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Soil physical properties as influenced by different agroforestry systems in Haryana

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ABSTRACT

The present investigation was conducted out at Research Farm, Department of forestry, CCS Haryana Agricultural University, Hisar to assess the influence of different agroforestry system on dynamic soil physical parameters. Soil samples were collected randomly from varying depths viz. 0-15, 15-30, 30-60 and 60-90 cm from different agroforestry system *viz.* Poplar + wheat, *Eucalyptus* + barley, *Melia* + wheat, Shisham + mustard, wheat, barley and mustard. Analysis of different physical properties was done at all depths except infiltration rate. Infiltration rate was observed at surface depth (0-15 cm) only. Soil texture, being a static property was not found to be affected by agroforestry system. Non-significant effect was observed in case of soil texture among different agroforestry system. Poplar + wheat recorded maximum infiltration rate which was at par with *Eucalyptus* + barley, *Melia*+ wheat and Shisham + mustard agroforestry system. Saturated hydraulic conductivity was maximum under *Eucalyptus* + barley based agroforestry system.The result of the study showed that tree-based agroforestry system can significantly improve the soil physical properties.

Key words: *Agroforestry, Infiltration, Saturated hydraulic conductivity, Texture*

Introduction

India is facing challenges like decline in crop productivity, poor soil health, loss of soil organic carbon, ground and surface water pollution, decline in farm profits and adverse impact of climate change. A wide range of resources to adapt to climate change and diverse livelihood portfolios are more likely to better cope with climate risks. Agroforestry can increase the resistance and resilience of the system to climate variability because the trees buffer against extreme climatic events, protect soils and water courses and diversify the production (Matocha *et al.*, 2012). The use of diversified land use system not only helps the farmer in attaining assured source of income but also improves soil health. The three important properties *viz.* physical, chemical and biological makes soil a functionally complete resource (Abera and Meskel, 2013). Agroforestry is a collective term for land-use systems where woody perennials are deliberately used on the same land-management units as agricultural crops, in the form of either spatial arrangement or temporal sequence (Pinho *et al.*, 2012). These land use system are considered as a panacea for various maladies of intensive agriculture and also play a crucial role in improving the site productivity through interaction among trees, soil and crops and

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thus aids in restoring soil fertility (Kumar, 2006). It is considered to be the most promising land use system to achieve sustainable land use with the potential to preserve soil organic carbon, increase the water extractable pool, enhance water uptake, prevent soil degradation and promote social and health benefits (Cannavo *et al.,* 2011).

Agroforestry aids in vertically enhancing soil health against adverse weather conditions (Bisht *et al.,* 2017). Agroforestry systems are among best solution for ever-escalating prices and shortage of chemical fertilizers for small-land holding farmers and to increase soil fertility in the developing world. Devi *et al.* (2021) observed that incorporation of trees along with crops enhance organic matter in soil due to litterfall. This litterfall has contributed towards improvement in soil properties. Singh *et al.* (2018) studied the effect of Poplar and *Melia* based agroforestry system on soil properties. These agroforestry tree species showed positive impact on soil properties in comparison to sole agriculture cropping system. At 0-15, 15-30 and 30-45 cm soil depth lowest soil bulk density (1.25, 1.27 and 1.28 g cm^{-3}) and particle density (2.62, 2.66 and 2.71 g/cm^{-3}) was recorded under different agroforestry system. Significant effect on soil physical properties was observed under agroforestry system. That's why, this study was conducted to evaluate the soil physical properties under agroforestry systems particularly in the semi-arid ecosystem of Haryana where the soil health is deteriorating at alarming rate.

Materials and Methods

The field trial was carried out at Research Farm, Department of Forestry, Chaudhary Charan Singh Haryana Agricultural University (CCS HAU), Hisar (29° 092 N; 75º 43' E, 215 meters above the mean sea level) for year 2018-19 which was a part of the research program started in 2015 in Department of Forestry. The experimental site was situated in arid and semi-arid region on North-western side of Haryana. The soil was sandy loam in texture. The site has extreme weather conditions with severe cold during winter and hot, dry desiccating winds during summer. Average annual rainfall in the region is 350-400 mm with sub-tropical climate.

