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Effect of Different Application Rates of Nitrogen and Potassium on Soil and Plant Micronutrient Status of Tea, *Camellia sinensis* (L.)

P.K.D.S.D. PITIGALA[1], G.P. GUNARATHNE[2], D.C. ABEYSINGHE[1] and M.N.D. FERNANDOPULLE[1]

[1]*Department of Plantation Management, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP)*

[2]*Soils and Plant Nutrition Division, Tea Research Institute of Sri Lanka, Talawakelle*

ABSTRACT

The study was conducted to reveal the effects of application of increasing rates of Nitrogen and Potassium on soil and plant micronutrients status of tea. Different rates of Nitrogen and Potassium were considered to determine the effect of them on soil and plant micronutrients such as Zinc, Copper, Manganese, Ferrous and Boron. Determination of micronutrients was done by using Diethylenetriaminepentaacetic acid extraction for soil analysis and dry ashing method for leaf analysis. The results indicated that soil pH levels did not vary significantly with increasing rates of Nitrogen and Potassium. Leaf and soil Ferrous, Zinc, Copper and Manganese concentration did not show any significant difference with increasing rate of Nitrogen and Potassium. However, there was a decrease trend of Manganese concentration observed with increasing rates of Nitrogen and Potassium. Leaf Boron level was significantly reduced with increasing rates of both Nitrogen and Potassium fertilizers but there was no significant difference with soil available Boron.

KEYWORDS: *Camellia sinensis*, Micronutrient status, Nitrogen, Potassium, Soil and leaf analysis

INTRODUCTION

Sri Lanka stands as one of the oldest Tea, *Camellia sinensis* (L.) O. Kuntze producing countries in the world. Although, Tea accounts for only 12% of the total cultivated area and it generates as much as 70% of the export revenues earned through agricultural exports (Anon, 2011). Tea in Sri Lanka is planted from almost mean sea level to around 2200 m above mean sea level in the wet and intermediate agro-ecological zones. In Sri Lanka the elevational category of a tea plantation is usually given as the elevational level of the processing factory. The plantations are thus classified into high-grown (above 1200 m), mid-grown (between 600-1200 m) and low-grown (below 600 m) elevational groups (Forrest, 1967). Approximately, the extents of these groups are 52,410, 61,386 and 74,175 ha respectively.

Tea plants respond to Nitrogen (N) fertilizers mainly as Urea and Sulphate of ammonia significantly, but for the other nutrients such as Potassium (K) and Phosphorus (P) the response is limited.

Consequently as the crop is the vegetative part, large amount of macro and micro nutrients are removed with crop. Therefore, a huge demand is created in the plant for nutrition to offer flush yield at 5 to 7 days interval. In addition to the major nutrients many micro nutrients also required for better growth of the plant as well as to produce a harvestable crop and among them Zinc (Zn), Manganese (Mn), Copper (Cu), Boron (B), and Ferrous (Fe) are prominent. Since these nutrients required by plants in very little quantities, those nutrients are normally termed as micronutrients. Although these nutrients are not supplied to the field as regularly as macro nutrients, long term negligence of micronutrients application and inherited low levels of micronutrients in the soil, the small amount of micronutrient requirement normally can lead to visible deficiencies in the tea fields.

The interaction between nitrogen and potassium is almost always positive which means that potassium increases crop resistance more when plant receive increasing rates of nitrogen than when they receive no nitrogen (Anon, 1990). In some cases, nutrient deficiencies can occur due to antagonisms between two nutrients. So the application of one nutrient should take into account the possible effects on others so as to maintain optimum ratios and concentrations in the plants (Tandon, 1995).

In order to get basic information about nutrient status of the Tea growing soils in Sri Lanka, this research was planned to carry out to study effect of application of increasing rate of N and K on soil and plant micro nutrient status and furthermore to develop micronutrient recommendations for mature tea.

MATERIALS AND METHODS

Experimental Site

The soils and foliar samples were collected from long term field experiment on effects of different rates of N (180, 240, 360 and 600 kg ha^{-1} yr^{-1} N) and K (0, 80 and 120 kg ha^{-1} yr^{-1} K_2O) on soil/plant nutrient status and yield of tea at Walpita Estate, Galle, AER: WL1. The soil and leaf samples were analyzed at the Soils and Plant Nutrition Division, Tea Research Institute of Sri Lanka, Talawakelle.

Sampling Procedure

Plant Samples

The mother leaves were sampled from experimental plots and leaves was oven dried at 80 ^{0}C and grounded prior to analysis.

