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Wind erosion and PM10 emission affected by tillage systems in the world's driest rainfed wheat region

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ABSTRACT

The Horse Heaven Hills of south-central Washington is the driest rainfed wheat growing region in the world. Low precipitation, high winds, poorly aggregated soils, sparse residue cover, and a tillage-based winter wheat (*Triticum aestivum* L.) – summer fallow (WW-SF) cropping system often combine to create soil surfaces which are susceptible to wind erosion. No-tillage summer fallow (NTF) and conservation tillage fallow (CTF) with an undercutter sweep implement were examined as alternative practices to traditional tillage fallow (TTF) with a tandem disk implement for reducing wind erosion and PM10 (particulate matter $\leq$10 μm in aerodynamic diameter) emissions during the fallow phase of the WW-SF rotation. Wind erosion and PM10 emissions were assessed with a wind tunnel after primary spring tillage in mid-to-late April and after sowing winter wheat in August. Sediment loss and PM10 vertical flux and loss were generally less for NTF than with TTF, likely due to retention of surface residue and maintaining a soil crust in NTF. Sediment and PM10 loss increased after sowing wheat in both the TTF and CTF treatments. Although NTF abated the loss of sediment and PM0 compared with TTF, NTF is not yet an economical option for most growers in the region. Conservation tillage fallow using the undercutter sweep is an economically viable alternative to TTF for reducing windblown sediment and PM10 loss from agricultural soils in the Horse Heaven Hills.

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1. Introduction

High winds, poorly aggregated soils, low biomass production, tillage-based summer fallow, and extended time periods without precipitation promote wind erosion of agricultural lands in the Columbia Plateau region of the US Pacific Northwest. Wind erosion impacts air quality in this region due to the emission of fine sediment or dust into the atmosphere during high winds. The sediment-laden air sometimes forces road closures due to zero visibility and is enriched in PM10 (particulate matter $\leq$10 μm in aerodynamic diameter), an air pollutant that adversely affects human health (Dockery and Pope, 1994; Paden, 2001). Based on the linkage between high PM10 concentration and respiratory ailments, air quality standards have been set for PM10 (USEPA, 2006). PM10 represents the chemically active portion of soil and has the potential to transport heavy metals, pesticides, and microbes (Garrison et al., 2003; Whicker et al., 2006). In addition, PM10 can also transport nutrients and organic matter that will affect soil productivity (Van Pelt and Zobeck, 2007). Zhang et al. (2003) suggested that fine particulates represent the most fertile part of the soil resource.

Wind erosion has long been a problem in the western United States. In the drier (<300 mm annual precipitation) zone of the Inland Pacific Northwest, where rainfed winter wheat is produced every other year on land managed in a WW-SF rotation, controlling wind erosion to maintain air quality is a major challenge for growers (Saxton et al., 2000). Wind erosion, mainly occurring from March through October, is a major cause of soil loss and also significantly degrades air quality.

Low precipitation, with the majority of precipitation occurring in winter, necessitates the use of summer fallow to store a portion of over-winter precipitation in the soil for successful establishment and profitable production of winter wheat. Average annual precipitation in the Horse Heaven Hills of south-central Washington, where 120,000 hectares is devoted to WW-SF production, ranges from a high of 200 mm in the east to a low of 150 mm in the west (Fig. 1). The western portion of the Horse Heaven Hills is considered the driest rainfed wheat producing region in the world (Schillinger and Young, 2004).

Summer fallow is necessary for profitable wheat production compared to alternate management practices such as no-tillage annual cropping in the low precipitation zone of the Inland Pacific

Abbreviations: CTF, conservation tillage fallow; NTF, no-tillage fallow; TTF, traditional tillage fallow; WW-SF, winter wheat-summer fallow.

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