Original Research Paper

Volume -10 | Issue - 4 | April - 2020 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Life Science

SEASONAL VARIATION OF COPPER, MANGANESE AND ZINC IN TEA (CAMELLIA SINENSIS L.) GROWING SOILS OF JORHAT DISTRICT OF ASSAM.

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ABSTRACT **INTRODUCTION:**Growing tea (Camellia sinensis L.) plant coupled with climatic variations affect the micronutrients status in soil. The present study discerns the seasonal variation of selected micronutrients, viz. copper (Cu), manganese (Mn) and zinc (Zn) in soil samples collected from the five tea estates of Jorhat district, Assam, India. **MATERIALS AND METHODS:**Soil samples were collected in the summer,monsoon and winter season from 2016 to 2018. Cu, Mn and Zn were estimated in soil samples following tri-acid digestion protocol using the Atomic Absorption Spectrophotometer. **RESULTS:**In soil, total Cu content ranged from 5.50 to 39.00 mg kg-1, 4.50 to 25.00 mg kg-1 and 5.00 to 23.50 mg kg-1 in summer, monsoon and winter season respectively. The same for Mn ranged from 24.98 to 226.00 mg kg-1, 5.00 to 147.50 mg kg-1, and 5.00 to 142.50 mg kg-1. Zn ranged from 45.00 to 230.00 mg kg-1, 9.50 to 90.00 mg kg-1, 25.99 to 350.00 mg kg-1 in summer, monsoon and winter season respectively. **CONCLUSION:**From the experimental results it has been observed that Cu and Mn concentrations in soil were higher in summer followed by monsoon and winter. However, for Zn it was observed that Zn concentration was higher in summer and winter but lower in monsoon. The concentration of Mn is generally high in tea growing soils with respect to Cu and Zn.

KEYWORDS : Tea plant, Copper, Manganese, Zinc,Seasonal variation, Soil

INTRODUCTION

Tea (Camellia sinensis L.) is aperennial evergreen crop of the Camellia family and one of the world's popularbeverages next to water1.It is native of China and Northern India with two main varieties,viz. Camellia sinensisvarsinensis (small leaf), regions of central China and Japan and Camellia sinensisvarassamica (broad leaf), found in Northeast of India2. For optimum growth of tea plant, adequate rainfall, temperature,good drainage system having good depth are essential3.The growth of tea plant depends on some factors like soil health condition, environmental and climatic factors like rainfall, temperature, humidity, day length etc.as those factors are the most important feature to get optimum tea shoot expansion and tea yield4. Tea plant takesaround 10 to 11 years to obtain its minimum quantity of flushing and able to give production up to the age of 70 years5. Being perennial crop, continuous harvesting of tea leave remove significant amount of micronutrients like copper (Cu), manganese(Mn) and zinc (Zn); since plants uptake itfrom soil and,therefore,regular fertilizer application in tea soil has become one of the main agricultural practice for sustainable tea cultivation.However, fertilizer recommendations for tea have always emphasized macronutrients$_{6}$.

Tea plant is known to accumulate several micronutrients of which Cu, Mn and Zn are very much important7. Tabu et al. reported that continuous harvesting of tea leaves remove micronutrients from the soil8. Therefore, micronutrients application is a vital for tea production as those are significantly improves the yield and quality of tea9,10. Cao et al. reported that micronutrients content in tea soils is very much limited and range of micronutrients falls frommilligram or microgram per kilogram soil11. Tea plants can uptake micronutrients from the soil when theyare present in soil as a soluble state.

Copper is one of the native essential and major micronutrient found in tea soil. It associated with the different cell functions and enzymatic activities mainly concerned with the oxidation reaction process. Zinc(Zn) is an another micronutrient which plays an important role in different plants metabolism process like of cell wall, respiration, photosynthesis, chlorophyll formation, enzyme activity and other biochemical functions etc. Application of Zn improves the chlorophyll content, net photosynthetic rate and water use efficiency, and consequently increases made tea yield12. Manganese (Mn) is a dietary source and essential element to plants.It helps in the physiological process of plants in photosynthesis by breaking down of water and releasing oxygen.

