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Effect of Bioinoculants and Organic Manure (Phosphocompost) on Growth, Yield and Nutrient Uptake of *Trigonella foenum-graecum* L. (Fenugreek)

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Abstract: ***The present field study was carried out to determine the effect of microbial bioinoculants along with organic manure (phosphocompost) on growth, yield and nutrient uptake of Trigonella in 2010 - 2011. The experiment consisted of ten combinations of microbial consortia and organic manure. Results revealed that combined inoculation with phosphocompost and bioinoculants Frateuria aurentia(Potassium mobilizer), Trichoderma viride, Rhizobium spp and Pseudomonas fluorescens significantly increased plant biomass, yield and nutrient content.***

Keywords: Bioinoculants, phosphocompost, rock phosphate, *Trigonella, Frateuria*

1. Introduction

Composting is an integral part of organic agriculture. Due to overexploitation of natural sources and abusive use of chemical fertilizers and synthetic inputs led to soil poorer in nutrients and became a serious threat to the environment. Therefore, it is a need to save the environment and sustain soil fertility as well as crop productivity. The supply of essential nutrients to the soil can be met through the application of organic manure and microbial bioinoculants.

Phosphorus (P) is an important macronutrient required for plant growth and development. It plays a vital role in development of root, stem and stalk and also required for flower and seed formation and early crop maturity. Therefore,demand of phosphorus can be met through the application of organic manure in the form of phosphocompost and by microbial inoculants i.e. phosphate solubilising microorganisms to the plants. Soil microorganisms play a key role in soil P dynamics and subsequent availability of phosphate to plants (Richardson, 2001).Phosphocomposting involves the incorporation of phosphatic fertilizers like rock phosphate to the highly enriched organic matter. During composting, the process of solubilisation of insoluble phosphates takes place by phosphate solubilising microbes.

Bioinoculants (microbial inoculum) being essential components of organic farming play vital role in maintaining long term soil fertility and sustainability. Microorganisms enhance the Phosphorus availability to plants by mineralizing organic P in soil and by solubilizing precipitated phosphates (Chen *et.al*. 2006, Kang *et.al*. 2002, Pradhan and Shukla, 2005). The use of phosphate solubilising microbes as bioinoculants increase the phosphorus uptake and crop yield (Yadav *et.al*. 2011).

*Trigonella foenum-graecum*L. belongs to the family Leguminosae commonly used as spices in India, is an important source of dietary protein. It has important medicinal properties too. In India fenugreek seeds are being used traditionally for treating diabetes. Presence of sapogenins and mucilaginous fibres in the seed possess the anti-diabetic and hypocholesterolaemic properties (Mansour & El-Adway, 1994).It is also known for symbiotic nitrogen fixation by *Rhizobium* present in its root nodules.

2. Materials and Methods

A field experiment was carried out in 2010 to 2011 at Dept. of Botany, Bangalore University, Bangalore,in replicated randomized block designs with three replications for each treatment. Bioinoculants used for treatments were *Frateuria aurentia* (potassium mobilizer), *Trichoderma viride* (biocontrol agent),*Rhizobium spp* (as nitrogen source), *Pseudomonas fluorescens* (growth promoting bacteria).

2.1Preparation of Compost

Composting were carried out by pit and heapmethod at Dept. of Botany, Bangalore University, Bangalore.Organic wastes from different locations of Jnana BharathiCampus viz., library, canteen, Gandhi Bhavan, were collectedand dumped at the backyard of Botany Dept., Bangalore University, Bangalore in pits and heaps for decomposition.

The heterogenous and homogenous compost were combined with low grade rock phosphate at recommended dosage and bioinoculants to produce phosphocompost. The phosphocompost thus, obtained were used for further experiments.

2.2Enrichment of Compost

Bioinoculants viz., *Frateuria aurentia* (KMB), *Trichoderma viride* (biocontrol agent), *Rhizobium* spp(nitrogen fixer), *Aspergillus awamori* (P solubilizer), *Pseudomonas fluorescens* (plant growth promoting rhizobacteria) wereinoculated into compost in different combinations and

theenriched compost thus obtained were used for various cropplants and the results were recorded.

