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Effect of Different Levels of Phosphorus on the Growth and Yield of Tea

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Abstract

To evaluate the role of variable doses of phosphorus on the growth and yield of tea (Camellia sinensis L., variety, Qi-Men), the present study was projected. The experiment was conducted during 2016-17 and repeated during 2017-18 at National Tea and High-value crops Research Institute, Shinkiari. Phosphorus was applied in six variable doses @ 0, 75, 112.5, 150, 187.5 and 225 kg ha^{-1} as Di-Ammonium Phosphate. Nitrogen and Potassium were applied as basal doses. Nitrogen was applied in the form of Urea @ 225 kg ha^{-1} while Potassium was applied as Sulphate of Potash @ 75 kg K_2O/ha. The full dose of phosphorus and Potassium was applied as basal dose while Nitrogen was applied in three split doses during March, July, September 2017& 2018. The experiment was laid out in Randomized Complete Block Design with 3 replications and six treatments. Plot size was kept as 2 rows 5 meter length and 1.2 meter width. Soil samples were collected before application of fertilizers for physico-chemical characteristics. All agronomic practices were kept uniform and plucking was done manually by keeping four leaves and a bud as standard. Results showed that the application of phosphorus significantly increased plant height, No .of leaves/plant, Leaf Length, No. of branches /plant. Tea was plucked 11 times each year and the total yield of each plot was obtained from the total harvest during 2016-17 & 2017-18. Maximum No. of branches/plant (9, 8), Plant Height (57, 55 cm), No. of Leaves (40, 41) and Leaf Length (17, 17 cm), Fresh leaves yield (5306, 3353 kg/ha), Made tea (1061, 671 Kg/ha) was obtained in treatment T_3 respectively when NPK was applied @ 225-150-175 while minimum Plant height (46, 40 cm), No. of leaves/plant (31, 29) Leaf length (12, 11 cm) and No. of branches (6, 5), Fresh leaves yield (3419, 2292 kg/ha), Made tea yield (684, 458 kg/ha) was obtained in control plot (without any fertilizer) during both the years respectively. It was concluded that:

1. *Phosphorus may be applied @ 225 kg ha^{-1} with combination of basal doses of nitrogen @ 245 kg/ha in three split doses and Potassium @ 75 kg K_2O/ha to obtain maximum possible yield of tea.*
2. *Further experiments on different combination of Phosphorus and other major elements like N and K are required for confirmation of results.*

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1. Introduction

Tea has its origin in Southern China, Burma and Assam of India. At present, tea is grown in many countries around the world from Georgia of the former Soviet Union (43°N latitude) to Corrientes (Argentina) (27°S latitude), the altitude varying from sea level to about 2300 m above sea level [1, 2]. Tea (*Camellia*

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sinensis L.) is an important commercial crop in many subtropical and tropical areas of the world. Tea is very popular among other beverages worldwide due to its favorable effects on human health [3].

Taking tea is an integral part of social life in Pakistan. The tea consumed in the country is imported making Pakistan the second largest importer after the United Kingdom. The consumption is increasing day by day mainly due to the rapid increase in population. Pakistan has a sizeable potential tea growing area that exist in different agro-ecological zones of northern highlands of Khyber Pakhtunkhwa. The climate of these areas appears appropriate for certain tea varieties of shrub-type which can tolerate cold and drought conditions. Successful cultivation of Chinese tea varieties at NTRI has demonstrated the potential of large scale tea production in the region.

It is a perennial plant, which repeatedly pruned at different intervals (3-6 years). Verma [4] reported that due to regular plucking of tea at 6-25 days interval, various elements are removed from the soil-plant system. Bonheure and Willson [5] Suggested applying certain major nutrients through various fertilizers. Barbora [6] Also revealed that its yield increases with increased levels of N and K to a certain point. Tea being a leaf crop, in the flush shoot the nitrogen content is the highest followed by potassium (K), calcium (Ca), phosphorus (P), sulphur (S), magnesium (Mg) and zinc (Zn). N promotes vegetative growth, improves shoot succulence, shoot size and leaf size, and lowers *banjhiness*, reduces flowering and fruit setting, governs utilization of phosphorus and potassium by the bush. It is also an essential constituent of plant substances viz., protein, chlorophyll, hormones, alkaloids and vitamins. It is estimated that harvestable crop contains 3.5-5% N on dry matter basis [4]. It was pointed out by Cloughly, et al. [7] that although applications of N can increase tea yields, the quality of the manufactured product is suppressed by large N rates. Zaman, et al. [1] in a study revealed that the nitrogenous level of 375 kg along with 125-75 P and K kg ha^{-1} increased fresh leaves yield significantly from (6796 to 8797 kg/ha), made tea yield (1352 to 1760 kg/ha) and shoot length (35 to 71 cm) over control.

