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Effect of Micronutrients and Sea Weed Sap on Fruit Set, Yield and Quality of Mango (*Mangifera indica* L.) cv. Dashehari

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The present investigation was carried out at GBPUA&T, Pantnagar, U.S. Nagar, Uttarakhand during the year 2015 to study the effect of micronutrients and sea weed sap in mango cv. Dashehari. The investigation has shown that the application of RDF + foliar spray of $ZnSO_4$ @ 0.4 % + $CuSO_4$ @ 0.2 % + Boric acid @ 0.2% (2 sprays at just before flowering and marble stage) was found to be most effective for increasing number of fruits per panicle at pea and marble stage (9.67 and 4.58, respectively), yield plant^{-1} (271.51 kg), yield ha^{-1} (27151 kg), per cent increase in yield (56.40 %), TSS (18.51 ^{o}B), total sugar (12.88 %), ascorbic acid content (43.62 mg 100 g^{-1} pulp) with reduced acidity (0.149 %). The higher fruit weight (221.98 g), fruit length (10.87 cm) and fruit width (6.54 cm) were observed with the application of RDF + 10 % sea weed sap (2 sprays at panicle emergence and marble stage) + $ZnSO_4$ @ 200 g + $CuSO_4$ @ 100 g + Boric acid @ 100 g (soil application). Thus, it is concluded that the basal application of recommended dose of fertilizer (RDF) with foliar spray of micronutrients may be helpful in upliftment of yield and quality of mango cv. Dashehari.

Introduction

Mango belongs to the genus *Mangifera* of the family *Anacardiaceae*, originated from Indo-Burma (Myanmar) region (Vavilov, 1926; Popenoe, 1920). "King of fruits" having sweetness along with delightfully blended acidity holds a prominent place among the fruits of world and most important fruit crop in India having a great cultural, socio-economic and religious significance. In India, the major mango growing states are Uttar Pradesh, Andhra Pradesh, Karnataka, Bihar, Maharashtra, Gujarat, Tamil Nadu, West Bengal and Orissa. As many as 111 countries of the world have been growing mango but India continues to be the largest mango producing country in the world. In India, it is grown on an area of 2.26 million hectares with annual production of 19.69 million tonnes having productivity of 8.70 metric tons per hectare (Anonymous, 2017).

Flowering, fruit setting, fruit development, fruit dropping, fruit ripening and fruit quality are governed by the availability of nutrients (Mengel and Kirky, 1987). The unbalanced fertilization, micronutrients deficiencies, poor management and inadequate cultural practices are mainly responsible for low productivity of

mango and quality related issues at national level. Micronutrients have a potential to improve productivity and quality *vis-a-vis* bringing stability and sustainability in the production system particularly in respect of tropical and sub-tropical fruits. Along with micronutrients, amendment of seaweed liquid fertilizers (SLF) also enhances the soil health by improving moisture-holding capacity and by promoting the growth of beneficial soil microbes. They are considered as an organic farm input to be used under organic and integrated nutrient management farming as they are environmentally benign and safe for the health of animals and humans (Raverkar *et al.*, 2016).

Therefore, considering the above facts and constraints, the present experiment was undertaken to study the effect of micronutrients and sea weed sap on fruit set, yield and quality of mango cv. Dashehari.

Materials and Methods

The field experiment was conducted at Horticulture Research Centreof Govind Ballabh Pant University of Agriculture & Technology, Pantnagar (29.5 ^{o}N latitude, 79.3 ^{o}E longitude and at an altitude of 243.84 meters above the mean sea level) Uttarakhand, India.The soil of the experimental plot has been classified as series II Patharchatta silty clay loam under the Order Mollisol (Deshpande *et al.*, 1971). Soil is dark coloured, imperfectly drained with organic matter content in medium range. The soil has high cation exchange and water holding capacity and also contains about 90 per cent saturation. Twenty-year old bearing mango trees of cv. Dashehari, planted at spacing of 10 m x 10 m, under uniform recommended management practices were selected. The experiment was laid out in a randomized block design with ten treatments replicated thrice with a unit of one plant per treatment per replication. The treatments were applied to individual tree as per the treatment details (Table 1).

