

## **Relationship of bulk density with other soil characteristics under polyhouses in mid-hill zone of Himachal Pradesh**

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### **ABSTRACT**

Bulk density is the property of soil which depends on porosity and soil structural conditions. In general it increases with profile depth, changes inorganic matter content, porosity and compaction. The main objective of this study was to investigate the relation of bulk density with other soil characters under the polyhouse soils in mid-hill zone of Himachal Pradesh. The relationships of bulk density (pb) with porosity, particle density, ph, electrical conductivity (EC), CEC, organic carbon (OC) content, total macro-and micro-nutrient content was studied in the soil samples taken from a depth of 0-15 cm from the three districts of Himachal Pradesh. Soil bulk density showed significant negative relationship with porosity and OC but non-significant negative correlation with pH, macro-and micro-nutrients. Particle density and EC were positively correlated to bulk density.

**Keywords:** Soil bulk density; organic matter content; particle density

### **INTRODUCTION**

Soils are composed of solids (minerals and organic matter) and pores which hold air and water. The soil having sufficient amount of air and water with enough pore space for easy root penetration is considered ideal for plant growth. Soil bulk density is a basic soil property that depends on porosity, organic carbon and

the total nutrient content. Knowledge of bulk density is essential for soil management and information about it is important in soil compaction as well as in the planning of modern farming techniques (Chaudhari et al 2013). Bulk density affects factors such as water, aeration status, root penetration, land use and management and therefore it is a very important soil parameter (Sakin 2012). Bulk density and

particle density of soil are often helpful in predicting soil porosity. Total porosity can be calculated by using the method given by Blake and Hartge (1986). Bulk density depends on several factors such as compaction, consolidation and amount of soil organic carbon (SOC) present in the soil but it is highly correlated to the organic carbon content. Soil organic matter plays a key role in soil health and helps to improve soil structure.

Organic matter is different from organic carbon in that it includes all the elements (hydrogen, oxygen, nitrogen, etc) that are components of organic compounds and not just carbon. Soil organic carbon (SOC), soil organic matter (SOM) and the correlation between bulk density are frequently used to estimate carbon pools (Post et al 1982). Sakin (2012) obtained the relationships between organic carbon, organic matter and bulk density in arid and semi-arid soils in southeast Anatolia region. Increase in organic matter leads to change in nutrient concentration of soil so that available nutrients in the soil may play an important role in the variation of bulk density of soil. The present study aims at finding the effect of texture, organic matter content and total nutrient content on bulk density of soils under polyhouses in mid-hill zone of Himachal Pradesh.

## MATERIAL and METHODS

**Study Area:** The study was carried out in three district of Himachal Pradesh (Solan,

Sirmour and Mandi) located at elevation of about 350-3650 meters (Fig 1). The area lies between 31°13'50" and 32°04'30" of the northern latitude and 76°37'20" and 77°23'15" of eastern longitude. The mean annual temperature of the area varies between 13 and 18°C. On an average the area gets 1000-2500 mm of rainfall in a year. The area had considerable diversity in its soils, land use pattern and cropping system.

The aim of this study was to determine bulk density of soil samples and its relationship with different physico-chemical properties of soil under polyhouse conditions of mid-hill zone of Himachal Pradesh. Ten soil samples each were collected from three districts at a depth of 0-15 cm. The samples were dried in shade, ground in a wooden pestle and mortar, passed through a 2 mm sieve and analyzed for physico-chemical properties using standard procedures. The pH and electrical conductivity were determined in soil/water (1:2) suspension (Jackson 1973). Organic matter (OM) was obtained from estimated organic carbon (OC) using the conventional conversion (Brady 1984):

$$OM = 1.7 \times OC$$

The soil bulk density was selected as dependent variable to determine statistical relationships of particle density, porosity, organic matter content and nutrient concentration with soil bulk density. Factors affecting bulk density are porosity,

texture and organic matter content. Clay soils tend to have a higher total porosity than sandy soils. Bulk density is closely related to the soil porosity through the following relationship (Morgan 2005):

$$\text{Porosity} = 1 - (\rho_b/\rho_s)$$

where  $\rho_b$  = bulk density,  $\rho_s$  = particle density

Available nitrogen was determined using alkaline potassium permanganate method (Subbiah and Asija 1956) and available phosphorous by Olsen's method (Olsen et al 1954). Available K, exchangeable Ca and Mg were determined using neutral ammonium acetate and content was determined by aspirating the extract in to flame photometer (Jackson 1973). The available sulphur in soils was extracted with 0.15 per cent  $\text{CaCl}_2$  solution as described by William and Steinbergs (1959) and DTPA extractable Zn, Fe, Mn and Cu were estimated as per the standard method given by Lindsay and Norvell (1978) (Table 1).

**Statistical analysis:** The relationship between different soil parameters and nutrient content of soils were determined using correlation coefficient 'r'.

$$r = \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{n(\sum x^2) - (\sum x)^2} \sqrt{n(\sum y^2) - (\sum y)^2}}$$

where n= number of pairs of data x, y

Simple correlation coefficients (r) between soil parameters and bulk density are listed in Table 2.

