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EFFECT OF FOLIAR APPLIED NITROGENOUS FERTILIZER ON GROWTH AND YIELD OF TEA *(CAMELLIA SINENSIS* L.)

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The experiment was undertaken at National Tea and High Value Crops Research Institute Shinkiari, Mansehra, Pakistan during 2011-12, to investigate the effect of different levels of urea on tea *C. sinensis* applied by foliar method. Experiment was laid out in RCBD with three replications. Treatments used were T_1 (control), T_2 (112.5-125-75 kg/ha NPK), T_3 (150-125-75 kg/ha NPK), T_4 (187.5-125-75 kg/ha NPK), T_5 (225-125-75 kg/ha NPK) and T_6 (262.5-125-75 kg/ha NPK). Urea © 1.0 percent was applied by foliar spray while phosphorus and potash were side dressed. During both the years foliar application of different doses of nitrogen significantly and linearly increased fresh leaves yield, processed tea yield, one year shoot length and leaf area. During 2011, the highest fresh leaves yield (17126.87 kg/ha), processed tea yield (3425.37 kg/ha), shoot length (35.20 cm) and leaf area (40.98 cm^2) were recorded in T_6 as compared to the lowest fresh leaves yield (10783.12 kg/ha) , processed tea yield (2156.62 kg/ha), shoot length (25.03 cm) and leaf area (24.82 cm) recorded in T_1. Similarly during the year 2012, the highest fresh leaves yield (14523.12 kg/ha), processed tea yield (2904.62 kg/ha), shoot length (35.86 cm) and leaf area (39.23 cm^2) were recorded in T_6. While the lowest fresh leaves yield (9414.25 kg/ha), processed tea yield (1882.87 kg/ha), shoot length (26.46 cm) and leaf area (26.03 cm^2) were obtained in control treatment T_1. It was concluded from the present study that nitrogen applied by foliar spray @ 262.5 kg/ha proved to be the recommended and more effective dose to increase tea yield and plant growth.

KEYWORDS: ***Camellia sinensis;*** **tea; nitrogenous fertilizer; urea foliar application; agronomic characters; fresh leaves yield; Pakistan.**

INTRODUCTION

Tea (*Camellia sinensis* L.O. Kuntze) belongs to family Theacea. The genus Camellia consists of 82 species, which are mostly indigenous to highlands of south India (19). The origin of tea is China where people started taking tea in the 6th century A.D. as a beverage. It was introduced in Japan in 1000 A.D. Later on it was introduced to Europe where British started its cultivation by the middle of 17th century. The Indian (south-east sub-continent) got familiar

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to tea during British rule in 18th century. Due to its wide adaptability, it is grown under various agro-ecological conditions, throughout the world. Commercial tea plantation has accomplished as far as Georgia (42^0 latitude) in USSR and south as Argentina (27 S^0 latitude) at altitude from 200-2200 m above sea level (22). Aside from water, tea is the most widely consumed beverage globally and the most favorite beverage in Pakistan. The utilization of both black and green tea in Pakistan is increasing day by day due to its popularity and rapid growth in population. Billions of dollars are being spent on tea import to cope with national need. Every year Pakistan import tea from different tea growing countries of the world, to meet this demand. The tea import during last eleven years is presented in Fig. 1. During 2011-12, Pakistan imported 124, 319 tons of black tea worth Rs. 31.91 billion with the major share from Kenya (53%) followed by India (15%) (Fig. 2) (1). Pakistan Agricultural Research Council (PARC) Islamabad established an institute at Shinkiari and started tea plantation in Mansehra (KPK) during 1982-83 to reduce heavy flow of foreign exchange. The institute is located at an altitude ranging from 1000-2000 m above sea level, latitude 34^o N and longitude 73^o E with 50 acres mature tea garden.