The data were analysed according to the procedure of analysis for Randomized Block Design given by Cochran and Cox (1983). The significance of difference between pair of means was tested by the least significant difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Effect of micronutrients and sea weed sap on number of fruit set per panicle (at pea stage and marble stage)

The data related to the fruit set per panicle at pea stage and at marble stage are presented in Table 2. All the treatments showed significant effect on number of fruit set per panicle at pea and marble stage as compared to control. The number of fruit set per panicle at pea stage was recorded maximum (9.67) in T_5 [RDF + foliar spray of $ZnSO_4$ @ 0.4 % + $CuSO_4$ @ 0.2 % + Boric acid @ 0.2 % (2 sprays at just before flowering and marble stage)] followed by T_8 (8.98), T_{10} (8.83) and T_9 (8.75) and the minimum (6.75) was noted in T_1 [Control (RDF)] followed by T_6 (7.99), T_2 (8.00) and T_3 (8.37). Number of fruit set at marble stage showed a significant effect of different combinations of inorganic fertilizers, micronutrients and sea weed sap during the study period. The higher number of fruit set at marble stage (4.58) was obtained with T_5 followed by T_8 (3.83), T_{10} (3.75) and T_9 (3.58), whereas, lower (1.91) was found with T_1. Increase in fruit set might be due to promoting effect of boron on cell division and multiplication as well as cell elongation of the plant.

Boron plays an important role in pollen germination and pollen tube growth which is associated with better pollination, fertilization and fruit setting (Thompson and Batjer, 1950).

Similar findings were also observed by Abd-El Motty (2006) in citrus, Solimanzadeh *et al.,* (2013) in pistachio nut and Mosa *et al.,* (2015) in apple.

Effect of micronutrients and sea weed sap on yield attributes

Fruit yield plant^{-1} and fruit yield hectare^{-1}

The data on fruit yield plant^{-1} and fruit yield hectare^{-1}at the time of harvest are presented in Table 2. The fruit yield plant^{-1} was observed higher (264.17 kg plant^{-1}) with the application of T_5 [RDF + foliar spray of $ZnSO_4$ @ 0.4 % + $CuSO_4$ @ 0.2 % + Boric acid @ 0.2 % (2 sprays at just before flowering and marble stage)] followed by T_8 (242.33 kg plant^{-1}) and T_{10} (232.30 kg plant^{-1}). The lower yield tree^{-1} (168.90 kg plant^{-1}) was recorded in T_1 [Control (RDF)] followed by T_6 (202.42 kg plant^{-1}) and T_7 (217.15 kg plant^{-1}). The significant variation was also found with respect to fruit yield hectare^{-1} and it was ranged from 16890 to 26417 kg ha^{-1}. The maximum fruit yield hectare^{-1} (26417 kg ha^{-1}) was recorded with the application of T_5 followed by T_8 (24233 kg ha^{-1}) and T_{10} (23230 kg ha^{-1}). The minimum fruit yield per hectare (16890 kg ha^{-1}) was obtained with the application of T_1. The significant increase in fruit yield is a cumulative effect of increase in number of fruits because of reduction in fruit drop and also might be due to application of micronutrient that may influence the physiological processes resulting into higher fruit set and production of mango. The results are in conformity with the findings of Dutta and Dhua (2002), Singh *et al.,* (2003), Gaya *et al.,* (2008) and Gurjar *et al.,* (2015) in mango.