Soil Samples

Soil samples were collected to a depth of 0–6 cm, from experimental plots and soils were air dried and passed through a 2 mm sieve for K and micronutrient analysis. For Nitrogen analysis the soils were grounded and passed through 0.5 mm sieve.

Analytical Procedure

In this study, soil pH, soil available micronutrient contents, and leaf micronutrient contents and soil Total Nitrogen and potassium contents were monitored. Determination of soil pH was done using a pH meter 0.01N $CaCl_2$ with the ratio of 1:2.5 (soil:$CaCl_2$). Total nitrogen content was determined by using the Kjeldhal method (Bremner, 1965). Extraction of exchangeable potassium was done by using 1M Ammonium Chloride (pH- 7 adjusted) and Potassium was determined by using the Flame photometer (model 410) developed by Jackson (1958). Extraction of total Manganese, Iron, Copper and Zinc were done by using Diethylenetriaminepentaacetic Acid (DTPA) extraction and determination of trace elements were done by using Atomic Absorption Spectrophotometer (AAS) (GBC Avanta). Furthermore extraction of Boron was done by using hot water extractable Boron method and the determination was done by using double beam UV-Visible Spectrophotometer (Cintra 20).

The leaf samples were digested for trace elements by dry ashing method and determination of trace elements were done by using Atomic Absorption Spectrophotometer AAS (GBC Avanta).

Statistical Analysis

The data collected from field experiments were tabulated and Analysis of Variance (ANOVA) was done by using Statistical Analysis System (SAS) Version 9.2.

RESULTS AND DISCUSSION

Effects of Application of Increasing Rates of N and K on the Soil pH Status

Although soil pH levels did not vary significantly with increasing rates of N or either with increasing rates of K there was a trend of decreasing soil pH to lower levels at increasing rates of N fertilizer. This was due to the increased production of H^+ by applied N fertilizer through nitrification (Table 1).

Table 1. Effects of different rates of N and K on the soil pH status

N Level	K Level (kg ha^{-1} yr^{-1} as K_2O)			
(kg ha^{-1} yr^{-1} N)	0	80	120	Mean
180	4.65	4.15	4.20	4.34
240	4.35	4.31	4.44	4.37
360	4.26	4.55	3.95	4.26
600	3.82	4.73	4.10	4.22
Mean	4.27	4.44	4.18	4.30

LSD (K 0.05) = 0.43, LSD (N 0.05) = 0.49

Effects of Application of Increasing Rates of N and K on the Leaf and Soil Fe Status

Leaf and soil Fe concentration was not found to be significant with increasing rate of N and K (Tables 2 and 3).

Table 2. Effects of different rates of N and K on the leaf Fe status (mg/Kg)

N Level	K Level (kg ha^{-1} yr^{-1} K_2O)			
(kg ha^{-1} yr^{-1} N)	0	80	120	Mean
180	63	69	66	66
240	65	62	64	63
360	67	62	59	63
600	57	64	63	61
Mean	63	64	63	63

LSD (K 0.05) = 6.82, LSD(N 0.05) = 7.87

Table 3. Effects of different rates of N and K on the soil Fe status (mg/Kg)

N Level	K Level (kg ha^{-1} yr^{-1} K_2O)			
(kg ha^{-1} yr^{-1} N)	0	80	120	Mean
180	9	12	12	11
240	12	17	14	14
360	15	11	15	13
600	20	13	8	14
Mean	14	13	12	13

LSD (K 0.05) = 4.52, LSD (N 0.05) = 5.22

A synergistic effect of iron levels on the absorption of nitrogen by rice on vertisols was reported (Syed, 1993). Working with lentil Rai *et al.,* (1985) found that Fe-efficient plants were also more efficient in N fixation than Fe-deficient plants. Thus, positive relationship between Fe and N_2 fixation was indicated.

Effects of Application of Increasing Rates of N and K on the Leaf and Soil Mn Status

Significant variations of leaf and soil Mn concentrations were not observed with increasing rates of N and K (Table 4 and 5). However, decrease trend was observed with increasing rates of N and K. As behavior of Mn in soils depends largely on pH and redox potential, soil pH, has significant effect on Mn availability. Table 1 showed that pH has been decreased by application of nitrogen.