Phosphorus is an important nutrient in tea nutrition together with nitrogen and potassium. Phosphorus stimulates root formation and growth, counteracts the effect of excess nitrogen, being a constituent of nucleic acid, it is closely concerned with the vital growth processes. It is also essential for synthesis of starch, protein and fat. Dewal and Pareek [8] noted that Phosphorus, subsequent to nitrogen is the second most commonly off-putting macronutrient for plant augmentation. Phosphorus is taken up by plants as both H_2PO_4 and HPO_4 ions. The phosphorus inorganic form is not taken up by the plant. Most of the inorganic P is tied in phosphate rocks and minerals whereas organic P can be received from the vestiges of animals and plants. The phosphorous in inorganic form is present in the soil in combination with Fe, Al, Ca, Mg and other elements. Barbora [9] noted that Phosphorus is a basic structural element of the membrane system of the cell, the mitochondria and chloroplast.

Several studies have recorded improvement of tea yields following phosphate fertilizers application [10-12]. Gogoi, et al. [13] stated that in North East India, that the yield benefits recorded when P_2O_5 was applied up to 50 kg ha^{-1} $year^{1}$, the effect being attributed to the ability of phosphorus to enhance uptake and translocation of nitrogen. However, the application of more than 50 kg P_2O_5 ha^{-1} $year^{-1}$ was not beneficial and did not increase yields. Rates of phosphorus fertilizers up to 50 kg P2O5 ha-l year -l improved black tea quality [6, 12] by enhancing the levels of major catchiness and caffeine in tea shoots, and theaflavins, thearubigins, brightness and total color in made tea. However, there are no additional quality benefits from the application of higher rates of phosphorus.. Better yield response to nitrogen is obtained when there is an adequate supply of phosphorus and potassium [14]. Thus the application of both phosphate [15] and potash fertilizers Pay. Potassium and magnesium are required in large quantities and they are both involved in almost all biological reactions. Potassium is the second major nutrient for tea after N and makes up 1.5-2% of the dry matter in tea leaves [4, 16, 17]. It is essential for frame development. It provides resistance against drought, frost, pest and diseases, has synergistic effect with nitrogen, acts as an accelerator of enzyme action. Wu Xun, et al. [17] revealed that Magnesium occupies up to 0.30% of the leaves dry matter in the fresh leaves. Potassium and magnesium deficiencies widely occur in the tea plantation regions mainly due to the higher precipitation and consequently higher leaching as well as the higher demands [4]; [17]. It was revealed Bonheure and Willson [5] that response of potassium occurs in lower soil pH. It occurs when soil pH is lower than 5.2. Potassium chloride application was recommended by Malakouti [18] for Iranian tea orchards for increasing of plants resistance to pests, diseases and drought and improving tea yield and quality. He also reported that potassium chloride in some soil when chloride concentration is lower than 150 mg/kg will be used.

Keeping in view the effect of phosphorus on the yield of tea, the present experiment was conducted to find out effect of Phosphorus along with basal doses of Nitrogen and Potassium on the yield of tea.

