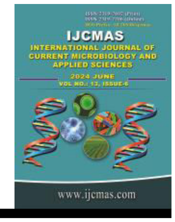
Int.J.Curr.Microbiol.App.Sci (2024) 13(06): 228-239

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 Volume 13 Number 6 (2024)
Journal homepage: http://www.ijcmas.com



Case Study https://doi.org/10.20546/ijcmas.2024.1306.024

A Case Study on Soil Health Assessment Under Different Annual and Perennial Cropping System

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A B S T R A C T

A field experiment was conducted on agriculture field located 2km away from NH-24 Delhi-Lucknow highway near Invertis village from Invertis university Bareilly (Uttar Pradesh). The experiment was conducted in a random manner with different combinations of organic and inorganic nutrients to know the effect of morphological characteristics, physical properties, chemical properties present in soil. At 0-15 cm depth the soil moisture content of soil in top layer was not affected significantly due to different cropping systems. However, the highest soil moisture content was recorded under guvava orchard. The maximum bulk density was recorded with cropping system Rice-wheat which remain at par with Rice-Berseem+Mustard and rice-sugarcane-ratoon-wheat. At 0-15 cm soil depth maximum porosity was recorded under the Guvava orchard which was found significantly at par with popular plantation. The lowest value of maximum porosity was found with grassland cropping system. At 15-30 cm depth the maximum porosity was recorded guvava orchard. The highest pH value was recorded under guvava orchard. The highest organic carbon was recorded under guvava orchard at both 0-15 and 15-30 cm soil depth. The maximum available nitrogen was recorded with guvava orchard at both 0-15 and 15-30 cm soil depth. At 0-15 cm soil depth the available potassium was influenced significantly due to various cropping systems. At 0-15 cm soil depth agricultural treatment CS_6 which was found statistically at par with guvava orchard and both were found to be comparable to each other. At 15-30 cm soil depth the available phosphorus among all the system was found comparable to each other. The highest available phosphorus was obtained with the agricultural (CS_6) which was followed by the popular plantation (CS_4). At 0-15 cm depth, the available sulphur was influenced significantly due to various cropping systems. The maximum available sulphur was recorded under the system guvava orchard CS_3 which was higher than rest of the treatments. At 15-30 cm soil depth, the available sulphur was affected significantly due to various cropping systems. The maximum value of available sulphur was obtained with the system Guava orchard (CS_3). Agricultural (CS_6) which remained at par with guvava orchard (CS_3) and both these treatments were found significantly superior over the rest of the systems.

Keywords

Orchard, guvava, cropping system, STCR, ratoon, bulk density, popular plantation

Article Info

Received: 29 April 2024
Accepted: 31 May 2024
Available Online: 10 June 2024

Introduction

Soil is a dynamic, living, natural body that represents a unique balance between physical, chemical and biological factors. Soils form slowly, averaging 100 to 400 years per centimeter of topsoil, through the interaction of climate, topography, vegetation and mineral parent material over time (Jenny, 1984; Lal, 1994).

The major components of soil include inorganic minerals and sand, silt and clay particles, reactive and stable forms of organic matter. Soil health or soil quality is defined as the ability of a specific kind of soil to function within a natural ecosystem boundary to support plant and animal productivity, maintain or enhance water or air quality, and provide support to human health and habitation (Karlen *et al.,* 1997). Soil serves as a medium for plant growth by providing physical support, water, essential nutrients, and oxygen for roots. Suitability of soil for sustaining plant growth and biological activity is a function of physical properties (porosity, water holding capacity, structure and tilth) and chemical properties (nutrient supplying ability, pH, salt content, etc.,) many of which are a function of soil organic matter content. Soil plays a key role in decomposing organic wastes and detoxifying certain hazardous compounds. The key role played by soils in recycling organic materials into CO and water and degrading synthetic compounds foreign to the soil is brought about by microbial decomposition and chemical reactions. Ability of a soil to store and transmit water is a major factor controlling water availability to plants and transport of environmental pollutants to surface and ground water. Monocropping is a highly nutrient exhaustive system and its continuous use has depleted inherent soil fertility, causing deficiency of several nutrients. The application of chemical fertilizers either in excess or less than optimum rates affects both yield and quality of crops to a greater extent (Meena *et al.,* 2003). Soil acidity is another factor which causes soil fertility problems such as Aluminium (Al) and Manganese (Mn) toxicity, calcium (Ca) and Magnesium (Mg) deficiency and low molybdenum (Mo) and phosphorus (P) availability highlighted the detrimental effects of soil acidity to plants and soil organisms.

