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Tillage Effects on Soil Hydraulic Characteristics

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ABSTRACT

Although the hydraulic characteristic of the plough layer and deeper soil horizons are often used as basis for calculating soil infiltration rate. Surface characteristics usually govern the entry of water into the soil during high rainfall rates. The effect of surface characteristics and surface connected non capillary sized holes and cracks are usually not determined in traditional soil physical based infiltration methods. However, Tillage operations influences both the surface (cover) and subsurface soil conditions. Therefore, four tillage treatments such as mouldboard plough followed by two passes of disk harrow, mouldboard plough followed by two passes of tine cultivator, Dyna drive followed by one pass of disk harrow and dyna drive followed by one pass of tine cultivator were used to study their effect on soil hydraulic characteristics. Tillage increased the immediately available pore space near the freshly tilled soil surface but decreased the amount of infiltrating water moving deeper into the soil profile with time. During both the yeas, rate of soil infiltration was consistent.

Key Words: Conventional Tillage; Conservation Tillage; Soil Hydraulic Characteristics

INTRODUCTION

The ability of soil to retain and transmit water is measured by the hydraulic characteristics of soil. These properties are determined by the geometry of the pore space. The latter is modified in various ways by tillage operations. Tillage pulverises the soil to such an extent that remains difficult to measure and characterise the arrangement of soil particles, their pore size distribution and the pore continuity of soil that has been disturbed by ploughing or any other form of tillage (Klute, 1982; Blevins *et al.,* 1983). The hydraulic characteristics of soil, particularly few centimetres below the top soil surface are critical. Macropores are, however, capable of rapid and far-reaching preferential transport of water and dissolved agro chemicals during infiltration. The size and continuity of these large pores in the surface soil often control the rate of water entering into the root zone (Hamblin, 1984).

To represent the effect of tillage on pore system of field soil approximately, it is useful for undisturbed measurements to be made in situation upon the soil surface. The fragile nature of soil surface macropores, their ventedness and connectedness can lead to temporal variation in the hydraulic character of tilled soil (Carter, 1988). Tillage loosen the soil surface, decreasing the soil bulk density, increasing porosity and hence, increases the amount of water held at high water potentials and decreases the amount of water held at lower potentials (Kalute, 1982). This often increases the hydraulic conductivity. These effects decline with time as the soil matrix reconsolidate. Thus techniques to measure soil physical characteristics should be fast and simple in order to monitor rapid changes in surface macroporosity .

The purpose of this study was to compare the effect of conventional and conservation tillage treatments on hydraulic characteristics, specifically soil infiltration rate and soil moisture content.

MATERIALS AND METHODS

Present research was conducted in the experimental area of the University of Newcastle upon Tyne continuously for two years. Research area was divided into 16 plots, each having a dimension of 24x6 m. The area was located at an elevation of 90 meters above the mean sea level. The climate of the region was temperate having mean rainfall of 650 mm unevenly distributed throughout the year. The land had been cultivated for the past 60 years under a crop rotation of wheat, winter barley and grass. The soil at site has been found a sandy clay loam texture.

Four tillage implements were used at the site at different depths. Mouldboard plough and dyna drive were considered as primary tillage implements, and used at a depth of 25 and 10 cm, respectively. Whereas, disk harrow and tine cultivator were considered as secondary tillage implements, and used at a depth of 10 cm in each case. Mouldboard plough followed by two passes of disk harrow and mouldboard plough followed by two passes of tine cultivator were considered treatments 1 and 2 and regarded as conventional tillage. Dyna drive followed by one pass of disk harrow and dyna drive followed by one pass of tine cultivator were considered as treatments 3 and 4 and regarded as conservation tillage. Each treatment was replicated four times in the whole area.

Measurements of soil infiltration rate were carried out immediately after the cultivation by using a double ring infiltrometer (Lal *et al.,* 1989). Infiltration rate of soil was measured in each plot at three different locations, randomly selected to get a basic infiltration rate for both the years. Soil sampling for per cent soil moisture content and dry bulk density of soil (Khan *et al.,* 1999) was immediately followed by the measurements of soil infiltration rate. Total soil porosity was calculated from soil bulk density data during both the years for each treatment. During year 1, it was 55, 52, 49 and 48% for treatments 1, 2, 3, and 4, respectively and during year 2 , it was 51, 50, 50 and 49% for treatments 1, 2, 3 and 4, respectively.

RESULTS AND DISCUSSION

During experiment 1, significantly greater soil infiltration rate was found under treatments 1 and 2 than those under 3 and 4 (Fig. 1). This is mainly associated with primary tillage implements used and per cent soil moisture content at the time of measurements (Fig. 2). But effect of secondary tillage implement cannot be ignored. The soil infiltration rate was greater in the beginning, because of initial soil surface conditions and total porosity affected by different tillage treatments, that was 55, 52, 49 and 48% for treatments 1, 2, 3 and 4, respectively. Decreased porosity with time take place when bigger pore spaces are filled with smaller soil particles which ultimately decrease the soil infiltration rate (Fig. 1). The soil infiltration rate after steady state condition was similar for all the four different tillage treatments (Fig. 1). Similar results were reported by Hermawan and Cameron (1993).

Fig. 1. Soil infiltration rate after cultivation during experiment 1

Fig. 2. Moisture content on dry weight basis after cultivation in soil profile

During experiment 2, significantly greater soil infiltration rate was found under treatments 1 and 2 than hose under 3 and 4 (Fig. 3). This is mainly associated with

Fig. 3. Soil infiltration rate after cultivation during experiment 2

Fig. 4. Moisture content on dry weight basis after cultivation in soil profile

soil surface conditions produced by different primary and secondary tillage implements. The disk harrow used as a secondary tillage implement had increased soil infiltration rate in their respective plots (Fig. 3). The greater soil infiltration rate in the beginning (Fig. 4) is associated with initial soil moisture content at the time of measurements, affected by different tillage treatments and total soil porosity which was 51, 50, 50.6 and 49% for treatments 1, 2, 3 and 4, respectively. This showed that soil infiltration rate was greater under conventional tillage than under conservation tillage. These results are similar to Ross and Hughes (1985) and contradictory to those of Edwards (1982) in which they said that soil infiltration rate of no-till is higher than tilled soil.

CONCLUSIONS

1. There was a consistency between soil infiltration rate, as affected by conventional and conservation tillage treatments during both the years because of freshly tilled soil at the time of measurements. Infiltration rate was much higher in plots when mouldboard plough was used as primary tillage implement.
2. The soil hydraulic characteristics studied during this investigation mainly depend upon the soil porosity and soil moisture content at the time of measurements after cultivation.

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