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Studies on the effect of foliar application of micronutrient mixture on quality attributing parameters of banana (*Musa* AAB) cv. Nendran

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Abstract
The aim of the experiment was to study the effect of foliar application of micronutrient mixture on quality attributing parameters of banana (*Musa* AAB) cv. Nendran. A field experiment was carried out at Regional Agricultural Research Station farm, Nileswar during the year 2015-16 employing randomized Block design having thirteen treatments replicated thrice such that four plants were maintained in each replication. Micro-nutrient mixture was foliar sprayed at 2nd, 4th and 6th month after planting. The quality attributing parameters of fruit in terms of titrable acidity, total soluble solids, pulp to peel ratio, reducing, non-reducing, total sugars, sugar / acid ratio, TSS / acid ratio and per cent loss in weight during ripening and keeping quality of the fruits at ambient condition were significantly improved with the foliar application of micronutrient mixture mostly at 1, 2 and 3 per cent mixture in three sprays. Lesser acidity indicates better quality and the lowest titrable acidity was recorded in T_{11} (3% micronutrient mixture as 3 sprays) whereas control T_{13} recorded the maximum acidity content of fruits. The highest TSS content (30.0 °brix) was found in T_{11} (3% micronutrient mixture as 3 sprays) whereas T_{12} (4% micronutrient mixture as 3 sprays) recorded highest pulp to peel ratio of 3.70. The highest total sugar content (21.3%) and reducing sugar content (19.0%) was recorded with T_{10} (2% micronutrient mixture as 3 sprays) and the highest non-reducing sugar content was recorded in T_5 (1% micronutrient mixture as 2 sprays) whereas T_{11} (3% micronutrient mixture as 3 sprays) recorded the lowest non-reducing sugar content. Highest sugar / acid ratio and keeping quality of the fruits at ambient condition were found in T_{10} (2% micronutrient mixture as 3 sprays). T_{11} (3% micronutrient mixture as 3 sprays) was found to have highest TSS / acid ratio and minimum loss in weight of fruits during ripening.

Keywords: Micronutrient mixture, banana, Nendran, foliar application, quality attributing parameters

Introduction
Micronutrients exist in very small amounts in both soils and plants, but their role is frequently as important as the primary and secondary nutrients. Essential micronutrients include six elements *viz*. zinc, boron, manganese, iron, copper and molybdenum (Stevenson, 1986) [25]. Micronutrients have assumed increasing importance in crop production under present day exploitative agriculture. Intensive cultivation of high yielding varieties with the use of high analysis fertilizers and limited use of manures along with restricted recycling of plant residues are some important factors which have led to accelerate exhaustion of soil micronutrients and this in turn limits the crop production. The availability of the essential micronutrients to plants is often poorly related to their total quantity in the soil.

According to KSPB (2013) [11], after a detailed study in all 14 districts reported that Kerala state soils are deficient in Zn (12%), Cu (15%) and B (59%). The acid leaching environment of Kerala soils is not conducive for retention of boron arrested by highly porous nature dominated by low activity clays, which resulted in widespread deficiency of B. Iron and manganese deficiency is noticed some zones in like Onattukara and coastal sandy tracts. Keeping this in view now Government of Kerala had notified the use of zinc, copper and boron for foliar as well as soil application.

Banana is globally ranked fourth, next to rice, wheat and maize in terms of gross value of production. Presently, it has emerged as the major cash-subsistence crop across all parts of the world (Robinson, 1996) [21] as it is a complete fruit-food with delicious taste, necessary energy and health giving nutrients along with pleasant flavor. 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 B2.

Quality standards have become most important factor for determining monetary yield as well as farmer’s income in case of high value crops like banana.

Any management system should aim to produce quality fruits, besides maximizing productivity (Kumar and Kumar, 2007) [12]. The role of micro-nutrients for production of quality traits have been already reported by several 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 an appropriate balance is fundamental for various physiological processes in plants. Primary nutrients play a vital role in promoting the plant vigour and productivity, whereas micronutrients like zinc, boron, copper and molybdenum perform a specific role in the growth and development of plant, quality of produce and uptake of major nutrients.

The fertilizers applied through soil are needed in higher quantities because some portion leaches down and some does not become available to the plants due to complex chemical reactions happening in soil or adverse soil conditions hindering uptake. The foliar application, therefore, offer a viable alternative way of applying nutrients to fruit plants in such conditions. Micronutrients availability can be enhanced by foliar application of the appropriate mineral forms (Alloway, 1986 [1]; House and Welch, 1989) [8]. Micronutrient content and uptake by plants is better enhanced with foliar application.

