*Journal of Integrative Agriculture* 2018, 17(4): 817–825

Available online at www.sciencedirect.com

ScienceDirect

ELSEVIER

RESEARCH ARTICLE

# Response of yield increase for dryland winter wheat to tillage practice during summer fallow and sowing method in the Loess Plateau of China

**LI Hui, XUE Jian-fu, GAO Zhi-qiang, XUE Nai-wen, YANG Zhen-ping**

*College of Agriculture, Shanxi Agricultural University, Taigu 030801, P.R.China*

**Abstract**

Soil moisture is the most critical limiting factor impacting yields of dryland winter wheat (*Triticum aestivum* L.) and it is strongly affected by tillage practice and sowing methods. This study was to assess the link between sowing method and tillage practice during summer fallow and their subsequent effect on soil moisture and grain yield. Furthermore, we sought to identify a more appropriate farming management practice for winter wheat production in Loess Plateau region of China. The experiment was conducted from 2011 to 2013, using a two-factor split plot design, including subsoiling (SS) or no tillage (NT) during summer fallow for main plots, and conventional drill sowing (DS) or plastic film drill sowing (FM) for sub-plots. Results showed that the maximum soil water storage (SWS) was under SS×FM treatment with values of 649.1 mm (2011–2012) and 499.4 mm (2012–2013). The SWS during the 2011–2012 growing season were 149.7 mm higher than that in the 2012–2013 growing season. And adoption of SS×FM significantly increased precipitation use efficiency (PUE) and water use efficiency (WUE) compared to other treatments for both seasons. Moreover, adoption of SS×FM significantly increased yield by 13.1, 14.4, 47.3% and 25.9, 39.1, 35.7% than other three treatments during the two growing seasons, respectively. In summary, combining subsoiling during summer fallow with plastic film drill sowing (SS×FM) increased SWS at sowing and effectively improved WUE, thus representing a feasible technology to improve grain yield of dryland winter wheat in the Loess Plateau of China.

**Keywords:** dryland winter wheat, subsoiling, sowing method, soil water storage, yield

## 1. Introduction

Wheat (*Triticum aestivum* L.) is one of the three indispensable food crops largely consumed in China. And dryland wheat represents an important fraction of the agricultural production in Northwest China. It has been shown that yield of dryland winter wheat is strongly influenced by soil moisture (Nielsen and Vigil 2010), which is greatly influenced by the lack of precipitation uniformity during growing seasons. Current farm management practices (e.g., soil tillage and film mulching) affect the physical, chemical, and biological properties of soil, in turn changing the soil moisture distribution. However, soil moisture storage and preservation ability can be salvaged with the appropriate tillage and sowing practices (Williams 2008).

Studies have shown that adoption of subsoiling (SS) can

Received 9 May, 2017 Accepted 13 September, 2017
Correspondence GAO Zhi-qiang, Tel: +86-354-6287226, E-mail: gaosxau@163.com


doi: 10.1016/S2095-3119(17)61806-9

improve soil water storage (SWS) at sowing by decreasing soil bulk density and increasing soil porosity (Al-Adawi and Reeder 1996; Schiettecatte *et al*. 2005; Sun *et al*. 2015b). Zhao *et al*. (2013) showed that SS increased SWS in 0–300 cm soil profile compared to no tillage (NT) at sowing. Hou *et al*. (2009) also concluded that SWS under SS treatment was significantly higher than that under NT. However, contrary results have shown that NT was more effective in increasing soil moisture than SS, where NT improved SWS by 3.0% compared to SS at sowing (Wang *et al*. 2009). These differences may have been caused by differences in precipitation. In addition, Hou *et al*. (2009) reported that water use efficiency (WUE) in dryland winter wheat for SS was higher than that for NT, while soil water consumption during the growing season was larger for SS treatment compared to NT treatment. Increases in soil water consumption during growth periods has been shown to be related to the increases in SWS and the reduction of soil evaporation. Adoption of SS and NT has been shown to increase 47 mm of soil water consumption compared to traditional tillage, but no significant difference was found between SS and NT (Wang *et al*. 2003). Moreover, numerous studies have demonstrated that SS can increase grain yield through an increase of spike and kernels per spike from the anthesis stage to maturity (Li *et al*. 1999; Zhao *et al*. 2013; Sun *et al*. 2015b). Consequently, adoption of SS is an effectively method to increase precipitation capture, thus increasing the yield of dryland winter wheat (Zhao *et al*. 2013).