Table 4. Effects of different rates of N and K on the leaf Mn status (mg/Kg)

N Level	K Level (kg ha^{-1} yr^{-1} K_2O)			
(kg ha^{-1} yr^{-1} N)	0	80	120	Mean
180	544	1005	630	726
240	459	687	475	540
360	838	704	710	751
600	1005	549	635	730
Mean	712	736	613	687

LSD (K 0.05) = 224, LSD (N 0.05) = 258

Table 5. Effects of different rates of N and K on the soil Mn status (mg/Kg)

N Level	K Level (kg ha^{-1} yr^{-1} as K_2O)			
(kg ha^{-1} yr^{-1} N)	0	80	120	Mean
180	3.49	2.72	3.68	3.30
240	1.91	3.15	3.92	2.99
360	7.61	2.40	1.65	3.88
600	2.20	2.44	2.53	2.39
Mean	3.80	2.68	2.94	3.14

LSD (K 0.05) = 2.45, LSD (N 0.05) = 2.83

Effects of Application of Increasing Rates of N and K on the Leaf and Soil Zn status

Leaf and soil Zn concentration was not significantly differed with N and K rates (Table 6 and 7).

Table 6. Effects of different rates of N and K on the leaf Zn status (mg/Kg)

N Level	K Level (k g ha^{-1} yr^{-1} as K_2O)			
(kg ha^{-1} yr^{-1} N)	0	80	120	Mean
180	18	16	17	17
240	17	18	17	17
360	16	18	16	17
600	15	20	15	17
Mean	16	18	16	17

LSD (K 0.05) = 2.21, LSD (N 0.05) = 2.55

In a soil deficient in both Zn and K, a positive and significant interaction between Zn and K on grain yield of wheat was observed (Gupta and Raj, 1983). In the absence of zinc, grain yield decreased with K application but in the absence of K, Zn application increased it, which signifies that Zn supply was more limiting than K supply for crop growth in the soil. Increasing rates of Zn with higher rates of K resulted in further yield increase.

Table 7. Effects of different rates of N and K on the soil Zn status (mg/Kg)

N Level	K Level (kg ha^{-1} yr^{-1} as K_2O)			
(kg ha^{-1} yr^{-1} N)	0	80	120	Mean
180	0.47	0.45	0.67	0.53
240	0.48	0.65	0.53	0.55
360	0.73	0.38	0.53	0.55
600	0.47	0.46	0.32	0.42
Mean	0.54	0.49	0.51	0.51

LSD (K 0.05) = 0.21, LSD (N 0.05) = 0.25

Effects of Application of Increasing Rates of N and K on the Leaf and Soil Cu Status

Leaf and soil Cu concentration was not significantly differed with N and K rates (Table 8 and 9).

In studies, on Raya, when N and Cu were applied at different rates and combinations, both were antagonistic in terms of their content in the plant leaf (Antil *et al.*, 1988). In wheat increasing the Cu levels above 5 ppm significantly decreased the N content of plants and also the available N content of soil (Kumar *et al.*, 1990).

Table 8. Effects of different rates of N and K on the leaf Cu status (mg/Kg)

N Level	K Level (kg ha^{-1} yr^{-1} as K_2O)			
(kg ha^{-1} yr^{-1} N)	0	80	120	Mean
180	0.27	0.28	0.35	0.30
240	0.28	0.28	0.35	0.30
360	0.27	0.34	0.24	0.28
600	0.37	0.26	0.33	0.32
Mean	0.29	0.29	0.31	0.30

LSD (K 0.05) = 0.06 , LSD (N 0.05) = 0.07

Table 9. Effects of different rates of N and K on the soil Cu status (mg/Kg)

N Level	K Level (kg ha^{-1} yr^{-1} as K_2O)			
(kg ha^{-1} yr^{-1}N)	0	80	120	Mean
180	0.35	0.36	0.38	0.36
240	0.33	0.42	0.37	0.37
360	0.44	0.35	0.32	0.37
600	0.33	0.34	0.31	0.32
Mean	0.36	0.37	0.34	0.36

LSD (K 0.05) = 0.06, LSD (N 0.05) = 0.07

Effects of Application of Increasing Rates of N and K on the Leaf and Soil B Status

Leaf B level was significantly reduced with increasing rates of both N and K fertilizers but significant variation of soil available B was not observed (Table 10 and 11).

Table 10. Effects of different rates of N and K on the Leaf B status (mg/Kg)

N Level ($kg\ ha^{-1}\ yr^{-1}N$)	K Level ($kg\ ha^{-1}\ yr^{-1}$ as K_2O) 0	80	120	Mean
180	36	39	38	38a
240	35	30	33	33b
360	36	40	32	36ab
600	39	36	27	34b
Mean	37a	36a	32b	35

LSD (K 0.05) = 3.37, LSD (N 0.05) = 3.89

Means with same letters are not significantly different.

