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Studies on bioagents and consortium of bioagents (Biomix) on growth and yield of banana *Musa paradisiaca* L.

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Abstract

An investigation on "Studies on bioagents and consortium of bioagents (Biomix) in banana (*Musa paradisiaca* L.) Cv. Grand Naine" was conducted at Banana Research Station, Nanded, Taluka + District Nanded, Maharashtra, during year 2023-24. The field experiment was laid out in Randomized Block Design and replicated thrice. The experiment consists of eleven treatment combinations *viz*., T_1 - *Bacillus subtillis*, T_2 - *Pseudomonas fluorescence*, T_3 - PPFM (Pink pigmented facultative methylotropic), T_4 - *Trichoderma viride*, T_5 - *Trichoderma herzianum*, T_6 - *Trichoderma virens*, T_7 - Biomix, T_8 - *Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM, T_9 - *Trichoderma viride* + *Trichoderma herzianum* + *Trichoderma virens*, T_{10} - *Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM + *Trichoderma viride* + *Trichoderma herzianum* + *Trichoderma virens*, T_{11} – 100% RDF Control. The experiment framed was to study on bioagents and consortium of bioagents (Biomix) in banana (*Musa paradisiaca* L.) Cv. Grand Naine. Observations on growth attributes and yield attributes of individual treatments were recorded.

The results of present study indicated significant difference with respective growth, yield, quality and monetary returns among the different treatments tried. The growth attributes *viz*. maximum plant height (220.06 cm) was recorded by treatment T_{10} - *Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM + *Trichoderma viride* + *Trichoderma herzianum* + *Trichoderma virens* and plant girth (78.80 cm), number of leaves per plant (14.80 per plant) was recorded by treatment T_7 *i.e.*, Biomix. The minimum values of plant height, plant girth, number of leaves per plant were recorded by treatment T_{11} *i.e.*, 100% RDF (Control). The yield parameters *viz*., maximum weight of bunch (24.27 kg) and yield per hectare (107.80 Mt/ha) was recorded by treatment T_7 - Biomix. While the minimum weight of bunch and yield per hectare was recorded by treatment T_{11} *i.e*., 100% RDF (Control).

Keywords: Banana (*Musa paradisiaca* L.), Grand Naine, bioagents, consortium of bioagents, Biomix

Introduction

Banana (*Musa paradisica* L.) is an important fruit crop of tropical countries like India, Brazil, China, Philippines, *etc*. It is the second most important fruit crop next to mango and regarded as fruit of heaven or poor man's apple or Adam's fig. It belongs to Musaceae family and Musa genus to the order Zingiberales. Banana is native to tropical South and South-East Asia. The plants are considered as the symbol of prosperity and fertility. Owing to its greater socio-economic significance and multifunctional uses banana is popularly known as Kalpataru (a plant of virtues). Among all the fruits, banana is plentiful, most nourishing and relatively a cheaper source of nearly all essential nutrients including vitamins and minerals and rich source of energy. It provides a more balanced diet containing sufficient amount of carbohydrates and essential nutrients (Hazarika, 2011) [4]. The fruit is considered a good source of vitamins A, B_1, B_2 and C. Banana is a rich source of energy as it contains sugars such as fructose, sucrose, glucose and minerals like potassium, phosphorus, calcium, magnesium. So, it can be considered as a complete "food".

Banana is cultivated in the world in an area 5.20 million ha with global production 119.83 million Mt. having 23.03 Mt/ha yield in tonne per hactre. India stands first contributing 26% of the world banana production. Beside India, China ranked second, whereas, Indonesia ranked third country in the production, contributing 12 per cent and 8 per cent, respectively. Maharashtra is the second highest banana producer state in India, with 4.22 million Metric tonnes production in an area 84,260 ha. with 50.12 Mt/ha productivity and share 15.50

per cent production of total banana production in India (Horticulture statistics at a glance, 2021). The banana cultivars grown in Maharashtra are Dwarf Cavendish, Basrai, Robusta, Grand Naine, Ardhapuri, Lal Velchi, Safed Velchi, *etc*. In Maharashtra, nearly 60% area under banana is concentrated in Jalgaon district and other districts growing bananas are Parbhani, Nanded, Khandesh and Thane.

