Indian Journal of Agricultural Sciences **84** (6): 680–3, June 2014/Article

Influence of Integrated Nutrient Management on growth, yield and quality of tissue cultured banana (*Musa* × *paradisiaca*) cv Grand Naine

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Received: 26 February 2013; Revised accepted: 17 April 2014

ABSTRACT

To examine the influence of integrated nutrient management on growth, yield and quality of tissue cultured banana (*Musa* × *paradisiaca* L.) cv Grand Naine, a study was conducted during 2010-11 in the Department of Horticulture, C S Azad University of Agriculture and Technology, Kanpur (UP), India. The experiment was laid out in randomized block design with three replications and ten treatments. It was recorded that the height of pseudostem (150.27 cm), girth of pseudostem (67.98 cm), total number of leaves (34.66), total number of functional leaves at the time of emergence of inflorescence (17.33), length of inflorescence (118.50 cm) were maximum in the plants supplied with 100% RDF of NPK+50 g *Azospirillum*+50 g PSB+50g *Trichoderma harzianum* per plant with earliness in flowering (253.33 days) and flowering to harvesting of bunch (110.00 days) as compared to others. Same treatment also resulted maximum bunch weight (24.50 kg), number of fingers per hand (19.33) and per bunch (160.00), number of hands per bunch (8.33), finger weight (140.00 g), length (20.33 cm), diameter (15.20 cm), TSS (19.26 ^{0}Brix), total sugars (18.66%), pulp percentage (82.17%) and pulp:peel ratio (4.60) with reduced peel percentage (17.83%) and titratable acidity (0.40%).

Key words: *Azospirillum*, Banana cv Grand Naine, Flowering, Growth, NPK, PSB, *Trichoderma,* Quality, Yield

Banana is one of the leading fruit crops and considered as the "Apple of Paradise". In India, banana ranks first accounting for 39.8 per cent of total fruit production with 29.78 million tonnes of total production (Anonymous 2012). By nature, banana is a heavy nutrients feeder crop due to its size, growth rate, rooting pattern and phenomenon of bud differentiation which have positive relationship with the yield (Hazarika and Ansari 2010). In recent years, a new approach for utilization of available resources, viz. organic, inorganic and microbial inoculants with an integrated approach for sustainable economic yield termed as Integrated Nutrient Management (INM) has emerged which has already been receiving wide attention and are contributing substantially towards acceleration of crop productivity by maintaining chemical, physical and biological balance in soil-plant system. Bio-fertilizers such as *Azospirillum* and PSB are used in crops as soil application which results significantly increase in yield of crop with lower in soil p^H and make dissolution of bound forms of phosphate to available form. *Trichoderma* spp frequently enhances root growth and development, crop productivity, resistance to abiotic stresses and the uptake and use of nutrients (Gary *et al*. 2004).

Based on M Sc Ag (Horticulture) thesis of first author submitted to C S Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh 208 002.

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MATERIALS AND METHODS

Tissue cultured plants of banana cultivar Grand Naine were brought from the Government Tissue Culture Unit, Lucknow and planted in the garden of Horticulture Department of C S Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India. The planting was done at a spacing of 2 m × 2 m in the month of August. NPK, bio-fertilizers and *Trichoderma harzianum* were applied in the soil at the time of planting following treatment schedule. The experiment was laid out in randomized block design with three replications and ten treatments, viz. T_1 -100% RDF of NPK (110:30:330 g NPK), T_2 -100% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50g *Trichoderma harzianum*, T_3 -75% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum*, T_4 -50% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum*, T_5 -25% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum*, T_6 -50% RDF of N + 100% RDF of PK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum*, T_7 -50% RDF of P + 100% RDF of NK + 50 g *Azospirillum* + 50 g

PSB + 50 g *T. harzianum*, T_8 -50% RDF of K + 100% RDF of NP + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum*, T_9 -50% RDF of N + 100% RDF of PK + 50 g *Azospirillum* + 50 g *T. harzianum* and T_{10} -Control (without fertilizers). Observations were made on different vegetative and reproductive growth as well as yield and quality attributes. Other cultural practices like weeding, earthing up, desuckering, propping, irrigation, insect-pest and disease management were common in all treatments.

RESULTS AND DISCUSSION

Vegetative characters

Data presented in Table 1 clearly revealed that various treatments differed significantly in respect of different vegetative characters. The tallest plants (150.27 cm) with maximum pseudostem girth (67.98 cm) were produced in T_2(100% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum)* treatment, whereas, smallest plants (128.66 cm) with least pseudostem girth (56.92 cm) were recorded in untreated control plants (Table 1). The increase in height and girth of pseudostem might be due to the improvement of physical properties of soil, higher nutrients uptake and increased activity of micro-organisms which were manifested in the form of enhanced growth and higher carbohydrates production as explained by Kumar *et al.* (2008) and Hassan *et al.* (2001) in banana.

