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Evolution of soil and water conservation in rain-fed areas of China

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Abstract

Rain-fed (dryland) farming is an ancient agricultural production system in China. It occurs widely across almost the whole country, especially in the Northwest and North China. The semi-arid Loess Plateau is the most important region of rain-fed farming in China, but unfortunately, soil erosion on the Loess Plateau area is the highest in China, and indeed amongst the highest in the world. This highlights the necessity for developing practices that can reduce soil and water erosion, improve soil water use efficiency, improve crop productivity, and reduce rural poverty in the region. Many techniques of soil and water conservation are being used in rain-fed areas of China, including such systems as mulch, ridge and furrow systems. The Appendix describes a unique system of soil and water conservation, called *Shatian*.

Modern research on conservation tillage (No Till), although essential for reducing erosion, increasing crop productivity, and ameliorating poverty, is just beginning in China. Modern conservation tillage research started in the1990s' with support from Australia and other countries. The procedures, however, were modified to be in accord with local conditions and prevailing farmer experiences. With 10 years of experimentation, results show that the most successful conservation practice on the Western Loess Plateau is no till with stubble retention. This technique helps to conserve soil water, increases soil organic carbon, improves soil structure and water infiltration, reduces soil and water erosion, and improves crop productivity and sustainability of rain-fed farming systems. However, its adoption rate remains low due to barriers such as traditional attitude, insufficient rural extension, and so forth.

Key Words: Soil and water conservation, Rain-fed agriculture, Gravel sand mulch, Conservation tillage, No till, Crop residue management, Soil carbon

1 Introduction

Rain-fed or dryland agriculture is an ancient agricultural production system in China, dating back approximately 8,000 to 9,000 years. Currently, rain-fed farming systems occur widely across most of the country, especially in the Northwest and Northern China. The arid and semi-arid regions account for about 52.5% of the total land area in China. The total arable land is about 120 million ha, of which about 80% are located in arid and semi-arid regions.

Rain-fed agriculture is the most widespread land use system in the semi-arid Loess Plateau (Wei & Wang,

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1999). Soil erosion is high to extreme in the Loess Plateau, due to intense thunderstorms during the summer-dominant rainfall period, the low soil aggregate stability, and the poor vegetative cover of the loess soils (Huang et al., 2006). Soil erosion is the highest in China (Liu, 1999), and indeed it is amongst the highest in the world (Fu, 1989). Serious soil erosion in this area leads to high nutrient losses and low soil water use efficiency, resulting in low crop yields, and fragile agricultural production systems highly susceptible to droughts. It also results in high sediment yields in downstream areas, and negative environmental impact (Huang, 2003). Therefore, developing techniques that can reduce soil and water erosion, improve soil water use efficiency, impart some degree of drought proofing, and improve the environmental impacts is critical to sustained crop production in this region.

China has a long history of practices of conservation agriculture (Huang, 2003), but systematic research on modern soil conservation commenced only in the 1990's. This paper reviews the status of soil conservation measures in China, and describes some research on modern conservation tillage and its adoption. An interesting ancient, but still used practice of soil and water conservation, called *Shatian*, is described in the Appendix.

2 The status of soil erosion and control in China

A national census of soil erosion and soil conservation was completed in China in 2010−2012 (Liu, 2013). The results showed that the total area of soil loss was approximately 2.95×10^8 km^2 of which 44% was attributed to water erosion and 56% to wind erosion. Water erosion occurred mainly in high population areas and on the Loess plateau, while wind erosion mainly in Northwest China. This level of erosion, although extensive, is still a total reduction of 17.1% since the Second National Survey in 2002, with water erosion reduced by 21.7%, and wind erosion reduced by 13.2% (Liu, 2013). The greatest reductions were in slight and moderate water erosion areas, and in severe and extreme wind erosion areas.

Severe erosion persisted in the upper and middle reaches of the Yangtze and Yellow Rivers, the black soil region in Northeast China, and the mountainous regions in Southwest China. However, the results also showed that in Eastern China, with relatively advanced economies and higher living standards, erosion was brought under control, probably because of improved living standards, and people demanded better water quality and good ecological living conditions.

The 2013 census also catalogued the type, area, and distribution of soil and water conservation measures. The results showed that approximately 9.9×10^5 km^2 benefited from soil and water conservation measures, with 20% benefiting from engineering measures, 78% from biological measures, and 13% from other measures (Liu, 2013). However, the areas benefiting from conservation measures declined, due mostly to the occurrence of natural hazards, such as droughts and floods, and extensive construction projects.

Since the 1980s, the Government of China has identified the Loess Plateau and the Yangtze River basin as strategic areas for erosion control, with corresponding policies and programs to mitigate erosion. Results of the 2013 census illustrated some successes achieved, whereby erosion decreased by17.9%−44.95%, depending on the area (Liu, 2013). Regardless, the Loess Plateau continues to experience high rates of water erosion and gully formation, in fact some of the highest in the world. Engineering approaches, such as terraces, water diversion channels, sediment traps, etc., provide partial solutions to the problem, but even after decades of using such techniques, the evidence is that simple solutions will not work for such complex problems. Current efforts are to integrate these engineering approaches with better biological and ecologically based solutions, including Conservation Tillage and No Tillage. In this paper, we use these two terms interchangeably.

3 Modern conservation tillage (no till)

3.1 *The necessity for use of conservation tillage* (*CT*) *on the Loess Plateau*

The severe soil erosion on the Loess Plateau is a serious and continuing problem contributing to environmental pollution and uncertainty of food security and poverty in the region. The reasons are many, among which the use of traditional agricultural practices is one of the leading causes. These traditional practices normally involve plowing (moldboard) three times and harrowing twice between harvest and spring sowing. Thus, the soil surface is left uncovered during the 7-8 month fallow period, which includes part of the rainy season. Also, all stubble and residues are removed from the fields at crop harvest for use as forage, fuel, etc. The