## RESULTS and DISCUSSION

### Relationship of bulk density with particle density and porosity of soil

The particle density and porosity of collected samples ranged between 2.00-2.20  $\text{mg/m}^3$  and 43.00-47.80 per cent respectively (Table 1). The bulk density indirectly provides a measure of the soil porosity. Soil porosity is the ratio of the volume of soil pores to the total soil volume. Thus the bulk density of soil is inversely related to the porosity. Strong negative significant correlation was found ( $r = -0.952$ ) between porosity and bulk density of soil samples (Table 2). It might be due to clayey nature of soils which lowered the pore spaces. Ahad et al (2015) found the same strong negative correlation ( $r = -0.79$ ) between porosity and bulk density of soil.

### Relationship of bulk density with pH and electrical conductivity of soil samples

The pH (6.60-7.00) values indicated that soils were neutral in nature. The values of electrical conductivity (0.51-0.63  $\text{ds/m}$ ) showed that all soil samples were normal ie non-saline in nature.

It was observed that the bulk density was independent whether the soil was acidic or alkaline. Statistical correlation studies showed non-significant positive correlation of bulk density with electrical conductivity ( $r = 0.005$ ) of soil as in Table

Table 1. Physico-chemical properties of soil under polyhouses in mid-hill zone of Himachal Pradesh

| Parameter                       | District |        |         |
|---------------------------------|----------|--------|---------|
|                                 | Mandi    | Solan  | Sirmour |
| BD (mg/m <sup>3</sup> )         | 1.10     | 1.20   | 1.20    |
| PD (mg/m <sup>3</sup> )         | 2.00     | 2.20   | 2.20    |
| Porosity (%)                    | 46.70    | 47.80  | 43.00   |
| pH (1:2)                        | 7.00     | 7.00   | 6.60    |
| EC (ds/m)                       | 0.51     | 0.63   | 0.55    |
| OC (%)                          | 1.80     | 1.90   | 1.70    |
| CEC (cmol (p <sup>+</sup> )/kg) | 14.60    | 16.20  | 14.10   |
| N (kg/ha)                       | 277.70   | 319.40 | 365.30  |
| P (kg/ha)                       | 52.60    | 92.70  | 103.50  |
| K (kg/ha)                       | 506.20   | 505.40 | 494.40  |
| Ca (cmol (p <sup>+</sup> )/kg)  | 11.70    | 11.70  | 10.80   |
| Mg (cmol (p <sup>+</sup> )/kg)  | 0.50     | 0.40   | 0.40    |
| Fe (mg/kg)                      | 25.90    | 23.5   | 25.50   |
| Mn (mg/kg)                      | 8.10     | 4.20   | 7.30    |
| Cu (mg/kg)                      | 2.60     | 7.30   | 3.00    |

Table 2. Pearson correlation coefficient between soil properties under polyhouses

| Related soil property | Correlation coefficient (r) | Level of significance                      |
|-----------------------|-----------------------------|--------------------------------------------|
| B D - PD              | 0.152                       | Positively correlated but not significant  |
| B D - porosity        | -0.952                      | Highly negatively significantly correlated |
| B D - pH              | -0.216                      | Negatively correlated                      |
| B D - EC              | 0.005                       | Positively correlated but not significant  |
| B D - OC              | -0.408                      | Negatively significantly correlated        |
| B D - N               | -0.267                      | Negatively correlated                      |
| B D - P               | -0.254                      | Negatively correlated                      |
| B D - K               | -0.101                      | Negatively correlated                      |
| B D - Ca              | -0.193                      | Negatively correlated                      |
| B D - Mg              | -0.440                      | Negatively correlated                      |
| B D - Fe              | -0.113                      | Negatively correlated                      |
| B D - Mn              | -0.31                       | Negatively correlated                      |
| B D - Cu              | -0.237                      | Negatively correlated                      |

2. Correlation between bulk density and pH ( $r = -0.216$ ) was negative but not so significant. However Shaffer (1998) observed highest correlation between pH and BD in the soil at 0 to 15 cm depth.

#### **Relationship between bulk density and organic carbon of soil samples**

Organic carbon content of soil samples varied between 1.70-1.90 per cent. Significant negative correlation ( $r = -0.408$ ) was found between organic matter and bulk density of soil samples (Table 2). Morisada et al (2004) and Sakin (2012) obtained the relationship between organic matter and bulk density of soils and showed strong correlation between the two. SOM is known to decrease BD because of its abundance of pores and its tendency to increase porosity by aggregating soil particles (Hillel 1980). This elucidates that with increase in soil organic carbon bulk density decreases. This is required for the proper growth of the plants.

