Relationship between compaction levels (bulk density) and chemical properties of different textured soil

Prashant Deo Singh, Ashok Kumar, BP Dhyani, Satendra Kumar, UP Shahi, Adesh Singh and Anand Singh

Abstract
The investigation entitled “Study of relationship between compaction level (bulk density) and chemical properties of different textured soil” was carried out using various research materials and analytical techniques during 2017-18 at department laboratory of Soil Science at Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, UP, India. Results of study reveals that levels of compaction does not affect pH and EC significantly however soil OC was affected significantly. More impact was found in organic carbon as compare to pH and EC. Effect of compaction on amount of OC in different textured soil indicates that more organic carbon was found in sandy clay loam soil followed by sandy loam and minimum in loamy sand at same degree of compaction. A strong negative correlation of bulk density with pH (r = -0.912, -0.943 and -0.943) EC (r = -0.988, -0.991 and -0.992) and OC% (r = -0.993, -0.985 and -0.989) for loamy sand, sandy loam and sandy clay loam soil, respectively was observed. The available macro nutrients (N, P and K) of soil decreased significantly with an increase in the level of compaction. A strong negative correlation of bulk density with available N (r = -0.993, -0.995 and -0.992), available P (r = -0.985, -0.983 and -0.980) and available K (r = -0.925, -0.979 and -0.984) for loamy sand, sandy loam and sandy clay loam soil, respectively was found. Unlike available macro nutrient, the micro nutrient of soil also decreased with an increase in the level of compaction. A strong negative correlation between bulk density and available micronutrients Zinc r = -0.925, -0.944 and -0.929 and Iron r = -0.981, -0.974 and -0.931 for loamy sand, sandy loam and sandy clay loam soil, respectively was also recorded.

Keywords: Relationship, bulk density, chemical

Introduction
The ever-increasing population of the world necessitates the intensification of farming and cropping systems to cope with the demand for more food. As a result, more and heavier farm machinery and/or animals per land surface area have become common all over the world. This intensification of the farming system has led to soil compaction and deterioration in soil fertility. Soil compaction adversely affects soil physical properties, fertility, particularly storage and supply of water and nutrients through increasing soil bulk density, decreasing porosity, increasing soil strength, decreasing soil water infiltration and water holding capacity. These adverse effects reduce fertilizer efficiency and crop yield, increase water-logging, runoff and soil erosion with undesirable environmental pollution problems. Intensification of agriculture could be more worsen when heavy tillage is employed to manipulate soil conditions. Tillage operation consisting of primary and secondary tillage, employed to increase the soil’s structural macro porosity, while excessive tillage operations over these freshly tilled soils cause soil compaction (Wang et al. 2004). It is hard to identify one single cause responsible for soil compaction rather, a combination of causes are responsible to develop the problem, compaction also govern the nutrient availability in soil. Laiho, et al. 2004 (15) studied the variability in mineral nutrient concentrations (Ca, K, Mg, Mn, Fe, Zn) and bulk density within floristically described peat land sites. Reintam, et al. 2005 (17) reported the impact of bulk density on nutrient (N, P, K) assimilation and on cell fluid pH of spring barley with distinct tiers of fertilization. Soil compaction reduces the availability of macro and micro nutrients because of changing the soil ecosystem through reduction in...
organic carbon and porosity ultimately the degradation of soil. Soil compaction reduces the yield of many crops by 12-23% (Ishaq et al. 2001a) [10]. About 68 million ha of the soil worldwide are estimated to be affected by the soil compaction from the vehicular traffic. The soil compaction is responsible for 33, 18, 10 and 4 million ha soil degradation in Europe, Africa, Asia and Australia, respectively and some areas of North America (Flowers and Lal 1998: Hamza and Anderson 2003). Therefore regular monitoring of soil health particularly its compactness is highly required. Knowledge of soil bulk density is imperative for soil management. Keeping this in mind we conducted a study to find out relationship between compaction level (bulk density) and chemical properties of different textured soil.

Materials and Methods
The investigation entitled “Study of relationship between compaction level (bulk density) and chemical properties of different textured soil” was carried out using various research materials and analytical techniques during 2017-18 at department laboratory of soil science at Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, UP, India. The study area falls in the district of Meerut from 29°04’ N latitude and 77°42’ E longitude at an altitude of 237 meter above the mean sea level (MSL). Climate of study area are sub tropical and semi arid climate with hot desiccating summers and cold winters.

