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Effect of different bioinoculants on growth attributes of mango grafts under nursery condition

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Abstract
The field experiment has been conducted for one year to study the effect of different bioinoculants on growth attributes of Mango grafts. The combine effect of application of bioinoculants such as *Azotobacter* and Phosphate Solubilizing Bacteria (PSB) in a potting mixture significantly shows improvement in growth components such as graft survival, number of leaves, number of shoot, height, girth and root length of the plants. The microbial population such as bacterial population and fungal population was significantly higher in combine treatments of bioinoculants which may be involved in increasing the growth attributes of the grafts. However the Actinomycetes population did not significantly influenced by different treatments. The treatments containing *Trichoderma* act as a biocontrol agent also did not significantly control the Anthracnose disease of the Mango grafts during the whole year.

Keywords: Mango grafts, bioinoculants, *Azotobacter*, PSB, *Trichoderma*, bacteria, fungi, actinomycetes, anthracnose, growth attributes

Introduction
Mango (*Mangifera indica* L.) is the most important and commercially grown fruit crop in India and is considered as national fruit. India ranks first among world's Mango producing countries accounting for 50 percent of world Mango production, The agro climatic conditions of Konkan region of Maharashtra state are favourable for Mango production and hence it has been predominantly Mango zone in the state. Among the major horticultural and plantation crops, Mango plays an important role in earning the foreign exchange through export.The beneficial use of nitrogen-fixing microorganisms, *viz*. *Azotobacter*, and phosphate-solubilizing bacteria as biofertilizers used as a supplementary source of plant nutrition on agricultural crops is well documented (Gajbhiye *et al*. 2003) [4]. Therefore, the study was carried out to see the effect of biofertilizers on the growth attributes of Mango graft, microbes and nutrient content of the potting mixture under nursery condition.

Materials and Methods
A Field experiment was conducted on Mango grafts for one year started from 2021-22 at the Regional Fruit Research Station, Vengurla, Dist. Sindhudurg. The experiment was laid in Randomized Block Design (RBD) with three replications and nine treatments. The fresh Mango stone were sown in Polybags of size 6 x 9 inch filled with different media treatments in the month of May (third week) and grafting was done in the first week of June. After grafting, 100 successful grafts per treatment per replication were selected and for three replications total 2700 Nos. of grafts were selected for experimentation. The uniform package of practices were followed for all treatments including fertilizer application through potting media with 19:19:19 @ 2 gm, plant protection measure and application of water, regular removal of sprouts below graft union etc. The bioinoculants such as *Azotobacter* and PSB biofertilizer is prepared by using local strain isolated from mango plant. The estimation of microbes and soil analysis has done at initial stage and final stage (After one year of the mango graft) by serial dilution plate count technique and soil standard techniques respectively.

The observations on anthracnose incidence were recorded using 0-5 rating scale as follows.

0 = No infection	1 = 1-20% infection	2 = 21-40% infection
3 = 41-60% infection	4 = 61-80% infection	5 = 81-100% infection.

Percent Disease Intensity (PDI) was calculated by using the formula.

$$PDI = \frac{\text{Sum of all numerical rating}}{\text{No. of flushes observed x Maximum rating}} \times 100$$

Results and Discussion

The present study was conducted at RFRS, Vengurla for one year to know the effect of different bio-inoculants on growth of mango grafts. Results of present research revealed that the combine application (T_5 and T_9) of biofertilizers such as *Azotobacter* and Phosphate Solubilizing Bacteria (PSB) in a potting mixture shows significant improvement in microbial population (Total bacterial and total fungal population), nutrient content (Total nitrogen and Total Phosphorous) and growth components (Graft survival, Number of leaves, Number of shoot, height, girth as well as root length of the plants) as compared to potting mixture (Control) after one year of the graft (Table no. 2 & 3). The more addition of *Azotobacter* and PSB in the form of biofertilizers directly increases the total bacterial population and indirectly stimulates the fungal population. The added population in the form of bioinoculant and native population of *Azotobacter* and PSB in the *rhizosphere* shows combine beneficial benificial effect on growth attributes of Mango graft in the (T_5 and T_9) treatments. The *Azotobacter* and PSB promotes the biochemical activities such as nitrogen fixation and phosphate solubilisation and increases the nitrogen and phosphorous content in potting mixture (Table no. 3) which has been absorbed by the roots of the plant. The absorption of available nitrogen and available phosphorous further significantly improves the growth attributes of the mango grafts.

