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Effect of foliar application of micronutrients on physical parameters of fruit and quality of mandarin orange (*Citrus reticulata* Blanco.) cv. Tamenglong Mandarin

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Abstract
An experiment was conducted at the Horticulture Research Farm (HRF), CAU, Andro, Imphal East during the year 2015 to 2016 to study the "Effect of Foliar Application of Micronutrients on physical parameters of fruit and quality of Mandarin Orange (*Citrus reticulata* Blanco.) cv. Tamenglong Mandarin". The design of the experiment was laid on RBD with 3 replications and 9 treatments to assess the effect of different doses of Boron (T_1=0.3%, T_2=0.4%), Copper (T_3=0.3%, T_4=0.4%), Iron (T_5=0.3%, T_6=0.4%), Zinc (T_7=0.3% T_8=0.4%) and Control (T_o=distilled water). The maximum fruit weight was recorded maximum at treatment T_8 (Zinc @ 0.4 percent) and the minimum was recorded in T_0 (control) with 110.43g and 65.92g respectively. The maximum fruit length and diameter 6.11 cm and 6.29 cm was exhibited by T_8 (Zinc @ 0.4 percent) respectively and the minimum was recorded with T_0 (control) 4.78 cm and 4.98 cm respectively. The maximum juice yield was recorded by application of T_8 (Zinc @ 0.4 percent) with 45.69% and was found significant with all other treatment tested and minimum juice percentage was observed by control (T_0) with 34.97%. Significant differences of vitamin C content was recorded for various treatments with T_8 (Zinc @ 0.4 percent) 29.57mg/100 ml exhibiting the highest vitamin C content and lowest vitamin C content was recorded in T_0 (control) 22.61mg/g. The maximum titratable acidity (0.99%) was recorded in T_0 (control) and minimum was recorded in T_8 (Zinc @ 0.4 percent) at 0.68%. The maximum TSS (9.90^{0}Brix) was recorded in T_8 (Zinc @ 0.4 percent) and lowest by T_0 (Control) at 8.70^{0}Brix. Specific gravity was found maximum by application of T_8 (Zinc @ 0.4 percent) 1.17 and minimum was recorded by T_0 0.94.

Keywords: Mandarin orange, micronutrients, physical parameters, quality

Introduction
Among the Citrus, Mandarin orange (*Citrus reticulata* Blanco.) is one of the most important fruit crops of the globe, extensively cultivated in tropical and sub-tropical climate. Citrus belongs to the sub-family *Aurantioideae* of the family *Rutaceae* and is considered to be originated from the North East region of India eastward through the Malay Archipelago, North into China and Japan and South to Australia and also to New Caledonia and New Guinea (Roose *et al.*, 1995) [13]. The established nutrient values of citrus fruits are beyond providing vitamin C (Nagy 1980) [10]. The fruits are abundant in macronutrients such as simple sugars and dietary fibre, and are rich sources of many micronutrients including folate, thiamin, niacin, vitamin B_6, riboflavin, pantothenic acid, Potassium, Calcium, Phosphorus, Magnesium and Copper which are essential for maintaining health and normal growth (Rouseff and Nagy 1994; Economos and Clay 1999) [14, 5]. Micronutrients are required in very small quantities, yet they are very effective in regulating plant growth. Application of these mineral nutrients in deficiency condition improves the growth and development of citrus tree and also physicochemical composition of fruits.

Application of micronutrients through foliar spray have resulted perceptible changes in several aspects of growth, flowering, fruit set, yield and quality of citrus species (Babu and Yadav, 2005) [3]. Foliar application of nutrients often gives a quicker response than application to soil (Obreza et al., 2010; Anees *et al.*, 2011) [11, 1], since plant nutrients are readily absorbed through the leaf surface. The present study was therefore, carried out to find the suitability of the micronutrients on the vegetative growth and flowering of Mandarin orange.

Materials and Method
The experiment "Effect of Foliar Application of Micronutrients on Growth, Yield and Quality of Mandarin Orange (*Citrus reticulata* Blanco.) cv. Tamenglong Mandarin" was laid out at Horticulture Research Farm (HRF) Andro, Central Agricultural University, Imphal, Manipur

during 2015 and 2016. The experiment was carried out on 5 years old grafted (Rootstock- *Citrus jambhiri* Lush.) Mandarin orange planted at a spacing of 4m x 3m consisted of 9 treatments with 3 replications laid out in Randomized Block Design.