Biofertilizers is internationally accepted as an alternative source to chemical fertilizers (Mahanty *et al.*, 2016) [9] and can be used to ensure a sustainable banana production (Mia *et al.*, 2010) [10]. The synergistic effects of organic and inorganic nutrient sources enhance the plant use efficiency with less input cost (Sharma and Dua, 1995) [14]. In order to reduce the cost due to chemical fertilizers and to avoid environmental pollution the banana farmers are switching over to other alternate agricultural system known as integrated nutrient management system. The component of the integrated system of nutrient application suitable for easy adoption include the use of bio-fertilizers like *Bacillus subtillis*, *Pseudomonas fluorescence*, PPFM (Pink pigmented facultative methylotropic), *Trichoderma viride*, *Trichoderma herzianum*, *Trichoderma virens*, biomix, *etc.* which are available easily nowadays. Bio-fertilizer is an important component of INM and its application is known to improve the soil fertility and crop productivity in several crops through atmospheric nitrogen fixation, solubilization of fixed phosphorus and other nutrients. In banana cultivation, considering the facts we discuss above the ultimate option to get better plant growth and higher yield we need to utilize Bioagents and their efficient combinations.

Materials and Methods

The present investigation entitled, “Studies on bioagents and consortium of bioagents (Biomix) in banana (*Musa paradisiaca* L.) cv. Grand Naine" was carried out at Banana Research station, Nanded working under VNMKV Parbhani, Maharashtra during 2023-2024. The experiment was laid out in randomized block design with three replications and having 11 treatments *viz*, T_1: *Bacillus subtillis*, T_2: *Pseudomonas fluorescence*, T_3: PPFM (Pink Pigmented Facultative Methylotropic), T_4: *Trichoderma viride*, T_5: *Trichoderma herzianum*, T_6: *Trichoderma virens*, T_7: Biomix, T_8: *Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM, T_9: *Trichoderma viride* + *Trichoderma herzianum* + *Trichoderma virens*, T_{10}: *Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM + *Trichoderma viride* + *Trichoderma herzianum* + *Trichoderma virens*, T_{11}: Control. The treatments were applied as for Soil application - 200 gm/ 10 Litre at 1st, 3rd, 5th and 7th months after planting and for Foliar application - 100 gm / 10 Litre at 1st, 3rd, 5th and 7th months after planting. Observations were recorded in respect of growth and yield attributes of banana crop. The statistical analysis of the data in respect of growth and yield component of flower and plant was done according to standard procedure given for Randomized Block Design by following the Fisher's analysis of variance (ANOVA) technique as given by Panse and Sukhatme (1967) [11].

Results and Discussion

Growth Attributes

The growth attributes of banana plants can significantly impact their growth, yield and quality. Some key growth parameters such as height of plant, girth of stem, number of leaves per plant and number of suckers per plant are discussed below:

Height of plant (cm)

The maximum height of plant (220.06 cm) was recorded by treatment T_{10} *i.e.*, *Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM + *Trichoderma viride*, *Trichoderma herzianum* + *Trichoderma virens*, which was found at par with T_7 *i.e.*, Biomix (209.13 cm), T_8 *i.e.*, *Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM (212.73 cm), T_9 *i.e.*, *Trichoderma viride* + *Trichoderma herzianum* + *Trichoderma virens* (215.33 cm). While, the minimum height of plant (180.13 cm) was recorded by treatment T_{11} *i.e.*, 100% RDF Control. Provided the evidence to support the claim that the largest plant heights were caused by enhanced uptake of nitrogen, which is the primary component of protein, amino acids, and chlorophyll. Thus, the current findings were consistent with those of Tiwary *et al.*, (1998) [15], Hazarika and Ansari (2010) [3], Kumar and Shanmugavelu (1988) [7].