Table 1: Initial Microbial and Nutrients status of the potting mixture of mango graft

A. Microbial population (CFU)		
1	Total bacterial population	37 x 10^6
2	Total fungal population	1 x 10^4
3.	Total actinomycetes population	3 x 10^3
B. Nutrients		
1	pH	6.20
2	EC	0.56
3	Total Nitrogen (%)	1.17
4	Total Phosphorous (%)	0.84
5	Total Potassium (%)	1.34

Table 2: Effects of different bio-inoculants on growth parameters of the one year mango grafts

Tr. No.	Treatments	Percent Sprouting (%)	Grafts survival (%)	No. of leaves	No. of shoot	Height of the plant (cm)	Girth of the plant (cm)	Root length of the plant (cm)
T_1	Potting mixture alone	82.80	45.54	22.53	1.14	42.26	4.32	28
T_2	Potting mixture + *Azotobacter* 50 g	85.50	52.20	27.60	1.35	52.21	4.84	32
T_3	Potting mixture + PSB 50 g	91.10	50.40	26.33	1.32	48.88	4.30	33
T_4	Potting mixture + Talc based *Trichoderma* 50 g	90.18	47.52	23.32	1.21	44.55	4.46	28
T_5	Potting mixture + *Azotobacter* 50 g + PSB 50 g + Talc based *Trichoderma* 50 g	88.00	53.55	34.47	1.47	59.62	5.75	35
T_6	T_2 + Spraying of *Trichoderma* (Spore formulation) 3 times at 2 months interval @ 1 g/10 L	86.40	52.90	26.30	1.39	51.45	4.55	33
T_7	T_3 + Spraying of *Trichoderma* (Spore formulation) 3 times at 2 months interval @ 1 g/10 L	89.90	49.80	25.76	1.26	47.21	4.25	33
T_8	T_4 + Spraying of *Trichoderma*(Spore formulation) 3 times at 2 months interval @ 1 g/10 L	87.30	48.50	22.84	1.15	43.56	4.12	29
T_9	T_5 + Spraying of *Trichoderma*(Spore formulation) 3 times at 2 months interval @ 1 g/10 L	89.01	53.20	32.63	1.42	58.22	5.13	36
	SE.+-	1.55	0.97	0.82	0.02	0.75	0.16	1.13
	C.D.@5%	NS	2.91	2.48	0.06	2.27	0.50	3.40

Table 3: Effects of different bio-inoculants on microbial population and nutrient status of the one year mango grafts.

Tr. No.	Treatments	Microbial population (CFU)			Nutrient Status		
		Bacteria X 10^6	Fungi X 10^4	Actinomycetes X 10^3	Total N (%)	Total P (%)	Total K (%)
T_1	Potting mixture alone	45	05	08	1.14	0.79	1.31
T_2	Potting mixture + *Azotobacter* 50 g	61	07	08	1.24	0.79	1.31
T_3	Potting mixture + PSB 50 g	58	06	09	1.15	0.90	1.32
T_4	Potting mixture + Talc based *Trichoderma* 50 g	49	10	07	1.14	0.79	1.30
T_5	Potting mixture + *Azotobacter* 50 g + PSB 50 g + Talc based *Trichoderma* 50 g	77	05	07	1.22	0.86	1.31
T_6	T_2 + Spraying of *Trichoderma* (Spore formulation) 3 times at 2 months interval @ 1 g/10 L	59	08	08	1.25	0.80	1.31
T_7	T_3 + Spraying of *Trichoderma* (Spore formulation) 3 times at 2 months interval @ 1 g/10 L	55	09	08	1.14	0.91	1.32
T_8	T_4 + Spraying of *Trichoderma* (Spore formulation) 3 times at 2 months interval @ 1 g/10 L	47	12	06	1.13	0.79	1.31
T_9	T_5 + Spraying of *Trichoderma* (Spore formulation) 3 times at 2 months interval @ 1 g/10 L	74	08	07	1.22	0.88	1.31
	SE.+-	1.96	1.11	1.20	0.02	0.01	0.02
	C.D. @ 5%	5.89	3.33	NS	0.07	0.05	NS

Table 4: The month wise status of the Percent Disease Index (PDI) of anthracnose disease of mango grafts

