



# Dynamics of Soil Physical and Chemical Properties under Fruit Tree based Agroforestry Systems in Sub-humid Agro-climatic Zone

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**Abstract:** The dynamics of soil physical and chemical properties under different fruit tree based agroforestry systems and in open conditions was observed during two consecutive years 2020-2021. The physical and chemical properties of soil were favourably affected by systems. Soil moisture (9.75%) was maximum under pear based agroforestry system and minimum under open conditions. The chemical properties viz., soil available nitrogen (268.37 Kg ha<sup>-1</sup>), soil available potassium (269.42 Kg ha<sup>-1</sup>), soil available phosphorus (39.16 Kg ha<sup>-1</sup>), soil pH (7.06), soil organic carbon (1.30%) were maximum in pear based agroforestry system and minimum under open conditions. Soil electrical conductivity (0.21 dSm<sup>-1</sup>) was also more under pear based agroforestry system as compared to open system.

**Keywords:** Agroforestry systems, Soil organic carbon, Soil pH

Soil is a component of lithosphere and biosphere system. It is a vast natural resource on which life supporting systems and socioeconomic development depends. Organic matter is one of the most important constituents of soil, a good amount of organic carbon/matter increase soil fertility. The core constraints in relation to land use include depletion of organic carbon, soil macronutrients and micronutrients. (Kumar et al 2017). Potential land use assessment is likely to the prediction of land potential for productive land use type (Dadhwal et al 2011) land productivity capacity or land quality is a comprehension, at the same time a precise concept in terms of agricultural activities (Dengiz and Saglam 2012).

Forests and tree based systems can play a crucial role in supplementing agricultural production to provide better and more equitable nutrients for cooking (Vinceti et al 2013). Food sustainability in all its facets, in an environment at risk of breaching global limits through its human exploitation and alteration of nature, atmosphere, water and nutrient cycles (Rockstorm et al 2009). Climate-Smart Agroforestry (CSA) seeks to contribute to adaptation and tolerance of climate change in agricultural systems, while also contributing to mitigation (reduction of emissions) and food protection (Campbell et al 2014, World Bank 2016). Fruit tree based agroforestry system is highly popular among resource limited producers worldwide due to its relative pre-production phase of fruit trees, the high market value of their products. Many fruit tree species have been identified to have tolerance to sodic soils and other soil related constraints (Pandey 2019).

The present production system has endangered health and environmental security due to abundant use of chemical fertilizers and pesticides. Eminent position in global

cultivation of wheat, pulses, vegetables and fruits etc. is occupied by Indian agriculture and reason of physical, chemical condition of whatever land is indispensable for proper implementation of the other management practices. Thus the physico-chemical study is very important because both physical and chemical properties which bear upon the soil productivity. The physico chemical study of soil is based on various parameters like pH, EC, moisture, available nitrogen, phosphorus and potassium (Kekane et al 2015). Maintenance or enhancement of soil quality is a more important criterion for analysis and sustainability of soil ecosystems. The effect of combined plantation of selective fruit species for improvement of poor fertile soils has not been worked out so far. This study assessed the performance of two fruit tree based agroforestry systems in order to obtain knowledge on sustainable farming system for the region.

## MATERIAL AND METHODS

Experiment was conducted at Dr. YSP University of Horticulture and Forestry, Nauni, Solan (H P). The experimental site falls in mid hill zone of Himachal Pradesh at 30°51' N latitude and 76° 11' E longitude, with an elevation of 1200 m amsl. The area falls in sub-tropical, sub-humid agro-climatic zone of Himachal Pradesh, India. May and June are the hottest months, whereas December and January are the coldest months and experience severe frost during winter. On an average the annual rainfall received varies from 1000-1400 mm; about 75 per cent being received during the monsoon period (June-September). The soils of the area belongs to Typic Eutrochrept at subgroup level according to Soil Taxonomy of USDA.