Texture of soils collected from three locations (1.Crop research centre Chiorri Meerut, 2.Horticulture research centre SVPUAT Campus and 3.Basmati export development foundation modipuram Meerut) was determined using hydrometer method. Different level of compaction was created by maintaining different bulk density (1.1 to 1.8 Mg/m³) in 12 inch long plastic pipe of 4 inch diameter through adopting the formula of bulk density equals to mass of soil divided by volume of soil. Different chemical properties of soil like pH, Ec, organic carbon, available nitrogen, phosphorus, potassium, zinc and iron were assessed in the laboratory and furthermore correlation were established using statistical procedure.

Results and Discussions
Different chemical properties viz pH, Ec, organic carbon, available nitrogen, phosphorus, potassium, zinc and iron estimated from the soil filled in pipe at different level of compaction (1.1 to 1.8 Mg/m³) showing different bulk densities are presented in Table 1, 2 and 3. Texture of the soil sample collected from three locations were loamy sand (80% sand,10% silt and 10% clay), sandy loam(58% sand,24% silt and 18% clay) and sandy clay loam(50% sand,22% silt and 28% clay). Data on correlation study (r) for different textured soil are presented in Table 1, 2 and 3.

Effect of different levels of compaction on pH, EC and Organic carbon:
Data presented in Table 1, 2 and 3 indicates effect of compaction levels on pH in different textured soil. The maximum pH (7.53), (8.41) and (8.29) for was found at bulk density 1.10, 1.20 and 1.30 Mg m⁻³, respectively for loamy sand sandy loam and sandy clay loam and minimum pH (7.50), (8.39) and (8.27) at bulk density 1.70 and 1.80 Mg m⁻³ respectively for loamy sand, sandy loam and sandy clay loam soil. This may be due to compaction decreases porosity and induced anaerobic condition in soil which may produces carbonic acids responsible for lowering the pH. Chaudhary et al 2013 also reported that the bulk density is dependent on calcareous and saline nature of soils but independent on whether the soil is acidic or alkaline. However, Shaffer (1998) observed highest correlation between pH and BD at 0 to 15 cm, but he did not indicate the reasons. Similarly Nath 2014 [13] also found a negative relationship of bulk density with soil pH, electrical conductivity, total organic matter and macronutrients.

Compaction levels does not resulted any significant effect on EC although the maximum EC(0.290), (0.221) and (0.210) dSm⁻¹ for loamy sand, sandy loam and sandy clay loam soil, respectively was found at 1.10 Mg m⁻³ bulk density while minimum EC (0.274), (0.189) and (0.175) dSm⁻¹ with 1.80 Mg/m³ bulk density. It was observed that the bulk density is independent of whether the soil is acidic or alkaline. Compaction levels does not resulted any significant effect on EC although the more EC was found at low compaction while low EC was recorded at high compaction. The similar findings were also recorded by Chaudhary et al. 2013. They reported that high EC was found with low compaction. Similarly Nath 2014 [13] also found a negative relationship of soil bulk density with soil pH, electrical conductivity, total organic matter and macronutrients.

The bulk density differ with several factors such as compaction, consolidation and amount of soil organic carbon present in the soil and among these it is highly related with organic carbon content. Level of organic carbon decreased as the levels of compaction increased. Data presented in Table 1, 2 and 3 showed that the maximum organic carbon content (0.65, 0.74 and 0.98 percent) was found where level of compaction was minimum (1.10 Mg m⁻³) while minimum organic carbon content (0.47, 0.60, 0.75 percent) for loamy sand, sandy loam and sandy clay loam soil, respectively where level of compaction was maximum (1.80 Mg m⁻³). Our studies showed that the higher organic carbon content was found at low compaction while low organic carbon content was recorded at compaction high. Felton and Ali (1992) [9] reported that the addition of organic matter to B-horizon soils leads to an increase in the porosity and the water retention and to a decrease in bulk density determined by proctor test. The soil compaction affects concentration of carbon dioxide (Conlin and Van den Driessche 2000) [3] and mineralization of the soil organic carbon and nitrogen in the soil (De Neve and Hofman 2000) [5].

