International Journal of Chemical Studies

**P-ISSN: 2349–8528**
**E-ISSN: 2321–4902**
IJCS 2018; 6(2): 3446-3451

Received: 15-01-2018
Accepted: 16-02-2018

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# Effect of soil and foliar application of macro and micronutrients on nutrient concentration in soil and leaves of mango (*Mangifera indica*) cv. Dashehari

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**Abstract**
The present investigation was carried out at Horticulture Research Centre, Pattharchatta, G. B. Pant University of Agriculture and Technology, Pantnagar, district- Udham Singh Nagar, Uttarakhand during the year 2015-16. The results showed that the foliar application of macro and micronutrients exhibited improvement in fruit set, fruit yield, quality and nutrient status of soil and leaf. The investigation has shown that the application of treatment $T_{10}$: RDF + NPK: 20:20:20 @ 1% (2 Spray: first-15 days and Second- 45 days after fruit set) + foliar spray of $ZnSO_4$ @ 0.4% + Boric acid @ 0.2% + $CuSO_4$ @ 0.2% (2 Spray at just before flowering and marble stage) was found very effective for increasing yield plant$^{-1}$ (228.24 kg).The results related to soil and leaf nutrient status are varied and showed that higher available nitrogen (212.47 kg ha$^{-1}$) in soil was found with the application of $T_{10}$ treatment whereas, the higher available phosphorus (75.79 kg ha$^{-1}$) and potassium (223.46 kg ha$^{-1}$) in soil were found with the application of $T_8$: RDF + IIHR Mango Special @ 5 g/l (2 sprays at two months before flowering and marble stage).The micronutrient status of soil showed that the available boron (1.70 ppm) and iron (22.92 ppm) were found higher in soil with the application of $T_{10}$ treatment However, higher zinc (0.91 ppm), copper (3.24 ppm) and manganese (26.09 ppm) content in soil were found with the application of $T_8$ treatment. The significantly higher leaf nitrogen (1.96 %), phosphorus (0.99 %), potassium (0.87 %), iron (198.27 ppm), boron (19.87 ppm) and manganese (60.88 ppm) were found with the application of $T_8$ treatment whereas, zinc (33.14 ppm) and copper (37.40 ppm) were found higher with the application of $T_7$: RDF + $ZnSO_4$ @ 100 g + $CuSO_4$ @ 50 g + Boric acid @ 50 g (soil application) + Foliar spray of $ZnSO_4$ @ 0.2 % + $CuSO_4$ @ 0.1 % + Boric acid @ 0.1 % (2 sprays at just before flowering and marble stage).

**Keywords:** dashehari, mango, foliar, macro, micronutrients

## Introduction

Mango is the national fruit of India and it has developed its own importance all over the world. Being a useful and delicious fruit, it is a part of culture and religion since long time. Mango can be grown under both tropical and sub-tropical climate. It is originated from Indo-Burma (Myanmar) region (Vavilov, 1926; Popenoe, 1920) [22, 18]. It occupies prime place in fruit crops and has largest area under fruit cultivation in India and it is grown on an area of 2.21 million hectare with annual production of 18.51 million tonnes having productivity of 7.30 metric tons per hectare during the year 2014 (Anonymous, 2015) [2].

The productivity of mango is low at national level due to various factors such as indiscriminate use of chemical fertilizers, scanty use of micronutrients, alternate bearing, fruit drop, mango malformation, spongy tissue and susceptibility to major disease and pests (Iyer and Degani, 1997) [10, 11]. An indiscriminate use of chemical fertilizers paved the way for deterioration of soil health and in turn affect trees with yield and fruit quality. Major elements/ macronutrients are quickly taken up and utilized by the tissues of the plants by catalyzing effect of micronutrients/minor elements (Phillips, 2004) [17]. Nutrients are quickly available to the plants by the foliar application than the soil application (Bahadur *et al*., 1998; Silberbush, 2002) [3]. Moreover, the regular and targeted assessment of mango tree mineral status will facilitate improved management of mango trees. Hence, our aim behind the soil and leaf nutrient study is to observed the current status of macro and micronutrients in crop production and to develop recommendations for farmers and information for extension worker for their adaptability in the field.