Design and Treatments Detail

The experimental field was laid out in factorial randomized block design with 7 treatments i.e. Poplar + wheat, *Eucalyptus*+ barley, *Melia*+ wheat, Shisham + mustard, wheat, barley and mustard. Collection of soil samples was done at four depths i.e. 0-15, 15-30, 30-60, and 60-90 cm with each treatment replicated 4 times. Wheat, barley and mustard were cropped in association with Poplar and *Melia*, *Eucalyptus* and Shisham trees, respectively. In the adjoining fields, wheat, barley and mustard crop were grown as sole crop. Each treatment was supplied with the recommended packages of practices each separately for tree as well as intercrop. Recommended dose of fertilizer was applied to each treatment (nitrogen in 2 splits and P and K at sowing time). Under trees 8 kg FYM was incorporated around each tree every year in the rainy season (June-July).

Analysis

Soil texture was determined using International Pipette Method of Robinson as described by Piper (1966). The relative proportion of sand, silt and clay fractions in the sample was determined using textural triangle proposed by International Society of Soil Sciences (ISSS) now known as International Union of Soil Sciences. Infiltration rate was measured for different treatments using double ring infiltrometer. For determination of saturated hydraulic conductivity, soil cores were used. The saturated soil cores were used for evaluation of saturated hydraulic conductivity using constant head method (Richard, 1954) in the laboratory.

Statistical analysis

Statistical method by Panse and Sukhatme (1989) were followed to analyze different parameters. "Analysis of variance" technique given by Fisher (1950) was used to analyze the data statistically in order to find the significant effect of treatments. 'F' test at 5% level of significance was opted to relate the significant difference among the means of two treatment effects, the critical difference (CD) was calculated by:

$$CD = \frac{\sqrt{2\ XEMS}}{N} \text{ x t value}$$

where, CD, critical difference; EMS, error mean sum of square; N, number of observations and t, value of t-distribution at 5% level of error degree of freedom

Results and Discussion

Soil texture

Soil texture was recorded at 0-15, 15-30, 30-60 and 60-90 cm soil depths. It is a static property of soil i.e. not easily influenced by cultivation practices. It was observed that there exists no major difference in soil texture. No significant difference was obtained among different agroforestry system. Upto 30 cm soil depth, sandy loam soil texture was recorded. But, with the increase in soil depth, clay content in soil increased that led to sandy clay loam texture in lower soil profile. Similar results were observed by Salim *et al.*(2018) in *Eucalyptus*, teak, acacia and mixed plantation site at surface depth (Table 1).

Infiltration rate

Infiltration rate differed significantly among different agroforestry system. Highest infiltration rate was recorded under Poplar + wheat agroforestry system (1.59 cm hr^{-1}) which was at par with *Eucalyptus*+ barley, *Melia* + wheat and Shisham + mustard agroforestry system. Poplar + wheat and *Melia* + wheat recorded an increase of 15.2 and 10.9%, respectively as compared to wheat sole cropping treatment. In barley and mustard sole cropping, reduction in infiltration rate was found to be 8.9 and 12.3% as compared to *Eucalyptus* + barley and Shisham + mustard agroforestry system, respectively (Table 1).

Poplar + wheat agroforestry system recorded maximum infiltration rate which was at par with *Eucalyptus* + barley, *Melia* + wheat and Shisham + mustard based system. While it differed significantly with sole crop treatments. Among sole cropped ones, highest infiltration rate was in wheat which was at par with all the crop treatments and *Eucalyptus* + barley agroforestry system. Higher Infiltration rate was reported under tree system due to decrease in bulk density with the increase in tree component and this is correlated to more organic matter, which led to better soil structure and more porosity (Koul and Panwar, 2012 and Chauhan *et al.*, 2018). The infiltration rate is mainly influenced by different soil properties such as texture, structure, bulk density and water repellency. These results corroborate with the findings of Lodhiyal *et al.* (2002) who explained that the forest ecosystem act as nutrient reservoir for intra-system cycling processes, enhanced the infiltration rate and water holding capacity of soil.