The nature of tea soil is mostly acidic and suitable for the production of crop yield. It is noteworthy that micronutrients are important not only for human nutrition, but for plant nutrition as well.The mineral composition of plants depended, not only on the species or varieties, but also on the growing conditions such as soil and geographical condition.Ozyazici et al. reported that quality of tea in the eastern Black Sea Region, Turkey depends on the micronutrients status in tea growing soils13. However, it has been observed that micronutrient status in tea growing soils of Jorhat district influenced by seasonal variation is very much limited even not available.Therefore, the main objective of this study was to understand the effect of seasonal variation (summer, monsoon and winter) of micronutrients (Cu, Mn and Zn) availability in tea growing soil in fiveselected tea gardens of Jorhat district of Assam, India.

MATERIALSAND METHODS

SAMPLING LOCATION

Jorhat (26°45' 28.34" N latitude and 94° 12' 35.36" E longitude) is one of the major tea growing district in Assam. Five tea estates (TEs), Borbhetta Experimental Tea Estate (BETE), Tocklai Tea Estate (TTE), Bokahola Tea Estate (BKTE), Teok Tea Estate (TETE) and Deha Tea Estate (DTE) were selected for the present experiment. Top (0-15 cm) and sub soil samples (15-30 cm) were collected in 2016-2018 during summer (February-May), monsoon (June-September) and winter (October-January) seasons.

SOIL PROCESSING

Soil samples were collected and pre-treated following the protocol described by Rubio and Ure14. In brief, soil samples were air dried, grinded and sieved through 2 mm mesh, packed in an air tight container with proper labelling.

ANALYTICAL PROCEDURE

TOTAL MICRONUTRIENTS (CU, MN AND ZN) CONTENT IN SOIL

Total concentrations of Cu, Mn and Zn in soils were obtained after tri acid digestion15. For the digestion process, 0.2 g of air dried sieved soil was weighed into 100 mL of Erlenmeyer flask. Sample was wetted with a few drops of distilled water. Thereafter, tri acid mixture (Concentrated HNO3: Concentrated H2SO4:Concentrated HCl::10:4:1) were added into the flask and carefully mixed with the soil. The mixture was gently heated on a hot plate until half dried and subsequently reattacked with the same tri acid mixture and heated until the reaction died down. The residue was redissolved with 20 mL of 2.5 N HCl and filtered (Whatman No.1). Finally, the solution was collected in a 25 mL polycarbonate volumetric flask and diluted to 25 mL with deionized water. A blank digest was carried out in the same way. Cu, Mn and Zn were determined using atomic absorption spectrometry (model: AA 240, Agilent, Malaysia).

QUALITY CONTROL FOR MICRONUTRIENTS ANALYSIS

Micronutrients were analysed in two certified reference materials, viz. Montana Soil (SRM-2710a) and Tomato Leaves (SRM-1573a) for

quality assurance of the analytical results following the same protocol as that for samples. The values obtained were in excellent agreement with the certified values. Standard reference materials (SRMs) were procured from National Institute of Standards and Technology, Standard Reference Materials, Madison, USA.

STATISTICALANALYSIS

All the data sets were statistically analyzed. All the statistical analyses were performed using the SPSS 15.0 statistical package (SPSS Inc., Chicago, USA).

RESULT AND DISCUSSION

MICRONUTRIENTS CONTENTS OF SOILSAMPLES

COPPER

Average total copper (Cu) content in the studied soils was 71.38 mg kg-1 and ranged between from 5.0 to 226 mg kg-1 (Table 1). It was observed that around 72.86% of analysed soil samples below the permissible limits prescribed by the European Union legislation (50 to 140 mg kg-1) for acid soils16. Cu in top soils for the summer seasons was ranged from 7.00to 39.00 mg kg-1. The same for sub soils wereranged from 7.00 to 34.50 mgkg-1. Cu contents in monsoon and winter seasons were ranged from 4.5 to 25 mg kg-1 and 5.0 to 23.5 mg kg-1, respectively. Han et al. also had similar findings where they stated that the Cu content was highest in the summer period17. Ercisli et al. reported that Cu content in tea growing soils were depends on some climatic factors18. That the availability of Cu contents in soils has been found to fluctuate with seasonal variations which were also supported by Food Agriculture Organization19. Regarding soil depth, average Cu concentrations are significantly differ which similar with the findings reported by Pietrzak and McPhail where the top soil layer showed the higher amount of total Cu contents20. Nóvoa-Muñoz et al. concluded that profilic distribution of Cu seems to be a consequence of the traditional intense management of tea growers, which promotes high amount of total Cu in top soil16.