Micronutrient deficiency in mango can cause reduced vigour, lower production, smaller fruit size, deformed fruit, gummosis and poor fruit quality. Application of micronutrients to the fruit crops by farmers is less because of lack of proper information or their unawareness about the importance of micronutrients or due to non-availability of micronutrients. Moreover, foliar feeding of macro and micronutrients are more efficient and economical practice in addition to being more environmentally friendly and sustainable.

## Material and Methods

### Treatment Details

- $T_1$ Control (RDF)
- $T_2$ RDF + ZnSO4 @ 200 g + Boric Acid @ 100 g (soil application) in basin after harvest
- $T_3$ RDF + ZnSO4 @ 200 g + CuSO4 @ 100 g + Boric Acid @ 100 g (soil application) in basin after harvest
- $T_4$ RDF + Foliar spray of ZnSO4 @ 0.4 % + Boric Acid @ 0.2 % (2 sprays at just before flowering and marble stage)
- $T_5$ RDF + Foliar spray of ZnSO4 @ 0.4 % + CuSO4 @ 0.2 % + Boric Acid @ 0.2% (2 sprays at just before flowering and marble stage)
- $T_6$ RDF + ZnSO4 @ 100 g + CuSO4 @ 50 g + Boric Acid @ 50 g (soil application) in basin after harvest + Foliar spray of ZnSO4 @ 0.2 % + Boric Acid @ 0.1 % (2 sprays at just before flowering and marble stage)
- $T_7$ RDF + ZnSO4 @ 100 g + CuSO4 @ 50 g + Boric Acid @ 50 g (soil application) in basin after harvest + Foliar spray of ZnSO4 @ 0.2 % + CuSO4 @ 0.1 % + Boric Acid @ 0.1 % (2 sprays at just before flowering and marble stage)
- $T_8$ RDF + IIHR Mango Special @ 5 g/l (2 sprays at two months before flowering and marble stage)
- $T_9$ RDF + NPK: 20:20:20 @ 1 % (2 spray: first- 15 days and Second - 45 days after fruit set) + ZnSO4 @ 200g + Borax @ 100g + CuSO4 @ 100g (Soil application) in basin after harvest
- $T_{10}$ RDF + NPK: 20:20:20 @ 1 % (2 Spray: first-15 days and Second- 45 days after fruit set) + foliar spray of ZnSO4 @ 0.4 % + Boric acid @ 0.2 % + CuSO4 @ 0.2 % (2 Spray at just before flowering and marble stage)

**Note: RDF:** Recommended dose of fertilizers (1000 g N: 750 g P: 1000 g K)
IIHR Mango Special composition (Zn- 0.2 %, Fe- 0.2 %, Cu – 1 %, Mn- 1 %, B – 0.75 % and Mg – 1 %.