Table 11. Effects of different rates of N and K on the soil B status (mg/Kg)

N Level ($kg\ ha^{-1}\ yr^{-1}\ N$)	K Level ($kg\ ha^{-1}\ yr^{-1}$ as K_2O) 0	80	120	Mean
180	1.61	0.99	1.40	1.33
240	1.09	1.09	0.64	1.00
360	1.22	1.35	1.49	1.36
600	0.56	1.18	0.77	0.83
Mean	1.12	1.20	1.08	1.13

LSD (K 0.05) = 0.48, LSD (N 0.05) = 0.55

The relationship between B and N is inconsistent. Application of B significantly decreased the dry matter yield of 45 days old wheat from 14.2 to 6.6 g/pot and increased B concentration from 35.6 to 145.5 mg/kg whereas N application increased dry matter yield from 9.8 to 13.6 g/pot and decreased B concentration from 109.5 to 49.2 mg/kg (Aggarwal and Yadav, 1984). In another experiment, B application increased the N concentration in chickpea and wheat (Yadev and Manchanda, 1979) and also in lentil (Singh and Singh, 1983). Addition of 2 mg B/kg soil to groundnut increased N uptake appreciably. This was due to the favorable effect of B on nodulation as nodule counts increased to by 37% (Patel and Golakia, 1986).

CONCLUSIONS

The results of the study explores that the soil pH levels did not vary significantly with increasing rates of N and K although there was a trend of decreasing soil pH to lower levels at increasing rates of N fertilizer. Leaf and soil Ferrous, Zinc, Copper and Manganese concentration did not show any significant difference with increasing rate of N and K. However, there was a decrease trend of Manganese concentration observed with increasing rates of N and K. Leaf Boron level was significantly reduced with increasing rates of both nitrogen and potassium fertilizers but there was no significant difference with soil available Boron.

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REFERENCES

Aggarwal, S.C. and Yadav, D.V. (1984). Effect of boron and nitrogen on yield and boron content of wheat, *Journal of the Indian Society of Soil Science*, **32**, 197-200.

Anon. (1990). Factors influencing the effect of potassium, *Potassium and plant health.* 2nd ed. International potash institute, Switzerland, 155-159.

Anon. (2011). Central Bank Annual Report, Colombo, Central Bank of Sri Lanka.

Antil, R.S., Yadav, D.S., Kumar, V. and Singh, M. (1988). Nitrogen-Copper relationship in Raya (Brassica Juncea Cess), *Journal of Indian Society of Soil Science.* **36**, 704-708.

Bremner, J.M. (1965). Total nitrogen. *Method of soil analysis. Part2.* Agronomy monograph No.9.Eds. C.A. Black, A.L. Page, and R.H. Miller, Madison, Wisconsin, USA. 100 – 103.

Forrest, D.M. (1967). A hundred years of Ceylon Tea. Chatto and Windus, London. 1867-1967.

Gupta, V.K. and Raj, H. (1983). Zinc – Potassium relationship in wheat. *Haryana Agricultural University Journal Research*, **13** (1). 140-145.

Jackson, M.L. (1958). Soil Chemical Analysis. Prentice Hall, Inc., Erglewood, Cliffs, NJ, USA. 134 – 182.

Kumar, V., Yadav D.V. and Yadav, D.S. (1990). Effect of nitrogen sources and copper levels on yield, nitrogen and copper contents of wheat, *Plant and Soil*, **126**, 79-83.

Patel, M.S. and Golakia, B.A. (1986). Effect of calcium carbonate and boron application on yield and nutrient uptake by groundnut, *Journal of Indian Society of Soil Science,* **34**, 815-820.

Rai, R., Prasad V., Choudhury, S.K. and Sinha N.P. (1985). Iron nutrition and symbiotic N_2- Fixation of lentil genotypes in calcareous soil, *Journal of Plant Nutrition*, **38**, 410-415.

Singh, V. and Singh, S.P. (1983). Effect of applied boron on the chemical composition of lentil plants, *Journal of Indian Society of Soil Science*, **40**,876-877.

Ismail, S. (1993). Studies on some associated factors of iron chlorosis in rice on vertisols. PhD thesis. Parbhani, M.A.U.

Tandon, H.L.S. (1995). Micro nutrient in soils, crops and fertilizers.

Yadev, O.P. and Manchanda, H.R. (1979). Boron tolerance Studies in gram and wheat grown on a sierozem sandy soil, *Journal of Indian Society of Soil Science*, **27**, 174-180.