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Effect of Farmyard Manure and Compost Application with Chemical Fertilizers on Yield and Quality of Tea (Camellia Sinences L)

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Abstract

A field study was conducted to determine the effect of farm yard manure (FYM) and compost application with different levels of chemical fertilizers on the yield and quality of tea (Camellia sinences L) at National Tea and High Value Crop Research Institute (NTHRI) Shinkiari, Mansehra during 2017.The experiment was laid out in randomized complete block design (RCBD) with three replications. There were twelve treatments in plots measuring 2×4 m each. The treatments included control, compost and FYM@ 10 t ha^{-1}alone and in combination with different levels of chemical fertilizers. Composite soil samples at depths of 0-15, 15-30 and 30-45 cm were collected before fertilizers application. Top three fresh growing tea leaves with a bud were plucked four times during the experiment with 40 days interval and tea yield was recorded from the leaves fresh and dry weight. Tea quality parameters, poly phenol, amino acid and water extract were determined. The leaves samples for N, P and K concentrations were analyzed. Soil samples were also collected after plucking for determination of N, P and K contents. Results showed that fresh and dry tea yield increased significantly by compost application and FYM with inorganic fertilizers. Maximum fresh and dry tea yield of 491.6 and 327.4 kg ha^{-1} with 60 and 65 %increase over control were produced by the application of compost with 300, 67.5 and 45 kg ha^{-1} N, P and K, correspondingly fallowed by the yield of 458.3 and 275.1 kg ha^{-1} along with 45 and 50 % raise over control observed by the compost treatment applied with 200, 45 and 30 kg ha^{-1} N, P and K, respectively. Compost and FYM application with chemical fertilizers improved the tea quality parameters poly phenol and water extract and decreased amino acid. Tea leaves concentrations of N, P and K improved significantly with the application of compost and FYM with chemical fertilizers. Higher concentration of post plucking soil total N and AB-DTPA extractable P and K contents were recorded by the addition of FYM and compost with chemical fertilizers. Results suggest that compost and FYM application with chemical fertilizers have potential to improve tea yield and quality. Compost proved better and economical than FYM under the prevailing conditions.

Keywords: chemical fertilizer; farmyard manur; tea

Introduction:

Tea (Camellia SinensisL.) is the product of plant and is used as medicine and common beverages in almost all over the world. It is cheap and has very beneficial effects. It is a woody shrub, which is dicotyledonous, cross pollinated and evergreen plant belongs to the family Theaceae. Tea was originated in China and its regular drinking began there in 6^{th} century. It is grown in varying agro-ecological conditions across the world. Sri Lanka, kenya, India, Japan, Bangladesh, Indonesia, Uganda, Malawi, China, Java and Sumatra are the tea producing countries. Tea plant can be grown as a tree or shrub. Tea is prepared from the small tender of the bush leaves and buds. It is found in far north as Georgia (42° N latitude) to far south as Brazil (30° S latitude) at an altitude ranging from sea level in Japan to more than 2000 meter in Kenya.

According to current statistic, the calculated amount of world tea production reaches to 2.8 million tons per year, 70% black tea and 30% green tea and on average 3 billion cups of tea is drinking every day. Pakistan imports 1,50,000 m of tons at the cost of Rs. 10 billion for tea, the per capita consumption is one kilogram [1]. Tea cultivation in Pakistan was started in 1958 for the first time at Baffa village (District Mansehra) in the supervision of Pakistan Tea Board. These hard works were not become fruitful due to certain political reasons. Agriculture Development Corporation was also failed second time in 1964 due to unfavorable soil and climatic condition at Rawalpindi. After that, Pakistan Agriculture Research Council (PARC) Islamabad had taken a project in order to find out systematic studies on tea in 1976-77. The PARC invited Chinese experts to survey and identify the potential tea growing area of NWFP now Khyber Pakhtunkhwa. The expert surveyed area and given the feasibility report on tea cultivation in Pakistan.

The experts of China visited growing areas of tea and written an effective report on economic possibility and cultivation in Pakistan for tea. Upon the recommendation of survey, National Tea Research Istitute (NTRI) started at Shinkiari District Mansehra in 1986 with the technical assistance of Peoples Republic of China on 50 acres of land. A tea processing unit and well equipped laboratory of soil have been established. A tea garden on 30 acres land with Chinese type has been prepared with a better infrastructure on 12 acres of area for tea nursery.

Rainfall and temperature is the most important factors affecting tea yields. The range of annual rainfall ranges should be 1000 to 1500 mm with 60% humidity for good yield of tea. The range of temperature for tea plant is 12 to 30°C. For good yield it should not less than 12°C and should not exceed than 30°C. Tea requires acidic soil, specifically the soil which has the pH range from 4.5 to 6.5. Tea cannot be grown in alkaline soils. Loam, well drained, porous friable, deep and acidic soil having humus is most suitable for tea plant.

