Soil & Tillage Research 105 (2009) 236–241

Contents lists available at ScienceDirect

Soil & Tillage Research

journal homepage: www.elsevier.com/locate/still

Friction velocity and aerodynamic roughness of conventional and undercutter tillage within the Columbia Plateau, USA

Brenton Sharratt [a,*], Guanglong Feng [b]

[a] USDA-Agricultural Research Service, 213 LJ Smith Hall, WSU, Pullman, WA 99164, United States
[b] Department of Biosystems Engineering, Washington State University, Pullman, WA, United States

ARTICLE INFO

Article history:
Received 31 March 2009
Received in revised form 14 August 2009
Accepted 18 August 2009

Keywords:
Wind erosion
Air quality
Dust emissions
Conservation tillage

ABSTRACT

Friction velocity (u_*) and aerodynamic roughness (z_o) at the soil–plant–atmosphere interface affect wind erosion, but no attempts have been made to quantify these parameters as affected by tillage systems within the Columbia Plateau region of the Pacific Northwest United States. Wind velocity profiles above adjacent field plots (>2 ha), with plots subject to conventional or undercutter tillage during the summer fallow phase of a winter wheat–summer fallow rotation, were measured over 50 high wind events (wind velocities in excess of 6.4 m s^{-1} at a height of 3 m) during 2005 and 2006 near Lind, Washington to determine u_* and z_o of tillage treatments. Wheat stubble plots were subject to either conventional (disks) or undercutter (wide V-shaped blades) tillage in spring and then periodically rodweeded prior to sowing winter wheat in late summer. Prior to sowing, u_* for conventional and undercutter tillage respectively averaged 0.36 and 0.46 m s^{-1} in 2005 and 0.38 and 0.40 m s^{-1} in 2006 while z_o for conventional and undercutter tillage respectively averaged 2 and 7 mm in 2005 and 2 and 4 mm in 2006. The aerodynamically rougher surface of undercutter tillage was predicted to suppress vertical dust flux; this was collaborated with observations in the field where undercutter tillage reduced dust flux as compared with conventional disk tillage. Undercutter tillage, therefore, appears to be an effective management practice to roughen the surface and thereby suppress dust emissions from agricultural land subject to summer fallow within the Columbia Plateau.

Published by Elsevier B.V.

1. Introduction

Wind erosion removes fertile topsoil and is therefore a concern for global societies in maintaining food and fiber production for future generations. Wind erosion damages crops as a consequence of saltating particles sandblasting seedlings (Fryrear, 1986) and can impair visibility and human health as a result of increasing the atmospheric dust load through the emission of fine particulate matter from soils. In fact, windblown dust has caused vehicular accidents as a result of reduced visibility (Hudson and Cary, 1999) and has contributed to exceedance of the US Environmental Protection Agency ambient air quality standard for PM10 (particulate matter ≤10 μm in diameter) within the Columbia Plateau region of the Pacific Northwest United States (Sharratt and Lauer, 2006).

Wind erosion is initiated when friction velocity (u_*) exceeds the threshold friction velocity. Threshold friction velocity is the minimum friction velocity, at the height where momentum is absorbed by surface roughness elements, that is required to initiate movement of an aggregate or particle resting on the soil surface; aggregate or particle movement is achieved when drag and lift forces overcome gravitational and inter-particle cohesive forces acting on the aggregate or particle at the soil surface. While threshold friction velocity is governed by the size, shape, and mass of aggregates or particles at the soil surface, threshold friction velocity is also influenced by soil surface water content and crusting, surface roughness, and biomass cover. Friction velocity, however, is governed by the apparent roughness of the surface and atmospheric convection or stability (Stull, 2000). The apparent roughness of an agricultural field is comprised of roughness cast by aggregates on the soil surface, tool marks or ridges created by tillage implements, and vegetation protruding above the soil surface. Abatement of wind erosion of an agricultural field, therefore, can be attained by altering soil surface characteristics (e.g. size of aggregates, biomass cover).

Developing strategies to mitigate wind erosion is imperative to conserving the soil resource and improving air quality within the Columbia Plateau. In the drier part (annual precipitation <300 mm) of this region, about 1.5 million ha of land is managed in a winter wheat–summer fallow rotation. Conventional summer fallow generally entails cultivating soils with sweeps, disks, or cultivators after wheat harvest in late summer and again the

* Corresponding author. Tel.: +1 509 335 2724; fax: +1 509 335 3842.
E-mail address: Sharratt@wsu.edu (B. Sharratt).

0167-1987/$ – see front matter. Published by Elsevier B.V.
doi:10.1016/j.still.2009.08.004