Impact of Land Use Conversion from Paddy Fields to Apple Orchards on Soil Physical Properties in Kashmir

Abstract

There has been considerable increase in establishing the orchards on the elsewhere paddy fields from last few decades and considerable change in the soil properties are obvious to witness with this land use change. Inorder to ascertain the possible change in soil properties survey was carried out in three apple growing districts Baramulla, Pulwamma and Shopian. Soil samples from three depths (0-30, 30-60, 60-90 cm) were taken from both conventional and paddy converted apple orchards. The soil texture varied from Clay loam to silty clay loam.The mean of bulk density, porosity, aggregate stability, and soil water content in conventional and converted apple orchards was 1.109Mg $m^{-3}$and 1.107 Mg m^{-3}, 49.593 % and 50.860 %, 0.409mm and 0.280 mm, 14.274% and 13.940 %, respectively. Further, it was observed that bulk density, particle density, and porosity showed no significant difference in conventional and converted apple orchards, whereas, the aggregate stability and soil water content was higher in conventional orchards as compared to converted apple orchards.

Keywords: Apple orchards, Conventional orchards, Converted orchards, Physical Properties

1. Introduction

The land is a resource of prime importance in the economy of the country, and the increasing population coupled with an increase in demand for food has forced the conversion of land. Farmers are facing the problems of low income from their traditional farming system, which force them to move remunerative cropping system because of this they started following the trend of converting their agricultural land to horticultural land which is economically more beneficial. Inadequate soil management can quickly reduce vast amounts of land, which often threatens rural livelihood in many developing and developed countries (Gonzalez et al 2014). Land use change can drastically affect the soil environment, which in turn markedly influences soil properties (Chen et al 2000). Land use conversion from paddy to orchards has led to a decline in soil moisture, organic carbon, and physical properties such as bulk density, particle density and porosity (Dar et al 2015).

Apple (*Malus domestica* Borkh.) is the most popular and widely grown fruit crop throughout the world. In India, it is grown in Himachal Pradesh, Jammu and Kashmir, and Uttarakhand. The area and production under apple crop in Jammu and Kashmir was 163432 hectares including Kashmir 144733 hectares and Jammu 18699 hectares. The production of apples in the state is 1170306 metric tons with 1139180 metric tons in Kashmir and 31126 metric tons in the Jammu region (Anonymous, 2015). The leading districts of Kashmir in production and area are Shopian, Baramulla, Kulgam, Anantnag, and Pulwama, however Shopian and Pulwama districts of south Kashmir are well known for quality and production (Ganai et al 2018).

Changing how we use land can have a big impact on how soil works. This affects how things move around in the soil. From the surface to deeper down, and changes how the soil behaves (Bashir et al., 2022). The physical characteristics of soil are vital for providing nutrients to plants. When the bulk density of the soil increases, it becomes compacted, making it harder for roots to penetrate. This hinders root growth and, as a result, the absorption of nutrients and water is affected. Similarly, porosity is important for soil aeration, water retention, and root penetration. Increased soil compaction reduces soil porosity, leading to waterlogging and decreased aeration. Another crucial soil property is aggregate stability, which is linked to the amount of organic matter on the surface. However, as we go deeper into the soil, the organic matter decreases, and compaction increases. This can break down pore spaces and increase resistance to water infiltration.Several studies have been conducted to determine the nutrient status in soils of orchards of converted land from paddy fields but less importance was given to the physical properties. This paper discusses the effect of physical properties in conventional and converted apple orchards. Therefore, the present study entitled "Effect of Land Use Conversion from Paddy to apple orchards on soil physical properties in soils of Kashmir" has been carried out.

2. Material and methods

2.1 Details of the study area:

District Baramulla is known as the fruit bowl of the valley. The district is situated at 34.1980^o N longitude and 74.3636^o E latitude, extending over an area of 4190 Km^2 and situated at altitude of 1240 to 2500 meters above the sea level. The Baramulla district has temperate and sub-temperate/subtropical climate zones. Temperatures begin to increase in March and remain high until August. The hottest month is July, with a mean high temperature of 20.6^{o}C and a mean low temperature of 11.7^{o}C and 30^{o}C and 18^{o}C in Baramulla, respectively.

