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Impact of microbial consortia on the physico-chemical and biological properties of soil in jamun (*Syzygium cumini* L.) cv. Goma Priyanka

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ABSTRACT

An experiment was conducted on recently planted Jamun cv. Goma Priyanka orchard at the Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalarapatan, Jhalawar, Rajasthan with a view to investigate the impact of microbial consortia on the physico-chemical and biological properties of the soil in Jamun (Syzygium cumini L.) cv. Goma Priyanka. It was observed that the treatment $T_9(M_3T_3)$- (Azospirillum, PSB, KSB, VAM and Trichodermaharzianum) (100g)was found better in improving the soil parameters including organic carbon percentage, available N, P and K content of soil and soil microbial population was found significantly superior over other treatments. Like-wise, soil pH and electrical conductivity also had significant moderation under this treatment. The treatment $T_8(M_3T_2)$ - (Azospirillum, PSB, KSB, VAM and Trichodermaharzianum) (75g) was in next order in its impact on vegetative growth and developmental parameters of jamun plant besides better soil parameters of the orchard under the study.

***Keywords*:** Biological Properties of soil, microbial consortia, physico-chemical properties of soil, *Syzygium cumini.*

INTRODUCTION

Only by using inexpensive, environmentally safe nutrient sources can achieve long-term sustainability in agriculture. In this sense, biofertilizers are crucial in maintaining soil health and crop productivity more effectively. According to Yadav and Chandra (2012), biofertilizers are rhizosphere microorganisms that have been inoculated to increase plant growth and nutrition and decrease the requirement for N and P fertilizers, hence increasing grain output.Since then, biofertilizers have gained acceptance as significant nutrient inputs under both the organic management approach and the integrated nutrient management plan. Now, a variety of other microorganisms have been discovered and are being used commercially as microbial inoculants, the journey that began with Rhizobium has been expanded. On the other hand, frequent inputs of phosphate-solubilizing biofertilizers, mycorrhizal-biofertilizers, Rhizobium, Azotobacter and Azospirillum have been acknowledged.The microbial formulation protects plants from plant diseases, decreases the demand for soluble minerals and fertilisers with nitrogen, releases important plant nutrients and so lessens the need for chemical pesticides and fertilisers.

Two or more microbial populations coexisting in harmony is known as a microbial consortium. Microbial consortia are superior to single species, or “superbugs,” in a number of ways, including robustness, efficiency and modularity. In their native environments, microorganisms coexist in groups and some even help plants. Microbes in tiny consortia have been shown to improve defensesignaling cascades, which in turn leads to increased transcriptional activation of many metabolic pathways (Kumar and Jagadeesh, 2016).

When incorporated into soil, microbial consortia—which are composed of many microorganisms—are certain to have a synergistic effect. The consortiums could include A gram-