Activities of soil organisms are reduced leading to the inhibition of biological nitrogen fixation (BNF) by legumes and decomposition of organic matter. Low pH may also result in the deficiency of Ca and Mg in soils. Soil acidification is a natural process, but it does also occur under managed ecosystems. Regular fertilizer use is one of the major causes of soil acidification under managed ecosystems. Fertilizer caused soil acidification occurs due to long term use of acidifying fertilizer such as urea and diammonium phosphate coupled with continuous monoculture. Maintenance and improvement of soil health in continuous land use systems are especially important to sustain agriculture productivity for the future which are not only helpful to the farming community in providing assured income but also protect the land from its degradation. A better understanding of the impact of continuous cropping system on chemical, physical and biological properties of soil is essential for evaluation of soil quality and thereby enhancing sustainability (Aparicio and Coasta, 2007).

Materials and Methods

A field experiment was conducted during spring 2019-20 in an agriculture field located 2 km from NH-24 Delhi-Lucknow highway near Invertis village from Invertis University Bareilly (Uttar Pradesh). Soil sample were collected from different cropping pattern system (rice, wheat, mustard, sugarcane, potato). The soil sample were collected from zig-zag type with khurpi (v shape) from 0-15 cm depth and 15-30 cm soil depth and 12 samples core borers than the texture of the soil sample was taken in polythene bags and were brought to the laboratory for chemical analysis. All the 42 soil samples were predominantly alluvial soils. The soil colour hue, value and chroma were measured using Munsell soil colour chart, and soil was further analysed for the physical, chemical and biological analysis in the soil science laboratory.

Results and Discussion

The highest soil moisture content (%) at saturation was recorded with guvava orchard at 0-15 cm soil depth and 15-30 cm soil depth. This could be attributed to finer and more matted network of root system found in guvava orchard as compared to other plantations.

The highest amount of bulk density was found in grassland cropping system as compared to other cropping system both at 0-15 cm and 15-30 cm soil depth. This could be attributed due to more extensive root system found and in grasses as compared to other cropping system.

Table.1 Different physical, chemical and biological properties analyzed during experiment**.**

<table>
<tr><th>S. No.</th><th>Characteristics analyzed</th><th colspan="7">Name of the property analyzed</th><th colspan="5">Reference</th></tr>
<tr><td>1.</td><td>Morphological characteristics</td><td colspan="7">Soil colour</td><td colspan="5">Munsell soil colour chart</td></tr>
<tr><td>2.</td><td>Physical Properties</td><td colspan="7">Mechanical analysis</td><td colspan="5">Bouycous (1997).</td></tr>
<tr><td></td><td></td><td colspan="5">Bulk density</td><td>Porosity</td><td>Soil moisture</td><td>Black (1965) for bulk density</td><td colspan="4">Saha (2004) for porosity.</td></tr>
<tr><td>3.</td><td>Chemical properties</td><td>Soil pH</td><td>Electrical conductivity</td><td>Organic carbon</td><td>Available nitrogen</td><td>Available phosphorus</td><td>Available potassium</td><td>Cation exchange capacity</td><td>Jackson (1967) for soil pH.</td><td>Jackson (1967) for EC</td><td>Subbiah et al., (1965) for available nitrogen</td><td>Muhr et al., (1965) for available potassium.</td><td>Black (1965) for CEC.</td></tr>
<tr><td>4.</td><td>Biological properties</td><td colspan="3">Basal soil respiration rates</td><td colspan="4">Microbial biomass carbon</td><td colspan="2">Anderson, (1982) for Basal soil respiration study</td><td colspan="3">Jenkson et al., (1976) for Microbial biomass carbon</td></tr>
</table>

Table.2 Effect of different cropping systems on soil moisture content (%) at saturation at different soil depth.

S. No.	Treatments	Soil depth	
	Cropping system	**0-15 cm**	**15-30 cm.**
CS 1.	Grassland	44.23	42.90
CS 2.	Mango Orchard	52.93	47.06
CS 3.	Guvava Orchard	57.80	52.83
CS 4.	Popular plantation	53.46	51.50
CS 5.	Agroforestry mixed plantation	48.90	46.76
CS 6.	Agricultural	45.86	44.40
	Sem+	2.210	2.568
	C.D. at 5%	7.054	-

Table.3 Effect of different cropping systems on bulk density (g/cc) at different soil depth.

S. No.	Treatments	Soil depth	
	Cropping system	**0-15 cm**	**15-30 cm**
CS 1	Grassland	1.413	**1.490**
CS 2	Mango Orchard	1.293	**1.367**
CS 3	Guvava orchard	1.253	**1.327**
CS 4	popular plantation	1.270	**1.370**
CS 5	Agroforestry mixed plantation	1.300	**1.407**
CS 6	Agricultural	1.370	**1.477**
	Sem+	0.033	**0.034**
	C.D. at 5%	**0.104**	**0.108**

Table.4 Effect of different cropping systems on Porosity at different soil depth.

