



P-ISSN: 2349-8528

E-ISSN: 2321-4902

www.chemijournal.com

IJCS 2020; 8(2): 1136-1140

© 2020 IJCS

Received: 04-01-2020

Accepted: 08-02-2020

Vivek Kumar

Department of Soil Science, Dr.
Rajendra Prasad Central
Agricultural University, Pusa,
Bihar, Dholi Campus,
Muzaffarpur, Bihar, India

Sanjay Kumar Singh

Department of Soil Science, Dr.
Rajendra Prasad Central
Agricultural University, Pusa,
Bihar, Dholi Campus,
Muzaffarpur, Bihar, India

Pankaj Singh

Department of Soil Science, Dr.
Rajendra Prasad Central
Agricultural University, Pusa,
Bihar, India

Sanjay Tiwari

Department of Soil Science, Dr.
Rajendra Prasad Central
Agricultural University, Pusa,
Bihar, India

Corresponding Author:**Sanjay Kumar Singh**

Department of Soil Science, Dr.
Rajendra Prasad Central
Agricultural University, Pusa,
Bihar, Dholi Campus,
Muzaffarpur, Bihar, India

Effects of long-term practices of different cropping systems on Physico-chemical parameters of soil quality

Vivek Kumar, Sanjay Kumar Singh, Pankaj Singh and Sanjay Tiwari

DOI: <https://doi.org/10.22271/chemi.2020.v8.i2r.8921>

Abstract

The long-term inclusion of pulses in cropping systems improved the soil fertility, subsequently increased the crop nutrient acquisition and crop productivity. The present research work carried out during 2017-18 at research farm of Tirhut College of Agriculture, Dholi, Muzaffarpur. In the college premises, the various types of types of cropping pattern has been adopted on same piece of land since last more than five years with normal cultivation practices. Soil samples were collected from each treatment (cropping system) at harvesting of crops after completion of one cropping cycle for the analysis of soil Physico-chemical properties. The lowest soil pH exhibited in rice-wheat cropping system followed by pigeon pea cropping system might be attributed to submergence of soil during rice cultivation and greater amount of leaf litters fall throughout crop life cycle in pigeonpea field. The lower value of bulk density (1.21 Mg m^{-3}) and (1.24 Mg m^{-3}) was recorded with mustard mungbean and pigeon pea cropping system. The reduction in bulk density may be attributed to the higher soil organic carbon due to more addition of roots and plant biomass as compared to the fallow land. The variability in Cation Exchange Capacity was ranged from 16.66 to 28.62 ($\text{Cmol (P}^+ \text{ kg}^{-1})$). Mean weight diameter in different treatment varied from 2.51mm to 4.49mm and the highest MWD was recorded in pigeonpea cropping system whereas; the lowest was noticed in fallow lands.

Keywords: Soil organic carbon, mean weight diameter, carbon stock, calcareous soil

Introduction

The land use pattern for different crops and soil management practices influence the soil nutrients and related soil processes, such as erosion, oxidation, mineralization and leaching etc. (Celik, 2005; Liu *et al.*, 2010) [4, 9]. However, practice of particular type of cropping system for many years on same piece of land which leads variation in soil fertility. Continuous practice of cereal-cereal rotations in the Indo-Gangatic Plains of India has caused nutrient imbalance, soil degradation, and the intensification of pest pressure (Ladha *et al.*, 2003; Chauhan *et al.*, 2012) [8, 5]. The long-term inclusion of pulses in maize-wheat rotation improved the soil fertility, subsequently increased the crop nutrient acquisition and crop productivity (Venkatesh *et al.*, 2012) [17].

Increases in both OM quality and quantity can have beneficial effects on soil quality because OM is related to aggregation, soil structure, soil strength and water infiltration and availability for crop production (Doran and Parkin, 1994) [6]. Soil quality considers those attributes of soil that may be influenced by management practices and have the capability to enhance or diminish the soil health. In recent years, soil quality has become a major concern of developing country, where the intensification of production has become widespread.