Effect of different levels of compaction on available macro nutrient
The available N content of soil decreased significantly with an increase in the level of compaction. Data presented in Table 1, 2 and 3 showed that the maximum available N (189.41,170.45, and,284.84 kg ha⁻¹ for loamy sand, sandy loam and sandy clay loam soil, respectively was recorded at 1.10 Mg m⁻³ bulk density while minimum available N (164.87,146.89 and 263.99 kg ha⁻¹ where level of compaction was maximum (1.80 Mg m⁻³). Tan et al. (2008) [20] also reported the same observations. They found that the soil compaction reduces the available N and efficiency of N use by the crops decreases (Douglas and Crawford 1991) [6], which can increase the fertilizer requirements. In case of lower bulk density porosity will be more which will favour aerobic condition in soil and consequently more mineralization of organic matter and thereby more availability of nitrogen and phosphorus.

Alike available nitrogen, available P in soil decreased with an increase in the level of compaction. Data presented in Table 1,
among bulk density and pH of soil for loamy sand, sandy loam and sandy clay loam soil, respectively. We also found a strong negative correlation \( r = -0.988, -0.991 \) and -0.992 among bulk density and EC for loamy sand, sandy loam and sandy clay loam soil, respectively. Statistical correlation studied by Chaudhary et al., 2013 between bulk density and, pH & EC showed negative correlations. Bulk density showed negative correlation with CaCO3 \( (r = -0.4952) \) content and electrical conductivity \( (r = 0.6611) \).

It was observed a strong negative correlation between bulk density and total organic carbon content of the soil samples \( r = -0.993, -0.985 \) and -0.989 for loamy sand, sandy loam and sandy clay loam soil, respectively, which indicate that as the organic carbon increases the bulk density of soil decreases. The bulk density bears an inverse relationship with the soil organic matter \( (White, 1987) \) [22]. Many researchers \( (Morisada et al. 2004 \) and Leifeld et al 2005) [11] obtained the relationship between organic matter and bulk density of soils and showed strong correlation between them. Curtis and Post \( (1964) \) [4] stated a reverse correlation between organic matter and bulk density. E. Sakin \( (2011) \) [8] determined the strongest correlation between bulk densities and organic matter among the data attained from the analysis results. They obtained similar results with strong negative correlation \( (r = -0.8869) \) between organic matter and bulk density of soil samples.

**Relationship between compaction levels (bulk density) and macro nutrients of soil**

The bulk density of the soil samples decides the available macronutrients in the soil. It was found that as the bulk density decreases the macronutrient contents in the soil increases. Data presented in Table 4, 5 and 6 showed a strong negative correlation \( r = -0.993, -0.995 \) and -0.992 among the bulk density and available N for loamy sand, sandy loam and sandy clay loam soil, respectively. A strong negative correlation \( r = -0.985, -0.983 \) and -0.980 was found between bulk density and available P for loamy sand, sandy loam and sandy clay loam soil, respectively. Similarly a strong negative correlation \( r = -0.925, -0.979 \) and -0.984 was found between bulk density and available K for loamy sand, sandy loam and sandy clay loam soil, respectively. Chaudhari, et al \( (2013) \) [2] also studied the statistical correlation and found strong negative correlation of bulk density with available total primary macronutrients \( (r = -0.8615) \) in the soil.

**Relationship between compaction levels (bulk density) and micro nutrients of soil**

It was found that as bulk density decreases the total micronutrient contents in the soil increases. Statistical correlation studies showed \( Table 4, 5 \) and 6) a strong negative correlation between bulk density and available micronutrients Zinc \( r = 0.925, -0.944 \) and -0.929 for loamy sand, sandy loam and sandy clay loam soil, respectively and Iron \( r = -0.981, -0.974 \) and -0.931 for loamy sand, sandy loam and sandy clay loam soil, respectively. Correlation studies conducted by Chaudhary et al. 2013 also showed strong negative correlation between bulk density and available total micronutrients \( (r = -0.7089) \) in the soil. Laiho, et al. 2004 [15] also reported that the total variances of Fe and Zn decreases with increase in bulk density.