S. No.	Treatments	Soil depth	
	Cropping system	**0-15 cm**	**15-30 cm**
CS 1	Grassland	46.667	**43.767**
CS 2	Mango Orchard	51.200	**48.400**
CS 3	Guvava orchard	52.733	**49.933**
CS 4	popular plantation	52.100	**48.300**
CS 5	Agroforestry mixed plantation	50.933	**46.900**
CS 6	Agricultural	48.300	**44.267**
	SEm+	1.235	**1.278**
	C.D. at 5%	**3.942**	**4.079**

Table.5 Effect of different cropping systems on pH at different soil depth.

S. No.	Treatments	Soil depth	
	Cropping system	**0-15 cm**	**15-30 cm**
CS 1	Grassland	6.500	**6.000**
CS 2	Mango Orchard	7.000	**6.833**
CS 3	Guvava orchard	6.933	**6.900**
CS 4	popular plantation	6.300	**6.267**
CS 5	Agroforestry mixed plantation	6.800	**6.533**
CS 6	Agricultural	6.700	**6.607**
	SEm+	0.172	**0.145**
	C.D. at 5%	**NS**	**0.464**

Table.6 Effect of different cropping systems on EC at different soil depth.

S. No.	Treatments	Soil depth	
	Cropping system	**0-15 cm**	**15-30 cm**
CS 1	Grassland	0.243	**0.222**
CS 2	Mango Orchard	0.342	**0.316**
CS 3	Guvava orchard	0.336	**0.338**
CS 4	popular plantation	0.324	**0.323**
CS 5	Agroforestry mixed plantation	0.225	**0.205**
CS 6	Agricultural	0.295	**0.273**
	SEm+	0.013	**0.005**
	C.D. at 5%	**0.041**	**0.017**

Table.7 Effect of different cropping systems on organic carbon percent at different soil depth.

S. No.	Treatments	Soil depth	
	Cropping system	**0-15 cm**	**15-30 cm**
CS 1	Grassland	1.430	**1.273**
CS 2	Mango Orchard	2.393	**2.183**
CS 3	Guvava orchard	2.713	**2.460**
CS 4	popular plantation	2.573	**2.313**
CS 5	Agroforestry mixed plantation	2.303	**2.080**
CS 6	Agricultural	1.663	**1.507**
	SEm+	0.243	**0.175**
	C.D. at 5%	**0.776**	**0.559**

Table.8 Effect of different cropping systems on Nitrogen (kg/ha) at different soil depth.

S. No.	Treatments	Soil depth	
	Cropping system	**0-15 cm**	**15-30 cm**
CS 1	Grassland	178.333	**169.667**
CS 2	Mango Orchard	221.333	**210.333**
CS 3	Guvava orchard	235.000	**231.667**
CS 4	popular plantation	234.000	**217.333**
CS 5	Agroforestry mixed plantation	216.000	**213.333**
CS 6	Agricultural	201.333	**184.667**
	SEm+	7.679	**7.805**
	C.D. at 5%	**24.510**	**24.913**

Table.9 Effect of different cropping systems on potassium (kg/ha) at different soil depth.

S. No.	Treatments	Soil depth	
	Cropping system	**0-15 cm**	**15-30 cm**
CS 1	Grassland	161.333	**157.167**
CS 2	Mango Orchard	174.600	**168.433**
CS 3	Guava orchard	170.100	**166.533**
CS 4	popular plantation	165.000	**163.167**
CS 5	Agroforestry mixed plantation	166.500	**164.533**
CS 6	Agricultural	185.167	**179.000**
	SEm+	3.275	**4.218**
	C.D. at 5%	**10.454**	**NS**

Table.10 Effect of different cropping systems on phosphorus (kg/ha) at different soil depth.

S. No.	Treatments	Soil depth	
	Cropping system	**0-15 cm**	**15-30 cm**
CS 1	Grassland	8.700	**8.567**
CS 2	Mango Orchard	9.300	**9.167**
CS 3	Guvava orchard	9.667	**9.467**
CS 4	popular plantation	9.467	**9.800**
CS 5	Agroforestry mixed plantation	8.800	**8.133**
CS 6	Agricultural	11.933	**10.900**
	SEm+	0.627	**0.522**
	C.D. at 5%	**2.000**	**1.665**

Table.11 Effect of different cropping systems on Sulphur (kg/ha) at different soil depth.

