

Effect of Integrated Nutrient Management on Population of Biofertilizers in Rhizosphere of Okra (*Abelmoschus esculentus* (L.) Moench)

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ABSTRACT: A field experiment was conducted to study the effect of biofertilizers on rhizosphere microbial population of okra (*Abelmoschus esculentus* (L.) Moench). Biofertilizer application along with FYM had a positive influence on the inoculated microbes. Application of *Azospirillum*, Arbuscular Mycorrhizal Fungi (AMF) and *Frateuria* along with double dose of FYM recorded higher population of the inoculated microbes

KEYWORDS: Okra, *Azospirillum*, Arbuscular Mycorrhizal Fungi, *Frateuria*, FYM

I. INTRODUCTION

Soil is one of the most precious natural resource as it integrates all part of the ecosystem. It supports plant life and thereby all living beings on this earth. It is not just a growing medium; rather it is a living dynamic and ever so a changing environment. The life or soul of soil is the millions of microorganisms that inhabit the soil. The fertility of soil not only depends on the physicochemical properties of the soil but also on the qualitative and quantitative nature of these microorganisms. These microbial communities alter the physicochemical properties of the soil by their metabolic activities and makes it favourable for plant growth. But, unfortunately the excessive and indiscriminate use of chemicals have disturbed the natural balance of the soil by destroying these beneficial microorganisms that maintains soil health and quality. The only way to replenish the soil is by extraneous application of beneficial microorganisms. The use of biofertilizers gains importance in this context.

II. RELATED WORK

Biofertilizers are carrier based preparations containing live or latent cells of efficient strains of beneficial microorganisms in a viable state which when applied on to seed, soil or root augment the extent of availability of nutrients in a form which can be easily assimilated by the plants (Rao, 1995). They play an important role in various chemical transformations in soil and thus influence the availability of major nutrients like N, P and K to plants (Chaurasia, 2008). They influence total soil microflaura, soil enzyme activity and in turn soil health (Dar *et al.*, 2010) Significant improvement in growth, yield and quality of vegetables with respect to biofertilizer application have been reported in various crops.

Azospirillum is an associative symbiotic, microaerophilic, nitrogen fixing bacteria with high potential for nitrogen fixation. It fixes about 20-25 kg/ha of nitrogen under ideal conditions and thereby effecting a reduction of 25% nitrogenous fertilizers. The production of phytohormones like gibberellins, cytokinins (Parvatham *et al.*, 1989) and more specifically the auxins (IAA) have been recognised as an important factor in plant growth promoting ability of

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Azospirillum (Dobbeleare *et al.*, 1999). It has the ability for better root induction. As a result, plants are capable of absorbing more and more available nutrients from soil which results in better establishment of plant and its subsequent growth (Govindan and Purushothaman, 1989).

Arbuscular Mycorrhizal Fungi (AMF) are obligate symbiotic fungi associated with agricultural crops which improves the uptake of available phosphorus. AMF with their extramatrical hyphae increases absorption of relatively immobile elements in soil such as P, Cu, Zn (Haymann and Mosse, 1971), N, K, Ca, Mg and Fe (Linderman, 1992). In addition, mycorrhizal plants have shown greater tolerance to toxic heavy metals, drought (Sieverding, 1983), high soil temperature, saline conditions, adverse pH, transplantation shocks and root pathogens especially nematodes and pathogenic soil fungi than non-mycorrhizal plants (Jalali and Tareja, 1980). They produce growth hormones, improve rhizosphere conditions and alter host physiological and biochemical properties. They also synergistically interact with other beneficial microorganisms (Azcon, 1989) and improves soil aggregation (Singh *et al.*, 2010).

Frateuria aurantia is a gram negative, motile, rod shaped bacterium which belongs to Pseudomonaceae family. It was recently isolated from acidic soils (Curtis *et al.*, 2002) and showed exponential growth under very diverse growth conditions including wide temperature (10-36°C) and pH range (3.5-11) (Joyeux *et al.*, 2004; Murugesan, 2008). It mobilizes elementary or mixture of potassium or solubilize the fixed form of potassium into easily absorbable simpler form. It can mobilize K in all types of soil especially in low K content soils. By using *Frateuria*, about 50-60 per cent of potash fertilizers could be reduced (Chandra *et al.*, 2005).