---

2 and 3 showed that the maximum available P \( (15.15, 19.35 \) and 49.40 kg ha\(^{-1}\) for loamy sand, sandy loam and sandy clay loam soil, respectively at low compaction \( (1.10 \text{ Mg m}^3) \) while minimum available P \( (14.91, 19.13 \) and 49.27 kg ha\(^{-1}\) for where level of compaction was maximum \( (1.80 \text{ Mg m}^3) \). Mathan et al. \( (1994) \) [12] also reported the relationship between bulk density and available P for loamy sand, sandy loam and sandy clay loam soil, respectively in Table 1, 2 and 3 clearly showed that the maximum available K \( (62.08, 210.66 \) and 259.70 kg ha\(^{-1}\) was found at \( 1.10 \text{ Mg m}^3 \)bulk density while minimum available K \( (58.97, 199.18 \) and 249.31 kg ha\(^{-1}\) for loamy sand, sandy loam and sandy clay loam soil, respectively at maximum bulk density \( (1.80 \text{ Mg m}^3) \). Agrawal \( (1991) \) [1] advocated that compaction of sandy soil favorably affects hydraulic parameters, viz, moisture retention, infiltration and saturated hydraulic conductivity, which are important for improving their water status and reducing the leaching losses of soluble nutrients. Rhoton et al., \( (1993) \) [16] also observed the same results.

**Effect of different levels of compaction on available micro nutrient**

The available Zn content of soil decreased with an increase in the level of compaction. Data presented in Table 1, 2 and 3 clearly showed that the maximum available Zn \( (0.98), (1.50) \) and \( (1.40) \) ppm for loamy sand, sandy loam and sandy clay loam soil, respectively was found in \( T_1 \) where level of compaction in term of bulk density was minimum \( (1.1 \text{ Mg m}^3) \) while minimum available Zn \( (0.93), (1.42) \) and \( (1.34) \) ppm for loamy sand, sandy loam and sandy clay loam soil, respectively in \( T_3 \) where level of compaction in terms of bulk density was maximum \( (1.8 \text{ Mg m}^3) \). Chaudhary et al. \( 2013 \) also recorded the similar observations. They noticed the available micronutrients \( (\text{Fe + Mn + Zn + Cu}) \) in the soil also varied with bulk density of the soil. It was found that the bulk density decreases as the total micronutrient contents in the soil increases.

The available Fe content of soil decreased significantly with an increase in the level of compaction. Data presented in Table 1, 2 and 3 showed that the maximum available Fe \( (13.29), (16.05), (18.54) \) ppm for loamy sand, sandy loam and sandy clay loam soil, respectively was found in \( T_1 \) where level of compaction in term of bulk density was minimum \( (1.10 \text{ Mg m}^3) \) while minimum available Fe \( (12.62), (15.25) \) and \( (17.80) \) ppm for loamy sand, sandy loam and sandy clay loam soil, respectively in \( T_3 \) where level of compaction in term of bulk density was maximum \( (1.80 \text{ Mg m}^3) \). The available micronutrients \( (\text{Zn + Fe}) \) in the soil also differ with bulk density of the soil. Similar results were also recorded by Laiho, et al. \( 2004 \) and Chaudhary et al \( 2013 \) [15].

**Relationship between compaction level (bulk density) and pH, EC & organic carbon of soil**

Data presented in Table 4, 5 and 6 indicated that, pH and EC decreases as the bulk density increases. Statistical correlation studies showed a strong negative correlation \( r = -0.912, -0.943 \) and -0.943
| Treatment | Level of Compaction/ Bulk density (Mg m⁻³) | pH | EC (dsm⁻¹) | OC (%) | Available Nutrient |
|-----------|------------------------------------------|----|-------------|--------|------------------|
| T1        | 1.10                                     | 7.53 | 0.290 | 0.65 | N Kg ha⁻¹: 189.41, P Kg ha⁻¹: 15.15, Zn ppm: 62.08, Fe ppm: 0.98, Available Nutrient: 13.29 |
| T2        | 1.20                                     | 7.53 | 0.290 | 0.64 | N Kg ha⁻¹: 187.65, P Kg ha⁻¹: 15.13, Zn ppm: 62.05, Fe ppm: 0.98, Available Nutrient: 13.29 |
| T3        | 1.30                                     | 7.53 | 0.287 | 0.62 | N Kg ha⁻¹: 184.37, P Kg ha⁻¹: 15.11, Zn ppm: 61.97, Fe ppm: 0.98, Available Nutrient: 13.06 |
| T4        | 1.40                                     | 7.52 | 0.285 | 0.58 | N Kg ha⁻¹: 180.33, P Kg ha⁻¹: 15.08, Zn ppm: 61.75, Fe ppm: 0.97, Available Nutrient: 12.98 |
| T5        | 1.50                                     | 7.52 | 0.281 | 0.56 | N Kg ha⁻¹: 174.05, P Kg ha⁻¹: 15.05, Zn ppm: 61.38, Fe ppm: 0.97, Available Nutrient: 12.95 |
| T6        | 1.60                                     | 7.52 | 0.280 | 0.53 | N Kg ha⁻¹: 171.28, P Kg ha⁻¹: 15.01, Zn ppm: 60.75, Fe ppm: 0.96, Available Nutrient: 12.88 |
| T7        | 1.70                                     | 7.50 | 0.278 | 0.51 | N Kg ha⁻¹: 167.13, P Kg ha⁻¹: 14.96, Zn ppm: 60.16, Fe ppm: 0.94, Available Nutrient: 12.74 |
| T8        | 1.80                                     | 7.50 | 0.274 | 0.47 | N Kg ha⁻¹: 164.87, P Kg ha⁻¹: 14.91, Zn ppm: 58.97, Fe ppm: 0.93, Available Nutrient: 12.62 |

