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Biomediated Transformation of Sulphur in the Rhizosphere of Various Nursery Fruit Plants Amended with Organic and Biofertilisers

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Abstract: **A pot culture experiment was conducted with various fruit nursery plants of guava, aonla, ber, mango and kinnow as test crops. The six number of treatments viz., T_1 (Control), T_2 (FYM @ 250 g/10 kg soil), T_3 (Compost @ 200 g/10 kg of soil), T_4 (Recommended N, P, K), T_5 (Vermicompost @ 160 g / 10 kg soil), and T_6 (PSB + NS nitrogen fixer @ 3 g/10 kg soil) were taken into consideration each treatment having three replications. The treatment effect was monitored in the rhizosphere soils of fruit nurseries at 30, 60, 90 and 120 days interval in terms of total number of bacterial and fungal populations, sulphatase enzyme activity, mineral sulphur and organic sulphur. The maximum bacterial population of the order of 63 cfu x10 ^{5} was recorded with the treatment (T_6) i.e. non-symbiotic N_2 fixers + PSB at 90 days of plant growth.The sulphatase enzyme activity was found to increase from 30 days to 90 days and soils treated with Vermicompost (T_5) exhibited maximum sulphatase enzyme activity.The maximum mineral sulphur content was found with the Vermicompost treatment (T_5) and the organic sulphur content was observed to be higher with the Vermicompost (T_5) and increased from 30 days to 120 days in all the treatments.**

Keywords: **Biomediated, Sulphur, Rhizosphere, Nursery, Fruit, Organic, Fertilisers.**

I. INTRODUCTION

The rhizosphere is known to be a hot spot of plant-microbial interactions and a driving force of soil processes. Plant species could affect quantity and quality of carbon resources in the rhizosphere, which would influence the composition and diversity of microbial community in these environments [1]. Different plant species can promote proliferation of different microbial communities by releasing different amount and types of root exudates. Coexistence of multiple plant species may enhance the complexity of soil microorganisms by increasing the heterogeneity of root exudates and carbon that are contributed from roots and decomposing litter [21]. Plant growth promoting rhizobacteria are one of the most commonly studied rhizosphere components in terms of direct plant growth promotion and biological control [12].Soil microorganisms have an important role in ecological processes such as the nutrient cycling [13]. Soil enzyme activities reflect soil nutrient transformation status, appear higher complexity due to be affected by many soil factors, and are directly much influenced with minor elements, organic matter and available nitrogen [2]. Sulphur in soils undergoes biological and chemical processes which drives the complicated transformation of different forms of sulphur in soil..

II. REVIEW OF LITERATURE

Conventional nursery management practices with the intensive use of agro-chemicals are often responsible for a decrease on soil biological fertility and conversely, management practices with organic materials influence agricultural sustainability by improving physical, chemical and biological properties of soils through increasing the contents of organic carbon, microbial biomass, CEC, and biological activities of soils [9]. The composition, activity and biomass of soil microbial communities have been shown to be influenced by manure addition [4].The plants alter rhizosphere populations through root exudation and the sloughing of root cells. Microorganisms in the soil maintain biogeochemical cycles in the soil by virtually degrading organic compounds sooner or later.Total microbial counts were commonly found to be increased 10-50 folds in the rhizosphere..Microbial activity in the rhizosphere affects rooting patterns and supply of available nutrients to the plants thereby modifying the quality and quantity of root exudates [7].

