International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(1): 2134-2138

Received: 01-11-2017
Accepted: 02-12-2017

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Studies on the effect of different micro-nutrients on quality attributing parameters of banana (*Musa paradisiaca* L.) cv. Grand Naine

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Abstract
A field experiment on the "Effect of different micro-nutrients on growth parameters of banana (*Musa paradisiaca* L.) cv. Grand Naine" was carried out at instructional farm Pt. Kishori Lal Shukla College of Horticulture and Research Station (IGKV) Rajnandgaon, Chhattisgarh during the year 2015-16 employing randomized block design having eleven treatments replicates thrice. The treatment consisted eleven different combination of micronutrients along with recommended dose of fertilizers *viz.* RDF + $FeSO_4$ (0.5%), RDF +$ZnSO_4$(0.5%), RDF + $CuSO_4$ (0.2%), RDF +Borax (0.1%), RDF + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.5 %), RDF + $ZnSO_4$ (0.5%) + $CuSO_4$ (0.2 %), RDF + $ZnSO_4$ (0.5%) + Borax (0.1%), RDF + $FeSO_4$ (0.5 %) + $CuSO_4$ (0.2 %), RDF + $FeSO_4$ (0.5 %) + Borax (0.1%), RDF + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.5 %) + $CuSO_4$ (0.2 %) + Borax (0.1%) and water spray (control). The experiment was conducted on banana crop cv. Grand Naine with foliar application of micro-nutrients singly and in combinations along with fertigation of recommend dose of fertilizers applied at 3rd, 5th and 7th month after planting.
The quality parameters of fruit in terms of total soluble solids, reducing, non-reducing, total sugar and ascorbic acid content was proved to be best showing a higher status with the treatment F5. The maximum total soluble solids (23.85%), reducing sugar (11.92%), non-reducing sugar (6.48 %), total sugar (18.40) and ascorbic acid (12.98 mg/100 g) was recorded under the treatment F5 (RDF + ZnSO4 (0.5%) + FeSO4 (0.5 %)), however the minimum was recorded under the treatment RDF+Control. The acidity of fruit decreased by the application of RDF + ZnSO4 (0.5%) + FeSO4 (0.5 %).
The maximum weight of pulp (147.12g) was observed under the superiority of treatment RDF + ZnSO4 (0.5%) + FeSO4 (0.5% however, the minimum (95.84 g) was recorded under the treatment (RDF + control) (F0). The minimum weight of peel (34.59 g) was observed under the treatment F5 (RDF + ZnSO4 (0.5%) + FeSO4 (0.5%) and the maximum weight of peel (42.59 g) was noticed under the treatment F0 (RDF + control). Application of (RDF + ZnSO4 (0.5%) + FeSO4 (0.5 %)) showed significant difference and recorded maximum pulp: peel ratio (4.21), while minimum pulp: peel ratio (2.25) was noticed under the treatment F0 (RDF + Control).

Keywords: Micro-nutrients, Banana, Grand Naine, Foliar spray, quality parameters etc

Introduction
Banana (*Musa paradisiaca* L.) is the most important fruit in the world. It belongs to family Musaceae. Banana is native to tropical South and South East Asia. It has nutritional, medicinal, industrial as well as aesthetic value in Hindu region. Owing to its greater socio-economic significance and multifaceted uses banana is popularly known as *Kalpataru* (A plant with virtues). All parts of the plant including leaves, pseudostem, flower bud and corn can be used in one or another way (Chaddha, 1974) [5]. In India, banana is fourth important food crop in terms of gross value exceeded only by paddy, wheat and milk products. It is also a dessert fruit for millions apart from a staple food owing to its rich and easily digestible carbohydrates with a calorific value of 67-137/100 g edible fruit. It is a good source of vitamin ''A'' (190 IU per 100 g of edible portion) and vitamin ''C'' (100 mg/ 100g) and fair source of vitamin B and B_2.

Banana is one of the most important commercial crops in the world. It is estimated that 87% of banana production is for local food consumption. According to 2012 statistics, India leads the world in banana production by producing around 18% of the world wise crop of 139 million metric tonnes.

Banana is cultivated in the world in an area of 4.80 million ha with global production of99.99 million tonnes having productivity of 20.80 Mt/ha.

