DOI: 10.15740/HAS/AU/12.TECHSEAR(7)2017/2067-2076 *Agriculture Update*
Volume **12** | TECHSEAR-7 | 2017 | 2067-2076
Visit us : *www.researchjournal.co.in*

RESEARCH ARTICLE :

Impact of fertigation and biofertgation on soil microbial activity under coffee plantation environment

■ **M. KARUTHAMANI, V. LAKSHMANAN AND K. SUNDHARAIYA**

ARTICLE CHRONICLE :
Received :
19.07.2017;
Accepted :
03.08.2017

SUMMARY : In soil, billions of bacteria, fungi, algae, protozoa exist together with plant root systems searching for food and sources of energy, destroying and creating mineral and organic substances. Soil enzyme activity is considered as an index of biological fertility of the soil. Soil fertility depends not only on its chemical composition, but also on the qualitative and quantitative nature of micro-organisms inhabiting it. A field experiment on Impact of Fertigation and Biofertgation on soil microbial activity under Coffee Plantation Environment was conducted at Green Pearl Estate at Kottachedu, Yercaud, during 2007-2009. Totally eleven treatments including three levels of nitrogen, Phosphorous and potassium and liquid biofertlizers with combinations applied through fertigation. The experiment was laidout in a Randomized Block Design (RBD) with three replications. The results revealed that application of 75% RDF through fertigation along with liquid biofertilizers registered higher microbial activities in the soil *viz.*, soil fungi population, soil bacteria population and soil actinomycetes population at all the stages of crop growth *viz.*, vegetative stage, flowering stage, fruiting stage and at harvest stage during 2008 and 2009. Similarly, drip fertigation and biofertigation had significant influence on soil enzyme activities. application of 75% RDF through fertigation along with liquid biofertilizers registered significantly higher soil enzyme activities *viz*., dehydrogenase activity, acid phosphatase activity and urease activity at all the stages of crop growth *viz.*, vegetative stage, flowering stage, fruiting stage and at harvest stage during 2008 and 2009.

KEY WORDS :
Fertigation, Biofertigation, Coffee, Soil mircrobial activity, Enzyme activity

How to cite this article : Karuthamani, M., Lakshmanan, V. and Sundharaiya, K. (2017). Impact of fertigation and biofertgation on soil microbial activity under coffee plantation environment. *Agric. Update*, **12**(TECHSEAR-7) : 2067-2076; **DOI: 10.15740/HAS/AU/12.TECHSEAR(7)2017/2067-2076.**

Author for correspondence :
M. KARUTHAMANI
Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA

See end of the article for authors' affiliations

BACKGROUND AND OBJECTIVES

In soil, billions of bacteria, fungi, algae, protozoa exist together with plant root systems searching for food and sources of energy, destroying and creating mineral and organic substances. The soil microbes are agents responsible for all of these biological transformations of nutrient in the soil. These are carried out through a variety of biochemical reactions namely hydrolysis, oxidation and reduction etc. All these reactions in the soil are of tremendous importance from the point of view of the fertility of soils. The reactions

are carried or catalysed by group of enzymes known as 'Soil Enzymes'; these enzymes are generated in the soil as a result of the activity of micro-organisms. Soil enzyme activity is considered as an index of biological fertility of the soil. Therefore any management practice that influences the microbial population of the soil would be expected to produce changes in the soil enzyme activity and the level of enzyme activity can be used as an indicator of soil fertility (Skujins and Mclaren, 1976 and Paul *et al.*, 1998). Soil micro-organisms in the rhizosphere influence the plant growth, play a major role in the carbon, nitrogen, phosphorus and sulphur cycles and availability of certain trace elements, besides influencing the permeability, water holding capacity and tilth of the soil (Subba Rao, 1977). Raguramulu (2001) reported that fertility of soil depends not only on its chemical composition, but also on the qualitative and quantitative nature of micro-organisms inhabiting it. Population of fungi, bacteria, actinomycetes, algae and protozoa is greater in the root system of plants than the soil away from plant roots. With this background the present investigation on Arabica coffee (*Coffea arabica*) var. Chandragiri was formulated to study the influence of drip fertigation and bio fertigation on soil microorganism and soil enzyme activities.