negative motile bacterium called *Azospirillum* fixes atmospheric nitrogen and makes it available to plants in a non-symbiotic way. This process can replace between 50 and 90 percent of the nitrogen fertilizer that plants need. Similar to this, fumaric acid, succinic acid, acetic acid, gluconic acid, lactic acid and other organic acids are secreted by Phosphate Solubilizing Bacteria (PSB). These organic acids aid in the soil's solubilization of insoluble tricalcium phosphate and rock phosphate, enabling crop plants to use it. For faster crop growth, the insoluble form of potassium can be mobilised with the aid of potassium-solubilizing bacteria (KSB). They can withstand a large range of soil pH and temperature, cut the cost of applying potash by 50–60% and increase crop production and growth by 20–30%. The *vesicular-arbuscularmycorrhiza* (VAM) consortia, which are endomycorrhiza fungi, are well known for their effects on phosphate uptake. Additionally, by associating with plant roots, these fungi can assist citrus plants manage water stress through stomatal regulation. Vesicular *Arbuscular Mycorrhiza* (VAM) develops a symbiotic relationship with the host plant, improving soil fertility, plant health and nutrient absorption while also promoting plant development (Ramasamy *et al*., 2011). The consortia that include the bio-fungicide *Trichoderma harzianum* are made up of free-living fungus that is widespread in the ecosystem of soil and roots. This fungus protects plants from most soil-borne illnesses, such as root rot, damping off and wilting, while also encouraging plant growth. Microbial consortiums have a variety of uses, including rhizosphere bioremediation of pesticides, bio-fertilizers, bio-control agents against diseases, soil reclamation and efficient breakdown of organic wastes. Despite the fact that several strains of plant growth-promoting rhizobacter (PGPR) and its consortia have demonstrated their ability to promote plant growth and enhance productivity in field conditions across a variety of crops, farmers have not been as inclined to utilise these products owing to a lack of awareness and a lack of access to high-quality consortia. It is suggested to assess microbial consortiums in jamun against the backdrop of their effectiveness in multidirectional aspects of plant growth, such as nutrient mobilisation, disease management, stress management and the biodegradation of organic waste, among many other things. Additionally, consortiums are economical to utilise since they combine fungi and rhizobacteria in a synergistic manner. The crop jamun is greatly neglected and there has been very little research done on microbial consortiums in this crop. Thus, it was suggested that an experiment be conducted to determine how microbial consortia affect the growth and development of jamun.

MATERIALS AND METHODS

The current study was carried out in the recently planted Jamun cv. Goma Priyanka orchard at the Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalarapatan, Jhalawar, Rajasthan during 2019 and 2020. The Jhalawar district is situated between 23°4' and 24°52' N Latitude and 75°29' to 76°56' E Longitude. Zone V agro-climatically, the district is called the Humid South Eastern Plain. The area receives 954.7 mm of rain on average. Summertime temperatures range from 43 to 48°C, while wintertime lows are between 1.0 and 2.6°C.

Before the experiment started, soil samples were randomly taken from various locations inside the experimental site at a depth of 0 to 30 cm in order to evaluate the physico-chemical characteristics of the soil there. A representative sample was made and mechanical, physical and chemical analyses were performed on it. The experiment site's soil has a texture similar to clay loam (black cotton soil).

Three types of microbial consortia symbionts with each other and having ability to survive at high temperature which prevails in Jhalawar condition were used. These microbial consortia were obtained from Department of Microbiology, University of Horticultural Sciences, Bagalkot, Karnataka. Each consortia had mixture of equal weight of respective microbial strain.

The details regarding microbial consortia and their doses is furnished as under microbial consortia

- **M1**
  - *Azospirillum*
  - Phosphate Solubilising Bacteria (PSB)
  - Potassium Solubilising Bacteria (KSB)

- **M2**
  - *Azospirillum*
  - Phosphate SolubilisingBacteri (PSB)
  - Potassium Solubilising Bacteria (KSB)
  - vesicular-arbuscularmycorrhiza (VAM)
- **M3**
  - *Azospirillum*
  - Phosphate Solubilising Bacteria (PSB)
  - Potassium Solubilising Bacteria (KSB)
  - vesicular-arbuscularmycorrhiza (VAM)
  - *Trichoderma harzianum*

Treatment details

Treatment notation	Treatment content	Treatment notation	Treatment content
T_0 (Control)	No application of Microbial consortia	T_6 (M_2T_3)	Microbial consortia 100g
T_1 (M_1T_1)	Microbial consortia 50g	T_7 (M_3T_1)	Microbial consortia 50g
T_2 (M_1T_2)	Microbial consortia 75g	T_8 (M_3T_2)	Microbial consortia 75g
T_3 (M_1T_3)	Microbial consortia 100g	T_9 (M_3T_3)	Microbial consortia 100g
T_4 (M_2T_1)	Microbial consortia 50g		
T_5 (M_2T_2)	Microbial consortia 75g		

Each consortia was used at the rate of 50, 75 and 100g. These doses were denominated as T_1, T_2 and T_3 as detailed as under:T_1: 50 g,T_2: 75 g and T_3: 100 g.

