Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2582-2845.8745

ISSN: 2582 – 2845

Ind. J. Pure App. Biosci. (2021) *9*(3), 289-304

Indian Journal of Pure & Applied Biosciences

Peer-Reviewed, Refereed, Open Access Journal

Research Article

Impact of Seasonal Variation on Physico-Chemical Properties of Orchard Soil and their Relationship with Different Fruit Tree Species under Semiarid Irrigated Conditions

Dinesh Kumar[1*], R.P.S. Dalal[1], Rakesh Kumar[2], Jagdish Parshad[2], R.N. Sheokand[3], and Jaipal Jaipal[1]

[1]Department of Horticulture, [2]Department of Microbiology,

[3]Department of Mathematics and Statistics,

CCS Haryana Agricultural University Hisar- 125004, Haryana

*Corresponding Author E-mail: palri.ado@gmail.com

Received: 7.04.2021 | Revised: 13.05.2021 | Accepted: 22.05.2021

ABSTRACT

The chemical properties in the rhizosphere of fruit tree species were investigated during different season at CCS HAU, Hisar. Results revels that pH value, OC, N, P, K, Zn contents increased significantly with all the fruit orchards over control (uncultivated land). However, maximum pH, EC, OC, CN ratio, available N, P, K, Zn and Fe (8.30, 0.33 dS/m, 0.54 %, 11.63, 126.26 kg/ha, 32.24 kg/ha, 284.93 kg/ha, 2.10 ppm and 3.34 ppm) was found in aonla, sweet orange, jamun, jamun, guava, sweet orange, guava, ber and sweet orange, respectively. Highest EC, CEC, OC and available K were found in winter season but pH, EC, available N, Zn, Mn and B contents were recorded maximum in summer season.CN ratio and available P were maximum in rainy season. Inter row spaces soil had highest pH, CEC, CN ratio and Zn contents while maximum OC, Available N, P, K, Fe, Mn and B contents was observed under the canopy of fruit trees.

Keyword: *Fruit tree species, Soil chemical properties, Rhizosphere, Seasons and Sampling site.*

INTRODUCTION

Soil is the first base for fruit tree cultivation, in recent years' fruit orchards are facing a major problem of decreased soil fertility, which has resulted in weakened tree vigour, decline in production and deterioration in fruit quality thus, seriously hampering the healthy economic development of the fruit industry. Any fluctuations in the soil ecosystem sensitizes, soil microbial diversity for change (Cheng et al., 2017). Similarly, different seasons and plant species are also known to have significant impact on soil physicochemical properties, organic matter content and its quality.

Cite this article: Kumar, D., Dalal, R. P. S., Kumar, R., Parshad, J., Sheokand, R. N., & Jaipal, J. (2021). Impact of Seasonal Variation on Physico-Chemical Properties of Orchard Soil and their Relationship with Different Fruit Tree Species under Semiarid Irrigated Conditions, *Ind. J. Pure App. Biosci.* *9*(3), 289-304. doi: http://dx.doi.org/10.18782/2582-2845.8745

Rhizosphere is the narrow region of soil that is directly surrounded and influenced by the plant roots and is known to be a driving force of soil processes.

Soils under particular land use system affect physicochemical properties in rhizosphere which may modify fertility status and nutrient availability of plants. Plant species also affect quantity and quality of carbon resources in the rhizosphere, which influence the composition and absorption of plant nutrients in these environments. Plant species are responsible for releasing soil enzymes which are essential for catalysing reactions, necessary for organic matter decomposition, nutrient cycling and thus, affect soil fertility and plant growth. Soil organic carbon significantly differed among plant species in the surface (0–15-cm) layer, when compared with abandoned pasture and mature forest. The change in soil organic carbon over 15 years ranged from 0.03 to 0.66 Mg C ha^{-1} yr^{-1}. The species differed in chemical composition and quantity with their difference in production (Russell et al., 2007).

In the rhizosphere of *Aegle marmelos* the amount of water affect soil chemical properties. Soil pH, organic carbon, C:N ratio, available N and available P were recorded maximum in monsoon, whereas electrical conductivity and total nitrogen content were found maximum in post-monsoon Shilpkar et al. (2010). Cold temperature during winter reduces nutrient availability however, in summer very high temperature fixes the added P. shading, irrigation and agronomic practices favorably lower the soil temperature. Changes in temperature and moisture content affected net nitrogen mineralization. Temperature sensitivity was maximal at 25^0C and optimum soil moisture for nitrogen mineralization was 80% to 100% Guntinas (2012). The availability of micronutrients depends on soil pH, organic carbon content and absorptive surface like $CaCO_3$ and clay content and other physical, chemical and biological conditions of the rhizosphere Shukla et al. (2015). In citrus orchards, the soil pH was found within safe limits and available N (N) and phosphorus (P) were reported low while micronutrients like Fe, Mn and Cu were found in optimum and Zn in deficient limit Ghagare (2017). Soil physicochemical properties in rhizospheric soils of eight common deciduous fruit trees in northern China were studied by Peng et al. (2018) and found that the available minerals, pH, microbial utilization of six types of carbon (C) substrates varied among tree species. Wang et al. (2018) reported that all the edaphic properties and soil enzymatic activities in rhizospheric soil were significantly affected by the seasonal changes, except for the C/N ratio. Luo *et al.*, 2019 found that Simpson and Shannon-Wiener indexes were significantly negatively correlated with seasonal changes in the soil pH, TOC, TN and CEC.

The present study was carried out with the objective to study; the physico-chemical properties during different seasons in the rhizospheric soils of seven fruit species that are commonly grown in Northern India to develop new strategies for nutrient management and better health of fruit orchards through nutrient cycling.

MATERIALS AND METHODS

Study Plants

Soil samples were collected from the experimental orchards of the Department of Horticulture, CCS Haryana Agricultural University, Hisar, situated at 215.2 m above mean sea level with coordinates of 29º10^0 N latitude and 75º46^0 E longitudes. The following seven orchards of fruit tree species (Table 1) were used during the course of this investigation to assess chemical properties of soil and microbial populations in rhizosphere along with control i.e. uncultivated land.

Table 1: List of fruit tree species orchards studied during investigation

S.No.	Fruit Tree Species	Scientific name	Rootstock	Spacing
1	Mango	*Mangifera indica*	Deshi mango seedling	10 m x 10 m
2	Guava	*Psidium guajava*	L-49	6 m x 6 m
3	Sweet orange	*Citrus sinensis*	Rough lemon seedling	6 m x 6 m
4	Jamun	*Syzygium cuminii*	Deshijamun seedling	10 m x 10 m
5	Aonla	*Emblica officinalis*	Deshiaonla seedling	10 m x 10 m
6	Bael	*Aegle marmelos*	Deshibael seedling	10 m x 10 m
7	Ber	*Ziziphus mauritiana*	*Ziziphus rotundifolia*	10 m x 10 m

Collection and preparation of soil samples

For maximum representation of orchards, each fruit orchard was divided into three replication block. Ten samples from each replication were collected with the help of auger from the rhizospheric soil (under canopy) i.e. one meter away from the tree trunk and 0-30 cm depth as well as from inter row spaces (non-rhizospheric soil) during summer, rainy and winter season in zig-zag pattern for randomization. For control, soil samples were collected in the same manner from uncultivated land/fallow land near the orchard. Each set of ten samples/replication were mixed together to make a composite sample. Nearly 1.0 kg of soil sample was taken from each composite samples and this sample was placed in a sterile well marked plastic bag. The soil samples were shade dried in the laboratory for determination of physico-chemical properties. Soil reaction (pH) was determined using pH meter, electrical conductivity (dSm^{-1}) was determined using a conductivity meter, (Jackson, 1973). cation exchange capacity (CEC) was determined by using flame photometer, organic carbon was determined by Walkley and Black's "Wet Digestion Method" as outlined by Jackson (1973). CN Ratioof carbon and nitrogen in the rhizospheric soils, available nitrogen was determined Subbaiah and Asija's 1956 method; available phosphorus was estimated by Olsen, 1954 method, available potassium was estimated by Muhr et al. 1965 method, available Fe, Mn and Zn were determined by DTPA method (Lindsay and Norvell, 1978). available boron was assessed by Berger and Troug 1939 method.