RESOURCES AND METHODS

The present investigation on "Studies on impact of drip fertigation and biofertigation on soil microbial activity under coffee (*Coffea arabica*) cv. CHANDRAGIRI" plantation environment was conducted at Green Pearl Estate at Kottachedu, Yercaud, during 2007-2009. The present experiment was carried out with six-year-old coffee plants of cv. CHANDRAGIRI from 2008 to 2009. The spacing adopted was at 1.8 m x 1.8 m, with a plant population of 1200 plants acre^{-1}. The treatments included three levels of nitrogen, Phosphorus and potassium and liquid biofertlizers with combinations through fertigation. The experiment was laidout in a Randomized Blocks Design (RBD) with three replications. Totally eleven treatments including Absolute control (T_1), Drip irrigation alone (T_2), Soil application of NPK 50% RDF (T_3), Soil application of NPK 75% RDF (T_4), Soil application of NPK 100% RDF (T_5), Drip fertigation 75 % RDF (T_6), Drip fertigation 100 % RDF (T_7), Drip fertigation 125 % RDF (T_8), Drip fertigation 75 % RDF + Liquid biofertilizers (T_9), Drip fertigation 100 % RDF + Liquid biofertilizers (T_{10}) and Drip fertigation 125 % RDF + Liquid biofertilizers (T_{11}). Recommended dose of fertilizers for five-year-old trees of coffee plant was 70: 55: 75 Kg NPK year^{-1}acre^{-1} (as per the package of practices of coffee). The fertilizer dose was increased for the second year crop to the level of 80: 62: 80 g NPK plant^{-1} year^{-1}. Liquid biofertilizers were applied through drip irrigation system @ 50 ml each in liquid form as per the Tamil Nadu Agricultural University recommendation containing *Azospirillum* and Phosphobacteria (Anonymous, 2010). For fertigation, the above fertilizers were divided into twenty splits and applied at fortnightly intervals. Fertigation and liquid biofertilizers were given at three time intervals as per the technical programme. Biometrical observations *viz.*, dehyderogenase activity **(**changes in OD at 480 nm of Triphenyl Tetra Zolium Formazan (TPF) formed per gram of soil per day (Casida *et al*., 1964), phosphatase activity **(**µm p-nitrophenol g soil^{-1} min^{-1} at $35^0 \pm 1^0$C at pH 5.4 (Rao *et al.*, 1990), urease activity **(**mg NH_4-N 100g^{-1} soil h^{-1}), The rhizosphere soil sample from coffee was analyzed for bacteria fungi and actinomycetes as Serial dilution of soil sample method suggested by Parkinson *et al.* (1957) and expressed in per g of dry weight of the soil.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Effect of different levels of fertigation and biofertigation on soil microbes :

Results of the present study revealed that drip fertigation with liquid biofertilizer had significant influence on soil microbial population (Table 1 to 6). The results obtained in this study are supported by the findings of Rajalingam (2000) in tea and Krishnakumar and Saravanan (2005) in rice. Significant difference was noticed among the treatments in relation to soil microbial population *viz.*, fungi, bacteria and actinomycetes. The highest soil fungi population of 8.10, 10.90, 9.60 and 8.10 (x 10^4 cfu g^{-1} soil) and 8.20, 11.30, 10.90 and 8.95 (x 10^4 cfu g^{-1} soil), soil bacterial population of 19.90, 27.30, 25.60 and 22.70 (x 10^9 cfu g^{-1} soil) and 19.20, 28.56, 26.20 and 21.50 (x 10^9 cfu g^{-1} soil) and soil actnomycetes population of 7.60, 8.76, 8.00 and 7.80 (x 10^4 cfu g^{-1} soil) and 8.00, 8.98, 8.10 and 7.81 (x 10^4 cfu g^{-1} soil) during the year

2008 and 2009 was registered by the treatment T_9 (75 % RDF drip fertigation and biofertigation) at vegetative, flowering, fruit development and harvesting stage, respectively. The lowest soil fungi population of 6.81, 6.88, 6.98 and 6.40 (x 10^4 cfu g^{-1} soil) and 6.20, 7.67, 7.08 and 5.81 (x 10^4 cfu g^{-1} soil), soil bacterial population of 17.00, 19.77, 18.99 and 16.04 (x 10^9 cfu g^{-1} soil) and 16.91, 19.40, 17.91 and 16.90 (x 10^9 cfu g^{-1} soil) and soil actnomycetes population of 4.31, 6.90, 5.80 and 5.11 (x 10^4 cfu g^{-1} soil) and 5.81, 7.20, 6.49 and 5.81 (x 10^4 cfu g^{-1} soil) during the year 2008 and 2009 was recorded by absolute control T_1 at vegetative, flowering, fruit development and harvesting stage, respectively.

