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## IMPACT OF DIFFERENT MICROBIAL CULTURES AND THEIR CONSORTIA ON PHYSICO-CHEMICAL PROPERTIES OF SOIL UNDER SOYBEAN

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### ABSTRACT

The present field experiment was undertaken at Research Farm, Department of Soil Science, College of Agriculture, Vasantrya Naik Marathwada Krishi Vidyapeeth, Parbhani during *Kharif* season of 2023. Ten different treatment combinations were used in the experiment which included different microbial cultures and their consortia *i.e* *Rhizobium spp.* + *Bacillus megaterium* (Consortia-I), *Rhizobium spp.* + *Frateuria aurantia* (Consortia-II), *Rhizobium spp.* + *Thiobacillus thioxidans* (Consortia-III), *Rhizobium spp.* + *Pseudomonas strita* (Consortia-IV), *Rhizobium spp.* + *Bacillus megaterium* + *Frateuria aurantia* (Consortia-V), *Rhizobium spp.* + *Bacillus megaterium* + *Thiobacillus thioxidans* (Consortia- VI ), *Rhizobium spp.* + *Bacillus megaterium* + *Pseudomonas strita* (Consortia- VII ), and control replicated thrice in RBD (Randomized Block Design). Seed treatment of soybean was done with microbial consortia @ 10 ml kg<sup>-1</sup> seed before sowing with recommended dose of fertilizers. Among all the treatments, *Rhizobium spp.* + *Bacillus megaterium* + *Frateuria aurantia* (Consortia- V) significantly increased the organic carbon, available N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O, Cu, Zn, Fe and Mn content in soil. However, pH, EC and calcium carbonate was found non-significant after harvesting of the crop due to above properties don't change in one cropping season.

**Keywords :** Microbial consortia; Treatment; soybean; vertisol.

### Introduction

In addition to the excessive use of chemicals over the previous forty years, modern agricultural farming practices have led to not only loss of natural habitat balance and soil health, but they have also resulted in a number of risks, including genetic erosion, soil erosion, decreased groundwater levels, soil salinization, fertilizer and pesticide pollution, adverse effects on the environment, lower food quality and higher cultivation costs, which make farmers' lives worse every year (Reddy *et al.*, 2003 and Rahman *et al.*, 2020). The negative impacts on modern agricultural methods have now made environmentally friendly and healthy farming methods necessary. By encouraging environmentally friendly farming techniques and lowering dependency on chemical fertilizers, the use of biofertilizers could assist in the development of sustainable agricultural practices

(Soverda *et al.*, 2009). biofertilizers are made of living microorganisms that can mobilize nutrients through a variety of biological processes from an unusable state to a useable state (Yadav *et al.*, 2019). In sustainable agricultural production, the function and significance of various biofertilizers, particularly those of *Rhizobium* and *Azospirillum*, have been recorded and examined by various authors (Aserse *et al.*, 2020 and Khanna *et al.*, 2019). Legume crop roots work in symbiosis with *Rhizobium* (diazotroph) (Kushwaha *et al.*, 2017). Certain legumes allow it to invade their roots, forming tumor-like growths known as root nodules that serve as producers of the formation of ammonia. Organic acids produced by *Bacillus sp.* are soluble exudates that are known to be a key mechanism in the release of phosphates from hydroxyl apatites. As a potassium solubilizer, *Frateuria aurantia* promotes the potassium content in soil. Additionally, while the individual isolates of EM (Effective Microbial) culture

have already shown benefits, their consortia containing two or more beneficial microorganisms is more beneficial in boosting the supply of nutrients through induced phyto resistance, solubilization, anti-phyto pathogenicity, and phyto stimulator (Kumar *et al.*, 2021).

