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Wheat farmers adopt the undercutter fallow method to reduce wind erosion and sustain profitability

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ABSTRACT

Blowing dust from excessively tilled fallow fields is a major soil loss and air quality concern in the low precipitation (<300 mm annual) wheat (*Triticum aestivum* L.) production region of the Inland Pacific Northwest (PNW) of the United States. A 2-year tillage-based winter wheat-summer fallow (WW-SF) rotation is practiced on >90% of rainfed cropland in the region. Earlier research proved the undercutter method for non-soil inversion primary spring tillage to be environmentally superior and agronomically and economically equivalent to high-soil-disturbance conventional tillage. In this study, we conducted comprehensive surveys of 47 wheat farmers who purchased undercutters through the USDA-Natural Resources Conservation Service (NRCS). Farmers received 50% cost shares on the condition they used the undercutter as prescribed by university scientists on at least 65 ha of land for three consecutive years. Participating farmers were interviewed each year from 2008 to 2010 regarding the agronomic and economic performance of the undercutter versus conventional fallow on their farms. The survey revealed equivalent average WW grain yields and profitability for the two systems from 104 paired comparisons. Survey results also showed that 90% of farmer participants were satisfied with the undercutter system. We conclude the soil-conserving undercutter fallow system provides farmers equal profitability as the conventional-tillage fallow system.

1. Introduction

Research in the Great Plains and Corn Belt of the USA, both summer rainfall regions, has shown economic benefits for direct seeding (no-till) (Dhuyvetter et al., 1996; Horowitz et al., 2010; Uri, 1999; Wiese et al., 1994). Similarly, direct seeding has become increasingly popular in the intermediate (300–450-mm) and high (450–650-mm) average annual precipitation zones of the Inland PNW, where winter precipitation is dominant (Kok et al., 2009; Papendick, 1996; Young et al., 1999).

This study focuses on the low-precipitation (<300 mm annual) zone of east-central Washington and north-central Oregon that encompasses 1.5 million ha of non-irrigated cropland. Essentially all this cropland is in a tillage-based WW-SF rotation. Excessive tillage during SF pulverizes soil clods and buries residue and is the cause of recurrent wind erosion that seriously degrades soil and air quality. Urban locations within this region frequently fail to meet federal clean air standards for PM_{10} emissions during windstorms (Sharratt and Lauer, 2006). The sandy silt loam soils found throughout the WW-SF region have a greater potential to emit PM_{10} even though these soils are composed of a smaller percentage of PM_{10} compared to the finer-textured silt loam soils found in the intermediate and high precipitation zones of the PNW (Feng et al., 2011).

Long-term cropping systems studies in the low-precipitation zone have examined the feasibility of direct seeding spring-sown wheat, barley (*Hordeum vulgare* L.), and numerous other crops as well as the practice of no-till SF where herbicides are used as a substitute for all tillage operations. Studies have conclusively shown that no alternative crop or cropping system so far tested can compete with tillage-based WW-SF for average and stable profitability (Schillinger and Young, 2004; Schillinger et al., 2007). The absence of significant summer rainfall in the PNW penalizes yields and returns of spring crops and increases their riskiness. Other studies have shown that no-till SF, although ideal for wind erosion control (Sharratt et al., 2010), loses seed-zone water at a faster evaporative rate than does tilled SF during the hot, dry summer (Hammel et al., 1981; Wuest, 2010). This makes it difficult or impossible for farmers to plant WW into carryover soil moisture in late summer with no-till SF whereas adequate seed-zone moisture for planting in late summer can generally be

Abbreviations: CRP, Conservation Reserve Program; NRCS, USDA Natural Resources Conservation Service; PNW, Pacific Northwest; WAWG, Washington Association of Wheat Growers; WW-SF, winter wheat-summer fallow.

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achieved with tilled SF. The physics of water loss in tilled versus no-till SF and the grain yield penalties associated with delayed planting of WW are described by Wuest and Schillinger (2011) and Higginbotham et al. (2011).