Pulwama district is located at 32 km away from Srinagar. Pulwama is situated between 33^o, 50` to 33$^o$, 54` North latitudes and 74^o, 52` to 74$^o$, 58` East longitudes. The total notified area of Pulwama is 1398 Sq. Km. The karewas of the district are famous for the cultivation of saffron, apple, and almonds. Besides, major crops grown in the district are Rice, Wheat, Maize, Vegetables and fruits, oilseeds, and saffron. Pulwama district has sub humid temperate type of climate and temperature varies between -3^o to 32^{o}C. The Average temperature in the district is 19^{o}C. Overall the weather condition of the district is summer is slightly muggy while the winters are extremely cold.

Shopian district is known as Apple bowl of State. Itis one of the 22 districts in the state of Jammu and Kashmir. It is located at 33.72^{o} N 74.83^{o} E, latitude 33.61^{o} – 33.84^{o}, longitude 74.52^{o} – 75.00^{o}. It has an average elevation of 2057 meters above mean sea level. It is located in the southern part of Kashmir Valley bounded by Pulwama, Kulgam, and Anantnag districts. It has climate conditions with severe winter. The average temperature of the region is between -11 to 35^{o}C.

2.2 Site selection and sample collection

Two land use systems viz conventional and converted apple orchards were selected under three districts Baramulla, Pulwamma and Shopian. The age of the orchards selected for conventional apple orchards were more than 30-40 years and paddy converted orchards were not more than 10 years. Ten locations from these three districts were selected for the purpose and soil sampling was conducted at 3 sites per location. Soil sampling was done after harvest of the apple and soil samples were collected from three depths of 0-30, 30-60, and 60-90 cm. A total one hundred eighty soil samples were collected from these two land uses. The soil samples were then stored properly and taken to the laboratory of Division of Soil Science and Agricultural Chemistry, SKUAST K for further processing and analysis.

2.3 Laboratory analysis

The samples from apple orchards were air dried, processed and then analyzed for the different soil physical properties by adopting standard procedures. The particle size analysis was worked out by hydrometric method as described by Bouyoucos (1951) and the bulk density was determined by Core method as prescribed by Blacke and Hartge 1986. The particle density by the pycnometer method as given by Gupta and Dakshinamoorthy 1980, Aggregate stability was determined by wet sieving method (Yoder, 1936). The porosity was determined by using bulk density and particle density as below.

$$\text{Soil porosity} = (1\text{-}Bd/Pd*100)$$

Soil water content was determined by gravimetric method.

$$\text{Soil water content \%} = \frac{\text{weight of wet sample} - \text{weight of dry sample}}{\text{Weight of dry sample}} \times 100$$

2.4 Statistical analysis

Design of survey was random stratified sampling.The data was statically analyzed by using R-Software.

3. RESULTS AND DISCUSSION

3.1 Particle size distribution

The soil texture of conventional and converted apple orchards exhibited variations ranging from clay loam to silty clay loam, as presented in Table 1. The mean percent of sand, silt and clay in conventional orchards were 13.306, 52.679, and 33.970, whereas, in the converted apple orchards it was 16.291, 50.662, and 33.058. Although there was variations in the soil separates between the two types of orchards but was not statistically significant. Sand content in both types of orchards increased with the depth of soil from surface to subsurface but the other soil separates silt and clay were not affected by the soil depth. There were some erratic variations in silt and clay content with soil depth. The irregular distribution of sand content with increasing soil depth was observed, that might be due to the in-situ weathering of parental materials. Furthermore, the higher clay content at lower depths could be indicative of the translocation of clay from the surface to subsurface horizons through illuviation. These findings align with the observations made by Nabi et al. (2020), Dar et al. (2015), and Surwase et al. (2016).