India contributes 29 per cent in total world production of banana and ranked first in area and production in the world. In India, banana occupies 20 per cent area (776000 ha) among the total area under fruit crops and produces 25.51 million tonnes with a productivity of 34.20 Mt/ha (Anon., 2013) [1]. Chhattisgarh is one of the State in which banana is produced in an area of 20792 ha having annual production of 498814 metric tonnes with the average productivity of 23.99 Mt/ha (Anon., 2014) [2]. Climate of Chhattisgarh is well-suited for cultivation of banana; therefore it is being grown almost in all districts of Chhattisgarh. Although, production of banana in the country as well as in State is very high, but export quality production is very low. There are number of constraints for export quality production of banana such as lack of exportable varieties, lack of consistency of supply, large tracts of low and unproductive plantation, poor crop management, lack of awareness about essential micro-nutrients, heavy post-harvest losses and all these factors also results for high cost of production. Among management practices, balanced dose of nutrition including micronutrients plays an important role in quality improvement in banana. The role of micro-nutrients for production of quality traits have been already reported by many scientists. Zinc aids in regulating plant growth hormone and enzyme system, necessary for carbohydrate and starch formation, iron (Fe) promotes formation of chlorophyll pigment, which acts as an oxygen carrier involving cell division and growth. Copper (Cu) catalyzes several plant processes like photosynthesis, development of reproductive stage, indirect role in chlorophyll production, increase sugar content, intensifies colour and improves flavour of fruit on ripening and Boron (B) is necessary for translocation of sugars and promotes fruit maturity.

Application of essential nutrients in appropriate quantity is fundamental for various physiological processes in plants. Nutrients like nitrogen, phosphorus and potash play a vital role in promoting the plant vigour and productivity, where micro-nutrients like zinc, boron, copper and molybdenum perform a specific role in the growth and development of plant, quality produce and uptake of major nutrients. The fertilizers applied through soil are also needed in higher quantities because some portion leaches down and some does not become available to the plants due to complex chemical reaction. However, a nutrient management schedule especially for micro- nutrient *i.e.,* Zn, B, Cu and Fe etc. has to be developed, which maintains productivity and quality of banana. Quality attributing parameters are believed to be influenced by foliar application of micro-nutrients. A significant goal of foliar fertilizer studies is to develop cultural practices by which crop nutrient requirements are satisfied through maximum uptake of nutrients from a minimum quantity of applied nutrients. In general foliar application of micro-nutrients gives a better crop response than either band or broadcast application. Foliar application gives flexibility of fertilization, which enables the specific nutritional requirements of the crop to be met at different stages of its growth. Banana cv. Grand Naine is a dominant cultivar in Chhattisgarh State.

Materials and methods

The present investigation entitled ''Studies on the effect of different micro-nutrients on quality attributing parameters of banana (*Musa paradisiaca* L.) cv. Grand Naine‟ was carried out during the year 2015-2016 at instructional farm, Pt. Kishori Lal Shukla College of Horticulture and Research Station (IGKV) Rajnandgaon Chhattisgarh during the year 2015-16 employing randomized block design having eleven treatments replicates thrice. The treatment consisted eleven different combination of micronutrients along with recommended dose of fertilizers *viz.* RDF + $FeSO_4$ (0.5%), RDF +$ZnSO_4$(0.5%), RDF + $CuSO_4$ (0.2%), RDF +Borax (0.1%), RDF + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.5 %), RDF + $ZnSO_4$ (0.5%) + $CuSO_4$ (0.2 %), RDF + $ZnSO_4$ (0.5%) + Borax (0.1%), RDF + $FeSO_4$ (0.5 %) + $CuSO_4$ (0.2 %), RDF + $FeSO_4$ (0.5 %) + Borax (0.1%), RDF + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.5 %) + $CuSO_4$ (0.2 %) + Borax (0.1%) and water spray (control).

The soil of experimental field is sandy-loam, which is locally known as "Matasi‟ in the region. For analysis of nutrient status of experimental soil, the soil sample were collected randomly from 4-5 places up to a depth of 20 cm in the field and mixed up thoroughly to make a composite sample. The composite sample was analyzed for Physico-chemical characters and the results are presented as under:

Chhattisgarh is reputed for producing the best quality of Grand Naine (G-9) banana. Therefore it was selected for the present investigation. The planting materials were healthy tissue culture banana plants of cv. Grand Naine and were procured from tissue culture laboratory Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.).The desired concentrations of micro-nutrients were prepared and sprayed at the interval of 3rd, 5th and 7th month after the planting of banana plants.

All the experimental plants were uniformly maintained and were provided same cultured practices *i.e.* fertilization irrigation and plant protection measures during whole period of investigation. Irrigation and fertilizers has been provided to the plants through the drip system of irrigation.