RESULT AND DISCUSSION

pH

The pH of orchard soil varied in different fruit tree orchards, seasons and sampling sites. The highest pH (8.31) was found in aonla orchard which was at par with sweet orange (8.27), mango (8.26) and bael (8.21) orchards while minimum pH (8.10) was found in ber orchard which was at par with guava (8.11) orchards. Similarly, Lakshmanan et al. (2014) also reported that soil properties are modified by range of processes occurring during tree growth and plant roots can influence the surrounding soil and inhabiting organisms and thereby, changing soil properties (Table 2).

Orchard soil pH differed significantly among the seasons. Maximum pH (8.26) was recorded during summer season followed by rainy season (8.18) and winter season (8.05). Shilpkar et al. (2010) commented that amount of water in rhizosphere soil was found to affect chemical properties of soil and contrast to our findings reported maximum pH in monsoon season.

While comparing sampling sites, higher pH (8.19) was observed in inter row non-rhizospheric soil which was significantly higher than under canopy rhizospheric soil pH (8.13). The lower pH under the canopy of fruit orchards may be due to higher organic matter due to litter fall than inter rows of fruit trees. Moreover, under the canopy, fertilizer application and addition of FYM during orchard management further decreases the pH due to release of organic acid and more depletion of basic ions by crops. Balota et al. (2011) also confirmed our results that pH under the tree canopy was lower than in the inter row because acidification processes are more intense near the edge of the tree canopy.

These results are in accordance with the findings of Wong et al. (2008) who reported decrease in pH with the addition of organic residue and manure due to production of organic acid in fertilized plot over control.

Table 2: Effect of seasonal variation and sampling sites on pH in orchard soil of different fruit tree species

2a: Fruit tree species x Seasons x Sampling sites (Ax B x C)

Seasons (B)	Sampling sites (C)	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	Mean
Summer	Under Canopy	8.27	8.17	8.07	8.21	8.42	8.34	8.37	7.93	8.22
	Inter row space	8.41	8.26	8.24	8.32	8.40	8.35	8.42	7.93	8.29
Rainy	Under Canopy	8.22	8.09	8.05	8.17	8.34	8.25	8.29	7.84	8.16
	Inter row space	8.30	8.21	8.19	8.29	8.34	8.23	8.23	7.84	8.20
Winter	Under Canopy	8.19	7.86	7.93	8.01	8.11	8.21	8.11	7.76	8.02
	Inter row space	8.19	8.07	8.15	8.17	8.21	7.89	8.21	7.76	8.08
	Mean	**8.26**	**8.11**	**8.11**	**8.20**	**8.30**	**8.21**	**8.27**	**7.84**	

2b: Fruit tree species x Seasons (A x B)

Seasons (B)	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Summer	8.34	8.22	8.15	8.27	8.41	8.35	8.39	7.93	**8.26**
Rainy	8.26	8.15	8.12	8.23	8.34	8.24	8.26	7.84	**8.18**
Winter	8.19	7.96	8.04	8.09	8.16	8.05	8.16	7.76	**8.05**

2c: Fruit tree species x Sampling sites (A x C)

Sampling sites (C)	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Under Canopy	8.23	8.04	8.01	8.13	8.29	8.27	8.26	7.84	**8.13**
Inter row space	8.30	8.18	8.19	8.26	8.31	8.16	8.29	7.84	**8.19**
Mean	**8.26**	**8.11**	**8.11**	**8.20**	**8.30**	**8.21**	**8.27**	**7.84**	

2d: Seasons x Sampling sites (B x C)

Seasons (B)	Under Canopy	Inter Row space	Mean
Summer	8.22	8.29	8.26
Rainy	8.16	8.20	8.18
Winter	8.02	8.08	8.05
Mean	8.13	8.19	

CD	(P=0.05)
Fruit Species (A)	0.09
Seasons (B)	0.06
Sampling sites(C)	0.05
A X C	NS
B X C	NS
A X B	NS
A X B X C	NS

Electrical Conductivity (EC)

Electrical conductivity (EC) of all fruit orchards differed significantly from control except jamun (0.26 dS/m^{-1}) which was found at par with control (0.27 dS/m^{-1}). The highest electrical conductivity (0.33 dS/m^{-1}) was observed in sweet orange orchard followed by ber (0.31 dS/m^{-1}) while lowest EC (0.24 dS/m^{-1}) was recorded in aonla and bael orchard which was found at par with mango, guava and jamun, The results are in confirmation with Pal et al. (2013) and Sharma et al. (2013) who reported that no significant difference was found in EC under different land use systems. QingxiaFu et al. (2015) reported that age of the kiwifruit affected the EC in comparison to wasteland. Root exudates having phenolic compounds, ferulic acid, HCN and benzoic acid have serious effect on soil EC (Table 3).

Among the different seasons studied lowest EC (0.25 dS/m^{-1}) was recorded during rainy season while maximum (0.28 dS/m^{-1}) was found during winter and summer season (0.28 dS/m^{-1}). This might be due to highest moisture content during rainy season as compared to winter season. Shilpkar et al. (2010) commented that amount of water in rhizosphere soil was found to affect chemical properties of soil. Similar to our findings, electrical conductivity was found maximum in post-monsoon.

No significant difference was observed in both the sampling sites i.e. under canopy (0.27 dS/m^{-1}) rhizospheric soil and non-rhizospheric soil of inter row space (0.26dS/m^{-1}).

Table 3: Effect of seasonal variation and sampling sites on electrical conductivity (dSm^{-1}) in orchard soil of different fruit tree species

3a: Fruit tree species x Seasons x Sampling sites (Ax B x C)										
Seasons (B)	**Sampling sites (C)**	**Fruit tree species (A)**								
		Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	Mean
Summer	Under Canopy	0.27	0.24	0.31	0.28	0.25	0.26	0.34	0.29	0.28
	Inter row space	0.25	0.26	0.29	0.29	0.23	0.24	0.32	0.29	0.27
Rainy	Under Canopy	0.24	0.22	0.30	0.22	0.24	0.20	0.32	0.26	0.25
	Inter row space	0.22	0.23	0.27	0.24	0.22	0.20	0.31	0.26	0.24
Winter	Under Canopy	0.27	0.28	0.32	0.28	0.26	0.27	0.34	0.25	0.28
	Inter row space	0.26	0.29	0.33	0.27	0.24	0.24	0.32	0.25	0.27
	Mean	**0.25**	**0.25**	**0.30**	**0.26**	**0.24**	**0.24**	**0.33**	**0.27**	
3b: Fruit tree species x Seasons (A x B)										
Seasons (B)		**Fruit tree species (A)**								
		Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Summer		0.26	0.25	0.30	0.29	0.24	0.25	0.33	0.29	**0.28**
Rainy		0.23	0.23	0.29	0.23	0.23	0.20	0.32	0.26	**0.25**
Winter		0.26	0.28	0.33	0.28	0.25	0.26	0.33	0.25	**0.28**
3c: Fruit tree species x Sampling sites (A x C)										
Sampling sites (C)		**Fruit tree species (A)**								
		Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Under Canopy		0.26	0.25	0.31	0.26	0.25	0.24	0.33	0.27	**0.27**
Inter row space		0.24	0.26	0.30	0.27	0.23	0.23	0.32	0.27	**0.26**
Mean		**0.25**	**0.25**	**0.30**	**0.26**	**0.24**	**0.24**	**0.33**	**0.27**	
3d: Seasons x Sampling sites (B x C)										
Seasons (B)		**Seasons (B)**				CD				(P=0.05)
		Under Canopy	Inter Row space	Mean		Fruit Species (A)				0.02
Summer		0.28	0.27	0.28		Seasons (B)				0.01
Rainy		0.25	0.25	0.25		Sampling sites(C)				NS
Winter		0.28	0.28	0.28		A X C				NS
Mean		0.27	0.26			B X C				NS
						A X B				NS
						A X B X C				NS

