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Correlation between physical, chemical and biological properties of soil under different land use systems

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Abstract
Present study was undertaken to study the correlation between physical, chemical and biological properties of soil under different land use systems. Study area was Norman E. Borlaug Crop Research Centre, G. B. Pant University, Pantnagar. The land use systems selected for study were rice–wheat–green gram, rice–pea (vegetable)-maize, rice-potato–okra, rice–berseem + oat + mustard (fodder)-maize + cowpea (fodder), maize–wheat–cowpea, sorghum (fodder)-yellow sarson-black gram, guava + lemon, poplar + turmeric, eucalyptus + turmeric and fallow (uncultivated land). Soil samples were taken from 0-20cm depth were analyzed for various physical, chemical and biological properties. Correlation among the various physical, chemical and biological properties of soil was worked out. It was concluded that there exist a significant correlation between different physical, chemical and biological properties of soil.

Keywords: Correlation, physical properties, chemical properties, biological properties, land use systems

Introduction
Soil a very diverse and complex system consists of mineral particles, organic matter, water and pore spaces. Mineral particles contain nutrients, released during weathering; organic matter and humus vary in quantities, resulting from the decomposition of biomass and minute pores are filled with air or water (IFOAM, 2002) [1]. Soils are characterized by a high degree of variability due to the interplay of physical, chemical, biological and anthropogenic processes that operate with different intensities at different scales (Goovaerts, 1998) [2]. These processes in turn influence the nature and properties of soil hence, knowledge of soil properties is important in determining the best use to which a soil may be put (Amusan *et al*., 2004) [3].
Correlation analysis provides a scientific basis for monitoring and controlling the soil fertility and ultimately soil health. Therefore, present study was undertaken to evaluate relationship between various physical, chemical and biological properties of soil.

Material and method
Present study was undertaken at Norman E. Borlaug Crop Research Centre, Pantnagar in Mollisol soil.
Five composite soil samples (0-20 cm depth) representing the whole area were collected randomly from different land use systems of the same block during kharif, 2017-18. These samples were analysed for different physical, chemical and biological properties and data was used to work out pearson correlation analysis.

Result and Discussion
Relationship between
1. Physical and chemical properties
Significant positive correlation existed between organic carbon and water holding capacity (r=0.946**), porosity(r=0.766*) and clay% (r=0.729*). On the other hand, soil organic carbon was inversely correlated with bulk density (r = -0.978**) and particle density (r= -0.966**). CEC showed significant positive correlation with clay content (r=0.699*) and soil organic carbon (r=0.993**) (Table 1) (Somasundaram *et al*., 2013) [4].
Positive correlations between organic carbon and different physical properties (WHC, porosity and clay) clearly indicates the importance of soil organic carbon in maintenance and improvement of physical soil health.

The inverse correlation between bulk density and particle density with organic carbon suggested the desirability of low bulk density and particle density which are considered good for plant growth. Organic matter makes the soil porous, loose and well aggregated therefore lowers bulk density. Patil and Prasad (2004) [5] were also of similar opinion.

2. Chemical and biological properties

Highly significant and positive correlation (r = 0.939**) between total soil phosphatase activity with the available phosphorus was observed under the study which indicated that dynamics of phosphorus in the soil is governed to a large extent by these enzymes (Table-2) (Debnath *et al*., 2015) [6].

The results showed that highly significant and positive correlation between organic carbon and dehydrogenase (r = 0.899**), total phosphatase (r = 0.958**), urease (r = 0.946**) and fungal count (0.931**) (Table 2). Radhakrishnan *et al.*, (2016) [7] also observed similar results. All kinds of enzymatic activities were found to be significantly correlated with soil organic carbon content (Debnath *et al*., 2015) [6].

3. Physical and biological properties

Results showed positive correlation between porosity and bacterial population (r = 0.798**), fungi population (r = 0.780**), actinomycetes population (r = 0.661**), *Azotobacter* population (r = 0.870**) and PSB population(r = 0.729**) (Table 3). The growth of microorganisms improved with increase in porosity (Collins, 2010) [8].

