**Response of Tissue Cultured Banana (*Musa paradisiaca* L.) to Integrated Doses of Plant Nutrients**

**Abstract**

To assess the influence of integrated nutrient management on vegetative and reproductive growth and bunch weight of tissue cultured Banana (*Musa paradisiaca* L.); a field experiment was conducted at Horticulture Garden, Department of Fruit Science, C.S. Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh), India, during the cropping season 2019-2020. The experiment was laid out in randomized block design using three replications and eleven treatments*.* Results obtained from the present study clearly showed that plants supplied with 75% RDF of NPK + 50g *Azotobacter + 50g PSB + 50g T. harzianum*, produced the highest pseudostem height (158.64cm), girth (71.26cm), total number of leaves (35.10), number of functional leaves (18.12), length of inflorescence (120 cm), minimum number of days from planting to flowering (251), number of days from flowering to harvesting (95.33), with maximum bunch weight (26.75 kg), number of fingers per bunch (176.05), number of hands per bunch (8.66), number of fingers per hand (20.33), finger weight (154.18 g), finger length (21.66 cm), finger diameter (16.50 cm) and Yield (66.87 t/ha).

**Keywords**: Banana, Grand Naine, INM, NPK, *Azotobacter*, and PSB.

**Introduction**

Banana (*Musa species*) is an important commercial fruit crop in tropical and sub-tropical regions of the world. The fruits are very delicious and sweet in taste. 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). In India, banana is grown in different states under different climatic conditions. 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). Banana is a monocotyledonous, perennial herb within the order Zingiberales, and the family *Musaceae*. The *Musaceae* is divided into two genera: *Musa* and *Ensete*. *Musa* consist of about 40 species and is distributed through India, New Guinea, Australia and South East Asia (Simmonds, 1962). Integrated nutrient management (INM) is found beneficial for maintenance of soil fertility and plant nutrient supply to an optimum level for sustaining crop productivity through optimization of benefits from all possible sources of plant nutrients in an integrated manner. It was found that early vegetative phase of growth of banana especially up to 3rd/6th month after transplanting and bunch development stage are the critical stages of banana at which yield is affected (Prameela, 2010).

**Materials and methods**

Tissue cultured plants of banana cultivar Grand Naine were brought from the Government Tissue Culture Unit, Lucknow and planted in the Horticulture Garden, Department of Fruit Science, C.S. Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh), India. The planting was done at spacing of 2 m × 2 m. All the treatments were applied in the soil at the time of planting. The experiment was laid out in randomized block design using three replications and eleven treatments. Observations on pseudostem height, girth, total number of leaves, number of functional leaves, length of inflorescence, number of days from planting to flowering, number of days from flowering to harvesting, bunch weight, number of fingers per bunch, number of hands per bunch, number of fingers per hand, finger weight, finger length, finger diameter and yield **(**t/ha). Other different intercultural operations like weeding, earthing up, desuckering, propping, irrigation, insect-pest and disease management were done during crop production period which are common in all treatments.

**Result and discussion**

**Height and girth of pseudostem:** Data presented in the Table 1 clearly revealed that various treatments differed significantly in respect to height and girth of pseudostem. The height and girth of pseudostem were increased significantly with the use of integrated dose of nutrients along with bio-fertilizers. The maximum height (158.64 cm) and girth (71.26 cm) of pseudostem was obtained with the application of 75% RDF of NPK + 50g *Azotobacter* + 50g PSB + 50g *T.* *harzianum* per plant. The height and girth of pseudostem get reduced with the reduction in doses of different levels of chemical and bio-fertilizers and they were minimum under control (125.78 and 51.80 cm, respectively). 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 Hazarika and Ansari (2010) and Nayyer et al. (2014) in banana. These investigations get the support of Tripathi (2017) in banana, Dutta et al., (2010) in papaya and Tripathi et al., (2010) in strawberry.

**Total number of leaves and number of functional leaves per plant:** The total number of leaves and number of functional leaves per plant at the time of emergence of inflorescence were increased significantly with the use of integrated dose of nutrients and bio-fertilizers (Table 1). The maximum number of leaves and number of functional leaves per plant (35.10 and 18.12, respectively) at the time of emergence of inflorescence were produced in the plants treated with 75% RDF of NPK + 50g *Azotobacter + 50g PSB + 50g T. harzianum* per plant, whereas, the minimum number of leaves and number of functional leaves per plant at the time of emergence of inflorescence (23.16 and 10.12, respectively) were recorded in plants which were kept under control (T11) without any treatment. 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 and number of functional leaves might have increased due to the increased photosynthetic activity resulting in higher accumulation of carbohydrates. These findings are in complete agreement with that of Hazarika and Ansari (2010)and Gogoi *et al.,* (2004) and Tripathi (2017) in banana.