Table 2: Chemical properties of sandy loam soil under different level of compaction (BD)

| Treatment | Level of Compaction/ Bulk density (Mg m⁻³) | pH | EC (dsm⁻¹) | OC (%) | Available Nutrient |
|-----------|------------------------------------------|----|-------------|--------|------------------|
| T1        | 1.10                                     | 8.41 | 0.221 | 0.74 | N Kg ha⁻¹: 170.45, P Kg ha⁻¹: 19.35, Zn ppm: 210.66, Fe ppm: 1.50, Available Nutrient: 16.05 |
| T2        | 1.20                                     | 8.41 | 0.219 | 0.73 | N Kg ha⁻¹: 168.83, P Kg ha⁻¹: 19.35, Zn ppm: 210.56, Fe ppm: 1.50, Available Nutrient: 16.05 |
| T3        | 1.30                                     | 8.41 | 0.214 | 0.71 | N Kg ha⁻¹: 163.41, P Kg ha⁻¹: 19.32, Zn ppm: 209.91, Fe ppm: 1.50, Available Nutrient: 16.00 |
| T4        | 1.40                                     | 8.40 | 0.206 | 0.70 | N Kg ha⁻¹: 160.11, P Kg ha⁻¹: 19.29, Zn ppm: 207.81, Fe ppm: 1.48, Available Nutrient: 15.87 |
| T5        | 1.50                                     | 8.40 | 0.200 | 0.68 | N Kg ha⁻¹: 157.33, P Kg ha⁻¹: 19.26, Zn ppm: 205.70, Fe ppm: 1.48, Available Nutrient: 15.74 |
| T6        | 1.60                                     | 8.40 | 0.199 | 0.66 | N Kg ha⁻¹: 155.38, P Kg ha⁻¹: 19.22, Zn ppm: 203.48, Fe ppm: 1.46, Available Nutrient: 15.52 |
| T7        | 1.70                                     | 8.39 | 0.193 | 0.63 | N Kg ha⁻¹: 150.93, P Kg ha⁻¹: 19.18, Zn ppm: 201.85, Fe ppm: 1.43, Available Nutrient: 15.44 |
| T8        | 1.80                                     | 8.39 | 0.189 | 0.60 | N Kg ha⁻¹: 146.89, P Kg ha⁻¹: 19.13, Zn ppm: 199.18, Fe ppm: 1.42, Available Nutrient: 15.25 |

Table 3: Chemical properties of sandy clay loam soil under different level of compaction (BD)