**Initial mineral nutrition status of soil:** Soil samples were collected initially before the commencement of experiment *i.e.* before the application of macro and micronutrients in soil as well as leaf.
Available nitrogen: 159.60 kg/ha, phosphorus: 53.26 kg/ha, potassium: 168.45 kg/ha,
Available boron: 0.43ppm, Zinc: 0.62 ppm, Iron: 12.26 ppm, Manganese: 21.45 ppm, Copper: 1.86 ppm.
The soil samples were collected from each replication of each treatment tree after harvesting of fruits for analysis of macro and micro nutrient. The samples were collected from 0-30 cm depth with the help of post hole auger and after collection, each sample was thoroughly mixed and kept in sampling bag with suitable labels. The samples were dried in shade and grounded with the help of pestle morter and passed through 2 mm sieve. The prepared samples were stored in bags with suitable labels. Finally the samples were further analyzed for determination of N, P, K, B, Fe, Zn, Cu and Mn by using following methods: Available nitrogen in soil sample was calculated by alkaline $KMnO_4$ method (Subiah and Asija, 1956) which is based on the extraction of inorganic and readily oxidizable nitrogen from organic compounds. The nitrogen was extracted with 0.32 per cent $KMnO_4$, ammonia distilled by adding 2.5 per cent NaOH and absorbed in 2 per cent boric acid solution containing indicator. The ammonia was estimated through titration using standard hypochloric acid (0.02 N HCl) as standardized method by Tandon (1998). Available phosphorus was determined by Olsen's method (Olsen *et al.*, 1954) [16] using 0.5 N $NaHCO_3$ as an extractant developed blue colour using ascorbic acid (Murphy and Riley, 1962). The intensity of blue colour was recorded on spectrophotometer at 730 nm wavelength. Available potassium in soil was determined by extraction with neutral 1N ammonium acetate (Hanway and Heidal, 1952) [8]. The 5 g soil was taken in 100 ml conical flask, Then 25 ml of neutral 1N ammonium acetate was added and shacked for 5 min and after that the contents were filtered through filter paper (Whatman No. 1). The concentration of potassium was determined by flame photometer. Available boron, iron, zinc, copper and manganese in soil was determined by DTPA extraction method (Lindsay and Norvell, 1978). Ten (10) gram air dried soil sample was weighed in a 150 ml conical flask and 20 ml of DTPA extractant was added to it and kept on horizontal shaker for 2 hours. For extractant preparation, 1.967 g DTPA, 14.9 g TEA and 1.47 g $CaCl_2.2H_2O$ were dissolved in 200 ml distilled water. Sufficient time for dissolution of DTPA was allowed and diluted to approximately 900 ml. The pH of solution was adjusted to 7.3 + 0.05 with 1N HCl and diluted to 1 litre. After shaking, the suspension was filter through Whatman No. 42 filter paper. The resultant filtrate was directly used for estimation of boron, iron, copper, manganese, zinc by atomic absorption spectrophotometer (AAS). To examine the nutrient status of leaf the sampling was done in last week of July, according to guidelines of Chadha *et al.* (1980). From each experimental tree, 30 healthy leaves were collected in paper bag from 5-6 month old new shoots from all the direction around the tree. After sampling the leaves were gently washed in running tap water to remove the dirt, soil particle sand spray residues and then the leaves were washed with distilled water. The washed samples of leaves were put in brown paper bags. The samples were dried in oven at 60 $^0$C ± 1 $^0$C for nearly 48 hours until reaching at constant dry weight. After drying samples were grounded in Willey Mill with a 40-mesh sieve to obtain fine samples. The sample were analysed for macro and micro nutrients. Digestion for nitrogen: The dried sample of 0.2 g of leaves was taken into Kjeidahl flask and digested in 10 ml of concentrated $H_2SO_4$ in presence of 1 g digestion accelerator, prepared by mixing of 2.5 g Selenium dioxide ($SeO_2$), 100 g Potassium sulphate (K2SO4) and 20 g Copper sulphate penta hydrate (CuSO4.5H2O). Digestion for phosphorus, potassium, boron, iron, copper, manganese and zinc take 1 gram of dried sample of leaf was digested with 10 ml diacid mixture (Nitric acid: Perchloric acid, 9:4 v/v) under a ventilated hood (Jackson, 1967). The digestion extract was then filtered through Whatman No. 43 filter paper in 100 ml volumetric flask and final volume was made up to 50 ml by distilled water. The digested sample was used for phosphorus, potassium, boron, iron, copper, manganese and zinc. The data were analysed according to the procedure of analysis for Randomized Block Design as given by Cochran and Cox (1983). The mean values for all parameters were calculated

and analysis of variances (ANOVA) for the characters was accomplished by F-variance test.