The micronutrients applied were Boron (T_1=0.3%, T_2=0.4%), Copper (T_3=0.3%, T_4=0.4%), Iron (T_5=0.3%, T_6=0.4%), Zinc (T_7=0.3% T_8=0.4%) and Control (T_o=distilled water). The plant growth regulators were sprayed on the plants till the leaves / twigs were wet and droplets of solutions started trickling down. The fruit length and diameter were measured with a Caliper and measuring tape in centimetre and average length and diameter was calculated. The average fruit weight was taken per treatment. The specific gravity of the fruit was measured by water displacement method. The fruits were weighed in balance (w_1), a wide mouth jar was filled with water up to the brim and the fruits were submerged into the water, and the displaced water was collected in the container and measured in the measuring cylinder (w_2) and the specific gravity was determined as:

Specific gravity = Weight of fruits (W_1) ÷ Amount of run off (W_2) or, Quantity of displaced water (W_2). The TSS of the fruit was measured by Erma Hand Refractometer (Japanese Made) and average was recorded.

Juice was extracted from fruit with the help of a hand rotary juice extractor and strained through muslin cloth. The juice was measured with the help of graduated cylinder and percent of juice was worked out by the following formula,

Juice (%) = Volume of juice extracted (ml) ×100÷ weight of fruit (g)

The ascorbic acid was estimated by the Visual titration method as described by Rangana (1977) [12]. The volume of filtered 5ml of juice was made up to 50ml with 3 percent meta phosphoric acid (HPO_3) and centrifuged. Extract of sample was titrated against 0.02% 2-1-6- dichlorophenol indophenol dye. A standard was run simultaneously with pure ascorbic acid solution.

The acidity of juice as anhydrous citric acid was estimated by indicator method (AOAC, 1975) [2]. The acidity percentage was calculated by using the relationship: 1ml of 0.1N Sodium hydroxide is equivalent to 0.0064g of anhydrous citric acid. The data recorded was analysed using the statistical procedure as described by Gomez and Gomez (1984).

Results and Discussion

The results obtained from the present investigation are summarized below:

Effect on fruit weight (g), fruit Length (cm) and fruit diameter (cm)

Significant differences of fruit weight were recorded by various treatments tested. The maximum fruit weight was recorded maximum at treatment T_8 (Zinc @ 0.4 percent) and the minimum was recorded in T_0 (control) with 110.43g and 65.92g respectively. The maximum fruit length and diameter 6.11 cm and 6.29 cm respectively was exhibited by T_8 (Zinc @ 0.4 percent) and the minimum was recorded with T_0 (control) 4.78 cm and 4.98 cm respectively (Table 2). The increase in length and fruit diameter of Mandarin fruit as influenced by application of zinc 0.4 percent also exhibited for better increase in size of fruit. Similar findings were found by Kumar *et al*. (1988) [8] who noted the application of zinc in the form of zinc sulphate was found to be more effective for increasing length and diameter of fruit crops like grapes. Similary, Bhambota *et al.* (1962) [4] also reported the increase in number of fruits, diameter, volume and mean weight of fruits in Citrus.

Effect on percentage of juice yield (%)

The maximum juice yield was recorded by application of T_8 (Zinc @ 0.4 percent) with 45.69% and was found significant with all other treatment tested and minimum juice percentage was observed by control (T_0) with 34.97% (Table 2). Highest juice content were exhibited by zinc @ 0.4% followed by boron 0.4%. This result was in conformity with the findings of Ilyas *et al*. (2015) [6] foliar application of micronutrients (0.3 percent zinc,0.1percent copper and 0.2 percent boron) enhanced juice volume at both sites as compared to other levels of nutrients.

