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Three-stage Subsoil Interval Mixing Plough for Improvement of Planosol*

— Part 2: Soil Improvement and Crop Yield —

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Abstract

To improve planosol soil conditions, a new Three-stage Subsoil Interval Mixing Plough (hereafter, TSIM-plough) was constructed in 2010. The TSIM–plough resolved three problems encountered by the original Three-stage Subsoil Mixing Plough (hereafter, TSM-plough) developed in 1996. In this paper, the improved soil penetration resistance (trafficability) and crop yields in the field operated with this TSIM-plough are discussed. The new plough produced greater soil penetration resistance, and so greater trafficability of vehicles. The difference of the soybean yield was small between the TSM-plough and the TSIM-plough, and so the usage of the TSIM-plough is preferred.

[Keywords] planosol, soil improvement, subsoil interval mixing, soil penetration resistance, soil water content, crop yield

I Introduction

Fig. 1 shows the planosol of a cultivated field at State Farm 853 in the Hongxinglong district, P. R. of China. The first horizon (Ap) is a humic soil that is suitable for plant growth and has a thickness of about 200 mm. The second horizon (Aw) is a lessivage soil that is dense and impermeable and has a thickness of about 200 mm. The third horizon (B) below about 400 mm depth is diluvial heavy clay (Akazawa, 1986; 1987).

With the impermeable Aw horizon, plants suffer both from drought and excess moisture. The soil hardness (penetration resistance) of the Aw horizon is more than 5.0 MPa (cone penetrometer having 30º cone angle and 16 mm base diameter). Roots of plants cannot penetrate the Aw horizon, and soil microorganisms cannot live beneath it (Zhao and Hong, 1983).

Araya (1991) investigated the structure of planosol and found the particle size distribution of the Aw horizon was well suited for soil compaction. The Aw soil is a bidisperse (binary) mixture in which mainly silt forms the frame structure and clay fills the pore spaces. To disturb the bidisperse mixture characteristics of the Aw soil, the Aw and B horizons should be mixed one-to-one, and the clay percentage should be increased.

A Three-stage Subsoil Mixing (TSM) Plough was developed in 1996-1998 to improve planosol (Araya *et al*., 1996a; 1996b; 1996c; 1996d; 1996e; 1996f; Jia *et al*., 1998a; 1998b; Liu *et al*., 1998a; 1998b). The TSM-plough can mix the second (Aw) and the third (B) horizons of planosol in a one-to-one ratio, while leaving the first (Ap) horizon undisturbed. With the clay from the B horizon mixed into the Aw horizon, the subsoil hardness no longer recovers to its original level (Zhao *et al*., 1989), and hence, a long-term improvement of planosol can be obtained by the use of the TSM-plough.

Since the initial development of the TSM-plough, the authors have been focusing on its large-scale extension in the planosol farmland area (Liu *et al*., 2001; Jia *et al*., 2005). However, three issues were found that required attention. 1) Its working width was 460 mm (just one-third that of conventional subsoilers), so its operational cost was nearly three times as expensive as the subsoilers. As a result, its large-scale extension was limited in practice. 2) A great draught moment was caused on the tractor by the plough draught, which made it difficult for the driver to keep the tractor running straight. 3) The TSM-plough sometimes produced excessively soft subsoil. This triggered poor trafficability for vehicles under waterlogged conditions and subsequently delayed the timing of harvesting, especially in

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the first year after operation.