**Macronutrients concentration in soil and leaves**

The data on the available nitrogen, phosphorus and potassium in soil and leaves showed in table 1. and fig.1 & 2. The data with respect to available nitrogen showed the significant variation with different treatments. The maximum available nitrogen (212.47 kg $ha^{-1}$) in soil was recorded with the application of $T_{10}$, which was statistically at par with $T_7$. The minimum available nitrogen in soil (170.99kg $ha^{-1}$) was recorded with $T_1$ [control (RDF)], which was statistically at par with $T_3$ (176.50 kg $ha^{-1}$). The maximum phosphorus (75.79 kg $ha^{-1}$) was recorded with the application of $T_{8,}$ which was statistically at par with $T_7$ (73.17 kg $ha^{-1}$). The minimum (61.15 kg $ha^{-1}$) available phosphorus in soil was recorded with $T_3$. Similarly, the maximum available potassium (223.46 kg $ha^{-1}$) was obtained with the application of $T_8$ which was statistically at par with $T_7$ (218.25). The minimum available potassium in the soil (175.92 kg $ha^{-1}$) was recorded with $T_1$ [Control (RDF)]. The data showed that there was significant variation in nitrogen, phosphorus and potassium concentration present in leaf with the application of macro, micronutrients, and their combinations during the period of study. The maximum nitrogen content (1.96 %) was recorded with the application of $T_8$ which was statistically at par with $T_{10}$ (1.91 %). The minimum (1.72 %) nitrogen content was observed with $T_1$ [Control (RDF)]. The higher phosphorus content (0.99 %) in the leaf obtained with the application of $T_8$. The lower phosphorus content (0.67 %) in leaf was recorded with $T_1$ [Control (RDF)]. This might be due to phosphorus uptake by leaves, phosphorus metabolism and translocation to plant or maximum availability of the soil phosphorus and the phonological stage of tree. Similar increase in phosphorus uptake with the increase in application of phosphorus has been reported by Yadav *et al.* (2006) [23] in aonla. Similarly, the higher potassium content (0.87 %) in leaves was recorded in $T_8$ which was statistically at par with $T_{10}$ (0.84 %). The minimum potassium content (0.60 %) in the leaf was recorded in $T_1$ [Control (RDF)] which was statistically at par $T_2$ (0.61%). The higher potassium content in the leaf may be due to application of murate of potash (MOP) in the soil and foliar application in form of (NPK 19:19:19) as a source of potassium which could be easily absorbed by the plants and translocated to the leaves.

**Table 1:** Effect of soil and foliar application of macro and micronutrients on available nitrogen, phosphorus and potassium in soil and leaves under different treatments.

| Treatments # | Available nitrogen in soil (kg $ha^{-1}$) | Available phosphorus in soil (kg $ha^{-1}$) | Available potassium in soil (kg $ha^{-1}$) | Nitrogen in leaves (%) | Phosphorus in leaves (%) | Potassium in leaves (%) |
|---|---|---|---|---|---|---|
| $T_1$ | 170.99 | 63.36 | 175.92 | 1.72 | 0.67 | 0.60 |
| $T_2$ | 187.60 | 65.28 | 193.04 | 1.75 | 0.85 | 0.61 |
| $T_3$ | 176.50 | 61.15 | 198.44 | 1.84 | 0.87 | 0.65 |
| $T_4$ | 183.41 | 69.18 | 206.20 | 1.86 | 0.88 | 0.66 |
| $T_5$ | 199.76 | 72.15 | 212.52 | 1.82 | 0.94 | 0.68 |
| $T_6$ | 184.77 | 71.43 | 207.32 | 1.80 | 0.86 | 0.74 |
| $T_7$ | 206.73 | 73.17 | 218.28 | 1.80 | 0.98 | 0.78 |
| $T_8$ | 185.42 | 75.79 | 223.46 | 1.96 | 0.99 | 0.87 |
| $T_9$ | 194.72 | 71.59 | 209.35 | 1.86 | 0.95 | 0.75 |
| $T_{10}$ | 212.47 | 72.09 | 211.55 | 1.91 | 0.98 | 0.84 |
| SEm± | 1.49 | 1.19 | 1.72 | 0.016 | 0.010 | 0.008 |
| CD (5%) | 4.45 | 3.56 | 5.11 | 0.050 | 0.030 | 0.026 |