Pooled mean values showed that the application of 75% RDF through fertigation and biofertigation (T_9) recorded the highest soil fungal population (8.15, 11.10, 10.25 and 8.53 x 10^4 cfu g^{-1} soil), soil bacterial population (19.55, 27.93, 25.90 and 22.10 x 10^9 cfu g^{-1} soil) and soil actinomycetes population (7.80, 8.87, 8.05 and 7.81 x 10^4 cfu g^{-1} soil) at vegetative, flowering, fruit development and harvesting stages, respectively. The soil microbial activity of the study was in the order of bacteria, fungi and actinomycetes. This could be due to the enhanced organic carbon content of the soil as a result of

Table 1 : Effect of drip fertigation and biofertigation on fungal population of rhizosphere soil at vegetative and flowering stage of coffee (*Coffea arabica*) CV. CHANDRAGIRI

Treatments	Fungal population (X 10^4 cfu g^{-1} soil)					
	Vegetative stage		Mean	Flowering stage		Mean
	2008	2009		2008	2009	
T_1	6.81	6.20	6.51	6.88	7.67	7.28
T_2	6.88	6.42	6.65	7.80	7.90	7.85
T_3	6.90	6.88	6.89	8.80	8.10	8.45
T_4	6.91	6.92	6.92	8.87	8.90	8.89
T_5	7.00	7.10	7.05	8.90	9.42	9.16
T_6	7.20	7.31	7.26	10.20	9.82	10.01
T_7	7.90	7.80	7.85	10.20	10.40	10.30
T_8	7.00	7.20	7.10	9.70	9.50	9.60
T_9	8.10	8.20	8.15	10.90	11.30	11.10
T_{10}	8.00	7.90	7.95	10.23	10.80	10.52
T_{11}	7.25	7.50	7.38	10.21	10.10	10.16
S.E.±	0.050	0.040		0.045	0.057	
C.D. (P=0.05)	0.105	0.084		0.095	0.119	

Table 2 : Effect of drip fertigation and biofertigation on fungal population of rhizosphere soil at fruit development and harvesting stage of coffee (*Coffea arabica*) CV. CHANDRAGIRI

Treatments	Fungal population (X 10^4 cfu g^{-1} soil)					
	Fruit Development stage		Mean	Harvesting stage		Mean
	2008	2009		2008	2009	
T_1	6.98	7.08	7.03	6.40	5.81	6.11
T_2	7.10	7.10	7.10	6.41	6.20	6.31
T_3	7.60	7.40	7.50	6.60	6.50	6.55
T_4	7.70	7.60	7.65	6.70	6.80	6.75
T_5	7.90	8.20	8.05	6.82	7.10	6.96
T_6	8.10	8.40	8.25	7.30	7.90	7.60
T_7	9.10	9.30	9.20	7.40	8.10	7.75
T_8	8.00	8.21	8.11	6.80	7.90	7.35
T_9	9.60	10.90	10.25	8.10	8.95	8.53
T_{10}	9.20	9.70	9.45	7.71	8.65	8.18
T_{11}	8.20	8.85	8.53	7.35	7.91	7.63
S.E.±	0.049	0.058		0.045	0.044	
C.D. (P=0.05)	0.104	0.121		0.095	0.092	

biofertilizer application which break down the complex substances and increase humus in the soil due to the application of bioinoculants. Combined application of drip fertigation and biofertigation released the highest microbial population in the soil than the conventional method of fertilization and drip irrigation indirectly denoted the post harvest status of soil nutrients. These results are well supported by Dhakar and Mishra (1983).

Effect of different levels of fertigation and biofertigation on soil enzyme activity :

Analysis of the data pertaining to dehydrogenase activity, Acid phosphatase activity and Urease activity exhibited significant difference due to different fertigation and biofertigation treatments (Table 7 to 12). Among the different fertigation and biofertigation treatments, T_9 (75 % RDF fertigation and biofertigation) recorded the highest dehydrogenase activity (0.250, 0.330, 0.240 and 0.210 changes in OD at 485 nm and 0.260, 0.350, 0.320 and 0.220 changes in OD at 485 nm), Acid phosphatase activity (0.240, 0.390, 0.340 and 0.190 µmoles PNP released g^{-1} min^{-1} and 0.250, 0.410, 0.380 and 0.190 µmoles PNP released g^{-1} min^{-1}) and urease activity (140.00, 151.00, 143.00 and 132.00 µg NH_4N released

Table 3 : Effect of drip fertigation and biofertigation on bacterial population of rhizosphere soil at vegetative and flowering stage of coffee (*Coffea arabica*) CV. CHANDRAGIRI

Treatments	Bacterial population (X 10^9 cfu g^{-1} soil)					
	Vegetative stage		Mean	Flowering stage		Mean
	2008	2009		2008	2009	
T_1	17.00	16.91	16.96	19.77	19.49	19.63
T_2	17.11	17.00	17.06	21.00	20.80	20.90
T_3	17.80	17.70	17.75	22.00	21.60	21.80
T_4	17.90	17.90	17.90	23.40	22.30	22.85
T_5	17.91	18.00	17.96	24.10	24.10	24.10
T_6	18.10	18.20	18.15	25.00	25.20	25.10
T_7	18.80	18.90	18.85	26.10	27.20	26.65
T_8	18.00	18.00	18.00	24.80	24.80	24.80
T_9	19.90	19.20	19.55	27.30	28.56	27.93
T_{10}	19.00	19.10	19.05	27.10	28.00	27.55
T_{11}	18.70	18.70	18.70	25.10	27.00	26.05
S.E.±	0.118	0.114		0.127	0.140	
C.D. (P=0.05)	0.247	0.238		0.264	0.293	

