Soil Physical Properties and Residue Cover in Alternative Cropping Systems.

A. Moulin[1], S.S. Malhi[2], S. Brandt[3], D. Leach[2]

[1]AAFC, Brandon, MB, R7A 5Y3, [2]AAFC, Melfort, SK, S0E 1A0, [3]AAFC, Scott, SK, S0K 4A0

Introduction

The objective of this study was to determine the potential for soil erosion in components of cropping systems. Aggregate size distribution, crop residue, hydraulic conductivity and soil moisture all affect the potential of soil to be eroded by wind and water erosion. Rotation phases following tillage fallow and phases with low crop residue, are components of the production systems to be evaluated in the study.

Methods

Experimental Design

The study is designed to evaluate to evaluate input and diversity of cropping systems on a sandy loam soil at Scott, Saskatchewan. The study was initiated in 1994 with a baseline study followed by cropping systems treatments in 1995 to 1997. Three levels of input were assigned to main plots in a split-split-plot factorial design. Three levels of cropping diversity were assigned to sub-plots within each main plot to enhance detection of diversity level differences. Input levels were organic, reduced and high, while cropping-diversity levels were low diversity wheat, diverse annual and diverse annual perennial. The second and sixth phase of the treatments are described in Table 1. Fallow treatments in organic and high input systems were tilled in the fall with a heavy-duty cultivator, and field cultivators in the spring. Plots were prepared for seeding in organic and high input systems with a field cultivator with mounted tine harrows followed by a heavy-duty cultivator. Fallow treatments were not tilled in reduced input systems. Plots were direct seeded in reduced input systems.

Table 1. Treatments

Input		Organic			Reduced			High	
Diversity	Mono wheat	Diverse Annual	Diverse Perennial	Mono wheat	Diverse Annual	Diverse Annual Perennial	Mono wheat	Diverse Annual	Diverse Perennial
First phase	Lentil green manure fallow	Lentil green manure fallow	Canola	Cons. Fallow	Canola	Canola	Tillage Fallow	Canola	Canola
Second phase	Wheat	Wheat	Wheat	Wheat	Fall Rye	Wheat	Wheat	Fall Rye	Wheat
Third phase	Wheat	Pea	Barley	Wheat	Pea	Barley	Wheat	Pea	Barley
Fourth phase	Lentil green manure fallow	Barley	Hay	Cons. Fallow	Barley	Hay	Tillage Fallow	Barley	Hay
Fifth phase	Canola	Sweet Clover green manure fallow	Hay	Canola	Flax	Hay	Canola	Flax	Hay
Sixth phase	Wheat	Canola	Hay	Wheat	Wheat	Hay	Wheat	Wheat	Hay

Residue

Residue cover and bare soil were measured with a grid count of 144 points per quadrat (1 m^2) at two locations per plot. Percent cover was calculated from the number of points, which intersected soil, standing and fallen crop residue. Data were collected from the second and sixth phase of all treatments.

Aggregates, hydraulic conductivity, and soil moisture

Aggregates, bulk density and soil moisture were sampled from the 0 to 5 cm depth increment shortly after seeding in 1995, 1996 and 1997. Aggregate samples weighing approximately 2.5 kg were dry sieved with a rotary sieve. Bulk density and oven dry soil moisture were measured in a soil core taken at the same time. Samples were collected from the second and sixth phase of all treatments.

Hydraulic conductivity

Saturated hydraulic conductivity using the standing head technique was conducted on soil cores (0-7.5 cm) collected from selected phases of treatments. Soil cores were collected from the second and sixth phase of all treatments.

Statistical analyses

Statistical analyses were conducted for the soil and crop variables in each year of the study. A general linear model was calculated for phases 2 and 6 of the treatments with diversity nested within input. Error bars represent one least significant difference for significant effects specified in the appendices.

Results

Residue cover

Residue and plant cover following spring seeding was significantly higher in the second phase of canola-fall rye-pea-barley-flax-wheat under reduced and high input management due to the presence of fall rye in diverse annual and diverse annual perennial in 1997 (Figure 1). Low residue cover following spring seeding in the second phase of fallow-wheat-wheat-canola-fallow-wheat under organic and high inputs was attributed to the burial of residue during tillage operations.