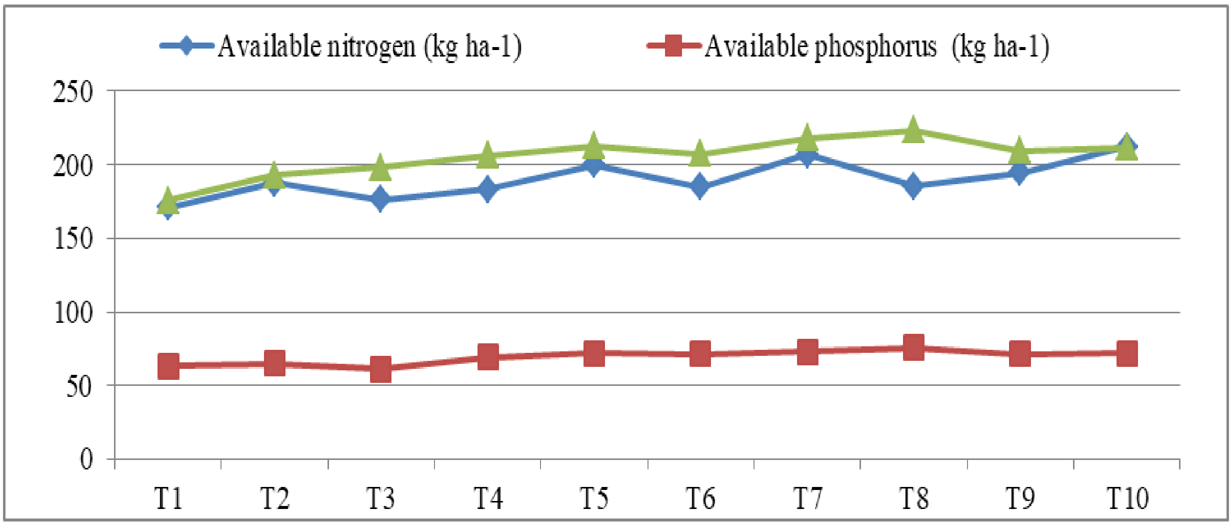


**Fig 1:** Effect of soil and foliar application of nutrients on available nitrogen, phosphorus and potassium in soil under different treatments

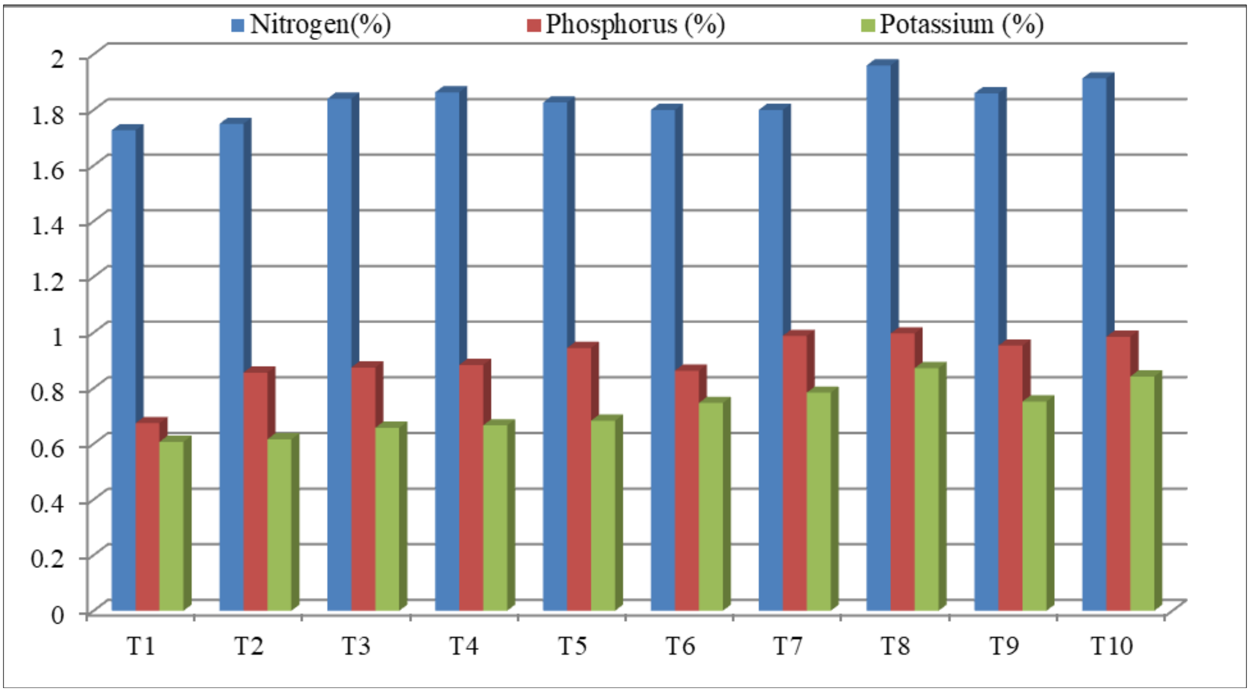


**Fig 2:** Effect of soil and foliar application of nutrients on nitrogen, phosphorus and potassium in leaves of mango cv. Dashehari