Results and discussion

Total soluble solids

The highest total soluble solids (23.85 per cent) were recorded under the treatment F5 (RDF + ZnSO4 (0.5%) + FeSO4 (0.5 %)), which showed non-significant differences with F7, F2 and F10 having respective total soluble solids 22.28, 21.38 and 21.27 per cent. Similarly the treatments *i.e.* F6, F8, F10, F2 & F7 and F1, F4, F3, F9, F6, F8 & F10 with total soluble solids 20.13, 20.15, 21.27, 21.38 & 22.28 and 19.35, 19.41, 19.45, 19.50, 20.13, 20.15 & 21.27 per cent, respectively showed statistically at par with each other. The lowest total soluble solids (15.71 per cent) were recorded under the control (F0) showed significantly differed from rest of the treatments under the present investigation.

The significant variation among various treatments has been reported under the present investigation. The highest total soluble solids were recorded under the treatments (RDF + ZnSO4 (0.5%) + FeSO4 (0.5 %)) (F5) and lowest TSS was observed under control (F0). The increase in total soluble solid may be accounted to the hydrolysis of polysaccharides, conversion of organic acids into soluble sugars and enhanced solublisation of insoluble starch and pectin present in cell wall and middle lamella. In conformity of this, similar observations were reported by Ghanta and Mitra (1993) [9] and Yadav *et al.* (2011) [22] in banana, Singh and Brahmachari (1999) [19] in guava.

Acidity

It is revealed from the data that acidity was ranged from 0.26 to 0.96 per cent under the different treatments in present investigation. The treatments F5 (RDF + ZnSO4 (0.5%) + FeSO4 (0.5 %)) recorded minimum per cent of acidity (0.26 per cent), however it was found to be at par with F1 (RDF +

FeSO4 (0.5 %)) having acidity percentage of 0.29. Similarly the treatments F1 & F10 and F10, F9 & F7 and F4, F6 & F8 having respective acidity percentage of 0.29 & 0.33 and 0.33, 0.36 & 0.38 and 0.82, 0.82 & 0.82 showed non-significant differences with each other. The maximum acidity per cent (0.96) was noticed under control (F0) which was recorded significant differences from all other treatments under the present investigation.

The decrease in titrable acidity appears to be due to conversion of acids in to sugars and their utilization as respiratory substrate during growth and development of fruit. The present findings are found similar to those reported by Singh and Chonkar (1983) [17] and Yadav *et al.* (2011) [22] and Yadav and Solanki (2015) [23] in banana.

Total sugar

It is evident from the data that maximum total sugar (18.40 per cent) was recorded under the treatment F5 (RDF + ZnSO4 (0.5%) + FeSO4 (0.5%), which was found statistically at par with treatment F10 (RDF + ZnSO4 (0.5%) + FeSO4 (0.5%) + CuSO4 (0.2%) + Borax (0.1%)) having total sugar of 16.44 per cent. Similarly the treatment F1, F4, F9, F8, F3, F2 & F6 and F9, F8, F3, F2, F6, F7 & F0 having respective total sugars of 13.59, 14.09, 14.39, 14.56, 14.85, 15.26 & 15.57 per cent and 14.39, 14.56, 14.85, 15.26, 15.57, 15.71 & 16.44 per cent showed non-significant differences with each other. The minimum total sugar (12.11 per cent) was observed under the treatment RDF+Control (F0) and was recorded statistically at par with F1 and F4 with respective total sugars of 13.59 and 14.09 per cent.

The total sugar of the fruit was significantly affected by the application different micro-nutrients. The maximum total sugar was recorded under the treatment F5 (RDF + ZnSO4 (0.5%) + FeSO4 (0.5%)), which was found at par with F1 and F4, whereas minimum was obtained under the treatment control (F0). The application of micro-nutrients induced maximum total sugar per cent of fruit. The increase in carbohydrate might be due to quick metabolic transformation of starch and pectin in to soluble compounds and enhanced conversion of organic acids into sugar. The above findings are also in support with the reports of Devi *et al.* (1997) [7] in Sweet orange, Deolankar and Firke (2001) [6] in banana.

Reducing sugar

The maximum reducing sugar (11.92 per cent) was observed under the treatment F5 (RDF + ZnSO4 (0.5%) + FeSO4 (0.5%), which showed non-significant differences with F2, F10 and F6 having 10.84, 10.86 and 11.39 per cent reducing sugar. Moreover the treatments F1, F8, F3, F4, F9 and F7 having respective reducing sugar of 8.41, 8.74, 8.90, 9.20, 9.31 and 9.69 per cent recorded statistically similar with each other. The treatment F0 (RDF + control) showed minimum reducing sugar per cent (8.13).

