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INTEGRATION OF FERTIGATION AND CONSORTIUM OF BIOFERTILIZERS AND THEIR EFFECTS ON QUALITY ATTRIBUTES OF BANANA CV. ROBUSTA (AAA)

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Abstract

An experiment was conducted to study the combined effects of fertigation and consortium of biofertilizers on quality attributes in the fruits of banana cv Robusta (AAA) at Indian Institute of Horticultural Research, Bangalore in the year 2010 and 2011. The results indicated that the combined application of fertigation and consortium of biofertilizers did not influence the total soluble solids. However, other quality attributes *viz.*, total sugars, reducing sugars, non reducing sugars, acidity and TSS:Acid ratio were significantly influenced by the combined application of fertigation and consortium of biofertilizers. The treatment of 100% recommended dose of fertilizer through fertigation (RDFTF) with 300 g of consortium of biofertilizers (CBF) recorded 40% higher total sugars as compared to 100% recommended dose of fertilizers through soil (RDFTS) in both main and ratoon crops. Similarly, the reducing and non reducing sugar contents were higher at 100% RDFTF with CBF followed by 75% RDFTF with CBF. Higher levels of fertigation and consortium of biofertilizers resulted in lesser acidity and higher TSS:Acid ratio of fruit pulp in both main and ratoon crops. The combined application of 100% RDFTF with 300 g of CBF recorded 92% and 94% higher TSS:Acid ratio as compared to RDFTS in the main and the ratoon crops, respectively.

Key words : Banana, fertigation, biofertilizers, quality.

Introduction

Banana is an important commercial fruit crop in tropical and sub tropical regions of the world. The fruit is very delicious and sweet. It is a staple food for millions of people all around the world. In India, banana is grown in different states under different climatic conditions (Butani *et al.*, 2012). At present, it has emerged as the major cash-subsistence crop across all parts of the world (Robinson, 1996). In the world of fruits, banana is a complete food fruit packed with all the necessary energy and health giving elements. On account of these properties combined with delicious taste and flavor, it is in great demand in fresh as well as processed form all over the world and has gained commercial popularity in the international fruit trade (Hazarika *et al.*, 2000). For appreciable consumer preference and acceptance in both national and international trade the produce should be with improved quality. Under this backdrop, an experiment was conducted to study the combined effect of fertigation and consortium of biofertilizers in the improvement of quality attributes of banana.

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Materials and Methods

The study was conducted at Indian Institute of Horticultural Research; Bangalore, situated at 13º 58' N and 78ºE at an altitude of 890 meters. Healthy suckers of the cultivar Robusta (AAA) weighing about 0.80 to 1.0 kg each were planted during the first week of January-2010 at a spacing of 1.5x1.5 m (4444 plants ha^{-1}) and the ratoon crop was continued in the year 2011. Single super phosphate in accordance with the treatment was applied in the pit before planting. After fifteen days, the consortium of biofertilizers was incorporated in the pit. Three levels of fertigation *viz.*, 100% Recommended Dose of Fertilizer (RDF) (200:110:200 N:P:K g $plant^{-1}crop^{-1}$), 75% RDF and 50% RDF and three levels (100, 200, 300g $plant^{-1}$ $crop^{-1}$) of consortium of biofertilizers (CBF) (*Azospirillum* sp., Phosphate Solubilizing Bacteria (PSB) and Arbuscular Mycorrhizal (AM) fungi were combined. Besides, there were three more treatments *viz.*, 100% RDF through fertigation (without consortium of biofertilizers), 100% RDF through soil application and farm yard manure with 300 g of consortium of biofertilizers. In total, there were 12 treatment

combinations with three replications and laid out in a randomized block design. Nitrogen and potassium were applied in the form of calcium ammonium nitrate and muriate of potash, respectively. The fertigation was started from 60th day of planting and given at weekly intervals up to 320 days (Reddy *et al.*, 2002) and continued for the ratoon crop once the bunch was harvested. Irrigation was given on daily basis replenishing 80% of evaporation losses (Hegde and Srinivas, 1991). Two emitters were placed for each plant at equal distance of 30 cm from the pseudo stem with a total discharge rate of 4 litre of water hour^{-1} emitter^{-1}. All the suckers were removed periodically until flowering in main crop and one sword sucker per plant was retained for the ratoon crop.

Ten fruits were selected at random from the middle portion of the bunch and when they attained the edible stage the total soluble solid was determined by using a hand refractometer (ERMA -Japan) and expressed as ^{0}brix at 21°C. Similarly, the titrable acidity, total sugar content as well as the reducing and non reducing fractions in the pulp was estimated as per the methods of Ranganna (2000) and expressed in per cent. The data were analyzed using Web Agri Stat Package version WASP 1.0. The data were subjected to one way analysis of variance (ANOVA). Treatment difference was evaluated using least significant difference (LSD) at $p \geq 0.05$.