Due to its great nutritional content, soybean (*Glycine max*), commonly known as "poor man's meat," is a pulse crop that first achieved prominence as a crop used as oilseed because it provides 20% cholesterol-free oil (Guleria *et al.*, 2019). In India, during *Kharif* 2023, the area under soybean was 118.54 lakh hectares with a production of 118.74 lakh MT. Among the states, Madhya Pradesh stood first with 52.647 Lakh MT production followed by Maharashtra with 46.91 Lakh MT. The average yield was higher in Maharashtra and Madhya Pradesh at 1028 and 1008 kg/ha during the same period SOPA, 2023. In addition to being a high-quality source of protein for people, soybeans are also known as "fertility restorer crops." They're able to use symbiotic nitrogen fixers for restoring atmospheric nitrogen. This contributes to the soil's improved nitrogen economy. Because chemical fertilizers are used extensively in pulse growing, it leads to there are numerous environmental problems. In consideration of this, the current study was conducted to assess the impact of microbial consortia along promote the usage of consortiums in these important crops grown in the Indian state of Maharashtra by using chemical fertilizers.

### Materials and Methods

The field experiment was carried at Research Farm, Department of Soil Science, Vasantrao Naik Marathwada Agricultural University, Parbhani (MAH) during *kharif* 2023. The soils of the region are medium to deep black (Vertisol). The soil had a clay-like texture, was moderately alkaline in response, had low levels of readily accessible nitrogen, available phosphorus and high levels of readily available potassium, but had deficient in Fe and Zn and sufficient in Cu and Mn.

Ten treatments were used in the experiment, viz. T<sub>1</sub> Absolute control, T<sub>2</sub> Recommended Dose of Fertilizer (RDF), T<sub>3</sub> Recommended Dose of Fertilizer (RDF) + *Rhizobium spp.*, T<sub>4</sub> Recommended Dose of Fertilizer RDF + *Rhizobium spp.* + *Bacillus megaterium* (PSB), T<sub>5</sub> Recommended Dose of Fertilizer (RDF) + *Rhizobium spp.* + *Frateria aurantia* (KSB), T<sub>6</sub> Recommended Dose of Fertilizer (RDF) + *Rhizobium spp.* + *Thiobacillus thiooxidans* (SSB), T<sub>7</sub> Recommended Dose of Fertilizer (RDF) + *Rhizobium spp.* + *Pseudomonas striata* (ZnSB), T<sub>8</sub>

Recommended Dose of Fertilizer (RDF) + *Rhizobium spp.* + *Bacillus megaterium* (PSB) + *Frateria aurantia* (KSB), T<sub>9</sub> Recommended Dose of Fertilizer (RDF) + *Rhizobium spp.* + *Bacillus megaterium* (PSB) + *Thiobacillus thiooxidans* (SSB), T<sub>10</sub> Recommended Dose of Fertilizer (RDF) + *Rhizobium spp.* + *Bacillus megaterium* (PSB) + *Pseudomonas striata* (ZnSB), the experiment was laid out in a Randomized Block Design (RBD) with ten treatments and three replications. Seeds were sown at the rate of 65 kg ha<sup>-1</sup> for soybean. The fertilizers were applied @ N: P<sub>2</sub>O<sub>5</sub> : K<sub>2</sub>O 30:60:30 kg ha<sup>-1</sup> respectively. Urea, single super phosphate and muriate of potash were used as fertilizer sources.

*Rhizobium spp.* with *Bacillus megaterium* (Consortia-I), *Rhizobium spp.* with *Frateria aurantia* (Consortia-II), *Rhizobium spp.* with *Thiobacillus thiooxidans* (Consortia-III), *Rhizobium spp.* with *Pseudomonas striata* (Consortia-IV), *Rhizobium spp.* with *Bacillus megaterium* and *Frateria aurantia* (Consortia-V), *Rhizobium spp.* with *Bacillus megaterium* and *Thiobacillus thiooxidans* (Consortia-VI), *Rhizobium spp.* with *Bacillus megaterium* and *Pseudomonas striata* (Consortia-VII) were obtained from ICAR-All India Network Project on Soil Biodiversity–Biofertilizers, Parbhani Center and used for seed treatment @ 10 ml per kg of soybean seed. Seed treatment was done before sowing. Seeds were dried in shed and used for sowing as dibbling. The variety of soybean is MAUS-158.