Effect on vitamin C content (mg/100 ml), acidity (%), TSS (^{0}Brix) and Specific gravity of fruits

Significant differences of vitamin C content was recorded for various treatments with T_8 (Zinc @ 0.4 percent) 29.57mg/100 ml exhibiting the highest vitamin C content and lowest vitamin C content was recorded in T_0 (control) 22.61mg/g. The maximum titratable acidity (0.99%) was recorded in T_0 (control) and minimum was recorded in T_8 (Zinc @ 0.4 percent) at 0.68%. The maximum TSS (9.90^{0}Brix) was recorded in T_8 (Zinc @ 0.4 percent) and lowest by T_0 (Control) at 8.70^{0}Brix. Specific gravity was found maximum by application of T_8 (Zinc @ 0.4 percent) 1.17 and minimum was recorded by T_0 0.94 (Table 3). The Vitamin C content of fruit juice was found significant with the application of micronutrient. The value of vitamin C ranges from 22.61 to 29.57mg/100ml. While the value of TSS content of fruits ranges from 8.70 ^{0}Brix to 9.90 ^{0}Brix and was found significant among the treatments tested. Kar *et al*. (2002) [7] reported that the application of micronutrients significantly increased ascorbic acid and TSS ratio. This increase in TSS may be due to increase in photosynthesis activity. Highest specific gravity of 1.17 was obtained with application of zinc 0.4 percent while the lowest value of 0.94 was found in control. Morton *et al*. (1987) [9] also reported that better quality of pineapple was obtained when the specific gravity value attained 1.02 and above.

Table 1: Effect of micronutrients on fruit weight (g), fruit length (cm) and diameter (cm)

Treatment (s)	Fruit weight(g)	Fruit length (cm)	Fruit diameter (cm)
T_1(Boron)0.3%	75.13	5.13	5.25
T_2(Boron)0.4%	89.02	5.13	5.27
T_3(Copper)0.3%	84.50	5.49	5.59
T_4(Copper)0.4%	87.45	5.62	5.75
T_5(Iron)0.3%	81.90	5.68	5.84
T_6(Iron)0.4%	81.68	5.50	5.63
T_7(Zinc)0.3%	104.26	5.87	6.02
T_8(Zinc)0.4%	110.43	6.11	6.29
T_0(Control)	65.92	4.78	4.98
SE(d)±	1.02	0.17	0.17
$CD_{(0.05)}$	2.16	0.35	0.35

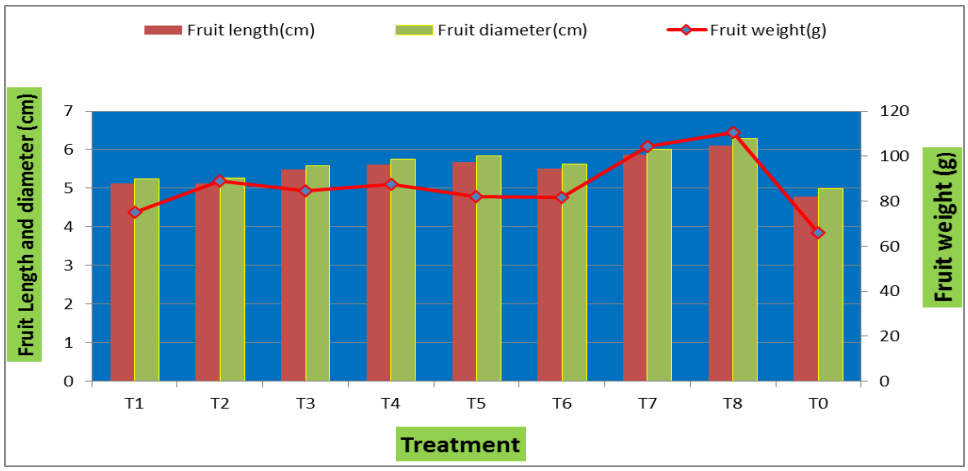

Fig 1: Effect of micronutrient application on fruit weight (g), fruit length (cm) and diameter (cm)

Table 2: Effect of micronutrients on fruit juice yield (%)

Treatment (s)	Fruit juice yield (%)
T_1(Boron)0.3%	41.73
T_2(Boron)0.4%	43.03
T_3(Copper)0.3%	42.19
T_4(Copper)0.4%	42.35
T_5(Iron)0.3%	41.37
T_6(Iron)0.4%	42.77
T_7(Zinc)0.3%	43.01
T_8(Zinc)0.4%	45.69
T_0(Control)	34.97
SE(d) ±	1.39
$CD_{(0.05)}$	2.95