Cation exchange capacity (CEC)

Cation exchange capacity (CEC) of all fruit orchards and control differed significantly. Jamun orchard soil had maximum CEC [0.67 Cmol (p+)/kg] which was found at par with bael orchard [0.66 Cmol (p+)/kg] while, lowest CEC [0.50 Cmol (p+)/kg] was obtained in aonla orchard. The reason behind this may be higher organic carbon content in the horticultural land use system and CEC is positively correlated to organic matter content which increases the surface area of soil and thus exchange capacity is increased. The results of the study are in confirmation with Somasundaram et al. (2009) and Sharma et al. (2013) as they found higher CEC in cultivated soils, agri-horticulture system than barren lands (Table 4).

During the different seasons, lowest CEC [0.54 Cmol (p+)/kg] was found during rainy season and increased significantly during summer season [0.59 Cmol (p+)/kg] and highest CEC [0.62 Cmol (p+)/kg] was recorded during winter season. Osobamiro et al. (2018) stated that temperature gives a significant negative correlation with O.C, O.M, CEC and % silt. As decreased rainfall predicted in climate change will lead to decrease in soil properties like CEC, % clay.

Between sampling sites higher CEC [0.60 Cmol (p+)/kg] was observed under canopy rhizospheric soil and lower CEC [0.57 Cmol (p+)/kg] was measured in inter row space of fruit orchards. The results are in accordance with Balota et al. (2011) as CEC under the canopy was found higher than inter row in different tree species. The increase in the rate of decomposition of organic materials leads to high CEC.

Table 4: Effect of seasonal variation and sampling sites on Cation exchange capacity [Cmol(p+)/kg] in orchard soil of different fruit tree species

4a: Fruit tree species x Seasons x Sampling sites (Ax B x C)

Seasons (B)	**Sampling sites (C)**	**Fruit tree species (A)**								
		Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	Mean
Summer	Under Canopy	0.64	0.58	0.55	0.69	0.51	0.63	0.58	0.50	0.58
	Inter row space	0.65	0.59	0.50	0.72	0.49	0.71	0.64	0.50	0.60
Rainy	Under Canopy	0.57	0.52	0.47	0.60	0.46	0.58	0.51	0.45	0.52
	Inter row space	0.67	0.60	0.44	0.63	0.44	0.68	0.61	0.45	0.56
Winter	Under Canopy	0.62	0.57	0.54	0.69	0.55	0.65	0.55	0.66	0.60
	Inter row space	0.73	0.61	0.58	0.66	0.54	0.70	0.67	0.66	0.64
	Mean	**0.65**	**0.58**	**0.51**	**0.67**	**0.50**	**0.66**	**0.59**	**0.54**	

4b: Fruit tree species x Seasons (A x B)

Seasons (B)	**Fruit tree species (A)**								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Summer	0.65	0.59	0.53	0.71	0.50	0.67	0.61	0.50	**0.59**
Rainy	0.62	0.56	0.45	0.61	0.45	0.63	0.56	0.45	**0.54**
Winter	0.67	0.59	0.56	0.68	0.55	0.68	0.61	0.66	**0.62**

4c: Fruit tree species x Sampling sites (A x C)

Sampling sites (C)	**Fruit tree species (A)**								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Under Canopy	0.61	0.55	0.52	0.66	0.51	0.62	0.55	0.54	**0.57**
Inter row space	0.68	0.60	0.50	0.67	0.49	0.70	0.64	0.54	**0.60**
Mean	**0.65**	**0.58**	**0.51**	**0.67**	**0.50**	**0.66**	**0.59**	**0.54**	

4d: Seasons x Sampling sites (B x C)

Seasons (B)	**Sampling sites (C)**		
	Under Canopy	Inter Row space	Mean
Summer	0.58	0.60	0.59
Rainy	0.52	0.56	0.54
Winter	0.60	0.64	0.62
Mean	0.57	0.60	

CD	(P=0.05)
Fruit Species (A)	0.01
Seasons (B)	0.01
Sampling sites(C)	0.01
A X C	0.02
B X C	0.02
A X B	0.01
A X B X C	0.03

Organic carbon

Organic carbon content in orchard soils of different fruit tree species was found highly significant over control (0.43 %). Highest organic carbon (0.54%) was observed in jamun orchard while lowest (0.43 %) was found in control. Higher organic carbon in horticultural crops may be accounted to continuous addition of organic waste or matter through litter fall and addition of FYM in the orchard soil (Table 5). Similar results are earlier reported by Somasundaram et al. (2009); Liding et al. (2011) and Sofi et al. (2012).

During different seasons, maximum (0.51%) organic carbon content was found during winter, followed by rainy (0.49 %) and summer season (0.47%). Sofi et al. (2012) reported higher organic carbon content due to lower ambient temperature in the higher altitude in apple orchards. In summer season increased soil temperature made soil susceptible to soil erosion and thereby reducing soil organic carbon. These results are in accordance with, Osobamiro et al. (2018) who reported that rainfall and percent relative humidity showed significant positive correlation with organic carbon, complementing with our results that OC content increased from summer to rainy season. Similar findings were given by Shilpkar et al. (2010) that OC content increase in monsoon season.

Between sampling sites, under canopy rhizospheric soils had higher organic carbon (0.53%) than inter row space (0.45%) of fruit orchards. This might be due to more shading and moisture content as well as decomposition of litter under the canopy as compared to inter row space.

Table 5: Effect of seasonal variation and sampling sites on organic carbon (%) in orchard soil of different fruit tree species

5a: Fruit tree species x Seasons x Sampling sites (Ax B x C)

Seasons (B)	Sampling sites (C)	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	Mean
		Fruit tree species (A)								
Summer	Under Canopy	0.53	0.52	0.51	0.58	0.46	0.53	0.52	0.41	0.51
	Inter row space	0.45	0.44	0.41	0.46	0.40	0.46	0.45	0.41	0.43
Rainy	Under Canopy	0.56	0.55	0.52	0.60	0.49	0.56	0.54	0.44	0.53
	Inter row space	0.48	0.46	0.43	0.47	0.42	0.48	0.46	0.44	0.46
Winter	Under Canopy	0.56	0.55	0.54	0.61	0.52	0.59	0.56	0.45	0.55
	Inter row space	0.51	0.47	0.44	0.49	0.42	0.51	0.49	0.45	0.47
	Mean	**0.52**	**0.50**	**0.48**	**0.54**	**0.45**	**0.52**	**0.50**	**0.43**	

5b: Fruit tree species x Seasons (A x B)