To evaluate the fertility status of soil, the soil sample (0-15 cm depth), from each plot at harvest of crop was taken. The samples were passed through 2 mm plastic sieve to avoid metallic contamination. The soil sample were analysed for pH, EC, calcium carbonate, organic carbon and available NPK and cationic micronutrients (Cu, Zn, Fe, Mn) content.

### Results and Discussion

#### Soil pH, electrical conductivity, calcium carbonate and organic carbon

Seed inoculation with different microbial cultures and their consortia the pH, EC and calcium carbonate values of soil usually does not change easily predominantly in Vertisol due to greater buffering capacity in Vertisol so the result occurred non-significant which is showed in Table-1. The soil pH as influenced by microbial inoculants and their consortia ranged from 7.80 to 7.70. The drop in soil pH at harvest stage may be attributed to the consortium, fungi and bacteria synthesising organic acids, similar results were reported by (Kumari *et al.*, 2017). The EC of the soil ranged between 0.23 and 0.33 dSm<sup>-1</sup>. There

was a modest increase in electrical conductivity, which could be the consequence of nutrients solubilizing them following the injection of RDF and promising bacteria isolates into the rhizosphere of the soil. Additionally, Hati *et al.*, (2007) demonstrated that electrical conductivity was elevated by PSM seed inoculation. The calcium carbonate was influenced by the application of different microbial cultures and their consortia ranged from 5.47 to 6.12 g kg<sup>-1</sup>. The production of organic acids by bacteria, fungi and actinomycetes, the release of CO<sub>2</sub> by microorganisms and the generation of mineral acids (H<sub>2</sub>SO<sub>4</sub>) as a result of sulphate dissociation may be responsible for the drop in CaCO<sub>3</sub> content SO<sub>4</sub><sup>2-</sup> (Said, 2011). The result on soil organic carbon are presented in Table-1. The different microbial cultures and their consortia influenced the soil organic carbon which ranged from 4.96 to 6.24 g kg<sup>-1</sup> showing higher soil organic carbon in T<sub>8</sub> (RDF+ *Rhizophos*+ KSB) whereas, lower 4.96 g kg<sup>-1</sup> soil organic carbon per plot were noted in absolute control. Using various microbial cultures and their consortia with RDF in the respective treatments to increase the organic carbon content over the control relative to the initial values. The rapid rate of organic matter breakdown caused by an increased microbial population, as well as the development of ideal conditions for the growth of soil microorganisms, root biomass, etc., could be the cause of this increase in the organic carbon content in the biofertilizer-treated rhizosphere soil (Ramalakshmi *et al.*, 2008).

#### Available nitrogen, phosphorus and potassium

The data presented in Table-2 indicate that available nitrogen, phosphorus and potassium in soil at the harvesting stage of soybean was significantly increased in all treatments with different microbial cultures and their consortia. Microbial cultures and their consortia influenced the available nitrogen which ranged between 155.67 to 185.00 kg ha<sup>-1</sup>, showing significantly higher (185.00 kg ha<sup>-1</sup>) available nitrogen in treatment T<sub>10</sub> (RDF + *Rhizophos* + ZnSB) which was at par with T<sub>8</sub> RDF + *Rhizophos* + KSB and T<sub>7</sub> RDF + *Rhizobium* + ZnSB (180.33 and 180.15 kg/ha respectively). The highest P content (17.63 kg ha<sup>-1</sup>) of the soil was noted in treatment T<sub>9</sub> (RDF+ *Rhizophos* + SSB inoculation) which was at par with T<sub>8</sub> RDF + *Rhizophos*+ KSB (17.00 kg ha<sup>-1</sup>). Significantly highest value of available potassium is in T<sub>8</sub> (RDF+ *Rhizophos* +KSB) which is 577.67 kg ha<sup>-1</sup> which was at par with T<sub>9</sub> (RDF+ *Rhizophos* + SSB) which is 566.67 kg ha<sup>-1</sup>. The soil community, which can affect soil fertility through processes like decomposition, mineralization, and nutrient release, may be the cause of increased macro nutrient availability. The combined application

