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Influence of biofertilizers on soil physico-chemical and biological properties during cropping period

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A field experiment was carried out to find out the influence of biofertilizers on soil physico-chemical and biological properties during cropping period at Agricultural Research Station (ARS), Kovilpatti. The present study revealed that the biofertilizers inoculation resulted in the shift in the pH reducing the alkalinity slightly and the organic carbon content increased slightly in all the biofertilizer inoculated treatments compared to uninoculated soil. The available Nitrogen in soil was higher where *Azospirillum* was a component. The mycorrhiza and phosphobacteria increased the available soil Phosphorus status. The soil Potassium was found to be higher in co inoculation of Azophos and mycorrhiza. The soils of the biofertilizer inoculated plots exhibited a higher population of total bacteria, fungi and actinomycetes in general than initial sample indicating an enhanced soil biological activity.

Key words : Black cotton soil, Biofertilizers, Major nutrients and Soil microbes.

INTRODUCTION

Soil although appears static and inert is in fact dynamic and versatile in nature beaming with biological activities and chemical reactions that goes on continuously unabated. Although the influence of biofertilizers and their favourable effects have been realized in many crops, the investigation on cotton is much limited particularly so, for the type of premonsoon sowing followed in rainfed system of the cotton belt of southern Tamil Nadu. The low soil organic matter and multiple nutrient deficiencies are the main reasons for lack of sustainability. Microbial inoculants which are ecofriendly and environmentally safe and of low cost technology, help to sustain the fertility of soil and improve productivity of rainfed agriculture as the farmers have to gamble with monsoon and they could not venture to go in for higher fertilizer option in premonsoon sowing fearing monsoon failures and consequent crop failure. The calcareous nature of this soil affects the availability of many micronutrients. These soils are inherently very fertile and predominantly used for growing cotton, millet, sorghum, soybean and pulses like, pigeonpea (Sehgal, 2000). The present study is proposed to investigate the influence of biofertilizers on soil physico-chemical and biological properties during the cropping period.

MATERIALS AND METHODS

The influence of biofertilizers was investigated in a premonsoon sowing in black cotton soil under rainfed conditions in KC-2 cotton variety at Agricultural Research Station (ARS), Kovilpatti during the year 2001-2002. The trial was laid out in RBD with 7 treatments with three replications in plots of 5 x 5 m size. The treatments were *Azospirillum*, Azophos, phosphobacteria, mycorrhiza, Azophos + mycorrhiza along with 75% of the recommended NPK of 40:20:0 kg ha^{-1} for rainfed cotton. Plots with mere recommended full level of NPK and uninoculated control without NPK were maintained as check. In each treatment, the soil samples were collected at regular intervals and pH, organic carbon, nitrogen, phosphorus and potassium were estimated and their microflora like bacteria, fungi and actinomycetes were enumerated.

The soil samples were suspended in distilled water in 1:2 ratio (w/v) and the pH was determined using Elico digital pH meter. The organic carbon was determined by the wet digestion method (Walkley and Black, 1934). The available nitrogen was estimated by Alkaline permanganate method (Subbiah and Asija, 1956). The available phosphorous and potassium were estimated by colorimetric method (Olsen *et al*, 1954) and Flame photometer (Stanford and English, 1949), respectively.

The microbial population in the soil was enumerated by serial dilution and plating the appropriate dilutions in different agar media. Aliquots of 1 ml of appropriate dilutions were plated in the nutrient agar (Rangaswami, 1966), Martin's Rose Bengal agar (Martin, 1950) and Kenknight's agar (Allen, 1953), respectively for total bacteria, fungi and actinomycetes. The plates were

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incubated at room temperature (30±2ºC) for 3 days for bacteria, 5 days for fungi and 7 days for actinomycetes. The colonies were counted and expressed as population per gram on oven dry basis.