It is well documented that nitrogen play an important role in improving vegetative growth of the crop and its availability in soils directly reflects in crop yield (10, 21). Fertilizer application is the second most expensive agronomic inputs in tea production after plucking/harvesting. Nutrients are lost during crop harvesting and leaching, therefore, it is necessary to replace the lost nutrients to sustain economic yields. Many studies have shown yield benefits from applying fertilizers especially nitrogenous fertilizers (3, 21). Tea plant has high demand for nitrogen; therefore it is the nutrient on which fertilizer formulation for tea is based and recommended (3. 15, 16). The annual fertilizer application rates to tea differ from country to country. The lowest annual application rates in Vietnam is 36 to 40 kg N, while in Japan fertilizer is applied @ 800 N kg per hectare (3). Nitrogen (N) is the major nutrient affecting tea growth, yield, and quality. Application of nitrogenous fertilizer substantially increases the production of new shoots and the content of functional compounds, such as amino acids (10, 21). Nitrogen is also a constituent of large number of necessary organic compounds such as amino acids, protein, co-enzymes, nucleic acids, ribosome's, chlorophyll, cytochrome and some vitamins (14). Phosphorus and potassium are also major nutrients for tea production but no significant yield responses have been observed in Kenya due to application of the two nutrients. However, the P and K are necessary in the formulation of fertilizers recommendation for tea as insurance against any deficiency (5).

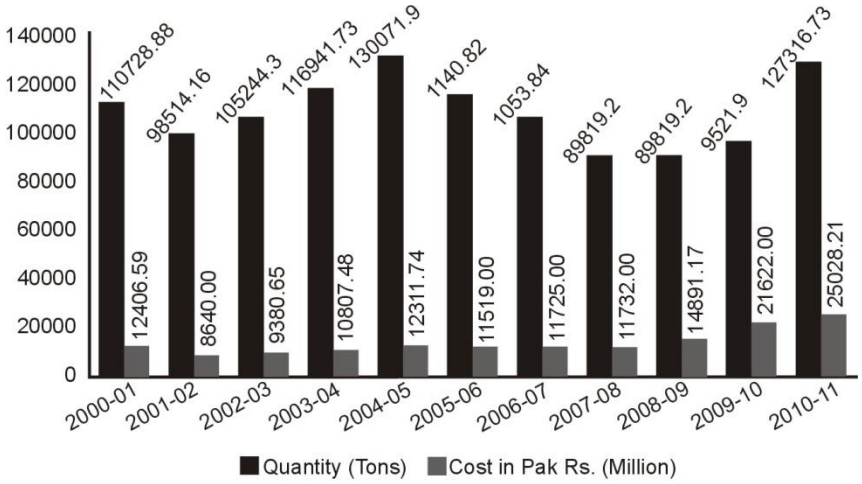

Fig. 1. Import of tea during last 11 years in Pakistan.

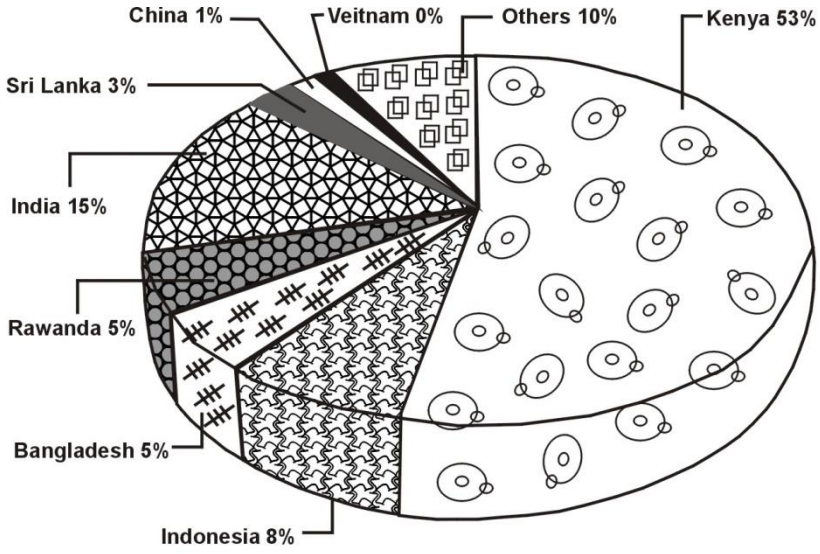

Fig. 2. Country wise share in tea import of Pakistan.