**Micronutrients in soil and leaves**

The data related to micronutrient (boron, zinc, copper, iron, manganese) content in soil and leaves given in Table 2, 3 and Figures. The higher available boron (1.70 ppm) content in soil was noted with the application of $T_{10}$. The content of zinc present in soil showed higher value (0.91 ppm) with the application of $T_8$ which was found statistically at par with $T_{10}$ (0.90 ppm). Kailash *et al*. (2012) in mango were also found similar results. The maximum iron content (22.92 ppm) in soil was obtained with the application of $T_{10}$ followed by $T_7$ (21.75 ppm), $T_6$ (21.25 ppm). It was suggested that optimum supply of nitrogen ensures optimum uptake of iron, manganese and zinc from the soils but excessive iron reduces zinc uptake was studied by Ujjwala *et al.* (2011). The content of copper present in the soil indicated the higher (3.24 ppm) value was recorded with the application of $T_8$ [RDF + IIHR Mango Special @ 5 g/l (2 sprays at two months before flowering and marble stage)], which was statistically at par with $T_7$ (3.20 ppm). The content of manganese present in the soil showed the higher value (26.09 ppm) with the application of $T_8$. It was suggested that optimum levels of manganese increases uptake of copper and excessive zinc reduces manganese uptake in soil. The similar results were observed in regard of manganese content in the soil are by Biswas *et al.* (2012) in aonla. The significantly higher boron content (19.87 ppm) in the leaf was recorded in $T_8$, which was found statistically at par with $T_7$ (18.38 ppm). The lower (13.97 ppm) boron content in leaf was recorded in $T_1$ [Control (RDF)]. The higher zinc content (33.14 ppm) in the leaf was obtained with the application of $T_7$. The lower (20.23 ppm) zinc content in the leaf was observed with $T_1$ [Control (RDF)] which was statistically at par with $T_2$ (21.31 ppm) and $T_3$ (22.35 ppm). It was suggested that optimal levels of zinc increase uptake of phosphorus. Zinc is a component of dehydrogenases, proteinase and peptidase enzyme. It promotes growth hormones and starch formation and promotes seed maturation. The results agreement with the findings of Adak *et al*. (2014) in mango. The higher iron content (198.27 ppm) in leaf was observed with $T_8$, which was statistically at par with $T_{10}$ (196.39 ppm). The minimum iron content in the leaf (172.30 ppm) was recorded with $T_1$ [Control (RDF)] which was statistically at par with $T_2$ (174.28 ppm).The data illustrated that the higher copper content (37.40 ppm) was obtained in $T_7$. The lower (25.24 ppm) copper content in the leaf was obtained with $T_1$ [Control (RDF)]. The increase in the copper content in the leaf may be due to the soil properties and more solublization of the bound nutrients making them available to the plants. The data given in Table 3 and Fig. 4 with regard to the manganese content in mango leaf revealed that there was significant increase in manganese content due to the application of macro, micronutrients and their combinations. The higher manganese content (60.88 ppm) in the leaf was recorded in $T_8$, which was found statistically at par with $T_{10}$ (57.17 ppm). The lower manganese content in leaf (41.01ppm) was recorded in $T_1$ [Control (RDF)] which was statistically at par with $T_2$ (42.25 ppm) and $T_3$ (43.22 ppm). It was suggested that the manganese was involved in photosynthesis, metabolism of nitrogen and its assimilation and carbohydrate, it also activates decarboxylase, dehydrogenase and oxidase enzymes thus, with the increasing dose of nitrogen, manganese content also increased in the leaves.

**Table 2:** Effect of soil and foliar application of nutrients on micronutrients (boron, zinc, iron, copper and manganese) in soil under different treatments