S. No.	Treatments	Soil depth	
	Cropping system	**0-15 cm**	**15-30 cm**
CS 1	Grassland	11.547	**10.267**
CS 2	Mango Orchard	11.007	**9.900**
CS 3	Guava orchard	12.687	**11.833**
CS 4	popular plantation	10.620	**9.567**
CS 5	Agroforestry mixed plantation	9.973	**9.327**
CS 6	Agricultural	12.200	**11.600**
	SEm+	0.604	**0.488**
	C.D. at 5%	**NS**	**1.558**

Table.12 Effect of different cropping systems on available soil organic stock (t/ha) at different Soil depth

S. No.	Treatments	Soil depth	
	Cropping system	**0-15 cm**	**15-30 cm**
CS 1	Grassland	2.782	**1.121**
CS 2	Mango Orchard	3.844	**3.272**
CS 3	Guava orchard	4.146	**2.628**
CS 4	popular plantation	1.594	**3.119**
CS 5	Agroforestry mixed plantation	2.961	**2.902**
CS 6	Agricultural	3.050	**2.071**
	SEm+	0.856	**0.735**
	C.D. at 5%	**N/A**	**N/A**

Figure.1 Effect of different cropping systems on soil moisture content (%) at saturation at different soil depth.

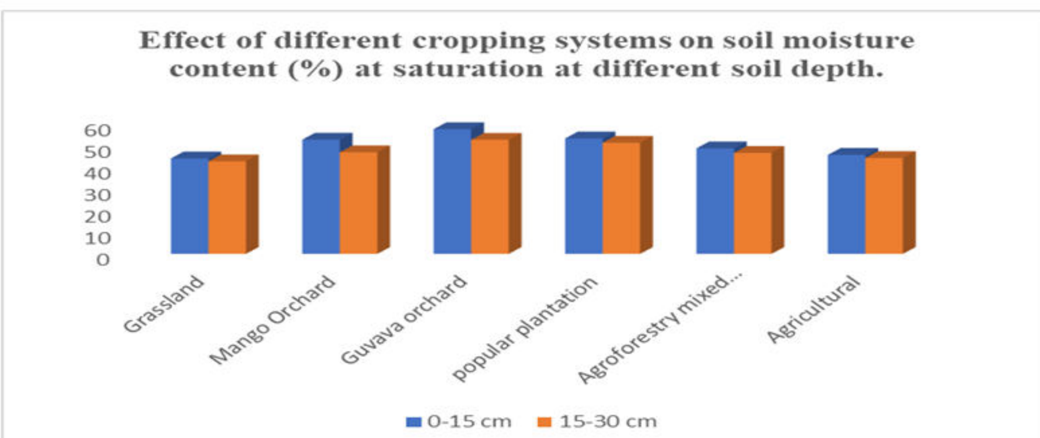


Figure.2 Effect of different cropping systems on bulk density (g/cc) at different soil depth.

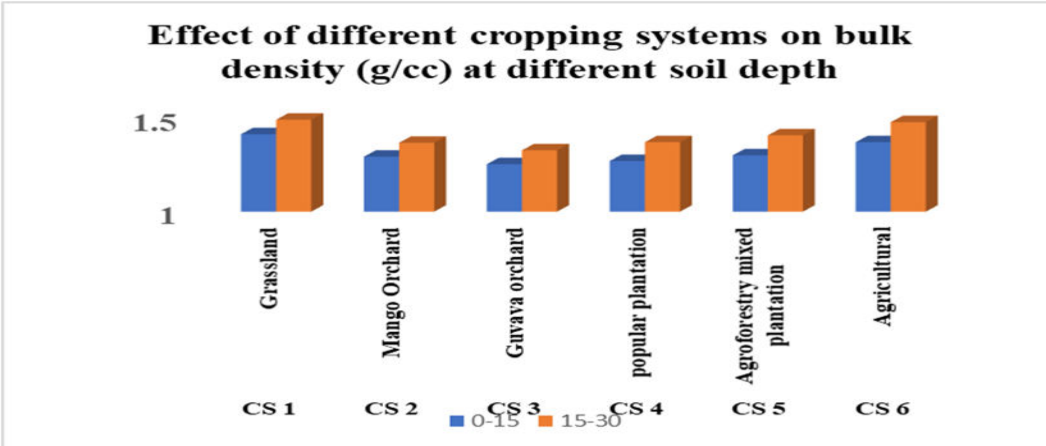


Figure.3 Effect of different cropping system on porosity at different soil depth.