of biofertilizers has been shown to improve N, P, and K nutrients (Prasad *et al.*, 2016). The buildup of soil available N could be attributed to the greater multiplication of microbial inoculants which helped in the mineralization of soil N leading to higher available nitrogen and quickly released nutrients as previously reported by Thakur *et al.*, 2010 and Yadav *et al.*, 2009 found that applying bioinoculants to the soil raised its accessible N concentration. By taking part in the soil phosphorus cycle, *pseudomonas* and *Bacillus* play a crucial role in regulating the amount of phosphorus that is available to plants. They either increase the growth of root system by directly solubilizing and mineralizing inorganic phosphorus or by promoting the mobility of organic phosphorus through the turnover of microbial consortia. Similar result has been recorded by (Khan and Gupta, 1984). Increased soil potassium is a sign that KSB can react with K-bearing minerals by forming organic acids. Potassium fixation may have decreased, while fertilizer additions have improved soil availability, contributing to the recent increase in potassium availability. Co-inoculation of PSB and KSB resulted in consistently higher P and K availability than in the control without bacterial inoculum and without rock material fertilizer. Integrated rock P with inoculation of PSB increased the availability of P and K in soil, the uptake of N, P and K by shoot and root, and the growth of plant (Han *et al.*, 2006).

#### DTPA micronutrients

The seed inoculated with different microbial cultures significantly increased DTPA extractable micronutrients (Zn, Fe, Mn and Cu) than control in post-harvest soil (Table 3). According to the results, highest available Fe (4.58 mg/kg), Zn (0.58 mg/kg), Cu (2.37mg/kg) and Mn (7.81 mg/kg) were recorded under Treatment T<sub>10</sub> (RDF + *Rhizophos* + ZnSB) which is at par with Treatment T<sub>8</sub> (RDF + *Rhizophos* + KSB). Inoculation with biofertilizers improved chelating agents and improved micronutrient availability (Fe, Zn, Cu and Mn) Prasad *et al.*, 2016. The bio- solubilization capacity of the microorganism was able to mobilize 60-80% of the iron and manganese during the research, where as 20% of zinc (Stefanescu *et al.*, 2010). According to Satwadhara., (2020), *Pseudomona striata* inoculation, a zinc-solubilizing microbial isolate, enhanced the availability of nutrients (DTPA Zn, Fe, Cu, and Mn) in the soil at a rate of 40 kg ZnSO<sub>4</sub> ha<sup>-1</sup> in a pot culture experiment.

#### Conclusion

Based on results, it can be concluded that soil pH, electrical conductivity and calcium carbonate content

was statistically non-significant at the harvesting stage of soybean. Significantly maximum nutrient availability in soil after harvesting of soybean crop was also registered with different microbial cultures and their consortia. The significantly highest values of organic carbon, available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were recorded maximum in treatment receiving the RDF + *Rhizophos* +KSB over the rest of the treatments. The

DTPA micronutrients (Fe, Mn, Zn and Cu) in the soil at the harvesting stage of soybean were also recorded significantly influenced by different microbial cultures and their consortia. DTPA micronutrients (Fe, Mn, Zn, and Cu) were noted maximum in treatment receiving the RDF + *Rhizophos* + ZnSB (Consortia - VII) at par with RDF+ *Rhizophos* +KSB (Consortia- V).

**Table 1 :** Effect of different microbial cultures and their consortia on pH, electrical conductivity, calcium carbonate and organic carbon

Treatment details	Soil Properties			
	pH	EC (dSm <sup>-1</sup> )	CaCO <sub>3</sub> (g kg <sup>-1</sup> )	OC (g kg <sup>-1</sup> )
T <sub>1</sub> :Absolute control	7.80	0.23	5.84	4.96
T <sub>2</sub> :RDF	7.78	0.25	6.12	5.68
T <sub>3</sub> :RDF+ <i>Rhizobium</i> inoculation	7.77	0.27	5.93	5.69
T <sub>4</sub> :RDF+ <i>Rhizophos</i> inoculation	7.73	0.30	5.69	6.00
T <sub>5</sub> :RDF + <i>Rhizobium</i> + KSBinoculation	7.76	0.27	5.74	5.71
T <sub>6</sub> : RDF + <i>Rhizobium</i> + SSBinoculation	7.74	0.28	5.73	5.72
T <sub>7</sub> : RDF + <i>Rhizobium</i> + ZnSB inoculation	7.74	0.28	5.73	5.73
T <sub>8</sub> :RDF + <i>Rhizophos</i> + KSBinoculation	7.70	0.33	5.47	6.24
T <sub>9</sub> : RDF + <i>Rhizophos</i> + SSBinoculation	7.73	0.32	5.68	6.18
T <sub>10</sub> :RDF + <i>Rhizophos</i> + ZnSBinoculation	7.72	0.32	5.67	6.22
SE(m) ±	0.03	0.02	0.43	0.32
C.D at 5%	NS	NS	NS	0.06
Initial	7.79	0.20	5.90	4.44