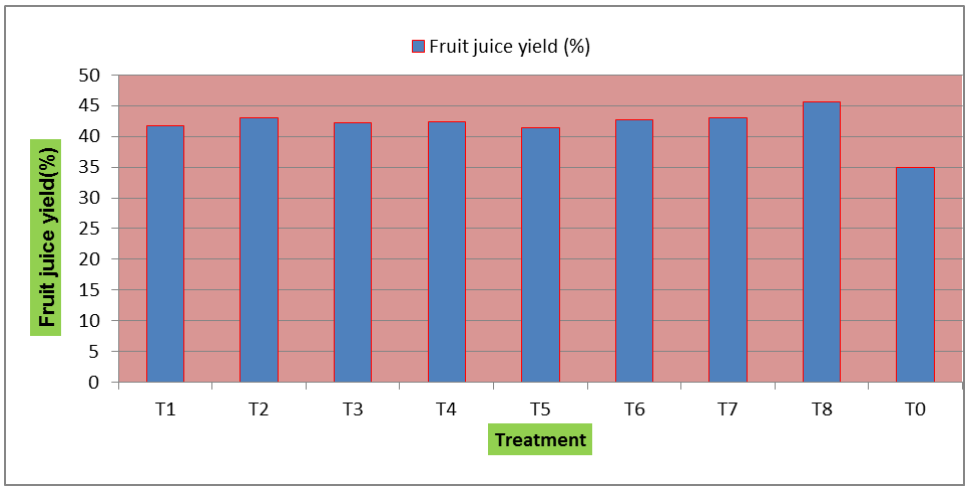

Fig 2: Effect of micronutrient on fruit juice yield (%)

Table 3: Effect of micronutrients application on vitamin C (mg/100ml), Acidity, TSS (^{0}Brix), Specific gravity

Treatment (s)	Vitamin c (mg/100ml)	Acidity	TSS (%)	Specific gravity
T_1(Boron)0.3%	25.70	0.77	9.57	1.02
T_2(Boron)0.4%	27.72	0.71	9.67	1.00
T_3(Copper)0.3%	24.38	0.80	9.53	1.06
T_4(Copper)0.4%	24.99	0.86	9.37	1.14
T_5(Iron)0.3%	26.93	0.77	9.47	1.11
T_6(Iron)0.4%	27.54	0.72	9.53	0.93
T_7(Zinc)0.3%	27.19	0.74	9.63	1.10
T_8(Zinc)0.4%	29.57	0.68	9.90	1.17
T_0(Control)	22.61	0.99	8.70	0.94
SE(d) ±	1.04	0.05	0.22	0.07
$CD_{(0.05)}$	2.21	0.11	0.46	0.15

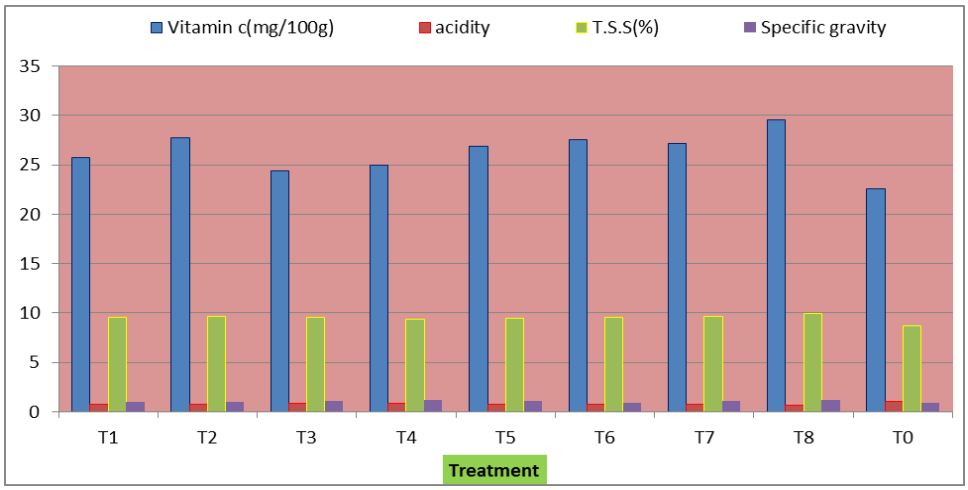

Fig 3: Effect of micronutrient on Vitamin C (mg/100ml), acidity TSS (^{0} Brix) and Specific gravity

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