4. Others

Available micronutrients in soil are significantly and negatively correlated with the soil pH with r = -0.858** for Zn, r = -0.920** for Fe, r= -0.871**for Cu and r= -0.923** for Mn (Table-2). Similar results were also observed by Vijaykumar *et al.*, (2011) [9]. The micronutrients are more available within a pH range of 4 to 6. At higher pH these micronutrients are very tightly bound to the soil and are therefore more available at low pH level than high pH level (Havlin *et al.*, 2010) [10]. Soil pH was negatively correlated with available phosphorus (r = -0.878**) and available nitrogen (r = -0.889**) indicating that at higher pH, these nutrients are less available to the crops (Somasundaram *et al.*, 2013) [4].

Table 1: Relationship between the physical and chemical properties of soil.

	WHC	SILT%	CLAY%	BD	PD	POR.	pH	OC	CEC	N	P	K	S	Zn	Fe	Cu	Mn
WHC	1																
SILT	-0.919**	1															
CLAY	0.892**	-0.988**	1														
BD	-0.960**	0.822**	-0.776**	1													
PD	-0.899**	0.697*	-0.635*	0.961**	1												
POR.	-0.864**	-0.878**	0.882**	-0.837**	-0.657*	1											
pH	-0.785**	0.510	-0.431**	0.864**	0.913**	-0.566	1										
OC	0.946**	-0.786**	0.729*	-0.978**	-0.966**	0.766**	-0.914**	1									
CEC	0.933**	-0.752*	0.699*	-0.974**	-0.981**	0.732*	-0.910**	0.993**	1								
N	0.934**	-0.760*	0.709*	-0.982**	-0.987**	0.743*	-0.889**	0.983**	0.994**	1							
P	0.966**	-0.800**	0.770**	-0.955**	-0.940**	0.777**	-0.878**	0.959**	0.956**	0.951**	1						
K	0.951**	-0.811**	0.755	-0.967**	-0.956**	0.757*	-0.876**	0.988**	0.985**	0.977**	0.938**	1					
S	0.867**	-0.647*	0.590	-0.941**	-0.994**	0.616	-0.901**	0.951**	0.977**	0.982**	0.919**	0.941**	1				
Zn	0.978**	-0.835**	0.799**	-0.955**	-0.941**	0.775**	-0.858**	0.970**	0.971**	0.964**	0.978**	0.975**	0.924**	1			
Fe	0.840**	-0.618	0.546	-0.903**	-0.970**	0.568	-0.920**	0.942**	0.964**	0.961**	0.890**	0.933**	0.976**	0.917**	1		
Cu	0.787**	-0.627	0.554	-0.891**	-0.887**	0.668*	-0.871**	0.919**	0.904**	0.896**	0.836**	0.864**	0.882**	0.811**	0.875**	1	
Mn	0.854**	-0.620	0.561	-0.899**	-0.967**	0.554	-0.923**	0.946**	0.967**	0.950**	0.913**	0.943**	0.972**	0.934**	0.971**	0.840**	1

WHC – Water holding capacity, BD- bulk density, PD- particle density, POR.- porosity, OC- organic carbon, CEC- cation exchange capacity.
**correlation is significant at the $p \leq 0.01$ level
*correlation is significant at the $p \leq 0.05$ level

Table 2: Relationship between the chemical and biological properties of soil.

