2. Water Infiltration and Evaporation from the Soil Surface Under Reduced Tillage

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INTRODUCTION

Water is the main factor limiting plant growth in the semi-arid regions of this country. The amount of water that can possibly be lost from the soil due to evaporation and crop water use, normally exceeds the amount of growing season precipitation. Consequently, a severe water shortage for plants can develop unless a reserve of available soil water is stored before planting. Tillage, or the lack of tillage, can affect each of these losses and therefore affects precipitation storage efficiency. In addition, tillage may alter several soil physical and chemical properties that may affect crop production and water use efficiency. Long-term research has indicated that the addition of only 1 cm of available water in the spring can translate into yield increases of up to 200 kg of grain per hectare. Increasing the efficiency of soil moisture conservation by practices such as residue management can therefore result in substantial yield increases.

Summerfallow was universally adopted in the prairies following the 1930's to accumulate sufficient soil water to reduce the risk of failure when the crop was planted. The main reasons for summerfallow are to conserve moisture and to control weeds and diseases. In the long-term, summerfallow has been found to result in reduced levels of soil organic matter and increased soil erosion by wind and water.

The efficiency of soil-water conservation (gain in soil water content relative to the total amount of precipitation) under summerfallow is low, ranging from less than 10% in the Dark Gray and Gray soil zones to around 25% in the Brown and Dark Brown soil zones. Considerable amounts of soil moisture are lost during the winter and summer periods in the 21-month summerfallow cycle

Herbicides such as 2,4-D and Banvel have made chemical weed control on stubble fields a viable alternative to fall tillage operations. Data on soil moisture conservation from the Innovative Acres Program (Dept. of Soil Science, Univ. of Saskatchewan), indicate that stubble fields gained an average of 3.4 cm more soil moisture from fall rains and winter snowfall than summerfallowed fields. Summerfallowed fields can actually lose considerable amounts of soil moisture during the late winter to early spring period in years of little snow cover.

Minimum tillage (1 to 3 operations) and zero tillage (direct seeding) may improve moisture storage efficiency some 5 to 10%, bringing the overall average efficiency up to 26 to 28% as compared to 25% for conventional fallow. Occasionally, greater improvements may be experienced in seasons having heavy wet snowfalls in late spring. The significant benefits of "reduced" tillage systems are better control of erosion by wind and water, and possibly reduced loss of moisture by evaporation after seeding if zero-till seeding is practiced.

The objective of this project was to determine soil-water conservation under reduced tillage, using microlysimeters. It was thought that microlysimeters would provide for a more accurate determination of changes in soil moisture content of the soil surface, as compared using neutron probes for determining field soil moisture contents. The experiment concentrated on changes in soil moisture content of the soil surface because the effect of reduced tillage on soil-water conservation is likely most pronounced in the soil surface layer.

MATERIALS AND METHODS

The plots were located at the Kernen farm (NE8-37-4-W3) on a Sutherland clay-clay loam (Ortic Dark Brown Chernozem) and consisted of replicate blocks of tillage plots: cultivated, offset disk, fall rye cover, and chemical fallow. The plots had been split into Haybuster-seeded and discer-seeded. The plots were part of a long-term study on reduced tillage systems and crop production by R.K. Foster. The test plots involved those that were in the fallow part of the crop rotation.

Microlysimeters consisted of 20-cm length sections of 15-cm (i.d.) PVC pipe (0.5 cm thick). In each of the split tillage plots, 3 reps of lysimeters were used. The lysimeters were pushed into the soil using the hydraulic system of a punch truck. The (soil-filled) lysimeters were removed from the soil surface and inserted into a large plastic bag (the open end of the plastic bag was rolled back and folded over the outside perimeter of the lysimeter), in order to prevent soil loss. The hole left by the excavated lysimeter was enlarged in order for a inverted pipe-end (cap) to be placed in the hole. The lysimeter with soil was weighed and placed back in the excavated hole on top of the pipe-end. Measurements were taken daily, except for week-ends by removing the lysimeters (including plastic bags), transporting them to the laboratory, and weighing them in the laboratory. They were then taken back to the field plots and re-inserted into the soil. Gravimetric soil samples for soil moisture content were collected at the start of the experiments from soil adjacent to the lysimeters.