RESULTS AND DISCUSSION

Influence of biofertilizers on soil physico and chemical properties:

The results on the effect of biofertilizer application on soil pH, organic carbon content, available nitrogen, available phosphorous and potassium content of soils are presented in Tables 1, 2 and 3.

Soil pH and organic carbon:

The pH of the soil in the experimental plots was 8.5 initially. There was only a slight variation in the pH due to biofertilizer application and crop growth. The biofertilizer inoculation resulted in the shift in the pH reducing the alkalinity slightly. Illmer and Schinner (1995) also proposed that acidification of rhizosphere could be through liberation of organic acids by proton extrusion mechanism. However, this shift in the pH to 7.8 from 8.5 was relatively marked in the soil wherein Azophos in combination with mycorrhiza was applied followed by phosphobacteria, Azophos and mycorrhiza (Table 1).

There was also an increase in the organic carbon content in the biofertilizer treated rhizosphere soil. Initially it was 0.30 per cent. The highest organic carbon (0.38 %) was recorded in the treatment with Azophos and mycorrhiza at 120 DAG (Table 1). Any increase in the organic carbon content also will result in increased nutrient availability to the plant by augmenting soil biological activity, thereby enhancing nutrient use efficiency.

Major nutrients:

There was significant increase in the soil available Nitrogen, Phosphorus and Potassium in the biofertilizer inoculated plots over the uninoculated control. The available nitrogen was higher in the coinoculation of Azophos and mycorrhiza with 153, 181, 184 and 182 kg/ha at 30, 60, 90 and 120 DAG, respectively. A similar increase in soil nitrogen was observed in the treatment of *Azospirillum* almost paralleling the Azophos and mycorrhiza combination at all intervals of sampling (Table 2). Mertens and Hess (1984) reported that inoculation of *Azospirillum* in wheat increased available nitrogen in soil

Table 1 : Effect of biofertilizers on pH and organic carbon content of black cotton soil during the cropping period

Sr. No.	Treatments	pH					Organic carbon (%)				
		DAG					DAG				
		0	30	60	90	120	0	30	60	90	120
1.	*Azospirillum* + 75% of NP	8.5	8.5	8.4	8.4	8.3	0.30	0.31	0.33	0.33	0.35
2.	Phosphobacteria + + 75% of NP	8.5	8.4	8.1	8.1	7.9	0.30	0.30	0.33	0.33	0.34
3.	Azophos + + 75% of NP	8.5	8.4	8.1	8.1	8.0	0.30	0.30	0.34	0.35	0.37
4.	Mycorrhiza + 75% of NP	8.5	8.5	8.0	8.0	8.0	0.30	0.31	0.34	0.35	0.37
5.	Azophos + Mycorrhiza + 75% of NP	8.5	8.5	8.0	8.0	7.8	0.30	0.31	0.35	0.35	0.38
6.	Recommended NPK (40 : 20 : 0 kg/ha)	8.5	8.5	8.4	8.4	8.4	0.30	0.31	0.32	0.32	0.34
7.	Control (uninoculated)	8.5	8.5	8.6	8.6	8.5	0.30	0.31	0.30	0.32	0.30
	S.E. $\pm$		0.037	0.098	0.058	0.058		0.002	0.012	0.013	0.016
	C.D. (P=0.05)		0.081	0.214	0.128	0.126		0.003	0.026	0.028	0.034

DAG – days after germination

Table 2 : Effect of biofertilizers on available nitrogen and phosphorus content of black cotton soil during the cropping period