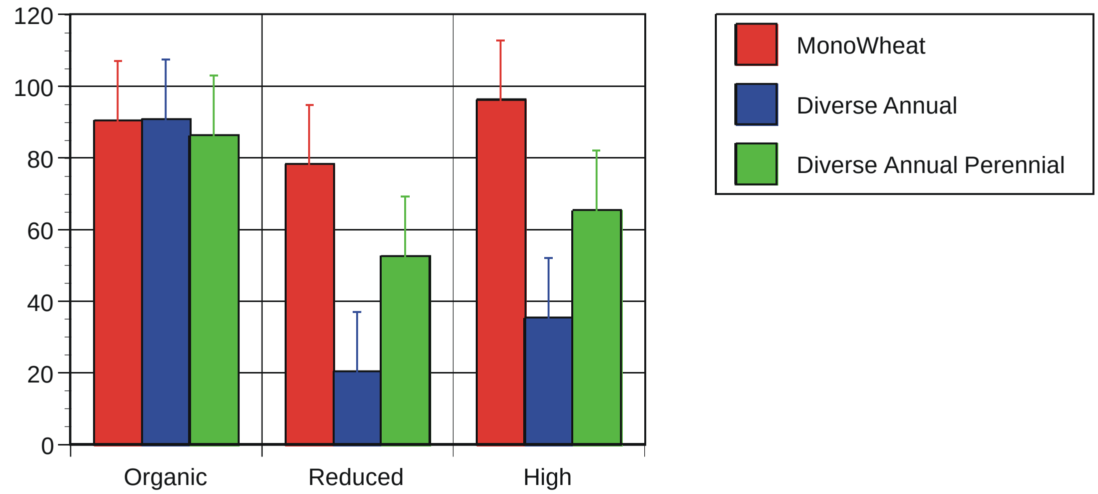

Figure 1. Bare soil (%) in second phase of rotations, spring 1997.

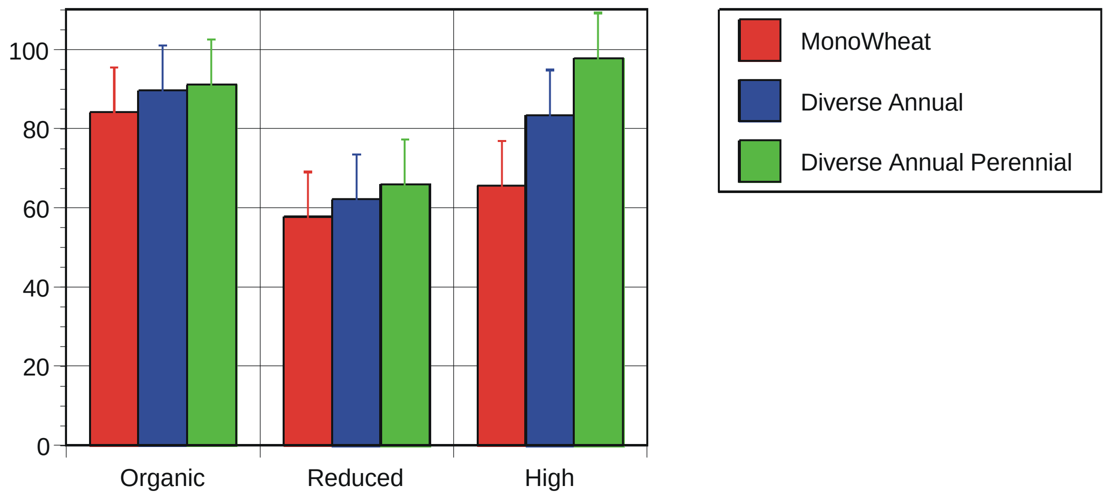

Figure 2. Bare soil (%) in sixth phase of rotations, spring 1997.

Residue cover was higher following spring seeding in the sixth phase in organic compared to reduced-input diversity. High-input systems in the sixth phase of fallow-wheat-wheat-fallow-canola-wheat had higher residue cover than organic systems following crop due to increased production. Residue cover was less than required for control of wind erosion of sandy loam (Table 2). Cover was higher in the hay phase of the diverse annual perennial rotation for 1996 compared to 1997 due to seeding of oats and peas for hay.

Aggregate size distribution

The proportion of aggregates in the fraction with the lowest sieve opening (<0.5 mm diameter) varied considerably, though it was significantly higher following fallow in the second phase of rotation for high-input systems in fallow-wheat-wheat-fallow-canola-wheat compared to the high and reduced-input diverse annual rotation (Figure 3). This was attributed to fall rye. Small aggregates (< 0.5 mm diameter) make up a large proportion of erodible aggregates (<0.84 mm).

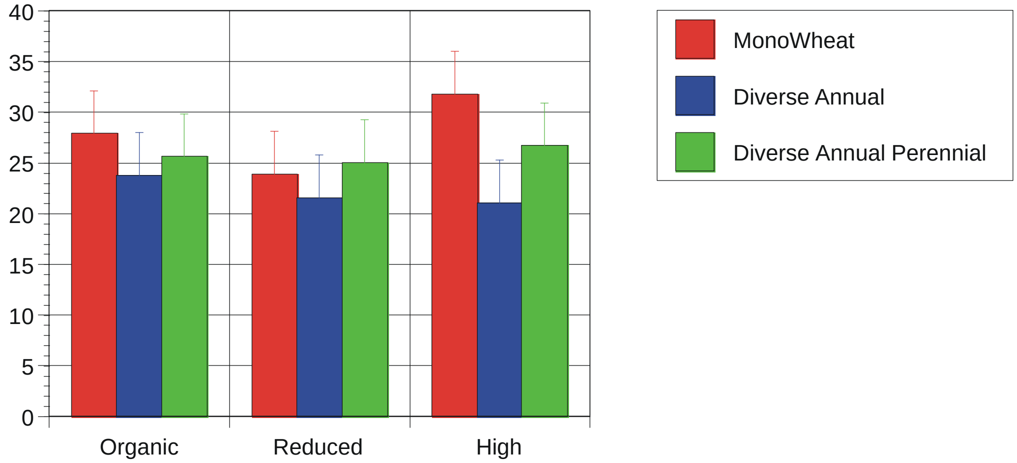

Figure 3. Dry sieved aggregates (%<0.5 mm) in second phase of rotations, spring 1997.

