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Agronomics and economics of no-till facultative wheat in the Pacific Northwest, USA

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Abstract

Winter wheat (*Triticum aestivum* L.) (WW) rotated with dust-mulch summer fallow (WW/SF) has been the dominant production practice in the low-precipitation zone (<300 mm annual precipitation) of the Pacific Northwest (PNW) since the early 1900s. Over time, WW/SF has experienced several problems including severe wind erosion, increased pest problems and costs of production, and reduced crop yields. Producers need system alternatives to replace or modify the traditional WW/SF system. One proposed alternative is production of no-till facultative wheat (*T. aestivum* L.) (FW). Generally, FWs have less cold tolerance, a shorter but distinct period required for vernalization, and start growing and initiate flowering earlier compared with true WWs. This study compares agronomic, economic, and soil moisture components of FW/chemical fallow (FW/ChF), FW/spring wheat (*T. aestivum* L.) (FW/SW), and WW/reduced tillage SF (WW/RSF) rotations as part of an inter-disciplinary, multi-component research trial conducted near Ralston, Washington, USA. Over the 4-year study period, spring soil water content (SWC) was greater for ChF compared with RSF at all depths except 0.3–0.6 m. In the fall, difference in SWC between ChF and SF disappeared at depths below 0.6 m but was less for ChF from the soil surface to 0.6 m. WW/RSF and FW/ChF were more productive, both economically and agronomically, than FW/SW, with WW/RSF being more productive than either FW rotation by a wide margin. The FW/SW rotation produced lower yields that were more susceptible to fluctuations in crop year precipitation, contained more weeds, cost more to produce, and was less profitable than either WW/RSF or FW/ChF. The FW/ChF rotation was less variable than WW/RSF; however, net returns over total cost were consistently negative for FW/ChF and averaged $69.00 rotational ha^{-1} less than WW/RSF. Even though FW/ChF yielded and earned less than WW/RSF, the FW/ChF rotation may be a viable conservation system with cost sharing and/or further research. The yield of FW following ChF was excellent in 2002 in large-scale demonstration plots, in 2003 in the main study where it out-yielded WW, and in 2006 when FW was planted into ChF without sulfentrazone herbicide. The advantages of FW/ChF include (1) spread-out fall planting and summer harvesting operations; (2) opportunities to control problem winter-annual weeds; (3) better competition with summer annual weeds than spring wheat; and (4) a late planting date that does not rely on seed-zone soil water like WW.
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1. Introduction

Since the early 1900s the dominant production practice in the low-precipitation zone (<300 mm annual precipitation) of the inland Pacific Northwest (PNW) has been to alternate winter wheat (*Triticum aestivum* L.) (WW) with dust-mulch summer fallow (WW/SF), resulting in one crop every 2 years (Papendick, 2004). During the summer fallow period, a weed-free dust-mulch is maintained to a depth of 100–150 mm by multiple tillage operations (Thorne et al., 2003) and serves as a barrier that reduces evaporation of soil moisture below the tillage line. The summer fallow period maximizes soil water storage and reduces the risk of crop failure or uneconomical yields (Peterson et al., 1996). The WW/SF system remains the major rotation in this

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region today because of the adaptation of WW to the area, its time-proven yield and economic stability compared with other small grain production systems, and uniform seasonal demand on farm machinery and labor.

The low-precipitation zone of the PNW is characterized by cool, moist winters with warm, dry summers, occasional drought cycles, and frequent winds that may reach speeds in excess of 80 km/h. Almost 70% of the annual precipitation is received from November to April (Young, 2004; Leggett et al., 1974). The climate, combined with the WW/SF system and poorly aggregated soils, results in significant dust storms that are most prevalent in the early spring, late summer, and fall (Papendick, 2004). The dust storms can result in significant topsoil losses (240–600 Mg ha^{-1} annually) (Papendick, 1996) and PM10 (particulates of dust 10 μm and smaller) emissions that negatively affect human respiratory health (Upadhyay et al., 2003).