The experiment was in randomized block design and treatment combinations include 2 (Tree components: apricot and pear), 2 planting condition (Inside and outside canopy), 3 varieties (Kranti, P-8, and Tender), 3 nutrient and fertilizer doses (RDF (75:50:50 NPK Kg ha<sup>-1</sup> + FYM @15 t ha<sup>-1</sup>), Jeevamrut (500 litres ha<sup>-1</sup>) and FYM (15 t ha<sup>-1</sup>). Open plots was an area where different okra varieties without trees (pear and apricot), and was established in close proximity to agroforestry systems. Okra varieties were sown at a spacing of 45 x 15 cm. The height, girth of trees and crown spread (m<sup>2</sup>) was measured during 2020-2021. Light Transmission Ratio of two systems pear and apricot was taken with the help of luxmeter. Fruit yield of tree was recorded during the two respective years (2020-2021).

**Statistical analysis:** IBMSPSS Statistics software was used for analysis.

**Soil analysis:** For soil analysis, viz., soil moisture, pH, EC, organic carbon, available N, P and K. composite soil samples were collected from 0-15cm depth from each plot, before sowing and after harvesting of crops. The pH and electrical conductivity of soil were determined by using 1:2.5 soil: water suspension (Jackson 1973). Organic carbon, available nitrogen and available phosphorus were determined by using rapid titration method (Walkley and Black 1934) and Olsen et al (1954), respectively. Available potassium was estimated using neutral 1 N ammonium acetate solution (Merwin and Peech 1951).

## RESULTS AND DISCUSSION

### Soil chemical properties

**Soil organic carbon (%):** The maximum soil organic carbon (1.30%) was in pear based agroforestry system followed by apricot based agroforestry system and minimum (1.24%) under open conditions. Olsson et al (2000) also reported higher soil moisture content under *Millettia ferruginea* as compared to outside the tree. Gupta et al (2009) observed that soil organic carbon increased from 0.36% in sole crop to 0.66% in agroforestry soils. The varieties revealed non-significant differences with respect to soil organic carbon. The maximum soil organic carbon was in FYM when applied FYM@15 t ha<sup>-1</sup>(1.32%) and minimum (1.24%) with the application of NPK: 75: 50: 50 Kg ha<sup>-1</sup> + FYM 15 t ha<sup>-1</sup> (Table 1).

**Soil available nitrogen (Kg ha<sup>-1</sup>):** The soil available nitrogen was maximum in pear based agroforestry system (268.37 Kg ha<sup>-1</sup>) followed by apricot based agroforestry system and minimum under open conditions (216.74 Kg ha<sup>-1</sup>). Mishra et al (2006) also observed increase in soil nitrogen under tree cover. Tripathi (2012) made a similar conclusion and reported significantly higher levels of available soil nitrogen under tree (peach) cover than in open condition which may be due to repeated addition of litterfall to the soil. Atta et al (2013) observed higher available nitrogen under tree canopy of *Acacia* species as compared to outside the tree canopy. This was due to immobilization of nutrients by microbes which

**Table 1.** Effect of systems, varieties and fertilizers on soil chemical properties under *Abelmoschus esculentus*

Treatments	Soil organic carbon (%)	Soil available nitrogen (kg ha <sup>-1</sup> )	Soil pH	Electrical conductivity (dSm <sup>-1</sup> )	Soil moisture (%)	Soil available potassium (kg ha <sup>-1</sup> )	Soil available phosphorus (kg ha <sup>-1</sup> )
<b>Systems</b>							
Apricot (S <sub>A</sub> )	1.28	248.24	7.06	0.19	7.05	265.02	36.87
Pear (S <sub>P</sub> )	1.30	268.37	6.79	0.21	9.75	269.42	39.16
Open (S <sub>O</sub> )	1.24	216.74	6.40	0.17	6.55	230.52	33.50
CD (p=0.05)	0.02	26.83	0.35	0.01	0.40	15.19	2.24
<b>Varieties</b>							
Kranti (V <sub>1</sub> )	1.27	232.64	7.25	0.19	6.58	245.08	35.61
P-8 (V <sub>2</sub> )	1.26	256.81	6.54	0.19	8.43	261.27	36.32
Tender (V <sub>3</sub> )	1.29	243.89	6.46	0.19	8.35	258.60	37.60
CD (p=0.05)	NS	NS	0.35	NS	0.40	NS	NS
<b>Fertilizers</b>							
RDF+ FYM (F <sub>1</sub> )	1.24	277.42	6.59	0.17	7.88	279.27	39.71
Jeevamrut (F <sub>2</sub> )	1.27	244.27	6.38	0.20	7.56	258.78	36.44
FYM (F <sub>3</sub> )	1.32	211.67	7.27	0.20	7.91	226.90	33.40
CD (p=0.05)	0.02	26.83	0.35	0.01	NS	15.19	2.24