**Length of inflorescence:** The maximum length of inflorescence (120.00 cm) was recorded in the plants which were fertilized with 75% RDF of NPK + 50g *Azotobacter + 50g PSB + 50g T. harzianum* per plant. However, the minimum length of inflorescence (91.33 cm) was recorded in the plants under control (T11). This phenomenon may be on account of prolonged growth of plants in the presence of NPK, *Azotobacter* and PSB*.* These findings are in accordance with the reports of Hazarika and Ansari (2010), Nayyer *et al.* (2014) and Tripathi (2017) in banana.

**Number of days from planting to flowering**: The minimum number of days taken from planting to flowering were recorded in the plants which were treated with 75% RDF of NPK + 50g *Azotobacter + 50g PSB + 50g T. harzianum* per plant (251.00 days), whereas, the maximum number of days (267.66 days) taken for flowering were recorded in control (T11) Table 1. The earliness in flowering might be due to simultaneous transport of growth substances like cytokinin to the auxiliary bud and breaks the apical dominance. These results have got the support of the findings of Hazarika and Ansari (2010) Nayyer *et al.* (2014) and Tripathi (2017)in banana.

**Number of days from flowering to harvesting:** the minimum numbers of days (95.33 days) taken from flowering to harvesting were recorded in the plants which were treated with 75% RDF of NPK + 50g *Azotobacter + 50g PSB + 50g T. harzianum* per plant. However, the maximum number of days (125.00 days) taken from flowering to harvesting was recorded in control plants (T11). These results have got the support of the findings of Nayyer *et al.* (2014) and Tripathi (2017) in banana, Tripathi *et al.,* (2010), Singh and Singh (2009) in strawberry, who also got advanced duration of harvesting (earliness) by approximately one month which obviously extended the period of harvesting.

**Number of fingers per bunch, Number of hands per bunch and Number of fingers per hand:** The maximum number of fingers per bunch (176.05), number of hands per bunch (8.66), number of fingers per hand (20.33) and was recorded when the plants were fertilized with 75% RDF of NPK + 50g *Azotobacter + 50g PSB + 50g T. harzianum* closely followed by 75% RDF of N + 100% RDF of PK + 50g *Azotobacter +50g PSB +* 50g *T. harzianum* (168.74 and 8.45, 19.97 respectively). However, minimum number fingers per bunch (104.29), number of hands per bunch (6.66) and fingers per hand (15.66) and were recorded under control (T11) (Table 2). 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. These finding are in agreement with the finding of Hazarika and Ansari (2010), Nayyer *et al.* (2014) and Tripathi (2017) in banana, who also obtained higher numbers of fingers per bunch and per hand with the application of 75% RDF of NPK + 50g *Azotobacter + 50g PSB + 50g T. harzianum*.

**Finger weight and Bunch weight:** The maximum weight of fingers (154.18 g) and bunch (26.75 Kg) was recorded in the plants fertilized with the 75% RDF of NPK + 50g *Azotobacter + 50g PSB + 50g T. harzianum* (T2) followed by 75% RDF of N + 100% RDF of PK + 50g *Azotobacter +50g PSB +* 50g *T. harzianum* (149.27 g and 25.18 Kg, respectively), treated plants whereas the minimum weight of fingers (110.84 g) and bunch (11.55 Kg) was recorded from the untreated control plants (T11) (Table 2). Relatively higher amount of carbohydrates could have promoted the growth rate, bunch size and in turn increased the fingers and bunch weight. These findings are in line with the findings of Patel *et al.,* (2018), Hazarika *et al.,* (2011), Hazarika and Ansari (2010) and Chezhiyen *et al*. (1999) in banana. These findings are in line with the findings of Tripathi (2017), Nayyer *et al.,* (2014) in banana, Tripathi *et al.,* (2014), Tripathi *et al.,* (2016) and Yashasvi *et al.,* (2021) in strawberry.

**Finger length, finger diameter and Yield:** The finger length and diameter were significantly increased with the use of integrated dose of different nutrients with other bio-fertilizers. The maximum finger length (21.66 cm) and diameter (16.50) were recorded in the plants fertilized with 75% RDF of NPK + 50g *Azotobacter + 50g PSB + 50g T. harzianum* (T2) followed by 75% RDF of N + 100% RDF of PK + 50g *Azotobacter +50g PSB +* 50g *T. harzianum* (T5), whereas, the minimum finger length (9.00 cm) and diameter (11.20 cm) were recorded under control (Table 2). These results are in accordance with the findings of Hazarika *et al.,* (2011) Nayyer *et al.* (2014) and Tripathi (2017), Panelo and Diza (2017) in banana. Maximum yield (66.87 t/h) recorded in 75% RDF of NPK + 50g *Azotobacter + 50g PSB + 50g T. harzianum* (T2). This 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. Similar results were also reported by Jeyabhaskaran *et al*., (2001) in banana.