Materials and Methods

The present investigation entitled "Studies on the effect of foliar application of micronutrient mixture on quality attributing parameters of banana (*Musa* AAB*)* cv. Nendran" was carried out during the year 2015-2016 at RARS farm, Nileswar employing randomized block design having thirteen treatments replicates thrice. The treatment consisted of twelve different combination of micronutrient mixture along with one control so that totally thirteen treatments was taken. Major nutrients *viz.* N, P, K and other cultural practices were uniformly followed for all plants as per PoP, KAU (2011) [9]. The treatments consisted of 4 levels of micronutrient mixture (1%, 2%, 3% and 4%) sprayed at 3 different intervals. The 3 different spray scheduled were one spray was given at 2 MAP, two sprays at 2 and 4 MAP and three sprays at 2, 4 and 6 MAP. T_1, T_2, T_3 and T_4 - one spray, T_5, T_6, T_7 and T_8 - two sprays and T_9, T_{10}, T_{11} and T_{12} - three sprays of 1, 2, 3 and 4 per cent concentration respectively and T_{13} was control.

Quality parameters of banana such as titrable acidity, Total Soluble Solids (TSS), total sugars, reducing sugars, non-reducing sugars and pulp to peel ratio were analyzed using standard methods. Sugar / acid ratio, TSS / acid ratio, loss in weight during ripening and keeping quality of fruits in ambient condition were also recorded and statistically analyzed and tested for its significance using WASP 2.0 software given by ICARGOA.

Results and Discussion

Acidity

The effect of treatment application on titrable acidity (%) of ripened banana fruits is presented in Table 1. The treatments had notable influence on titrable acidity as compared to control. T_{13} was recorded highest acidity of 0.53% which was on par with T_1 (0.50%), T_2 (0.45%) and T_3 (0.43%) while T_{11} was recorded with minimum acidity of 0.26% followed by T_{10} (0.27%) and T_9 (0.28%).

Highest acidity percentage was found in control plants (0.53%) and lowest acidity was found in 3 sprays of 3 per cent of micronutrient mixture (0.26%) which was status. A reduction in acidity is usually preferred and here it is found that the treatments have reduced the acidity percentage of fruits as compared to that of control. With increasing level and time of application of micronutrient mixture the titrable acidity per cent has been reduced and in case of control it has been increased greatly. The reduction of acidity in micronutrient treated fruit juice might be due to their utilization in respiration and rapid metabolic transformation of organic acids into sugars (Brahmachari *et al*., 1997 [3]; Ningavva *et al*., 2014) [15]. Similar results were also reported by Deolankar and Firake (2001) [4] in banana, Singh *et al*. (2003) [24] in pomegranate, Patil and Hiwarale (2004) [19] in acid lime.

Total soluble solids

The highest total soluble solids content (30.0 °brix) was recorded under the treatment T_{11} (3% micronutrient mixture with 3 sprays) which showed non-significant differences with T_{10} (29.9 °brix), T_9 (29.7 °brix) and T_4 (29.5 °brix). Control T_{13} recorded lowest total soluble solids of 26.3 °brix which was statistically on par with T_1 (26.6 °brix). 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) [6] and Yadav *et al.* (2011) [26] in banana.

Pulp to peel ratio

There was significant difference among the treatments. T_{12} (3 sprays of 4% micronutrient mixture) recorded highest pulp to peel ratio of 3.7 followed by T_{11} (3 sprays of 4% micronutrient mixture) of 3.6. Lowest ratio was found in T_2 (1 spray of 2% micronutrient mixture) of 2.8 which was statistically on par with control T_{13} and T_1 (1 spray of 1% micronutrient mixture). This might be due to foliar application of micronutrients especially B. This might have made rapid synthesis of metabolites particularly carbohydrates and their translocation to the fruits causing relatively greater pulp content. Higher pulp weight and lower peel weight might be due to increasing levels and times of application of micronutrient mixture. This can also be possible as the complexes of polyhydroxy compounds with B can facilitate transport of carbohydrates within phloem tissue (Hewitt, 1963) [7]. These are in agreement with those findings reported by Pathak *et al*. (2011) [18] in banana cv. Martaman, Yadlod and Kadam (2008a) [28] and Ningavva *et al*. (2014) [15] in banana cv. Grand Naine.