#### **Relationship between bulk density and available macro-nutrients in soil samples**

According to Methods Manual of Soil Testing in India the critical limits of nitrogen (N), phosphorus (P) and potassium (K) for normal growth of plant are 280 kg/ha, 10 kg/ha and 108 kg/ha respectively. With this consideration the available nitrogen content (277.71-365.27 kg/ha) of almost all samples was found to be in very low to medium categories. The phosphorus

content (52.59-103.49 kg/ha) of soils indicated that it was very high in all samples. The available potassium (494.37-506.24 kg/ha) in all the samples was high. All soil samples were containing adequate amount of available calcium (Ca) (10.77-11.74 cmol ( $p^+$ )/kg) and magnesium (Mg) (0.40-0.48 cmol( $p^+$ )/kg). The higher amount of these micro-nutrients in polyhouses can be attributed to regular addition of mixed/complex fertilizers. In the present study dependence of bulk density on available primary (N, P and K) and secondary (Ca and Mg) macro-nutrients in the soil was studied. It was found that the bulk density was correlated negatively with primary macro-nutrients and secondary nutrients ( $N = -0.267$ ,  $P = -0.254$ ,  $K = -0.101$ ,  $Ca = -0.8119$  and  $Mg = -0.193$ ). This may be attributed to higher crop production inside the polyhouse which leads to more organic matter production that further decreases the bulk density.

#### **Relationship between bulk density and available micro-nutrients in soil samples**

The available Fe, Mn and Cu ranged from 23.51-25.89, 4.23-8.10 and 2.64-7.30 mg/kg respectively. It was inferred that all the soil samples were high in available micro-nutrients. The probable reason for high micro-nutrient content inside the polyhouse could be due to the excessive application of micro-nutrient fertilizers. As that of macro-nutrients the available total micro-nutrients (Fe, Mn and Cu) in the soil also varied bulk density of the soil. It was

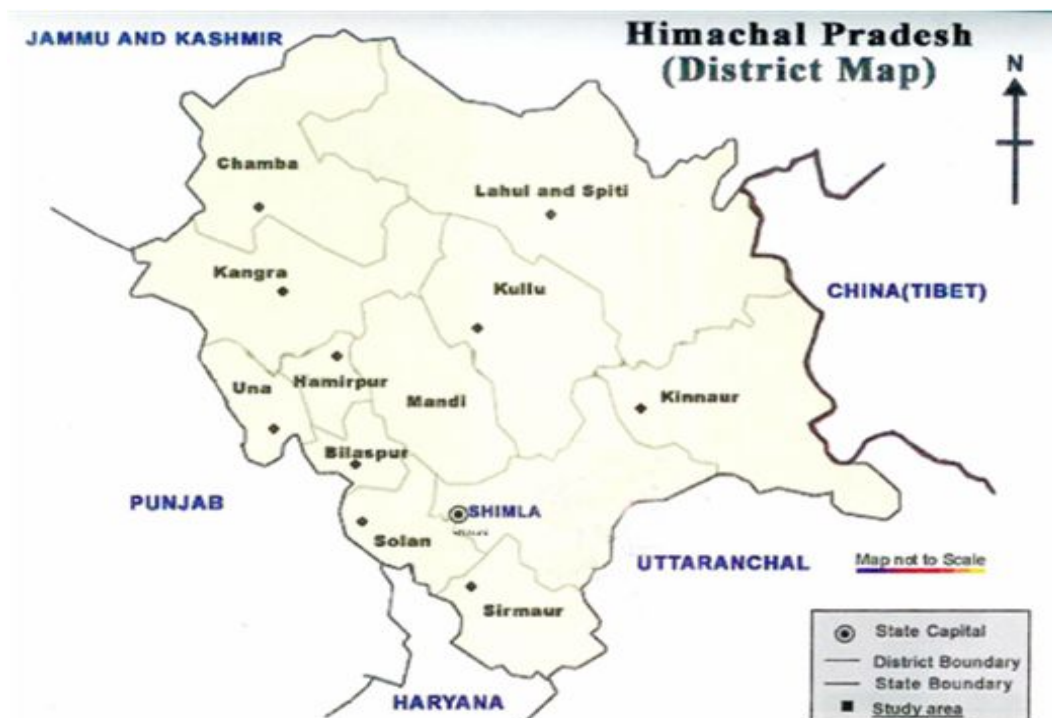


Fig 1. Map showing study area

found that the bulk density decreased as the Fe, Mn and Cu content increased. Laiho et al (2004) reported that the total variances of Fe and Zn decreased with increase in bulk density.

### CONCLUSION

The porosity in the soils under polyhouses in mid-hill zone of Himachal Pradesh has highly significant negative correlation with bulk density as compared to other soil properties. In the present study there was no effect of soil reaction on the bulk density. High degree of reverse correlation was found between

organic matter and bulk density. Organic matter plays an important role in soil productivity. It provides nutrients to the soil, improves its water holding capacity and maintains good soil tilth and thereby better aeration for germinating seeds and plant root development. As that of organic matter bulk density was dependent on available macro- and micro-nutrients in the soil, the total macro- or total micro-nutrient contents in the soil increased the organic matter content and decreased the bulk density. All the soil samples were having high organic matter content which means soils were having good fertility status under the polyhouses.

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**Received: 7.3.2015**

**Accepted: 4.6.2015**