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Study of soil microbial activity in different silvi-horti-agricultural system under rainfed plateau conditions of Jharkhand

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Abstract
An attempt was made at ICAR RCER, Research Centre, Ranchi to study the microbial population in soil in an already established 4 years old silvi-horti-agricultural system during 2018-2019. The study was laid out in split plot design with four treatments and four replications. Results revealed that the microbial population was significantly affected under different systems due to the presence of filler crops and the agricultural crops under different silvi-horti-agricultural system. The maximum number of fungal colonies and bacterial cells were observed under all silvi-horti-agricultural systems in comparison to the fallow/sole crop system. Among the different silvi-horti-agricultural system, mango + mahogany + peach system has the highest value. The highest dehydrogenase activity was recorded in mango + mahogany + peach system (11.25 micro gram TPF 24 hr^{-1} gm^{-1}).

Keywords: Microbial populations, bacterial cells, fungal colonies and dehydrogenase activity

1. Introduction

In view of the prevailing socioeconomic and agro-climatic conditions favourable for agriculture in the state, it is not possible to divert the fertile lowland into uplands. The only option to increase productivity is to integrate the tree species with agricultural crops on farm lands. Agro-forestry has caught the attention of farmers across the world, especially in India where both forest and agricultural land and are under severe stress due to population pressure and industrialization. The system is proposed as a strategy to combat soil degradation and to improve soil fertility and enhance crop productivity. Agro-forestry system besides it maintains the ecological balance and uplifts the socioeconomic status of the farmers greatly contributes toward production of wood for industries and other commercial purposes. At the same time it also helps in diversifying the traditional rice-wheat rotation system, responsible for deteriorating soil fertility and alarming depletion of underground water table. Productivity in agri-silvi-horticultural system is comparatively higher than the productivity of sole agriculture and seems to be a potential viable land use system for maximization and sustainable productivity on farmers' field.

Multipurpose trees are of great significance in agro-forestry systems, as they not only yield numerous products *viz*., timber, fuel wood, fruits, fodder, medicines, fibres, rubber, tanning agents but also perform soil amelioration functions. The soil quality and its production capacity can be restored and improved by adopting agro-forestry system like agri-silvi-horticultural system, which provides a way to sustain agricultural productions (Thakur & Kumar, 2006) [8]. Similarly, Tewari *et al*. (2007) [7] found that integrating trees enhance overall productivity and income by ameliorating harsh environment of the area, that is why, the farmers maintain and promote naturally growing sparse trees of *Prosopis cineraria* (L.), *Tecomella undulate* (L.), *Acacia leucophloea*, *Acacia nilotica*, *Zyziphus jujube*, *Zyziphus nummularia* (L.) and a few fodder and fruit tree species on their fields. These trees sustain the farmers during the crop failure by producing food, fodder and timber. However, current densities of these trees are very low and variable. Productivity of the arid and semi-arid region is about two times less as compared to humid and sub-humid regions. Enhanced productivity in these regions can be realized by cultivating agricultural crops with fruit plants and forest trees in agri-silvi-horticulture system. Under dry land, horticultural fruit trees like guava and *ber* integrated with short duration arable crops like pulses, vegetables and groundnut proved to be the most profitable oriented among different agro-forestry systems (Giri-Rao, 2009) [3].

Agroforestry research has so far placed high emphasis on technologies that stress the service functions of trees viz. soil fertility improvement and/or soil conservation. Too little attention has been given to high value or income generating trees. The choice of tree species is an important management decision that influences the resource use of any tree-crop system.

Mixing of species with different growth habits, rooting patterns, and quality of leaf residues may lead to higher biomass productivity by enhancing complementary use of growth resources, reducing pest problems, and promoting greater synchrony in the release of nutrients from litter in relation to crop requirements. Conceptually to the "Central" hypothesis to justify agroforestry is that trees must utilize resources such as water and nutrients that are not utilized by crops. This means that if the existing resources are under-utilized in a sole crop - only system because they are inaccessible to crop roots, then spatial and/or temporal differences in rooting and root dynamics in an agroforestry system (complementarity) would be an advantage.

At ICAR RCER, Research Centre, Ranchi, a field trial was established during the year 2014-2015 to study the effect of the tree crops, filler crops and agricultural crops on the soil microbial population in silvi-horti-agricultural under rainfed uplands of eastern plateau and hill region of Jharkhand. Monitoring of soil fertility status in grown up mango and mahogany based silvi-horti-agricultural systems can help in designing nutrient management strategies particularly under the low fertile soils of eastern plateau and hills so that the productivity of crops does not decline in long run. In the present paper, attempt has been made to analyze the effect of plant growth behavior of the soil.