Girth of stem (cm)

The maximum girth of plant (78.80 cm) was recorded by treatment T_7 *i.e.*, Biomix. Which was found at par with T_9 *i.e.*, *Trichoderma viride* + *Trichoderma herzianum* + *Trichoderma virens* (74.47 cm), T_{10} *i.e.*, *Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM + *Trichoderma viride Trichoderma herzianum* + *Trichoderma virens* (74.73 cm), However, minimum girth of plant (61.40 cm) was recorded by treatment T_{11} *i.e.*, 100% RDF Control. Comparable outcomes closely align with the conclusions obtained by Sarkar *et al.*, (2007) [13] and Hazarika and Ansari (2010) [3], Kumar and shanmugavelu (1988) [7].

Number of leaves per plant

The number of leaves (14.80) per plant were significantly more in treatment T_7 *i.e.*, Biomix, which was found at par with T_5 *i.e.*, *Trichoderma herzianum* (13.53) per plant, T_6 *i.e.*, *Trichoderma virens* (13.53) per plant, T_8 *i.e.*, *Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM (13.60) per plant, T_9 *i.e.*, *Trichoderma viride* + *Trichoderma herzianum* + *Trichoderma virens*, (13.67) per plant, T_{10} *i.e.*, *Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM + *Trichoderma viride Trichoderma herzianum* + *Trichoderma virens* (13.73) per plant. While the Treatment T_{11} *i.e.*, 100% RDF Control, recorded minimum number of leaves per plant (12.20). Ustad *et al.*, (2005) [16] and Hazarika and Ansari (2010) [3], and Patil and Shinde (2013) [12] also came to similar conclusions.

Number of suckers per plant

The treatment T_7 *i.e.*, *Biomix* recorded maximum No. of suckers per plant (5.93), which was found at par with T_5 *i.e.*, *Trichoderma herzianum* (5.27) per plant, T_6 *i.e.*, *Trichoderma virens* (5.27) per plant, T_8 *i.e.*, *Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM (5.40) per plant, T_9 *i.e.*, *Trichoderma viride* + *Trichoderma herzianum* + *Trichoderma virens* (5.73) per plant, T_{10} *i.e.*, *Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM + *Trichoderma viride Trichoderma herzianum* + *Trichoderma virens* (5.87) per plant, while the minimum No. of suckers per plant (4.80) was recorded by treatment T_{11} *i.e.*, 100%

RDF Control. Similar results were observed by Athani and Hulamani (2000) [1] in cv. Grand Naine.

Yield attributes

The results presented in Table 2 show significant variations in yield characteristics, including bunch weight and yield per hectare, among the different treatments. This indicates that the various treatments had a substantial impact on the yield parameters, resulting in recorded differences in the data.

Weight of bunch (kg)

The maximum weight of bunch (24.06 kg) was produced by treatment T_7 *i.e.,* Biomix. followed by T_{10} *i.e., Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM + *Trichoderma viride Trichoderma herzianum* + *Trichoderma virens* (22.53 kg). While the minimum weight of bunch (19.20 kg) was recorded by treatment T_{11} *i.e.,* 100% RDF Control. Consistent with these findings, Hazarika and Ansari (2010) [3] and Bhalerao *et al.,* (2009) [2] also reported similar results in banana, highlighting the importance of balanced nutrient application for enhanced fruit production.