2. Material and Methods

This experiment was conducted during March, 2017 & 2018 with the objectives to find out the optimum doses & role of Phosphorus along with basal doses of Nitrogen and Potassium for maximum yield of tea. Phosphorus was applied in the form of Di-Ammonium Phosphate while Nitrogen and Potassium were applied in the form of Urea and Sulphate of Potash respectively. Full doses of phosphorus@ 75,112.5, 150, and 187.5 &

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245 kg/ha and Potassium @ 75 kg K_2O/ha were applied as basal dose during March, 2016-2017 and 2017-18 while Nitrogen@ 245 kg/ha was applied in three split doses in March, July and September during both years. Soil samples were collected at 0-15cm and 16-30 cm depth. Before application of fertilizers to determine soil pH, Soil texture, Organic matter. The experiment was laid out in Randomized Complete Block Design with 3 replications and six treatments. Plot size was kept as 2 rows 5 meter length and 1.2 meter width. The data were collected on fresh leaves, made tea, Plant height cm, No. of leaves, Leaf length cm & No. of branches and analyzed statistically. Before the start of experiment, the soil pH was 5.54, Soil texture was sandy loam while organic matter content was 2.47%.

3. Results and Discussions

3.1. Plant Height

The data recorded during 2016-17 & 2017-18 revealed that maximum plant height was observed in T_3 (57 & 61 cm) followed by T_4 respectively Table 1& 2, Figure 1 & 2 while minimum plant height (46 & 40 cm) was found in T_0 respectively. Minimum plant height (40 cm) was found in T_0. Islam, et al. [19] also reported that plant height of tomato was increased with increase of organic and inorganic fertilizers.

3.2. No. of Leaves

During 2016-17 & 2017-18, maximum number of leaves were found in T_3 (40 & 42) followed by T_4 & T_5 (36 & 41) respectively (Table 1 & 2, Figure 1 & 2) while minimum no of leaves were found in T_0 (31 & 29) during both the years. No significant difference was found among the treatments. Islam, et al. [20] reported the same results and noted maximum No. of tea leaves (14.25) when NPK was applied by foliar application @ (30-30-30-10-03 NPK with combination of Mg and Zn kg/ha).

No of branches: In case of maximum number of branches, maximum No. of branches were found in T_3 (9, 8) during both the years Table 1& 2, Figure 1 & 2 while minimum No. of branches was observed in case of T_0 (6, 5) during the same years. Same results were also recorded by Islam, et al. [20].

Leaf length: Maximum leaf length was found in T_3 (17 & 18) while minimum leaf length was found in T_0 (12 & 11) respectively during 2016-17 & 2017-18 (Table 1& 2, Figure 1 & 2).

3.3. Fresh Tea Leaves Yield kg/ha

It is revealed from the data collected during 2016-17 Table 1, Figure 2 that maximum fresh tea leaves yield (5306 kg/ha, was obtained in T_3 when fertilizer was applied @ 225-150-75, followed by T_4 producing fresh leaves yield of (5253 kg/ha) and T_2 (4756 kg /ha fresh leaves yield) as compared to lowest fresh leaves yield of 3419 kg/ha in T_0 (control) plot. The data collected during 2017-18 Table 2, Figure 4 revealed that maximum fresh leaves yield of (3352.77 kg/acre) was obtained in T_5 when Phosphorus was applied @ 175 kg/ ha followed by T_4 producing (3269.43 kg/ ha) fresh leave yield. The lowest fresh leaves yield of (2291.65 kg/ ha) was recorded in T_0 (control) plot without any fertilizer. Similar results were obtained by Gogoi, et al. [11] who stated that in North East India, the yield benefits were only recorded on application of up to 50 kg P_2O_5 ha^{-1} $year^{1}$, the effect being attributed to ability of phosphorus to enhance uptake and translocation of nitrogen.

3.4. Made Tea kg/ha

The data obtained during 2016-17 & 2017-18 Table 1 & 2, Figure 2 & 4 shows that highest made tea yield was obtained in T_3 (1061 & 671 kg/ha) respectively. These results are in line with finding of Chaudhary, et al. [21] who reported 162.5 kg Nitrogen, 50 kg Phosphate and 162.5 kg Potash ha^{-1} $year^{-1}$ as best dose for tea yield.

Table-1. Effect of different levels of phosphorus on the growth and yield of tea during 2016-17.