2. Materials and Methods

The present study was carried out on 4-years-old already established silvi-horticultural system of agro-forestry at ICAR Research Complex for Eastern Region, Research Centre, Ranchi, Jharkhand, India, located at 23^0 16' 46" and 23^0 16' 48" N latitude and 85^0 24' 48" and 85^0 24' 51" E longitude at an average elevation of 629 m (2,064ft) above the mean sea level. The experiment was laid in split plot design. In main plot, rice and ragi were taken and subplot consisted different silvi-horti-agricultural system (Mango + mahogany + aonla, Mango + mahogany + peach and Mango + mahogany + no filler) and sole intercrop. The treatments consisted of 2 tree species, *i.e.,* Mango (*Mangifera indica* L.) variety Amrapali and Mahogany (*Swietenia mahogany)* variety local and 2 horticultural species, *i.e.,* Peach *(Prunus persica* (L.) Batcsh) variety Florida Prince and Aonla (*Embilica officinalis*) variety NA-7 were grown. The perennial woody plants, i.e. the main crop (Mango and Mahogany) was planted at a distance of 20×20 m from row to row and 10 x 10 m from plant to plant. Also the filler crops (Peach and Aonla) were planted at a distance of 5×5 m from row to row and 10 x 10 m from plant to plant. Third components of the system, *i.e.,* Kharif crops (Rice and Ragi) were taken in association with perennial woody plants and horticultural plants, thus forming silvi-horti-agricultural system of agro-forestry. Rice variety Anjali and ragi variety BM 2 were sown on 20th June during 2018-19 and 12th July during 2018-19 in lines at 12 cm spacing respectively.

There were eight treatments consisting of sole crop and intercropping with main crop, filler crop and agriculture crops. Each treatment was replicated four times in the experimental plot.

For soil microbial count, composite samples were collected at two depths (0-30 cm and 30-60 cm) using auger. The collected samples were homogenised and spread in trays to be cleaned of extraneous materials (pieces of root, leaves, small stems, etc.) followed by drying and storing in plastic containers. Microbial load was ascertained by standard serial dilution plate technique. 1 g of soil was transferred to 10 ml sterile distilled water and agitated vigorously. Different aqueous dilutions, 10^3 to 10^6 of the suspensions were prepared and plated on soil extract agar and potato malt agar for determining microbial load and fungal isolation respectively. For determining the load of microorganisms in the sample, colony forming units was determined by the formula (Johnson and Curl 1972) [4].

No. of microorganisms per gram of sample = No. of colonies × dilution factor

Dehydrogenase activity of the soil was estimated through the Triphenyl Tetrazolium Chloride (TTC) solution test and the results were expressed as mg TPF (Triphenyl Formazon) per hour per gram of soil.

The data were subjected to standard analysis of variance technique for split plot design. Statistical analysis was done for the individual year data for different parameters. The mean effect of treatments was compared at $P<0.05$ level of significance.

3. Results and Discussion

3.1 Effect of different silvi-horti-agricultural systems on microbial count in soil under rainfed conditions

Analysis of data presented in the table 1 reveals the microbial count of fungi and bacteria before sowing of the intercrops and after harvesting of the intercrops in the soil under different silvi-horti-agricultural systems. It can be inferred from the table that the maximum fungal colonies at initial stage under the sub-plots (filler crops) was observed in B_2 (16.61 x 10^4cfu/gm soil) which was significantly higher than all other systems, followed by B_1 (15.78 x 10^4cfu/gm soil), while B_3 (14.50 x 10^4cfu/gm soil) and B_4 (14.48 x 10^4cfu/gm soil) were at par with each other. At final stage, the maximum fungal colonies were observed in B_2 (41.63 x 10^4cfu/gm soil) which was at par with B_1 (40.30 x 10^4cfu/gm soil), followed by B_3 (35.06 x 10^4cfu/gm soil) and the lowest value was observed in B_4 (34.81 x 10^4cfu/gm soil).

Table 1 also reveals that the maximum cells of bacteria at initial and final stage under the sub-plots (filler crops) were observed in B_2 (11.86 x10^8 and 19.02 x10^8 cells per gm soil, respectively) which was at par with B_1 (19.02 x10^8 and 18.60 x10^8 cells per gm soil, respectively), followed with B_3 (7.67 x10^8 and 14.11 x10^8 cells per gm soil respectively), while the minimum cells were obtained in B_4 (7.57 x10^8 and 14.04 x10^8 cells per gm soil respectively).

The main crops (rice and ragi) effect and the interaction effect (A X B) were found to be nonsignificant in influencing the soil microbial count under different silvi-horti-agricultural systems.

Table 1: Effect of different silvi-horti-agricultural systems on microbial count in soil under rainfed conditions.