The treatments were applied during last week of March, 2019 after recording initial (base) growth and development parameters of plants as well as soil parameters. Observations recoded were soil pH, electrical conductivity, bulk density, soil particle density, porosity, soil organic carbon, available N,P and K content in the soil and soil microbial population count during monsoon and post-monsoon period.

Soil pH was determined from 1: 25 soil to water Suspension by dipping the combined electrode (glass electrode plus calomel electrode) of a digital pH meter as described by Jackson (1973). Electrical conductivity (ds m^{-1}) of soil was determined with the help of Systronic Conductivity Meter-306 using 1**:**2.5 soil**:** water suspension ratio (Jackson 1973). Organic carbon (%) was determined by following Walkley and Black wet oxidation method (Black 1965). Bulk density of soil (Mg m^{-3}) of 0-15 cm depth was determined. The core sampler was pressed in the soil for enough depth to fill the core. Carefully removed the sampler and trimmed the soil extending out of the core with a sharp knife. Soil was oven dried at 105^0C to a constant weight, cooled and weighed. Soil volume was taken equal to inner volume of core sampler. Bulk density was calculated using the following formula and expressed as mg/ m^3 as suggested by Piper, (1950). Bulk density = Mass of oven dry soil/ Volume of soil including pore space.

To calculate soil particle density, the mass and the volume of the solid particles in a soil sample was measured. For this purpose soil sample was put in a flask with distilled water. The soil/ water mixture was then boiled to remove all air from the sample. After the mixture was cooled, water was added to the mixture to obtain a specified volume. The mass of this mixture was then measured. The mass of the water is then subtracted from the mass of the soil and water. The particle density was calculated from the mass of the solid particles in a specified volume. Particle Density = Mass of dry soil /Volume of soil particles only (air removed) (g/cm^3) (Arya *et al*., 1981). The Porosity (%) was calculated at end of experiment as per the formulae Porosity (%) = 1- Bulk density X 100 Particle density (Hao *et al*., 2008).

Available nitrogen (kg ha^{-1}) was determined by alkaline permanganate (0.32% KMnO4) method (Subbiah and Asija, 1956). Available phosphorus (kg ha^{-1}) was determined by extracting the acid soil P in dilute acid fluoride (Bray and Kurtz, 1945) phosphorus in the extract was determined calorimetrically at 660 nm as described by Black (1965). Available potassium (kg ha^{-1}) was estimated on Systronics Flame Photometer-128 using neutralnormal- ammonium acetate (NH_4OAc, pH 7.0) as per procedure given by Jackson (1973). Soil microbial population was measured by standard serial dilution and plate count method Wollum (1982).

The data recorded for the evaluation of different parameters was statistical analyzed using standard procedure for ANOVA of Randomized Block Design in order to test the significance of experimental results with three replication. The analysis of variance was done by the method suggested by Fisher (1954) and using analysis as described by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

In present study, all recorded parameters (Table 1, 2 and 3) for soil nutrient status was found significantly influenced by applied consortia of different plant growth promoting rhizobacteria. Data as regard to the effect microbial consortia on soil parameters like soil pH (7.49), electrical conductivity (0.32 dS m^{-1}), bulk density (NS), particle density (NS) porosity (NS), organic carbon (0.71%), N (342.42 kg ha^{-1}), P (28.82 kg ha^{-1}), K(305.62 kg ha^{-1}) and microbial population were observed comparatively better in treatment $T_9(M_3T_3)$- (*Azospirillum,* PSB, KSB, VAM and *Trichoderma harzianum*) (100g). The improvement in physico-chemical properties of soil in treatment T_9 (M_3T_3)-(*Azospirillum,* PSB, KSB, VAM and *Trichoderma harzianum*) (100g)might be attributed to increased organic matter status of the soil and improved soil physical structure (bulk density, porosity) as cited by Gogoi *et al.* (2004). Relatively better soil pH in this treatment may be due to perhaps better production of various organic and inorganic acids produced by micro-organisms. In general microbial sources have tendency to keep the soil pH in neutral range.