Othieno (15) reported that recommended dose of fertilizer for tea in Kenya is 100 to 250 kg per hectare depending on tea yields. The genotypes having small phenotype and producing low yields need lower rate of fertilizer in the range of 100 kg per hectare N while varieties having large phenotypes with

higher yielding capacity needs higher rates up to 250 kg per hectare N per year. Bonheure and Willson (3) recommended NPK fertilizer @ 100 -200 and 100-250 kg N per hectare per year in South India and Kenya respectively. Chiang (4) observed some increase in tea yield by applying urea at a concentration of 1.2% but manganese sulphate applied @ 0.2% had no significant effect. Hamid *et al* (6) recommended 225 kg per hectare nitrogen in the form of ammonium sulphate as the optimal dose for better yield of tea crop in Pakistan. It has been reported by Krishnapillai and Ediriweera (11) that the increase in plant growth and yield as a result of increasing levels of nitrogen and potassium was due to increase in leaf chlorophyll content. They also reported that increase in leaf chlorophyll content resulted in the blackness of processed tea. Thus application of nitrogen not only increases the yield of the crop but also improves the quality of the processed tea.

Application of fertilizer through foliar method not only increase the crop yield but also reduced the amount of fertilizer applied through soil method. Foliar application also reduce the time between application and uptake of nutrients by the plants as it is directly absorbed by the photo-synthetically active leaves. The application of fertilizer through foliar spray has been in vogue among farmers as an effective and useful method since 1950s (2). It has been reported in several studies that even a minimum amount of fertilizers applied as foliar method significantly increases the yield of different crops (17, 8). Although foliar fertilization does not completely replaces soil applied fertilizer but it is useful for immediate effect on the crop and also reduces the loss of nutrient by leaching from soil. Foliar application method is particularly used for application of micronutrients due to their small amount needed for the crop but can also be effective for major nutrients such as N, P, and K (12).

The aim of present study was to investigate the cost effective level of fertilizer to obtain maximum yield of tea under present scenario.

MATERIALS AND METHODS

This study was conducted at National Tea and High Value Crops Research Institute, Shinkiari (Mansehra) Pakistan during 2011-12 to see the effect of different levels of urea fertilizer by foliar method on tea yield and other agronomic characters. Soil samples were taken from experimental sites at 0-15 cm, 16-30 cm and 31-45 cm depth and analyzed for physico-chemical properties before initiation of the trial (Table 1). The experiment was laid out in RCBD with three replications. Plot size was kept as two rows 5 meter long and 1.2 meter wide. Half meter alley was left between treatments and one guard row was left between the replications. Agronomic practices were

provided at par to each treatment. Treatments used were T_1 (control), T_2 (112.5-125-75 kg/ha NPK), T_3 (150-125-75 kg/ha NPK), T_4 (187.5-125-75 kg/ha NPK), T_5 (225-125-75 kg/ha NPK) and T_6 (262.5-125-75 kg/ha NPK).. The sources for P_2O_5 & K_2O were single super phosphate (SSP) and sulphate of potash (SOP) respectively. Full dose of P & K was applied as a basal dose while 1 percent solution of N was applied in two split doses during March & July (13). Mature tea bushes of variety Qi-men were selected for the trial. Plucking was done manually by keeping two leaves and a bud as standard from April to October at regular interval of 15 days. Black tea was made at Tea Processing Plant NTHRI, involving the withering, rolling, CTC, fermentation and drying process. Shoot length was measured above pruning height i.e. 75 cm. The leaf is the most important physiological and photosynthetic part of plant which affects crop growth and bio-productivity. Leaf area is an important parameter in studies of plant nutrition, plant soil-water relations, crop ecosystem and directly related to soil fertility (22). Leaf area was calculated by selecting five random leaves from each treatment/replication with following formula described by Hamdi *et al.*(7).

$$\textit{Leaf area } (cm^2) = \textit{Leaf length x leaf width x } 0.99$$

Table 1. Physico-chemical characteristics of soil.

Parameter	Unit	Value		
		0-15 cm depth	16-30cm	31-45 cm
pH	-	5.1	5.2	5.4
Organic matter	%	1.51	1.21	1.18
Total soluble salts	%	0.03	0. 03	0.03
Nitrogen	%	0.1	0.09	0,07
Phosphorus	mg kg^{-1}	61.2	36.2	33.51
Potassium	mg kg^{-1}	300.5	288.5	271.8
Textural class	-	Sandy loam		

Source: Soil Science Laboratory Agricultural Research Institute Tarnab Peshawar.

Data were recorded on fresh leaves yield (FLY) (kg/ha), processed tea weight (PTY) (kg/ha), shoot length (SL) (cm) and leaf area (LA) (cm^2) and analyzed statistically using MSTAT-C package. Treatment differences were calculated by using Least Significant Difference (LSD) test.