Table 4 : Effect of drip fertigation and biofertigation on bacterial population of rhizosphere soil at fruit development and harvesting stage of coffee (*Coffea arabica*) CV. CHANDRAGIRI

Treatments	Bacterial population (X 10^9 cfu g^{-1} soil)					
	Fruit development stage		Mean	Harvesting stage		Mean
	2008	2009		2008	2009	
T_1	18.99	17.91	18.45	16.04	16.90	16.47
T_2	19.88	18.59	19.24	16.80	17.90	17.35
T_3	20.10	19.80	19.95	16.81	18.20	17.51
T_4	20.60	19.90	20.25	17.13	18.70	17.92
T_5	21.60	20.10	20.85	17.20	18.90	18.05
T_6	22.40	22.70	22.55	18.56	19.10	18.83
T_7	24.80	24.50	24.65	20.80	20.20	20.50
T_8	22.10	20.40	21.25	18.10	18.90	18.50
T_9	25.60	26.20	25.90	22.70	21.50	22.10
T_{10}	25.20	25.10	25.15	22.10	20.50	21.30
T_{11}	22.80	23.80	23.30	19.80	20.10	19.95
S.E.±	0.132	0.138		0.128	0.120	
C.D. (P=0.05)	0.275	0.287		0.267	0.250	

g^{-1} hr^{-1} and 145.00, 151.50, 138.00 and 129.00 µg NH_4N released g^{-1} hr^{-1}) during both the years 2008 and 2009 at vegetative, flowering, fruit development and harvest stages. This was followed by T_{10} (Drip fertigation 100 % RDF + Liquid biofertilizers) which recorded dehydrogenase activity of 0.230, 0.280, 0.240 and 0.190 changes in OD at 480 nm and 0.230, 0.290, 0.250 and 0.220 changes in OD at 480 nm, Acid phosphatase activity of 0.240, 0.390, 0.210 and 0.190 µmoles PNP released g^{-1} min^{-1} and 0.250, 0.400, 0.230 and 0.190 µmoles PNP released g^{-1} min^{-1} and urease activity of 120.00, 137.00, 119.00 and 115.00 µg NH_4N released g^{-1} hr^{-1} and 113.33, 133.00, 112.00 and 110.00 µg NH_4N released g^{-1} hr^{-1} during 2008 and 2009, respectively at all stages of crop growth *viz.*, vegetative, flowering, fruiting and harvesting stage. The lowest values of dehydrogenase activity (0.110, 0.190, 0.140 and 0.110 changes in OD at 480 nm and 0.110, 0.190, 0.150 and 0.120 changes in OD at 480 nm), Acid phosphatase activity (0.120, 0.180, 0.160 and 0.120 µmoles PNP released g^{-1} min^{-1} and 0.110, 0.200, 0.150 and 0.120 µmoles PNP released g^{-1} min^{-1}) and urease activity (120.00,

Table 5 : Effect of drip fertigation and biofertigation on actinomycetes population of rhizosphere soil at vegetative and flowering stage of coffee (*Coffea arabica*) CV. CHANDRAGIRI

Treatments	Actinomycetes population (X 10^3 CFU g^{-1} soil)					
	Vegetative stage		Mean	Flowering stage		Mean
	2008	2009		2008	2009	
T_1	4.31	5.81	5.06	6.90	7.20	7.05
T_2	5.67	5.90	5.79	7.10	7.28	7.19
T_3	5.90	5.98	5.94	7.30	7.68	7.49
T_4	6.10	6.00	6.05	7.38	7.70	7.54
T_5	6.12	6.40	6.26	7.60	7.91	7.76
T_6	6.60	6.50	6.55	8.00	8.12	8.06
T_7	7.10	7.10	7.10	8.21	8.51	8.36
T_8	6.20	6.40	6.30	7.60	7.98	7.79
T_9	7.60	8.00	7.80	8.76	8.98	8.87
T_{10}	7.30	7.20	7.25	8.30	8.85	8.58
T_{11}	6.80	6.60	6.70	8.20	8.42	8.31
S.E.±	0.049	0.043		0.055	0.102	
C.D. (P=0.05)	0.104	0.090		0.115	0.214	

Table 6 : Effect of drip fertigation and biofertigation on actinomycetes population of rhizosphere soil at fruit development and harvesting stage of coffee (*Coffea arabica*) CV. CHANDRAGIRI