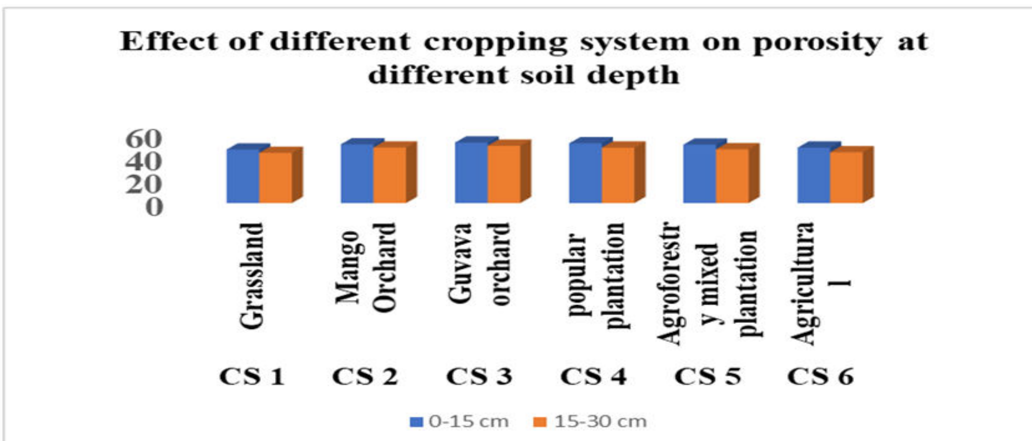


Figure.4 Effect of different cropping system on pH at different soil depth.

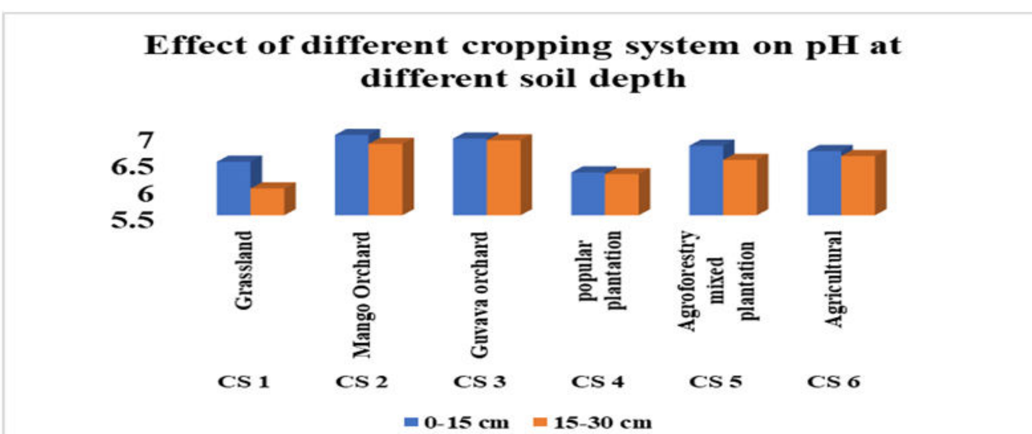


Figure.5 Effect of different cropping system on EC at different soil depth.

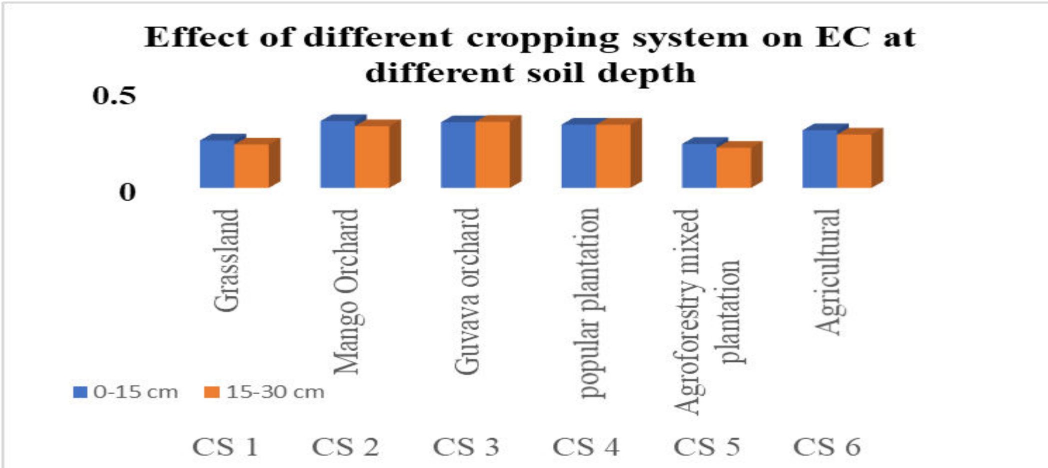


Figure.6 Effect of different cropping system on organic carbon percent at different soil depth