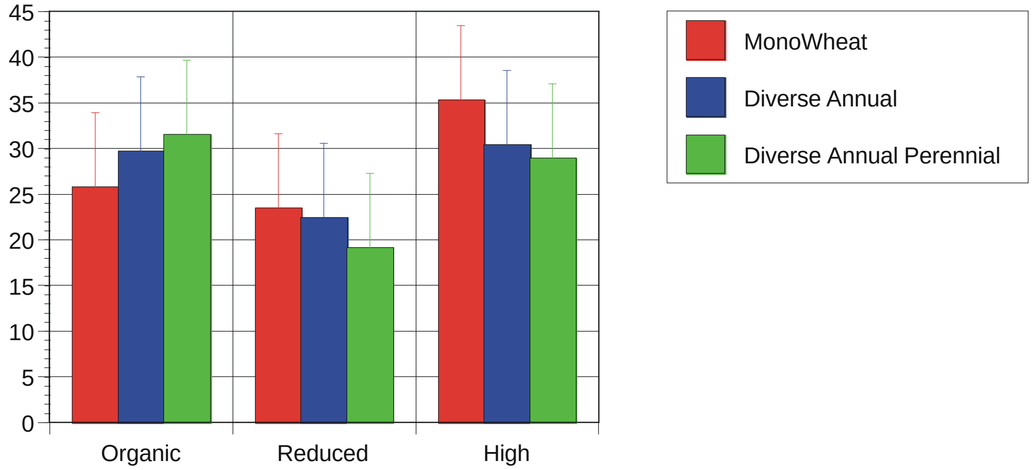

Figure 4. Dry sieved aggregates (%<0.5 mm) in sixth phase of rotations, spring 1997.

Soil Moisture and Bulk Density

Variability between samples of soil moisture (0-5 cm) was high consequently no clear trends were observed in 1996 and 1997 for soil moisture in rotations phases 2 and 6 due to input and diversity treatments. Bulk density (0-5 cm) did not vary significantly with treatment, with a range between 1.00 to 1.20 g cm^{-3}.

Hydraulic conductivity

In 1997 reduced input systems were significantly higher than organic or high input for the second phase of diverse annual and diverse annual perennial systems. Diverse annual systems were highest for the sixth phase of the reduced input.

Discussion

The potential for erosion was significantly higher in spring following fallow in fallow wheat-wheat-fallow-canola-wheat compared to other rotations. Potential was lowest in the second phase with fall rye in canola-fall rye-pea-barley-flax-wheat. High input systems following canola in the sixth phase of fallow-wheat-wheat-fallow-canola-wheat had higher residue cover than organic systems following crop due to increased production. These effects were attributed to the effect of tillage and the relative levels of productivity in the systems. Spring and fall tillage in organic systems reduced the amount of residue compared to reduced input systems. Amounts of residue cover required for erosion control vary depending on soil texture and field slope (Table 2). Levels of crop residue were low at the beginning of this study, and crop residue cover should be measured in future years to determine potential for erosion. Crop residue levels may not reflect the system's potential for soil erosion until two rotation cycles are complete.

Table 2. Residue cover required for erosion control and critical levels of bare ground (PFRA, 1998).

Wind Erosion	Residue cover (%)	Bare ground (%)^z
Soil texture		
Medium (loam)	45	55
Fine (clay)	60	40
Coarse (sandy)	75	25
Field slope		
Gentle (6-9%)	35-50	50-65
Moderate (10-15%)	50-70	30-50

^{z} Bare ground calculated from residue cover.

High amounts of aggregates in the erodible fraction will also contribute to significant levels of soil erosion (Table 3). Inclusion of fall rye in rotation for diverse annual systems significantly decreases the potential for erosion.

Table 3. Assessments of soil erodibility by wind (after Dolgilevich, Sofronova and Mayevskaya (1973) in Morgan 1986).

% dry stable aggregates < 0.84 mm	<20	20-50	50-70	70-80	>80
Erodibility (t ha^{-1} y^{-1}	<0.5	0.5-1.5	1.5-5	5-15	>15

Hydraulic conductivity may increase in diverse annual systems with reduced inputs due to inclusion of rye in rotation. Soil physical properties such as bulk density may also change due to these treatment effects as the experiment progresses.

Conclusions

Further research is required to confirm residue cover may not be sufficient for erosion control under organic and high input systems, particularly following years of low productivity for broadleaf crops. Low residue cover was also attributed to higher frequency of tillage in organic and high input compared to reduced systems. Fall rye in diverse annual systems significantly decreased the amount of bare soil and potential for erosion in the spring.

References

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2. Morgan, R.P.C. 1986. Soil erosion & conservation. Longman Scientific and Technical, Burnt Hill, Harlow, Essex, England. p 298.