2.3Response of Compost and Bioinoculants on Crop Plants:

Field experiments were carried out at Department of Botany, to evaluate the direct effect of phosphocompost along with bioinoculants. The traditional seed variety of *Trigonella* were used for the experiment which were procured from farmer's seed bank (Kolar and Green Foundation) were used for the experiments. The treatments are as follows:

T_1 = Rock Phosphate + Vermicompost, T_2 = Rock Phosphate + P-solubilizer+ vermicompost, T_3 = Rock phosphate + P-solubilizer+ *Frateuriaaurentia (F.a.)+Trichodermaviride(T.v.)+Rhizobium sp +Pseuodomonasfluorescens(P.f.)*+ vermicompost, T_4 = Rock phosphate+ P-solubilizer+ *Frateuria aurentia (F.a.)+Trichoderma viride(T.v.),*T_5 = Rock phosphate+ P-solubilizer ,C_1 = Vermicompost, T_6 = Rock phosphate+ Green Compost, T_7 = Rock Phosphate + P-solubilizer+ Green Compost,T_8 = Rock phosphate + P-solubilizer+ *Frateuriaaurentia (F.a.)+Trichodermaviride(T.v.)+Rhizobium sp +Pseudomonasfluorescens* (P.f.) + Greencompost, T_9 = Rock phosphate + P-solubilizer+ Frateuria aurentia (F.a.) + *Trichoderma viride*(T.v.),T_{10} = Rock Phosphate + P-solubilizer, C_2 = Green Compost

Treatments were given at 15th and 30th days of plants growth and harvested at 25th and 40th days. The following parameters were recorded: Plant growth and biomass, nutrients content viz., calcium, magnesium, phosphorus.

2.4 Estimation of nutrient content in Trigonella

Calcium and magnesium content were estimated by EDTA Titration method. Phosphorus content was estimated by following the standard method.

3. Results and Discussion

The field experimental results of different treatments in fenugreek revealed different significant responses of yield attributes viz., shoot length, number of leaves, fresh weight and dry weight. Among the different treaments T_4 and T_3 were found to be superior and effective in increasing growth parameters over control and other treatments respectively (Table-2). Number of leaves , fresh weight and dry weight were recorded maximum in T_4 i.e. combined inoculation with rock phosphate, potassium mobilizer , phosphate solubilizing bacteria and organic manure as vermicompost which is in agreement with the report of Nag and Singha Roy, 2008, showed that vermicompost application along with biofertilizers (*Azotobacter*& PhosphateSolubilizing Bacteria) significantly enhanced yield of wheat. The microbial consortia containing of rock phosphate, phosphate solubilizer, potassium mobilizer, *Trichoderma viride, Rhizobium, Pseudomonas fluorescens* and vermicompost proved to be the second best treatment in this present field experiment and the results are in conformity with the earlier findings of Ashif Ali *et.al*., 2009.

Table 1: Microbial consortia as bioinoculants for Rockphosphate-vermicompost

Treatments	
T_1	*Rock Phosphate + Vermicompost*
T_2	*Rock Phosphate + P-solubilizer+ vermicompost*
T_3	*Rock phosphate + P-solubilizer+ Frateuriaaurentia(F.a.)+Trichoderma viride(T.v.)+ Rhizobium sp +Pseuodomonasfluorescens(P.f.)+ vermicompost*
T_4	*Rock phosphate+ P-solubilizer+ Frateuria aurentia (F.a.)+ Trichoderma viride(T.v.),*
T_5	*Rock phosphate+ P-solubilizer*
C_1	*Vermicompost,*

Table 2: Influence of Microbial Enriched Phosphocompost (RockPhosphate+Vermicompost) on Growth Parameters of *Trigonella foenum-graecum* L.