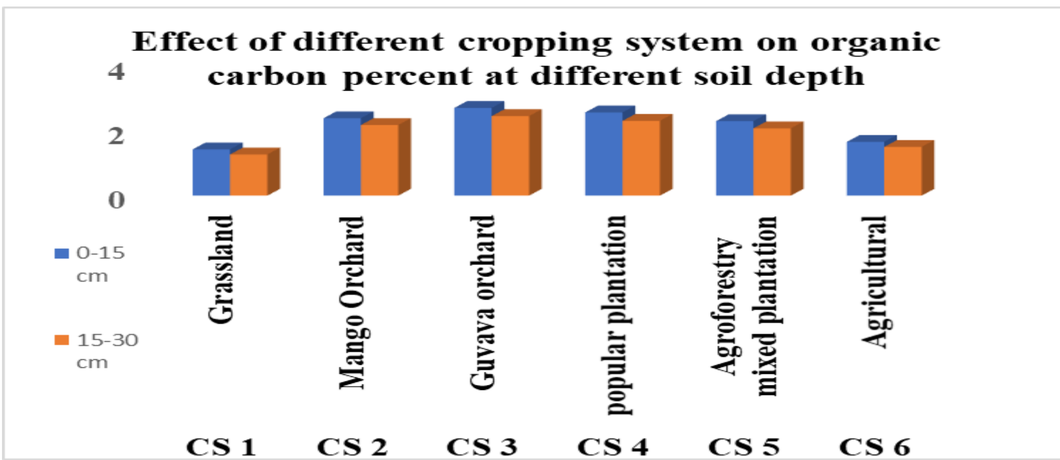


Figure.7 Effect of different cropping system on nitrogen (kg ha^{-1}) at different soil depth.

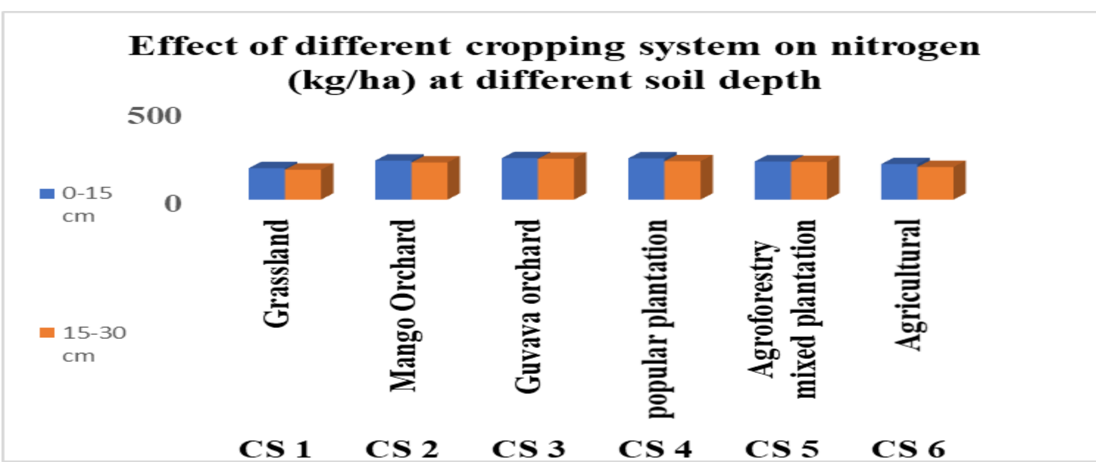


Figure.8 Effect of different cropping system on potassium (kg/ha) at different soil depth.

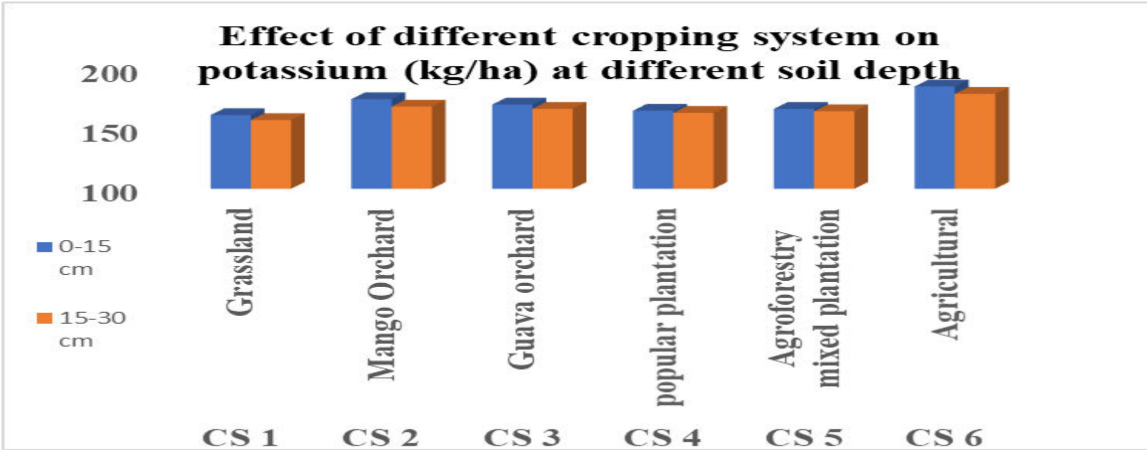


Figure.9 Effect of different cropping system on phosphorus (kg/ha) at different soil depth.