Total sugar

It is evident from data that with increasing levels and times of application of micronutrient mixture the total sugar content also increased but it decreased in 3 sprays of 4 per cent micronutrient mixture because of their toxicity effect. Total sugar content of ripened banana fruits was found to be highest in T_{10} (3 sprays of 2 per cent micronutrient mixture) with 21.3% which was found statistically on par with T_9 (21.0%), T_4 (19.7%) and T_{11} (19.4%). This is due to its action on

converting complex substances into simple ones, which enhances the metabolic activity in fruits and it results in increased total sugar of fruit. The minimum total sugar (13.3%) was observed in control (T_{13}) followed by T_1 (14.1%). Similar findings were reported by Paul and Nair (2015) [20] in banana cv. Nendran banana, Pathak *et al*. (2011) [18] in banana cv. Martaman, Yadlod and Kadam (2008b) [29] in banana cv.Shrimanti. The highest sugar content in juice of sweet orange fruits was observed with foliar application of $ZnSO_4$ (0.5%) + $FeSO_4$ (0.4%) + Borax (0.2%) as reported by Kulkarni (2004) [13].

Reducing sugar

The effect of treatment application was highly evident in case of reducing sugar content of fruits and the treatments showed superior and significant differences. Among the treatments, T_{10} (3 sprays of 2% micronutrient mixture) exhibited highest reducing sugar content of 19.0 per cent which showed non-significant difference with T_{11} (17.5%) whereas T_1 (1 spray of 1% micronutrient mixture) recorded lowest reducing sugar content of 9.3% followed by control T_{13} (9.7%). Increased in reducing sugars might be due to that formation and translocation of carbohydrate, which improves the fruit quality as reported by Pathak and Mitra (2008) [17]. With increasing levels and times of application of micronutrient mixture, the reducing sugar content of ripened fruits also increased because of their necessity in fruit quality attributes. At lower level and time of application the reducing sugar content of fruits decreased because its lower concentration may not be enough for enhancing fruit quality attributes. The multi-micronutrient mixture comprised of Zn and B and other micronutrients have an important role in sugar metabolism. Zinc promotes hydrolysis of starch into sugars and B expedites sugar transport across the membrane by a temporary formation of sugar borate complex (Gauch and Dugger, 1953) [5]. Similar results were also reported by Aziz and Wahab (1970) [2], Sharma (1976) [22], Paul and Nair (2015) [20] in banana cv. Nendran, Yadlod and Kadam (2008a) [28] in banana cv. Grand Naine.

Non-reducing sugar

The highest non-reducing sugar content was found in T_5 (2 sprays of 1% micronutrient mixture) with 4.9 per cent while T_{11} (3 sprays of 3% micronutrient mixture) recorded lowest non-reducing sugar content of 1.9%. Paul and Nair (2015) [20] also found that foliar spraying of micronutrient mixture ($ZnSO_4$ - 1.0% + $FeSO_4$ - 0.3% + $CuSO_4$ - 0.2% + H_3BO_3 - 0.2% + $(NH_4)_2MoO_4$ - 0.03%) reduced the non-reducing sugar content of banana cv. Nendran.

Sugar / acid ratio

The influence of treatment application on sugar / acid ratio of ripened banana fruits are presented in Table 2. Highest sugar / acid ratio was found in T_{10} (3 sprays of 2% micronutrient mixture) with 78.7 which were statistically on par with T_{11}, T_9 and T_7. Control T_{13} recorded lowest sugar / acid ratio of 25.3 which was on par with T_1, T_2 and T_3. It might be due to increase in sugar content and decrease in acidity level of fruits by these treatments.

TSS / acid ratio

The effect of treatment application was highly evident in case of TSS / acid ratio of fruits and the treatments showed superior and significant differences. Highest TSS/ acid ratio indicates better fruit quality. Among the treatments, T_{11} (3 sprays of 3% micronutrient mixture) exhibited highest TSS / acid ratio of 116.1 whereas control T_{13} reported lowest TSS / acid ratio of 50.2. With increasing levels and times of application of micronutrient mixture the sugar content of ripened fruits has improved greatly and acidity percent has been decreased. But in case of lower levels the sugar content decreased and acidity per cent increased which led to reduction in sugar / acid ratio and TSS / acid ratio of ripened banana fruit. Similar beneficial effect of foliar application of Zn, Mn B, Cu and Fe on mango, orange, banana and pineapple fruits have been reported by Singh and Rajput (1976) [23] and Nehete *et al*. (2011) [14] in mango, Patel *et al*. (2010) [16] in banana cv. Basrai, Pathak *et al*. (2011) [18] in banana cv. Martaman, Kavitha *et al*. (2000a) [10] in papaya, Yadav and Patel (2013) [27] in banana cv. Grand Naine.