| Treatments # | Available boron (ppm) | Available zinc (ppm) | Available iron (ppm) | Available copper (ppm) | Available manganese (ppm) |
|---|---|---|---|---|---|
| $T_1$ | 0.46 | 0.64 | 13.05 | 1.95 | 21.95 |
| $T_2$ | 0.68 | 0.67 | 17.05 | 2.45 | 22.26 |
| $T_3$ | 0.82 | 0.72 | 18.91 | 2.51 | 22.59 |
| $T_4$ | 0.87 | 0.74 | 16.67 | 2.49 | 23.64 |
| $T_5$ | 1.12 | 0.81 | 19.29 | 3.04 | 23.85 |
| $T_6$ | 1.15 | 0.78 | 21.25 | 3.12 | 24.10 |
| $T_7$ | 1.63 | 0.88 | 21.75 | 3.20 | 24.40 |
| $T_8$ | 1.23 | 0.91 | 20.24 | 3.24 | 26.09 |
| $T_9$ | 1.65 | 0.86 | 20.15 | 3.02 | 24.28 |
| $T_{10}$ | 1.70 | 0.90 | 22.92 | 3.05 | 24.72 |
| SEm± | 0.017 | 0.013 | 0.0449 | 0.021 | 0.036 |
| CD (5%) | 0.052 | 0.041 | 0.133 | 0.064 | 0.107 |

**Table 3:** Effect of soil and foliar application of nutrients on boron, zinc, iron, copper and manganese in leaves of mango cv. Dashehari

| Treatments # | Boron (ppm) | Zinc (ppm) | Iron (ppm) | Copper (ppm) | Manganese (ppm) |
|---|---|---|---|---|---|
| $T_1$ | 13.97 | 20.23 | 172.30 | 25.24 | 41.01 |
| $T_2$ | 15.75 | 21.31 | 174.28 | 26.46 | 42.25 |
| $T_3$ | 15.14 | 22.35 | 175.27 | 30.42 | 43.22 |
| $T_4$ | 15.34 | 24.39 | 184.35 | 30.93 | 47.49 |
| $T_5$ | 16.75 | 25.33 | 186.35 | 33.30 | 50.19 |
| $T_6$ | 16.13 | 27.68 | 190.15 | 31.00 | 48.33 |
| $T_7$ | 18.38 | 33.14 | 194.30 | 37.40 | 56.27 |
| $T_8$ | 19.87 | 30.34 | 198.27 | 33.27 | 60.88 |
| $T_9$ | 15.15 | 25.33 | 185.91 | 30.89 | 48.22 |
| $T_{10}$ | 15.46 | 30.98 | 196.39 | 35.47 | 57.17 |
| SEm± | 0.34 | 1.17 | 0.82 | 0.96 | 1.26 |
| CD (5%) | 1.02 | 3.48 | 2.43 | 2.85 | 3.76 |

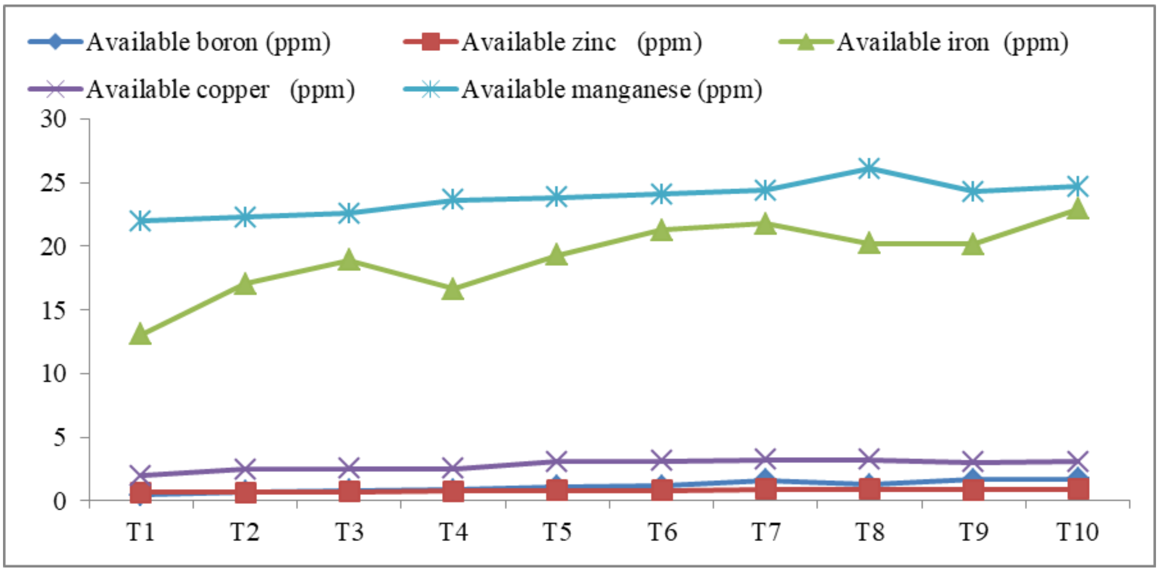


**Fig 3:** Effect of soil and foliar application of nutrients on micronutrients (boron, zinc, iron, copper and manganese) in soil under different treatments

