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Soil enzymes: Indicator for soil health under fruit based agri-horti system

Tilak Mondal*, J.K. Bisht, P.K. Mishra, B.M. Pandey, D. Mahanta, V.S. Meena, A. Pattanayak
ICAR-Vivekananda Institute of Hill Agriculture, Almora, India
*Corresponding author e-mail: mondalt.vpkas2013@gmail.com

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Introduction

Agroforestry as a sustainable land management system, which increases the yield of the land, combines production of crops (including tree crops) and forest plants and/or animals simultaneously or sequentially. Among the different agroforestry system practices in hill area agri-horti system is one of the most important system because of its specific environmental conditions and natural availability of wide range of fruit trees (citrus, apple, walnut, plum, peach, pear, apricot etc.). In North-western hill region *viz*. Uttarakhand, Himachal Pradesh and Jammu and Kashmir horticulture is the backbone of these states economy which supports about 1.5-2.0 million families and, provides direct or indirect employment to 8-10 million peoples with revenue of more than 1 billion $ (USD) annually. In several studies it was reported that plant's active root system releases about 17% of photosynthate detained in the form of organic compounds into the rhizosphere, most of which is available to the plant by the different soil microbial activities. The soil enzymatic activity play a significant role in efficient utilization of natural resources through agri-horti production system to enhance the soil sustainability and system productivity by the mechanisms of organic matter decomposition, soil stabilization, nutrient cycling, catalyzing several biochemical reactions in the soil system1,2. In recent years, studies soil enzymes activity have engaged the attention of many researchers. However, most of these studies are confined to agricultural cropping systems3 and forest ecosystems but, information regarding those under temperate fruit crops like peach, pear, apricot, lemon, plum etc., are very limited. The hypothesis of this experiment was that the different temperate fruit crops could have differential microbial activity in the rhizospheric soil (surface and sub-surface), influenced by management practice as well as quality of litter fall and root exudates. We assume that information produced from this study will help in understanding of microbial mediated nutrient dynamics and their management under temperate fruit crops in N-W hilly area.

Materials and Methods

This study was conducted at Hawalbagh experimental farm, ICAR-VPKAS, Almora, Uttarakhand, to reveal the effect of various fruit trees *viz*. Plum, Pear, Lemon and Apricot vis-à-vis control (without fruit tree) on different soil enzymatic activities such as, dehydrogenase, beta-glucosidase, phosphomonoesterase (acid and alkaline phosphatase) and urease under soybean-wheat cropping system. . Soil samples were collected randomly from the field at two depths: surface (0-15 cm) and subsurface (15-30 cm) and two different distances from trees (0-1 and 1-2 m) of four temperate fruit crops. A total of 500 gm composite soil samples were collected, sieved (2 mm mesh) to remove plant tissues and then placed in labeled plastic bags and kept at 4°C until further analysis.

Results and Discussion

In our study it was observed that all fruit crops significantly influenced soil enzymatic activities as compared to open conditions under both soil layers and sampling distance from trees. Data showed the significantly higher dehydrogenase activity was recorded under the plum plantation (68.84 and 56.89 g TPF g $soil^{-1}$ h^{-1} at 0-1 and 1-2 m radius, respectively), however, in control plot was found the significantly lower dehydrogenase (45.95 □ g TPF g $soil^{1}$ h^{-1}) activity in the surface soil. Similarly other enzyme activities also followed the same trend as like dehydrogenase, except urease enzyme activity which was presented in table 1 and 2. In case of urease activity significantly higher was recorded under lemon plantation (398.4 and 397.8 mg urea g $soil^{-1}$ hr^{1} at 0-1 and 1-2 m radius) followed by control (398.3 mg urea g $soil^{-1}$ hr^{-1}), respectively. All enzymatic activities in 15-30 cm soil layer followed the similar trend as surface soil. All the enzymatic activities sharply declined (2-3 fold) at sub-surface soil layer (15-30 cm) as compared to surface soil layer and simultaneously decrease with increase the distance from trees.