Yield efficiency and per cent increase in yield

The data recorded on yield efficiency and per cent increase in yield are presented in Table 2. The data revealed that the yield efficiency showed non-significant results, ranged from 0.465 to 0.551 kg m^{-3}. The maximum yield efficiency (0.551 kg m^{-3}) was obtained with the application of T_5 [RDF + foliar spray of $ZnSO_4$ @ 0.4 % + $CuSO_4$ @ 0.2 % + Boric acid @ 0.2 % (2 sprays at just before flowering and marble stage)] followed by T_8 (0.548 kg m^{-3}) and T_4 (0.537 kg m^{-3}). The minimum yield efficiency (0.465 kg m^{-3}) was obtained with the application of T_1 [Control RDF)]. The results recorded on per cent increase in yield revealed the variations with treatment combinations of inorganic manure, micronutrients and sea weed sap. The data showed that the maximum per cent increase in yield (56.40 %) was obtained with the application of T_5 followed by T_8 (43.45 %) and T_{10} (37.52 %), over the control.

Effect of micronutrients and sea weed sap on physical quality parameters

Fruit weight, fruit size (length and width)

It is apparent from the data presented in Table 3 that all the treatments were differed significantly in their fruit weight. The wide range of fruit weight 164.86 to 221.98 g was observed with various treatments under study. The maximum fruit weight (221.98 g) was recorded in T_{10} [RDF + 10 % Sea weed sap (2 sprays at panicle emergence and marble stage) + $ZnSO_4$ @ 200 g + $CuSO_4$ @ 100 g + Boric acid @ 100 g (soil application) in basin after harvest] which was statistically at par with T_9 (216.98 g), whereas, the minimum fruit weight (164.86 g) was recorded with T_1 [Control (RDF)]. The mean values for fruit length under different treatments varied from 8.16 cm to 10.87 cm. The maximum fruit length (10.87 cm) was recorded in T_{10} which was statistically at par with T_9 (10.49 cm), whereas, the minimum fruit length (8.16 cm) was observed with T_1. A perusal of observation on the fruit width also revealed the significant variation among trees of various treatments. The mean values of fruit

width showed a range of 5.44 cm to 6.54 cm. The maximum fruit width (6.54 cm) was recorded in T_{10} which was statistically at par with T_9 (6.52 cm), whereas, the minimum fruit width (5.44 cm) was recorded with T_1. The increase in fruit weight might be due to increased cell division and expansion. Appreciable improvement in fruit weight, fruit length and fruit diameter by sea weed sap application has also been reported by Chawdhury *et al.,* (2007), Karim *et al.,* (2008) and Ahmed *et al.,* (2014) in mango.

Effect of micronutrients and sea weed sap on chemical quality parameters

Total soluble solids, titratable acidity and total sugars

The critical examination of the data indicated the presence of significant variation for total soluble solids (T.S.S) content with various treatments under study (Table 3 and Fig. 1). The mean values of T.S.S content ranged from 16.21 to 18.51 ^{o}B. Among all the treatments, T_5 [RDF + foliar spray of $ZnSO_4$ @ 0.4 % + $CuSO_4$ @ 0.2 % + Boric acid @ 0.2 % (2 sprays at just before flowering and marble stage)] possessed the higher amount of total soluble solids (18.51 ^{o}B) followed by T_8 (18.30 ^{o}B), however, these values were statistically at par with each other. The lower content (16.21 ^{o}B) of total soluble solids was found in T_1 [Control RDF)]. The enhancement in quality of fruit could be due to the catalytic action of micronutrients. Hence, the foliar applications of micronutrients quickly increase the uptake of macronutrients in the tissues and organs of the plant and decrease the nutritional deficiencies that finally lead to improvement in the fruit quality. In the conducted trial, the maximum titratable acidity (0.309 %) was observed in T_1 [Control (RDF)] which was followed by T_6 (0.285 %) and T_7(0.269 %), whereas, the minimum acidity (0.149 %) was found in T_5 [RDF + foliar spray of $ZnSO_4$ @ 0.4 % + $CuSO_4$ @ 0.2 % + Boric acid @ 0.2 % (2 sprays at just before flowering and marble stage)].