Treatments: N- P_2O_5- K_2O $kgha^{-1}$	Plant height cm	No. of leaves	Leaf length cm	No. of branches /plant	Fresh tea leaves yield kg/acre	Made tea kg/acre
T_0 00-00-00	46 c	31 c	12 d	6 b	3419 c	684 c
T_1 225-75-75	51 b	34 bc	13 cd	7 ab	4541 b	908 b
T_2 225-112.5 -75	51 b	33bc	15 b	8 a	4756 b	951 b
T_3 225-150-75	57a	40 a	17 a	9 a	5306 a	1061 a
T_4 225-187.5-75	51 b	36 ab	14bc	7 ab	5253 a	1051 a
T_5 225-225-75	48 bc	36 ab	16ab	8 a	4653 b	931 b
LSD 0.05%	3.98	4.62	5.84	1.69	372.94	74.56
CV%	4.31	7.27	1.55	12.4	4.40	4.40

Source: National Tea and High value crops Research Institute, Shinkiari.

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Table-2. Effect of different levels of Phosphorus on the growth and yield of Tea during 2017-18.

Treatments: N -P_2O_5- K_2O $Kgha^{-1}$	Plant height cm	No. of leaves	Leaf length cm	No. of branches /plant	Fresh tea leaves yield kg/ha	Made tea kg/ha
T_0 00-00-00	40 c	29 c	11 e	5 b	2292 d	458 d
T_1 225-75-75	52 b	35 b	13 d	7 a	2861 c	572 c
T_2 225-112.5 -75	54 b	35 b	16 bc	8 a	3047 bc	609bc
T_3 225-150-75	61 a	42a	18 a	8a	3353 a	671 a
T_4 225-187.5-75	58 ab	38 b	15c	8a	3144 ab	629 ab
T_5 225-225-75	55 ab	41a	17 ab	8a	3269 ab	654ab
LSD 0.05%	6.48	3.38	1.36	1.59	282.34	56.4
CV%	6.69	5.02	5.02	11.67	5.18	5.18

Source: National Tea and High value crops Research Institute, Shinkiari.

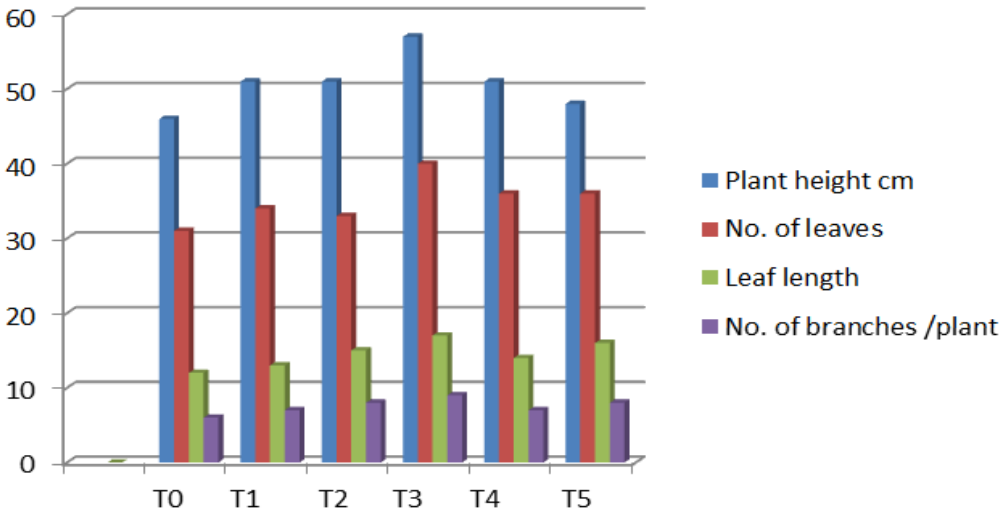

Figure-1. Effect of Phosphorus on the growth performance of tea during 2016-17.
Source: National Tea and High value crops Research Institute, Shinkiari.