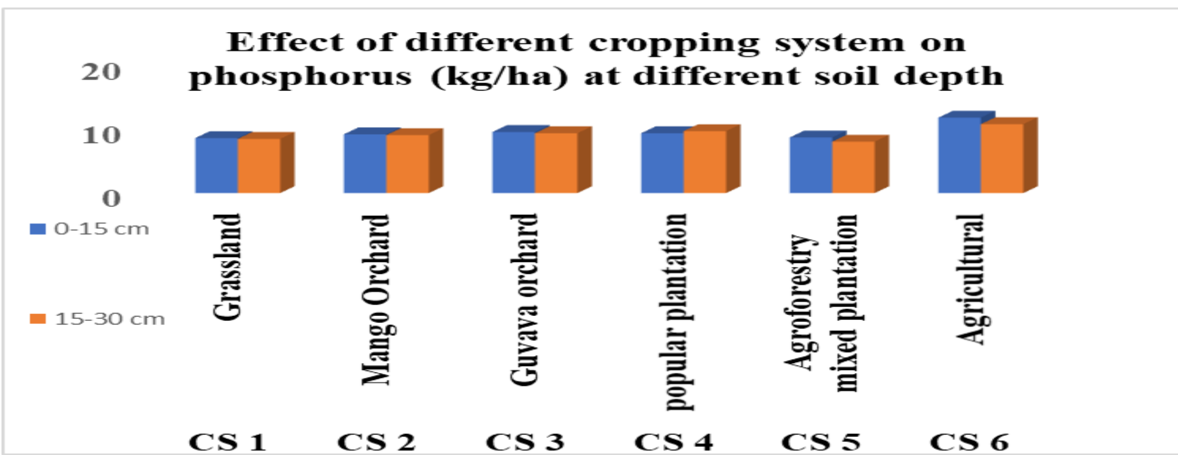


Figure.10 Effect of different cropping system on sulphur (kg/ha) at different soil depth.

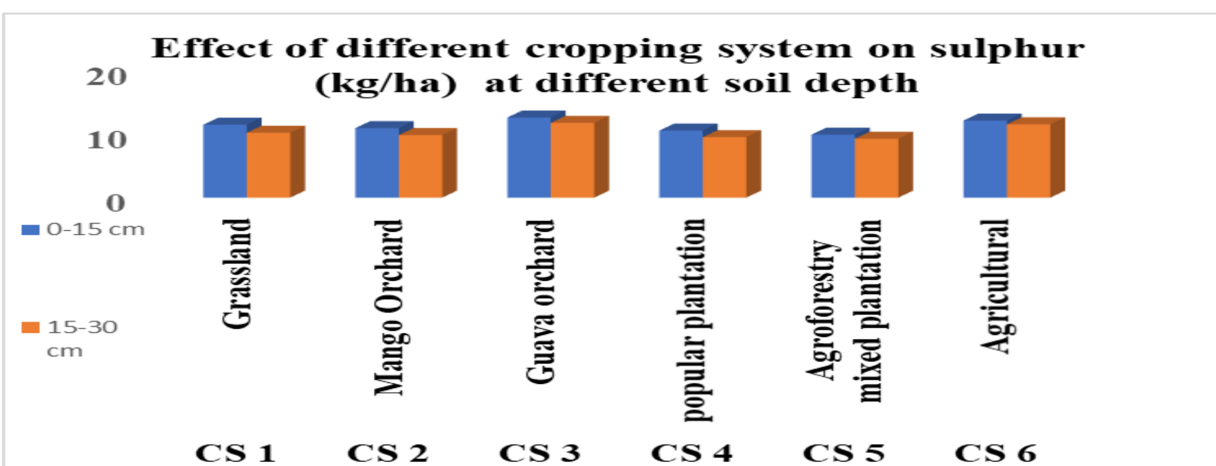
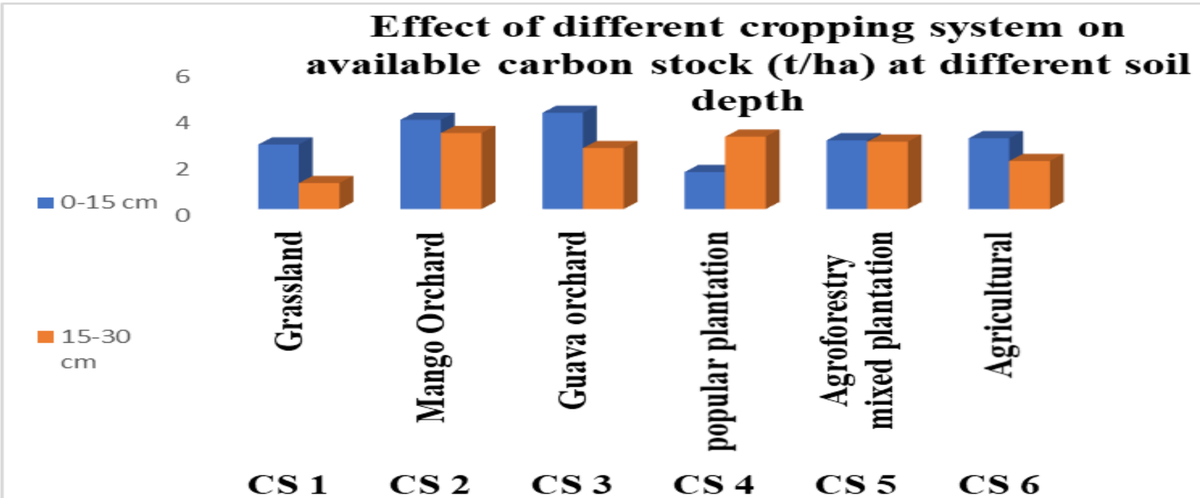