The cropping system can incorporate higher biomass as per crops, changes in soil OM, nutrient cycling, and C sequestration for soils (Acosta-Martínez, 2011) [1]. The microbial community structure in processing tomato soils changed with extended cropping, resulting to a decline in a soil microbial biomass, which may be cause and a reflection of the poor soil quality. Microbial biomass and enzymatic activities of soils are being evaluated increasingly as sensitive indicators of soil health because of the clear relationships between microbial diversity, soil and plant quality, and ecosystem sustainability (Doran *et al.*, 1994) [6]. In non-cultivated land, the type of vegetative cover is a factor influencing the soil organic carbon content (Liu *et al.*, 2010) [9].

A better understanding of the impact of continuous cropping systems on physical, chemical and biological soil properties is essential for the quantification of soil quality impact and thereby enhancing the cropping system sustainability (Aparicio and Costa, 2007) [2]. An evaluation of individual physical, chemical and biological properties of soil is one of the ways of studying the impact of cropping systems on soil quality. These studies have shown that the fertility status of soil on different cropping pattern with management of inputs can bring changes in the physical, chemical and biological properties of soil (Singer and Ewing, 2000) [14].

Bulk density (BD) is a major factor in soil compaction and will obviously be changed almost immediately following tillage-induced soil disturbance. Intense operation of heavy machinery and implements in the field causes soil compaction which may increase bulk density and reduce the transportation of water and air through the soil. Soil aggregates are also an important physical character which helps to facilitate a good soil structure. Improved soil management may enhance the activities of soil flora and fauna, including decomposition of organic residues, assimilation and release of plant nutrients, creation of biopores, and production of compounds in soil thought to enhance aggregate. Since, past many years, no data had been generated with respect to fertility status on different cropping system in this region. Therefore, it current needs to generate accurate information regarding soil fertility status. Considering the above facts, the present study was aimed to evaluate the nutrients status of soil under different cropping systems being practiced for last five or more than five years on calcareous soils. This study may be helped in the selection of cropping system for a given environment in terms of

sustainability.

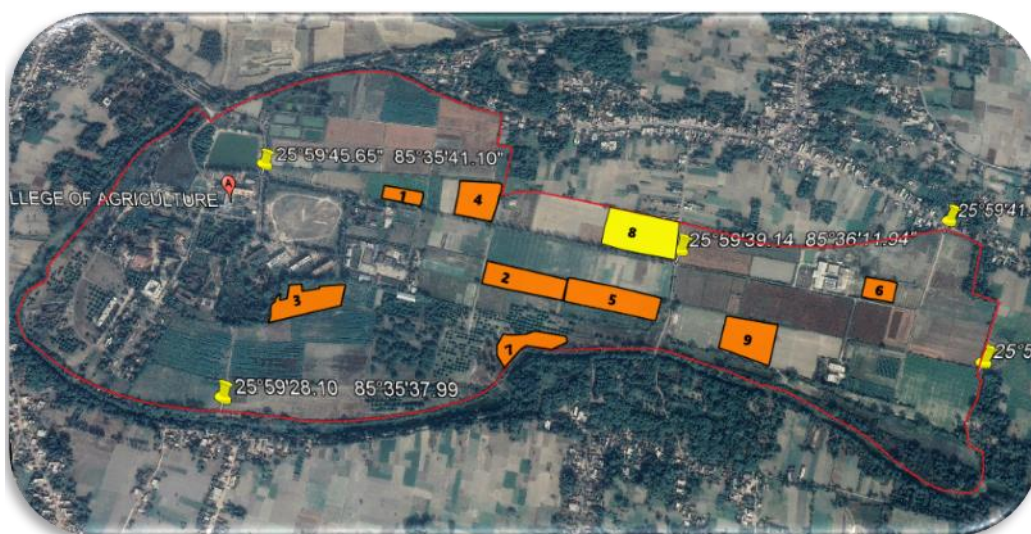
Materials and Methods

The present investigation was carried out during 2017-18 at research farm of Tirhut College of Agriculture, Dholi, Muzaffarpur a campus of Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar. In the college premises different types of cropping pattern has been adopted on same piece of land since last more than five years. Each crop was grown with normal irrigation practices and recommended dose of fertilizer. The Dholi campus is situated on the southern bank of the river *Burhi Gandak* at an elevation of 52.18 meter above mean sea level and intersected by 25.98°N latitude and 85.60°E longitude. It has semi- arid, sub-tropical climate with hot dry summer, moderate rainfall and cool winter season. The research sites representing upland and fairly uniform in topography and the soil was deep, well drained and calcareous alluvium soil, mostly alkaline in reaction, developed on the sediments of the river *Burhi Gandak* mainly by the deposition of the sediment through the ages.