The first experiment involved measurements taken from June 18 to June 24, 1991. The microlysimeters were then removed, emptied of soil and cleaned by washing. The second experiment involved measurements taken from August 21 to October 8, 1991 following the installation of the "cleaned" microlysimeters.

RESULTS AND DISCUSSION

High amounts of rainfall created considerable problems for the June measurements. Some of the lysimeters were flooded, others became contaminated with soil from nearby, and plastic bags became mud-filled.

The lysimeter data collected in the second experiment, August 21 to October 8, is shown in Table 2.1. There was no consistent trend in the data. The soil moisture contents at the start of the experiment varied from 12% to 30%, which might explain some of the

Table 2.1 Changes in soil water content of the soil surface in the tillage plots from August 21 to October 8, 1991.

Tillage	Seeder	Soil MC % (w/w)	Time period and precipitation (P)					
			August 21-22 P= 1.8 (mm)	August 22-23 P= 0 (mm)	August 23-24 P= 4.0 (mm)	August 24-26 P= 0 (mm)	August 26-29 P= 1 (mm)	Aug 29- Sep 1 P= 0 (mm)
Cultivated	Discer	17.73	8.62	-23.31	30.52	-23.05	-39.32	-39.42
Offset disk	Discer	21.63	9.27	-27.52	23.13	-27.23	-43.41	-34.18
Fall rye cover	Discer	21.07	9.33	-23.53	29.70	-24.08	-38.46	-33.85
Chem fallow	Discer	19.74	12.12	-22.87	29.70	-22.31	-41.75	-37.37
Cultivated	Haybuster	19.64	10.22	-25.18	40.01	-22.31	-34.61	-26.32
Offset disk	Haybuster	20.82	7.98	-35.39	27.91	-31.76		-28.53
Fall rye cover	Haybuster	15.43	10.10	-27.52	43.19	-22.51	-36.80	-35.95
Chem fallow	Haybuster	17.84	13.16	-22.58	43.61	-24.07	-43.06	-43.99

Tillage	Seeder	Time period and precipitation (P)						
		September 1-3 P= 0 (mm)	September 3-5 P= 5.8 (mm)	September 5-7 P= 0 (mm)	September 7-9 P= 0 (mm)	September 9-16 P= 2.0 (mm)	Sep 16- Oct 8 P= 0 (mm)	Aug 21- Oct 8 P= 14.6 (mm)
Cultivated	Discer	-16.97	87.82	-55.89	-9.26	-26.48	-39.53	-146.27
Offset disk	Discer	-32.73	82.13	-57.67	-7.63	-27.74	-78.34	-221.92
Fall rye cover	Discer	-19.39	81.05	-47.28	-10.54	-33.11	-36.73	-146.89
Chem fallow	Discer	-19.69	89.32	-46.98	-9.59	-27.32	-22.00	-118.74
Cultivated	Haybuster	-37.64	80.00	-51.99	-6.42	-21.46	-33.33	-129.03
Offset disk	Haybuster	-12.69	82.15	-49.30	-6.71	-21.09	0.58	-79.53
Fall rye cover	Haybuster	-19.57	92.12	-48.58	-10.20	-25.64	-28.74	-110.10
Chem fallow	Haybuster	-24.08	98.36	-44.07	-11.81	-24.24	-28.74	-111.51

large variability in the data. The data set was modified by including only replicate lysimeters where the initial soil moisture contents fell in a narrow range between 16% and 20% (w/w). These values of soil moisture content are below that for the wilting point of this soil (~ 28%). The second "adjusted" data set is shown in Table 2.2. There were some trends in the data, which is shown more clearly in Figure 2.1.

There was a trend in the data for the Haybuster-seeded plots, between the chemical fallow and the cultivated plots. Soil-moisture recharge following rainfall was greatest in the chemical fallow plots. Soil-water evaporation rates were lowest under chemical fallow for the initial period after rainfall; however, subsequent evaporation rates were higher in these plots. This would suggest that the soil surface of the cultivated soils loses moisture rapidly as the area of bare soil exposed to the atmosphere is larger than that of the reduced tillage plots. However, once the surface has dried out, subsequent loss of soil -water is reduced considerably, probably because of limiting soil hydraulic conductivity. On the other hand, the chemical fallow plots have less bare soil surface exposed to the atmosphere, which would reduce soil-water evaporation. However, the chemical fallow plots probably have a more continuous soil macro-pore system, which would facilitate initially a slower but more continuous soil drying (and soil wetting).