Sulphatase is the main S transforming enzyme in the soil that catalyses the mineralisation of organic S leading to the release of plant available inorganic S thus playing a crucial role in sulphur transformation in the soil. The sulphatase activity was higher in the immediate vicinity of the roots [11]. They also recorded higher sulphatase activity in the soil following the application of compost and manure and was estimated to be 300-500 mg p-nitrophenol/g/h and 240-400 mg p-nitrophenol/g/h respectively. The sulphatase activity was significantly higher in the rhizosphere than in the bulk soil. The organic treatments significantly increased the sulphatase activity due to increase in the amount of substrate for microorganisms [23].The sulphur in soil which is is organic form is directly impacted by microbial activity through decomposition [20].Biomediated transformation involves the release of inorganic forms of S from organic materials by soil microorganisms. They also reported that the sulphur transformation in the soil involves both biological and biochemical processes and is often closely associated with other nutrient transformations. The enzymes play an essential role in the sulphur transformation in the rhizospheric soil and is an indicator of sulphur mineralisation in the soil.They observed that the sulphate sulphur content in the potato fields ranges from 21.49-24.3 g/kg and the sulphatase activity ranged from 0.010 – 0.024 mMpNP /g/h and also that sulphate sulphur and sulphatase activity showed an increase with FYM treatment and nitrogen fertiliser treatment respectively [24].

III. MATERIALS AND METHODS

To carry out the experiment, fruit saplings (approx. 3 years of age) of guava, aonla, ber, mango, kinnow were taken into account as test crops.Treatment comprises of chemical fertilizer, organic amendments, and bio-fertilizers and as such, there are six treatment combinationsThe soil samples prepared were passed through a 2 mm sieve and divided into two parts: one fraction for the determination of bacterial and fungal population, and other fraction for measuring of sulphatase enzymes activity and sulphur transformation were stored at 4^0C.

The microbial population in terms of total bacterial and total fungal population were enumerated by plate count method and total bacterial population was determined at 10^{-5} and total fungal population at 10^{-3} dilution. Dilution plate count technique was followed using soil extract agar and Rose Bengal agar, respectively for bacterial and fungal count [14].The sulphatase enzyme activity was determined according to Tabatabai (1994). 1g of soil was incubated with 0.25ml toluene, 1ml of 0.1M p-nitrophenylsulphate solution and 4 ml acetate buffer (0.5M,pH 5.8) for 1h at 37^{o}C.After addition of 0.5M $CaCl_2$ and 0.5M NaOH, the samples were filtered and the concentration of p-nitrophenol released was determined at 400 nm wavelength. Mineral S was determined by the method as proposed by $BaSO_4$ turbidity method [3] with a spectrophotometer at 420 nm was taken. SO_4^{2-} concentration in sample was estimated by comparing turbidity with a calibration curve prepared by carrying sulphate standards through the entire procedure. For determination of organic sulphur,a known weight of soil was leached with distilled water and then with 10% HCl to remove sulphate S.After making soil chloride free, for half an hour.Sulphur in the filterate was determined .

IV. RESULTS

The data pertaining to total bacterial population in rhizospheric soils presented in the table 1 shows that different organic amendments and bio-fertilizer increased the bacterial population significantly irrespective of the fruit nursery rhizosphere. The interactive effects of treatment and days also exhibit the significant effect in terms of microbial populations in fruit rhizosphere. The total bacterial population in fruit crops was more in treatment (T_6) Non Symbiotic N_2 fixers + PSB and the overall treatment effect follows the order: PSB + NS N-fixers > vermicompost > compost > FYM > NPK > control; whereas in case of total fungal population,the order was: Vermicompost > PSB + NS N-fixer > compost > FYM > NPK > control.

The treatment effect on sulphatase enzyme activities in the rhizospheres of different fruit plants is presented in table 3 shows that there was significant enhancement in sulphatase activity with different organic amendments, and biofertilizer addition. The sulphatase enzyme activity was found to increase significantly with approaching the days from 30 days to 90 days and thereafter it was decreased significantly at 120 days of growth, irrespective of fruit crop and the order was: Vermicompost > PSB + NS N-fixer > compost > FYM > NPK > control.

The treatment effect on mineral sulphur content in the rhizospheres of different fruit plants is presented in table 4 shows that there was significant enhancement in mineral sulphur content with different organic amendments, and biofertilizer addition. The mineral sulphur content was found to increase significantly with approaching the days from 30 days to 120 days of growth, irrespective of fruit crop and the mineral sulphur content with was high in vermicompost treated soils at 120 days and the order was Vermicompost > PSB + NS N-fixer > compost > FYM > NPK > control.