The soil samples were collected from each treatment (cropping system) at the end of Rabi season (Mid April to Mid-May, 2018) after completion of one cropping cycle for the analysis of soil physico-chemical properties. Each cropping systems were represented by three plots with area 5 x 5 m. and the total of 27 (9 cropping system x 3 plots) samples were collected in replications then it brought into laboratory for analysis. Soil samples were air dried, crushed with wood mortar on wooden plank and pass through 2 mm sieve.

Table 1: The geographic coordinates of nine locations under cropping system.

S. No.	Treatments	Cropping systems	Latitude	Longitude	Range
1.	T ₁	Onion-garlic	25°59'44.73"N	85°35'50.86"E	366m
2.	T ₂	Tuber-Moongbean	25°59'39.55"N	85°36'03.28"E	829m
3.	T ₃	Pigeon Pea	25°59'35.68"N	85°35'43.19"E	365m
4.	T ₄	Rice-Potato	25°59'43.58"N	85°35'43.29"E	853m
5.	T ₅	Mustard-Mungbean	25°59'37.67"N	85°36'80.48"E	1083m
6.	T ₆	Turmeric-Mungbean	25°59'36.65"N	85°36'27.94"E	828m
7.	T ₇	Fallow land	25°59'30.59"N	85°35'57.36"E	2785m
8.	T ₈	Rice-Wheat	25°59'41.53"N	85°36'80.43"E	1428m
9.	T ₉	Maize-Maize	25°59'33.83"N	85°36'14.29"E	1080m



Map 1: Map of the study locations under different cropping systems.

The processed soil samples were taken for analysis of soil parameters used prescribed standard parameters (Jackson, 1973)^[7].

The soil organic stock was calculated by soil organic carbon (%) x bulk density (Mg m^{-3}) x depth (cm) expressed in t ha^{-1} . Mean Weight Diameter (MWD) was estimated by Van Bavel 1949 using following formula:

$$\text{MWD} = \sum x_i w_i$$

Where, w_i is the proportion of each aggregate class in relation to whole soil, and x_i is the mean diameter of the class (mm).

The analysis of variance (ANOVA) enunciated by Fisher (1938) was followed to calculate the nature and magnitude of treatment effects revealed by 'F'-test.

Results and Discussion

The fig.-1 & 2 indicated that the effect of different cropping systems on soil pH variability in soils of surface layer ranged from 7.79 to 8.79 whereas, in sub surface, soil at 15-30cm was recorded highest 8.81 and lowest 7.85 under different cropping systems. The lowest soil pH exhibited in rice-wheat cropping system followed by pigeon pea cropping system might be attributed to submergence of soil during rice cultivation and greater amount of leaf litters fall throughout crop life cycle in pigeon pea field. The percentage decrement in soil pH was noticed in rice-wheat (12.84%) and pigeon-pea cropping system (11.54%) over maize-maize cropping system obtained highest pH (8.79). Similar finding related to the soil pH also reported by Trehan *et al.*, (2001)^[16] under different cropping system found statistically significant.

The effect of cropping system on electrical conductivity (dSm^{-1}) at 5% level depicted in fig 1 & 2. The variability in electrical conductivity ranged from 2.54 to 1.16 dSm^{-1} and 1.14 to 2.37 dSm^{-1} salt concentration at 0-15cm and 15-30cm soil depth indicated in pigeon pea cropping system, whereas, it was found higher in rice-potato cropping system at surface soil and onion and potato in sub-surface soil. The soil and crop management practices and organic matter content may influence the variability in salts concentration. The salt content noticed decreasing in trend with increasing of soil depth depicted in fig 1 & 2. The concentration of total soluble salts showed optimum in range i.e. less than 2 dSm^{-1} in all cropping systems except onion-garlic cropping system. The variation in electrical conductivity influenced with cropping

system and it was statistically found significant.