Table 1 Total Copper (mg Kg-1) Content In Soils Collected From Different Tea Estates Of Jorhat District Of Assam (values Are Presented As Mean Of Three Replications ± Se)

Sample ID*	Year								
	2016			2017			2018		
	Season								
	Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter
	Total Cu								
BTET	16.5±0.1	12.5±0.1	12.5±0.2	14.0±0.0	20.0±0.1	16.5±0.1	26.0±0.0	25.0±7.7	10.0±0.0
BTES	12.5±0.1	12.0±0.0	11.0±0.0	17.0±0.0	9.5±0.1	16.5±0.1	16.0±0.0	15.0±5.8	5.0±0.0
TTET	8.5±0.1	8.0±0.0	11.5±0.1	14.5±0.1	4.5±0.1	16.5±0.1	9.5±0.1	5.0±1.7	5.0±0.0
TTES	9.5±0.1	6.5±0.1	11.0±0.0	16.0±0.0	9.0±0.0	14.0±0.6	7.5±0.1	10.0±2.7	5.0±0.0
BKTET	7.0±0.0	5.5±0.1	11.5±0.1	16.5±0.0	15.0±0.6	21.0±0.0	5.5±0.1	5.0±0.6	5.0±0.0
BKTES	8.5±0.1	9.0±0.1	13.0±0.0	18.5±0.1	17.0±0.0	15.5±0.1	7.0±0.0	5.0±0.2	5.0±2.9
TETET	12.5±0.1	22.0±0.0	18.0±0.1	21.0±0.0	18.0±0.0	23.5±0.1	21.5±0.1	20.0±8.7	5.0±0.0
TETES	10.5±0.1	7.0±0.0	13.0±0.0	20.5±0.1	14.0±0.0	20.0±0.1	18.5±0.1	20.0±7.6	5.0±0.0
DTET	10.5±0.1	10.0±0.0	17.5±0.1	39.0±0.0	13.0±0.0	20.5±0.1	13.0±0.0	15.0±4.1	10.0±0.0
DTES	12.0±0.0	10.5±0.1	10.0±0.0	34.5±0.0	15.0±0.0	18.5±0.2	8.0±0.0	10.0±3.4	15.0±0.0

*BTET: Borbhetta Tea Estate top soil; BTES:Borbhetta Tea Estate sub soil; TTET:Tocklai Tea Estate top soil; TTES:Tocklai Tea Estate sub soil; BKTET:Bokahola Tea Estate top soil; BKTES:Bokahola Tea Estate sub soil; TETET:Teok Tea Estate top soil; TETES:Teok Tea Estate sub soil; DTET:Deha Tea Estate top soil andDTES:Deha Tea Estate sub soil

MANGANESE

Manganese (Mn) is one of the most abundant micronutrients in the lithosphere as reported by Kabata-Pendias and Pendias21.Total Mn in experimental soils was ranged from5.0 to 226.0 mg kg-1 (Table 2). Mn contents in top soils for the summer seasons were found to be in theranged from 29.95 to 163.00 mg kg-1 and in sub soils were ranged from 24.98 to 226.0 mg kg-1.Mn contents in monsoon and winter seasons were ranged from 5.0 to147.5 mg kg-1 and 5.0 to 142.5 mg kg-1, respectively. Kabata-Pendias and Pendias reported that common range of Mn in rocks is 350 to 2000 mg kg-1, 21. McKenzie concluded that lithiophorite and hollandite are the most common crystalline forms of Mn found in acidic soil22. Seasonal variation of Mn in tea soil could be due to accumulation pattern of Mn by tea plant influenced by growth season. According to Nath, Mn content of tea soil collected from Sibsagardistrict was found from 96.25to 384.64 mg kg-1,23. Kacar reported that the Mn content in soil vary from 42.7 to 78.7 mg kg-1 in Eastern Black Sea Region soil of Turkey24. Mupenzi et al. reported that lower amount of iron in tea growing soils induced Mn concentration25.

