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Effect of Compactions on Infiltration Characteristics of Soil

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Abstract: The field research was conducted at Sindh Agriculture University Tandojam, Pakistan. The treatments were soil compactions (uncompacted, 5 and 10 times compacted soil) and their effect on water infiltration rate in silt loam soils. It was observed that infiltration rate was higher during initial irrigation application, but, gradually reduced and became constant when the soil was saturated. The bulk density of uncompacted, 5 and 10 times compacted soils was recorded as 1.13 to 1.20, 1.19 to 1.29 and 1.19 to 1.32 g/cc, respectively at 0 to 90 cm soil profile. The infiltration rate was higher (17.10 mm/hr) in the uncompacted soil compared to those 5 and 10 times compacted soils (13.89 and 9.78 mm/hr.) respectively. The increased infiltration rate in the uncompacted soil was mainly due to soil porous medium having low bulk density values.

Key words: Infiltration-silt, loam soil, soil compactions

Introduction

The infiltration rate of the soil is influenced by various factors depending on the condition of the soil surface, its chemical, physical characteristics, and distribution of water (U. S. Salinity Laboratory Staff, 1954). Stern (1980) reported that the rate of entry of water was greatest when the soil was dry at the start of watering, but, it decreased as the topsoil became saturated. FAO (1988) also reported that the infiltration rate was rapid when the water is first applied to the soil, but when the topsoil becomes saturated, the swelling of the clay is caused and hence, the infiltration gradually becomes constant (Donen and Westcot, 1988; McNeal and Coleman, 1973). The decrease in infiltration rate with time is mainly due to the depth of wetted zone. The metric potential gradient tends to zero and steady at the approximate hydraulic conductivity of the soil (Hillel, 1971). However, cracks developed in dry soil are closed by swelling of clay particles and the volume of water passing through decreases sharply with time due to filling of the cracks (Kosmas and Moustakes, 1991). Oster (1999) reported that, in order to grow crops, farmers must maintain adequate physical properties by using various combinations of crop, soil, water, and tillage practices. The primary properties of concern are water and air movement into and through soil, and the ability to prepare seed beds with a tilth that fasters seed germination, a critical step in crop growth. Furthermore, hydraulic conductivity must be adequate so that salts can be removed from the root zone through leaching. Soil physical conditions, such as slow re-distribution, compaction and poor aeration, and traffic ability are often the consequences of low hydraulic conductivity. The conditions can occur quickly in the salt affected soil when the salinity is too low to compensate for the effects of exchangeable sodium on soil properties. Oster and Jayawardane (1998) reported that infiltration rates, hydraulic conductivities, and soil tilth decrease with decreased soil salinity and with increasing exchangeable sodium. At the soil surface, infiltration rates and soil tilth are particularly sensitive to salt and exchangeable sodium levels. The mechanical impact and stirring action of the irrigation water, or rain, combined with the freedom for soil particle movement at the soil surface can result in low infiltration rate when the soil is wet, and cause hard, dense soil crusts when the soil is dry. Crusts can block the emergence of seedlings. Tillage of crusted soil can result in hard soil clods that are particularly difficult to reduce in size when the clod is dry. Extensive tillage can be required to prepare a seed bed with sufficient tilth to assure adequate seed contact with soil for seed germination. Morin and Benyamini (1977) suggested that when water is applied to the soil surface at a rate exceeding infiltration rate, whether through rainfall or by irrigation, some enters the soil, while the remainder either accumulates on the surface or is carried as runoff. Generally, infiltration rate is high during the initial stage of soil wetting but decreases exponentially with time to approach a constant rate. Two main factors are responsible for this decrease: (1) a decrease in the matric potential gradient, which occurs as infiltration proceeds, and (2) the formation of a seal or crust at the soil surface. Soils in semi-arid and arid regions, where the organic matter content is usually low, soil structure is unstable, and sealing is major factor determining the steady-state infiltration rate.

Materials and Methods

The field experiments were conducted at Sindh Agriculture University Tandojam, Pakistan. The treatments were the effect of compacted and uncompacted soil types on infiltration rate of water. The compacted soils were prepared by Ford-6610 tractor wheels (5 and 10 times compacted than uncompacted soil). The textural class of the soil was silty loam. The average bulk density of the uncompacted soil was 1.13, 1.15, 1.17, and 1.20 gm/cc at 0-15, 15-30, 30-60, and 60-90 cm soil depths, respectively. The bulk density of five and ten times compacted soil was 1.27, 1.22, 1.19, and 1.29 gm/cc and 1.32, 1.27, 1.20, and 1.19 gm/cc, respectively at above mentioned soil depths. The infiltration rate of the soil was identified by the double ring infiltrometer by following procedure:

Buffer cylinder was installed in the soil with the help of big driving plate and hammer. Intake cylinder was installed with the help of small driving plate with hammer. Both the cylinders were leveled and then checked with the help of spirit level. Hookguage was fixed in intake cylinder. Straws were used as puddling protection device into the intake cylinder before putting water into the cylinder. Straws were removed from the intake cylinder after filling with water. Digital watch was used for time recording. Initial time and initial hookguage readings were taken simultaneously. Initially hookguage readings were checked after every five minutes, after thirty minutes, after another seventy minutes. After passing one hundred thirty minutes the hookguage readings were taken after every thirty minutes. The elapsed time was taken from time readings, and accumulated depth was taken from hoockguage readings. The equation selected for determining infiltration was: Iave = D/T x 60, where Iave = average infiltration rate (mm/hour), D = Accumulated depth (mm), and T = Elapsed time (minutes).

Results and Discussion

The infiltration rate in the uncompacted silt loam soil was higher in all three tests (17.84, 16.42, and 17.05 mm/hr) respectively by recording an average value of 17.10 mm/hr in three hours (Table 1) . The average infiltration rate in 5 and 10 times compacted soil was 13.89 and 9.78 mm/hr, respectively (Table 1) which was quite lower than uncompacted soil. The fact for higher intake in uncompacted profile was due to the low bulk density of the soil, ranging from 1.13 to 1.20 g/cc where porosity was high which allowed water to penetrate soil profile easily, whereas in 5 and 10 times compacted soil profiles, the bulk densities

Table 1: Average infiltration rate of uncomapcted, 5 and 10 times compacted silt loam soil

Nature of soil	Test No.	Infiltration Rate (mm/hr)	Average
Uncompacted soil	1	17.84	
	2	16.42	17.10
	3	17.05	
5 times compacted soil	1	13.89	
	2	13.42	13.89
	3	14.36	
10 times compacted soil	1	9.78	
	2	10.42	9.78
	3	9.15	

were higher 1.19 to 1.29 and 1.19 to 1.32 g/cc, respectively at 0 to 90 cm soil profile. The results agree with the findings of Oad *et al.* (2001) who concluded that the intake rate was badly affected by swelling of soil particles, and porosity of the soil. Thus compacted soils exhibited lower intake rate as compared to uncompacted soil profiles. Further, it was observed that initially when the soil was dry, the infiltration rate was also higher. FAO (1988) also reported similar findings and expressed that the infiltration rate takes place most rapidly when the water is first applied to the soil, but as the topsoil becomes saturated, the swelling of the clay is caused and hence, the infiltration gradually becomes constant (Donen and Westcot, 1988; McNeal and Coleman, 1973). The decrease in infiltration rate with time is mainly due to the depth of wetted zone.

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