Tr. No.	Treatments	PDI											
		Jul - 21	Aug-21	Sept-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	April-22	May-22	June-22
T_1	Potting mixture alone	1.33 (6.55)	1.07 (5.74)	1.33 (6.55)	1.60 (7.27)	2.40 (8.91)	6.13 (14.30)	5.60 (13.69)	4.27 (11.83)	3.20 (10.31)	1.87 (7.71)	0.27 (2.98)	0.53 (4.17)
T_2	Potting mixture + *Azotobacter* 50 g	0.80 (5.13)	1.60 (7.27)	1.60 (7.27)	1.87 (7.71)	2.40 (8.91)	3.73 (10.09)	3.47 (10.63)	2.93 (9.91)	2.40 (8.91)	0.53 (4.17)	0.00 (0.00)	0.00 (0.00)
T_3	Potting mixture + PSB 50 g	1.07 (5.74)	1.33 (6.55)	1.33 (6.55)	1.87 (7.71)	1.87 (7.71)	1.87 (7.71)	1.87 (7.71)	1.60 (7.27)	1.33 (6.55)	0.80 (5.13)	0.27 (2.98)	0.00 (0.00)
T_4	Potting mixture + Talc based *Trichoderma* 50 g	1.07 (5.74)	0.80 (5.13)	0.80 (5.13)	1.07 (5.74)	1.07 (5.74)	1.60 (7.27)	1.60 (7.27)	1.33 (6.55)	1.07 (5.74)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
T_5	Potting mixture + *Azotobacter* 50 g + PSB 50 g + Talc based *Trichoderma* 50 g	0.27 (2.98)	0.80 (5.13)	0.80 (5.13)	0.80 (5.13)	1.07 (5.74)	2.40 (8.91)	2.40 (8.91)	2.13 (8.33)	1.87 (7.71)	0.80 (5.13)	0.00 (0.00)	0.27 (2.98)
T_6	T_2 + Spraying of *Trichoderma* (Spore formulation) 3 times at 2 months interval @ 1 g/10 L	1.07 (5.74)	1.07 (5.74)	1.33 (6.55)	1.60 (7.27)	0.53 (4.17)	1.90 (7.92)	1.87 (7.71)	1.60 (7.27)	1.33 (6.55)	0.27 (2.98)	0.00 (0.00)	0.00 (0.00)
T_7	T_3 + Spraying of *Trichoderma* (Spore formulation) 3 times at 2 months interval @ 1 g/10 L	0.80 (5.13)	1.07 (5.74)	1.07 (5.74)	1.33 (6.55)	1.07 (5.74)	2.93 (9.81)	2.40 (8.91)	2.13 (8.33)	1.60 (7.27)	0.27 (2.98)	0.00 (0.00)	0.00 (0.00)
T_8	T_4 + Spraying of *Trichoderma* (Spore formulation) 3 times at 2 months interval @ 1 g/10 L	0.53 (4.17)	0.53 (4.17)	0.80 (5.13)	1.07 (5.74)	0.53 (4.17)	1.07 (5.74)	1.87 (7.71)	1.07 (5.74)	0.80 (5.13)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
T_9	T_5 + Spraying of *Trichoderma* (Spore formulation) 3 times at 2 months interval @ 1 g/10 L	0.53 (4.17)	0.27 (2.98)	0.80 (5.13)	1.33 (6.55)	0.53 (4.17)	2.13 (8.33)	2.40 (8.91)	2.13 (8.33)	1.33 (6.55)	0.53 (4.17)	0.27 (2.98)	0.00 (0.00)
	SE.+-	1.39	1.30	1.49	1.51	1.34	1.77	1.66	2.26	2.07	2.02	0.98	1.01
	C.D.@5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

This has been supported by Kamil (2008) [5] who shown that the *Azotobacter* is capable of converting nitrogen to ammonia which in turn is taken up by the plants. The *Azotobacter* has been reported to contribute 15 Kg N ha^{-1} per year. It has been also observed that inoculation of soil or seed with *Azotobacter* causes increase in growth attributes of different crops (Sindhu *et al*. 2010) [8]. Whereas the phosphate-solubilizing bacteria active in solubilizing insoluble P improving growth attributes of various crops. (Cattelan *et al*. 1999) [3]. These organisms solubilize the unavailable forms of inorganic P like tricalcium phosphate iron phosphate, aluminium phosphate and rock phosphates into soluble forms by release of a variety of organic acids like succinic, citric, malic, fumaric, glyoxylic and gluconic acids.(Venkateswarlu *et al*. 2008) [9]. The results were also in line up with that of Prabhu *et al*. (2003) [6] Asad *et al*. (2017) [2] and Ritik Chawla and Ramesh Kumar Sadawarti (2020) [7]. They revealed that the application of bio fertilizer rate directly help in increasing plant height, Plant leaves which might be due to the nutrient uptake of plants, that is important to improved chlorophyll content, carbohydrate synthesis and increased the activity of hormones. Thus Bio-fertilizer increases overall development of vegetative growth parameters like in higher growth rates stem girth of plant. (Alam and Seth, 2014) [1]. However the Actinomycetes population did not significantly influenced by any of the treatment (table no. 3 & 4). This may be due to lack of its application of Actinomycetes population in potting mixture at the same time there was no significant effect of *Trichoderma* on Anthracnose of mango.

Conclusion

It is thus concluded that the combine application of *Azotobacter* and PSB in the form of biofertilizers significantly add the microbial population and increases the nutrient content such as nitrogen and phosphorous of the potting mixture which further improve the growth attributes of Mango grafts.

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