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# Soil Response to Compaction (A Case study in north of Khuzestan, Iran)

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**ABSTRACT:** Soil compaction is a process whereby soil bulk density increases. Compaction of agricultural soils may be caused by artificial means through use of heavy machinery currently used in agricultural and land reclamation practices and through animal grazing. Techniques that could minimize compaction include determining appropriate moisture for trafficking, use of amendments, cropping system and grazing management. The response of three different texted soils to compaction under varying soil moistures was investigated. Either field capacity or plastic limit, whichever is less, can be used as threshold moisture content in order to indicate compaction hazard. For al1 three soils the addition of fly ash significantly ($P \leq 0.05$) decreased plasticity index, and thus reduced soi1 susceptibility to compaction.

***Keywords*:** Soil compaction, Tillage, Bulk density, Plastic limited

## INTRODUCTION

Soils are considered to be compacted when the total porosity and, in particular, air-filled porosity are so low as to restrict soil aeration and also when soil has high strength and its pores are small so as to impede root penetration and drainage (Bennie 2001). Compatibility refers to the maximum density to which a soil can be packed by a given amount of energy. There are several factors that influence soil compatibility. Inherent bulk density, soil structure, organic matter content, soluble salt concentration and most importantly water content and comp active effort (Thacker et al. 2005). These factors also influence soil workability and traffic ability. Workability is defined as the mechanical manipulation of soil with little or no structural damage, while traffic ability refers to the ability of a soi1 to bear traffic load without structural damage (Larson et al. 2003). Traffic ability results from soil-wheel or track interactions and it determines the ability of a soil layer to react to a given implement under given conditions of initial structure and water content (Guerif 2000). Agronomists have traditionally used water retention at field capacity as the appropriate upper Lit for soi1 water content that provides a balance between good soil aeration and uptake of water by plants (Hillel 2004). The wilting point has been defined as the lower limit for soil water content below which plants will not be able to extract water, and thus will start to wilt and eventually die. Soi1 scientists define moisture content retained at 0.033 MPa as the field capacity, while water retained at 1.5 MPa is the wilting point In the field, a working definition of field capacity is the moisture content of soil that has drained for 2-3 days after a rain or irrigation without evapotranspiration (Hillel 2004). Farmers usually wait for at least two days after a rainfall to start cultivating the land. This implies that cultivation practices are not likely to be carried out at moisture contents above field capacity. Hence the cultivation zone moisture content is between field capacity and wilting point However, in fine textured soils the soil is in a plastic state at moisture contents below field capacity. Cultivating the soi1 in its plastic state poses severe compaction hazard. In addition, given larger tractors and wider cultivators, farmers are now able to cultivate much closer to water bodies and thus under higher soi1 moisture contents than previously. Several studies have reported empirical relationships between bulk density, water content and penetration resistance. For example Ehlers et al (2005) found that penetration resistance increases with an increase in bulk density and a decrease in water content for both tilled and untilled soils. In a more recent study, penetration resistance was found to vary markedly with time and was closely related to changes in soil water content (Martino and Shaykewich 2000). Thus generally it is accepted that penetration resistance is related to moisture content and bulk density. However, such a relationship may Vary from one soil to another depending on soil texture (Taylor and Ratliff 2006). Cone penetrometers which measure penetration resistance (PR) provide an easy technique for assessing compaction, but the relationship of PR with moisture content and bulk density needs to be investigated. This study was conducted to test the following hypotheses:

1) Soil consistency limits, agronomic limits and the Proctor critical moisture content are not related and cannot be used to define moisture ranges over which maximum compaction occurs.

2) There is no functional relationship between penetration resistance, bulk density, moisture content and soil texture.

## MATERIALS AND METHODS

The experiment was conducted at Shuoshtar region (49º 14′ E and 23º 2′ N), 90 Km north of khozestan, province, Iran.