Lower acidity in the fruits results due to higher accumulation of sugars, better translocation of sugars into fruit tissues and conversion of organic acids into sugars. Similar findings were also observed by Beniwal *et al.,* (1992) in grapes and it was also suggested that the rapid utilization of organic acid in respiration at senescence stage of fruits or delayed ripening might have another possible reasons responsible for minimizing the titratable acidity (Goswami *et al.,* 2012). Present results regarding TSS and acidity are in accordance with the findings of Singh *et al.,* (2003), Dutta *et al.,* (2004), Gaya *et al.,* (2008) and Anees *et al.,* (2011) in mango.

It is clear from the data presented in Table 3 that the total sugars were found significantly varying with various treatments under study. The higher total sugar content (12.88 %) was recorded in T_5 [RDF + foliar spray of $ZnSO_4$ @ 0.4 % + $CuSO_4$ @ 0.2 % + Boric acid @ 0.2 % (2 sprays at just before flowering and marble stage)]which was found statistically at par with T_8 (12.34 %), T_4 (12.01 %), T_9 (11.45 %) and T_{10} (11.34 %), whereas, the lower total sugar content (10.62 %) was observed in T_1 [Control (RDF)]. The initial rise in sugar content of fruits might be due to conversion of starch into sugar while decreasing trend of sugar under higher doses of chemicals might be due to consumption of more sugar for respiration during storage. The higher percentage of total sugar might be due to efficient translocation of photosynthates to the fruits by regulation of zinc substances. These results are in agreement with the findings of Dutta and Banik (2007) in guava, Samant *et al.,* (2008) in ber and Goswami *et al.,* (2012) in guava.

Table.1 Treatment details of micronutrient and sea weed sap application on mango cv. Dashehari

Treatment symbol	Treatment details
T_1	Control (RDF)
T_2	RDF + $ZnSO_4$ @ 200 g + Boric acid @ 100 g (soil application) in basin after harvest
T_3	RDF + $ZnSO_4$ @ 200 g + $CuSO_4$ @ 100 g + Boric acid @ 100 g (soil application) in basin after harvest
T_4	RDF + foliar spray of $ZnSO_4$ @ 0.4 % + Boric acid @ 0.2 % (2 sprays at just before flowering and marble stage)
T_5	RDF + foliar spray of $ZnSO_4$ @ 0.4 % + $CuSO_4$ @ 0.2 % + Boric Acid @ 0.2% (2 sprays at just before flowering and marble stage)
T_6	RDF + $ZnSO_4$ @ 100 g + $CuSO_4$ @ 50 g + Boric acid @ 50 g (soil application) in basin after harvest + foliar spray of $ZnSO_4$ @ 0.2 % + Boric acid @ 0.1 % (2 sprays at just before flowering and marble stage)
T_7	RDF + $ZnSO_4$ @ 100 g + $CuSO_4$ @ 50 g + Boric acid @ 50 g (soil application) in basin after harvest + foliar spray of $ZnSO_4$ @ 0.2 % + $CuSO_4$ @ 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 + 10 % Sea weed sap** (2 sprays at panicle emergence and marble stage)
T_{10}	RDF + 10 % Sea weed sap** (2 sprays at panicle emergence and marble stage) + $ZnSO_4$ @ 200 g + $CuSO_4$ @ 100 g + Boric acid @ 100 g (soil application) in basin after harvest

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

Table.2 Effect of micronutrients and sea weed sap on number of fruits and yield attributes of mango cv. Dashehari

Treatments #	Number of fruit set per panicle		Yield attributes			
	At pea stage	**At marble stage**	**Yield plant^{-1}(kg)**	**Yield ha^{-1}(kg)**	**Per cent increase in yield over the control**	**Yield efficiency (kg m^{-3})**
T_1	6.75	1.91	168.90	16890	0.00	0.465
T_2	8.00	2.33	218.65	21865	29.44	0.495
T_3	8.37	2.66	222.40	22240	31.66	0.530
T_4	8.57	3.16	227.76	22776	34.83	0.537
T_5	9.67	4.58	264.17	26417	56.40	0.551
T_6	7.99	3.06	202.42	20242	19.83	0.523
T_7	8.66	3.30	217.15	21715	28.55	0.533
T_8	8.98	3.83	242.33	24233	43.45	0.548
T_9	8.75	3.58	221.43	22143	31.08	0.530
T_{10}	8.83	3.75	232.30	23230	37.52	0.522
CD (5%)	0.39	0.12	9.91	1090.36	-	NS