In the present study, electrical conductivity (EC) of the soil decreased with the application of increasing doses of different microbial sources. Sharma *et al.* (2017) recorded that by application of *Azospiriflum* 50 g + PSB 50g + VAM 20 g significantly decreased soil electrical conductivity in custard apple. Srivastava *et al.* (2019) observed decrease in soil electrical conductivity with the application of 25% vermicompost + microbial consortium which corroborates the present findings.

The increased in available nitrogen and phosphorus content as observed in the experiment in $T_9(M_3T_3)$- (*Azospirillum,* PSB, KSB, VAM and *Trichoderma harzianum*) (100g) may be due to better response of it over other treatments in increased biological nitrogen fixation and phosphate solubilization. Some bacteria have the ability to solubilize inorganic P due to chelation, exchange reaction, phosphate production and excretion of organic acids that have moderating effect on soil pH and in rendering the insoluble phosphate into soluble form. Generally, the solubility of calcium phosphates and magnesium also increases with decreasing pH. The increase in potassium content under microbial consortium was better in treatment in $T_9(M_3T_3)$- (*Azospirillum,* PSB, KSB, VAM and *Trichoderma harzianum*) (100g) which may be due to comparatively better dissolution rate of silicates and minerals which releases K, production of enzymes like chitinase and cellulases that causes breakdown of minerals and, increased root exudation accompanied by accelerated microbial proliferation and respiration which may lead to O_2 depletion in the rhizosphere and facilitate denitrification specifically. These findings were in agreement with the work of Sharma *et al*. (2017), Dutta and Kundu (2012), Esitken *et al*. (2010), Srivastava *et al*. (2019) and Hussain *et al.* (2017).

The results of present study inferred that the applied treatment T_9 (M_3T_3)- (*Azospirillum,* PSB, KSB, VAM and *Trichoderma harzianum*) (100g) perhaps had stimulating effect on micro-organisms growth in soil as well as root. Application of different microbial consortia had significant increased the total rhizobacterial counts on nutrient agar. The increase in rhizobacterial counts may be

Table 1: Effect of microbial consortia on soil pH, EC, N, P_2O_5 and K2O of Jamun (*Syzygium cumini* L.) cv. Goma Priyanka during growth period, 2019-20

Treatments	Soil parameters				
	pH	EC(dS m^{-1})	N(kg ha^{-1})	P(kg ha^{-1})	K(kg ha^{-1})
Initial value	7.75	0.45	312.62	21.14	278.32
T_0 (Control)	7.86	0.43	325.74	23.37	283.74
T_1 (M_1T_1)	7.64	0.41	327.73	25.71	290.67
T_2 (M_1T_2)	7.62	0.40	331.80	24.31	293.41
T_3 (M_1T_3)	7.59	0.37	336.15	26.42	292.60
T_4 (M_2T_1)	7.63	0.40	334.41	24.31	289.74
T_5 (M_2T_2)	7.52	0.39	329.60	25.82	294.80
T_6 (M_2T_3)	7.51	0.36	336.17	27.51	298.30
T_7 (M_3T_1)	7.53	0.38	331.42	26.14	294.43
T_8 (M_3T_2)	7.55	0.35	341.10	27.45	301.40
T_9 (M_3T_3)	7.49	0.32	342.42	28.82	305.62
SEm (±)	**0.04**	**0.01**	**1.54**	**0.34**	**1.41**
CD (5%)	**0.13**	**0.04**	**4.58**	**1.39**	**4.19**

Table 2: Effect of microbial consortia on soil OC, BD, PD and porosity of Jamun (*Syzygium cumini* L.) cv. Goma Priyanka during growth period, 2019-20