RESULTS AND DISCUSSION

Fresh leaves yield (kg/ha)

Data (Table 2 & 3) regarding fresh leaves yield clearly indicated the superiority of increasing doses of nitrogenous fertilizer over control applied by

foliar method. It was revealed that fresh leaves yield increased with increasing levels of nitrogenous fertilizer. During the year 2011, the highest fresh leaves yield (17126.87 kg/ha) was recorded in T_6 followed by T_5, T_4, T_3 and T_2 with fresh leaves yield of 16118.12, 15341.25, 13970.62 and 12391.87 kg per hectare respectively. Control treatment (T_1) yielded the lowest fresh leaves yield (10783.12 kg/ha). Treatments were found significant at 5% probability level.

Table 2. Effect of foliar applied nitrogenous fertilizer on the fresh leaves yield, processed tea yield, shoot length and leaf area during 2011.

Treatment (kg/ha NPK)	Fresh leaves yield (kg/ha)	Processed tea yield (kg/ha)	Shoot length (cm)	Leaf area (cm^2)
T_1 = (0-125-75)	10783.12e	2156.62e	26.46e	24.82e
T_2 = (112.5-125-75)	12391.87d	2478.37d	27.25d	29.19d
T_3 = (150.0-125-75)	13970.62c	2791.25c	27.85d	32.46c
T_4 = (187.5-125-75)	15341.25b	3068.25b	29.25c	38.97b
T_5 = (225.0-125-75)	16118.12b	3236.25ab	32.61b	39.39b
T_6 = (262.5-125-75)	17126.87a	3425.37a	35.86a	40.98a
LSD ($p < 0.05$)	807.62	215.10	0.712	1.21
CV %	3.75	4.97	1.58	1.94

Means followed by different alphabets within column differ significantly at $p<0.05$.

Table 3. Effect of foliar applied nitrogenous urea fertilizer on the fresh leaves yield, processed tea yield, shoot length and leaf area during 2012.

Treatment (kg/ha NPK)	Fresh leaves yield (kg/ha)	Processed tea yield (kg/ha)	Shoot length (cm)	Leaf area (cm^2)
T_1 = (0-125-75)	9414.25 f	1882.87f	25.03f	26.03f
T_2 = (112.5-125-75)	10695.62e	2139.12e	26.94e	28.68e
T_3 = (150.0-125-75)	11729.37d	2345.87d	27.87d	31.35d
T_4 = (187.5-125-75)	12383.12c	2476.50c	28.60c	36.36c
T_5 = (225.0-125-75)	13469.37b	2693.87b	32.24b	37.27b
T_6 = (262.5-125-75)	14523.12a	2904.62a	35.50a	39.23a
LSD ($p < 0.05$)	268.67	53.77	1.082	0.61
CV %	1.48	1.48	2.45	1.02

Means followed by different alphabets within column differ significantly at $p<0.05$.

During 2012, significant increase in fresh leaves yield was observed due to foliar application of nitrogen fertilizer. Treatment T_6 produced highest fresh leaves (14523.12 kg/ha) followed by T_5 (13469.37 kg/ha), T_4 (12383.12 kg/ha), T_3 (11729.37 kg/ha) and T_2(10695.62 kg/ha). Whereas, T_1 produced the lowest fresh tea yield (9414.25 kg/ha). These results are in conformity with the findings of Islam *et al*. (9) who reported that ammonium sulphate applied by foliar @ 300 kg per hectare increased fresh leaves yield from

4521.65 kg per hectare to 7181.45 kg per hectare. Chiang (2) also observed 28.26% increases in yield of tea due to foliar application of urea and manganese. These results are also in agreement with Rauthann and Schnitzer (17) who observed that foliar application of NPK significantly increased the yield of crop. Similar results have also been reported by Haq & Mallarina (8).