III. METHODOLOGY

A field experiment was conducted at the Department of Olericulture, College of Horticulture, Kerala Agricultural University, Thrissur to determine the effect of biofertilizers *viz.*, *Azospirillum*, Arbuscular Mycorrhizal Fungi and *Frateuria* on the microbial population of inoculated microbes in the rhizosphere of okra cv. Arka Anamika. The soil of the experimental site was a well-drained laterite loam soil and was acidic in reaction with pH 4.13, EC 0.053 dSm⁻¹, available nitrogen 115.66 kg/ha, available phosphorus 36.59 kg/ha, available potassium 63.16 kg/ha and organic carbon 0.41%. The experiment was laid out in randomised block design with 13 treatments and 3 replications. The plot size adopted was 3.6 x 3.6 m with a spacing of 60 x 45 cm. The manures and fertilizers were given as per Package of Practices recommendation of Kerala Agricultural University *i.e.* FYM @ 12 t ha⁻¹ and N: P₂O₅: K₂O @ 50:8:25 kg ha⁻¹. The thirteen treatments were T₁ - FYM + *Azospirillum*, T₂ - FYM + AMF, T₃ - FYM + *Frateuria*, T₄ - FYM + *Azospirillum* + AMF, T₅ - FYM + *Azospirillum* + *Frateuria*, T₆ - FYM + AMF + *Frateuria*, T₇ - FYM + *Azospirillum* + AMF + *Frateuria*, T₈ - FYM (double dose) + *Azospirillum* + AMF + *Frateuria*, T₉ - FYM (as per POP) + ½ (NPK) + *Azospirillum* + AMF + *Frateuria*, T₁₀ - FYM (as per POP) + ¾ (NPK) + *Azospirillum* + AMF + *Frateuria*, T₁₁ - POP + *Azospirillum* + AMF + *Frateuria*, T₁₂ - *Azospirillum* + AMF + *Frateuria* and T₁₃ - Manures and fertilizers as per POP recommendation (control). All the biofertilizers were applied as soil application @ 2 kg ha⁻¹ along with FYM @ 12 t ha⁻¹. Enumeration of *Azospirillum*, AMF and *Frateuria* in the rhizosphere were carried out before treatment application and at final harvest. Serial dilution and plate count technique (Johnson and Curl, 1972) was used for enumeration of *Azospirillum* and *Frateuria* in rhizosphere soil. Modified Okon's media was used for *Azospirillum* (Lakshmikumari *et al.*, 1980) and Glucose-Yeast extract-CaCO₃ Agar was used for *Frateuria* (Lisdiyanti *et al.*, 2003). The total spore count of AMF from rhizosphere soil were counted by wet sieving and decanting method (Gerdeman and Nicolson, 1963).

IV. EXPERIMENTAL RESULTS

The initial count of *Azospirillum* was 3.17 x 10⁶ cfu/g soil. At the time of final harvest, an increase in the *Azospirillum* population was noticed in all the treatments and it showed significant differences (Table 1). After the completion of the crop, it was highest in T₈ (FYM (double dose) + *Azospirillum* + AMF + *Frateuria* each @ 2 kg/ha) with 45.50 x 10⁶ cfu/g soil. It was on par with T₁₀ (FYM (as per POP) + ¾ (NPK) + *Azospirillum* + AMF + *Frateuria* each @ 2 kg/ha) and T₉ (FYM (as per POP) + ½ (NPK) + *Azospirillum* + AMF + *Frateuria* each @ 2 kg/ha) which recorded 43 x 10⁶ cfu/g and 40 x 10⁶ cfu/g respectively (Fig. 1). Application of double dose of FYM might have helped soil to improve the nutrient status which helped the multiplication of *Azospirillum*.