No soil in the world can meet all the requirement of the nutrient but they are fulfilled by the application of fertilizers. A productive soil should contain sufficient amount of nutrients in an available form for plant uptake. Organic food grown in a quickly growing industry and the concern over the residues of pesticide in food and the environment has increased organic food demand. Foods that are grown organically had better quality, more nutritious and healthier than conventional counterparts [2]. Organic fertilizers such as farmyard manure and compost are found to contain nitrogen especially in inorganic form [3] and can provide nutrients instantly to the plants like the chemical fertilizers. The investigations aim was to evaluate the tea productivity with organic fertilizers comparing with chemical fertilizing.

Several research studies have been conducted on the effect on soil nutrient status by enriched cattle manure, nitrogen uptake and tea yield. Integrated Soil Fertility Management (ISFM) recommended the combine use of inorganic and organic fertilizer to improve soil health and crop yield. Organic manure and enriched manure up to the rate of 150 kg N ha^{-1} increase mature leaf quality. A higher N, P and K levels were observed in the mature leaf when high rate of NPKS were applied. The application of organic manure and enriched manures showed higher P and K contents throughout the soil depths by NPKS treatment. Inorganic fertilizers with enriching organic manures increased yield of the tea. [4].

Keeping the important role of incorporated use of organic and inorganic nutrient, this study was conducted to determine the effect of farmyard manure and compost with different chemical fertilizers levels on the quality and yield of tea.

Objects and Methods:

A field research was conducted to determine the cause of farmyard manure and compost application with different levels of N, P and K fertilizers. The experiment was conducted at National Tea and High value crop Research Institute (NTHRI) Shinkiari, Mansehra during 2017. Three years old tea bushes were pruned in early February. The experiment was laid out in Randomize Complete Block Design (RCBD) with three replications. The row to row distance of plants was 1 m and the size of each sub plot was 2x4 m. There were 12 treatments in experiment and the treatments combinations were as follows:

$T_{1.}$ Control (No fertilizers)
$T_{2.}$ Farmyard manure (FYM) @ 10 t ha^{-1}
$T_{3.}$ Compost @ 10 t ha^{-1}
$T_{4.}$ N, P and K @ 100-22.5-15 kg ha^{-1} respectively (F-I)
$T_{5.}$ N, P and K @ 200-45-30 kg ha^{-1} respectively (F-II)
$T_{6.}$ N, P and K @ 300-67.5-45 kg ha^{-1} respectively (F-III)
$T_{7.}$ FYM + F-I
$T_{8.}$ FYM + F-II
$T_{9.}$ FYM + F-III
$T_{10.}$ Compost + F-I
$T_{11.}$ Compost + F-II
$T_{12.}$ Compost + F-III

Nutrients nitrogen, phosphorus and potassium were applied in the shape of urea, single supper phosphate (SSP), sulfate of potassium (SOP), FYM and compost prepared from tea leaves. All Farmyard manure, Compost, P and K fertilizers were applied in the month of March, while N fertilizer will be applied in three splits form before plucking. Farmyard manure and compost were analyzed for their N and P contents before use. The following parameters were recorded during this study.

Tea yield:

Top three fresh growing tea leaves were plucked four times during this experiment with 40 days interval and tea fresh weight was recorded. The fresh tea leaves were air dried upto constant weight and their dry weight was noted.

Tea quality:

The following tea quality parameters ware recorded during this study.

Total poly phenols:

Total poly phenol in the tea sample was determined by the method as described by [5]. For the determination of poly phenol, 3g ground tea sample was taken in the beaker and added 450 mL boiling distilled water to it. Beaker was placed into the boiling water for 45 minutes and shaken them once after every 10 minutes. Tea liquor was filtered by absorbent cotton and washed the filtered residues with boiling water. Then integrated the liquor into 500 mL volumetric flask and diluted the flask with distilled water upto 500mL.From this tea liquor, 1 mL with pipette was taken and putt into a volumetric flask of 250 mL and added 4 mL

distill water and 5 mL solution of iron tartrate. Dilute the suspension upto 250 mL with solution as buffer and gently and carefully shaken. The optical density at 450nm was noted with the help of spectrophotometer with 10mm colorimetric cup.

Tea poly phenol content (%) $= \frac{E \times 3.913}{1000} X \frac{L1}{L2 \times M \times Mr} X\ 100$

L_1: tea liquor total volume, L_2: tea liquor pipetted volume

M: the mass of tea sample, Mr: the net mass of tea sample excluding moisture. **Amino acid**

For the determination of Amino acid, 3 g ground tea sample was taken in the beaker and added 450 mL boiling distilled water into it. Placed the beaker into the boiling water for 45 minutes and shaken them once after every 10 minutes. Filtered the tea liquor by absorbent cotton and washed the filtered residues with boiling water, then integrated the liquor into the 500 mL volumetric flask, and diluted the flask with distilled water to 500mL.From this tea liquor, 1 Ml was taken with pipette and putt into a 250 mL volumetric flask, and added 0.5ml of pH 8.0 buffer solutions and 0.5 mL of 2% ninhydrin solution to the volumetric flask. Heated it for 15minutes in boiling water and cooled to room temperature and then diluted to 25 mL with distilled water. The optical density E of the solution at 570nm was noted by spectrophotometer with 5mm colorimetric cup, using distilled water as a blank reference [5].