3.2 Bulk density

Bulk density is a relationship between the mass of individual soil particles and the overall soil volume, specified at predetermined moisture content. The bulk density exhibits an ascending trend from the soil surface to subsurface as the depth increases. The average bulk density for conventional apple orchards was 1.109 Mg m^{-3}, whereas for converted apple orchards, it stands marginally lower at 1.107 Mg m^{-3} (Table 2). The diminished bulk density at the surface can be attributed to the presence of organic matter, leaf litter, and the application of farmyard manure in orchards, contributing to a decline in bulk density at deeper layers. These findings align with prior research by Sofi et al. (2018), Geetha et al. (2021). Similarly, Bashir et al. (2022) observed that with increase in depth the bulk density of the orchards increases from surface to subsurface.

3.3 Particle density

The mean value of particle density in the conventional apple orchard was found to be 2.230 Mg m^{-3}, while the converted apple orchards showed a slightly higher mean value of 2.262 Mg m^{-3} (Table 2). No significant variation in particle density was observed between the two types of orchards *i.e.* the conversion from paddy to apple orchards did not affected the particle density of soil. The increased particle density was observed at shallower depths which may be attributed to the lack of organic matter in the sub-surface layers. The increase in particle density is particularly pronounced with greater soil depth. These findings align with previous studies by Chowdhury et al. (2007) and Wei et al. (2022), where an increase in particle density with depth was noted. Similarly, Singh et al.

(2022) reported a non-significant mean difference in particle density with increasing depth.

3.4 Porosity

The porosity in conventional and converted apple orchard showed thedecreasing trend as the depth increases. Notably, there exists no statistically significant distinction in the mean porosity values between conventional and converted orchards, registering at 49.593% and 50.860%, respectively (Table 2). The increased porosity near the surface is attributed to the substantial presence of organic matter and leaf litter. However, at greater depths, porosity experiences a decrease, corresponding with an increase in bulk density. This inverse relationship between porosity and bulk density aligns with the principle that increased bulk density serves as an indicative marker of diminished porosity and causes thesoil compaction, as posited by Nanganoa et al. in 2019. Importantly, these findings are in align with the outcomes reported by Bangroo et al. in 2019, and Bhavya et al. 2018.

3.5 Aggregate stability

The aggregate stability in conventional apple orchards exhibited higher mean value of 0.409 mm, whereas, in converted apple orchards, it was lower with mean value of 0.280 mm. The aggregate stability showed the decreasing trend with increase in depth (Table 3). The increased aggregate stability in conventional apple orchards can be attributed to the accumulation of leaf litter over preceding years, the buildup of organic matter near the surface, which significantly contributes to the establishment of a good soil structure, and the creation of stable aggregates within the soil matrix. These findings are substantiated by the corroborative research of Xiao-Li et al. (2010). Numerous investigations have underscored the pivotal role of soil organic carbon as the principal binding agent, exerting a substantial influence on the stability and composition of water-stable aggregates.

3.6 Soil water content

The surface soil water content in conventional apple orchards was observed to be higher compared to converted apple orchards, with mean values of 14.274 % and 13.940 %, respectively (Table 3). There was no significant difference in the mean values between the two types of orchards, indicating a consistent decreasing trend with an increase in depth. The relationship between soil water content and clay content is noteworthy, as clayey soils exhibit higher porosity and water-holding capacity. Consequently, the moisture content in the soil generally decreases with an increase in depth. This observation aligns with the findings of Chowdhury et al. in 2007, who also noted a decrease in soil water content with increasing soil depth. Furthermore, Chia et al. in 2022, reported a similar decrease in soil water content with increasing depth following land use conversion.

4. Conclusion

Converting paddy field to the apple orchards, and their concurrent effects on soil physical properties was studied in this research and noticeable effect was observed on the aggregate stability which was higher in case of conventional orchards *i.e.* decrease in the aggregate stability was observed through change from paddy field to apple orchards. this physical property is important as far as the soil water retention, erodibility and uptake of nutrients is concerned.