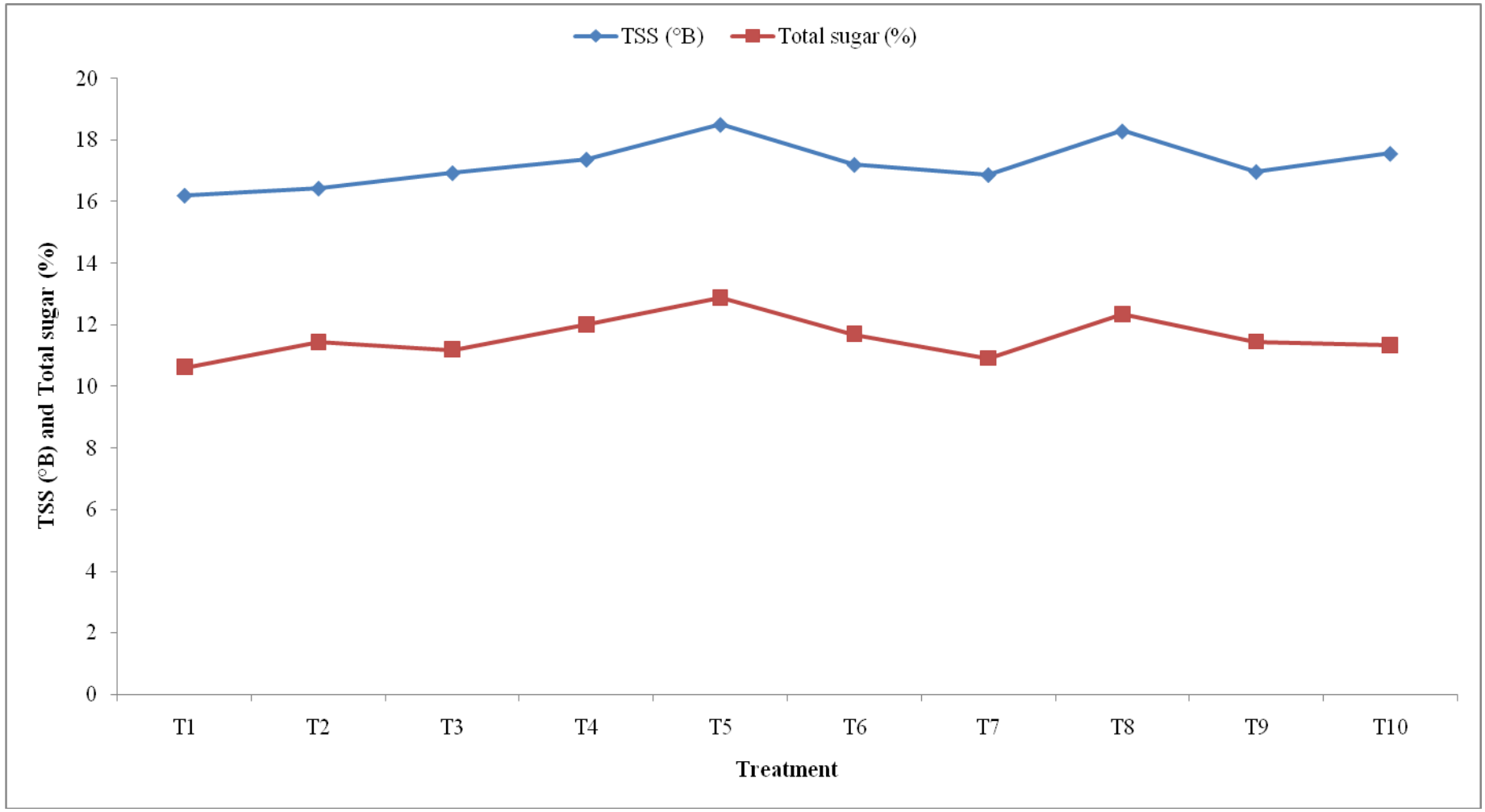
 # See the treatment details from Table 1.