Plastic film drill sowing (FM) can preserve soil moisture by trapping precipitation below plastic mulch. Numerous studies have indicated that film mulching on the soil surface can conserve precipitation and effectively decrease soil water evaporation at the soil surface, resulting in increasing SWS (Chakraborty *et al*. 2010; Zhou *et al*. 2011). Hou *et al*. (2013) reported that film mulching can increase soil water use from deep soil layers, consequently improving grain yield of winter wheat, particularly during dry years. Drill sowing with plastic film mulching has been reported as one of the most available methods to increase water use efficiency (WUE) and yield in rain-fed regions (Liu *et al*. 2009). This may be due to the increase of spike numbers for FM compared to no mulch (Li *et al*. 2008). However, contrary to this result, Li *et al*. (2001) reported that FM led to insufficient spike number, causing crop yield reduction.

The aforementioned studies have shown that adoption of SS and FM has a strong effect on SWS and yield for dryland winter wheat. However, there are few studies discussing the interaction between tillage during summer fallow and sowing method on SWS and yield for dryland winter wheat. We posit that tillage during summer fallow coupled with sowing practices will improve SWS and yield of dryland winter wheat. The objectives of this study were (i) to assess the effect of tillage during summer fallow and sowing methods on soil water storage, (ii) to evaluate the effect of tillage during summer fallow and sowing methods on soil water consumption, and (iii) to study the effect of tillage during summer fallow and sowing methods on the yield of dryland winter wheat.

## 2. Materials and methods

### 2.1. Experimental site

The experiment was conducted from July 2011 to June 2013 in the Wenxi Experimental Station of Shanxi Agricultural University (111°22´E, 35°35´N) in Shanxi Province, located in the Loess Plateau, China. The region has a temperate continental monsoon climate with a mean annual temperature of 12.6°C, a mean annual precipitation of ~440 mm, a potential evapotranspiration of 1838.9 mm, and a sunshine duration of 2461 h. The experimental field soil was classified as silty clay loam. The basic soil properties in the 0–20 cm layers were 11.88 g $kg^{-1}$ of organic matter, 38.62 mg $kg^{-1}$ of available nitrogen, and 14.61 mg $kg^{-1}$ of available phosphorus prior to sowing in 2011 to 2012 growing season. During the 2012 to 2013 season, the basic soil properties in the 0–20 cm layer were 12.72 g $kg^{-1}$ of organic matter, 36.78 mg $kg^{-1}$ of available nitrogen, and 16.20 mg $kg^{-1}$ of available phosphorus. The precipitation at the experimental site was shown in Table 1. And according to the annual precipitation type division standard of Zhang *et al*. (2008), the 2011–2012 growing season was considered as a wet year, but the 2012–2013 growing season was considered

**Table 1** The distribution of precipitation (mm) at the experimental site from 2005 to 2013[1)]

| Growing season | Fallow period | BS–WS | WS–JS | JS–AS | AS–MS | Total |
|---|---|---|---|---|---|---|
| 2005–2011 mean | 256.57±76.05 | 43.60±11.95 | 32.77±13.27 | 32.08±4.84 | 62.00±5.45 | 427.02±63.44 |
| 2011–2012 | 459.90 | 137.40 | 28.20 | 20.50 | 27.10 | 673.10 |
| 2012–2013 | 171.10 | 19.80 | 26.30 | 20.80 | 104.90 | 342.90 |

[1)] Data source: Meteorological Observation Station of Wenxi County, Shanxi Province, China. Fallow period, from middle June to late September. BS (before sowing)–WS (wintering stage), from early October to late November; WS–JS (jointing stage), from early December to early April; JS–AS (anthesis stage), from middle April to early May; AS–MS (mature stage), from middle May to early June.

Values are mean±SE.