**Table 2 :** Effect of different microbial cultures and their consortia on the availability of macronutrients in soil.

Treatment detail	Available N (kg ha <sup>-1</sup> )	Available P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	Available K <sub>2</sub> O (kg ha <sup>-1</sup> )
T <sub>1</sub> :Absolute control	155.67	10.00	453.99
T <sub>2</sub> :RDF	163.00	12.70	497.96
T <sub>3</sub> :RDF+ <i>Rhizobium</i> inoculation	172.00	15.39	513.71
T <sub>4</sub> :RDF+ <i>Rhizophos</i> inoculation	176.18	16.64	556.19
T <sub>5</sub> :RDF + <i>Rhizobium</i> + KSB inoculation	173.66	15.78	550.33
T <sub>6</sub> : RDF + <i>Rhizobium</i> + SSB inoculation	173.92	16.22	546.67
T <sub>7</sub> : RDF + <i>Rhizobium</i> + ZnSB inoculation	174.00	15.85	547.37
T <sub>8</sub> :RDF + <i>Rhizophos</i> + KSB inoculation	180.33	17.00	577.67
T <sub>9</sub> : RDF + <i>Rhizophos</i> + SSB inoculation	180.15	17.63	566.67
T <sub>10</sub> :RDF + <i>Rhizophos</i> + ZnSB inoculation	185.00	16.96	562.66
SE(m) ±	2.10	0.77	6.89
C.D at 5%	6.23	2.28	20.46
Initial	154.07	9.85	449.34

**Table 3 :** Effect of different microbial cultures and their consortia on DTPA extractable Fe, Zn, Cu, Mn (mg kg<sup>-1</sup>) in soil.

Treatment detail	DTPA Fe (mg kg <sup>-1</sup> )	DTPA Zn (mg kg <sup>-1</sup> )	DTPA Cu (mg kg <sup>-1</sup> )	DTPA Mn (mg kg <sup>-1</sup> )
T <sub>1</sub> :Absolute control	3.46	0.38	1.75	7.34
T <sub>2</sub> :RDF	4.07	0.45	2.03	7.49
T <sub>3</sub> :RDF+ <i>Rhizobium</i> inoculation	4.17	0.47	2.29	7.57
T <sub>4</sub> :RDF+ <i>Rhizophos</i> inoculation	4.45	0.51	2.33	7.74
T <sub>5</sub> :RDF + <i>Rhizobium</i> + KSBinoculation	4.28	0.48	2.31	7.65
T <sub>6</sub> : RDF + <i>Rhizobium</i> + SSBinoculation	4.29	0.49	2.32	7.70

T <sub>7</sub> : RDF + <i>Rhizobium</i> + ZnSB inoculation	4.44	0.50	2.33	7.72
T <sub>8</sub> : RDF + <i>Rhizophos</i> + KSB inoculation	4.54	0.55	2.35	7.79
T <sub>9</sub> : RDF + <i>Rhizophos</i> + SSB inoculation	4.54	0.53	2.34	7.76
T <sub>10</sub> : RDF + <i>Rhizophos</i> + ZnSB inoculation	4.58	0.58	2.37	7.81
<b>SE(m) ±</b>	0.08	0.01	0.05	0.04
<b>C.D at 5%</b>	0.24	0.03	0.15	0.11
<b>Initial</b>	3.40	0.32	1.72	7.26

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