Amino acid (%) $= \frac{N \times \frac{L1}{L2} \times 1/1000}{M \times Mr} X\ 100$

N: amino acid reading, L_1: tea liquor total volume, L_2: tea liquor pipetted volume M: mass of tea samples, Mr: net mass of tea sample excluding moisture content

Water extract:

For the determination of water extract, 3g ground tea sample was taken in the beaker and added 450 mL boiling distilled water into it. Placed the beaker into the boiling water for 45 minutes and shaken them once after every 10 minutes. Filtered the tea liquor by absorbent cotton and washed the filtered residues with boiling water. Integrated the liquor into the 500 mL volumetric flask and diluted the flask with distilled water to 500mL. Volume of 50ml of the tea liquor was taken with pipette and infused into the known weight evaporation pan, then evaporated the tea liquor in boiling water until the liquor was almost dried. Put the pan into the electric drying oven with the temperature of 103 ^{0}C for 2 hours. Transferred the material into the desiccators to cool to room temperature, weighted and final reading was noted [5].

Water extracted substance (%) $= \frac{M1-M0}{M} X \frac{500}{50} X100$

M_0: weight of evaporation pan, M_1: weight of evaporation pan and extracted substances M_2: the weight of tea sample

Soil analysis:

Prior to the use of fertilizers took composite soil sample and did analysis for following characteristics (properties).

Soil texture:

In dispersion cups 20g air dried soil sample and distilled water was taken. Then 10 mL 1 N Na_2Co_3 was mixed to it. For 5-10 minutes these cups were stirred with stirrer, then transferred this suspension to another thousand mL cylinder. First reading was taken at span of 40 seconds and another after 2 hours on hydrometer. These readings were then compared with textural triangle [6] to evaluate soil texture.

Soil pH:

In a conical flask soil water suspension (1:5) was made ready by ten grams soil sample and fifty mL distilled water. For 30 seconds the suspension was shaken by mechanical shaker. Throughout this process pH meter and room temperature were kept under standard conditions. pH was calculated with the help of pH meter [7].

Soil organic matter content:

In order to find soil organic matter content, one gram sample of soil is mixed with potassium dichromate upto ten mL and twenty mL concentrated sulphuric acid. To complete reaction by keeping it for 30 minutes. Then added 200 mL of distilled water. After filtration added ortho phenophthaline (two- three drops) in suspension and titration was done against 0.5 N $Fe_2SO_4.7H_2O$ until the dark brown color appeared [8]. The soil OM content was calculated as follow:

$$\text{Organic matter (\%)} = \frac{(\text{ml of } K_2Cr_2O_7 \times N).(\text{ml of } Fe_2SO_4.7H_2O \times N)}{\text{weight of soil (g)}} \times 0.69$$

Soil total nitrogen content:

In order to find and evaluate total nitrogen content of soil Kjeldhal method was used [9]. In this method 2-gram soil sample was taken in a digestion tube and then 1.1 g digestion mixture was added to it. Distilled water was added upto (2-3 mL) go after by 3 mL addition of concentrated H_2SO_4. The digestion tube was then placed for the time of 3-4 hours in a digestion block at 350^{o}C for digestion process. As greenish color appeared the digestion process was stopped. Then took out digestion tube from the digestion block and keep in open air for some time for cooling down. To make solution diluted 100 mL distilled water was added.

In process of distillation in a distillation flask a twenty mL sample was taken. Then 4 mL 40 percent NaOH was poured in the sample. In presence of mix indicator of boric acid, it was distilled till it touched to 65 mL volume. Then titrated distillate of this 65 mL volume against 0.005 N HCL for analysis of total nitrogen. 20 mL distilled water in blank sample having as a substitute of soil sample was run. Total nitrogen of soil was measured using the formula:

$$\text{Total Nitrogen (\%)} = \frac{(\text{Sample-Blank}) \times 0.005 \times 0.014 \times 100 \times 100}{\text{weight of soil}} \times 20$$

Extractable phosphorus and potassium:

Determined Extractable P and K in soil using the technique as illustrate by [10]. Shaken 10 g of soil sample with 20 mL of AB-DTPA extract in an open flask for 15 min through electric shaker. Once shaken, the suspension was filtered through wahtman-42 filter paper and noted P content in soil by using spectrophotometer and K by using Flame photometer.