V. DISCUSSION

It was recorded during the investigation that soil microbial population increased upto 90 days and then showed a little decrease attributed to the rhizospheric microbial population very much influenced by plant root exudates,similar trend has been observed by [19]. The vermicompost treatment showed maximum fungal population 31cfu $x10^{-3}$in strawberry and mango plant which is in accordance with the findings of [19] attributing it to the increase of organic matter in the soil thus providing conducive environment for the soil fungi. The fungal population was found to be maximum in vermicompost treated soils that might have resulted from the higher amount of substrate with the increase in the potential for microbial degradation which were used as energy and carbon source by soil microbiota, similar trend was found by [6].

Our results are also at par with the findings of [8] who recorded that the total bacteria and total fungi in the organically managed orchards are more numerous than in the control attributing it to the plant species effect by means of rhizodeposits and organic matter content. The present study has shown positive relation between soil enzymes and soil microbial biodiversity. The soil enzymes play a very immense role in biomediated transformation of nutrients like N,P and S. Similar results have been obtained by research workers like [10]. The sulphatase enzyme activity was positively correlated with the microbial activity.The results from this study seem to confirm previous findings that indicated the importance of various organic and biofertiliser amendments on the sulphatase enzyme activity linked with the increase in the organic matter content [5].The available S and organic S showed an increase with the addition of organic and inorganic fertilisers and higher content was observed in vermicompost treatment which is at par with the findings of [16] attributing it to the vermicompost being more effective in improving the soil fertility and soil biological properties. Similar results have been reported by [15] attributing the increase to the vermicompost enhancing the microbial population. The addition of the organic material in form of FYM, compost and vermicompost increased the mineral S and organic S in the soil which is similar to the observations reported by [17] in litchi soils and explained that it might be due to the beneficial effects of organic manures resulting in increasing the nutrient availability.

VI. SUMMARY AND CONCLUSION

The results illustrated that with the addition of the various organic inputs and biofertilizers, the microbial population in terms of total microbial population and the sulphatase enzyme activity was found to increase which increased the bioavailability of sulphur in the soils and the order was: Vermicompost > PSB + NS N-fixer > compost > FYM > NPK > control.

In order to grow sustainable nursery fruit plants, this study was chalked out with various organic, inorganic and biofertiliser amendments and their impact was studied on various aspects including microbial population in the nursery rhizosphere, enzyme activities, consequent sulphur transformation.This study approach may serve as the basis for future studies trying to identify impact of microbial communities in the rhizosphere of fruit nursery in soil processes and health, plant productivity and the nutritional value of fruit crops. The effect of various treatments induced significant changes in the quality, chemical composition and molecular size of organic matter which in turn influenced the activities of enzymes involved in the S transformations.

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APPENDIX - A

Table No.1:Effect of organic amendments, inorganic fertilizers and biofertilizers on total bacterial population (cfu*10^5) in soils of different fruit plants

Treatments	Guava				Aonla				Ber				Mango				Kinnow			
	30 d	60 d	90 d	120d	30 d	60 d	90 d	120d	30 d	60 d	90 d	120d	30 d	60 d	90 d	120d	30 d	60 d	90 d	120d
T_1=Control	38	36	42	33	42	40	47	35	43	44	52	37	37	37	44	29	41	33	48	26
T_2=FYM	40	46	48	45	45	47	54	40	43	46	53	40	41	42	50	34	41	41	50	37
$T_{3=}$ Compost	42	46	50	45	45	47	55	38	44	46	54	38	41	45	51	36	42	47	51	40
T_4= Recommended dose of NPK	40	43	48	41	41	45	52	36	43	45	51	37	42	47	48	40	40	40	49	35
T_5=Vermicompost	43	46	50	43	46	50	61	42	46	49	57	42	42	49	53	42	44	48	56	41
T_6=Non symbiotic N_2fixers+PSB	46	47	**51**	46	43	46	**62**	41	46	51	**60**	44	48	52	**63**	43	45	48	**57**	43
Mean	41	44	48	42	44	45	55	38	44	46	54	39	41	45	51	37	42	42	51	37
CD(T)*	0.81				0.95				1.05				0.95				0.93			
CD(d)*	0.66				0.77				0.85				0.78				0.76			
CD(Txd)*	1.63				1.91				2.11				1.91				1.85			