5. References

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Table 1: **Particle size distribution of conventional and converted apple orchards at different depths**

	Sand		Silt		Clay	
Depth (cm)	Conventional Orchard	Converted Orchard	Conventional Orchard	Converted Orchard	Conventional Orchard	Converted Orchard
0-30	11.682^{c}	15.837^{abc}	54.255^{a}	50.132^{a}	34.062^{a}	34.067^{a}
30-60	12.747^{bc}	17.036^{a}	53.557^{a}	49.961^{a}	33.696^{a}	32.999^{a}
60-90	15.488^{abc}	16.000^{ab}	50.226^{a}	51.893^{a}	34.151^{a}	32.107^{a}
Mean	13.306^{B}	16.291^{A}	52.679^{A}	50.662^{A}	33.970^{A}	33.058^{A}
CD ($p<0.05$)	Depths (D) =2.897 Orchards (O) =2.365 Depth*Orchards (D*O) = 4.096		Depths (D) =3.211 Orchards (O) =2.621 Depth*Orchards (D*O) =4.540		Depths (D) =2.331 Orchards (O) =1.903 Depth*Orchards (D*O) =3.296	

Table 2: Soil bulk density, particle density and porosity of conventional and converted apple orchards

	Bulk Density		Particle Density		Porosity	
Depth (cm)	Conventional Orchard	Converted Orchard	Conventional Orchard	Converted Orchard	Conventional Orchard	Converted Orchard
0-30	1.074^{c}	1.066^{c}	2.094^{c}	2.197^{b}	47.209^{b}	51.171^{a}
30-60	1.141^{a}	1.111^{b}	2.276^{ab}	2.261^{ab}	49.657^{ab}	50.627^{a}
60-90	1.113^{b}	1.143^{a}	2.320^{a}	2.330^{a}	51.913^{a}	50.781^{a}
Mean	1.109^{A}	1.107^{A}	2.230^{A}	2.262^{A}	49.593^{A}	50.860^{A}
CD ($p<0.05$)	Depths (D) = 0.016 Orchards (O) = 0.013 Depth*Orchards (D*O) = 0.022		Depths (D) = 0.064 Orchards (O) = 0.052 Depth*Orchards (D*O) = 0.090		Depths (D) = 2.151 Orchards (O) =1.756 Depth*Orchards (D*O) = 3.042	

Table 3: Aggregate stability and soil water content in conventional apple orchard and converted apple orchards at different depths

	Aggregate stability		Soil water content	
Depth (cm)	Conventional Orchard	Converted orchards	Conventional Orchard	Converted orchards
0-30	0.475^{a}	0.289^{b}	14.578^{a}	14.402^{ab}
30-60	0.417^{ab}	0.289^{b}	12.966^{bc}	15.373^{a}
60-90	0.336^{ab}	0.260^{b}	12.106^{c}	15.172^{a}
Mean	0.409^{A}	0.280^{B}	13.217^{B}	14.982^{A}
CD (p<0.05)	Depths (D) =0.130 Orchards (O) = 0.106 Depth*Orchards (D*O) = 0.184		Depths (D) =1.035 Orchards (O) =0.845 Depth*Orchards (D*O) =1.464	