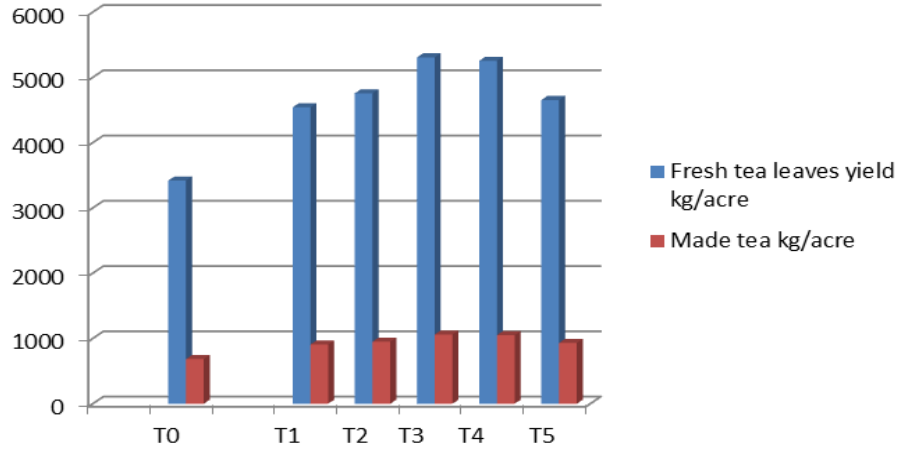

Figure-2. Effect of Phosphorus on the yield of tea during 2016-17.
Source: National Tea and High value crops Research Institute, Shinkiari.

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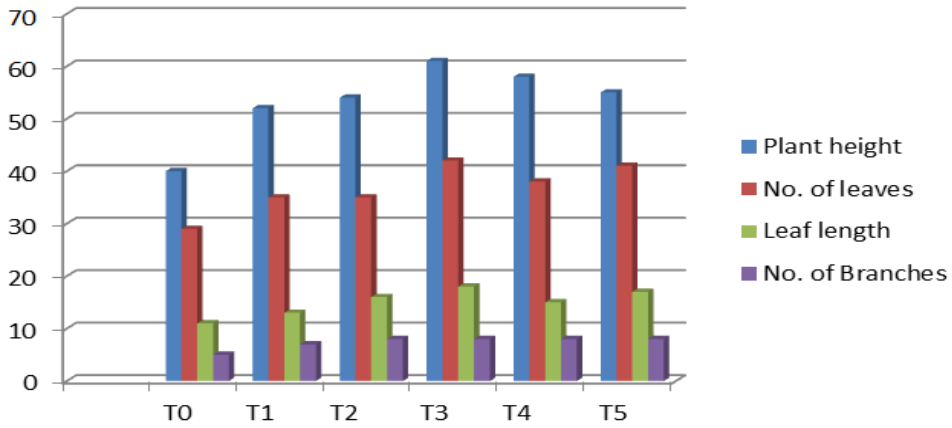

Figure-3. Effect of Phosphorus on the growth performance of tea during 2017-18.
Source: National Tea and High value crops Research Institute, Shinkiari.

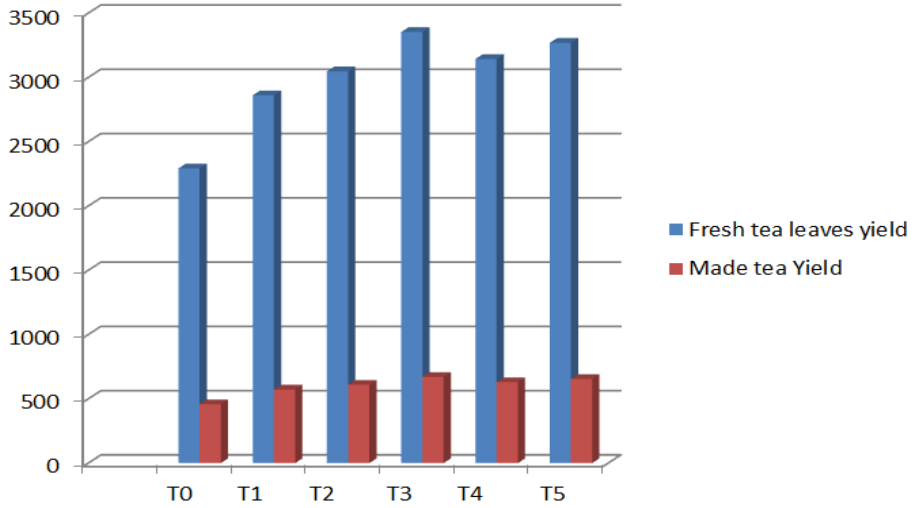

Figure-4. Effect of Phosphorus on the yield of tea during 2017-18.
Source: National Tea and High value crops Research Institute, Shinkiari.

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