Similarly, the amount of organic carbon content under different cropping systems ranged from 0.33 to 0.63% at 0-15cm soil depth reflected in the fig 1 & 2. The highest organic carbon (0.63%) was associated with pigeon pea cropping system followed by mustard moongbean (0.62%), pigeon pea (0.61%) and rice-wheat (0.55%) respectively at surface soil layer. The legume based cropping system contributing more organic matter scoring good quality of soil irrespective of soil organic carbon. The lowest organic carbon (0.33%) was observed with fallow land. The distribution of soil organic matter reported decline with the soil depth and found comparatively less as compared to surface soil. The mean value of organic carbon under cropping system obtained 0.5% and it was in order pigeon pea > mustard-moongbean > maize-maize > rice-wheat > turmeric-moongbean > onion-garlic > tuber-moongbean > rice-potato > fallow land respectively in surface soil layer.

In legume based cropping system particularly pigeon pea based system, the fallen leaves and root mass undergo decompose and improve the soil structure through enrichment of the organic content (Singh *et al.* 2012)^[15]. The inclusion of leguminous crops in cereals based cropping system promoted favourable chemical indicators (Porpavai *et al.* 2011)^[11].

Fig. 1 & 2 revealed that irrespective of carbon stock in different cropping systems varied from 6.98 to 11.95 t ha^{-1} and 4.89 to 10.81 t ha^{-1} in surface and sub-surface soil layer under different cropping systems. Among the cropping systems, a higher carbon stock was found in the surface and sub-surface soil layer in maize-maize cropping system followed by pigeon pea whereas, the lowest carbon stock was noticed in fallow lands. The variability in carbon stock depends upon the organic carbon and bulk density.

In the study, the bulk density was recorded greater in the fallow land than the rest of the cropping system as noticed decreased in manner. It was observed decline in surface soil depth as compared to sub-surface soil depth. The lower value of bulk density (1.21 Mg m^{-3}) and (1.24 Mg m^{-3}) was recorded with mustard mungbean and pigeon pea cropping system followed by 1.31 Mg cm^{-3} associated with tuber mongbean, rice-potato and maize-maize cropping systems shown in fig. 1 & 2. The reduction in bulk density may be attributed to the higher soil organic carbon due to more addition of roots and plant biomass as compared to the fallow land. Similar finding was also obtained by (Brar *et al.* 2015)^[3].