Several studies have examined the economic performance of alternative conservation tillage cropping systems in the low-precipitation zone of the PNW. Two studies examined the performance of a no-till annual hard red spring wheat (*T. aestivum* L.) (HRSW) cropping system in two precipitation zones (Juergens et al., 2004; Schillinger and Young, 2004). At a site in Benton County, Washington (<200 mm annual precipitation), one of the driest wheat production areas in the world, annual net returns over total costs before government farm payments were negative for both no-till continuous HRSW and WW/SF, with HRSW returning \$95.35 rotational ha^{-1} less than WW/SF (Schillinger and Young, 2004). A rotational ha of a given 2-year system, for example WW/SF, would include 0.5 ha of WW and 0.5 ha of SF. At a second site in Adams County, Washington (200–300 mm annual precipitation), WW/SF returned \$113.00 rotational ha^{-1} more than no-till continuous HRSW. The HRSW system also demonstrated more annual income risk than WW/SF. Similarly, an 8-year study conducted in Adams County found WW/SF to be most profitable compared with six other alternative rotations examined (Young, 2005). Over the first 5 years of the study, during which time record-high precipitation was received, continuous no-till soft white spring wheat (*T. aestivum* L.) (SWSW) was economically competitive with WW/SF. However, over the complete 8-year study, profitability of continuous no-till SWSW lagged conventional WW/SF by \$60.00 rotational ha^{-1} (Young, 2005). Juergens et al. (2004) compared the economics of two additional alternative crop rotations with WW/SF. They included a 4-year rotation of safflower (*Carthamus tinctorius* L.)/yellow mustard (*Brassica hirta* Moench.)/SWSW/SWSW, and a 2-year rotation of SWSW/spring barley (*Hordeum vulgare* L.). The two alternative rotations were not economically competitive with WW/SF. The lower average returns and higher risk of spring crops in comparison with the traditional WW/SF system have deterred many growers from annual spring cropping in the low-rainfall region of the PNW.

One crop that has not been examined in a rotation system in the PNW or other locations in the United States is facultative wheat (*T. aestivum* L.) (FW). To date, no clear definition of FW exists and the genetic properties to distinguish it from WW and spring wheat (SW) are not clear. FWs, often derived from SW by WW crosses (Braun, 1997), are usually characterized by strong photosensitivity and partial sensitivity to vernalization (Stelmakh, 1998). In addition, FWs have less cold tolerance, a shorter but distinct vernalization period, and initiate spring growth and flowering earlier compared with true WWs (Braun and Săulescu, 2002; Hodson and van Ginkel, 2004).

Interest in FW as an alternate crop in the PNW was sparked by research conducted by Young (2004) in 1996 and 1997 in Adams County, Washington. The study evaluated the response of specifically chosen fall-planted SW varieties for grain and biomass production and to suppress spring weed growth, especially of Salsola tragus Sennen & Pau. Three SW varieties and a WW variety were planted at four different dates ranging from early November to late March. Spring wheat varieties were chosen based on their facultative tendencies and other agronomic and adaptive qualities. In general, the yield of FW planted in November was similar to WW planted in November and to the same variety of SW planted at the normal mid-March planting date. In May, FW planted in November was 50% taller than FW planted in March, which indicated promise for weed suppression. Of the three spring wheat varieties planted 'Alpowa' performed best, and yielded higher with greater biomass production. Based on these results a pilot study was conducted to determine how 'Alpowa' planted in November of 2001 would perform in a large (9 × 152 m), single-strip demonstration plot previously managed under chemical fallow (ChF). Yield of FW exceeded SW (planted at normal mid-March planting date) following ChF and was similar to WW following reduced tillage SF (RSF). The success of the two FW studies indicated promise for FW as a potential alternative crop for growers.

Considerable research has been published on ChF, although little has been conducted in the PNW. The efficiency of ChF to store soil moisture has varied by location. Several studies have found that, contrary to the effectiveness of ChF to increase total soil water storage in high-rainfall areas (Greb et al., 1967; Smika and Wicks, 1968), ChF was often only equivalent in total water storage to conventional SF in low-rainfall environments (Al Mulla, 2004; Pannkuk et al., 1997; Incerti et al., 1993; Overson and Appleby, 1971; Wiese et al., 1960). These studies also showed that the efficiency of ChF to store soil water when compared with SF varied by time of year. Rainfall distribution over the fallow period (Incerti et al., 1993; Lindstrom et al., 1974), amount of soil surface residue (Pannkuk et al., 1997; Incerti et al., 1993), and soil texture, which influences the thermal and hydraulic properties of the soil (Hammel et al., 1981), affects the efficiency of ChF to store soil water and may explain the variability in results