 444-449 (2007).

[20] Squire, G. R. and Callender, B. A., "Tea plantations. In: T.T. Kozlowski (ed.), Water Deficits and Plant Growth", Vol. **6**: pp. 471-510. Academic Press, New York (1981).

[21] Yu, Z. J., Yang, X. C and Wei, C. L.,"The effect of N, P and K compound fertilizer on growth and yield of treetops of spring tea in tea garden", *Tea.* 23(4): 16-18 (1987).