| Treatment | Level of Compaction/ Bulk density (Mg m⁻³) | pH | EC (dsm⁻¹) | OC (%) | Available Nutrient |
|-----------|------------------------------------------|----|-------------|--------|------------------|
| T1        | 1.10                                     | 8.29 | 0.210 | 0.98 | N Kg ha⁻¹: 284.84, P Kg ha⁻¹: 49.40, Zn ppm: 259.70, Fe ppm: 1.40, Available Nutrient: 18.54 |
| T2        | 1.20                                     | 8.29 | 0.205 | 0.97 | N Kg ha⁻¹: 283.92, P Kg ha⁻¹: 49.40, Zn ppm: 259.61, Fe ppm: 1.40, Available Nutrient: 18.54 |
| T3        | 1.30                                     | 8.29 | 0.199 | 0.95 | N Kg ha⁻¹: 280.47, P Kg ha⁻¹: 49.39, Zn ppm: 258.43, Fe ppm: 1.40, Available Nutrient: 18.49 |
| T4        | 1.40                                     | 8.28 | 0.193 | 0.91 | N Kg ha⁻¹: 278.82, P Kg ha⁻¹: 49.37, Zn ppm: 257.09, Fe ppm: 1.40, Available Nutrient: 18.40 |
| T5        | 1.50                                     | 8.28 | 0.188 | 0.87 | N Kg ha⁻¹: 274.31, P Kg ha⁻¹: 49.34, Zn ppm: 254.83, Fe ppm: 1.38, Available Nutrient: 18.33 |
| T6        | 1.60                                     | 8.28 | 0.186 | 0.84 | N Kg ha⁻¹: 270.55, P Kg ha⁻¹: 49.32, Zn ppm: 252.97, Fe ppm: 1.37, Available Nutrient: 18.25 |
| T7        | 1.70                                     | 8.27 | 0.183 | 0.80 | N Kg ha⁻¹: 267.76, P Kg ha⁻¹: 49.30, Zn ppm: 250.76, Fe ppm: 1.35, Available Nutrient: 18.12 |
| T8        | 1.80                                     | 8.27 | 0.175 | 0.75 | N Kg ha⁻¹: 263.99, P Kg ha⁻¹: 49.27, Zn ppm: 249.31, Fe ppm: 1.34, Available Nutrient: 17.80 |

Table 4: Simple correlation coefficient (r) between bulk densities with soil (Loamy sand) chemical parameters:

| Related soil parameters | Correlation Coefficient (r) | Level of Significance |
|-------------------------|-----------------------------|-----------------------|
| Bulk density—pH         | -0.912                      | Negative but not significant |
| Bulk density—Electrical conductivity | -0.988                      | Strong negative |
| Bulk density—Organic matter (%) | -0.993                      | Strong negative |
| Bulk density—N           | -0.993                      | Strong negative |
| Bulk density—P           | -0.985                      | Strong negative |
| Bulk density—K           | -0.925                      | Strong negative |
| Bulk density—Zn          | -0.925                      | Strong negative |
| Bulk density—Fe          | -0.981                      | Strong negative |

Table 5: Simple correlation coefficient (r) between bulk densities with soil (Sandy loam) chemical parameters:

| Related soil parameters | Correlation Coefficient (r) | Level of Significance |
|-------------------------|-----------------------------|-----------------------|
| Bulk density—pH         | -0.943                      | Negative but not significant |
| Bulk density—Electrical conductivity | -0.991                      | Strong negative |
| Bulk density—Organic matter (%) | -0.985                      | Strong negative |
| Bulk density—N           | -0.995                      | Strong negative |
| Bulk density—P           | -0.983                      | Strong negative |
| Bulk density—K           | -0.979                      | Strong negative |
| Bulk density—Zn          | -0.944                      | Strong negative |
| Bulk density—Fe          | -0.974                      | Strong negative |
Table 6: Simple correlation coefficient (r) between bulk densities with soil (Sandy clay loam) chemical parameters:

| Related soil parameters                          | Correlation Coefficient (r) | Level of Significance       |
|-------------------------------------------------|----------------------------|------------------------------|
| Bulk density—pH                                 | -0.943                     | Negative but not significant|
| Bulk density -Electrical conductivity            | -0.992                     | Strong negative             |
| Bulk density—Organic matter (%)                 | -0.989                     | Strong negative             |
| Bulk density—N                                  | -0.992                     | Strong negative             |
| Bulk density—P                                  | -0.980                     | Strong negative             |
| Bulk density—K                                  | -0.984                     | Strong negative             |
| Bulk density—Zn                                  | -0.929                     | Strong negative             |
| Bulk density—Fe                                  | -0.931                     | Strong negative             |

Conclusions
Results of study reveals that levels of compaction does not affects pH & EC significantly but affect soil OC significantly. More impact was found in organic carbon as compare to pH and EC. Effect of compaction on amount of OC in different textured soil indicates that more organic carbon was found in sandy clay loam soil followed by sandy loam and minimum in loamy sand at same degree of compaction. The available macro nutrient of soil decreased significantly with an increase in the level of compaction. Alike available macro nutrient, the micro nutrient of soil also decreased with an increase in the level of compaction. Statistical correlation studies showed a very strong negative correlation between compaction levels and soil chemical properties.