Treatments	Actinomycetes population (X 10^3 CFU g^{-1} soil)					
	Fruit development stage		Mean	Harvesting stage		Mean
	2008	2009		2008	2009	
T_1	5.86	6.49	6.18	5.11	5.81	5.46
T_2	5.98	6.52	6.25	5.70	5.89	5.80
T_3	6.00	6.72	6.36	5.80	5.99	5.90
T_4	6.20	6.81	6.51	5.89	6.20	6.05
T_5	6.69	6.82	6.76	5.90	6.21	6.06
T_6	6.90	7.60	7.25	7.00	6.40	6.70
T_7	7.40	7.71	7.56	7.20	6.98	7.09
T_8	6.71	7.10	6.91	6.00	6.20	6.10
T_9	8.00	8.10	8.05	7.80	7.81	7.81
T_{10}	7.80	7.90	7.85	7.30	7.00	7.15
T_{11}	7.20	7.68	7.44	7.10	6.82	6.96
S.E.±	0.057	0.045		0.177	0.044	
C.D. (P=0.05)	0.119	0.095		0.369	0.099	

137.00, 119.00 µg NH_4N released g^{-1} hr^{-1} and 115.00 and 113.33, 133.00, 112.00 and 110.00 µg NH_4N released g^{-1} hr^{-1}) were recorded by absolute control (T_1) in 2008 and 2009 respectively at all the stages of crop growth.

Pooled mean values also showed similar trend that the application of 75% RDF through fertigation and biofertigation (T_9) recorded the highest dehydrogenase activity (0.255, 0.340, 0.280 and 0.215 changes in OD at 480 nm), acid phosphatase activity (0.245, 0.400, 0.360 and 0.190 µmoles PNP released g^{-1} min^{-1}) and Urease activity (142.50, 151.25, 140.50 and 130.50 µg NH_4N released g^{-1} hr^{-1}) at vegetative, flowering, fruit development and harvest stages, respectively.

The soil dehydrogenase was considered as an integral part of the intact cells of microorganisms and dehydrogenase activity was thought to reflect the total range of oxidative activities of the soil microflora (Casida *et al*., 1964). The increased dehydrogenase activity noticed by drip fertigation and biofertigation might have been due to the increased population of soil microbes. These findings are in line with the findings of Kalidurai (1988) and Balasubramaniam (2008).

Table 7 : Effect of drip fertigation and biofertigation on dehydrogenase activity of rhizosphere soil at vegetative and flowering stage of coffee (*Coffea arabica*) CV. CHANDRAGIRI

Treatments	Soil dehydrogenase (µg TPF released g^{-1} of soil day^{-1})					
	Vegetative stage		Mean	Flowering stage		Mean
	2008	2009		2008	2009	
T_1	0.110	0.110	0.110	0.190	0.190	0.190
T_2	0.120	0.120	0.120	0.200	0.190	0.195
T_3	0.150	0.140	0.145	0.210	0.190	0.200
T_4	0.150	0.150	0.150	0.240	0.210	0.225
T_5	0.160	0.160	0.160	0.247	0.230	0.238
T_6	0.180	0.200	0.190	0.260	0.250	0.255
T_7	0.210	0.210	0.210	0.280	0.280	0.280
T_8	0.170	0.180	0.175	0.250	0.240	0.245
T_9	0.250	0.260	0.255	0.330	0.350	0.340
T_{10}	0.230	0.230	0.230	0.280	0.290	0.285
T_{11}	0.190	0.210	0.200	0.270	0.270	0.270
S.E.±	0.013	0.002		0.015	0.002	
C.D. (P=0.05)	0.028	0.004		0.031	0.004	

Table 8 : Effect of drip fertigation and biofertigation on dehydrogenase activity of rhizosphere soil at fruit development and harvesting stage of coffee (*Coffea arabica*) CV. CHANDRAGIRI

Treatments	Soil dehydrogenase (µg TPF released/ g soil/day)					
	Fruit development stage		Mean	Harvesting stage		Mean
	2008	2009		2008	2009	
T_1	0.140	0.150	0.145	0.110	0.120	0.115
T_2	0.140	0.160	0.150	0.110	0.120	0.115
T_3	0.150	0.160	0.155	0.120	0.130	0.125
T_4	0.170	0.180	0.175	0.120	0.130	0.125
T_5	0.170	0.180	0.175	0.130	0.160	0.145
T_6	0.200	0.220	0.210	0.150	0.180	0.165
T_7	0.230	0.250	0.240	0.160	0.190	0.175
T_8	0.200	0.210	0.205	0.130	0.170	0.150
T_9	0.240	0.320	0.280	0.210	0.220	0.215
T_{10}	0.240	0.250	0.245	0.190	0.220	0.205
T_{11}	0.220	0.230	0.225	0.160	0.180	0.170
S.E.±	0.002	0.002		0.001	0.002	
C.D. (P=0.05)	0.004	0.004		0.003	0.004	