There was no consistent trend amongst the other Haybuster-seeded plots; fall rye cover and offset disk. It is possible that some water uptake by the rye plants affected the results.

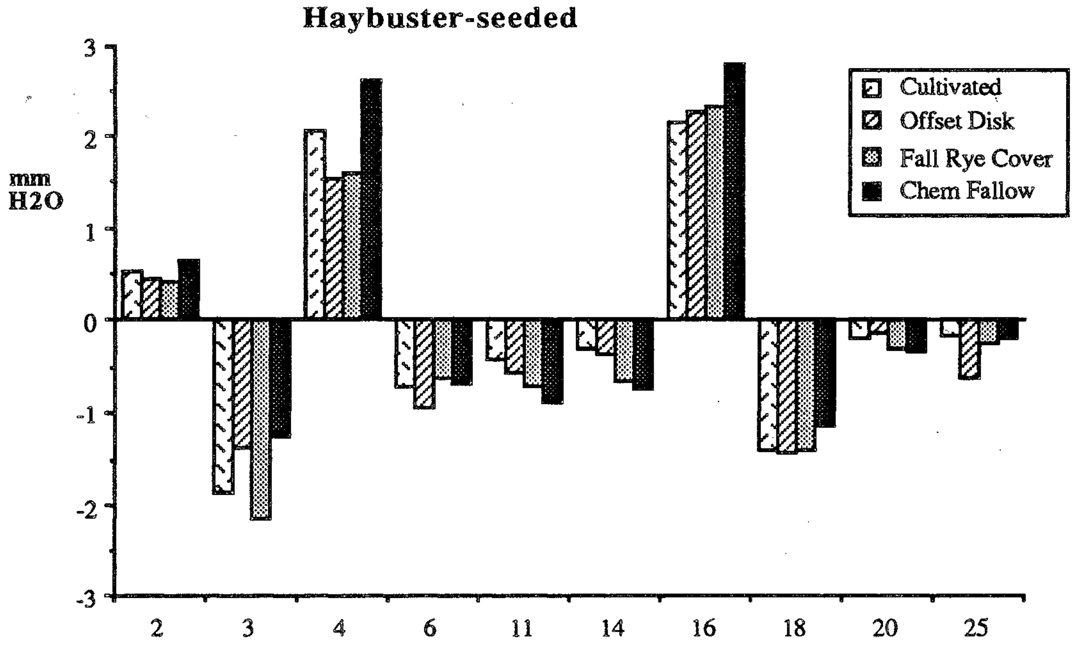
The discer appeared to have reduced the effect of chemical fallow on both soil-water infiltration and on soil-water evaporation. This suggests that enough soil disturbance is created by the discer to disrupt the continuity of the soil macro-pore system.

This experiment is by no means conclusive of the effect of reduced tillage on soil-water of the soil surface. However, it shows the applicability of microlysimeters in a field study where accurate determination of changes in soil-moisture contents are required. The experiment was carried out by taking measurements every 2 to 7 days apart; consequently

Table 2.2 Change in soil water content of the soil surface in the tillage plots from August 21 to October 8, 1991. (Only lysimeter data indicating similar initial soil moisture contents ,16-20% w/w, were used)

Tillage	Seeder	Soil in microlysim. field weight (g)	Soil MC % (w/w)	Time period and precipitation (P)				
				August 21-22 P= 1.8 (mm)	August 22-23 P= 0 (mm)	August 23-24 P= 4.0 (mm)	August 24-26 P= 0 (mm)	August 26-29 P= 1 (mm)
Cultivated	Haybuster	2953	19.7	10.0	-34.3	37.7	-25.9	-32.6
Cultivated	Discer	2886	16.1	8.3	-25.6	25.2	-24.3	-38.8
Offset disk	Haybuster	2656	20.0	8.0	-24.9	27.9	-34.7	
Offset disk	Discer	2645	16.6	6.2	-32.6	34.2	-33.0	
Fall rye cover	Haybuster	2691	19.8	7.7	-39.2	29.4	-22.5	-39.6
Fall rye cover	Discer	3002	17.5	8.3	-27.1	26.5	-24.2	-38.1
Chem fallow	Haybuster	2999	19.6	12.1	-23.1	47.7	-24.7	-44.9
Chem fallow	Discer	2888	16.8	12.0	-21.2	20.1	-21.2	-37.7