Seasons (B)	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
	Fruit tree species (A)								
Summer	0.49	0.48	0.46	0.52	0.43	0.50	0.48	0.41	**0.47**
Rainy	0.52	0.50	0.48	0.54	0.46	0.52	0.50	0.44	**0.49**
Winter	0.54	0.51	0.49	0.57	0.47	0.55	0.53	0.45	**0.51**

5c: Fruit tree species x Sampling sites (A x C)

Sampling sites (C)	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
	Fruit tree species (A)								
Under Canopy	0.55	0.54	0.52	0.61	0.49	0.56	0.54	0.43	**0.53**
Inter row space	0.48	0.45	0.43	0.47	0.42	0.48	0.47	0.43	**0.45**
Mean	**0.52**	**0.50**	**0.47**	**0.54**	**0.45**	**0.52**	**0.50**	**0.43**	

5d: Seasons x Sampling sites (B x C)

Seasons (B)	Under Canopy	Inter Row space	Mean
	Sampling sites		
Summer	0.51	0.44	0.47
Rainy	0.53	0.46	0.49
Winter	0.55	0.47	0.51
Mean	0.53	0.45	

CD	(P=0.05)
Fruit Species (A)	0.02
Seasons (B)	0.01
Sampling sites(C)	0.01
A X C	NS
B X C	0.02
A X B	NS
A X B X C	NS

CN ratio

CN ratio observed in rhizospheric and non rhizospheric soils of different fruit tree species significantly varied from control (9.95) with highest CN ratio observed in jamun orchards. Osobamiro et al. (2018) reported that arable soils have the highest C/N ratio though the maximum value for oil palm soil is higher than that of arable soil. Excess C may be released in form of CO_2 when C/N ratio is low; organisms make use of the available carbon and excess N loss as ammonia (Table 6).

During different seasons, highest CN ratio (10.21) was found in rainy season followed by winter (9.76) and summer (8.63) in different fruit orchards. Shilpkar et al. (2010) commented similar to our findings that CN ratio in soil was maximum during monsoon season. Osobamiro et al. (2018) stated similarly that C/N ratio in rainy season is higher than in dry season in all the sampled soils.

Between sampling sites, under canopy rhizospheric soil was found to have lower CN ratio (9.02) as compared to inter row space (10.05) of different fruit orchards. This may be due to lesser increase in organic carbon and more decrease in the N content in inter row space as compared to rhizospheric soil as evident from the present investigation. More the C/N ratio above 10-12; there is greater the chances of these nutrients being immobilized by micro-organisms which render them unavailable to plants (Brady & Weil, 2008).

Table 6: Effect of seasonal variation and sampling sites on carbon to nitrogen ratio (C:N) in orchard soil of different fruit tree species

6a: Fruit tree species x Seasons x Sampling sites (Ax B x C)

Seasons (B)	Sampling sites (C)	Fruit tree species (A)								
		Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	Mean
Summer	Under Canopy	9.10	7.02	6.10	10.16	8.22	8.11	6.44	9.55	8.09
	Inter row space	8.95	7.23	7.81	11.14	9.87	9.65	9.55	9.17	9.17
Rainy	Under Canopy	10.57	6.94	7.67	13.33	10.59	10.13	7.66	10.34	9.65
	Inter row space	11.33	10.08	8.56	12.11	10.71	11.45	11.58	10.34	10.77
Winter	Under Canopy	9.97	7.51	7.38	11.04	9.54	10.01	8.86	10.14	9.31
	Inter row space	11.33	8.87	9.15	11.99	9.98	11.06	9.16	10.14	10.21
	Mean	**10.21**	**7.94**	**7.78**	**11.63**	**9.82**	**10.07**	**8.88**	**9.95**	

6b: Fruit tree species x Seasons (A x B)

Seasons (B)	Fruit tree species (A)								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Summer	9.03	7.13	6.96	10.65	9.05	8.88	8.00	9.36	**8.63**
Rainy	10.95	8.51	8.12	12.72	10.65	10.79	9.62	10.34	**10.21**
Winter	10.65	8.19	8.26	11.52	9.76	10.54	9.01	10.14	**9.76**

6c: Fruit tree species x Sampling sites (A x C)

Sampling sites (C)	Fruit tree species (A)								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Under Canopy	9.88	7.16	7.05	11.51	9.45	9.42	7.65	10.01	**9.02**
Inter row space	10.54	8.73	8.51	11.75	10.19	10.72	10.09	9.88	**10.05**
Mean	**10.21**	**7.94**	**7.78**	**11.63**	**9.82**	**10.07**	**8.88**	**9.95**	

6d: Seasons x Sampling sites (B x C)

Seasons (B)	Sampling sites		
	Under Canopy	Inter Row space	Mean
Summer	8.09	9.17	8.63
Rainy	9.65	10.77	10.21
Winter	9.31	10.21	9.76
Mean	9.02	10.05	

CD		(P=0.05)
Fruit Species (A)		0.52
Seasons (B)		0.32
Sampling sites(C)		0.26
A X C		NS
B X C		0.73
A X B		NS
A X B X C		1.27

Available Nitrogen

All the fruit tree orchards had significantly higher available nitrogen over control (85.61 kg/ha). Guava orchard soil had maximum available nitrogen (126.26 kg/ha) while, lowest available nitrogen (91.44 kg/ha) was found in jamun orchard. Maximum nitrogen in guava orchard may be due to high application nitrogenous fertilizers and minimum in jamun might be due to deep rooted, hardy nature of crop and poor orchard management practices as compared to other fruit crops. The amount of nitrogen found higher (26.98%) under cultivated soils as compared to uncultivated soils (Table 7). The possible reason identified for the result is higher addition of fertilizers and manures under the canopy in cultivated or orchard soil and also has better physical condition of soil. The increase in available N in soils of Haryana under different cropping system with the application of fertilizers and manures was also reported by several workers (Antil & Singh, 2007; & Devraj et al., 2013).

During the different seasons, lowest available nitrogen (98.50 kg/ha) was found during rainy season while highest available nitrogen (111.15 kg/ha) was measured during summer season. This may be due to excessive application of fertilizer in the spring season or less during rainy season is due to leaching as well as maximum utilization of nitrogen by the plants as new growth takes place during rainy season. Contrast to our findings, Shilpkar et al. (2010) reported that available nitrogen in soil was found minimum in post monsoon and maximum in monsoon.

Between sampling sites, lower available nitrogen (90.04 kg/ha) was observed in inter row space of fruit orchards while, higher available nitrogen (119.39 kg/ha) was measured under canopy rhizospheric soil. Balota et al. (2011) available nitrogen under the canopy was found higher than inter row in different tree species. Kreyling et al. (2012) reported the concentration of soil organic matter changed seasonally due to litter input and the microbial degradation activity, as well as other nutrients, such as N and P cycling.