Leaves analysis:

The analysis of plucked leaves samples of tea was made by wet digestion method from each treatment for N, P and K concentrations as follow;

Leaves nitrogen concentration:

Used [9] method to determine N concentration of plant. Took half

gram leaves ground sample in digestion tube. Then 2 g of digestion mixture and 10 mL of strong H_2SO_4 were added. For digestion purpose the tube was shifted under flame hood of digestion block and kept there until blue green colored smoke appeared. Then 20 mL of distil water and 40 mL of NaOH was poured to the mixture and started spontaneous steam. In flask ammonia is produced and was collected as in the form of NH_4OH consisting 20 mL of 4 percent boric acid solution with some drops of adopted methyl red indicator, distillation be persistence at least for 3-4 minutes. Then titration of distillate was made against 0.1 N HCL. Appearance of Pink color was the indication of end point of the process and % N was measured.

Leaves phosphorus and potassium concentrations:

By using [11] procedure Phosphorus and potassium content in leaves was determined. In 50 mL conical flask took 0.5 g of sample and 10 mL of per-chloric acid and HNO_3 (1:5) were added. Heated continuously sample from in heater having temperature of 100 to 350 ºC till the white color fume appeared in flask. After taking out from heater and cooling, diluted the mixture with fifty mL distillated water. Then took 5 mL solution with A and B mixture was in addition and again diluted to 50 mL. Sample was then run for readings of P with the help spectrophotometer and for K on flame photometer.

Economic analysis of applied fertilizers:

Calculated the net return and value cost ratio of the applied organic and inorganic fertilizers by formula as follows;

$$\text{Net Return} = \text{Value of incresed yield} - \text{Cost of fertilizer}$$

$$\text{Value Cost Ratio} = \text{Value of incresed yield}/\text{Cost of fertilizer}$$

Statistical analysis:

The data recorded on different soil and tea leaves parameters were statistically analyzed with analysis of variance technique. Means were compared by using LSD test at 0.05 level of probability when the F-values were significance (Jan et al., 2009).

Results and Discussion:

The results of field experiment on the effect of farmyard manure and tea leaves compost application with different chemical fertilizers on the quality and yield of tea are presented in the following table. Table 1 shows the pre-experimental physico-chemical properties of the soil under investigation.

Property	Unit	0-15	15-30	30-45
		---------- (cm) ----------		
Silt	(%)	40	42	49
Sand	//	42	38	32
Clay	//	18	20	19
Textural class	------	Loam	Loam	Loam
pH	------	5.1	5.2	5.4
Organic matter	(%)	1.3	1.1	1.1
N	//	0.1	0.09	0.07
P	(mg kg^{-1})	5.2	4.5	4.0
K	//	200	158	145

Table 1: Soil physico-chemical properties of tea garden before fertilizers application.

Data in Table 1 show that the soil of the experimental site was loam in texture and acidic in reaction. Total soil nitrogen content of the area under tea garden was 0.1%, 0.09% and 0.07% and DTPA extractable P content as 5.2, 4.5 and 4.0 mg kg^{-1} at 0-15cm, 15-30cm and 30-45cm depths respectively.

The organic fertilizers such as farmyard manure and compost were analyzed for their N and P contents, and the data are presented in Table 2.

S. No	Organic fertilizer	Total Nitrogen	Extractable Phosphorus
		---------- (%) ----------	
1	Compost (prepared from tea leaves)	0.9	0.3
2	Farmyard manure	0.6	0.18

Table 2: Analysis of Farmyard manure and Compost under use.

Total N contents in FYM and compost were 0.6 and 0.9% and extractable P was 0.3 and 0.18% respectively (Table 2).

Tea yield:

Top three fresh growing tea leaves with a bud were plucked four times during this experiment with 40 days interval and tea yield was recorded from the leaf fresh and dry weight. Data regarding fresh and dry tea yield as influenced by compost and FYM applied with different levels of chemical fertilizers are presented in Table 3.

Treatments	Fresh tea	Dry tea
	----------yield (kgha^{-1}) ---------	
Control (No fertilizer)	306.7 g *	188.2 i*
Farmyard manure (FYM) @ 10 t ha^{-1}	348.3 f	206.3 h
Compost @ 10 t ha^{-1}	358.3 ef	216.4 g
N, P & K @ 100-22.5-15 kg ha^{-1} (F-I)	371.7 def	220.5 g
N, P & K @ 200-45-30 kg ha^{-1} (F-II)	381.7 cdef	239.5 e
N, P & K @ 300-67.5-45 kg ha^{-1} (F-III)	396.7 cd	242.3 e
FYM + F-I	376.7 cdef	227.2 f
FYM + F-II	388.3 cde	250.1 d
FYM + F-III	413.3 bc	267.3 c
Compost + F-I	405.0 cd	268.2 c
Compost + F-II	458.3 a	275.1 a
Compost + F-III	491.6 a	327.4 a
LSD (0.05)	37.53	4.59

Table 3: Tea yield as affected by farmyard manure and compost applied with different levels of chemical fertilizers

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*Means with different letter(s) in columns are significantly different at $P \leq 0.05$