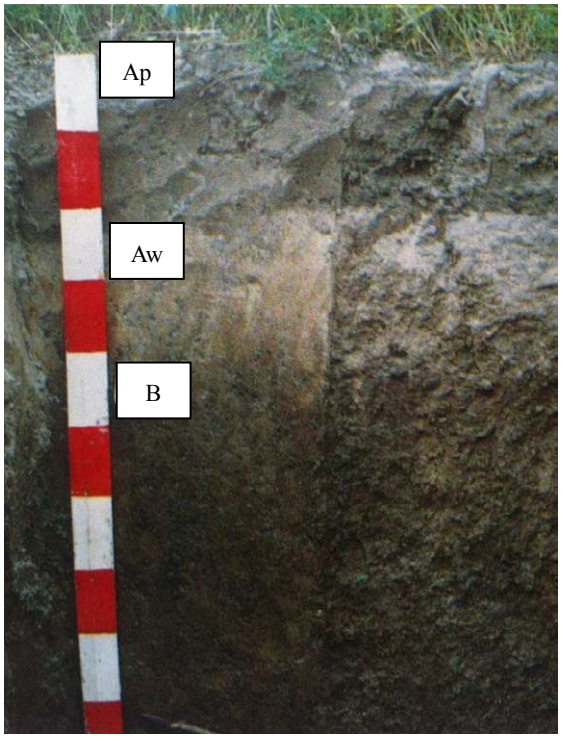

Fig. 1 Typical planosol (Baijiangtu) at State Farm 853, Hongxinglong district, P. R. C. (Each graduation on the scale represents 100 mm) (Jia *et al*., 2013)

Fig. 2 Three-stage Subsoil Interval Mixing Plough (TSIM-plough) developed in 2010 (Jia *et al*., 2013)

In order to resolve these three problems, a Three-stage Subsoil Interval Mixing (TSIM) Plough (Fig. 2) was developed in 2010. In the previous paper (Jia *et al*., 2013), the draught and moment of the TSIM-plough were reported. In this paper, we discuss the soil penetration resistance (trafficability) and crop yields of the field operated with this TSIM-plough.

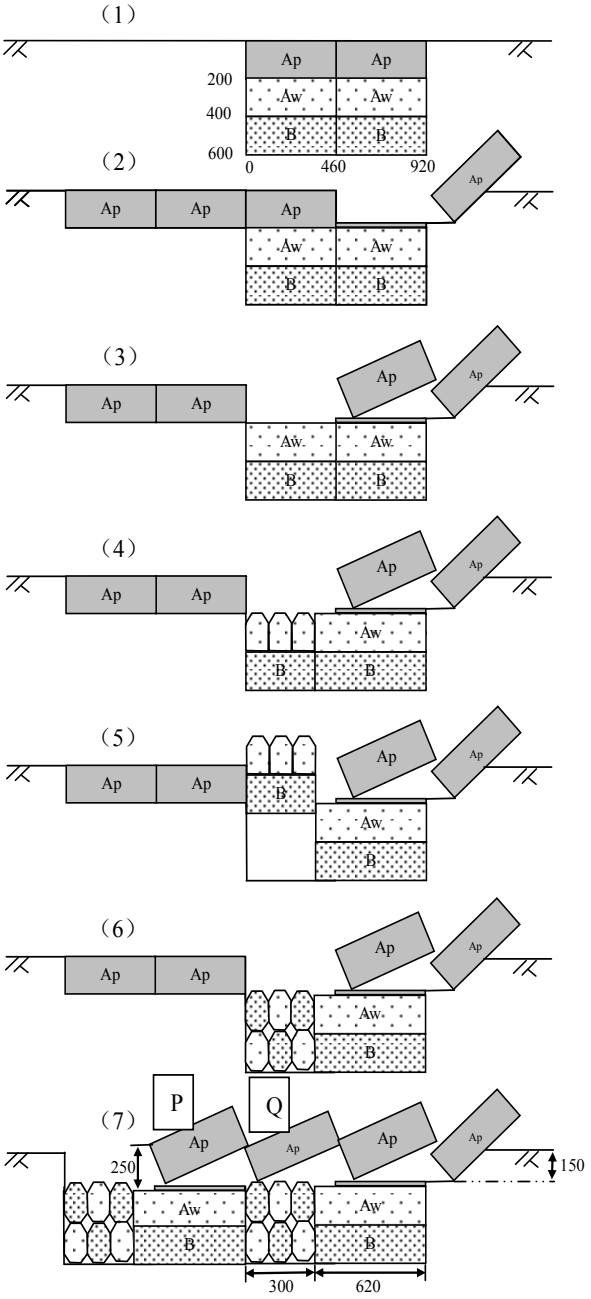

Fig. 3 Schematic diagram of mixing Aw and B horizons bt TSIM-plough, measurements in mm (Jia *et al*., 2013)

II TSIM-plough

1. Plough assembly

The detailed dimensions of the 1st, 2nd and 3rd plough bodies in Fig. 2 were given in a previous paper (Araya *et al.*, 1996f). An extra 1st plough body which is identical to the original 1st plough body was mounted on the right side of the original TSM-plough. With the newly installed extra 1st plough body, the total working width was increased from 460 mm to 920 mm.