Treatments	Soil parameters			
	Organic carbon (%)	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	Porosity (%)
Initial value	0.49	1.38	2.66	48.12
T_0 (Control)	0.53	1.38	2.65	47.92
T_1 (M_1T_1)	0.57	1.37	2.66	48.49
T_2 (M_1T_2)	0.60	1.35	2.65	49.05
T_3 (M_1T_3)	0.63	1.33	2.64	49.62
T_4 (M_2T_1)	0.59	1.36	2.67	49.06
T_5 (M_2T_2)	0.65	1.34	2.69	50.18
T_6 (M_2T_3)	0.69	1.30	2.64	50.75
T_7 (M_3T_1)	0.62	1.33	2.66	50.00
T_8 (M_3T_2)	0.68	1.29	2.64	51.13
T_9 (M_3T_3)	0.71	1.26	2.63	52.09
SEm (±)	**0.003**	**0.012**	**0.005**	**0.057**
CD (5%)	**0.021**	**NS**	**NS**	**NS**

due to favourable environmental conditions for growth and their rapid multiplication rate as created by plant growth promoting rhizobacteria in soil. The results of present study are in agreement with the observations of Kumar and Shweta (2013) and Dutta and Kundu (2012).

Moreover, it is well recognised that the rhizosphere is a zone with elevated microbial and, by extension, enzyme activity. This could be because of the high concentration of readily degradable substrates in root exudates, which promotes the growth of microorganisms in the rhizosphere and helps plants develop their own unique microflora that may work in harmony with them (Bais *et al.*, 2006). Thanks to ideal soil moisture and temperature conditions that correlate with increased microbial activity and decomposition, the microbial population was

Table 3: Effect of microbial consortia on soil microbial population of Jamun (*Syzygium cumini* L.) cv. Goma Priyanka during growth period, 2019-20

Treatments	Bacteria ($x10^6$ cfu/g soil)	Fungi ($x10^4$ cfu/g soil)	Bacteria ($x10^6$ cfu/g soil)	Fungi ($x10^4$ cfu/g soil)
Initial (Pre monsoon)	**3.4**	**2.3**	**—-**	**—-**
Season	**Monsoon**		**Post monsoon**	
T_0 (Control)	2.50	1.80	2.00	1.20
T_1 (M_1T_1)	4.50	3.20	4.10	2.90
T_2 (M_1T_2)	4.80	3.90	4.40	3.10
T_3 (M_1T_3)	5.20	4.10	4.90	3.80
T_4 (M_2T_1)	4.80	3.80	4.50	3.20
T_5 (M_2T_2)	5.40	4.20	4.80	3.90
T_6 (M_2T_3)	5.80	4.80	5.20	4.00
T_7 (M_3T_1)	5.00	4.10	5.00	3.70
T_8 (M_3T_2)	6.20	4.70	5.50	4.30
T_9 (M_3T_3)	6.70	4.90	5.80	4.50
SEm (±)	**0.04**	**0.03**	**0.04**	**0.03**
CD (5%)	**0.13**	**0.11**	**0.12**	**0.10**