In general the increase in sugar is mainly due to hydrolysis of starch in to simple sugar, which subsequently increases total soluble solids. In the present investigation, there was a general trend of increasing in reducing sugar under different treatments of micro-nutrient as compared to control. This may be due to hydrolysis of starch into sugar and ultimately observed the more total soluble solids under the application of micro-nutrients. These findings were also in conformity with the findings of Deolankar and Firake (2001) [6] in banana.

Non-reducing sugar

The Maximum non-reducing sugar (6.48 per cent) was recorded under superiority of treatment F5 (RDF + ZnSO4 (0.5%) + FeSO4 (0.5%)), which showed non-significant differences with F7, F3, F8 and F10 having non-reducing sugar percentages of 6.02, 5.95, 5.82 and 5.58, respectively. However the treatment F0 (RDF + control) obtained minimum non-reducing sugar (3.98 per cent) which was observed non-significant differences with F6, F2 and F4, with reducing sugar percentages of 4.18, 4.42 and 4.89, respectively.

Application of micro-nutrients induced maximum non-reducing sugar (F5) while, minimum was recorded under control, (F0). These might be due to conversion of organic acids into sugars. Similar findings were also observed by Ghanta and Mitra (1993) [9], Suresh and Savithri (2001) [21] and Yadav *et al.* (2011) [22] in banana and Dutta and Dhua (2002) [8] in mango.

Ascorbic acid

A preview of the data indicated that banana plants treated by RDF + ZnSO4 (0.5%) + FeSO4 (0.5%), (F5) registered maximum ascorbic acid 12.98 mg/100g pulp, which showed non-significant difference with the treatment F7 having ascorbic acid content of 12.40 mg/100g pulp. The minimum ascorbic acid (9.87 mg/100g pulp) was observed under the treatment F0 (RDF+Control), showed non-significant differences among the treatments F1, F4 and F3 having ascorbic acid content of 10.22, 10.26 and 10.31 mg/100 pulp, respectively.

It is apparently from the data that all the micro-nutrients significantly increased the ascorbic acid content of fruits. The perceptive increase in ascorbic acid content might be due to catalytic influence of micro-nutrients on its biosynthesis or inhibition of its conversion to hydro ascorbic acid by enzyme ascorbic acid oxidase or both. These observations are in close agreement with the reports of Singh and Rajput (1997) [18], Kumar and Jaya Kumar (2001) [11] and Patel *et al.* (2010) [14] in banana. The increase in ascorbic acid content of fruit by micro-nutrient may also be due to perpetual synthesis of glucose - 6- phosphate throughout the growth and development of fruit, which is thought to be precursor of vitamin 'C'. Similar findings were also reported by Patel *et al.* (2010) [14] in banana.

Weight of pulp

The maximum weight of pulp (147.12g) was observed under the superiority of treatment RDF + ZnSO4 (0.5%) + FeSO4 (0.5% (F5), which showed statistically at par with F7 (RDF + ZnSO4 (0.5%) + Borax (0.1%)) having pulp weight of 145.68 g. The minimum weight of pulp (95.84 g) was recorded under the treatment (RDF + control) (F0) and was recorded significant differences among all other treatments. The pulp content of finger was increased by the application of different concentrations of micro-nutrients. The maximum pulp weight (147.12 g) was observed with foliar spray of micro-nutrient *i.e.* ZnSO4 (0.5%) + FeSO4 (0.5%) along with recommended dose of fertilizers. However the minimum pulp weight (95.84 g) was noticed under control (F0).

The increase in pulp weight could be attributed to increased size, diameter and weight of fruits. Moreover, probably there was a greater diversion of photosynthates to sink (Fruit), which ultimately added to the pulp weight. The results corroborates with the findings of Yadav and Solanki (2015) [23], Ghanta and Mitra (1993) [9] and Subramanium and Pillai (1997) [20] in banana. The increased pulp weight by the spray of micro-nutrients were also due to increased cell size and intercellular spaces coupled with accumulation of water, sugars and other soluble solids in greater amount as a result of translocation of metabolites towards the finger.

Weight of peel
The minimum weight of peel (34.59 g) was observed under the treatment F5 (RDF + ZnSO4 (0.5%) + FeSO4 (0.5%)), which was statistically at par with treatments F4, F1, F9, F8 and F3. The maximum weight of peel (42.59 g) was noticed under the treatment F0 (RDF + control).

In present investigation, there was a general trend of decreasing of peel weight in different concentrations of micro-nutrients as compared to control. The reduction in peel weight probably might be due to thin layer of peel under the treatment F5 and F4.