Table 1 Effect of INM on the vegetative characters of tissue cultured banana cv Grand Naine

Treatment	Pseudostem height at shooting (cm)	Pseudostem girth (cm)	Total number of leaves per plant	Number of functional leaves per plant
T_1	132.66	60.16	25.66	11.00
T_2	150.27	67.98	34.66	17.33
T_3	148.66	67.06	34.33	16.66
T_4	145.00	66.00	32.00	14.33
T_5	136.33	64.16	28.00	12.00
T_6	142.66	65.46	30.66	13.33
T_7	147.03	66.28	33.33	15.66
T_8	140.33	65.02	29.33	12.66
T_9	134.33	63.08	27.00	11.66
T_{10}	128.66	56.92	23.33	10.33
SEm±	0.33	0.73	0.70	0.90
CD (P = 0.05)	0.98	2.18	2.07	2.66

T_1-100% RDF of NPK (110 + 30 + 330g NPK),T_2-100% RDF of NPK+50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum,*T_3-75% RDF of NPK+50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum,*T_4-50% RDF of NPK+50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum,*T_5-25% RDF of NPK+50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum,*T_6-50% RDF of N + 100% RD of PK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum,*T_7-50% RDF of P + 100% RDF of NK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum,*T_8-50% RD of K + 100% RD of NP + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum,*T_9-50% RDF of N + 100% RDF of PK + 50 g *Azospirillum* + 50 g *T. harzianum,*T_{10}-Control (without fertilizers and bio-fertilizers).

Perusal of data presented in Table 1 clearly revealed that the maximum number of leaves (34.66) and number of functional leaves (17.33) per plant at the time of emergence of inflorescence were noticed in 100% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum* (T_2) treatment, whereas, these number were recorded lowest under control (T_{10}). These findings are in complete agreement with that of Gogoi *et al.* (2004) in banana. The increase in vegetative growth and other parameters might be due to the production of more chlorophyll content with the inoculation of nitrogen fixers. Increased number of leaves might have increased the photosynthetic activity resulting in higher accumulation of carbohydrates.

Flowering and yield characters

Data pertaining to Table 2 revealed that the maximum inflorescence length (118.50 cm) and minimum duration from planting to flowering (253.33 days) was recorded with 100% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum* (T_2) treatment, whereas, the minimum inflorescence length (89.33 cm) and maximum duration (265.33 days) from planting to flowering were recorded in control (T_{10}). This earliness in flowering might be due to simultaneous transport of growth substances like cytokinin to the auxiliary bud. These results have got the support of the findings of Hazarika and Ansari (2010) in banana.

The duration from flowering to harvesting was recorded minimum (110.00 days) in T_2, whereas, it was maximum (132.00 days) in untreated (T_{10}) plants (Table 2). These results have got the support of the findings of Tripathi *et al.* (2010) in strawberry and Singh and Singh (2009) in strawberry, who got advanced duration of harvesting (earliness) by approximately one month which obviously extended the period of harvesting.

The maximum weight of finger (140.00 g) and bunch (24.50 kg) was recorded in the plants fertilized with the 100% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum* (T_2), whereas, these values were recorded minimum (112.00 g and 15.00 kg, respectively) in untreated (T_{10}) plants (Table 2). Relatively higher amount of carbohydrates could have promoted the growth rate, bunch size and in turn increased the bunch weight. These findings are in line with the findings of Hazarika *et al.* (2011) in banana.

The maximum number of hands (8.33), number of fingers per hand (19.33) and fingers per bunch (160.00) were recorded when the plants were fertilized with 100% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum* closely followed by 75% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum* (8.00, 19.00 and 152.66, respectively). This increase in number of fingers per hand and per bunch may be due to the facts that bio-fertilizers, i e nitrogen fixers not only increased the availability of nitrogen to the plant roots but also increased their translocation from root to flower through plant foliage (Singh and Singh 2009) and ultimately increase the number of fingers.