Sr. No.	Treatments	Nitrogen (kg/ha)					Phosphorus (kg/ha)				
		DAG					DAG				
		0	30	60	90	120	0	30	60	90	120
1.	*Azospirillum* + 75% of NP	134	142	181	182	181	7.1	7.3	8.0	8.1	8.0
2.	Phosphobacteria + + 75% of NP	134	139	169	171	170	7.1	10.3	11.0	11.1	11.0
3.	Azophos + + 75% of NP	134	142	178	180	179	7.1	10.1	10.6	10.8	10.7
4.	Mycorrhiza + 75% of NP	134	145	176	177	176	7.1	10.3	11.0	11.0	10.9
5.	Azophos + Mycorrhiza + 75% of NP	134	153	181	184	182	7.1	10.5	11.0	11.2	11.1
6.	Recommended NPK (40 : 20 : 0 kg/ha)	134	137	175	176	175	7.1	10.3	10.9	10.9	10.8
7.	Control (uninoculated)	134	133	131	132	132	7.1	7.1	7.2	7.1	7.0
	S.E. $\pm$		1.811	1.108	2.084	2.086		0.212	0.215	0.180	0.197
	C.D. (P=0.05)		3.946	2.414	4.541	4.544		0.460	0.469	0.393	0.429

DAG – days after germination

by fixation of atmospheric nitrogen.

Phosphate solubilizing bacterium/ microorganism has enormous potential to solubilize about 50 to 60 per cent of fixed phosphorus in the soil by secreting organic acids with in a short time. The increased availability of soil phosphorus due to phosphobacteria inoculation was observed by Sundaravadivel *et al.* (1999). Higher soil phosphorous content of 11.2 kg/ha was observed in the treatment with Azophos and mycorrhiza while 11.1 and 11.0 kg/ha was observed in the treatment of phosphobacteria and mycorrhiza, respectively at 90 DAG (Table 2). There was an increase in the potassium content upto 90 DAG in all treatments after which there was fluctuation in its content. The potassium content in soil was higher in the treatment with Azophos and mycorrhiza at 30, 60, 90 and 120 DAG (Table 3).

In the present study all the treatments had nitrogen fixer and /or phosphate solubilizing and /or mobilizing microbes. The soils of the biofertilizer inoculated treatment had a higher content of available nitrogen, phosphorus and potassium. These results showed that there is a direct relationship between inoculation and the available nutrients.

Influence of biofertilizers on soil biological properties:

The results on the effect of biofertilizers application on total bacteria, fungi and actinomycetes in black cotton soil during the cropping period were summarized in Tables 4 and 5. The bacterial population fluctuated during the crop growth (Table 4). Initially, the bacterial population was 47.6 x 10^6 g^{-1} and subsequently increased at 30 DAG.

Table 3 : Effect of biofertilizers on available potassium content of black cotton soil during the cropping period

Sr. No.	Treatments	Potassium (kg/ha) DAG 0	30	60	90	120
1.	*Azospirillum* + 75% of NP	366	373	377	413	413
2.	Phosphobacteria + + 75% of NP	366	370	373	420	419
3.	Azophos + + 75% of NP	366	400	407	430	429
4.	Mycorrhiza + 75% of NP	366	406	426	437	437
5.	Azophos + Mycorrhiza + 75% of NP	366	427	440	457	456
6.	Recommended NPK (40 : 20 : 0 kg/ha)	366	366	373	400	399
7.	Control (uninoculated)	366	360	363	364	364
	S.E. ±		10.63	15.19	8.96	5.54
	C.D. (P=0.05)		23.17	33.09	19.52	12.08

DAG – days after germination

Table 4 : Effect of biofertilizers on the polulation* of total bacterial and fungin in black cotton soil during the cropping period