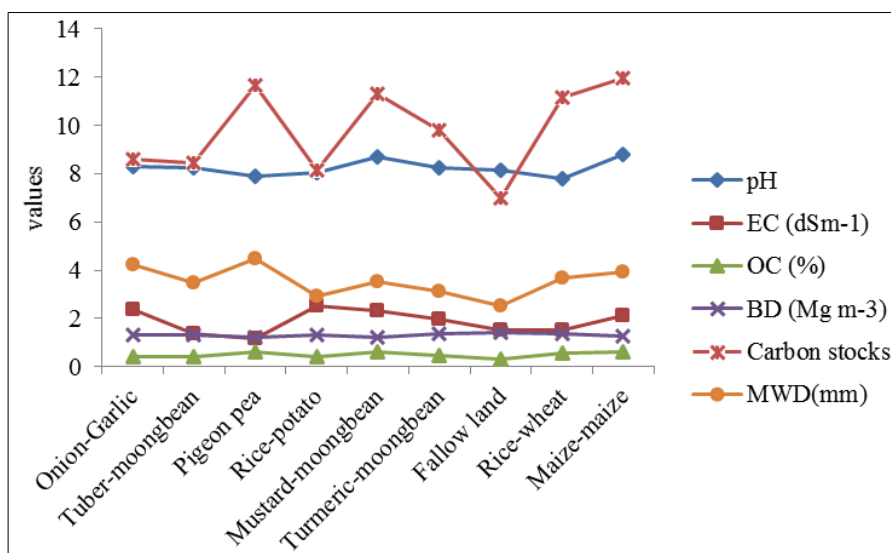


Fig 1: Effect of cropping system on soil properties at 0-15cm depth

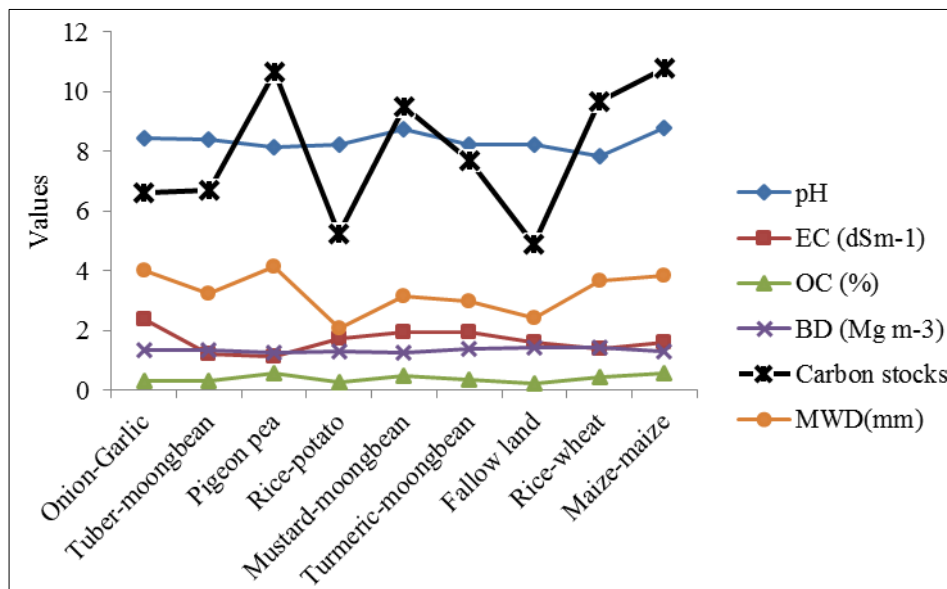


Fig 2: Effect of cropping system on soil properties at 15-30cm depth

The observations on Cation Exchange Capacity ($\text{Cmol (P}^+\text{ kg}^{-1}\text{)}$) showed in fig. 3 & 4. The variability in Cation Exchange Capacity was ranged from 16.66 to 28.62 ($\text{Cmol (P}^+\text{ kg}^{-1}\text{)}$) in which mustard moong bean system recorded higher cation exchange capacity ($\text{Cmol P}^+\text{ kg}^{-1}\text{}$) than other systems as because leading to higher organic matter in this cropping system. However, the lowest cation exchange capacity ($\text{Cmol (P}^+\text{ kg}^{-1}\text{)}$) was noticed in fallow land. This resulted in high variability of cation exchange capacity ($\text{Cmol P}^+\text{ kg}^{-1}\text{}$) among the cropping systems may be attributed to organic carbon content. Regular additions of organic materials to soil are required to improve and maintain SOC pools as well as to help in increasing nutrient cycle, cation exchange capacity

(CEC), aggregate stability and biological activity for sustainable crop production (Singh, *et al.* 2010).

This study revealed that the maximum water holding capacity (42.20%) was recorded in soils of pigeon pea cropping system in the surface layer and 40.36% was recorded in sub-surface layer however, the minimum (36.46%) and (35.61%) was noticed in fallow land at both the soil depth. Observations on different cropping systems indicated that out of which only three cropping system *viz.* tuber moong-bean, onion garlic and fallow lands contained less than 40% maximum water holding capacity in the surface (0-15cm) soil. The maximum water holding capacity found in pigeonpea cropping system as because soil contained greater amount of organic matter which hold the water.