Data indicated that the addition of FYM and compost applied with chemical fertilizers improved the tea yield significantly. Maximum fresh tea yield of 491.6 kg ha^{-1}with increase of 60% over control (Fig. 1) was recorded by the application of compost with N, P and K @ 300-67.5-45 kg ha^{-1} (F-III), respectively which was statistically similar with compost applied with N, P and K @ 200-45-30 kg ha^{-1}(F-II) with the yield of 458.3kg ha^{-1}with increase of 45% (Fig. 2). Minimum tea yield of 306.7 kg ha^{-1} was noted in control (Table 3). Dry yield of tea was maximum as 327.4

kg ha^{-1} in the treatment of 300-67.5-45 kg ha^{-1} with increase of 65% N, P and K, respectively applied with compost (Table 3) followed by the treatment of 200-45-30 kg ha^{-1} N, P and K applied with compost as 275.1 kg ha^{-1} with increase of 55% over control (Fig. 2). Same findings were reported by [5] that the tea yield improved significantly by the increment of chemical fertilizers.

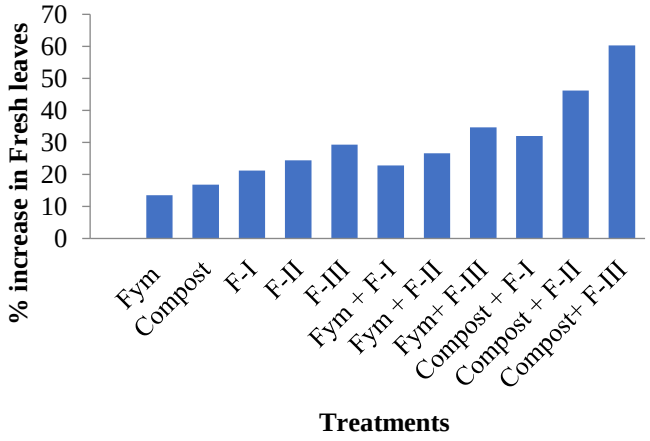

Figure 1: % increase in fresh leaves over control as affected by FYM and compost with fertilizer

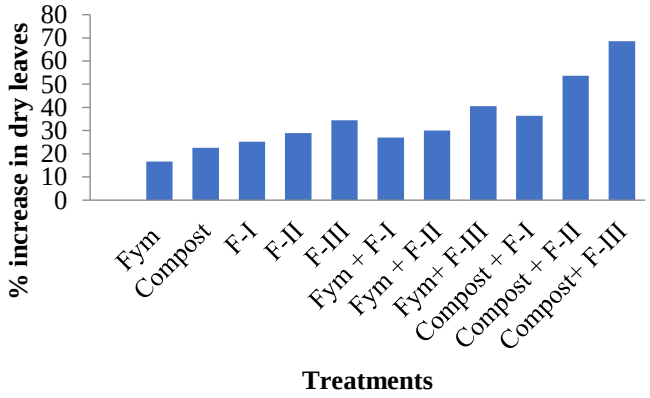

Figure 2: % increase in dry leaves over control as affected by FYM and compost with chemical fertilizer

Tea quality:

Tea quality parameters poly phenol, amino acid and water extract were determined and compared with standard values as given in Table 4.

S. No	Parameters	Unit	Ranges
1	Poly phenol	(%)	5 – 15
2	Amino acid	//	0.5 – 5
3	Water extract	//	15 – 50

Table 4: Standard values of tea quality parameters.
Source: [5]

Poly phenol:

The poly phenol content in fresh leaves plucked from various treatments of compost and FYM applied with chemical fertilizers is presented in Table 5. Data revealed that the highest poly phenol content of 9.48% was found by compost applied with maximum level of chemical fertilizer (F-III) which was statistically similar with compost applied with recommended level of chemical fertilizer (F-II) as 9.1%. This observation suggests that compost with recommended level of chemical fertilizer (F-II) is beneficial and economical for improving the quality of tea.

Amino acid:

Amino acid content in fresh leaves plucked from various treatments of compost and FYM applied with chemical fertilizers is presented in Table 5. Data revealed that the highest amino acid content of 2.4% was found in control (No fertilizer) and minimum amino acid were recorded by compost applied with maximum level of chemical fertilizer (F-III) as 0.83% which was statistically similar with compost applied with recommended level of chemical fertilizer (F-II) as 0.85%.