***Soil physical and chemical properties***

The three soils used in the study included two soils from a reclaimed surface mine site 90 km north of Khuzestan, Iran (a clay loam topsoil and a sandy loam subsoil), and one soil (Orthic Black Chernozem of loam texture) from a grazing land at Gotvand region 25 km north of shoushtar, Khuzestan. All soils were air dried and ground to pass a 2-mm sieve. Particle size distribution was determined using the hydrometer method (Sheldrick and Wang 2004). Water retention characterstics were determined using pressure plates. The amount of gravimetric moisture retained at pressures of 0.010, 0.033, 0.050, 0.10, 0.30 and 1.50 kPa was determined in replicates of three. Soil chemical properties determined in replicates of five for the soils included pH, electrical conductivity (EC), sodium adsorption ratio (SAR), soluble cautions (Ca, Mg, Na and K), and organic matter content (OM). The pH was determined by glass electrode in 1:2 ratios of soil to 0.01 M $CaCl_2$ and soil to distilled water suspensions (Sheldrick 1999). Saturation paste extracts (Richards 1954) were prepared and analyzed to determine electrical conductivity and soluble cautions. Electrical conductivity provides a rapid and reasonably accurate determination of solute concentration and depends on the ionic composition of the solution. Soluble calcium and magnesium concentrations were measured using atomic absorption spectrophotometry while sodium and potassium concentrations were measured using flame emission. Organic carbon was determined using the modified titrimetric dichromah redox Walkley and Black method outlined by Tiessen and Moir (2002).

***Soil compacttibility and consistency limits***

The liquid limit (LL) was determined using the one-point Casagrande method (McBride 1993). A mechanical device consisting of a specified size cup made of bras and weighing about 200 g, a Cam and crank mounted on a hard rubber block and a grooving tool, was used for the test. The gravimetric moisture content (w) of the soi1 at which between 20 and 30 blows were required to close a groove dong a distance of 13 mm was determined by oven-dying. Two coactive dousers of the groove were observed before taking a sample for moisture content determination. The liquid limit (LL) was then determined from the number of blows (N) and the gravimetric moisture content (w) of the sample:

$$\mathbf{LL = w\ (N/25)^{0.12}}$$

The plasticity index (PI) was calculated as the difference between the liquid limit (LL) and the plastic limit (PL) and reflects the range of moisture content over which the soil is susceptible to compaction by external forces (McBride 1993). The higher the PI value, the greater the range of moisture over which the soil is susceptible to compaction.

***Statically analyses***

Statistical analyses were conducted using a SAS package (SAS Institute 2007). Analysis of variance was conducted using the Generalized Linear Models procedure for the completely randomized design. Test for normality of data distribution for each data set was conducted using the W-test (Shapiro and Wilk 1995). Multiple linear regression analysis was performed using a stepwise procedure to determine the best regression model to describe variation in the penetrometer resistance as a function of bulk density and moisture content From this, conclusions were drawn about which variable or variables were dominant in determining the variability of penetration resistance.

## RESULTS

Soil physical and chemical properties The organic matter content was greatest in the loam and least in the sandy loam soi1 (Table 1). The sandy loam was slightly alkaline while the clay loam and loam were acidic. Moisture retention for all three soils increased as matric suction decreased. However, the rate of decrease of water retention with an increase in matric suction was pater in sandy loam than in day loam soil. Statistical analysis indicated that both field capacity and wilting point were significantly different among soils (P≤0.05) (Table 2). The values of FC for sandy loam and loam soils were within three percentage points of the corresponding critical moisture content (CMC) values.

### *Soil compactibility and consistency Limits*

The Proctor maximum bulk density, critical moisture content, liquid bit, plastic limit, field capacity and wilting point were significantly (P≤0.05) different among soils of different texture (Table 2). Plasticity indices for sandy loam and loam were similar. Test for normality of data distribution using the W-test (Shapiro and Wilk 2000) indicated that data each of the limits determined were normally distributed as required in parametric statistics.

The liquid limit (LL) for the day loam soil was significantly (P≤0.05) greater than that for either sandy loam or loam soil (Table 2). The plastic limits (PL) for sandy loam, loam and clay loam were significantly (P≤0.05) different from each other. However, the Pls for these soils were within three percentage points of each other. The plasticity index (PI) for clay loam was significantly (P≤0.05) greater than that for either sandy loam or loam while PI for sandy loam was similar to that for loam soil. This means that the day loam is prone to compaction over a wider range of moisture contents than either the sandy loam or loam soils.