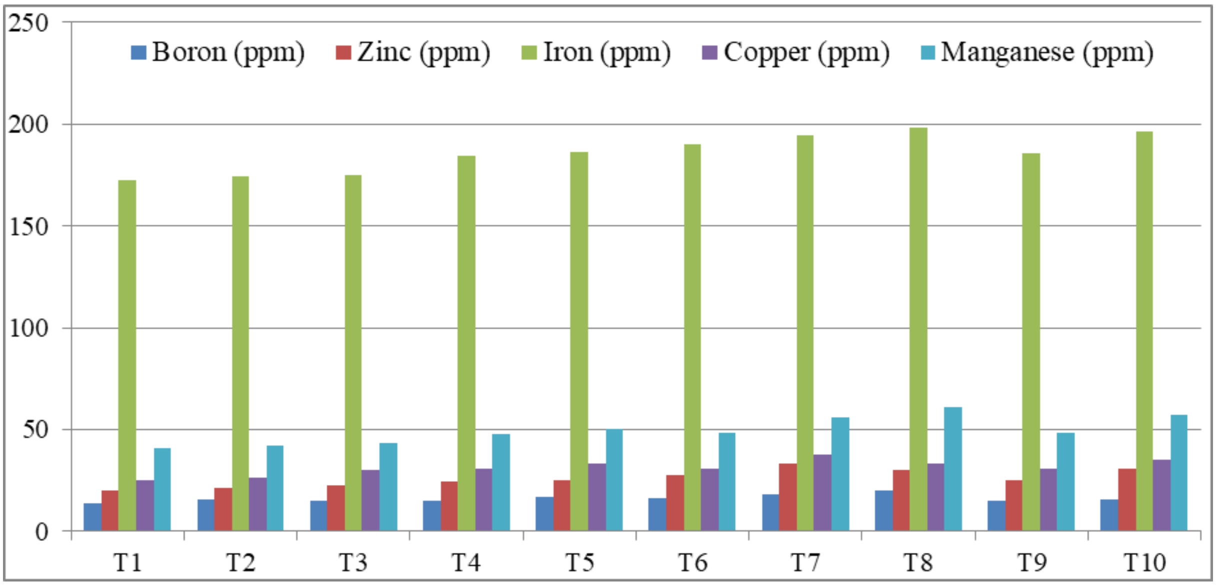


**Fig 4:** Effect of soil and foliar application of nutrients on boron, zinc, iron, copper and manganese in leaves of mango cv. Dashehari

## Conclusion

On the basis of results, it may be concluded that the application of RDF + NPK: 20:20:20 @ 1 % (2 spray: first-15 days and second 45 days after fruit set) + foliar spray of $ZnSO_4$ @ 0.4 % + Boric acid @ 0.2 % + $CuSO_4$ @ 0.2 % (2 spray at just before flowering and marble stage) have been found most effective for increasing the number of fruit yield per plant (228.24 kg), the available nitrogen (212.47 kg $ha^{-1}$), boron (1.70 ppm) and iron (22.92 ppm) in soil. It was found that the application of RDF + IIHR Mango Special @ 5 g/l (2 sprays at two months before flowering and marble stage) have increased the available phosphorus (75.79 kg $ha^{-1}$), potassium (223.46 kg $ha^{-1}$), zinc (0.91 ppm), copper (3.24 ppm), manganese (26.09 ppm) in soil and nitrogen (1.96 %), phosphorus (0.99 %), potassium (0.87 %), boron (19.87 ppm), iron (198.27ppm) and manganese (60.88 ppm) in leaves of mango. Thus, finally it may be concluded that the micronutrients must also be supplied with application of NPK to the plants to have better quality and productivity in mango. To standardize the optimum doses and time of foliar application of macro and micronutrients, the long term study is suggested to arrive at valid recommendation.

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