Table 7: Effect of seasonal variation and sampling sites on available nitrogen (kg/ha) in orchard soil of different fruit tree species

7a: Fruit tree species x Seasons x Sampling sites (Ax B x C)

Seasons (B)	**Sampling sites (C)**	**Fruit tree species (A)**								
		Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	Mean
Summer	Under Canopy	114.00	148.00	163.67	112.67	110.33	128.67	157.67	84.67	127.46
	Inter row space	98.67	118.33	104.00	81.33	82.33	94.33	92.10	87.67	94.85
Rainy	Under Canopy	104.33	155.33	134.00	89.67	92.03	108.00	138.33	84.33	113.25
	Inter row space	83.67	88.87	98.55	76.29	77.61	82.13	78.47	84.33	83.74
Winter	Under Canopy	110.33	143.00	143.67	108.67	106.33	115.67	125.67	86.33	117.46
	Inter row space	89.33	104.00	94.33	80.00	83.33	90.67	104.33	86.33	91.54
	Mean	**100.06**	**126.26**	**123.04**	**91.44**	**91.99**	**103.25**	**116.10**	**85.61**	

7b: Fruit tree species x Seasons (A x B)

Seasons (B)	**Fruit tree species (A)**								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Summer	106.33	133.17	133.83	97.00	96.33	111.50	124.88	86.17	**111.15**
Rainy	94.00	122.10	116.28	82.98	84.82	95.07	108.40	84.33	**98.50**
Winter	99.83	123.50	119.00	94.33	94.83	103.17	115.00	86.33	**104.50**

7c: Fruit tree species x Sampling sites (A x C)

Sampling sites (C)	**Fruit tree species (A)**								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Under Canopy	109.56	148.78	147.11	103.67	102.90	117.44	140.56	85.11	**119.39**
Inter row space	90.56	103.73	98.96	79.21	81.09	89.04	91.63	86.11	**90.04**
Mean	**100.06**	**126.26**	**123.04**	**91.44**	**91.99**	**103.25**	**116.10**	**85.61**	

7d: Seasons x Sampling sites (B x C)

Seasons (B)	**Sampling sites**		
	Under Canopy	Inter Row space	Mean
Summer	127.46	94.85	111.15
Rainy	113.25	83.74	98.50
Winter	117.46	91.54	104.50
Mean	119.39	90.04	

CD	(P=0.05)
Fruit Species (A)	3.84
Seasons (B)	2.35
Sampling sites(C)	1.92
A X C	6.65
B X C	5.43
A X B	3.33
A X B X C	9.41

Available Phosphorus

Sweet orange orchard soil had maximum available phosphorus (38.24 kg/ha) while, lowest available phosphorus (28.70 kg/ha) was found in bael orchard. Somasundaram et al. (2009) reported higher phosphorus in cultivated land or kitchen garden than barren land because of addition of fertilizers and manures in cultivated land and replenishment of nutrients which reduces losses due to erosion and fixation. Maximum phosphorus content in sweet orange orchard may be due to more application of phosphatic fertilizers (Table 8).

During the different seasons, lowest available phosphorus (27.02 kg/ha) was found during summer season while highest available phosphorus (31.62 kg/ha) was measured during rainy season. Wekha et al. (2016) also found similar results indicating higher phosphorus levels in soil during rainy season. Similar findings were earlier reported by Shilpkar et al. (2010) who found that after application of mono-calcium phosphate fertilizer, it reacts with moisture to form phosphoric acid which progressively releases hydrogen ions to the soil leading to an acidifying effect, decreasing soil pH and increasing availability and uptake of phosphorus.

Between sampling sites, all the fruit orchards had lower available phosphorus (27.30 kg/ha) in inter row space while higher available phosphorus (31.41 kg/ha) was measured under the canopy of fruit orchards. Balota et al. (2011) confirmed our results that soil P concentration was higher under the tree canopy than in the inter row where P fertilizer is applied onto soil surface and organic matter is high due to litter fall. Augustine and Joseph (1992) also found higher level of P under the canopy of trees than open grasslands.

Table 8: Effect of seasonal variation and sampling sites on available phosphorus (kg/ha) in orchard soil of different fruit tree species

8a: Fruit tree species x Seasons x Sampling sites (Ax B x C)

Seasons (B)	**Sampling sites (C)**	**Fruit tree species (A)**								
		Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	Mean
Summer	Under Canopy	27.15	35.33	24.74	31.80	27.25	29.50	43.38	13.27	29.05
	Inter row space	24.74	26.54	18.36	27.55	25.94	25.55	37.88	13.27	24.98
Rainy	Under Canopy	34.79	38.00	37.56	36.33	35.38	33.57	37.67	12.54	33.23
	Inter row space	29.00	39.82	32.25	32.11	28.99	26.64	38.81	12.54	30.02
Winter	Under Canopy	31.30	40.75	34.90	33.58	32.28	32.18	37.92	12.72	31.95
	Inter row space	25.79	36.08	29.14	26.83	26.04	24.74	33.78	12.72	26.89
	Mean	**28.80**	**36.09**	**29.49**	**31.37**	**29.31**	**28.70**	**38.24**	**12.84**	

8b: Fruit tree species x Seasons (A x B)

Seasons (B)	**Fruit tree species (A)**								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Summer	25.95	30.94	21.55	29.67	26.60	27.52	40.63	13.27	**27.02**
Rainy	31.90	38.91	34.91	34.22	32.18	30.11	38.24	12.54	**31.62**
Winter	28.54	38.41	32.02	30.20	29.16	28.46	35.85	12.72	**29.42**

8c: Fruit tree species x Sampling sites (A x C)

Sampling sites (C)	**Fruit tree species (A)**								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Under Canopy	31.08	38.03	32.40	33.90	31.64	31.75	39.66	12.84	**31.41**
Inter row space	26.51	34.14	26.58	28.83	26.99	25.64	36.82	12.84	**27.30**
Mean	**28.80**	**36.09**	**29.49**	**31.37**	**29.31**	**28.70**	**38.24**	**12.84**	

8d: Seasons x Sampling sites (B x C)

Seasons (B)	**Sampling sites**		
	Under Canopy	Inter Row space	Mean
Summer	29.05	24.98	27.02
Rainy	33.23	30.02	31.62
Winter	31.95	26.89	29.42
Mean	31.41	27.30	

CD	(P=0.05)
Fruit Species (A)	2.10
Seasons (B)	1.29
Sampling sites(C)	1.05
A X C	3.64
B X C	NS
A X B	NS
A X B X C	NS

Available Potassium

Guava orchard soil had maximum available potash (284.93 kg/ha) while, lowest available potash (230.28 kg/ha) was found in aonla orchard. Mandal and Jayaprakash (2012) reported higher available K in citrus orchards compared to maize soil. Higher amount of K in horticulture orchards is due to higher and frequent use of potassic fertilizers and moreover, continuous litter fall replenish the uptake pool of K. Peng et al. (2018) reported that available K content of peach soil was much higher than of the other samples, while the lowest available K content was found in the grape and cherry soils (Table 9).

During the different seasons, highest available K (258.57 kg/ha) was found during winter season while lowest available K (252.96 kg/ha) was observed during summer season. However, available K during rainy season was found at par with summer season (253.21 kg/ha). This may be due to maximum utilization of potash by the growing plants during summer season and higher potash during winter might be due to foliar sprays of water soluble fertilizers on fruit trees added to the under canopy soils, due to dipping and fall. Between sampling sites at different fruit orchards lower available K (242.97 kg/ha) was observed in inter row space of fruit orchards while higher available K (266.86 kg/ha) was found under the canopy of fruit trees. This might be due to more application of K to fruit orchards under the canopy only, more buildup of K due to shading and more moisture effect as well as more litter fall under the canopy.