Table.3 Effect of micronutrients and sea weed sap on physical and chemical quality parameters of mango cv. Dashehari

Treatments#	Physical quality parameters			Chemical quality parameters				
	Fruit weight (g)	Fruit size						
		Length (cm)	Width (cm)	TSS (^{0}Brix)	Titratable acidity (%)	Total sugars (%)	Ascorbic acid content (mg 100 g^{-1} pulp)	Total carotenoids content (mg 100 g^{-1} pulp)
T_1	164.86	8.16	5.44	16.21	0.309	10.62	43.82	9.90
T_2	169.89	8.69	5.56	16.44	0.245	11.44	39.60	9.98
T_3	168.44	8.88	5.58	16.94	0.249	11.20	38.00	9.93
T_4	170.53	9.51	5.79	17.38	0.236	12.01	36.80	10.03
T_5	186.25	9.82	5.80	18.51	0.149	12.88	43.62	10.09
T_6	172.56	9.31	5.67	17.21	0.285	11.69	41.31	9.92
T_7	178.66	9.46	5.84	16.88	0.269	10.91	38.00	9.27
T_8	191.73	10.02	5.94	18.30	0.168	12.34	42.84	9.78
T_9	216.98	10.49	6.52	16.98	0.175	11.45	43.32	9.98
T_{10}	221.98	10.87	6.54	17.57	0.178	11.34	41.18	9.77
CD (5%)	8.90	0.46	0.23	0.75	0.91	0.16	1.93	NS

 # See the treatment details from Table 1.

Fig.1 Effect of micronutrients and sea weed sap on TSS and total sugar of mango cv. Dashehari.



Ascorbic acid and total carotenoids content

The data on ascorbic acid and total carotenoids given in Table 3 revealed significant variation with the use of different treatments. The maximum ascorbic acid content (43.82 mg 100 g^{-1}) was calculated with T_1[Control (RDF)] which was found statistically at par with T_5 (43.62 mg 100 g^{-1}), T_9 (43.32 mg 100 g^{-1}) and T_8 (42.84 mg 100 g^{-1}). The minimum ascorbic acid content (36.80 mg 100 g^{-1}) was recorded with application of T_4 [RDF + foliar spray of $ZnSO_4$ @ 0.4 % + Boric acid @ 0.2 % (2 sprays at just before flowering and marble stage)].

As far as total carotenoids content is concerned, the mean values showed that the different treatments were not able to affect the total carotenoids content. The mean value for this parameter exhibited a range of 9.27 to 10.09 mg 100 g^{-1}. In the present trial, maximum total carotenoids content (10.09 mg 100 g^{-1}) was observed in T_5 [RDF + foliar spray of $ZnSO_4$ @ 0.4 % + $CuSO_4$ @ 0.2 % + Boric acid @ 0.2% (2 sprays at just before flowering and marble stage]followed by T_4 (10.03 mg 100 g^{-1}), whereas, the minimum total carotenoids content (9.27 mg 100 g^{-1}) was found in T_7 [RDF + $ZnSO_4$ @ 100 g + $CuSO_4$ @ 50 g + Boric acid @ 50 g (soil application) in basin after harvest + foliar spray of $ZnSO_4$ @ 0.2 % + $CuSO_4$ @ 0.1 % + Boric acid @ 0.1 % (2 sprays at just before flowering and marble stage)]. These results were supported by the findings of Hasan *et al.,* (2013) in mango, Ali *et al.,* (2014) in peach and Ghosh *et al.,* (2014) in sweet orange.

Thus, it is concluded that the application of recommended dose of fertilizer (RDF) with foliar spray of micronutrients may be adopted for improving fruit set, yield and quality of mango cv. Dashehari.

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