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Deep Tillage Plough down to 600 mm for Improvement of Salt-affected Soils*

- Part 3: Field Experiments -

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Abstract

A method is proposed for soil improvement of salt-affected soils to till down to about 600 mm in depth by a special plough. The goal is to cut off the capillary rise of the groundwater by creating a coarse layer of tilled subsoil. Earlier, a plough configuration to produce soil clods with the proper size in the subsoil was determined in an indoor soil bin. In this paper, we designed and tested prototypical plough bodies in field experiments. A plough blade length less than 130 mm produced large soil clods and a blade length more than 130 mm generated small ones. With any length, deeper operating depth caused larger soil clods to form. The proper specifications of the third and fourth plough bodies of the special plough are as follows: the plough blade length is 130 mm, the operating width is 300 mm, the operating depth is 200 mm and the cutting angle is 20°.

[Keywords] salt-affected soils (solonchak and solonetz), soil improvement, subsoil, soil clods, plough configuration, field tests

I Introduction

Salt-affected soils [saline soil (solonchak) and sodic soil (solonetz)] are formed in dry areas of the world (Abrol *et al.*, 1988). In this paper, these two kinds of salt-affected soils distributed in China are of concern in our research.

In the previous paper (Guo *et al.*, 2006), a method of soil improvement was discussed for salt-affected soils with sufficient rainfall to percolate into subsoil in summer; it consisted of providing a coarse layer below the subsoil (B horizon). Soil column experiments in an indoor test room demonstrated that the capillary water from groundwater could be cut off at the coarse layer, thus preventing the rise of dissolved salts to the soil surface. The salts normally accumulating in the topsoil (A horizon) were otherwise leached out by every rainfall, which would then make pH values to decrease.

In order to cut the capillarity, deep ploughing has been previously performed (Antipov, 1954; Botov, 1959; Fesko & Strugeleva, 1959; Maksimyuk, 1958; Rasmussen *et al.*, 1972; Cairns, 1962; 1976a; Bowser & Cairns, 1967; Karkanis & Cairns, 1981; Buckland & Pawluk, 1985). However, such ploughing was performed by a back-hoe (Cairns, 1962) or a single mouldboard plough (Bowser & Cairns, 1967), and so every soil horizon was evenly mixed. The topsoil (A horizon) contains a fair amount of organic matter and is fertile, so it should not be mixed into the lower infertile horizons (Guo *et al.*, 2002). Antipov & Pak (1965) and Cairns (1976b) also reported that the A horizon should be retained on the surface during ploughing.

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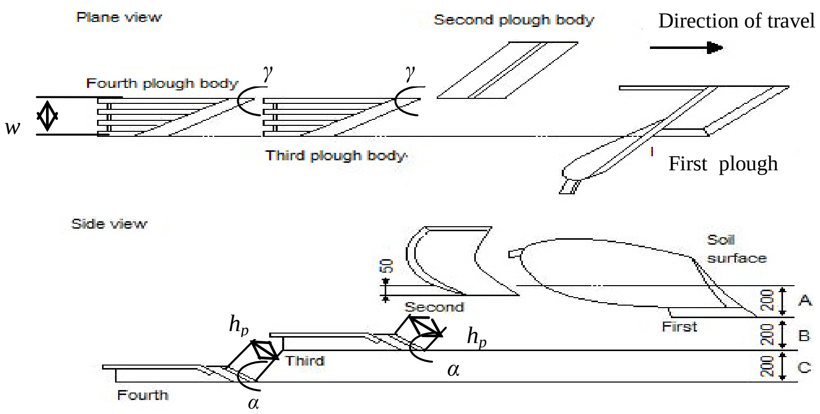

Fig. 1 Schematic diagram of plough bodies of a four-stage subsoil plough for improvement of salt-affected soils. The third and fourth plough bodies are identical. A, B and C are soil horizons; all dimensions are in mm (Araya *et al.*, 2011a).

We developed a four-stage subsoil plough (Fig. 1) which tilles the layers down to 600 mm (to the C horizon) and retains the topsoil (A horizon). The plough consists of four plough bodies. The first plough body is a conventional mouldboard plough which tills and inverts the A horizon at a depth of 0-200 mm. When there is efflorescence (alkali spots) on the soil surface, the second plough body scraps an adjacent furrow on the land side which runs next to the first, third and fourth plough bodies, precisely 50 mm deep below the surface of the A horizon and transfers this thin soil slice to the preceding furrow onto the third plough body. If there is no efflorescence on the soil surface, the second plough is not operated by rising the plough body. The B horizon (200-400 mm) is then tilled by the third plough body, and the soil clods are produced here in the B horizon. The C horizon (400-600 mm) is then tilled by the fourth plough body, and soil clods are produced also in the C horizon. Subsequently, the first mouldboard plough body tills the remainder of the A horizon, inverting the A furrow slice, thus covering the tilled soil in the preceding furrow (Guo *et al.*, 2002).

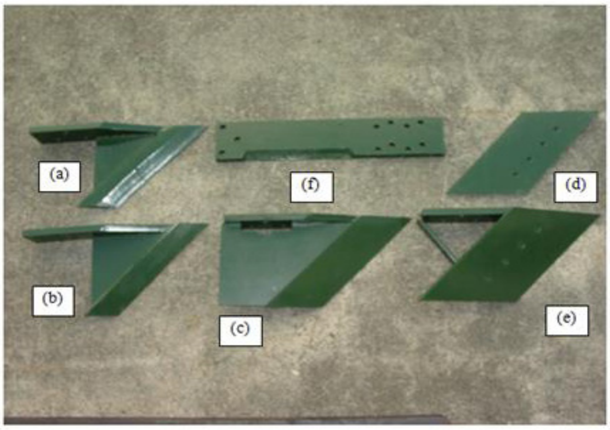

Fig. 2 Components of 3rd and 4th plough bodies. Cutting angle (cutting angle) α=20°; cutting angle γ=45°; operating width w=300 mm; (a) Blade length h_p=50 mm; (b) h_p=80 mm; (c) h_p=130 mm; (d) h_p=200 mm; (e) h_p=250 mm; (f) plough standard.

This plough had been originally developed for improvement of the planosol (Araya *et al.*, 1996a; 1996b; 1996c; Guo *et al.*, 2002), but the configuration of the No. 3 and No. 4 plough bodies for improvement of salt-affected soils is different from that for improvement of the planosol. In another previous paper (Araya *et al.*, 2012a), a proper plough configuration of the No. 3 or No. 4 plough body (each has the same design) was determined in an indoor soil bin to produce soil clods with the proper size (100-140 mm, Araya *et al.*, 2010) for cutting capillary rise. In the present paper, a prototypical No. 3 or No. 4 plough body was designed and built from the results of the soil bin tests, and its field experiments were carried out.

II Materials and Methods

1. Field in this study

The test site was in Japan, and the field experiments were carried out in an indoor test field. The soil in the indoor test field was a pseudogley soil from Japan. In the previous paper (Zhang *et al.*, 2009), one of the salt-affected soils in China is a saline soil (solonchak) which is found in Hebei and Inner Mongolia provinces (Table 1), and the other is a sodic soil (solonetz) which is common in the Heilongjiang, Jilin and Liaoning provinces. The previous paper (Guo *et al.*, 2004) reported that the subsoils of both salt-affected soils in China are heavy clay soils (Table 1), and the distribution of their soil particle size is similar to that of pseudogley soil in Japan, which is a typical Japanese clay and is not a salt-affected soil