Table 9: Effect of seasonal variation and sampling sites on available potassium (kg/ha) in orchard soil of different fruit tree species

9a: Fruit tree species x Seasons x Sampling sites (Ax B x C)

Seasons (B)	Sampling sites (C)	Fruit tree species (A)								
		Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	Mean
Summer	Under Canopy	292.61	315.33	275.67	272.67	233.83	239.67	253.00	224.67	263.43
	Inter row space	266.70	246.27	265.67	247.67	222.83	235.17	231.00	224.67	242.50
Rainy	Under Canopy	296.43	325.67	277.70	282.57	237.33	244.67	249.67	210.63	265.58
	Inter row space	265.67	245.67	264.67	246.67	223.33	236.00	234.00	210.63	240.83
Winter	Under Canopy	303.00	330.33	281.33	286.00	239.00	247.67	253.00	232.08	271.55
	Inter row space	268.33	246.30	269.67	248.33	225.33	238.33	236.33	232.08	245.59
	Mean	**282.12**	**284.93**	**272.45**	**263.99**	**230.28**	**240.25**	**242.83**	**222.46**	

9b: Fruit tree species x Seasons (A x B)

Seasons (B)	Fruit tree species (A)								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Summer	279.66	280.80	270.67	260.17	228.33	237.42	242.00	224.67	**252.96**
Rainy	281.05	285.67	271.18	264.62	230.33	240.33	241.83	210.63	**253.21**
Winter	285.67	288.32	275.50	267.17	232.17	243.00	244.67	232.08	**258.57**

9c: Fruit tree species x Sampling sites (A x C)

Sampling sites (C)	Fruit tree species (A)								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Under Canopy	297.35	323.78	278.23	280.41	236.72	244.00	251.89	222.46	**266.86**
Inter row space	266.90	246.08	266.67	247.56	223.83	236.50	233.78	222.46	**242.97**
Mean	**282.12**	**284.93**	**272.45**	**263.99**	**230.28**	**240.25**	**242.83**	**222.46**	

9d: Seasons x Sampling sites (B x C)

Seasons (B)	Sampling sites		
	Under Canopy	Inter Row space	Mean
Summer	263.43	242.50	252.96
Rainy	265.58	240.83	253.21
Winter	271.55	245.59	258.57
Mean	266.86	242.97	

CD	(P=0.05)
Fruit Species (A)	2.46
Seasons (B)	1.51
Sampling sites(C)	1.23
A X C	4.26
B X C	3.48
A X B	2.13
A X B X C	NS

Available Micronutrients

Sweet orange orchard soil had maximum iron content (3.34 ppm), manganese content (8.09 ppm) and boron content (2.93 ppm) while ber orchard soil had maximum zinc content (2.10 ppm). The DTPA extractable micronutrients (Fe, Mn and Zn) along with boron content in rhizospheric and non-rhizospheric soils showed wide variation in different fruit tree species and during different seasons under the canopy and in inter rows of fruit orchards. Usha Kumari (2016) found that highest content of micronutrients like zinc in citrus orchard in comparison to guava orchard and vegetable cropping system. Contrast to it, Ajayi (2014) found that mineral elements (Fe, Cu, Ca and Pb) found under the pepper and plantain rhizosphere soils are in close range. So, no difference of crop species was reflected on micro-elements (Table 10, 11, 12, 13).

Table 10: Effect of seasonal variation and sampling sites on iron content (ppm) in orchard soil of different fruit tree species

10a:Fruit tree species x Seasons x Sampling sites (Ax B x C)

Seasons (B)	**Sampling sites (C)**	**Fruit tree species (A)**								
		Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	Mean
Summer	Under Canopy	2.73	2.50	2.73	3.27	2.61	2.43	3.19	2.06	2.69
	Inter row space	2.66	2.38	2.45	3.14	2.42	2.23	3.12	2.06	2.56
Rainy	Under Canopy	3.40	3.24	2.90	3.52	3.34	3.18	3.80	1.74	3.14
	Inter row space	3.26	3.11	2.56	3.49	3.26	3.05	3.64	1.74	3.02
Winter	Under Canopy	2.93	2.91	2.77	3.48	2.87	2.48	3.26	1.87	2.82
	Inter row space	2.77	2.57	2.56	3.00	2.74	2.88	3.05	1.87	2.68
	Mean	**2.96**	**2.79**	**2.66**	**3.32**	**2.87**	**2.71**	**3.34**	**1.89**	

10b: Fruit tree species x Seasons (A x B)

Seasons (B)	**Fruit tree species (A)**								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
-Summer	2.70	2.44	2.59	3.21	2.52	2.33	3.15	2.06	**2.63**
Rainy	3.33	3.18	2.73	3.51	3.30	3.12	3.72	1.74	**3.08**
Winter	2.85	2.74	2.67	3.24	2.81	2.68	3.15	1.87	**2.75**
Mean	**2.96**	**2.79**	**2.66**	**3.32**	**2.87**	**2.71**	**3.34**	**1.89**	

10c: Fruit tree species x Sampling sites (A x C)

Sampling sites (C)	**Fruit tree species (A)**								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Under Canopy	3.02	2.88	2.80	3.43	2.94	2.70	3.41	1.89	**2.89**
Inter row space	2.90	2.69	2.52	3.21	2.81	2.72	3.27	1.89	**2.75**
Mean	**2.96**	**2.79**	**2.66**	**3.32**	**2.87**	**2.71**	**3.34**	**1.89**	

10d: Seasons x Sampling sites (B x C)

Seasons (B)	**Sampling sites**				CD	(P=0.05)
	Under Canopy	Inter Row space	Mean		Fruit Species (A)	0.14
Summer	2.69	2.56	2.63		Seasons (B)	0.19
Rainy	3.14	3.02	3.08		Sampling sites(C)	0.07
Winter	2.82	2.68	2.75		A X C	0.24
Mean	2.89	2.75			B X C	NS
					A X B	NS
					A X B X C	NS

During the different seasons highest iron content (3.08 ppm) was found in rainy season while zinc, manganese and boron content in fruit orchards was recorded highest in summer season. The possible reason might be that fruit crops are highly responsive to micronutrients and application time is spring season, so all the applied micronutrients are not taken up by the plants as the summer season approaches. Shukla et al. (2015) reported that current status of Fe, Mn, Zn and B in soils of Haryana was 21.6%, 6.2%, 15.3% and 3.3% deficient, respectively. It may be because of improper management in orchard soils and response varies with crop, season and genotypes.

Table 11: Effect of seasonal variation and sampling sites on zinc content (ppm) in orchard soil of different fruit tree species

11a: Fruit tree species x Seasons x Sampling sites (Ax B x C)

Seasons (B)	**Sampling sites (C)**	**Fruit tree species (A)**								
		Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	Mean
Summer	Under Canopy	1.47	1.78	2.2	1.43	1.49	1.98	2.27	0.98	1.70
	Inter row space	1.87	1.89	2.23	1.58	1.79	2.11	2.39	0.98	1.86
Rainy	Under Canopy	1.37	1.76	2.08	1.39	1.36	1.86	1.99	0.85	1.58
	Inter row space	1.63	1.81	2.16	1.45	1.59	1.96	2.17	0.85	1.70
Winter	Under Canopy	1.68	1.56	1.92	1.84	1.71	1.69	1.64	1.03	1.63
	Inter row space	1.54	1.57	1.98	1.7	1.89	1.55	1.86	1.03	1.64
	Mean	**1.59**	**1.73**	**2.10**	**1.57**	**1.64**	**1.86**	**2.05**	**0.95**	

11b: Fruit tree species x Seasons (A x B)

Seasons (B)	**Fruit tree species (A)**								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Summer	1.67	1.83	2.22	1.51	1.64	2.05	2.33	0.98	**1.78**
Rainy	1.5	1.79	2.12	1.42	1.48	1.91	2.08	0.85	**1.64**
Winter	1.61	1.57	1.95	1.77	1.8	1.62	1.75	1.03	**1.64**
Mean	**1.59**	**1.73**	**2.10**	**1.57**	**1.64**	**1.86**	**2.05**	**0.95**	

11c: Fruit tree species x Sampling sites (A x C)

Sampling sites (C)	**Fruit tree species (A)**								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Under Canopy	1.51	1.7	2.07	1.55	1.52	1.85	1.97	0.95	**1.64**
Inter row space	1.68	1.76	2.12	1.58	1.75	1.87	2.14	0.95	**1.73**
Mean	**1.59**	**1.73**	**2.10**	**1.57**	**1.64**	**1.86**	**2.05**	**0.95**	