**Conclusion**

Its concluded that plants fertilized with 75% RDF of NPK + 50g *Azotobacter* + 50g PSB + 50g T. *harzianum* per plant significantly increased the height of pseudostem, girth of pseudostem, total number of leaves, total number of functional leaves at the time of emergence of inflorescence, length of inflorescence, gave earliness in flowering and flowering to harvesting of bunch. Maximum weight of bunch with the higher number of fingers per plant, also produced fingers of significantly maximum length, diameter, weight and yield with more benefits, whereas the minimum height of pseudostem, girth of pseudostem, total number of leaves, total number of functional leaves at the time of emergence of inflorescence, length of inflorescence, flowering and flowering to harvesting of bunch was recorded from the plants kept under control. So far as the quality characters of fingers are concerned 75% RDF of NPK + 50g *Azotobacter* + 50g PSB + 50g T. *harzianum* fertilized plants produced fingers with maximum TSS, total sugars, TSS: acid ratio, reducing sugars, non-reducing sugars, sugar: acid ratio, pulp percentage and more pulp/peel ratio, whereas, minimum titratable acidity and peel percent were also found in 75% RDF of NPK + 50g *Azotobacter* + 50g PSB + 50g T. *harzianum* fertilized plants.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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**Table 1: Response of Tissue Cultured Banana (*Musa paradisiaca* L.) to Integrated Doses of Plant Nutrients**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Pseudostem height at shooting (cm)** | **Pseudostem girth (cm)** | **Total number of leaves per plant** | **Number of functional leaves per plant** | **Length of inflorescence (cm)** | **Number of days from planting to flowering** | **Number of days from flowering to harvesting (Days)** |
| **T1** | 135.48 | 58.46 | 29.76 | 13.81 | 104.33 | 260.33 | 101.33 |
| **T2** | 158.64 | 71.26 | 35.10 | 18.12 | 120.00 | 251.00 | 95.33 |
| **T3** | 146.31 | 60.82 | 30.81 | 14.72 | 107.66 | 259.66 | 99.66 |
| **T4** | 126.80 | 59.78 | 25.84 | 11.24 | 93.33 | 265.33 | 115.00 |
| **T5** | 156.76 | 69.42 | 33.91 | 17.36 | 118.00 | 253.33 | 96.33 |
| **T6** | 132.81 | 62.12 | 28.54 | 12.97 | 101.66 | 262.66 | 104.66 |
| **T7** | 149.76 | 65.20 | 30.87 | 16.48 | 113.33 | 257.00 | 97.33 |
| **T8** | 130.44 | 56.12 | 27.10 | 12.14 | 98.66 | 263.66 | 109.00 |
| **T9** | 148.30 | 62.80 | 31.93 | 15.61 | 110.77 | 258.33 | 97.66 |
| **T10** | 128.12 | 52.74 | 26.92 | 11.59 | 95.00 | 264.00 | 112.33 |
| **T11** | 125.78 | 51.80 | 23.16 | 10.12 | 91.33 | 267.66 | 125.00 |
| **SEm±** | 5.16 | 2.14 | 1.15 | 0.64 | 3.40 | 3.28 | 1.38 |
| **CD at 5%** | 15.65 | 6.48 | 3.49 | 1.94 | 10.32 | 9.96 | 4.18 |

**Table 2: Response of Tissue Cultured Banana (*Musa paradisiaca* L.) to Integrated Doses of Plant Nutrients**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Number of fingers per bunch** | **Number of hands per bunch** | **Number of fingers per hand** | **Finger weight (g)** | **Finger length (cm)** | **Finger diameter (cm)** | **Bunch weight (kg)** | **Yield t/ha** |
| **T1** | 141.28 | 7.81 | 18.09 | 128.84 | 14.66 | 13.50 | 18.20 | 45.50 |
| **T2** | 176.05 | 8.66 | 20.33 | 154.18 | 21.66 | 16.50 | 26.75 | 66.87 |
| **T3** | 147.71 | 7.95 | 18.58 | 134.39 | 16.33 | 14.06 | 19.89 | 49.47 |
| **T4** | 113.65 | 7.02 | 16.19 | 113.78 | 9.66 | 12.03 | 12.93 | 32.32 |
| **T5** | 168.74 | 8.45 | 19.97 | 149.27 | 20.00 | 15.66 | 25.18 | 62.96 |
| **T6** | 136.34 | 7.69 | 17.73 | 124.36 | 13.33 | 13.20 | 16.95 | 42.38 |
| **T7** | 161.61 | 8.25 | 19.59 | 145.52 | 18.66 | 15.03 | 23.51 | 58.79 |
| **T8** | 129.41 | 7.52 | 17.21 | 120.16 | 11.66 | 13.03 | 15.54 | 38.87 |
| **T9** | 155.79 | 8.11 | 19.21 | 139.61 | 17.66 | 14.66 | 21.07 | 54.37 |
| **T10** | 122.33 | 7.33 | 16.69 | 116.26 | 10.33 | 12.66 | 14.22 | 35.55 |
| **T11** | 104.29 | 6.66 | 15.66 | 110.84 | 9.00 | 11.20 | 11.55 | 28.89 |
| **SEm±** | 4.89 | 0.38 | 0.69 | 5.69 | 0.77 | 0.84 | 0.72 | 1.00 |
| **CD at 5%** | 14.82 | 1.15 | 2.09 | 17.26 | 2.34 | 2.56 | 2.19 | 3.03 |