Dehydrogenase is an indication of intensive microbial activity. When WSF was applied through drip fertigation the enzyme activity was higher than conventional method of fertilization with normal NPK fertilizers as reported by Trevors (1984). It was also noticed that the dehydrogenase activity was gradually increased from vegetative stage and attained peak at flowering stage thereafter it declined (Fig.1). Similar results were also made by Baruah and Mishra (1984) and Damodaran (1987). Phosphatase enzyme releases organic phosphates from phophotic compounds which are taken up by the plants from soil (Pallab *et al*., 1991). Higher levels of phosphorus present in the applied nutrients would have resulted in higher phosphatase activity. This was in conformity with the results of the present study. Higher phosphatase activity observed in drip fertigation and biofertigation treatments than soil fertilization and drip irrigation (Fig. 2) might be due to increased biomass carbon and soil microbial activities (Subramanian *et al*., 2001). Activity of phosphobacteria in soil in the applied biofertilizer inoculants also increased the phosphatase activity by enhanced production of available soil P and

Table 9 : Effect of drip fertigation and biofertigation on acid phosphatase activity at vegetative and flowering stage of coffee (*Coffea arabica*) CV. CHANDRAGIRI

Treatments	Acid phosphatase (µm p-nitrophenol g soil^{-1} min^{-1})					
	Vegetative stage		Mean	Flowering stage		Mean
	2008	2009		2008	2009	
T_1	0.120	0.110	0.115	0.180	0.200	0.190
T_2	0.140	0.130	0.135	0.220	0.210	0.215
T_3	0.150	0.160	0.155	0.240	0.210	0.225
T_4	0.150	0.160	0.155	0.260	0.240	0.250
T_5	0.170	0.160	0.165	0.260	0.250	0.255
T_6	0.190	0.190	0.190	0.290	0.290	0.290
T_7	0.220	0.240	0.230	0.380	0.390	0.385
T_8	0.170	0.180	0.175	0.280	0.250	0.265
T_9	0.240	0.250	0.245	0.390	0.410	0.400
T_{10}	0.240	0.250	0.245	0.390	0.400	0.395
T_{11}	0.200	0.210	0.205	0.330	0.320	0.325
S.E.±	0.002	0.002		0.003	0.003	
C.D. (P=0.05)	0.004	0.004		0.006	0.007	

Table 10 : Effect of drip fertigation and biofertigation on acid phosphatase activity at fruit development and harvesting stage of coffee (*Coffea arabica*) CV. CHANDRAGIRI

Treatments	Acid phosphatase (µm p-nitrophenol g soil^{-1} min^{-1})					
	Fruit development stage		Mean	Harvesting stage		Mean
	2008	2009		2008	2009	
T_1	0.160	0.150	0.155	0.120	0.110	0.115
T_2	0.180	0.160	0.170	0.120	0.130	0.125
T_3	0.180	0.160	0.170	0.120	0.140	0.130
T_4	0.180	0.180	0.180	0.120	0.150	0.135
T_5	0.180	0.190	0.185	0.160	0.150	0.155
T_6	0.190	0.190	0.190	0.180	0.180	0.180
T_7	0.210	0.210	0.210	0.190	0.180	0.185
T_8	0.180	0.190	0.185	0.180	0.160	0.170
T_9	0.340	0.380	0.360	0.190	0.190	0.190
T_{10}	0.210	0.230	0.220	0.190	0.190	0.190
T_{11}	0.200	0.200	0.200	0.180	0.180	0.180
S.E.±	0.002	0.003		0.001	0.001	
C.D. (P=0.05)	0.004	0.005		0.003	0.002	

concomitant increase in soil organic matter and microbial number. Similar reports were made by Farell *et al.* (1994) and Kennedy and Smith (1995). It was also noticed that the urease activity was increased with increased level of fertilizers. Application of 125% RDF fertigation and biofertigation registered the highest activity of urease (Fig. 3). It was on par with 100% RDF fertigation and biofertigation treatments and 75% RDF drip fertigation and biofertigation treatments. Conventional system of fertilization recorded lower urease activity which might be due to poor hydrolyzing nature of soil in the absence of organic and inorganic nutrients. This indicated the significance of the method of fertilization on urease activity. These results are in agreement with the findings of Evdokimova and Tishchenko (1984). The increased urease activity with higher level of N fertilizer might be due to higher availability of substrate nitrogen which promoted urease activity. These are in line with the findings of Zantua and Bremner (1997) and Pal and Chonkar (1979). Application of biofertilizer particularly *Azospirillum* which aiding in fixing of atmospheric nitrogen into the soil resulted in higher level of available

Table 11 : Effect of drip fertigation and biofertigation on urease activity at vegetative stage and flowering of coffee (*Coffea arabica*) cv. CHANDRAGIRI