11d: Seasons x Sampling sites (B x C)

Seasons (B)	**Sampling sites (C)**				CD	(P=0.05)
	Under Canopy	Inter Row space	Mean		Fruit Species (A)	0.09
Summer	1.70	1.86	1.78		Seasons (B)	0.05
Rainy	1.58	1.70	1.64		Sampling sites(C)	0.04
Winter	1.63	1.64	1.64		A X C	0.15
Mean	1.64	1.73			B X C	NS
					A X B	0.08
					A X B X C	NS

Between sampling sites of different fruit tree species higher iron content manganese content and boron content was found under the canopy in rhizospheric soil of fruit trees, while zinc content was observed higher in non-rhizospheric soil of inter rows of fruit orchards. Higher amount of iron, manganese and boron are found in the soils having higher organic matter. Litter fall further enhances organic carbon under the canopy of fruit trees and so is the micronutrient content. Moreover, the foliar spray of micronutrients on fruit trees is added to the canopy soils, due to dipping and litter fall. Cheng et al. 2017 reported that Fe and Mn contents in orchard soils were higher than those in cropland soil and unused soil. Similar to it, Debnath et al. (2015) found that iron and manganese content was found higher in apricot orchard and other fruit tree species over the control, zinc content was found higher in control.

Table 12: Effect of seasonal variation and sampling sites on manganese content (ppm) in orchard soil of different fruit tree species

12a: Fruit tree species x Seasons x Sampling sites (Ax B x C)

Seasons (B)	Sampling sites (C)	Fruit tree species (A)								
		Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	Mean
Summer	Under Canopy	7.74	9.2	7.19	7.88	7.8	6.95	8.67	4.44	7.48
	Inter row space	7.67	7.71	6.98	7.7	7.69	6.76	8.47	4.44	7.18
Rainy	Under Canopy	7.52	8.97	6.96	7.54	7.77	6.78	7.91	4.4	7.23
	Inter row space	7.34	7.23	6.22	7.42	7.52	6.65	7.89	4.4	6.83
Winter	Under Canopy	7.21	7.68	6.54	7.43	7.43	6.53	7.7	4.35	6.86
	Inter row space	7.03	6.94	6.45	7.41	7.35	6.45	7.88	4.35	6.73
	Mean	**7.42**	**7.96**	**6.72**	**7.56**	**7.59**	**6.69**	**8.09**	**4.40**	

12b: Fruit tree species x Seasons (A x B)

Seasons (B)	Fruit tree species (A)								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Summer	7.7	8.45	7.08	7.79	7.74	6.86	8.57	4.44	**7.33**
Rainy	7.43	8.1	6.59	7.48	7.64	6.71	7.9	4.4	**7.03**
Winter	7.12	7.31	6.5	7.42	7.39	6.49	7.79	4.35	**6.80**
Mean	**7.42**	**7.96**	**6.72**	**7.56**	**7.59**	**6.69**	**8.09**	**4.40**	

12c: Fruit tree species x Sampling sites (A x C)

Sampling sites (C)	Fruit tree species (A)								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Under Canopy	7.49	8.62	6.9	7.62	7.66	6.75	8.09	4.4	**7.19**
Inter row space	7.35	7.29	6.55	7.51	7.52	6.62	8.08	4.4	**6.92**
Mean	**7.42**	**7.96**	**6.72**	**7.56**	**7.59**	**6.69**	**8.09**	**4.40**	

12d: Seasons x Sampling sites (B x C)

Seasons (B)	Sampling sites				CD	(P=0.05)
	Under Canopy	Inter Row space	Mean		Fruit Species (A)	NS
Summer	7.48	7.18	7.33		Seasons (B)	0.12
Rainy	7.23	6.83	7.03		Sampling sites(C)	0.09
Winter	6.86	6.73	6.80		A X C	0.33
Mean	7.19	6.91			B X C	0.27
					A X B	0.19
					A X B X C	NS

Table 13: Effect of seasonal variation and sampling sites on boron content (ppm) in orchard soil of different fruit tree species

13a: Fruit tree species x Seasons x Sampling sites (Ax B x C)

Seasons (B)	Sampling sites (C)	Fruit tree species (A)								
		Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	Mean
Summer	Under Canopy	1.56	2.69	2.7	2.12	1.59	1.59	3.09	1.44	2.10
	Inter row space	1.45	2.68	2.68	1.99	1.48	1.54	2.97	1.44	2.03
Rainy	Under Canopy	1.34	2.47	2.61	2.86	1.43	1.51	2.94	1.31	2.06
	Inter row space	1.3	2.41	2.56	1.91	1.41	1.5	2.92	1.31	1.92
Winter	Under Canopy	1.3	2.39	2.32	1.78	1.4	1.48	2.85	1.28	1.85
	Inter row space	1.26	2.36	2.5	1.65	1.38	1.4	2.8	1.28	1.83
	Mean	**1.37**	**2.50**	**2.56**	**2.05**	**1.45**	**1.50**	**2.93**	**1.34**	

13b: Fruit tree species x Seasons (A x B)

Seasons (B)	Fruit tree species (A)								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Summer	1.51	2.69	2.69	2.05	1.53	1.56	3.03	1.44	**2.06**
Rainy	1.32	2.44	2.58	2.39	1.42	1.5	2.93	1.31	**1.99**
Winter	1.28	2.37	2.41	1.71	1.39	1.44	2.83	1.28	**1.84**

13c: Fruit tree species x Sampling sites (A x C)

Sampling sites (C)	Fruit tree species (A)								
	Mango	Guava	Ber	Jamun	Aonla	Bael	Sweet orange	Control	**Mean**
Under Canopy	1.4	2.52	2.54	2.25	1.47	1.52	2.96	1.34	**2.00**
Inter row space	1.34	2.48	2.58	1.85	1.42	1.48	2.9	1.34	**1.92**
Mean	**1.37**	**2.50**	**2.56**	**2.05**	**1.45**	**1.50**	**2.93**	**1.34**	

13d: Seasons x Sampling sites (B x C)

Seasons (B)	Sampling sites				CD	(P=0.05)
	Under Canopy	Inter Row space	Mean		Fruit Species (A)	NS
Summer	2.10	2.03	2.07		Seasons (B)	0.06
Rainy	2.06	1.92	1.99		Sampling sites(C)	0.05
Winter	1.85	1.83	1.84		A X C	0.16
Mean	2.00	1.93			B X C	0.13
					A X B	0.09
					A X B X C	0.22

CONCLUSIONS

All the fruit tree species, season and sampling site and their interaction were found significantly affecting the pH CEC CN ratio, Electrical conductivity, available N, P, and K contents. Orchards showed an increase in available N, P, and K significantly over control i.e. uncultivated land. Zinc and iron contents were influenced significantly with fruit tree species, season and sampling sites. Manganese and boron content was not influenced significantly with fruit tree species treatment and influenced significantly by season and sampling sites.

REFERENCES

Ajayi, O. A. (2014). Rhizosphere microflora and physic chemical nature of selected garden soil.*Advances in Life Sciences, 4*(6), 253-259.

Antil, R. S., & Mandeep, S. (2007). Effect of organic manures and fertilizers on organic matter and nutrient status of the soil. *Archives of Agronomy and Soil Science, 53*(5), 519-528.

Augustine, Isichei, O., & Joseph, I. M. (1992). The effects of tree canopy cover on soil fertility in a nagave savanna. *Journal of Tropical Ecology, 8,* 329-336.