Saturated hydraulic conductivity

Table 2 depicted effect of different agroforestry system on saturated hydraulic conductivity of soil. The effect of saturated hydraulic conductivity under different agroforestry system, soil depth and their interaction was found to be significant. Highest saturated hydraulic conductivity was obtained under *Eucalyptus* + barley agroforestry system (0.82 cm hr^{-1}) and lowest in wheat (0.36 cm hr^{-1}). Incorporating trees, Poplar and *Melia* in cropping system led to significant increase of 75% as compared to wheat sown alone. Maximum increment in saturated hydraulic conductivity, i.e. 95.2% was obtained under *Eucalyptus* + barley system. While in Shisham + mustard system, saturated hydraulic conductivity raised by 39.5% in comparison to Mustard system. Saturated hydraulic conductivity decreased with increase in soil depth.

Hydraulic conductivity is strongly influenced by soil texture, structure, compaction, organic matter

Table 1. Effect of different agroforestry system on soil texture and infiltration rate (cm hr^{-1}) at different soil depth

Treatments	Soil texture (%)												Infiltration rate (cm hr^{-1})
	Soil Depth (cm)												
	0-15			15-30			30-60			60-90			
	Sand	Silt	Clay	Sand	Silt	Clay	Sand	Silt	Clay	Sand	Silt	Clay	
Poplar + wheat	80	6	14	75	8	17	76	6	18	73	3	24	1.59
Eucalyptus + barley	78	4	8	84	6	10	74	10	16	74	8	18	1.46
Melia + wheat	79	11	10	75	13	12	65	13	22	67	9	24	1.53
Shisham + mustard	79	8	13	76	9	15	73	11	16	68	12	20	1.55
Wheat	82	4	14	78	6	16	75	7	18	70	8	22	1.38
Barley	83	3	14	76	7	17	70	10	20	68	11	21	1.33
Mustard	86	4	12	80	7	13	74	8	18	71	9	20	1.36
LSD (p=0.05)	-	-	-	-									0.18

Table 2. Effect of different agroforestry system on saturated hydraulic conductivity (cm hr^{-1}) at different depths

Treatments	Soil depth (cm)				Mean
	0-15	15-30	30-60	60-90	
Poplar + wheat	1.38	0.77	0.30	0.08	**0.63**
Eucalyptus + barley	1.34	1.20	0.59	0.17	**0.82**
Melia + wheat	0.91	1.08	0.32	0.21	**0.63**
Shisham + mustard	1.20	0.54	0.28	0.10	**0.53**
Wheat	0.68	0.42	0.24	0.09	**0.36**
Barley	0.74	0.57	0.28	0.10	**0.42**
Mustard	0.70	0.47	0.22	0.12	**0.38**
Mean	**0.99**	**0.72**	**0.32**	**0.12**	
LSD (p=0.05)	Treatment (T)		Soil depth (D)		T×D
	0.04		0.03		0.08

and fluidity of soil. At surface layer, maximum saturated hydraulic conductivity was observed under Poplar + wheat agroforestry system. It significantly differed among different agroforestry system except *Eucalyptus* + barley based system. While the average saturated hydraulic conductivity was highest under *Eucalyptus* + barley agroforestry system which differed significantly with the agroforestry system. Highest hydraulic conductivity was at surface layer due to huge amount of organic matter and it differed significantly with lower soil profile. It decreased due to decrease in organic matter with depth.

Conclusion

The soil physical properties improved under tree based system due to more organic matter leading to improvement in infiltration rate and saturated hydraulic conductivity of the soil. Poplar + wheat agroforestry system depicted maximum infiltration rate and saturated hydraulic conductivity at surface depth. Thus, adoption of different agroforestry system improved soil physical properties as compared to sole cropping.

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Conflict of Interest

There is no conflict associated with the manuscript.

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