Fig 1. Graphical presentation showing bulk density

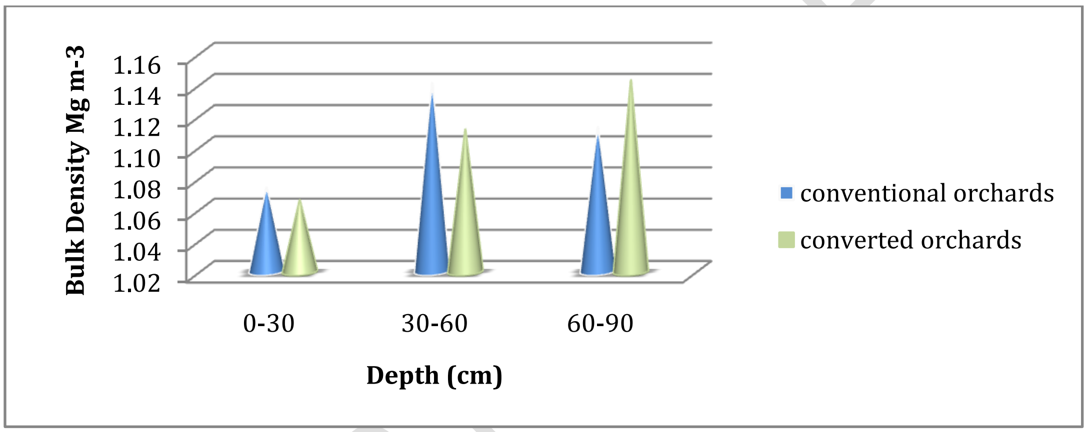

Fig 2. Graphical presentation showing Particle density

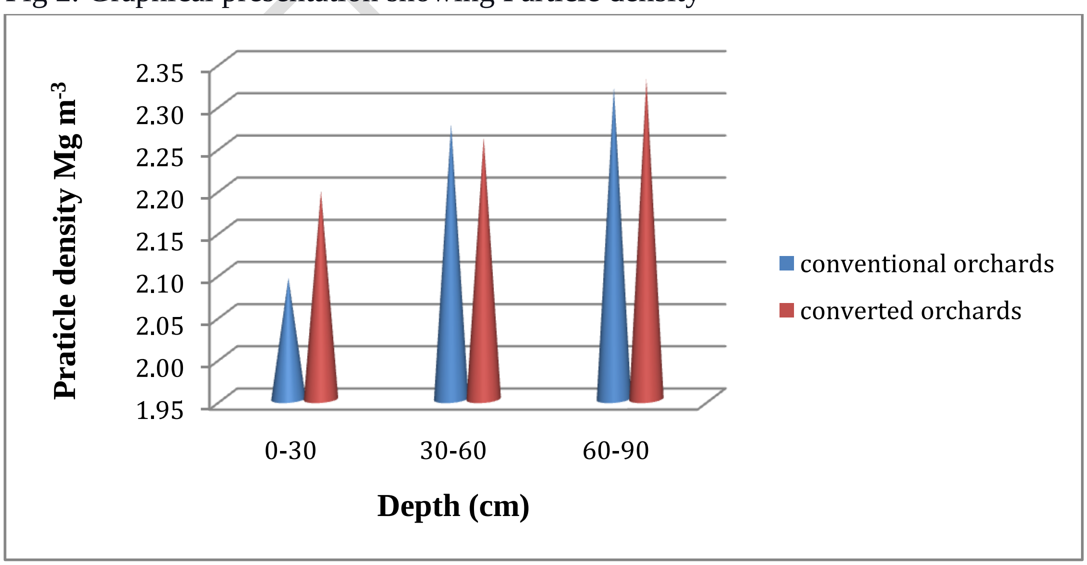

Fig 3 Graphical presentation showing Porosity