Sr. No.	Treatments	Bacteria ($x10^6 g^{-1}$) DAG 0	30	60	90	120	Fungi ($x10^6 g^{-1}$) DAG 0	30	60	90	120
1.	*Azospirillum* + 75% of NP	47	586 (2.77)	92 (1.96)	220 (2.34)	52 (1.72)	18	45 (1.65)	66 (1.82)	76 (1.88)	125 (2.10)
2.	Phosphobacteria + + 75% of NP	47	629 (2.80)	96 (1.98)	171 (2.23)	110 (2.04)	18	18 (1.26)	22 (1.34)	144 (2.16)	92 (1.96)
3.	Azophos + + 75% of NP	47	1037 (3.02)	90 (1.95)	152 (2.18)	79 (1.90)	18	38 (1.58)	25 (1.40)	46 (1.66)	106 (2.03)
4.	Mycorrhiza + 75% of NP	47	686 (2.84)	75 (1.88)	129 (2.11)	53 (1.72)	18	32 (1.51)	85 (1.93)	101 (2.00)	56 (1.75)
5.	Azophos + Mycorrhiza + 75% of NP	47	773 (2.89)	50 (1.70)	135 (2.13)	70 (1.85)	18	33 (1.52)	39 (1.59)	62 (1.79)	98 (1.99)
6.	Recommended NPK (40 : 20 : 0 kg/ha)	47	586 (2.75)	121 (2.08)	59 (1.77)	36 (1.56)	18	46 (1.66)	42 (1.62)	85 (1.93)	101 (2.00)
7.	Control (uninoculated)	47	278 (2.44)	96 (1.41)	92 (1.96)	47 (1.67)	18	42 (1.62)	22 (1.34)	37 (1.57)	39 (1.59)
	S.E. ±		0.005	0.021	0.018	0.028		0.063	0.069	0.045	0.048
	C.D. (P=0.05)		0.012	0.047	0.039	0.062		0.137	0.150	0.098	0.105

* on oven dry basis ; Figures in parentheses are log values, DAG – days after germination.

Table 5 : Effect of biofertilizers on the population* of actionomycetes in black cotton soil during the cropping period

Sr. No.	Treatments	Actinomycetes (x $10^{-4}g^{-1}$) DAG 0	30	60	90	120
1.	*Azospirillum* + 75% of NP	55	6 (0.78)	11 (1.04)	13 (1.11)	18 (1.26)
2.	Phosphobacteria + + 75% of NP	55	8 (0.90)	7 (0.85)	11 (1.04)	25 (1.40)
3.	Azophos + + 75% of NP	55	7 (0.85)	8 (0.90)	18 (1.26)	19 (1.28)
4.	Mycorrhiza + 75% of NP	55	9 (0.95)	13 (1.11)	23 (1.36)	31 (1.49)
5.	Azophos + Mycorrhiza + 75% of NP	55	5 (0.70)	19 (1.28)	24 (1.38)	39 (1.59)
6.	Recommended NPK (40 : 20 : 0 kg/ha)	55	16 (1.20)	7 (.085)	8 (0.90)	13 (1.11)
7.	Control (uninoculated)	55	3 (0.48)	3 (0.47)	6 (0.78)	7 (0.85)
	S.E. $\pm$		0.1085	0.1132	0.1015	0.0626
	C.D. (P=0.05)		0.2365	0.2466	0.2212	0.1363

* on oven dry basis ; Figures in parentheses are log values, DAG – days after germination.

The total bacteria increased significantly in all treatments including the uninoculated but in the biofertilizer inoculated plots the increase was relatively higher than uninoculated soil. The fungal population increased significantly in all biofertilizers inoculated plots (Table 4). The results revealed that the fungal population was low initially and subsequently increased during cropping period in all the treatments but the increase was relatively higher due to biofertilizer treatments. The population of actinomycetes was initially 55 x 10^4 g^{-1} and subsequently decreased during cropping period even though the moisture content of soil was sufficient to encourage all types of micro flora (Table 5).

In over all, the soils of the biofertilizer inoculated plots exhibited a higher population of total bacteria, fungi and actinomycetes in general than initial sample. The phosphate solubilizing bacteria were highest in black soils of Aruppukottai when compared to clayey and red soils (Muralikannan and Anthoni Raj, 1998). Fulchieri and Frioni (1986) reported that the *Azospirillum* cells in the rhizosphere soil had increased ten fold in a short period as compared to the initial population of the inoculated soil. It is likely that the root exudates augmented the soil microbes in general by the crop growth.

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