when biologically transformed becomes available to plant. Varieties revealed non-significant differences with respect to soil nitrogen. Soil nitrogen was maximum in  $F_1$  (RDF + FYM) ( $277.42 \text{ Kg ha}^{-1}$ ) and minimum in  $F_3$  ( $211.67 \text{ Kg ha}^{-1}$ ) (Table 1).

**Soil pH:** Soil pH was maximum in apricot based agroforestry system (7.06) followed by pear based agroforestry system and minimum under open conditions (6.40). Akter et al (2020) in jackfruit turmeric based agroforestry observed maximum soil pH (4.75) in tree based agroforestry system as compared to sole cropping (4.72). Uthappa et al (2015) reported that soil physico-chemical properties influenced by varying tree densities in poplar based agroforestry system and soil pH in 0-15 cm layer was maximum (8.36) at tree density of 500 trees/ha as compared to minimum in sole crop (8.33). Varieties revealed that maximum soil pH was after harvesting of Kranti (7.25) and minimum in Tender variety (6.46). Among different fertilizer doses, maximum soil pH was in FYM (7.27) and minimum in Jeevamrut (6.38) (Table 1).

**Electrical conductivity ( $\text{d sm}^{-1}$ ):** Electrical conductivity was maximum in pear based agroforestry system ( $0.21 \text{ d sm}^{-1}$ ) during both the years. Varieties revealed non-significant result with respect to EC. Among fertilizers, maximum EC ( $0.21 \text{ d sm}^{-1}$ ) was in treatment of jeevamrut and minimum ( $0.17 \text{ d sm}^{-1}$ ) in RDF+FYM (Table 1).

**Soil moisture:** Soil moisture was maximum (9.75%) in pear based agroforestry system and minimum (6.55%) under open conditions. Among three varieties of *Abelmoschus esculentus* (soil moisture was maximum (8.43%) in P-8 variety and minimum in Kranti (6.58%). Rahman et al (2018) also observed maximum (12.07%) soil moisture in agroforestry system and minimum (10.37%) under open conditions. This was due to increase in water infiltration and reduced surface runoff. Different fertilizers usage revealed non-significant result for soil moisture during (Table 1).

**Soil available potassium ( $\text{Kg ha}^{-1}$ ):** The maximum soil available potassium was in pear based agroforestry system ( $269.42 \text{ Kg ha}^{-1}$ ) followed by apricot based agroforestry system and minimum under open conditions (Table 1). Uthappa et al (2015) in varying tree densities in poplar based agroforestry system found that available potassium (K) was greatly influenced by tree densities. Maximum available potassium in 0-15 cm layer was at tree density of 1000 trees/ha ( $228.11 \text{ kg ha}^{-1}$ ). Among different fertilizers, maximum potassium availability ( $279.27 \text{ kg ha}^{-1}$ ) was in RDF +FYM and minimum ( $226.90 \text{ kg ha}^{-1}$ ) with  $F_3$ . Varieties revealed non-significant result with respect to soil available potassium.

