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Influence of simulated rainfall on physical properties of a conventionally tilled loess soil

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Abstract

Rainfall simulations were conducted on a loess derived silt loam soil (Henan province, P.R. China) under conventional tillage. This tillage practice is widespread and involves the turning of the plough layer and the wheat stubble in July (primary tillage), followed by a secondary tillage operation in October. Soil samples were collected and in situ measurements were done before each rainfall simulation in order to analyse soil physical properties after successive simulated rainfall events. The purpose of this study was to determine rainfall induced changes in saturated hydraulic conductivity, bulk density, penetration resistance, water retention and soil erodibility. The results only showed significant differences in soil bulk density and erodibility when applying successive rainfall events. Penetration resistance and water retention (at matric potentials ≤ -3 kPa) were not significantly affected and soil surface sealing was not observed. This was also confirmed by the infiltration measurements, where no significant differences in saturated hydraulic conductivity were found. From a soil conservation point of view, this study indicated that the primary tillage operation

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(i.e. ploughing at the beginning of July) is rather disadvantageous: the saturated hydraulic conductivity is not significantly affected, but the soil erodibility is considerably higher in comparison to a consolidated soil. Furthermore, the beneficial effects of the wheat stubble on soil and water conservation are lost by the tillage operation.

Keywords: Field rainfall simulation; Loess soil; Conventional tillage; Soil properties; Consolidation

1. Introduction

The soils of the Chinese Loess Plateau are affected by severe soil erosion. Most areas are under conventional tillage, by which the upper soil layer is turned after harvest and before sowing. This results in an uncovered soil surface during July, August and September. These months are characterised by the highest rainfall amounts: more than half of the total annual rainfall occurs during this period (Fig. 1). Tillage can affect bulk density, water retention, surface roughness, penetration resistance and hydraulic conductivity (Cassel, 1983; Williams et al., 1984; Mapa et al., 1986; Somaratne and Smettem, 1993; Horton et al., 1994; Guérif et al., 2001). Therefore, tillage may increase infiltration rate and slow down runoff, preventing high erosion rates. However, depending on the soil type, the changes induced by tillage may disappear rapidly due to reconsolidation. During wetting by natural rainfall or irrigation, the soil can reconsolidate by three mechanisms (Ahuja et al., 1998): (i) raindrop impact; (ii) the effective stress in the soil approaching zero, which causes the soil matrix to collapse under its own weight, thus reducing the size and number of macropores; and (iii) the dynamic forces of water moving through the pores (adsorption and momentum), which tend to condense the matrix. During redistribution or drainage of the infiltrated water, the increasing negative

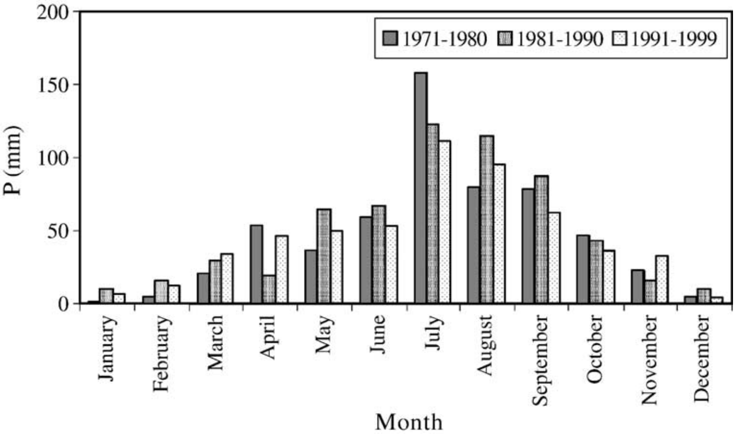

Fig. 1. Average monthly precipitation P over the period 1971–1999 at the Luoyang Dryland Farming Experimental Station (Henan Province, P.R. China).