Results and Discussion

Total Soluble Solids (TSS)

The total soluble solids (TSS) of the fruits was not significantly influenced by the fertigation treatments in both main and ratoon crops. However, the fertigation treatments with or without the combination of consortium of biofertilizers recorded relatively higher TSS, as compared to 100% recommended dose of fertilizers applied through soil (RDFTS) (tables 1 and 2).

Total sugars

In both main and the ratoon crop, the fertigation with consortium of biofertilizers significantly influenced the sugar percentage. The treatment of 100% recommended dose of fertilizers through fertigation (RDFTF) with 300 g of consortium of biofertilizers (CBF) recorded the highest total sugars (17.93%, 18.47%) and non reducing sugars (10.73%, 11.40%) than the rest of the treatments in the main and ratoon crops, respectively. Whereas, the reducing sugars was highest (7.31%, 7.16%) at 100% RDFTF with 100 g of CBF. It was also observed that in both main and ratoon crops, all the three levels of consortium of biofertilizers with 100% and 75% RDFTF recorded significantly higher total sugars, reducing and non reducing sugars than the 100% RDFTS.

Acidity

The acidity ranged from 0.23% (100% RDFTF with 200 g and 300 g of CBF) to 0.40% (100% RDFTS) in the main crop. Significantly higher acidity was recorded at 100% RDFTS as compared to 100 % RDFTF, 100% and 75% RDFTF with CBF. It was observed that, the acidity decreased as the levels of fertigation with consortium of biofertilizers increased.

Similarly, in the ratoon crop also the acidity of the fruits was significantly lower in fertigation treatments combined with consortium of biofertilizers as compared to 100% RDFTS. As the fertigation levels increased the acidity significantly decreased. The lowest acidity (0.22%) was recorded at 100% RDFTF with 200 g and 300 g of CBF and the highest acidity (0.39%) was at 100% RDFTS.

TSS : Acid ratio

In the main and the ratoon crops, 100% RDFTF with 300 g CBF recorded significantly higher TSS : acid ratio (90.65 and 95.45) than the 100% RDFTS (47.13, 49.09). Further, under each level of fertigation, 300 g of CBF resulted in higher TSS: acid ratio. It was also observed that all the three levels of consortium of biofertilizers with 100% and 75% RDFTF recorded significantly higher TSS: acid ratio than the 100% RDFTS. Besides, the TSS: acid ratio reduced with the reduction in the fertigation levels in the main as well as the ratoon crops.

The above results indicated that the quality attributes were significantly influenced by the combined application of fertigation and consortium of biofertilizers in general. Shamsuddin *et al.* (2001) found increased amounts of P and K uptake in banana plants inoculated with PGPR. Though the role of nitrogen in determining quality of fruits is insignificant, the effect of potassium on every fruit quality attributes, especially in banana is notable (Mustaffa, 1987, 1988; Ram and Prasad, 1988). The improved quality in terms of total sugars, and lower acidity and higher TSS: acid ratio in the combined application of fertigation and consortium of biofertilizers can be attributed to the active role of potassium which is involved in carbohydrate synthesis, breakdown and translocation and synthesis of protein and mineralization of physiologically important organic acids. This was obvious from the present results for these characters at 100% RDFTF in combination with 300 g of CBF in both main and ratoon crops. High levels of potassium (200 g K plant^{-1} crop^{-1}) increased all the above fruit quality with a significant reduction in acidity. These effects of higher

Table 1 : Effect of fertigation and consortium of biofertilizers on TSS, Total sugars, Acidity and TSS:Acid ratio (main crop).

Treatment	TSS (°brix)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Acidity (%)	TSS: Acid ratio
1. FYM&300 g CBF	18.25	13.14	5.79	6.98	0.29	62.93
2. 100 % RDFTF&100 g CBF	19.07	17.82	7.31	9.98	0.24	79.46
3. 100% RDFTF & 200 g CBF	19.68	17.82	6.95	10.32	0.23	85.57
4. 100% RDFTF & 300 g CBF	20.85	17.93	6.63	10.73	0.23	90.65
5. 75% RDFTF &100 g CBF	20.35	15.12	5.60	9.04	0.26	78.27
6. 75% RDFTF & 200 g CBF	21.00	15.63	5.79	9.34	0.27	77.78
7. 75% RDFTF & 300 g CBF	21.55	15.98	5.92	9.56	0.25	86.20
8. 50% RDFTF & 100 g CBF	19.03	12.52	5.39	6.77	0.37	51.43
9. 50% RDFTF & 200 g CBF	19.07	12.68	5.20	7.11	0.36	52.97
10. 50% RDFTF & 300 g CBF	19.75	13.93	5.44	8.07	0.33	59.85
11. 100% RDFTF	20.06	14.74	6.05	8.25	0.30	66.87
12. 100%RDFTS	18.85	12.79	5.89	6.56	0.40	47.13
SEm±	**0.96**	**0.74**	**0.30**	**0.42**	**0.01**	**3.56**
CD(P=0.05)	**NS**	**2.18**	**0.87**	**1.24**	**0.04**	**10.45**

RDFTF- Recommended dose of fertilizers through fertigation, **RDFTS-** Recommended dose of fertilizers through soil, **CBF**- Consortium of biofertilizers, **FYM**- farm yard manure.