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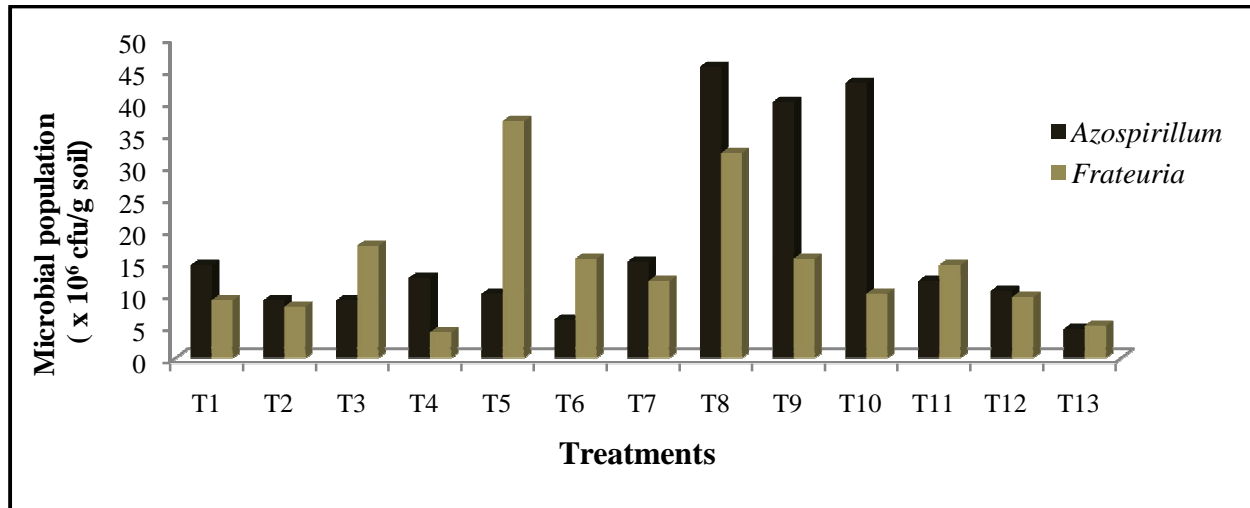
Table 1: Effect of different treatments on population of *Azospirillum*, AMF and *Frateuria* sp. in rhizosphere soil of okra

Treatments	<i>Azospirillum</i> (x10 ⁶ cfu/g soil)	Spore count of AMF (in 10 g soil)	<i>Frateuria</i> (x10 ⁶ cfu/g soil)
T ₁	14.50 (3.85 ^b)	17.50 ^a	9.00 (3.08 ^{bc})
T ₂	9.00 (3.06 ^b)	23.50 ^a	8.00 (2.69 ^c)
T ₃	9.00 (3.07 ^b)	14.50 ^a	17.50 (4.23 ^{abc})
T ₄	12.50 (3.58 ^b)	31.00 ^a	4.00 (2.11 ^c)
T ₅	10.00 (3.14 ^b)	14.50 ^a	37.00 (6.11 ^a)
T ₆	6.00 (2.41 ^b)	24.00 ^a	15.50 (4.00 ^{abc})
T ₇	15.00 (3.88 ^b)	18.50 ^a	12.00 (3.53 ^{abc})
T ₈	45.50 (6.72 ^a)	30.50 ^a	32.00 (5.67 ^{ab})
T ₉	40.00 (6.36 ^a)	27.50 ^a	15.50 (3.84 ^{abc})
T ₁₀	43.00 (6.59 ^a)	28.00 ^a	10.00 (3.21 ^{bc})
T ₁₁	12.00 (3.52 ^b)	26.50 ^a	14.50 (3.28 ^{bc})
T ₁₂	10.50 (3.27 ^b)	26.00 ^a	9.50 (3.07 ^{bc})
T ₁₃	4.50 (2.21 ^b)	20.00 ^a	5.00 (2.15 ^c)
Initial value	3.17	3.00	4.5

The table shows the initial and final population of applied biofertilizers in the rhizosphere of okra. Treatment means having similar alphabets in superscript do not differ significantly. Values given in parenthesis are square root transformed values. It can be noted that all the treatments showed an increase in the population of biofertilizers.

The count of *Frateuria* showed significant differences and it increased from the initial population of 4.5 x 10⁶ cfu/g to 37 x 10⁶ cfu/g in T₅ (FYM + *Azospirillum* + *Frateuria* each @ 2 kg/ha) which recorded the maximum population (Table 1). It was followed by T₈ (FYM (double dose) + *Azospirillum* + AMF + *Frateuria* each @ 2 kg/ha) (32 x 10⁶ cfu/g) (Fig. 1). Conjoint application of FYM, inorganic fertilizers and biofertilizers might have acted complementary and supplementary to each other and resulted in adequate and slow, but steady supply of nutrients which ultimately helped in better microbial population at the end of the experiment.