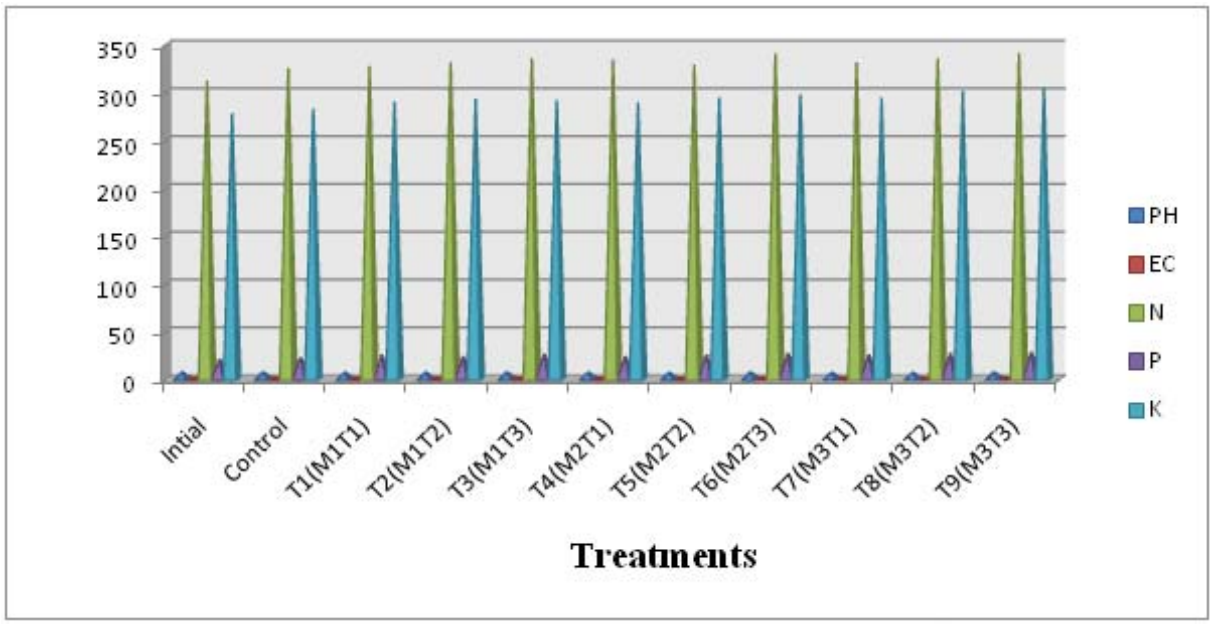

Fig. 1: Effect of microbial consortia on soil pH, EC, N, P2O5 and K2O of Jamun (*Syzygium cumini* L.) cv. Goma Priyanka during growth period, 2019-20

observed in the current experiment to be higher during the monsoon season than during the post-monsoon season (Table 3 and Figure 3a & b). Conversely, low ambient temperatures and increased physiological water stress which are otherwise essential for microbial growth and activity may be the cause of the lowest population counts throughout the winter. Tangjang and Arunachalam (2009) have also reported similar research findings.

CONCLUSION

Based on the findings of the experiment it is evident that the application of treatment T9 (M3T3)