Table No.2: Effect of organic amendments, inorganic fertilizers and biofertilizers on total fungal population (cfu*10^3) in soils of different fruit plants

Treatments	Guava				Aonla				Ber				Mango				Kinnow			
	30 d	60 d	90 d	120d	30 d	60 d	90 d	120d	30 d	60 d	90 d	120d	30 d	60 d	90 d	120d	30 d	60 d	90 d	120d
T_1=Control	17	11	19	6	14	13	18	7	15	13	20	6	17	13	21	7	16	13	21	7
T_2=FYM	21	14	26	7	16	18	22	13	17	17	21	10	19	16	27	10	20	17	26	10
$T_{3=}$ Compost	22	20	27	12	17	21	23	16	17	22	22	15	21	20	28	15	20	22	26	15
T_4= Recommended dose of NPK	21	17	26	10	15	18	22	12	16	17	21	11	19	19	26	11	17	19	26	12
T_5=Vermicompost	23	20	**30**	13	18	21	**27**	17	20	22	**28**	17	23	21	**31**	17	22	22	**28**	16
T_6=Non symbiotic N_2fixers+PSB	23	20	26	12	20	23	24	17	17	18	25	12	21	17	28	13	20	19	25	14
Mean	21	17	25	10	16	19	22	13	17	18	22	11	20	17	26	12	19	18	25	12
CD(T)*	0.84				0.78				0.83				0.75				0.89			
CD(d)*	0.69				0.64				0.67				0.61				0.73			
CD(Txd)*	1.68				1.56				1.65				1.49				1.79			

Table No.3: Effect of organic amendments, inorganic fertilizers and biofertilizers on sulphatase activity(mg p-nitrophenylsulphate g^{-1} soil h^{-1}) in soils of different fruit plants

Treatments	Guava				Aonla				Ber				Mango				Kinnow			
	30d	60 d	90 d	120d	30 d	60 d	90 d	120d	30 d	60 d	90 d	120d	30 d	60 d	90 d	120d	30 d	60 d	90 d	120d
T_1=Control	72.4	73.3	80.7	70.1	90.5	98.1	102.1	93.6	89.7	96.6	100	94.8	79.6	88.4	90.6	84.4	67.5	74.7	78.1	71.8
T_2=FYM	73.2	87.1	93.3	81.1	95.3	114	120.6	112	94.4	104.7	108	103.1	82.8	97.4	100	93.2	70.6	85.9	89.1	83.2
$T_{3=}$ Compost	74.2	85.4	95.1	83.4	97.1	124	127.9	122	96.7	120.1	122	118.2	84.1	102	104	99.6	71.8	85.9	88.2	83.7
T_4= Recommended dose of NPK	73.5	81.1	90.1	79.6	94.5	110	113.8	109	92.8	113.6	117	110.2	81.4	97.5	100	92.8	70.8	84.1	87.5	81.8
T_5=Vermicompost	74.7	90.3	**98.1**	85.6	97.1	126	**130.6**	123	97.9	124.9	**130**	122.7	83.4	112	**116**	108	72.7	86.2	**91.4**	84.1
T_6=Non symbiotic N_2fixers+PSB	74.1	88.5	96.4	84.3	96.5	125	129.5	123	97.2	122.9	125	120.8	83.2	109	108	107	71.4	84.8	89.3	83.7