Treatments	Urease activity (µg NH_4 N $g^{-1}h^{-1}$)					
	Vegetative stage		Mean	Flowering stage		Mean
	2008	2009		2008	2009	
T_1	120.00	113.33	116.67	137.00	133.00	135.00
T_2	123.00	125.00	124.00	138.00	132.00	135.00
T_3	124.00	127.00	125.50	138.50	132.50	135.50
T_4	125.00	128.00	126.50	139.00	132.00	135.50
T_5	126.00	128.27	127.14	140.00	132.33	136.17
T_6	128.00	131.00	129.50	145.00	140.00	142.50
T_7	130.00	140.00	135.00	148.00	143.00	145.50
T_8	126.00	129.00	127.50	144.00	138.00	141.00
T_9	140.00	145.00	142.50	151.00	151.50	151.25
T_{10}	138.00	137.00	137.50	148.50	148.00	148.25
T_{11}	129.00	134.00	131.50	146.00	142.33	144.17
S.E.±	0.251	0.293		0.199	0.271	
C.D. (P=0.05)	0.524	0.612		0.416	0.564	

Table 12 : Effect of drip fertigation and biofertigation on urease activity at fruit development and harvesting stage of coffee (*Coffea arabica*) cv. CHANDRAGIRI

Treatments	Urease activity (µg NH_4 N $g^{-1}h^{-1}$)					
	Fruit development stage		Mean	Harvesting stage		Mean
	2008	2009		2008	2009	
T_1	119.00	112.00	115.50	115.00	110.00	112.50
T_2	122.00	116.00	119.00	118.00	110.50	114.25
T_3	127.00	116.50	121.75	120.00	112.00	116.00
T_4	127.50	120.00	123.75	120.50	116.00	118.25
T_5	127.30	121.00	124.15	121.00	116.50	118.75
T_6	130.00	124.00	127.00	125.00	120.00	122.50
T_7	136.00	129.00	132.50	129.00	125.00	127.00
T_8	128.00	121.50	124.75	122.00	117.00	119.50
T_9	143.00	138.00	140.50	132.00	129.00	130.50
T_{10}	139.00	133.00	136.00	129.50	125.50	127.50
T_{11}	135.00	125.00	130.00	126.00	124.00	125.00
S.E.±	0.296	0.316		0.218	0.267	
C.D. (P=0.05)	0.617	0.659		0.455	0.557	

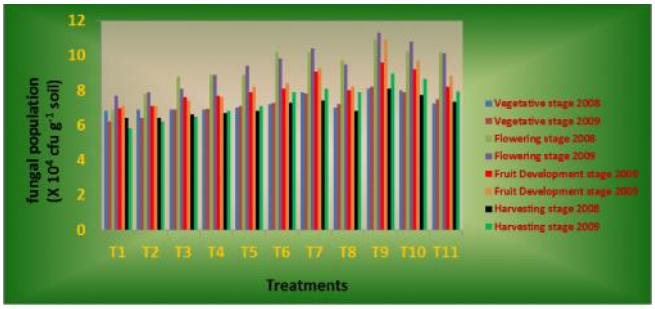

Fig. 1 : Effect of drip fertigation and biofertigation on fungal population (X 10^4 cfu g^{-1} soil)

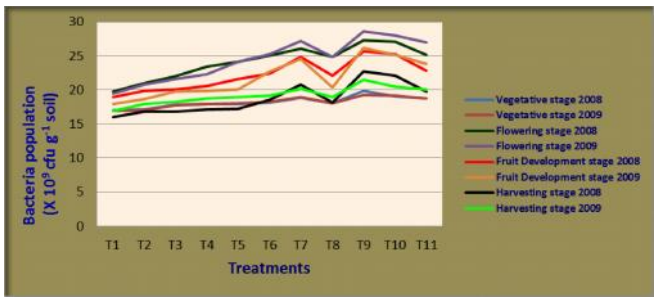

Fig. 2 : Effect of drip fertigation and biofertigation on bacterial population (X 10^9 cfu g^{-1} soil)

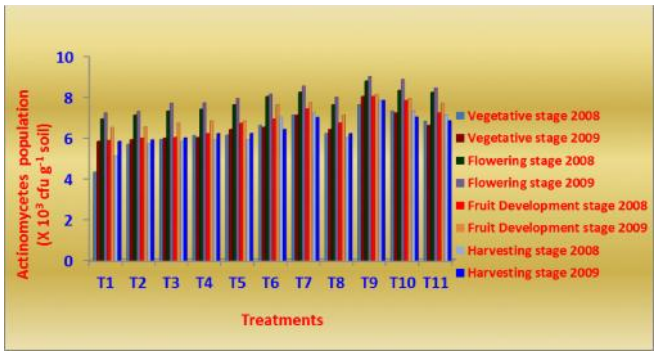

Fig. 3 : Effect of drip fertigation and biofertigation on actinomycetes population (X 10^3 cfu g^{-1} soil)

nitrogen in the soil. Higher level of available soil nitrogen might have resulted in higher urease activity. Further higher biomass carbon and soil microbes could have also contributed an increased activity of urease.