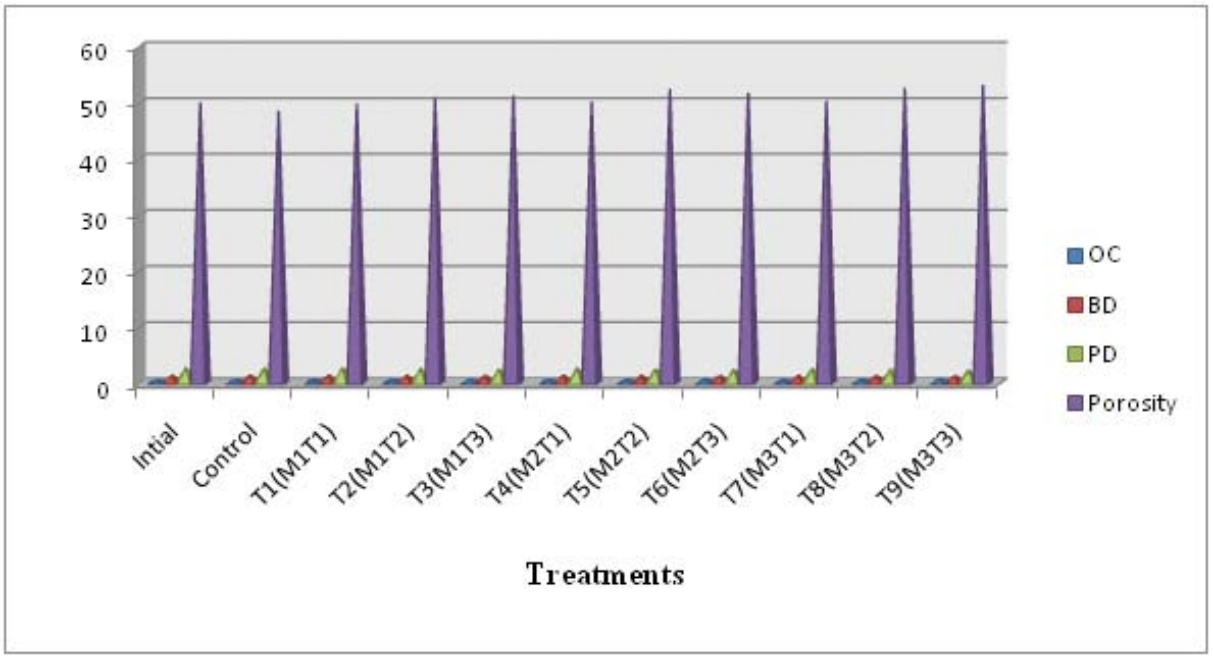

Fig. 2: Effect of microbial consortia on soil OC, BD, PD and porosity of Jamun (*Syzygium cumini* L.) cv. Goma Priyanka during growth period, 2019-20

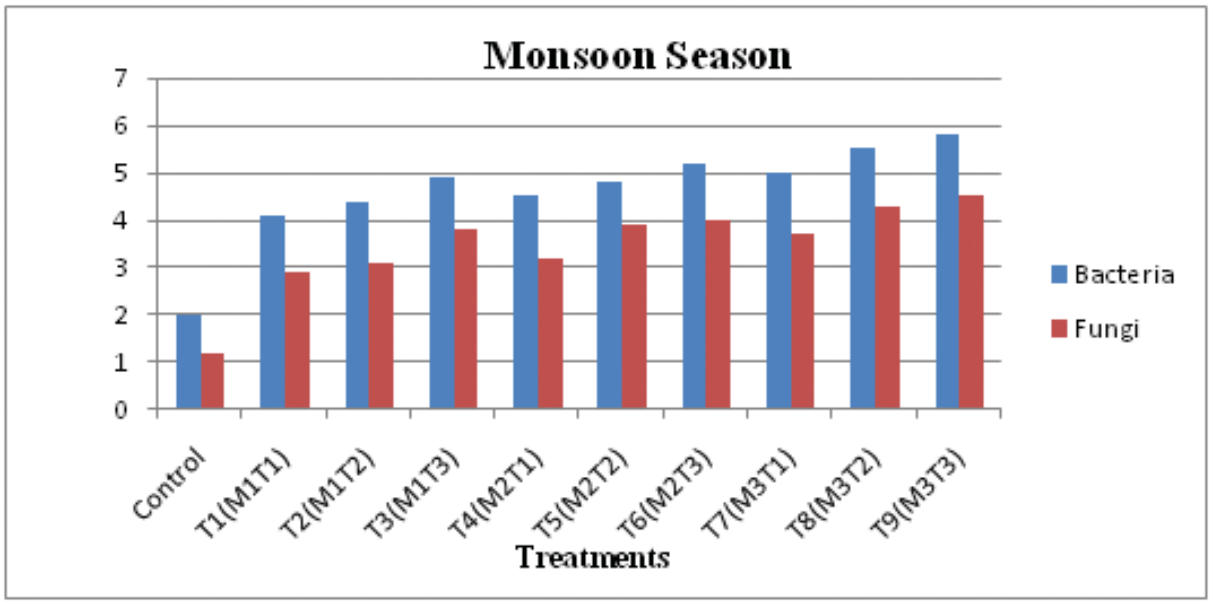

Fig. 3a: Effect of microbial consortia on soil microbial population of Jamun (*Syzygium cumini* L.) cv. Goma Priyanka during monsson season of growth period, 2019-20