In review, research conducted in the past two decades indicates that the most realistic method for farmers to mitigate wind erosion and achieve stable and profitable yields in the low-precipitation zone is to practice conservation tillage in a WW-SF rotation. The undercutter system of WW-SF farming was developed for this purpose. The undercutter is a primary tillage implement used in the spring to sever capillary pores and channels to halt liquid flow of water to the soil surface as required for retention of seed-zone water in SF. Undercutter implements are equipped with 80-cm-wide blades with 70 cm spacing between blades on two tiers. Blades have a narrow pitch to allow slicing below the soil surface with minimum soil lifting or disturbance of surface residue (Fig. 1 and Fig. 2). With this system, a tank cart is pulled in front of the undercutter (Fig. 1) to deliver nitrogen and often sulfur fertilizer through a manifold and tubing plumbed beneath both wings of individual undercutter blades. The optimum operating depth for the blades is ≈13 cm to provide a relatively thick, dry surface soil mulch to retard evaporation during the summer (Wuest, 2010). Conventional primary tillage implements in this region are the tandem disk and field cultivator, both of which mix and stir the surface soil, pulverize soil clods, and bury residue. Following primary spring tillage plus fertilizer injection, farmers use a rodweeder implement equipped with a 1-cm-diameter horizontal square steel rod that rotates opposite the direction of travel at an adjusted depth to uproot weeds with minimum surface disturbance during late spring and summer.

A 6-year field experiment conducted at Lind, WA (242 mm average annual precipitation) showed the undercutter fallow system to be statistically equivalent agronomically and economically to conventional fallow (Schillinger, 2001; Janosky et al., 2002). There were never any differences between undercutter and conventional tillage treatments in precipitation storage efficiency in the soil or in WW grain yield. However, the undercutter method consistently increased surface residue, surface clod mass, and surface roughness compared to conventional tillage (Schillinger, 2001). Wind tunnel tests have shown that the undercutter method reduces soil loss during high winds by up to 70% compared to conventional tillage fallow (Sharratt and Feng, 2009). In addition, due to the recent surge in the cost of diesel fuel and decline in the cost of glyphosate [N-(phosphonomethyl)glycine] herbicide, the undercutter method of farming has potential to provide higher economic returns to farmers compared to conventional tillage (Nail et al., 2007).

Fig. 1. A 375 horse power crawler tractor pulls a 3800 L tank cart filled with aqua NH_3-N and a 10-m-wide undercutter implement during primary spring tillage plus N fertilizer injection during the month of April.
Photo by W.F. Schillinger.

Fig. 2. The undercutter's narrow-pitched and overlapping 80-cm-wide V blades slice beneath the soil at a depth of 13 cm to completely severe capillary channels and halt the upward movement of liquid water to retain seed-zone water in summer fallow for late-summer planting of winter wheat. Most of the winter wheat residue from the previous crop is retained on the surface to control wind erosion. Photo by W.F. Schillinger.

The question is whether these promising experimental results could be duplicated on farmers' fields. To answer this question, the NRCS awarded a $905,000 Conservation Innovation Grant to the Washington Association of Wheat Growers (WAWG) to 50% cost share the purchase of undercutter implements with farmers. Forty-seven farmers located in 10 counties in Washington and Oregon purchased undercutters through this program. Individual cost-share payments averaged $15,320, including $980 for the manifold apparatus and tubing to allow fertilizer application with the undercutter during primary spring tillage. Total payments to farmers equaled $720,040 with administrative costs absorbing the remainder. As part of the project, participating farmers consented to personal interviews in 2008, 2009, and 2010 about their experience and opinions regarding the undercutter method of farming. The objective of this paper is to report the results of the farmer survey and to discuss the implications for the economic viability of the undercutter system of WW-SF farming in the inland PNW. This study provides a relatively rare multi-year on-farm statistical test of promising field results.

2. Materials and methods

2.1. Overview

The WAWG/NRCS project provided undercutter implements up to 10 m in width that were fitted to apply aqua or anhydrous NH_3-N at time of primary spring tillage. Undercutter implements determined as suitable for the project were manufactured by Duratech Industries™, Great Plains Manufacturing™, and Orthman Manufacturing™. All 47 participants accepted into the program farmed in the WW-SF region of south-central Washington and north-central Oregon where average annual precipitation ranged from 150 to 300 mm.

All participant farmers agreed to: (i) Leave winter wheat stubble standing and undisturbed from the time of grain harvest in late July–early August until the time of primary spring tillage; (ii) apply glyphosate herbicide at a rate no less than 0.42 kg acid equivalent per hectare in late March or April prior to primary spring tillage to control weeds; (iii) use the undercutter implement for primary spring tillage on at least 65 ha per year for three consecutive years; (iv) apply all nitrogen and sulfur fertilizer needed for the subsequent winter wheat crop with the undercutter during the primary spring tillage operation; (v) operate the undercutter blades at a depth of ≈13 cm below the soil surface to optimize seed-zone water retention; (vi) rodweed only as required