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Tillage and crop management effects on soil erosion in central Croatia

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Abstract

Soil erosion continues to be a primary cause for soil degradation and the loss of soil quality throughout the world. Our objectives were to quantify soil erosion (referred to as erosional drift) and to assign erosion risk to six tillage and crop management treatments evaluated from 1995 to 1999 for a 5-year maize (*Zea mays* L.), soybean (*Glycine hyspida* L.), winter wheat (*Triticum aestivum* L.), oil-seed rape (*Brassica napus* var. oleifera L.), and spring barley (*Hordeum vulgare* L.) plus double-crop soybean rotation on Stagnic Luvisols in central Croatia. Standard black fallow (tilled, unsown, and without any vegetative cover) Universal Soil Loss Equation (USLE) plots were used to establish the erosion potential associated with the rainfall pattern for each year. Soil loss from the check plots was several times greater than the T value, which is estimated to be $10\,t\,ha^{-1}$ per year. During the 2 years when spring seeded maize or soybean were grown (1995 and 1996) erosion risk was extremely high, especially for treatments where tillage and planting (row direction) were up and down the slope. When autumn seeded winter wheat or oil-seed rape were grown (1996/1997 or 1997/1998), soil erosion was insignificant. Also, except when plowing and sowing were up and down slope, erosion loss for the spring barley plus double-crop soybean crops in 1999 was insignificant. With no-tillage, soil erosion from the maize and soybean crops was reduced 40 and 65% compared to plowing up and down slope, even though the planting direction was still up and down the slope. With the exception of maize in 1995, erosion losses were moderate to insignificant when plowing and planting were performed across the slope. We conclude that erosion risk can be used as a reliable indicator of sustainable land management and that using no-tillage or plowing and planting perpendicular to the predominant slope are effective soil conservation practices for this region.

Keywords: Water erosion; Erosion risk; USLE; Sustainability; Soil conservation, Croatia

1. Introduction

Water induced soil erosion is influenced by tillage (especially the plowing direction in relation to slope), crop selection, planting direction or orientation, and the amount, distribution, and intensity of rainfall or irrigation. Quantifying and understanding the factors influencing soil erosion is especially important with regard to the soil quality and sustainability of Stagnic Luvisols in central Croatia. The physical composition (e.g. high content of fine sand), chemical properties (e.g. low pH value, calcium carbonate deficiency, low organic matter content), and very low aggregate stability make those soils highly susceptible to water erosion on sloping terrains (Richter, 1980; Le Bissonais et al., 1995; Kwaad

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et al., 1998; Rejman et al., 1998; Fleige and Horn, 2000).

The primary goals for this investigation were to determine how various tillage and cropping practices affected soil erosion in this region and to use those results to identify sustainable land management practices that would reduce soil erosion to a tolerable level. Working within an established crop rotation, we measured soil loss using standard Universal Soil Loss Equation (USLE) plots and identified the optimum tillage and crop management practices in terms of erosion risk. The results provide a scientific basis for sustainable management of Stagnic Luvisols in central Croatia and for other soils in similar agroecological zones throughout the world.

2. Materials and methods

2.1. Study site

The experiment was located near Daruvar in central Croatia and was initiated on Stagnic Luvisols following harvest of an oil-seed rape crop in the summer of 1994. Erosion was measured (FAO, 1990) on six plots, according to the USLE (Wischmeier and Smith, 1978) protocol, which specifies a plot area of 41.3 m^2 (22.1 m long and 1.87 m wide) on a 9% slope. Sheet-metal borders driven into the soil around each plot, were removed before each tillage operation and then replaced for the remainder of the growing season. Filtration equipment was set up at the lower end of each plot and clean water was collected in a container. To facilitate the use of agricultural machinery, the plots were set 15 m apart to allow the tractor with the longest trailing implement to easily turn around.

2.2. Tillage methods

Primary tillage for summer crops (maize, soybean and barley) was conducted during October with secondary tillage the following spring (April) prior to planting. Tillage for winter crops (primary and secondary) was carried out in August (oil-seed rape) or October (winter wheat). Mechanical operations, tillage direction (with respect to slope), and the row orientation or planting direction for the six treatments are described in Table 1. Except for the standard bare fallow (SBF) treatment, the crops grown on each experimental plot followed a typical rotation of maize (1995), soybean (1996), winter wheat (1996/1997), oil-seed rape (1997/1998), and double-crop spring barley followed immediately after harvest by soybean (1999).

2.3. Erosion risk

Erosion risk (Basic, 1992) was determined by computing a ratio between measured soil loss (erosional drift) and soil loss tolerance (T) as shown in Eq. (1). The T value for Stagnic

$$\text{erosion risk} = \frac{\text{erosional drift (t ha}^{-1}\text{ per year)}}{\text{soil loss tolerance }(T)} \qquad (1)$$

Luvisols at this site is 10 t ha^{-1} per year (McCormack et al., 1982; Schwertmann et al., 1987). Specific ratings assigned to each ratio (Eq. (1)) were those suggested by Auerswald and Schmidt (1986): insignif-

Table 1
Tillage and crop treatments evaluated for their effect on soil erosion from Stagnic Luvisols during a 5-year study in central Croatia

Treatment	Description	Tillage direction[a]	Planting direction[a]
SBF	Standard bare fallow (USLE protocol), plowed 30 cm deep, disked and harrowed	Up and down	No crop
PUDS	Plowed 30 cm deep, disked and harrowed	Up and down	Up and down
NT	No-tillage, drilled seed into mulch 2–3 weeks after applying herbicides	Up and down	Up and down
PAS	Plowed 30 cm deep, disked and harrowed	Perpendicular	Perpendicular
VDPAS	Plowed 60 cm deep, disked and harrowed	Perpendicular	Perpendicular
SSPAS	Subsoiled 60 cm deep with tines spaced 70 cm apart, plowed 30 cm deep, disked and harrowed	Perpendicular	Perpendicular

[a] Direction with respect to the predominant slope.