Table 1: Different soil enzyme activities in the fruit based agri-horti system of different fruit crops, at surface soil (0-15 cm)

Land use	Radius (m)	Acid phosphatase (mg PNP/g soil/hr)	Alkaline phosphatase (mg PNP/g soil/hr)	Dehydrogenase (µg TPF/g soil/hr)	Urease (mg urea/kg soil/hr)	Beta-glucosidase (mg PNG/g soil/hr)
Plum	0-1	444.72 ± 7.07^{a}	244.80 ± 5.40^{a}	68.84 ± 1.09^{a}	398.14 ± 0.04^{b}	451.71 ± 12.13^{a}
	1-2	369.24 ± 4.08^{c}	200.60 ± 8.02^{c}	56.89 ± 0.54^{b}	398.02 ± 0.04^{c}	395.37 ± 7.95^{b}
Pear	0-1	382.16 ± 11.56^{bc}	193.80 ± 5.40^{c}	55.70 ± 0.69^{b}	397.85 ± 0.04^{d}	411.89 ± 5.14^{b}
	1-2	274.72 ± 6.04^{f}	163.20 ± 7.72^{d}	45.53 ± 1.33^{e}	397.72 ± 0.04^{e}	368.17 ± 6.80^{c}
Lemon	0-1	363.80 ± 13.24^{cd}	157.76 ± 6.70^{d}	48.98 ± 1.00^{d}	398.44 ± 0.07^{a}	349.71 ± 5.83^{cd}
	1-2	224.40 ± 3.12^{g}	128.52 ± 2.04	38.76 ± 0.36^{f}	397.79 ± 0.02^{de}	330.29 ± 5.14^{d}
Apricot	0-1	396.44 ± 4.46^{b}	219.64 ± 3.60^{b}	52.13 ± 0.57^{c}	397.89 ± 0.03^{d}	391.49 ± 7.59^{b}
	1-2	298.52 ± 8.84^{e}	114.92 ± 1.80	37.63 ± 0.57^{f}	397.34 ± 0.02^{f}	333.20 ± 9.71^{d}
Open	0-1	344.08 ± 5.93^{d}	186.32 ± 2.96^{c}	45.95 ± 1.02^{e}	398.35 ± 0.05^{a}	331.26 ± 7.01^{d}

Data are presented as mean ± standard error (n = 3), Mean followed by similar latter within a column for a particular parameter are not significantly different (P <0.05) level of significance according to DMRT.

Table 2: Different soil enzyme activities in the fruit based agri-horti system of different fruit crops, at sub-surface soil (15-30 cm)

Land use	Radius (m)	Acid phosphates (mg PNP/g soil/hr)	Alkaline phosphates (mg PNP/g soil/hr)	Dehydrogenase (µg TPF/g soil/hr)	Urease (mg urea/kg soil/hr)	Beta-glucosidase (mg PNG/g soil/hr)
Plum	0-1	303.96 ± 5.40^{a}	135.32 ± 8.84^{a}	51.36 ± 0.73^{a}	397.87 ± 0.04^{c}	351.66 ± 4.23^{a}
	1-2	236.64 ± 9.35^{c}	134.64 ± 4.25^{a}	35.09 ± 0.84^{c}	397.58 ± 0.05^{de}	312.80 ± 4.86^{bc}
Pear	0-1	227.80 ± 6.49^{c}	102.00 ± 3.12^{bc}	43.22 ± 0.57^{b}	397.68 ± 0.03^{d}	328.34 ± 7.01^{b}
	1-2	173.40 ± 3.12^{d}	109.48 ± 5.57^{b}	33.82 ± 0.45^{c}	397.48 ± 0.02^{e}	270.06 ± 5.91^{d}
Lemon	0-1	261.12 ± 10.06^{b}	83.64 ± 4.71^{de}	35.37 ± 0.67^{c}	397.99 ± 0.03^{b}	306.00 ± 7.33^{c}
	1-2	129.20 ± 6.49^{e}	67.32 ± 8.49^{be}	25.56 ± 0.49^{d}	397.68 ± 0.03^{d}	213.71 ± 3.50^{f}
Apricot	0-1	176.12 ± 4.14^{d}	88.40 ± 4.14^{cd}	34.60 ± 0.68^{c}	397.51 ± 0.05^{e}	299.20 ± 2.57^{c}
	1-2	127.16 ± 5.31^{e}	76.84 ± 5.81^{de}	23.18 ± 0.21^{e}	397.16 ± 0.04^{f}	257.43 ± 4.23^{d}
Open	0-1	217.60 ± 9.52^{c}	104.04 ± 5.13^{bc}	24.97 ± 0.21^{d}	398.16 ± 0.06^{a}	234.11 ± 7.95^{e}

Data are presented as mean ± standard error (n = 3), Mean followed by similar latter within a column for a particular parameter are not significantly different (P <0.05) level of significance according to DMRT.

Conclusion

It can be concluded that enzyme activities were strongly influenced by the type of fruit crops in this region. The different response of enzyme activities between the fruit crops and control plot (open plantation) soils observed in this study. Despite deep rooted nature of these fruit crops, enzymatic activities declined with increase in soil depth as well as distance from plants. Among the four fruit trees in our experimental field, the soil enzymatic activities were significantly higher under plum followed by pear and apricot plantation.