Treatment	*Plant Growth (Days)*									
	15					*30*				
	R. L. (cm)	*S L. (cm)*	*No. of Leaves*	*F.W (g)*	*D.W. (g)*	*R. L. (cm)*	*S L. (cm)*	*No. of Leaves*	*F.W (g)*	*D.W. (g)*
T_1	4.5	9.7	42.0	11.5	1.5	7.7	18.2	77.2	71.7	23.2
T_2	3.5	9.2	25.2	8.3	1.0	5.7	18.5	103.	99.5	24.5
T_3	3.5	15	58.5	8.0	1.0	5.0	22.0	148.	123	23.5
T_4	3.7	10.	50.7	11.2	2.1	5.5	22.5	179.	189	27.7
T_5	5.5	5.2	22.2	4.7	1.0	4.5	10.5	44.5	44.7	9.75
C_1	2.5	5.2	17.0	3.1	.20	1.5	7.7	28.2	26.5	10.0
SEM ±	0.46	0.5	1.30	0.52	0.16	0.54	0.88	2.05	0.409	1.27
CD @	0.80	0.9	2.26	0.90	0.29	0.93	1.54	3.55	2.443	2.20

Table 3: Microbial consortia as bioinoculants for Rockphosphate-greencompost

Treatments	
T_6	*Rock Phosphate + Greencompost*
T_7	*Rock Phosphate + P-solubilizer+ Greencompost*
T_8	*Rock phosphate + P-solubilizer+ Frateuriaaurentia(F.a.)+Trichoderma viride(T.v.)+ Rhizobium sp +Pseuodomonasfluorescens(P.f.)+ Greencompost*
T_9	*Rock phosphate+ P-solubilizer+ Frateuria aurentia (F.a.)+ Trichoderma viride(T.v.),+Greencompost*
T_{10}	*Rock phosphate+ P-solubilizer*
C_2	*Greencompost,*

Table-4 depicts the response of different bioinoculants with phosphocompost (rock phosphate + green compost) on growth parameters viz., root length ,shoot length, number of leaves and fresh weight, dry weight and number of nodules of *Trigonella* at different duration. Among the various treatments significant increase in number of leaves were recorded in T_6 followed by T_7 and T_8 respectively. Application of rock phosphate along with greencompost, recorded the highest values with regard to number of nodules and growth parameters.

Table 4: Influence of Microbial Enriched Phosphocompost(RockPhosphate+GreenCompost) on Growth Parameters of *Trigonella foenum-graecum* L.

Treatme	Plant Growth (Days)											
	15						30					
	R. L. (cm)	S L. (cm)	No. of Leaves	F.W (g)	D.W. (g)	No. of Nodules	R. L. (cm)	S L. (cm)	No. of Leaves	F.W (g)	D.W. (g)	No. of Nodules
T_6	4.5	10	22.7	8.2	1.0	1.00	4.2	17.5	164.	130	20.5	18.5
T_7	3.5	10.4	20.5	6.2	.60	.00	2.7	11.2	103.	94	12.2	2.75
T_8	3.5	7.7	19.2	4.7	1.0	.00	2.7	9.7	50.5	44.2	9.75	2.00
T_9	4.2	8	21.5	5.1	.80	.00	3.0	7.0	38.5	34.2	4.75	.50
T_{10}	5.4	7.0	21.0	4.5	.98	.01	4.0	8.7	41.8	35.5	5.9	.50
C_2	1.7	4	14.0	3.2	1.1	.00	1.7	5.0	11.5	18.2	7.75	.25
SEM ±	0.31	0.44	0.84	0.44	0.06	0.333	0.37	0.93	1.13	0.78	0.75	0.485
CD @	0.55	0.76	1.46	0.76	0.10	0.577	0.64	1.62	1.96	1.36	1.30	0.842

These findings are in agreement with Janaki,2003, which showed that application of Phosphorus, SSP and RP in combination with green manure gave higher productivity in rice. Similarly, Sharma *et.al*., 2011, reported that combined application of *Azotobacter*, rock phosphate and phosphate solubilizing bacteria yielded maximum cabbage head.

Table 5: Influence of Microbial Enriched Phosphocompost(RockPhosphate+GreenCompost) and (Rock Phosphate + Vermi Compost) on Nutrient Uptake ofTrigonella foenum-graecum L.