- a combination of Azospirillum, PSB (Phosphate Solubilizing Bacteria), KSB (Potassium Solubilizing Bacteria), VAM (Vesicular ArbuscularMycorrhiza) and *Trichoderma harzianum* (100g) significantly enhanced various soil physicochemical and biological properties. Specifically, T9 (M3T3) demonstrated superior effects compared to other treatments across these parameters. Consequently, the results suggest that the application of T9 (M3T3) - a blend of *Azospirillum*, PSB, KSB, VAM and *Trichoderma harzianum*(100g) - in Jamun (*Syzygium cumini* L.) cv. GomaPriyanka cultivation is beneficial for improving plant growth and development characteristics, alongside enhancing soil parameters essential for establishing a robust plant framework and maintaining soil health.

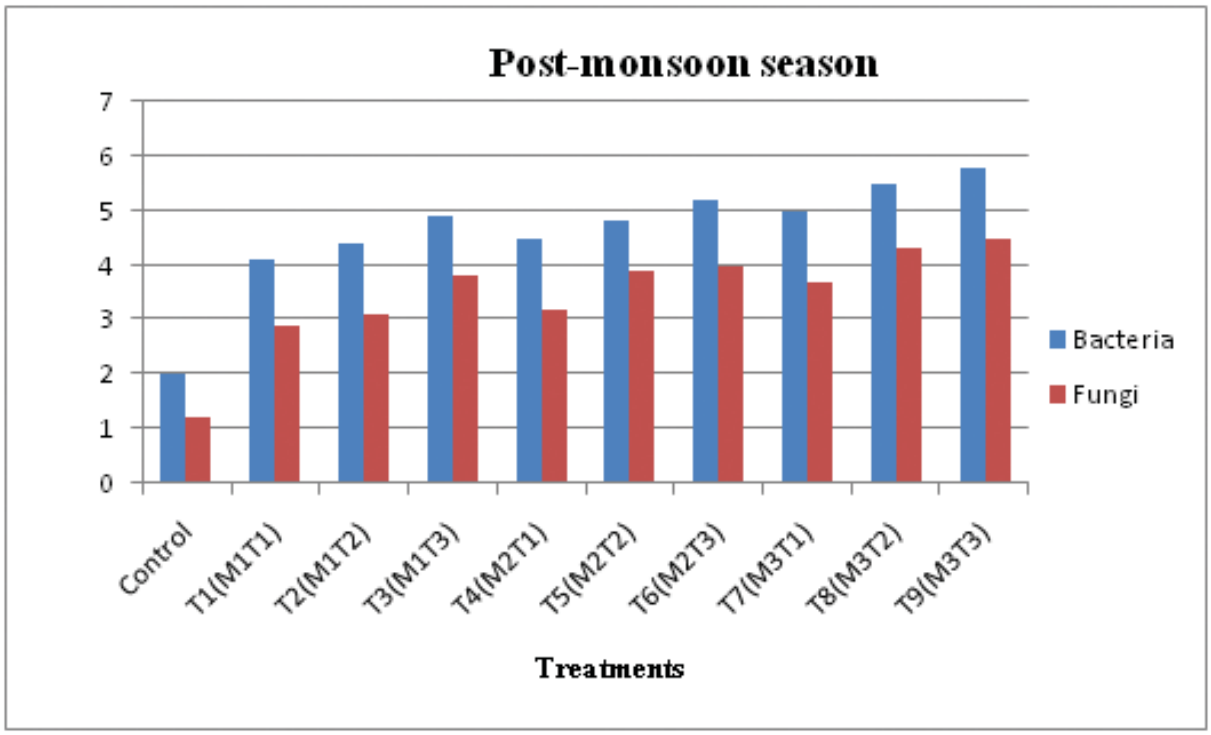

Fig. 3b : Effect of microbial consortia on soil microbial population of Jamun (*Syzygium cumini* L.) cv. Goma Priyanka during post-monsson season of growth period, 2019-20

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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