Yield of banana (Mt/ha)

Significantly, maximum yield per hectare (106.53 Mt/ha) was recorded in treatment T_7 *i.e.,* Biomix. Followed by T_{10} *i.e., Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM + *Trichoderma viride Trichoderma herzianum* + *Trichoderma virens* (100.10 MT/ha). However, the minimum yield per hectare (85.13 Mt/ha) was recorded by treatment T_{11} *i.e.,* 100% RDF Control. The maximum weight of bunch recorded in treatment T_7 (Biomix) can be attributed to the significant increase in yield. This finding aligns with the research of Krishnan and Shanmugavelu (1988) [7], who noted that plants with thicker pseudostems are desirable due to their positive correlation with bunch size and related characteristics. These findings are further supported by the research of Bhalerao *et al.,* (2010) [2], Patil and Shinde (2013) [12], Khedikar (2018) [6] and Lenka and Lenka (2014) [8], who also reported similar results.

Table 1: Effect of bioagents and consortium of bioagents (Biomix) on different growth attribute of banana Cv. Grand Naine.

Tr. No.	Treatment detail	Height of plant (cm)	Girth of stem (cm)	No. of leaves/plant	No. of suckers/plant
T_1	*Bacillus subtillis*	184.40	63.40	12.47	4.87
T_2	*Pseudomonas fluorescence*	187.56	62.80	12.67	4.93
T_3	PPFM (Pink pigmented facultative methylotropic)	193.23	62.93	12.33	4.80
T_4	*Trichoderma viride*	192.53	66.07	13.13	5.07
T_5	*Trichoderma herzianum*	195.06	66.33	13.53	5.27
T_6	*Trichoderma virens*	193.63	65.93	13.53	5.27
T_7	Biomix	209.13	78.80	14.80	5.93
T_8	*Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM	212.73	68.40	13.60	5.40
T_9	*Trichoderma viride* + *Trichoderma herzianum* + *Trichoderma virens*	215.33	74.47	13.67	5.73
T_{10}	*Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM + *Trichoderma viride* + *Trichoderma herzianum* + *Trichoderma virens*	220.06	74.73	13.73	5.87
T_{11}	Control	180.13	61.40	12.20	4.80
	S. Em. ±	2.21	1.87	0.46	0.23
	C.D. at 5%	6.53	5.51	1.38	0.70

Table 2: Effect of bioagents and consortium of bioagents (Biomix) on different yield attribute of banana Cv. Grand Naine.

Tr. No.	Treatment detail	Weight of bunch (kg)	Yield of banana (Mt/ha)
T_1	*Bacillus subtillis*	19.53	86.73
T_2	*Pseudomonas fluorescence*	19.66	87.40
T_3	PPFM (Pink pigmented facultative methylotropic)	19.53	86.47
T_4	*Trichoderma viride*	19.93	88.40
T_5	*Trichoderma herzianum*	19.80	88.03
T_6	*Trichoderma virens*	19.93	88.47
T_7	Biomix	24.27	107.80
T_8	*Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM	21.07	93.60
T_9	*Trichoderma viride* + *Trichoderma herzianum* + *Trichoderma virens*	21.13	93.87
T_{10}	*Bacillus subtillis* + *Pseudomonas fluorescence* + PPFM + *Trichoderma viride* + *Trichoderma herzianum* + *Trichoderma virens*	22.53	100.10
T_{11}	Control	19.20	85.13
	S. Em. ±	0.55	2.36
	C.D. at 5%	1.62	6.98

Conclusion

Close analysis of the present investigation revealed that the application of Biomix were able to increase the yield of banana Cv. Grand Naine. Among the eleven treatments the treatment T_7 Biomix of soil application (200 gm /10 lit.) & Foliar application (100 gm / 10 lit) was found more effective in increasing the yield & yield contributing characters. Significantly, maximum yield per hectare (106.53 Mt/ha) was recorded in treatment T_7 *i.e.,* Biomix. However, the minimum yield per hectare (85.13 Mt/ha) was recorded by treatment T_{11} *i.e.,* 100% RDF Control.

Hence it is concluded that among the eleven treatments T_7 (Biomix) emerged the most effective for enhancing growth yield & quality of Cv. Grand Naine bananas.

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