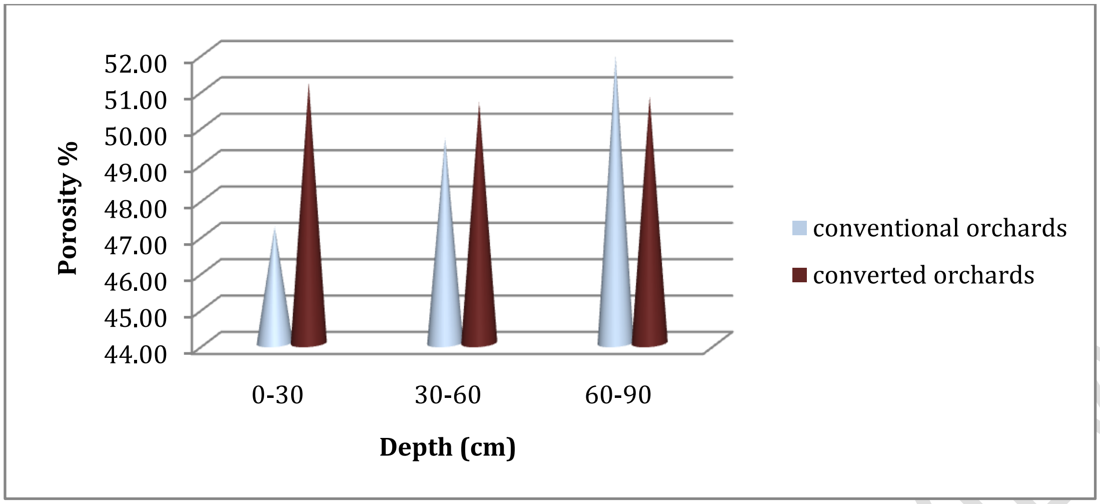

Fig 4 Graphical presentation showing Aggregate stability

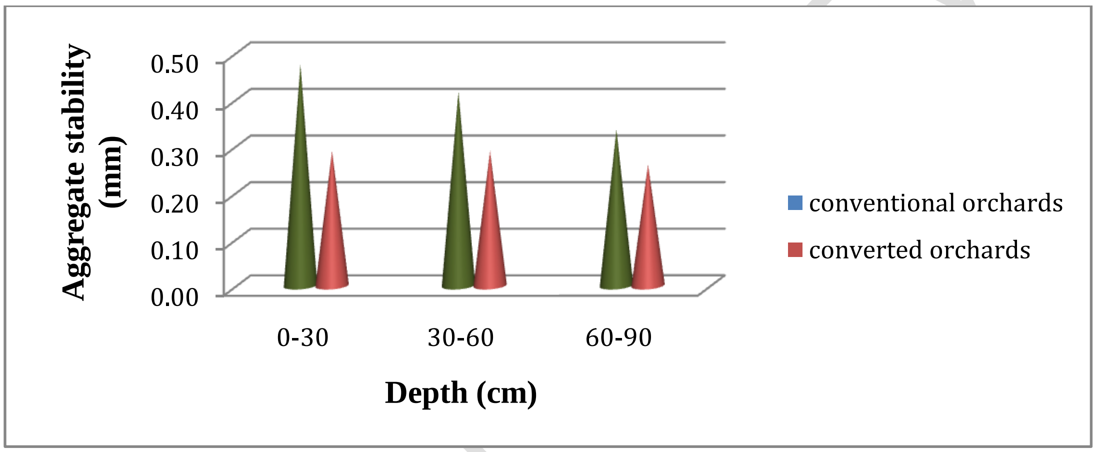

Fig 5 Graphical presentation showing Soil water content

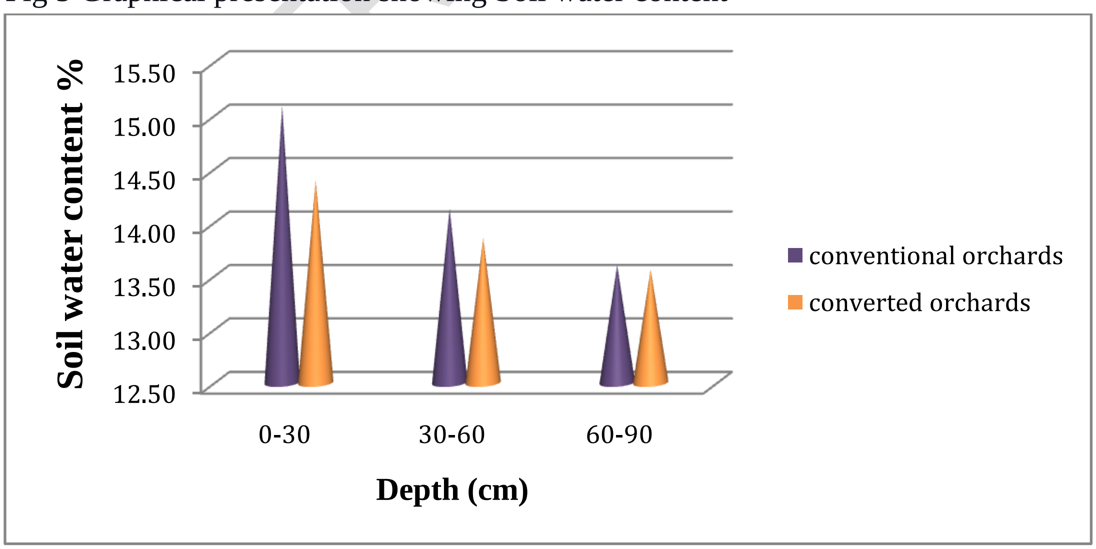

