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Seven rainfed wheat rotation systems in a drought-prone Mediterranean climate

William F. Schillinger

Department of Crop and Soil Sciences, Washington State University, Dryland Research Station, P.O. Box B, Lind, WA 99341, United States

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ABSTRACT

Increasing cropping intensity and use of no-till fallow (NTF) has been successful in many rainfed Mediterranean agricultural regions around the world, including of the Inland US Pacific Northwest (PNW) where annual precipitation exceeds 290 mm. However, in the low-precipitation (<290 mm annual) region east-central Washington and north-central Oregon, these practices have not been widely adopted and a 2-year winter wheat (*Triticum aestivum* L.)-tilled summer fallow rotation is practiced by the vast majority of farmers. The objective here was to evaluate the productivity of seven wheat rotation systems that reduce or eliminate tillage and increase cropping intensity in a 6-year study at Lind, WA. The study included: (i) soft white, hard red, and hard white market classes of wheat; (ii) both NTF and undercutter conservation-tillage summer fallow (UTF), and; (iii) continuous annual no-till cropping of wheat. Crop-year (September 1–August 31) precipitation over the six years averaged just 217 mm. Across years, market class, and rotation system, spring wheat (SW) grain yield was only 33% of winter wheat (WW) after UTF. Thus, although only one crop was produced every other year with WW-UTF, this system had water use efficiency (WUE) of 5.5 grain/mm precipitation versus as low as 3.0 kg grain/mm precipitation for SW with no preceding fallow year. Possible mechanisms for differences in grain yield and WUE among rotations were: (i) Russian thistle (*Salsola tragus* L.) weed infestation was at least eleven times greater in the various SW systems and much greater still with WW after SW with no fallow year compared to in WW after NTF and UTF, and; (ii) precipitation storage efficiency (PSE) in the 180 cm soil profile during fallow for NTF-WW-SW was only 30% compared to 39 and 42% for the UTF-WW-SW and UTF-WW treatments, respectively. Critically, the seed zone of NTF was too dry for early planting of WW in most years whereas adequate seed-zone water was present every year in the UTF systems. Primarily due to late planting necessitated from lack of seed-zone water, grain yield of WW after NTF was reduced 35% compared to WW after UTF. Optimum grain yields and soil conservation are both required for sustainable agriculture, and WW with the UTF method was the clear winner of systems evaluated in this study.

1. Introduction

A major problem with tillage-based fallow in all semiarid regions of the world is soil erosion. In the drylands of the PNW, wind erosion is of particular concern because soils are generally weakly structured and subject to pulverization with tillage. Soils also contain high quantities PM-10-sized particulates that are easily suspended and carried long distances in the wind stream (Sharratt and Vaddella, 2012).

Wheat has always been the dominant crop throughout the Inland PNW as it can be grown over a range of climatic and soil conditions (McGregor, 1982). Pioneer farmers and scientists soon learned that growing wheat after a year of fallow (i.e., only one crop every other year) increased and stabilized grain yields as well as helped control weeds and diseases compared to "recrop" wheat that was planted without a preceding year of fallow (McCall and Holtz, 1921).

In the US Great Plains, where summer rain is frequent, there is general agreement that an equal or slightly greater quantity of water is stored in the soil during the 14 month fallow period with no-till fallow (NTF) compared to tillage-based fallow (Nielsen and Vigil, 2010). The opposite is the case during 13 month fallow period in the PNW where summers are dry (Hammel et al., 1981; Wuest and Schillinger, 2011; Schillinger and Young, 2014).

Abbreviations: HRSW, hard red spring wheat; HWSW, hard white spring wheat; NTF, no-till summer fallow; PNW, Pacific Northwest of the United States; SW, generic term for spring wheat; SWSW, soft white spring wheat; WW, soft white winter wheat; UTF, undercutter conservation tillage summer fallow.

E-mail address: william.schillinger@wsu.edu

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