Parameters	Fungi (*10³cfu /gm soil)		Bacteria (*10⁶ cells per gm soil)	
	Initial	Final	Initial	Final
A_1	15.36×10^4	37.9×10^4	9.68×10^8	16.45×10^8
A_2	15.34×10^4	37.8×10^4	9.67×10^8	16.44×10^8
C.D. at 5%	NS	NS	NS	NS
SE(d)±	0.12	0.77	0.16	0.03
B_1	15.78×10^4	40.30×10^4	19.02×10^8	18.60×10^8
B_2	16.61×10^4	41.63×10^4	11.86×10^8	19.02×10^8
B_3	14.50×10^4	35.06×10^4	7.67×10^8	14.11×10^8
B_4	14.48×10^4	34.81×10^4	7.57×10^8	14.04×10^8
C.D. at 5%	0.48	2.30	0.36	1.29
SE(d)±	0.16	0.76	0.12	0.43
A_1XB_1	15.81×10^4	40.31×10^4	11.60×10^8	18.61×10^8
A_1XB_2	16.62×10^4	41.63×10^4	11.86×10^8	19.02×10^8
A_1XB_3	14.52×10^4	35.07×10^4	7.67×10^8	14.11×10^8
A_1XB_4	14.50×10^4	34.95×10^4	7.58×10^8	14.04×10^8
A_2XB_1	15.76×10^4	40.30×10^4	11.60×10^8	18.60×10^8
A_2XB_2	16.60×10^4	41.63×10^4	11.86×10^8	19.02×10^8
A_2XB_3	14.52×10^4	35.05×10^4	7.67×10^8	14.10×10^8
A_2XB_4	14.47×10^4	34.67×10^4	7.57×10^8	14.04×10^8
C.D. at 5% (B-A)	NS	NS	NS	NS
SE(d)±	0.25	1.53	0.24	0.86
C.D. at 5% (A-B)	NS	NS	NS	NS
SE(d)±	0.23	1.57	0.26	0.74
CV%	11.96	9.56	10.84	11.56

A_1=Rice, A_2=Ragi, B_1=Mango + mahogany + aonla, B_2= Mango + mahogany + peach, B_3= Mango + mahogany + no filler, B_4= Sole intercrop, NS= Non-significant.

The maximum number of microbial colonies were present under silvi-horti-agricultural system in comparison to the sole intercrop. This can be possibly due to high nutrient enrichment of the soil by litter decomposition. The result is in line with the observations recorded by Manna and Singh (2001) [5] who stated that there is increment in the organic carbon content in the soil with intercropping with fruits trees, Similar observations were also obtained by Wemedo & Onolleka (2012) [9].

Among different silvi-horti-agricultural system, Mango + Mahogany + Peach performed best because it has higher soil organic carbon content than other systems. Also the high moisture content in the system led to the maximum number of fungal and bacterial colonies. Similar observation was recorded by Bhattarai *et al.*, (2015) [1] and Tangjang *et al.* (2015) [6] who reported that moisture content in the soil is an important factor for the increase in microbial colonies count.

3.2 Effect of different silvi-horti-agricultural systems on dehydrogenase activity in the soil under rainfed conditions.

The data pertaining to the dehydrogenase activity in the soil under different silvi-horti- agricultural systems had been given in Table 2 and it can be inferred from the table that the maximum value under the sub-plots (filler crops), was recorded in B_2 (11.25 micro gram TPF 24 hr^{-1} gm^{-1}) which is significantly higher than all other systems, followed by B_1 (10.88 micro gram TPF 24 hr^{-1} gm^{-1}), B_3 (7.05 micro gram TPF 24 hr^{-1} gm^{-1}) and the lowest value was observed in B_4 (6.84 micro gram TPF 24 hr^{-1} gm^{-1}).

The main crops (rice and ragi) effect and the interaction effect (A X B) were found to be non-significant in influencing the dehydrogenase activity under different silvi-horti-agricultural systems.

The value of dehydrogenase activity was higher in silvi-horti-agricultural system in comparison to the sole intercrop. This can be due to improved soil quality in silvi-horti-agricultural system due to litter fall which leads to increased soil organic carbon. The results are in line with Chander *et al.* (1998) [2] who observed that higher organic C and total N, microbial biomass C, basal soil respiration and activities of dehydrogenase and alkaline phosphatase were observed in treatments with tree-crop combination than in the treatment without trees.

Among different silvi-horti-agricultural system, mango + mahogany + peach system performed best. It can be possibly due to its high nutrient content, moisture content and microbial colonies in comparison to other systems. The result was in accordance with Manna & Singh (2001) [5] who reported that increase in dehydrogenase activity is a factor of cropping system and perhaps the integration of the filler crops in the system is the main reason for the high value of dehydrogenase activity under the peach system.

Table 2: Effect of different silvi-horti-agricultural systems on dehydrogenase activity in the soil under rainfed conditions.

Parameters	Micro gram TPF 24 hr^{-1} gm^{-1}
A_1	9.02
A_2	8.99
C.D. at 5%	NS
SE(d)±	0.008
B_1	10.88
B_2	11.25
B_3	7.05
B_4	6.84
C.D. at 5%	0.34
SE(d)±	0.11
A_1XB_1	10.89
A_1XB_2	11.25
A_1XB_3	7.08
A_1XB_4	6.84
A_2XB_1	10.87
A_2XB_2	11.24
A_2XB_3	7.03
A_2XB_4	6.83
C.D. at 5% (B-A)	NS
SE(d)±	0.02
C.D. at 5% (A-B)	NS
SE(d)±	0.14
CV%	11.58

A_1=Rice, A_2=Ragi, B_1=Mango + mahogany + aonla, B_2= Mango + mahogany + peach, B_3= Mango + mahogany + no filler, B_4= sole intercrop, NS= Non-significant.

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