Fig. 1: Treatment effect on *Azospirillum* and *Frateuria* population in rhizosphere soil



It can be clearly noted from Fig. 1. that the *Azospirillum* population was maximum in T₈ where all the biofertilizers were applied @ 2 kg/ha along with double dose of FYM. The *Frateuria* population showed highest value in T₅ where *Azospirillum* and *Frateuria* were applied @ 2 kg/ha along with FYM.

All the treatments enhanced the spore count of AMF from the initial values of 3 spores/10 g soil eventhough, there was no significant difference between treatments (Table 1). After the harvest of crop, T₄ (FYM + *Azospirillum* + AMF each @ 2 kg/ha) recorded the highest spore count of 31 spores/10 g soil (Fig. 2). It was followed by T₈ (FYM (double dose) + *Azospirillum* + AMF + *Frateuria* each @ 2 kg/ha) which recorded 30.50 spores /10 g soil

Fig. 2: Treatment effect on spore count of AMF in rhizosphere soil

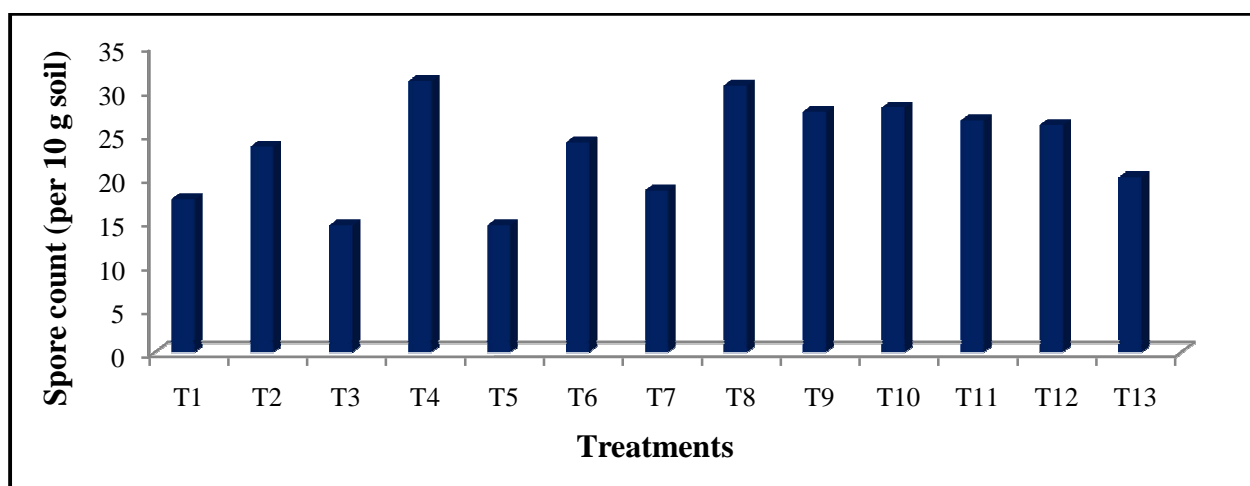


Fig 2. shows the number of spores of AMF in 10 g of rhizosphere soil. Irrespective of the treatments, the spore count shows an increase from the initial value with the highest in T₄ where *Azospirillum* and AMF were applied @ 2 kg/ha along with FYM.

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V. CONCLUSION

The microbial population increased when compared to the initial population. FYM might have provided nutrients for better establishment of inoculated microorganism along with accumulation of excess humus content (Hayworth *et al.*, 1996). It may be observed that treatments with FYM, inorganic fertilizers and the three biofertilizers recorded higher microbial count. As a cost effective supplement to chemical fertilizers, biofertilizers, could help to economize on the high investment needed for fertilizer use (Pandey and Kumar, 2002). When these microorganisms flourish in soil, they produce growth promoting substances and vitamins and help to maintain soil fertility and suppress the incidence of pathogen and control diseases (Bagyaraj, 2003). These non conventional sources of nutrients are gaining immense importance these days as they improve long term sustainability of soil.

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