Table 2 otal Manganese (mg Kg-1) Content In Soils Collected From Different Tea Estates Of Jorhat District Of Assam (values Are Presented As Mean Of Three Replications ± Se)

Sample ID*	Year								
	2016			2017			2018		
	Season								
	Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter
	Total Mn								
BTET	147.0±0.0	83.0±0.0	41.5±0.1	55.5±0.1	10.0±0.0	5.0±0.0	35.0±5.2	5.0±0.0	92.0±0.1
BTES	125.5±0.1	100.5±0.1	32.5±0.1	75.5±0.1	10.0±0.1	10.0±0.0	25.0±5.2	10.0±0.1	64.5±0.1
TTET	147.5±0.1	75.5±0.1	45.5±0.1	63.5±0.1	20.0±0.0	15.0±0.0	130.0±69.7	5.0±0.0	81.0±0.0
TTES	165.0±0.0	104.5±0.1	47.0±0.0	90.0±0.0	15.0±0.0	15.0±0.0	39.9±18.6	5.0±0.0	71.5±0.1
BKTET	149.0±0.0	90.0±0.1	45.5±0.1	79.5±0.1	20.0±0.0	35.0±0.0	30.0±14.2	5.0±0.0	84.5±0.1
BKTES	156.5±0.1	88.0±0.0	42.5±0.1	109.5±0.2	20.0±0.0	25.0±0.0	25.0±10.4	10.0±0.0	74.0±0.1
TETET	163.0±0.0	114.0±0.1	77.0±0.0	102.0±0.1	30.0±0.0	10.0±0.0	120.1±56.8	15.0±0.0	94.5±0.1
TETES	226.0±0.1	97.5±0.1	58.5±0.1	91.5±0.1	30.0±0.0	5.0±0.0	80.1±35.5	10.0±0.0	124.5±0.1
DTET	145.0±0.1	123.5±0.2	115.0±0.1	157.5±0.1	75.0±0.0	95.0±0.1	50.0±21.4	15.0±0.0	142.5±0.1
DTES	158.5±0.1	147.5±0.1	111.5±0.1	179.5±0.2	75.0±0.0	45.0±0.0	40.1±18.5	5.0±0.0	142.5±0.1

*BTET: Borbhetta Tea Estate top soil; BTES:Borbhetta Tea Estate sub soil; TTET:Tocklai Tea Estate top soil; TTES:Tocklai Tea Estate sub soil; BKTET:Bokahola Tea Estate top soil; BKTES:Bokahola Tea Estate sub soil; TETET:Teok Tea Estate top soil; TETES:Teok Tea Estate sub soil; DTET:Deha Tea Estate top soil and DTES:Deha Tea Estate sub soil

ZINC

Zinc (Zn) is considered to be relatively common micronutrient in soils26. As shown in Table 3,Zn contents in summer, monsoon and winter seasons were ranged from 45.0 to 230.0 mg kg-1, 9.5-90.0 mg kg-1 and 25.0-350.0 mg kg-1 respectively. It was also observed that Zn content in soil increased from summer to winter season irrespective of tea estates. Miyasaka and Grunes reported during winter season, Zn uptake by plant may have low levels which cause the buildup of Zn in this season27. It has been observed that, Zn content is high in top soils than sub soils. Comparatively higher amount of Zn in top soil could be due to formation of stable Zn compounds with organic matter present in top soil as suggested by Kabata-Pendias28. The average concentration of Zn in soil was found relatively higher than the world average soil Zn (90 mg kg-1) as reported by Bowen29. However, Kabata-Pendias and Pendias reported that mean total Zn contents in surface soils of different countries range from 17 to 125 mg kg-1 with the geometric mean 64 mg kg-1, 21. Nath (2013) reported that the Zn in soil vary between 24.57to 52.95 mg kg-1in tea growing soils collected from Sivasagar district of Assam, India23. Kacar reported in their research study of Turkey soil sample, found that Zn were ranges from

2.7 mg kg-1to 6.2 mg kg-1,24.Mupenzi et al. reported that Zn in tea growing soils collected from Rwandan tea growing areas ranges from 51 to 179 mg kg-1,25. Therefore, the present experimental result is in consistent with their findings.