References
1. Agrawal RP. Water and nutrient management in sandy soils by compaction. Soil & Tillage Res. 1991; 19:121-130.
2. Chaudhari PR, Ahire DV, Ahire VD, Chkhravarty M, Maity S. Soil bulk density as related to soil texture, organic matter content and available total nutrients of Coimbatore soil, International Journal of Scientific and Research Publications. 2013; 3(2):2250-3153.
3. Conlin T, Van den Driessche R. Response of soil CO2 and O2 concentrations to forest soil compaction at the long-term soil productivity sites in central British Columbia. Can J Soil Sci. 2000; 80:625-632.
4. Curtis RO, Post BW. Estimating Bulk Density from Organic Matter Content in Some Vermont Forest soils. Soil Sci. Soc. Am. Proc. 1964; 28:285-286.
5. De Neve S, Hofman G. Influence of soil compaction on carbon and nitrogen mineralization of soil organic matter and crop residues. Biol Fert Soils. 2000; 30:544-549.
6. Douglas J, Crawford C. Wheel-induced soil compaction effects on ryegrass production and nitrogen uptake. Grass Forage Sci. 1991; 46:405-416.
7. E Reintam, J Kuht, H Loogus, E Nigus, K Trükmann. Soil compaction and fertilisation effects on nutrient content and cellular fluid pH of spring barley.” Agronomy Research. 2005; 3(2):189-202.
8. E Sakin, A Deliboran, E Tutar. Bulk density of Harran plain soils in relation to other soil properties,” African Journal of Agricultural Research. 2011; 6(7):1750-1757.
9. Felton GK, Ali M. Hydraulic parameter response to incorporated organic matter in the B horizon. Trans. Am. Soc. Agric. Engg. 1992; 35:11531160.
10. Ishaq M, Hassan A, Saeed M, Ibrahim M, Lal R. Subsoil compaction effects on crops in Punjab, Pakistan: I. Soil physical properties and crop yield. Soil Tillage Res. 2001a; 59:57-65
11. J Leifeld, S Bassin, J Fuhrer, Carbon stocks in Swiss agricultural soils predicted by land-use, soil characteristics, and altitude, Agr. Ecosyst. Environ. 2001a; 105(2005):255-266.
12. Mathan KK, Natesan R, Rajkannan B. Effect of surface and subsoil compaction of a sandy soil on nitrogen and potassium availability and grain yield of maize. J. Indian Soc. Soil Sci. 1994; 42:450-452.
13. Nath TN. Soil bulk density and its impact on soil texture, organic matter content and available macronutrients of tea cultivated soil in Dibrugarh district of Assam, India. International Journal of Development Research. 2014; 4(2):343-346
14. Poesse GJ. Soil compaction and new traffic systems. In: Pellizzii, G., Bodria, L., Bosma, A. H., Cera, M., Baerdemaeker, J. de, Jahns, G., Knight, A. C., Patterson, D. E., Poesse,G. J., Vitlox, O. (Eds.), Possibilities Offered by New Mechanization Systems to Reduce Agricultural Production costs. The Netherlands, 1992, 79-91.
15. R Laiho, T Penttilä, J Laine. Variation in soil nutrient concentrations and bulk density within peatland forest sites,” Silva Fennica. 2004; 38(1):29-41.
16. Rhoton FE, Bruce RR, Buehring NW, Elkins GB, Langdale CW, Tyler DD et al. Chemical and physical characteristics of four soil types under conventional and no-tillage system. Soil & Tillage Res. 1993; 28:51-61.
17. Richard LA. Diagnosis and improvement of saline and alkali soils. USDA Hand book No, 1954, 60.
18. Shaffer MJ. Estimating Confidence Bands for Soil - Crop Simulation Models. Soil Sci. Soc. Am. J. 1988; 52:1782-1789.
19. T Aşkın, N Özdemir. Soil bulk density as related to soil particle size distribution and organic matter content, Agriculture. 2003; 9(2):52-55.
20. Tan X, Chang S, Kabzems R. Soil compaction and forest floor removal reduced microbial biomass and enzyme activities in a boreal aspen forest soil. Biol Fert Soils. 2008; 44:471-479
21. Wayne Pluske, Daniel Murphy, Jessica Sheppard. Note on Total organic carbon; soilquality.org.au
22. White RE. In: Introduction to the Principles and Practice of Soil Science. English Language Book Society/Blackwell Scientific Publication. London, 1987.