Figure.11 Effect of different cropping system on available carbon stock (t/ha) at different soil depth.



The highest amount of porosity was found in guvava orchard at 0-15 cm soil depth and at 15-30 cm soil depth as compared to other cropping system. This could be attributed due to prolific rooting system found in guava plantations and presence of deeper rooting system found in guvava plantations as compared to other cropping systems.

The highest pH was found in mango orchard at 0-15 cm soil depth and in 15-30 cm soil depth highest pH was found in guvava orchard as compared to other cropping systems. This could be attributed due to that as mango roots are not shallow but they are deep, invasive and wild, also they have fibrous root system due to which there could be more nutrient absorption from deep layers of soil. At 15-30 cm soil depth highest pH was found with guvava orchard this could be due to the reason that guvava tree root system forms a fine matted network of tendrils and they are not deep rooted.

The highest EC was found at mango orchard at 0-15 cm soil depth. This could be attributed to the reason as mango have deep rooted system so there could be more concentration of soluble ions at 0-15 cm soil depth as compared to 15-30 cm soil depth. The highest EC at 15-30 cm soil depth was found in guvava orchard this could be attributed to the reason that guvava root system is collection of fine matted network of root system and they are not deep rooted.

The highest organic carbon was found in guvava orchard at both 0-15 cm and 15-30 cm soil depth. This could be attributed due to the reason that guvava root system is collection of fine matted network of root system so there could be more accumulation of organic matter at both the depth i.e. 0-15 and 15-30 cm soil depth.

The nitrogen kg/ha was more in guava orchard at 0-15 and 15-30 cm soil depth as compared to other cropping systems. This could be due to more extensive and finer network of rooting system found in guvava cropping system.

The highest potassium was found in agricultural cropping system at 0-15 cm and 15-30 cm soil depth. This could be due to more extensive rooting system found in grasses as compared to other cropping system.

The highest amount of phosphorus was found in agricultural plantation at 0-15 cm soil depth and at 15-30 cm soil depth. This could be due to more extensive rooting system found in grasses as compared to other cropping system.

The highest amount of sulphur was found in guvava orchard at 0-15 and 15-30 cm soil depth. This could be attributed due to the reason that guvava root system is collection of fine matted network of root system so there could be more accumulation of sulphur at both the depth i.e. 0-15 and 15-30 cm soil depth.

The highest amount of available carbon stock at 0-15 cm soil depth was in guvava orchard. At 15-30 cm soil depth the highest amount of available carbon stock was found in mango orchard. This could be attributed due to the reason that guvava root system is collection of fine matted network of root system so there could be more accumulation of available carbon stock the depth i.e. 0-15 cm soil depth. At the depth of 15-30 cm soil depth more carbon stock was found in mango orchard. This could be attributed due to that as mango roots are not shallow but they are deep, invasive and wild, also they have fibrous root system due to which there could be more nutrient absorption from deep layers of soil.

Author Contributions

Sanjeev Kumar: Investigation, formal analysis, writing—original draft. Varun Tripathi: Validation, methodology, writing—reviewing. Jyoti Pandey:—Formal analysis, writing—review and editing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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How to cite this article:

Sanjeev Kumar, Varun Tripathi and Jyoti Pandey. 2024. A Case Study on Soil Health Assessment Under Different Annual and Perennial Cropping System. *Int.J.Curr.Microbiol.App.Sci.* 13(6): 228-239.
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