Table 3 Total Zinc (mgkg-1) Content In Soils Collected From Different Tea Estates Of Jorhat District Of Assam (values Are Presented As Mean Of Three Replications ± Se)

Sample ID*	Year								
	2016			2017			2018		
	Season								
	Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter
					Total Zn				
BTET	50.0±0.0	35.0±0.0	150.0±0.1	110.0±0.1	40.0±0.3	30.0±0.1	65.0±0.0	49.5±0.1	49.0±0.0
BTES	50.0±0.1	40.0±2.4	275.0±0.1	135.0±0.0	40.0±0.1	25.0±0.1	70.0±0.0	34.0±0.1	100.5±0.1
TTET	55.0±0.0	50.0±0.0	125.0±0.1	165.0±0.0	45.0±0.1	30.0±0.1	75.0±0.0	30.0±0.1	47.0±0.1
TTES	55.0±0.1	45.0±0.0	110.0±0.0	145.0±0.1	20.0±0.1	25.0±0.1	65.0±0.0	14.5±0.1	74.5±0.2
BKTET	45.0±0.0	35.0±0.1	110.0±0.1	140.0±0.1	35.0±0.1	30.0±0.1	45.0±0.0	9.5±0.1	51.0±0.1
BKTES	50.0±0.0	70.0±0.0	125.0±0.1	165.0±0.0	40.0±0.1	45.0±0.1	70.0±0.1	28.0±0.1	58.5±0.1
TETET	60.0±0.0	90.0±0.1	195.0±0.1	165.0±0.1	60.0±0.1	30.0±0.1	70.0±0.1	50.0±0.0	56.0±0.0
TETES	50.0±0.0	45.0±0.1	170.0±0.1	160.0±0.1	35.0±0.1	35.0±0.1	65.0±0.0	43.0±0.0	66.0±0.0
DTET	50.0±0.0	45.0±0.0	145.0±0.1	205.0±0.1	40.0±0.1	35.0±0.1	65.0±0.1	31.0±0.1	51.0±0.6
DTES	45.0±0.0	55.0±0.1	120.0±0.1	230.0±0.2	35.0±0.1	40.0±0.1	80.0±0.1	29.0±0.1	117.0±0.0

*BTET: Borbhetta Tea Estate top soil; BTES:Borbhetta Tea Estate sub soil; TTET:Tocklai Tea Estate top soil; TTES:Tocklai Tea Estate sub soil; BKTET:Bokahola Tea Estate top soil; BKTES:Bokahola Tea Estate sub soil; TETET:Teok Tea Estate top soil; TETES:Teok Tea Estate sub soil; DTET:Deha Tea Estate top soil and DTES:Deha Tea Estate sub soil.

CONCLUSION

The present study reveals that there is occurrence of large temporal variations in the concentration of Cu, Mn and Zn collected soil samples from different tea estates of Jorhat district of Assam. The studied micronutrients content in tea growing soils has shows the variation depending upon the climatic factors of the respective years. In these findings, it was observed that the Cu and Mn contents were found to be high from summer seasons to winter seasons except Zn. In monsoon seasons, Zn concentration was found to be fluctuating. Therefore, it is difficult to point out any general trends in availability of micronutrients in tea growing soils due to seasonal variations because of the complexity of factors simultaneously involved. Notwithstanding, the activities related to soil management practices may result in variation of total Cu, Mn and Zn levels in tea growing soils. Furthermore, unlike soil analysis, the seasonal trends of micronutrients in plant samples will be required to understand the distinct seasonal trends of micronutrients.

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