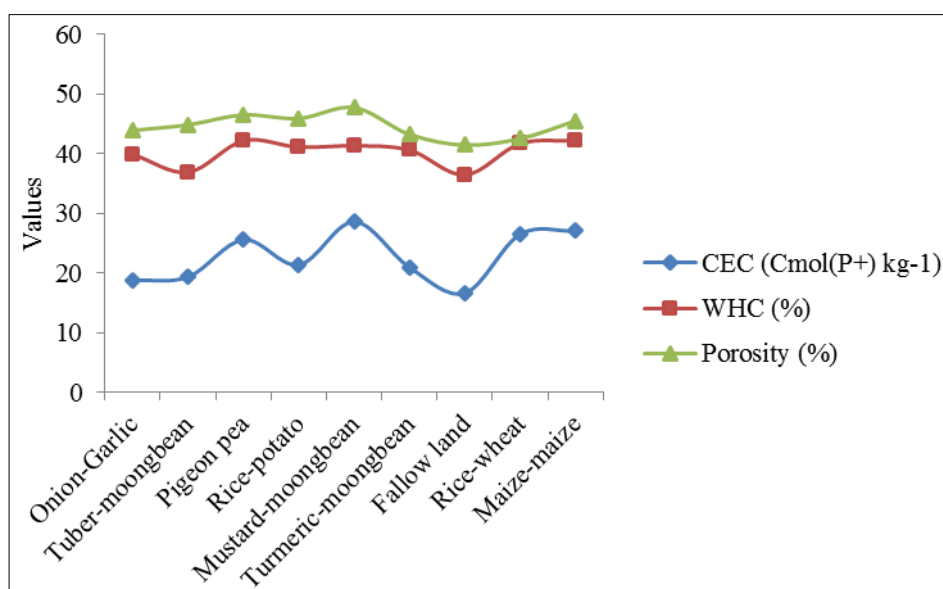


Fig 3: Effect of cropping system on soil properties at 0-15cm depth

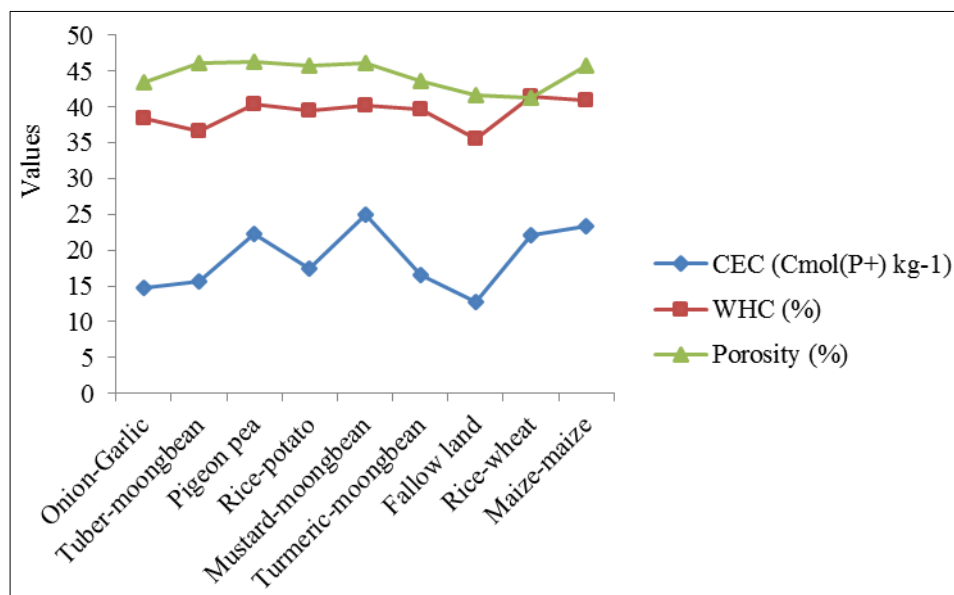


Fig 4: Effect of cropping system on soil properties at 15-30cm depth

The variation in porosity under different cropping system was ranges from 41.485 to 47.76% in surface layer, whereas, 41.32 to 46.2% was recorded in sub-surface soil. The mean weight diameter (MWD) values under different cropping system. Mean weight diameter in different treatment varied from 2.51mm to 4.49mm. The highest MWD was recorded in pigeonpea cropping system whereas; the lowest was noticed in fallow lands depicted in 1 & 2. This implies that this cropping system do not deteriorate the soil quality. Increases in macro-aggregate were associated with linear increases in carbon content of the aggregates (Shaver *et al.* 2003) ^[13]. The high organic matter deposition in pigeonpea cropping system by plant biomass leads to increase the mean weight diameter. Similar observation was also reported by Rehana *et al.*, (2007) ^[12].