**Soil available phosphorus ( $\text{Kg ha}^{-1}$ ):** The maximum soil available phosphorus was in pear based agroforestry system

( $39.16 \text{ kg ha}^{-1}$ ) followed by apricot based agroforestry system (and minimum ( $33.50 \text{ kg ha}^{-1}$ ) under open conditions. Manjur et al. (2014) reported that available phosphorus was higher under canopies of *Faidherbia albida* and *Croton macrostachys* tree species and all showed decreasing trend with increasing distance from tree base which was attributed to high accumulation of organic matter under tree canopies. Gulabrao (2016) made a similar conclusion and recorded that available phosphorus was higher where plants were grown under trees and supplied with higher doses of organic manures. Among fertilizers, maximum ( $39.71 \text{ kg ha}^{-1}$ ) was in  $F_1$  ( $75:50:50 \text{ NPK kg ha}^{-1} + \text{FYM @} 15 \text{ t ha}^{-1}$ ) and minimum ( $33.40$ ) in  $F_3$  ( $\text{FYM @} 15 \text{ t ha}^{-1}$ ).

#### Effect of systems, varieties and fertilizers on yield of

***Abelmoschus esculentus*:** The systems, varieties and fertilizers showed significant effect on number of fruits per plant. Among systems, maximum number of fruits per plant (11.53) were in open system followed by pear based agroforestry system and minimum (10.07) under apricot based system. The maximum number of fruits (11.51) per plant were in P-8 variety which was at par with Tender and minimum (10.06) in Kranti variety. However, different fertilizer doses revealed that the maximum number of fruits per plant (11.69) were in RDF+ FYM, followed by jeevamrut (11.00) and minimum (9.98) in FYM (Table 2). The maximum fruit yield plot<sup>-1</sup> ( $1.64 \text{ kg}$ ), was in open system, followed by pear based agroforestry system ( $1.55 \text{ kg}$ ) and minimum ( $1.44 \text{ kg}$ )

**Table 2.** Effect of systems, varieties and fertilizers on no. of fruits per plant, fruit yield and yield of *Abelmoschus esculentus*

Treatments	No of fruits per plant	Fruit yield plot <sup>-1</sup> (kg)	Yield ( $\text{q ha}^{-1}$ )
<b>Systems</b>			
Apricot ( $S_a$ )	10.07	1.44	72.38
Pear ( $S_p$ )	11.05	1.55	77.63
Open ( $S_o$ )	11.53	1.64	83.25
CD ( $p=0.05$ )	0.43	0.07	3.82
<b>Varieties</b>			
Kranti ( $V_1$ )	10.06	1.42	71.46
P-8 ( $V_2$ )	11.51	1.62	82.10
Tender ( $V_3$ )	11.09	1.58	79.69
CD ( $p=0.05$ )	0.43	0.07	3.82
<b>Fertilizers</b>			
RDF+ FYM ( $F_1$ )	11.69	1.70	85.11
Jeevamrut ( $F_2$ )	11.00	1.55	78.42
FYM ( $F_3$ )	9.98	1.38	69.72
CD ( $p=0.05$ )	0.43	0.07	3.82

in apricot based agroforestry system. The maximum fruit yield (83.25 q ha<sup>-1</sup>) was in open system followed by pear based agroforestry system and minimum under apricot based system. Among varieties, the maximum fruit yield plot<sup>-1</sup> (1.62 kg) was in P-8 variety which was at par with Tender and minimum (1.42 kg) was recorded in Kranti variety. The maximum (1.70 kg) fruit yield plot<sup>-1</sup> was in RDF + FYM followed by jeevamrut and minimum (1.38 kg) in FYM.

The maximum fruit yield (83.25 q ha<sup>-1</sup>) was in open system followed by pear based agroforestry system and minimum (72.38 q ha<sup>-1</sup>) under apricot based system. Among varieties, the maximum fruit yield (82.10 q ha<sup>-1</sup>) was in P-8 variety which was at par with Tender and minimum (71.46 q ha<sup>-1</sup>) was in Kranti variety. The different fertilizer doses revealed that the maximum fruit yield (85.11 q ha<sup>-1</sup>) was in RDF+ FYM, followed by jeevamrut and minimum in FYM (Table 2).

### CONCLUSION

The physical and chemical properties of soil were favorably affected with in agroforestry system. Most of the soil physical and chemical properties were found more under apricot tree based agroforestry system as compared to open conditions. The present study revealed the effect of different fruit tree species on soil physico chemical properties in the same area. However, more intensive studies are required in different agroecological regions for reliability and better acceptance.

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