Table 1. Physical and chemical properties of the three soils used in the study

| Soil characteristic | Sandy loam | loam | Clay loam |
|---|---|---|---|
| Sand (%) | 69 | 50 | 24 |
| Silt (%) | 13 | 33 | 34 |
| Clay (%) | 15 | 14 | 38 |
| Organic matter (%) | 0.5 | 8.5 | 3.4 |
| pH (using 0.01 M $CaCl_2$) | 7.3 | 4.7 | 5.7 |
| Electrical conductivity (ds $m^{-1}$) | 0.42 | 0.30 | 0.38 |
| Sodium adsorption ratio | 7.8 | 0.2 | 4.2 |
| Ionic strength (moles $L^{-1}$) | 0.006 | 0.004 | 0.005 |

Table 2. proctor maximum, bulk density, critical moisture content, agronomic and Atterberg limits for three soils of different textures

| Soil characteristic | Sandy loam | loam | Clay loam |
|---|---|---|---|
| proctor maximum density (Mg $m^{-3}$) | 1.74 | 1.49 | 1.45 |
| critical moisture content (g/100g) | 14.4 | 20 | 24.2 |
| Field capacity (g/100g) | 15.2 | 18.7 | 33 |
| Wilting point (g/100g) | 6.4 | 10.8 | 18 |
| Liquid limit (g/100g) | 30 | 33.8 | 50 |
| Plastic limit (g/100g) | 25 | 27 | 26 |
| Plasticity index (g/100g) | 5 | 6 | 23 |

Within rows, means followed by the same letter indicate non-significant difference (P≤0.05); n=3; field capacity measured at 0.033 MPa; wilting point at 1.50 MPa

## REFERENCES

Bennie, A.T.P. 2001. Growth and mechanical impedance. In: (Y. Waisel. A. Esheland U. Kaacafi (Eds.), Plant Roots: nie Hidden HnIf, pp. 393-411.

Ehlers, W., Kopke, U., Hesse, F. and Bohm, W. 2005. Penetration resistance and root growth of oats in Wed and untilled loess soil. Sd TiIL Res. 3: 261- 275.

Guérif, J. 2000. Effects of compaction on soil strength parameten. In: B.D. Soane and C van Ouwerkerk (Eds.), Soi1 Comp1u:tton in Crop Production, Elsevier Science, Amsterdam. pp. 191-214.

Hesammi, E . 2013. Striga and ways of control. International Journal of Farming and Allied Sciences. Volume 2 . 53-55 PP.

HilleI, D. 2004. Fundament & of Soi2 Physics. Academic Press, New York Jumikis, A.R. 19û4. Soi1 Mechanics. Robert E. Krieger Publishing Company., hc., Malabar, Florida.

Larson, W.E., Eynard, A., Hadas, A. and Lipiec, J. 2003. Control and avoidance of soil compaction in practice. IK B.D. Soane and C. van Ouwerkerk (Eds.), Soi2 Compaction in Crop Production, Elsevier Science, Amsterdam. pp. 597-625.

Martino, D.L. and Shaykewich, CF. 2003. Root petration profiles of wheat and barley as affecteci by $4 penetration resistance in field conditions. Cm. 1. Sd Sd. 74: 193-200.

McBride, RA. 1993. Soil consistency limits. In: M.R Carter (Ed.), Soi1 Sampling and methods of Analysis, Lewis Publishers, pp. 519-527

Shapiro, S.S. and Wilk M.B., 1965. Analysis of variance test for normality (complete samples). Biometrika 52: 591411

Sheldridc, B.H. and Wang C., 2004. Particle size distribution. in: M.R. Carter (Editor), Soi1 Sampling und Mefhods of Annlysis, Lewis Publishers pp. 499- 511.

Sheldrick, B.H. 1999. Analytical Methods Manual. LRRI Contribution No 84-30. Agriculture Canada, Ottawa, Ontario.

Stone, RJ. and Ekwue, E.L. 1993. Maximum bulk density achiwed duMg soil compaction as aff&ed by the incorporation of thme organic makrials. Trans. Amer. Soc WC. Eng. 36: 1713-1719.

Taylor, H.M. and Ratliff, L-F. 2006. Root elongation rabes of cotbn and peanuts as a function of soil strength and soil water content Soi1 Sd. 108: 113-119.

Terzaghi, C. 1926. SimpIified soil tests for subgrades and their physical significance. Public Rwds 7: 153-162

Thacker, D.J., Campbell, J.A. and Johnson, R.L. 2005. The effect of soil compaction on root penetration, mechanical impedance and moisture density relationships of seleded soils of Alberta. Alberta Conseniatia and Lund &chmation Management Group Repart #RRTAC OF-9.37 pp.

Tiessen, H. and Moir, J.O. 2002. Total and organic carbon. In. M.R. Carter (Editor), Sui2 Sampling and Mefhods of Andysis, Lewis Publishers, pp. 187- 199.