References

- Acosta-Martínez V, Lascano R, Calderón F, Jill D, Booker Ted M, Zobeck Dan R *et al.* Dryland cropping systems influence the microbial biomass and enzyme activities in a semiarid sandy soil. *Biology and Fertility of Soils*. 2011; 47:655-677.
- Aparicio V, Costa JL. Soil quality indicators under continuous cropping system in the Argentinean pampas. *Soil and Tillage Research*. 2007; 96:155-165.
- Brar BS, Dheri GS, Lal R, Singh K, Walia S. Cropping system impacts on carbon fractions and accretion in typicustochrept soil of Punjab, India. *Journal of Crop Improvement*. 2015; 29:281-300.
- Celik I. Land-use effects on organic matter and physical properties of soil in a southern Mediterranean highland of Turkey. *Soil Tillage Res*. 2005; 83:270-277.
- Chauhan BS, Mahajan G, Sardana V, Timsina JML. Productivity and sustainability of rice-wheat cropping system in the Indo-Gangetic Plains of the Indian sub-continent: problems, opportunities, and strategies. *Advance Agronomy*. 2012; 117:315-369.
- Doran JW, Parkin TB. Quantitative indicators of soil quality. *Soil Science Society of America*. 1994; 49:25-37.
- Jackson ML. *oil Chemical Analysis*. New Delhi, Prentice Hall, 1973, 48-302.
- Ladha JK, Pathak H, Tirol-Padre A, Dawe D, Gupta RK. Productivity trends in intensive rice-wheat cropping system: issues and impact. Madison, Wisconsin: USA: Aronomy series ASA-CSSA-SSSA Publishers, 2003, 45-76.
- Liu XL, He YQ, Zhang HL, Schroder JK, Li CL, Zhou J, Zhang Z. Impact of land use and soil fertility on Distributions of soil aggregate fractions and some nutrients. *Pedosphere*. 2010; 20:666-673.
- Motschenbacher JM, Brye KR, Anders MM. Soil bulk density as affected by rice-based cropping systems. *BR Wells Rice Research Series Arkansas Agricultural Experiment Station University of Arkansas*. 2011; 591:201-207.
- Porpavai S, Devasenapathy P, Siddeswaran K, Jayaraj T. Impact of various rice-based cropping systems on soil fertility. *Journal of cereals and oilseeds*. 2011; 2:43-46.
- Rehana R, Kukal SS, Hira GS. Soil physical fertility and crop performance as affected by long term application of FYM and inorganic fertilizers in rice-wheat system. *Soil and Tillage Research*. 2007; 96:64-72.
- Shaver TM, Peterson GA, Sherrod LA. Cropping intensification in dryland systems improves soil physical properties: regression relations. *Geoderma*. 2003; 116:149-164.
- Singer MJ, Ewing S. *Soil Quality*. In *Handbook of Soil Science* (Ed.-in-chief M.E. Sumner). Boca Raton, FL: CRC press. 2000.
- Singh A, Singh VK, Chandra R, Srivastava PC. Effect of integrated nutrient management on pigeon pea-based intercropping system and soil properties in mollisols of the Tarai region. *Journal of the Indian Society of Soil Science*. 2012; 60:38-44.
- Trehan SP, Sharma RC, Sharma HC. Long term effect of potato based systems, fertilizers and manures on properties of alluvial soil of Punjab. *Journal of the Indian Potato Association*. 2001; 28:207-215.
- Venkatesh MS, Hazra KK, Ghosh PK, Praharaj CS, Kumar N. Long-term effect of pulses and nutrient management on soil carbon sequestration in Indo-Gangetic plains of India. *Canadian Journal of Soil Science*. 2012; 93:127-136.