Processed tea yield (kg/ha)

The data (Tables 2 & 3) pertaining to processed tea yield also revealed highly significant results due to increase in nitrogenous fertilizer by foliar application during both the years. During 2011, the highest processed tea yield (17126.87 kg/ha) was recorded in T_6 followed by T_5 (16118.12 kg/ha) and T_4 (15341.25 kg/ha). While the lowest processed tea yield (2156.62 kg/ha) was recorded in control treatment (T_1). Similarly during 2012, the highest processed tea yield (Table 3) was also recorded in T_6 (2904.62 kg/ha) followed by T_5 (2693.87 kg/ha), T_4 (2476.50 kg/ha), T_3 (2345.87 kg/ha) and T_2 (2139.12 kg/ha). While the lowest processed tea yield (1882.87 kg/ha) was recorded in control treatment (T_1). Treatments were found significantly different from each other at 0.05% probability level. In general there was a linear increase in processed tea yield with increase in level of nitrogen from 0 to 262.5 kg per hectare. These results are in accordance with finding of Islam *et al*. (9) who reported that ammonium sulphate applied @ 300 kg per hectare significantly increased fresh leaves yield from 4521.65 to 7181.45 kg and processed tea yield from 906.65 to 1436.45 kg per hectare. Chiang (4) noted that foliar application of both urea and manganese fertilizers increased tea yield (28.26%) but quality of tea (black or green) was not affected.

Shoot length (cm)

The data on shoot length showed that foliar application of fertilizer significantly and linearly increased shoot length with increasing levels of nitrogen during both years. During 2011 the longest shoot length was noted in T_6 (35.85 cm) followed by T_5 (32.61 cm), T_4 (29.25 cm), T_3 (27.85 cm) and T_2 (27.25 cm). While the shortest shoot length (26.46 cm) was recorded in T_1 (Table 2). During 2012, the maximum shoot length (35.50 cm) was also recorded in T_6 followed by T_5 (32.24 cm), T_4 (28.60 cm), T_3 (27.87 cm) and T_2 (26.94 cm) as compared to T_1 with the shortest shoot length (25.03 cm). Our findings are supported by Ventakaramani (20) who observed significant increase in shoot length and number of roots of tea plant with the application of ammonium sulphate.

Table 4. Mean agro-meteorological data of NTHRI for the Year 2011 and 2012.

Month	Air temperature °C		Rain fall (mm)	Relative Humidity (%)
	2011			
	Max	Min		
April	25.90	10.50	122.80	58.13
May	34.30	15.40	19.50	51.90
June	36.20	19.30	66.50	55.65
July	32.50	19.90	219.10	74.25
August	30.90	19.90	270.00	73.45
September	31.00	17.00	94.30	69.50
October	28.30	10.03	42.44	53.20
	2012			
April	5.4	26.2	120.9	52.95
May	12.0	31.0	49.6	46.90
June	16.9	37.0	6.38	41.90
July	18.8	34.12	131.9	53.7
August	20.7	32.2	392.4	72.1
September	16.8	29.0	266.79	75.85
October	9.1	27.4	6.9	52.50

Source: National Tea and High Value Crops Research Institute, Shinkiari, Mansehra

Leaf area

Data relating to leaf area revealed that fertilizer application had significant effect on leaf area during both the years and increased linearly with increasing levels of foliar nitrogen. During 2011, maximum leaf area was obtained in T_6 (40.98 cm^2) followed by T_5 (39.39 cm^2), T_4 (38.97 cm^2), and T_3 (32.46cm^2) while the minimum leaf area (24.82 cm^2) was observed in T_1, During 2012, maximum leaf area (39.23 cm^2) was also recorded in T_6, followed by T_5 (37.27 cm^2), T_4 (36.36 cm^2) and T_3 (31.35 cm^2) as compared to T_1 with minimum leaf area (26.03 cm^2). All the treatments were found to be statistically significantly different from each other at 0.05% probability level. These results are in agreement with those reported by Rishiraj Dutta (18) who observed that tea yield was significantly influenced by age, pruning, and fertilizer application and found an empirical relationship between yield and leaf area index.

CONCLUSION

It was concluded that increasing level of nitrogen fertilizer from 0 to 262.5 kg per hectare applied through foliar application can increase the fresh leaves yield, processed tea yield and growth of tea plants. However, to obtain maximum tea yield, foliar application of N @ 262.5 kg per hectare along with basic doses of P_2O_5 and K_2O may be recommended.

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Qamar-uz-Zaman	**:**	**Gave concept and designed the experiment**
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F.S. Hamid	**:**	**Provided the guideline for the research work**
Fayaz Ahmad	**:**	**Reviewed literature and prepared the writeup**
Sohail Aslam		**Prepared the writeup**