Per cent loss in weight during ripening

Per cent loss in weight from the day of harvest to ripened fruit was recorded and statistically analyzed. Maximum per cent loss in weight was found in control T_{13} with 16.7% while minimum loss was recorded in T_{11} (3 sprays of 3% micronutrient mixture) with 11.9%. With increasing levels and times of application of micronutrient mixture loss in weight during ripening of fruits were reduced. Reduction in weight loss might be due to decreased rate of respiration and transpiration, restricting ethylene accumulation and production in fruits during ripening.

Keeping quality of fruits at ambient condition

Treatment application on keeping quality of fruits was recorded from the day of ripening to the end of saleable or edible life of fruits. Keeping quality of fruits showed notable difference among the treatments which is presented in Table 2. The highest keeping quality of fruits was recorded in T_{10} (3 sprays of 2% micronutrient mixture) with 4.40 days which was statistically on par with T_{11} (3 sprays of 3% micronutrient mixture) with 4.37 days and T_9 (3 sprays of 1% micronutrient mixture) with 4.08 days. T_3 (1 spray of 3% micronutrient mixture) was found have the lowest shelf life of 3.30 days. Foliar spraying of 2 or 3 per cent micronutrient mixture as 3 sprays shown to improve shelf life of ripened fruit as well as minimum loss in weight during ripening. Enhanced shelf life of banana fruits with the application of micronutrient mixture due to their ability to improve the quality of harvested produce. These results are in harmony with those obtained by Paul and Nair (2015) [20] in banana cv. Nendran, Yadlod and Kadam (2008 b,c) [29, 30] in banana cv. Shrimanti and Ardhapuri.

Table 1: Foliar application of micronutrient mixture on titrable acidity, TSS, pulp to peel ratio, total, reducing and non-reducing sugars of ripened banana fruits

Treatments	Titrable acidity (%)	TSS (°brix)	Pulp to peel ratio	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)
T_1	0.50	26.60	2.91	14.07	9.33	4.75
T_2	0.45	27.30	2.79	16.38	12.13	3.88
T_3	0.43	27.70	3.13	17.04	12.25	4.79
T_4	0.38	29.50	3.10	19.70	15.45	4.25
T_5	0.36	28.20	3.41	17.86	12.98	4.89
T_6	0.36	28.70	3.37	17.80	14.05	3.75
T_7	0.29	28.40	3.06	17.46	13.29	4.17
T_8	0.39	28.80	3.61	18.36	13.51	4.85
T_9	0.28	29.70	3.52	20.95	17.25	3.70
T_{10}	0.27	29.90	3.48	21.25	19.00	2.25
T_{11}	0.26	30.00	3.64	19.40	17.50	1.90
T_{12}	0.31	27.70	3.70	16.41	11.98	4.44
T_{13}	0.53	26.30	2.88	13.26	9.68	3.58
S.Em (±)	0.003	0.121	0.050	0.798	0.494	0.508
CD (0.05)	0.112	0.756	0.488	1.946	1.531	1.553

Table 2: Foliar application of micronutrient mixture on sugar / acid ratio, TSS / acid ratio, per cent loss in weight during ripening and keeping quality of fruits at ambient condition

Treatments	Sugar / acid ratio	TSS / acid ratio	Per cent loss in weight during ripening (%)	Keeping quality of fruits at ambient condition (days)
T_1	28.31	53.70	15.00	3.46
T_2	36.84	61.33	14.15	3.38
T_3	40.12	65.33	13.78	3.30
T_4	52.63	78.93	12.50	3.83
T_5	52.92	83.56	14.96	3.43
T_6	50.12	80.85	13.88	3.75
T_7	62.80	102.31	15.96	3.73
T_8	50.15	78.90	16.69	3.43
T_9	74.12	105.20	16.33	4.08
T_{10}	78.70	110.74	12.25	4.40
T_{11}	75.43	116.07	11.87	4.37
T_{12}	53.40	90.17	13.65	3.75
T_{13}	25.34	50.20	16.70	3.43
S.Em (±)	68.512	133.859	1.892	1.130
CD (0.05)	18.036	25.210	2.997	2.316

Conclusion

The results indicated that foliar application of micronutrient mixture as 3 percent micronutrient mixture (T_{11}) and as 2 percent micronutrient mixture (T_{10}) with 3 times of spraying at 2, 4 and 6 months after planting significantly enhances the quality attributing parameters of Nendran banana. Application of micronutrient mixture ensures the balanced supply of nutrients which in turn helps in improving quality attributes of Nendran banana.

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