Fig 6 Graphical presentation showing Sand content

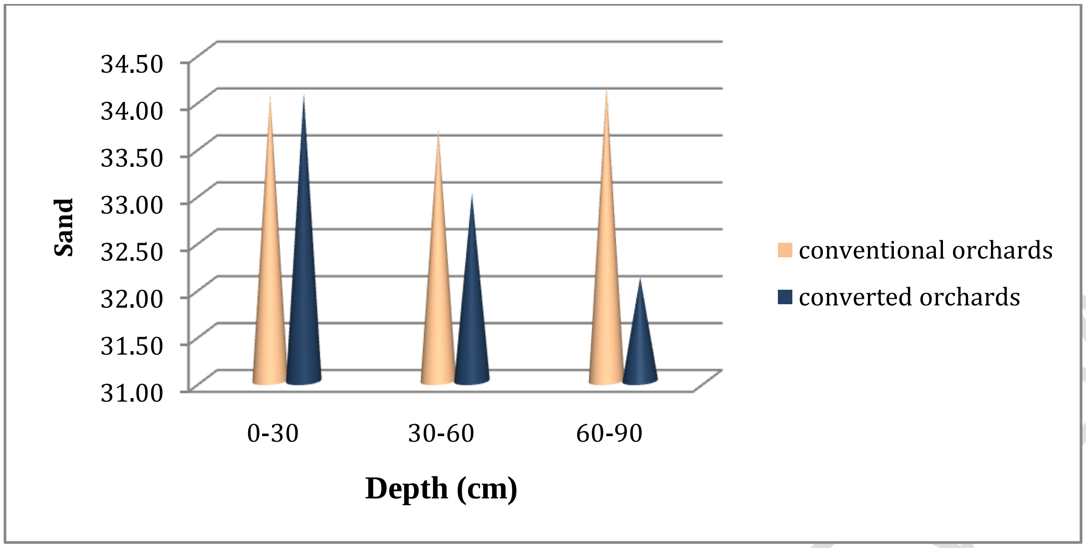

Fig 7 Graphical presentation showing Silt content

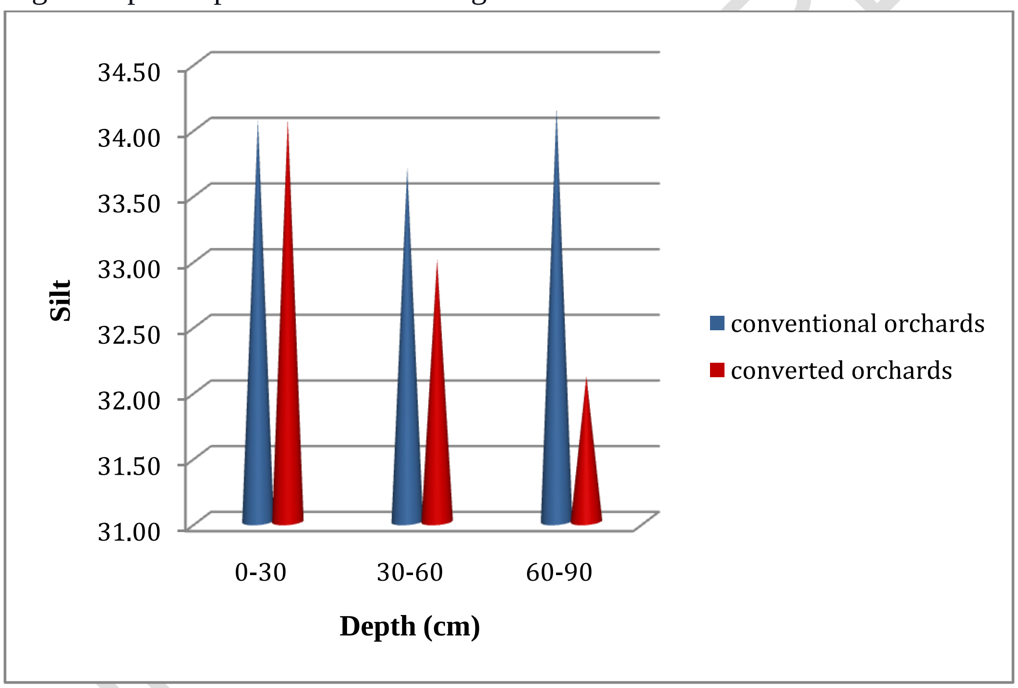

Fig 8 Graphical presentation showing Clay content