Balota, E. L., Machineski, O., Truber, P. V., & Auler, P. A. M. (2011). Effect of tillage systems and permanent groundcover intercropped with orange trees on soil enzyme activities. *Braz. Arch. Biol. Technol. 54*, 221–228.

Berger, K. C., & Truog, E. (1939). Boron determination in soils and plants. *Ind. Eng. Chem. Anal. Ed. 11*, 540-545.

Brady, N. C., & Weil, R. R. (2008). The Nature and Properties of Soils, 14th (ed); *Pearson Prentice Hall:* Upper Saddle River, NJ, USA.

Cheng, C., Zhao, D., Deguo, L. V., Shuang, L. I., & Du, G. (2017). Comparative study on microbial community structure across orchard soil, cropland soil, and unused soil.*Soil and water research 12*(4), 237-245.

Debnath, S., Patra, A. K., Ahmed, N., Kumar, S., & Dwivedi, B. (2015). Assessment of microbial biomass and enzyme activities in soil under temperate fruit crops in north western Himalayan region. *Soil Science and Plant Nutrition*, *15*(4), 848-866.

Raj, D., Antil, R. S., & Khokhar, K. K. (2013). Effect of nutrient management practices on yield, uptake and changes in soil fertility under cotton-wheat cropping system. *Indian Journal of Fertilisers*, *9*(7), 46-50.

Ghagare, R. B., Kuchanwar, O. D., Deotle, P. P., & Deshmukh, S. (2017). Effect of soil Fertility and nutrients availability in rhizosphere on citrus (*Citrus reticulata*) yield. *Current Horticulture 5*(1), 58-60.

Guntinas, M. E., Leiros, M. C., Trasar, C., & Gil-Sotres, F. (2012). Effects of moisture and temperature on net soil nitrogen mineralization: A laboratory study. *European Journal of Soil Biology*, *48*, 73-80.

Hinsinger, P., Bengough, A. G., Vetterlein, D., & Young, I. M. (2009). Rhizosphere: biophysics, biogeochemistry and ecological relevance. *Plant Soil*, *321*, 117–152.

Jackson, M. L. (1973).Soil chemical analysis. *Prentice Hall of India Pvt. Ltd*. New Delhi.

Kreyling, J., Persoh, D., Werner, S., Benzenberg, M., & Wollecke, J. (2012). Short-term impacts of soil freeze-thaw cycles on roots and root-associated fungi of Holcuslanatus and Calluna vulgaris. *Plant Soil*, *353,* 19–31.

Usha, K. (2016). Studies on soil organic carbon and organic nitrogen fractions under different land use systems of Haryana. M.Sc. Thesis, Chaudhary Charan Singh, Haryana Agricultural University, Hisar, India.

Lakshmanan, V., Selvaraj, G., & Bais, H. P. (2014). Functional soil microbiome: belowground solutions to an aboveground problem. *Plant Physiology, 166*, 689–700.

Lindsay, W. L., & Norvell, W. A. (1978). Development of a DTPA soil test for Zinc, iron, manganese and copper.*Soil Science Society of American Journal*, *42*, 421-428.

Luo, X., Wang, M. K., & Weng, G. B. (2019). Seasonal Change in Microbial Diversity and ItsRelationship with Soil Chemical Properties inan Orchard. *Plos one*, 1-15.

Mandal, D., & Jayaparkash, J. (2012). Land use effects on soil quality in humid sub-tropical region of India. *Journal of the Indian Society of Soil Science*, *60*(4), 269-275.

Muhr, G. R., Datta, N. P., Sankarasubramany, H., Laley, V. K., & Donahue, R. L. (1965). Critical soil test values for available N, P and K in different soils. In: Soil Testing in India. 2nd edition. USAID mission to India, New Delhi pp. 52-56.

Olsen, S. R., Cole, C. V., Watanabe, F. S., & Dean, L.A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *Circulation from United States Department of Agriculture*. 939. USDA, Washington, D.C.

Osobamiro, T. M., & Adewuyi, G. O. J. (2018). Determination of the Effect of Changes in Climatic Factors on the Variations in Soil Physicochemical Properties of Farm Settlements located in Ogun State, Nigeria. *Appl. Sci. Environ. Manage*, *22*(2), 252 -258.

Peng, S. I., Wei, S., Huili, Y., Xiaojing, Y., Dengtao, G., Xiansheng, Q., Zhiqiang, W., & Guoliang, W. (2018). Rhizosphere Microenvironments of Eight Common Deciduous Fruit Trees Were Shaped by Microbes in Northern China. *Frontiers in Microbiology, 9*, 3147.

QingxiaFu., Gu, J, Li., Qian, X., Sun, W., Wang, X., Gao, H., Zhen, L., & Lie, Y. (2015). Analysis of microbial biomass and community diversity in kiwifruit orchard soils of different planting ages. *Acta Ecologica Sinica, 35*, 22-28.

Russell, A. E., Raich, J. W., Valverde, O. J., & Fisher, R. F. (2007). Tree species effects on soil properties in experimental plantations in tropical moist Forest. *Soil SciSoc Am J, 71*, 1389–1397.

Sharma, Y. K., Sharma, A., & Sharma, S. K. (2013). An appraisal of physic-chemical characteristics and soil fertility status of forest and rice land use systems in Mokokchung district of Nagaland. *Journal of the Indian Society of Soil Sciences, 61*(1), 38-43.

Shilpkar, P., Shah, M. C., Modi, K. R., & Pate, S. M. (2010). Seasonal changes in microbial structure and nutrients content in rhizospheric soil of *Aegle marmelos* tree. *Annals of Forest Research. 53*(2), 135-140.

Shukla, A. K., Malik, R. S., Tiwari, P. K., Prakash, C., Behera, S. K., Yadav, H., Narwal, & R. P. (2015). Status of Micronutrient Deficiencies in Soils of Haryana Impact on Crop Productivity and Human Health. *Indian J. Fert*. *11*(5), 16-27.

Sofi, J. A., Rattan, R. K., & Datta, S. P. (2012). Soil Organic Carbon Pools in the Apple Orchards of Shopian District of Jammu and Kashmir. *Journal of Indian Society of Soil Sciences. 60*(3), 187-197.

Somasundaram, J., Singh, R. K., Parandiyal, A. K., & Prasad, S. N. (2009). Micronutrient status of soils under different land use systems in Chambal ravines. *Journal of Indian Society of Soil Sciences. 57*(3), 307-312.

Subbaiah, B. V., & Asija, G. L. (1956). A rapid procedure for the determination of available nitrogen in soil. *Current Science. 25*, 259-260.

Walkley, A. J., & Black, C. A. (1934). Estimation of soil organic carbon by the chromic acid titration method. *Soil Science*. *37*, 29-38.

Wang, H. H., Chu, H. L., Dou, Q., Xie, Q. Z., Tang, M., Sung, C. K., & Wang, Y. C. (2018). Phophorus and Nitrogen drive the seasonal dynamics of bacterial commiunities in pinus forest rhizospheric soil of the qinling mountains. *Frontiers in microbiology*, *9*, Article 1930.

Wekha, N. W., Korir, N. K., Ojulong, H. F., & Onyango, P. J. (2014). Effect of hosphaten levels on soil rhizosphere nutrient balances ond finger millet yield. *Asian Research Journal of agriculture*, *2*(1), Article-29606.

Wong, Vanessa, N. L., Dalal, R. C., Greene, & Richard, S. B. (2008). Salinity and sodicity effects on respiration and microbial biomass of soil. *Biology and Fertility of Soils*, *44*, 943-953.