Water extract:

Highest water extract in the tea leaves of 49 % was noted in treatment of the application of compost with N, P and K @ 300, 67.5, 45 kg ha^{-1} (F-III) which was statistically at par with compost applied with F-II levels of chemical fertilizers as 47.1 % (Table 5)

Treatments	Poly phenol	Amino acid	Water extract
	---------- (%) ----------		
Control (No fertilizer)	5.96 g*	2.40 a*	37.33 h*
Farmyard manure (FYM) @ 10 t ha^{-1}	6.20 g	1.32 bc	40.00 fg
Compost @ 10 t ha^{-1}	6.24 g	1.35 b	39.33 g
N, P & K @ 100-22.5-15 kg ha^{-1}(F-I)	6.81 f	1.29 bc	41.00 efg
N, P & K @ 200-45-30 kg ha^{-1} (F-II)	7.41 e	1.15 bcd	42.00 de
N, P & K @ 300-67.5-45 kg ha^{-1} (F-III)	7.83 d	1.18 bcd	41.33 ef
FYM + F-I	8.21 c	1.15 bcd	43.67 cd
FYM + F-II	8.39 bc	0.96 cd	45.33 bc
FYM + F-III	8.51 bc	0.87 d	47.00 b
Compost + F-I	8.47 bc	0.86 d	46.67 b
Compost + F-II	9.1 a	0.85 d	47.10 a
Compost + F-III	9.48 a	0.83 d	49.00 a
LSD (0.05)	0.34	0.39	1.90

Table 5: Effect of farmyard manure and compost applied with different levels of N, P and K on tea quality.

*Means with different letters in columns are significantly different at P ≤ 0.05

Data indicated that the addition of FYM and Compost applied with chemical fertilizers improved the tea quality. Best tea quality was recorded by the application of compost with maximum level of chemical fertilizer (F-III) which is statistically similar with compost applied with recommended level of chemical fertilizer

(F-II).

Similar results were reported by [5] that poly phenol content significantly increased up to certain level with the increase of nitrogen level but decreased with further increase of nitrogen. And enhanced the water extract substances while decreased the amino acid content with the increment of chemical fertilizers application.

Nutrients concentrations of tea leaves:

Tea leaves concentrations of N, P and K as affected by FYM and compost applied with different levels of chemical fertilizers are given in Table 6.

Treatments	Nitrogen	Phosphorus	Potassium
	---------- Concentration (%) ----------		
Control (No fertilizer)	2.20 f*	0.107 g*	1.53 g*
Farmyard manure (FYM) @ 10 t ha^{-1}	2.35 ef	0.110 fg	1.57 fg
Compost @ 10 t ha^{-1}	2.35 ef	0.107 g	1.57 gf
N, P & K @ 100-22.5-15 kg ha^{-1}(F-I)	2.34 ef	0.116 de	1.64 f
N, P & K @ 200-45-30 kg ha^{-1} (F-II)	2.39 de	0.121 cd	1.71 c
N, P & K @ 300-67.5-45 kg ha^{-1} (F-III)	2.48 cde	0.127 ab	1.77 ab
FYM + F-I	2.49 cde	0.108 g	1.58 f
FYM + F-II	2.55 cd	0.109 fg	1.59 ef
FYM + F-III	2.73 ab	0.122 bc	1.72 bc
Compost + F-I	2.61 bc	0.110 efg	1.60 ef
Compost + F-II	2.77 ab	0.114 ef	1.64 de
Compost + F-III	2.85 a	0.128 a	1.88a
LSD (0.05)	0.18	0.01	0.11

Table 6: Tea leaves N, P and K concentration as affected by farmyard manure and compost applied with different levels of chemical fertilizers.

*Means with different letter(s) in columns are significantly different at $P \leq 0.05$

Data indicated that N, P and K concentrations of tea leaves are significantly affected by the treatment of compost applied with different levels of chemical fertilizers. Maximum N, P and K as 2.85, 0.128 and 1.18% with 35%, 40% and 38% (Fig. 3, 4 and 5) increases over control were recorded by the application of compost with 300, 67.5 and 45 kg ha^{-1} N, P and K, respectively. This data was followed by 2.77% N, 0.114% P and 1.64% K with 30%, 35% and 33% increases over control (Fig. 3, 4 and 5) recorded by the treatment of compost applied with 200, 45 and 30 kg ha-^{1} N, P and K , respectively. There was no significant difference between these two treatments. Minimum N, P and K concentrations of 2.20, 0.107 and 1.53 % were recorded in control. Our results are also in support of [12] who reported that N, P and K concentrations of tea leaves are positively affected by chemical fertilizers.

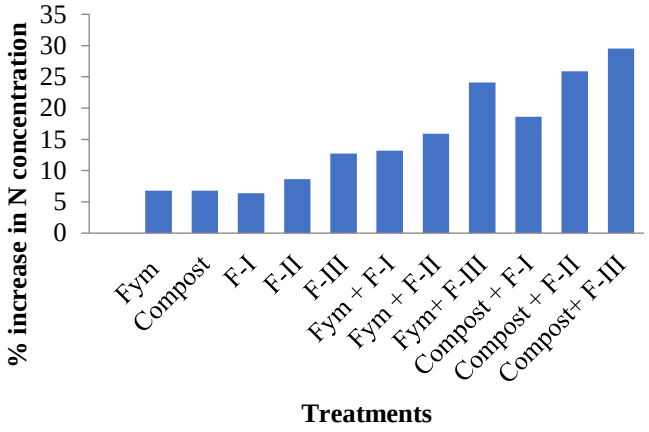

Figure 3: % increase in leaves N concentration over control as affected by FYM and compost with NPK.