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Mean	73.6	84.2	92.2	80.6	95.1	116	120.8	114	94.7	113.8	117	111.6	82.4	101	103	97.4	70.8	83.6	87.2	81.3
CD(T)*	0.48				0.47				0.81				0.83				0.81			
CD(d)*	0.39				0.38				0.82				0.97				0.92			
CD(Txd)*	0.96				0.95				0.96				0.98				0.71			

*(p=0.05)

Table No.4: Effect of organic amendments, inorganic fertilizers and biofertilizers on mineral sulphur (mg/kg) in soils of different fruit plants

Treatments	Guava				Aonla				Ber				Mango				Kinnow			
	30d	60d	90d	120d	30d	60d	90d	120d	30d	60d	90d	120d	30d	60d	90d	120d	30d	60d	90d	120d
T_1=Control	14.9	18.4	21.1	15.7	17.1	19.1	21.5	23.1	13.3	15.1	16.3	17.5	16.1	18.7	19.8	22.2	20.4	21.5	22.4	23.9
T_2=FYM	23.1	30.9	33.9	35.1	26.1	29.4	32.5	34.7	19.8	25.7	28.1	30.7	17.2	20.6	22.6	24.8	21.1	23.5	25.6	26.2
$T_{3=}$ Compost	24.8	33.6	37.5	38.9	26.4	30.7	32.1	35.8	20.3	26.1	30.8	31.8	17.7	20.1	23.2	25.5	22.4	24.4	26.7	27.1
T_4= Recommended dose of NPK	22.9	30.7	31.4	33.2	24.8	27.8	32.1	32.5	18.1	23.2	25.9	28.1	15.9	16.9	21.1	23.1	21.1	22.1	25.8	26.8
T_5=Vermicompost	24.7	35.2	40.6	**43.3**	28.2	32.1	33.6	**37.1**	23.8	27.1	31.9	**32.4**	18.1	20.6	24.6	**25.6**	22.5	24.4	27.2	**28.9**
T_6=Non symbiotic N_2fixers+PSB	22.7	32.5	40.7	42.3	27.2	30.7	33.7	35.1	22.7	25.8	28.7	30.8	17.1	19.9	23.9	26.3	21.9	24.7	27.5	28.8
Mean	22.2	30.2	34.2	34.7	25.1	28.3	30.9	33.1	19.6	23.8	27.2	28.6	17.1	19.5	22.53	24.6	21.6	23.43	25.8	26.9
CD(T)*	0.67				1.07				0.57				0.43				0.46			
CD(d)*	0.54				0.87				0.46				0.35				0.38			
CD(Txd)*	1.32				0.93				1.13				0.87				0.93			

*(p=0.05)

Table No.5: Effect of organic amendments, inorganic fertilizers and biofertilizers on organic sulphur (mg/kg) in soils of different fruit plants

Treatments	Guava		Aonla		Ber		Mango		Kinnow	
	30d	120d	30d	120d	30d	120d	30d	120d	30d	120d
T_1=Control	168.8	177.3	157.9	171.8	163.1	171.1	154.9	165.7	161.2	179.5
T_2=FYM	167.7	206.4	160.6	206.1	161.1	202.1	156.8	204.6	171.6	211.1
$T_{3=}$ Compost	168.1	210.9	158.7	208.8	163.6	202.8	156.4	207.7	173.3	214.7
T_4= Recommended dose of NPK	166.8	202.8	157.6	193.5	165.5	196.7	156.9	200.4	171.3	201.1
T_5=Vermicompost	168.4	**223.4**	157.7	**214.4**	163.4	**205.2**	157.6	**211.8**	174.5	**215.4**
T_6=Non symbiotic N_2fixers+PSB	167.9	210.8	157.3	208.6	161.8	202.1	157.7	207.7	173.8	213.7
Mean	168.1	205.3	158.3	200.5	163.1	196.67	156.7	199.6	171.2	205.9
CD(T)*	0.74		0.72		0.61		0.51		0.59	
CD(d)*	0.54		0.41		0.35		0.31		0.34	
CD(Txd)*	1.17		1.02		0.85		0.73		0.84	

*(p=0.05)