Table 2 Effect of INM on the reproductive characters of tissue cultured banana cv Grand Naine

Treatment	Inflorescence length (cm)	Days taken from planting to flowering	Days taken from flowering to harvesting (Days)	Bunch weight (kg)	Finger weight (g)	Number of fingers per hand	Number of fingers per bunch	Number of hands per bunch
T_1	95.66	264.00	128.66	17.00	115.00	14.66	118.00	5.66
T_2	118.50	253.33	110.00	24.50	140.00	19.33	160.00	8.33
T_3	114.50	254.66	113.66	23.00	135.00	19.00	152.66	8.00
T_4	109.33	257.66	119.33	21.50	130.00	17.00	138.66	7.33
T_5	101.50	262.00	124.33	18.66	122.33	15.66	124.33	6.33
T_6	107.00	258.66	120.66	20.00	127.00	16.66	132.66	7.00
T_7	112.66	256.00	118.00	22.00	132.66	17.33	145.66	7.66
T_8	104.33	260.66	122.00	20.25	125.00	15.33	130.33	6.66
T_9	98.33	263.33	126.00	18.50	117.33	15.00	120.00	6.00
T_{10}	89.33	265.33	132.00	15.00	112.00	13.66	110.00	5.33
SEm±	0.77	1.58	0.78	1.14	2.93	0.91	1.61	0.27
CD (P=0.05)	2.28	4.70	2.33	3.47	8.77	2.75	4.78	0.79

Quality characters

Finger length and diameter were also significantly increased with the use of integrated dose of different nutrients with other bio-fertilizers. The maximum finger length (20.33 cm) and diameter (15.20 cm) were recorded in 100% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum* (T_2) treated plants (Table 3). These results are in accordance with the findings of Hazarika *et al.* (2011) in banana. The increase in finger length and diameter might be due to the better filling of the fruits and their growth with increased uptake of nutrients from soil which has produced enough carbohydrates in the leaf for translocation to the sink for better filling of fruits.

The maximum TSS (19.26 ^{0}Brix) and total sugars (18.66%) contents were recorded in the fingers produced from the plants fertilized with 100% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum* (T_2), whereas, these values were found minimum (15.80 ^{0}Brix and 14.56%, respectively) under control (Table 3). Increase in TSS and total sugars contents with *Azotobacter* and PSB application may be attributed to the quick metabolic transformation of starch and pectin into soluble compounds and rapid translocation of sugars from leaves to the developing fruits. These findings are in agreement with the results of Mishra and Tripathi (2011), Tripathi *et al.* (2010) in strawberry and Attia *et al.* (2009) in Moghrabi banana.

Minimum titratable acidity contents in fingers (0.40%) was recorded in the plants treated with 100% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum* (T_2) followed by 0.61% in 75% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum* (T_3). The view was corroborated with the observations of Singh *et al.* (2009) in ber.

The minimum peel (17.83%) and maximum pulp (82.17%) in fingers were recorded in the plants treated with 100% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum* (T_2), whereas, the reverse trend was recorded under control (T_{10}). The increase in fruit pulp content might

Table 3 Effect of INM on the quality characters of tissue cultured banana cv Grand Naine

Treatment	Finger length (cm)	Finger diameter (cm)	Total soluble solid (^{0}Brix)	Titratable acidity (%)	Total sugars (%)	Total (%)	Total (%)	Pulp/peel ratio
T_1	14.66	10.66	16.03	0.95	15.00	24.26	75.83	3.12
T_2	20.33	15.20	19.26	0.40	18.66	17.83	82.17	4.60
T_3	19.66	14.50	19.00	0.61	18.09	18.85	81.50	4.30
T_4	17.66	13.66	18.00	0.70	17.06	20.30	79.66	3.93
T_5	15.66	12.06	17.01	0.80	16.20	22.14	77.83	3.51
T_6	16.66	13.06	17.85	0.80	16.83	20.80	79.20	3.80
T_7	18.33	14.03	18.70	0.70	17.63	19.16	80.83	4.21
T_8	16.00	12.50	17.56	0.85	16.50	21.84	78.16	3.57
T_9	15.33	11.33	16.56	0.90	15.46	23.69	76.33	3.22
T_{10}	13.66	9.83	15.80	1.10	14.56	25.50	74.50	2.92
SEm±	0.81	0.70	0.24	0.75	0.36	0.33	0.69	0.02
CD (P = 0.05)	2.42	2.09	0.72	(NS)	1.06	0.99	2.04	0.05

be due to on account of incorporation of organic manures and bio-fertilizers along with inorganic fertilizers. Organic manures and bio-fertilizers have direct role in nitrogen fixation, production of phytohormones like substances and increased uptake of nutrients hence quality improvement reflected in fruit character. These observations are in conformity with the findings of Patel *et al.* (2010) in sapota. The maximum pulp/peel ratio (4.60%) were also recorded in the plants treated with 100% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum* (T_2) followed by 75% RDF of NPK + 50 g *Azospirillum* + 50 g PSB + 50 g *T. harzianum* (T_3), whereas, the minimum pulp/ peel ratio (2.92%) were recorded under control. Almost similar results were obtained by Hazarika *et al.* (2011).

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