Pulp: peel ratio
It is apparent from the Table 2, the maximum pulp-peel ratio (4.21) was observed under the superiority of treatments F5 (RDF + ZnSO4 (0.5%) + FeSO4 (0.5 %)), which showed significant difference from rest of the treatments under the present investigation. The minimum pulp: peel ratio (2.25) was recorded under the treatment F0 (RDF+ Control) showed significant difference among all other treatments under the present experiment.

The increased pulp: peel ratio by the foliar feeding of micro-nutrients were also due to increased cell size and intercellular spaces coupled with accumulation of water, sugar and other soluble solids in greater amount as a result of translocation of metabolites towards the fingers. These finding are in close agreement with the findings of Ghanta and Mitra (1993) [9], Subramanium and Pillai (1997) [20] and Bauri *et al.* (2014) [3] in banana.

Table 1: Physico-chemical composition of experimental soil

S. No.	Particulars	Analytical Value	Classification	Methods
I Mechanical analysis				
1.	Sand (%)	49.35	Sandy loam (Matasi)	International pipette method (Black, 1965)
2.	Silt (%)	27.36		
3.	Clay (%)	23.29		
II Chemical analysis				
1.	Organic carbon (%)	0.51	Medium	Walkley and Black‟s method (Black, 1965)
2.	Available N (kg/ha)	331.24	Medium	Modified kjeldahl method (Piper, 1966)
3.	Available P2O5 (kg/ha)	23.69	Medium	Olsen method (Olsen, 1954)
4.	Available K2O (kg/ha)	197.18	Medium	Flame photometer (Jackson,1973)
5.	Soil pH	7.39	Normal	Carbon electrode pH meter method Piper, (1967)
III Micro nutrients				
1.	Zinc (mg/ha)	0.20	Low	DTPA Extract zinc (Lindsay and Norvell, 1978)
2.	Iron (mg/ha)	8.10	Medium	DTPA Extract iron (Lindsay and Norvell, 1978)
3.	Copper (mg/ha)	0.18	Low	DTPA Extract copper (Lindsay and Norvell, 1978)
4.	Boron (mg/ha)	0.40	Low	DTPA Extract copper (Lindsay and Norvell, 1978)

Table 2: Quality attributing parameters as influenced by foliar application of micro-nutrients in banana (*Musa paradisiaca* L.) cv. Grand Naine

Notation	Treatments	Total soluble solids (%)	Acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Ascorbic acid (mg/100g)	Weight of pulp (g)	Weight of peel (g)	Pulp :peel ratio
F_0	RDF + Control (water spray)	15.71	0.96	12.11	8.13	3.98	9.87	95.84	42.59	2.25
F_1	RDF + $FeSO_4$ (0.5 %)	19.35	0.29	13.59	8.41	5.18	10.22	108.95	37.13	2.93
F_2	RDF + $ZnSO_4$ (0.5%)	21.38	0.30	15.26	10.84	4.42	11.81	115.98	38.12	3.04
F_3	RDF + Borax (0.1%)	19.45	0.72	14.85	8.90	5.95	10.31	106.29	37.99	2.79
F_4	RDF + $CuSO_4$ (0.2 %)	19.41	0.82	14.09	9.20	4.89	10.26	104.96	36.46	2.87
F_5	RDF + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.5 %)	23.85	0.26	18.40	11.92	6.48	12.98	147.12	34.89	4.21
F_6	RDF + $ZnSO_4$ (0.5%) + $CuSO_4$ (0.2 %)	20.13	0.82	15.57	11.39	4.18	10.92	123.48	39.50	3.11
F_7	RDF + $ZnSO_4$ (0.5%) + Borax (0.1%)	22.28	0.38	15.71	9.69	6.02	12.40	145.68	41.27	3.52
F_8	RDF + $FeSO_4$ (0.5 %) + $CuSO_4$ (0.2 %)	20.15	0.82	14.56	8.74	5.82	10.95	113.98	37.62	3.02
F_9	RDF + $FeSO_4$ (0.5 %) + Borax (0.1%)	19.50	0.36	14.39	9.31	5.08	10.39	111.60	37.43	2.98
F_{10}	RDF + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.5 %) + $CuSO_4$ (0.2 %) + Borax (0.1%)	21.27	0.33	16.44	10.86	5.58	12.01	132.94	41.43	3.20
SEm±		0.91	0.01	0.72	0.50	0.40	0.32	2.14	1.50	0.12
CD at 5 %		2.71	0.05	2.13	1.50	1.19	0.95	6.34	4.44	0.37

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