From the result it was observed that the drip fertigation along with liquid biofertilizer (bio fertigation) had significantly increased the microbial activitiy *viz*., soil fungi, bacteria and actnimycetes which inturn increased the soil biological property in coffee eco system. Further it could be concluded that biofertgation in coffee is beneficially increased the fertility of soil by increasing the soil chemical composition and qualitative and quantitative nature of micro-organisms in the rhizosphere.

Authors' affiliations :

V. LAKSHMANAN AND K. SUNDHARAIYA, Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA

REFERENCES

Anonymous (2010). India Coffee Organization.

Balasubramanian, P. (2008). Comparative analysis of growth, physiology, nutritional and production changes of tomato (*Lycopersicum esculentum* Mill.) under drip, fertigation and conventional systems. Ph.D. (Hort.) Thesis, Tamil Nadu Agricultural University. Coimbatore, T.N. (India).

Baruah, M. and Mishra, R.R. (1984). Dehydrogenase and urease activities in rice field soils. *Soil Biol. Biochem.*, **16**: 423-424.

Casida, L.E., Klein, D.A. and Santoro, T. (1964). Soil dehydrogenase activity. *Soil Sci.*, **98**: 371-376.

Damodaran, S. (1987). Studies on changes in microbial, biochemical and chemical properties of soil under continuous cropping and fertilization. M.Sc. (Ag.) Thesis, Tamil Nadu Agricultural University. Coimbatore, T.N. (India).

Dhakar, S. and Mishra, R.R. (1983). Dehydrogenase and urease activities of maize (*Zea mays* L.) field soils. *Pl. Soil*, **70**: 327-333.

Evdokimova, N.V. and Tishchenko, A.T. (1984). Enzyme activity in genetically heterogenous soils in long-term fertilizer trials. Izvestiya Timiryazevskoisel's kokhozyaistevennoi Akademii, 1: 103-107.

Farrel, R. E. V., Gupta, V.S.R. and Germida, J.J. (1994). The effect of cultivation on the activity and kinetics of arylsulfalose in Saskatchewan soils. *Soil Biol. Biochem.*, *26* : 1033-1040.

Kalidurai, M. (1988). Studies on nitrogen fixation and nitrogen contribution by stem nodulating legume *Sesbania rostrata* in rice soil ecosystem. M.Sc.(Agri.,) Thesis TNAU, Coimbatore.

Kennady, A. C. and Smith, K.L. (1995). Soil microbial diversity and the sustainability of agricultural soils. Plant Soil, 170: 75-86.

Krishnakumar, S. and Saravanan, A. (2005). Microbial population and enzymatic activity as influenced by organic farming. *J. Agric. Biol. Sci.*, **1**(1): 85-88.

Pal, S. and Chonkar, P.K. (1979). Thermal properties and Kinetic properties Urease. *J. Indian Soc.Soil Sci.*, **27**: 43-47.

Pallab, De K., Arun, K. and De, S.K. (1991). Soil enzymes: Activities and Agricultural importance. *Indian J. Agri. Chem.*, **22**(2-3):223-227.

Parkinson, D.J.R., Gray and Williams, S.T. (1957). Method for studying ecology of soil micro organisms. Oxford Blackwell Scientific Publication. pp. 116.

Paul, J.V., Joseph and Kabeer, T. Ahammed. (1998). Fertilizer irrigation – An over view. In: Proc. of All India seminar on modern irrigation techniques. June 26-27. Bangalore: 191-195.

Raguramulu, Y. (2001). Scope of biofertilizers in coffee production. *Indian Coffee*, **7**: 19-20.

Rajalingam, G.V. (2000). Studies on the effect of digested coir pith compost and biofertilizers on the soil health, growth and productivity of tea (*Camellia sp*.). Ph.D. Thesis, Tamil Nadu Agricultural University. Coimbatore, T.N. (India).

Skujins, I.J. and Mclaren, A.D. (1976). Enzyme reaction rates at limited water activities. *Sci.*, **158**: 1569-1570.

Subba Rao, N.S. (1977). *Soil microorganisms and plant growth.* Oxford and IBH Publication Co., New Delhi.

Subramanian, K.S., Sivasamy, N. and Thangaraj, T. (2001). Integrated nutrient management for turmeric. *Spice India*, **14**(12): 25-26.

Trevors, J.T. (1984). Effect of substrate concentration, inorganic nitrogen, oxygen concentration, temperature of pH on dehydrogenase activity in soil. *Pl. Soil*, **77**: 285-293.

Zantua, M.I. and Bremner, J.M. (1997). Production and persistence of urease activity in soils. *Soil Biol. Biochem*., **8** : 369-374.