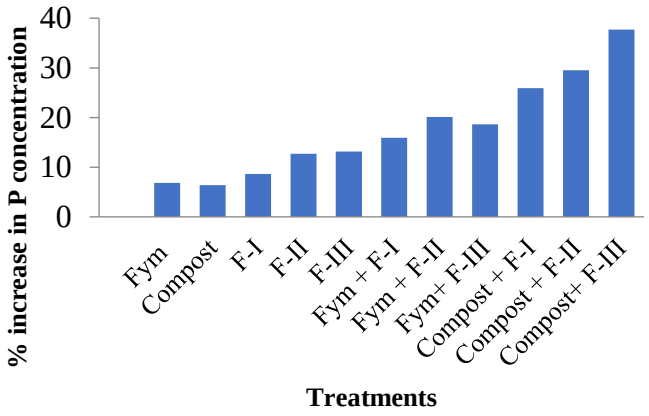

Figure 4: % increase in leaves P concentration over control as affected by FYM and compost with NPK.

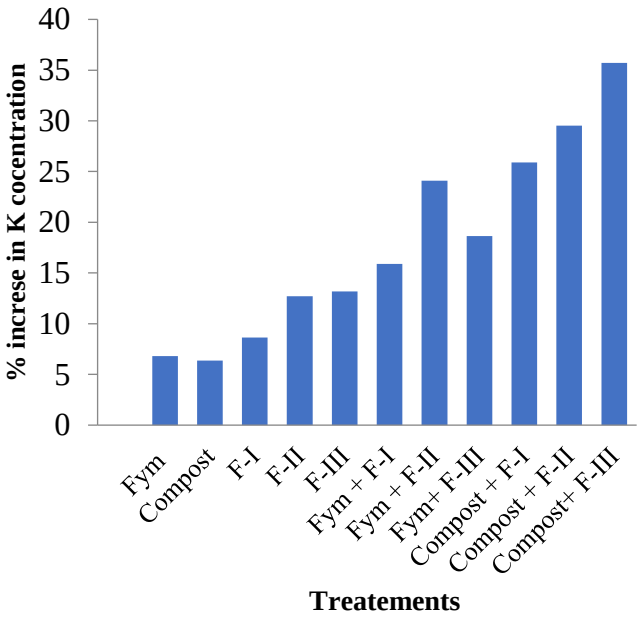

Figure 5: % increase in leaves K concentration over control as affected by FYM and compost with NPK.

Post plucking soil nutrient content:

Post plucking data of soil total N, AB-DTPA extractable phosphorus and K contents as influenced by compost and FYM application with different levels of fertilizers N, P and K respectively are shown in Table 7.

Treatments	Nitrogen	Phosphorus	Potassium
	----------Contents (mgkg^{-1}) ----------		
Control (No fertilizer)	967 j*	5.2 f*	99 j*
Farmyard manure (FYM) @ 10 t ha-1	1200 i	5.4 ef	114 i
Compost @ 10 t ha^{-1}	1400 h	5.5 cde	114 i
N, P & K @ 100-22.5-15 kg ha^{-1} (F-I)	2267 f	5.5 cde	120 fg
N, P & K @ 200-45-30 kg ha^{-1} (F-II)	2500 de	5.6 abcde	124 f
N, P & K @ 300-67.5-45 kg ha^{-1} (F-III)	3000 a	5.8 a	131 e
FYM + F-I	2467 e	5.7 abcd	114 i
FYM + F-II	2667 cd	5.7 abcd	119 gh
FYM + F-III	2800 bc	5.6 abcde	146 b
Compost + F-I	1900 g	5.4 def	141 c
Compost + F-II	2300 f	5.7 abc	157 a
Compost + F-III	2933 ab	5.8 a	136 d
LSD (0.05)	151	0.25	2.67

Table 7: Post plucking soil total N, AB-DTPA extractable P and K contents as affected by FYM and compost application with chemical fertilizers.

*Means with different leter(s) in columns are significantly different at $P \leq 0.05$

Table 7 shows post plucking soil total N, ABDTPA extractable P and K contents as affected by farmyard manure and compost applied with different levels of chemical fertilizers. Data indicated that N, P and K contents of soil are significantly affected. Highest soil total nitrogen content of 2933 mg kg^{-1}, AB-DTPA extractable P substance of 5.8 mg kg^{-1} and K content of 136 mg kg^{-1}were recorded by the treatment of compost application with maximum level of chemical fertilizer followed by the treatment of compost applied with recommended level of chemical fertilizers.

The main reason of low nitrogen content in soil may be due to leaching by high rainfall (Snow and Greene, 1935). Nitrogen is essential for the growth and development of all living tissue, promote branching, enlargement of leaf surface and yield [5] Tea plants have high nitrogen demand as compare to other plants. There is no soil in the world is able to meet full needs of nitrogen, phosphorus and potassium for high yield. The nitrogen need of tea plant can be fulfilled by the application of nitrogenous fertilizers in organic and inorganic form.