Tillage	Seeder	Time period and precipitation (P)						
		Aug 29-Sep 1 P= 0 (mm)	September 1-3 P= 0 (mm)	September 3-5 P= 5.8 (mm)	September 5-7 P= 0 (mm)	September 7-9 P= 0 (mm)	September 9-16 P= 2.0 (mm)	Sep 16-Oct 8 P= 0 (mm)
Cultivated	Haybuster	-24.1	-10.7	78.8	-50.8	-6.2	-20.5	-28.3
Cultivated	Discer	-34.0	-16.1	81.7	-58.1	-8.1	-25.6	-38.9
Offset disk	Haybuster	-31.2	-12.7	82.7	-51.6	-4.9	-22.8	-16.2
Offset disk	Discer	-26.4	-11.6	91.6	-53.5	-7.3	-23.0	-77.1
Fall rye cover	Haybuster	-40.0	-24.3	84.4	-50.3	-11.9	-32.3	-63.6
Fall rye cover	Discer	-30.3	-20.2	77.0	-51.0	-14.2	-38.3	-94.9
Chem fallow	Haybuster	-47.8	-26.8	101.8	-41.8	-12.1	-24.8	-24.7
Chem fallow	Discer	-33.1	-16.4	75.8	-47.6	-9.1	-26.1	-39.7



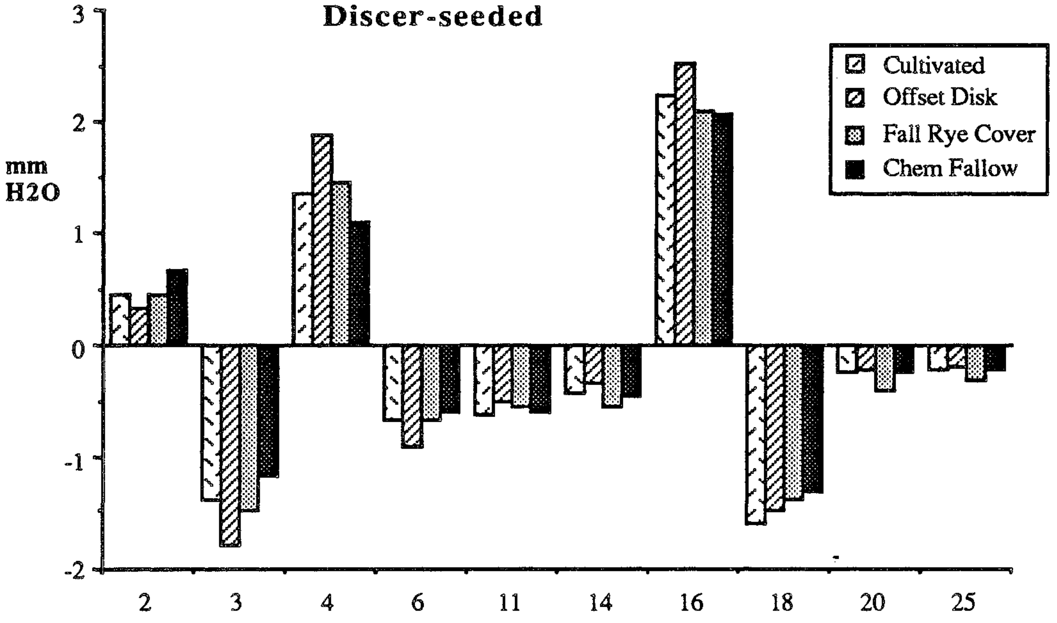


Figure 2.1 Change in soil water content (mm d^{-1}) in the tillage plots during the period from August 21 (day 1) to September 16 (day 25).

soil-water recharge and soil-water evaporation indicated by these measurements are only relative, and these measurements in fact include both processes. Furthermore, the experiments were carried out when the soil surface was relatively dry (< PWP), future work may involve irrigating the plots to field capacity prior to measuring soil-water evaporation rates. Further work is planned for 1992, involving 2 farm sites and 2 different soil textures.

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