Treatment	Plant growth (Days)					
	15			30		
	Ca (µg/g)	Mg (µg/g)	P (µg/g)	Ca (µg/g)	Mg (µg/g)	P (µg/g)
T_1	3.6	4.2	20.7	4.3	4.3	39.7
T_2	3.4	3.7	26.0	8.0	8.2	46.5
T_3	2.0	4.6	30.2	3.2	3.3	44.5
T_4	2.1	3.2	20.7	4.0	4.5	42.0
T_5	2.5	3.3	22.2	4.1	5.4	35.0
C_1	1.5	1.8	13.2	3.0	4.2	22.0
0.820		0.1076	0.5713	0.0736	0.1067	1.587
0.139		0.1859	0.9908	0.1286	0.1859	2.753

Treatment	Plant growth (Days)					
	15			30		
	Ca (µg/g)	Mg (µg/g)	P (µg/g)	Ca (µg/g)	Mg (µg/g)	P (µg/g)
T_6	1.7	2.0	17.0	4.1	4.2	39.5
T_7	2.7	3.0	16.2	3.3	4.1	36.0
T_8	3.5	3.6	17.7	4.0	4.7	36.0
T_9	4.2	3.6	19.2	3.9	5.1	30.2
T_{10}	3.4	3.4	21.6	3.2	5.0	32.9
C_2	1.2	1.4	12.0	2.9	4.2	18.5
SEM ±		0.158	0.729	0.081	0.170	1.143
CD @ 5%		0.274	1.265	0.139	0.295	1.9832

Present field study revealed that microbial enriched phosphocompost had positive influence on nutrient uptake by plant tissues.Highest total uptake of nutrients viz., Calcium, Magnesium and Phosphorus of*Trigonella* was recorded in T_2 among various treatments (Table-5). The different biochemical changes due to different bioinoculants treatments were thorough studied by analysing the samples drawn at 15 and 30 day of harvest. Similar reports ondual inoculation with *Rhizobium* and Phosphate Solubilising Bacteria showed superioirity by retaining higher available Nitrogen and Phosphorus in soil (Singh, *et.al.,* 2010). Further, the nutrients uptake in*Trigonella* was observed maximum in microbial consortia over control. Bioinoculants along with organic manures might have influenced the nutrient uptake of plant tissues and the results are similar to the findings of Sunitha. *et.al.* 2010.

Green manuring with different legume crops has positive effect on growth and plant biomass which is in accordance with Mandal and Pal, 2009. Application of rock phosphate with greencompost significantly increased the growth parameters in both 15 and 30 days old plants than control. The reports are in accordance with Mishra *et.al*., 2006 in *Oryza sativa* reported that incorporation of vermicompost in combination with rice residue significantly increased the growth. Incorporation of rock phosphate and dual inoculation with bioinoculants showed highest dry matter production may be due to faster decomposition of organic matter by making the nutrients more available. This results are in accordance with Asif Ali, 2009 reported on Fenugreek. Khan,*et.al*.,2009,reported that phosphorus solubilising bacteria mainly *Bacillus, Pseudomonas* and *Enterobacter* were effective in increasing the plant available P in soil growth and yield of crops. Phosphorus solubilising bacteria has enormous potential for increased fixed P in the soil. Singh, *et.al*., 2009, reported that dual inoculation with biofertilizers viz., *Rhizobium* + *Azotobacter* + PSB + FYM and application of FYM has significantly increased plant growth, grain yield and total N,P,K uptake in soyabean.

The data were analysed statistically with the help of IBM SPSS 20 statistical package.

4. Conclusion

Maintaining soil fertility as well as sustainability of crop production, by using different organic manures viz.,vermicompost, greencompost, farmyard manure, phosphocompost has attracted the farmers to replace the use of chemical fertilizers.The manipulation of factors for composting is done mainly to enhance the microbial activity, where the rate of decomposition of organic wastes is enhanced. Thus this microbial inoculants enhance the process of composting on the nutrient content. The enriched compost through microbial inoculants had higher nutrient content there by enhance the crop yield. From this present study it can be concluded that out of ten different treatments, T_4 is the best treatment in regard to growth and yield parameters where as T_2 was found to be the best in context of nutrient uptake among all the treatments.

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