Table 2 : Effect of fertigation and consortium of biofertilizers on TSS, total sugars, acidity and TSS : Acid ratio (ratoon crop).

Treatment	TSS (°brix)	Total sugars (%)	Reducing Sugars (%)	Non-reducing sugars (%)	Acidity (%)	TSS: Acid ratio
1. FYM&300 g CBF	18.50	13.53	5.95	7.20	0.27	68.52
2. 100 % RDFTF&100 g CBF	20.00	18.35	7.16	10.63	0.23	86.81
3. 100% RDFTF & 200 g CBF	20.50	18.35	6.79	10.98	0.22	92.84
4. 100% RDFTF & 300 g CBF	21.00	18.47	6.47	11.40	0.22	95.45
5. 75% RDFTF &100 g CBF	20.75	15.57	5.76	9.32	0.25	83.13
6. 75% RDFTF & 200 g CBF	21.00	16.10	5.96	9.63	0.26	81.02
7. 75% RDFTF & 300 g CBF	21.55	16.46	6.01	9.93	0.23	93.70
8. 50% RDFTF & 100 g CBF	19.25	12.90	5.39	7.13	0.33	58.33
9. 50% RDFTF & 200 g CBF	19.50	13.06	5.33	7.34	0.35	56.42
10. 50% RDFTF & 300 g CBF	19.00	14.35	5.81	8.11	0.32	59.97
11. 100% RDFTF	21.00	15.18	6.32	8.39	0.29	72.92
12. 100%RDFTS	18.85	13.17	6.13	6.69	0.38	49.09
SEm±	**0.97**	**0.76**	**0.30**	**0.44**	**0.01**	**3.85**
CD(P=0.05)	**NS**	**2.24**	**0.88**	**1.30**	**0.04**	**11.30**

RDFTF- Recommended dose of fertilizers through fertigation, RDFTS- Recommended dose of fertilizers through soil, CBF- Consortium of biofertilizers, FYM-farm yard manure

potassium were due to its involvement in carbohydrate synthesis, breakdown and translocation of starch, synthesis of protein and neutralization of physiologically important organic acids (Tisdale and Nelson, 1966). Many earlier works also firmly established the involvement of K^+ in carbohydrate synthesis and its absolute requirement for the enzyme and starch synthesize activity (Evans and Sorger, 1966; Akatsula and Nelson, 1966; Murata and Akazawa, 1968) apart from fructokinase enzyme activity (Gauch, 1972).

Improvement of quality in banana can also be linked to the role of microbes as increase in fruit quality in terms of fairly high TSS was reported by Tiwary *et al.* (1998) by using microbial inoculants in banana. The beneficial effects of bio-inoculants with respect to quality parameters may also be attributed to higher photosynthetic activity and their role in efficient nutrient uptake (Ustad *et al.*, 2004). Further, in a fertigation system less water than the conventional system of irrigation is utilized. Under the application of less water, the starch hydrolysis was

higher resulting in higher sugar levels (Gates, 1968). This suggests that quality of fruits under fertigation may be improved by manipulating water levels at later stages of bunch development prior to harvest.

In the present investigation, the total sugars increased with the increase in the dose of fertilizers through fertigation and consortium of biofertilizers. Marked increase in total sugars in banana fruit pulp with higher fertilizer doses through fertigation may be due to more accumulation of photosynthates because of high nitrogen and potassium nutrients through combined application of fertigation and consortium of biofertililzers. Similar findings were reported by Natesh *et al.* (1993). Split application of nitrogen and potassium at weekly intervals would have also helped in accumulation of more photosynthates and better availability of nutrients during cropping period which ultimately favored the increase in the total sugar content in banana (Agrawal *et al.*, 1997).

Conclusion

The present findings have clearly indicated that the combined application of fertigation and consortium of biofertilizers significantly enhanced the quality attributes *viz.*, total sugars, reducing and non reducing sugars, acidity and TSS: Acid ratio. Fertigation with 100% recommended doses of fertilizers along with consortium of biofertilizers recorded significantly higher total sugars, reducing and non reducing sugars, TSS: Acid ratio apart from reducing the acidity followed by 75% recommended dose of fertilizers applied through fertigation with the combination of consortium of biofertilizers in both main and ratoon crops of cv. Robusta (AAA). However, the fertigation and consortium of biofertilizers did not significantly influence the total soluble solids (TSS).

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