Post plucking soil pH and organic matter:

Post plucking data of soil pH values and organic matter content as affected by the addition of compost and FYM with different levels of chemical fertilizers are shown in Table 8.

Treatments	Soil pH	SOM
	--------	(%)
Control (No fertilizer)	5.42	0.8
Farmyard manure (FYM) @ 10 t ha^{-1}	5.27	1.13
Compost @ 10 t ha^{-1}	5.25	1.17
N, P & K @ 100-22.5-15 kg ha^{-1} (F-I)	5.28	1.17
N, P & K @ 200-45-30 kg ha^{-1} (F-II)	5.35	1.20
N, P & K @ 300-67.5-45 kg ha^{-1} (F-III)	5.33	1.22
FYM + F-I	5.26	1.23
FYM + F-II	5.31	1.24
FYM + F-III	5.34	1.29
Compost + F-I	5.35	1.25
Compost + F-II	5.30	1.29
Compost + F-III	5.32	1.30

Table 8: Post plucking soil pH and OM contents as affected by farmyard manure and compost application with different levels of chemical fertilizers.

Data in Table 8 indicated that soil under investigation was acidic in reaction. Applications of compost and FYM with different level of chemical fertilizers affect soil pH slightly. The pH values of soil ranged from 5.2 to 5.42 and are suitable for the growth of tea plants.

Post plucking soil organic matter was improved non significantly by the application of FYM and compost with different levels of chemical fertilizer. Maximum post plucking soil organic matter content of 1.3 was recorded by the addition of compost with 300, 67.5 and 45 kg ha^{-1}N, P and K, respectively followed by the content of 1.29 % noted by compost application with F-II level of fertilizer (Table 8).

Economic analysis of fertilizer application:

Net return and value cost ratio (VCR) of the fertilizers applied were calculated and presented in Table 9.

Treatments	Yield	Yield Increase	Increased Yield value	Cost of fertilizers	Net * return	** VCR
	----- (Kg ha^{-1}) ---		---------- (Rs.ha^{-1}) ----------			
Control (No fertilizer)	306.67					
Farmyard manure (FYM) @ 10 t ha^{-1}	348.33	41.66	13331	2000	11331	6.6:1
Compost @ 10 t ha^{-1}	358.33	51.66	16531	4000	12531	4.1:1
N, P & K @ 100-22.5-15 kg ha^{-1} (F-I)	371.67	65.00	20800	5082	15718	4.0:1
N, P & K @ 200-45-30 kg ha^{-1} (F-II)	381.67	75.00	24000	10164	13836	2.3:1
N, P & K @ 300-67.5-45 kg ha^{-1}(F-III)	396.67	90.00	28800	15246	13524	1.8:1
FYM + F-I	376.67	70.00	22400	7082	15318	3.1:1
FYM + F-II	388.33	81.66	26131	12164	13967	2.1:1
FYM + F-III	413.33	106.66	34131	17246	16885	1.9:1

Compost + F-I	405.00	98.33	31465	9082	22383	3.4:1
Compost + F-II	458.33	151.66	48531	14164	34367	3.4:1
Compost + F-III	491.61	184.94	59180	19246	39934	3.0:1

Table 9: Economic analysis of fertilizer used in the experiment. Price of tea = Rs. 320 kg^{-1}, FYM = Rs 0.5 kg^{-1}, Compost = Rs. 4 kg^{-1}, SSP =Rs. 17 kg^{-1}, SOP = Rs. 80 kg^{-1}, and Urea = Rs. 35 kg^{-1}.

*Net Return = Value of increased yield – Cost of fertilizer**VCR = Value of increased yield /Cost of fertilizer

Table 9 shows the economic analysis of different fertilizers used. Compost application with chemical fertilizer proved better economical treatment than farmyard manure with maximum net return of Rs.34367 and VCR of 3.4:1. So tea leaves compost applications with chemical fertilizers are recommended for better tea yield under the prevailing conditions.

Conclusions:

Following conclusions are drawn from the outcome of the conducted study work.

- Fresh and dry tea yield increased significantly by the application of compost and farmyard manure with chemical fertilizers.
- Compost and farmyard manure application with chemical fertilizer improved the tea quality parameters poly phenol and water extract and decreased amino acid significantly.
- Tea leaves concentrations of N, P and K improved significantly with the application of compost and farmyard manure with chemical fertilizer.
- Significantly higher concentration of post tea plucking of total soil N and ABDTPA extractable P and K contents were recorded by the addition of farmyard manure and compost with chemical fertilizers.
- Post plucking soil pH and organic matter content were slightly affected by the addition of compost and farmyard manure with chemical fertilizers.

Compost appliScation with chemical fertilizers proved better economical treatment than farmyard manure with maximum net return of Rs.34367 and VCR of 3.4:1.

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