	OC	N	P	K	Zn	Fe	Cu	Mn	BAC	FUNG	ACT	AZO	PSB	DHA	TOTP	UR
OC	1															
N	0.983**	1														
P	0.959**	0.951**	1													
K	0.988**	0.977**	0.938**	1												
Zn	0.970**	0.964**	0.978**	0.975**	1											
Fe	0.942**	0.961**	0.890**	0.933**	0.917**	1										
Cu	0.919**	0.896**	0.836**	0.864**	0.811**	0.875**	1									
Mn	0.946**	0.950**	0.913**	0.943**	0.934**	0.971**	0.840**	1								
BAC	0.984**	0.986**	0.934**	0.970**	0.947**	0.941**	0.922**	0.915**	1							
FUNG	0.931**	0.956**	0.933**	0.900**	0.905**	0.891**	0.880**	0.865**	0.966**	1						
ACT	0.857**	0.881**	0.805**	0.869**	0.822**	0.854**	0.757**	0.799**	0.886**	0.862**	1					
AZO	0.931**	0.924**	0.939**	0.923**	0.935**	0.831**	0.798**	0.847**	0.945**	0.953**	0.830**	1				
PSB	0.974**	0.992**	0.924**	0.975**	0.943**	0.956**	0.884**	0.943**	0.983**	0.947**	0.920**	0.920**	1			
DHA	0.899**	0.925**	0.808**	0.898**	0.835**	0.872**	0.873**	0.828**	0.950**	0.927**	0.850**	0.892**	0.934**	1		
TOTP	0.958**	0.968**	0.939**	0.981**	0.975**	0.911**	0.783**	0.934**	0.948**	0.906**	0.874**	0.940**	0.970**	0.877**	1	
UR	0.946**	0.961**	0.892**	0.918**	0.896**	0.986**	0.921**	0.960**	0.951**	0.917**	0.844**	0.841**	0.958**	0.881**	0.893**	1

OC- organic carbon, BAC- bacteria, FUNG- fungi, ACT- actinomycetes, AZO- azotobacter, PSB- phosphate solubilising bacteria, DHA- dehydrogenase enzyme, TOTP- total phosphatase, UR- urease.
**correlation is significant at the $p \leq 0.01$ level
*correlation is significant at the $p \leq 0.05$ level

Table 3: Relationship between the physical and biological properties of soil.

	POR	WHC	BAC	FUNG	ACT	AZO	PSB	DHA	TOTP	UR
POR	1									
WHC	0.864**	1								
BAC	0.798**	0.930**	1							
FUNG	0.780**	0.903**	0.966**	1						
ACT	0.661	0.803**	0.886**	0.862**	1					
AZO	0.870**	0.952**	0.945**	0.953**	0.830**	1				
PSB	0.729*	0.909**	0.983**	0.947**	0.920**	0.920**	1			
DHA	0.745*	0.835**	0.950**	0.927**	0.850**	0.892**	0.934**	1		
TOTP	0.762*	0.951**	0.948**	0.906**	0.874**	0.940**	0.970**	0.877**	1	
UR	0.596	0.822**	0.951**	0.917**	0.844**	0.841**	0.958**	0.881**	0.893**	1

POR.- porosity, WHC – Water holding capacity, BAC- bacteria, FUNG- fungi, ACT- actinomycetes, AZO- azotobacter, PSB- phosphate solubilising bacteria, DHA- dehydrogenase enzyme, TOTP- total phosphatase, UR- urease.

**correlation is significant at the $p \leq 0.01$ level

*correlation is significant at the $p \leq 0.05$ level

A significant positive relationship between organic carbon and both macronutrients, and micronutrients (r= 0.983**, r= 0.959**, r= 0.988**, r= 0.951**, r= 0.970**, r= 0.942**, r= 0.946** and r= 0.919** for available N, available P, available K, available S, available Zn, available Fe, available Mn and available Cu respectively (Table-2). Similar results were also reported by Patel *et al*., (2014) [11] and Verma *et al*., (2008) [12]. The reason for high micronutrients availability with increase in soil organic carbon might be due to the ability of organic matter to form chelates and thus increase its availability. Among the various soil fertility parameters available N, available P and available K showed strong positive correlation with soil organic carbon. Higher correlation between soil organic carbon and nitrogen was also reported by Cao *et al*., (2012) [13] and Somasundaram *et al*., (2013) [4].

Conclusion

Correlation study revealed that there exist a significant positive relationship between organic carbon and macronutrients, micronutrients, enzymes, total microbial count, WHC and clay percent. However, BD and PD were inversely correlated with organic carbon. Micronutrients in the soil were significantly and negatively correlated with the soil pH.

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