WATER USE BY SOYBEANS IN STUBBLE AND ON BARE SOIL

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Partly as a result of high production and energy costs, farmers are becoming more interested in reduced-tillage systems. Collins (1982) reported a majority of farmers who reduced tillage did so for economic reasons. While the farmer's immediate concern is reducing production costs, tillage systems that maintain residues reduce soil erosion and can increase soil water content as well.

Water loss from soil can be described by the three stages of evaporation. Stage one evaporation occurs when the soil surface is at or near field capacity. Evaporation will be at the maximum or potential rate controlled by climatic conditions. Stage two evaporation results as the surface dries and evaporation decreases from the potential rate. When the upper several inches of soil are very dry there is little evaporation because of the slow transfer of water through the dry layer. This is stage three evaporation and is very low regardless of climatic conditions.

Stage one evaporation is climatically controlled but can be microclimatically altered by the presence of crop residues. Most research in the northern and central plains has shown small grain residues conserve soil water. Greb et. al. (1967) showed fallow efficiency increased from 16 percent to 28 percent as surface residue increased from 0 to 6000 pounds per acre. Bond and Willis (1969) found increasing rates of residue reduced the rate of evaporation when the soil was at or near field capacity. For short time periods during first stage evaporation, there were large differences in cumulative evaporation, but after one to two months differences were small. Furthermore, the position of residues is an important factor in water conservation. According to Smika (1983) standing wheat straw had a greater effect on wind speed than flat straw or bare ground and thus reduced evaporation and increased fallow efficiency.

The timing of tillage operations, the type of implement used and the amount of residue remaining are important factors in whether or not water is saved by tillage (Black and Siddoway, 1979). Black[1] has stated that 2000 pounds per acre of wheat straw residue may be the critical amount in evaporation reduction and water conservation. In general, the higher amounts of residue and taller stubble found with winter wheat production in the central plains are more effective in reducing evaporation than the residue after spring wheat in the northern plains. For example, French and Riveland (1980) reported no difference in fallow water conservation with no-till chemical, chemical/tillage, and tillage fallow methods at Williston, ND.

The purpose of this report is to show the effect of wheat stubble on water conservation compared to a bare soil treatment. Water use by soybeans over the growing season was also evaluated.

FIELD METHODS

The research was conducted on the North Dakota Main Experiment Station at Fargo. Two weighing lysimeters (Brun et al., 1983) were used to monitor evapotranspiration. Actual water content in the lysimeters was monitored by neutron attenuation.

Ellar spring wheat was grown on the northwest lysimeter (NW) and northeast lysimeter (NE) in 1981. On October 29, 1981 the stubble on NW was spaded and the surrounding area was rototilled leaving a surface almost devoid of residue. The stubble on NE (10 inches tall, 4000 pounds per acre) was not disturbed.

On May 25, 1982 the NW and surrounding area were again spaded and rototilled. The NE area was not disturbed. Evans soybeans were planted on each lysimeter in 30-inch rows by making a narrow slot in the soil with a flat-bottom spade. This was closed by foot-pressure and resulted in almost no residue disturbance. The area outside the lysimeters was planted with a John Deere[2] flex-planter with a cutting coulter. Plant population on NW and NE was adjusted to 87,120 plants per acre after emergence. Fertilizer was applied broadcast after seeding in recommended amounts so as to not limit yield. Weeds were controlled by hand weeding and hoeing.

Overwinter Soil Water Change

During the winter, snow that fell on the bare NW area was swept off by winter winds while snow accumulated and filled in the stubble on the NE area to a depth of 12

[1] Personal Communication.

[2] Brand names given for convenience of the reader and do not imply endorsement by the NDSU Agricultural Experiment Station.

to 14 inches by February. From November 10, 1981 to May 26, 1982 there were 6.43 inches of precipitation as snow and rainfall.

The change in soil water during this period was evaluated by both neutron attenuation and lysimeter readings shown in Table 1. The results show NE gained about 2.5 inches more soil water than NW. This means just over 50 percent of the precipitation received was stored as soil water on NE.

Table 1. Change in soil water in NW and NE based on neutron attenuation and lysimeter readings from November 10, 1981 to May 26, 1982.

Method	Change in Soil Water Content (inches)	
	NW	NE
Neutron Attenuation	0.93	3.43
Lysimeter Readings	0.79	3.81

Figure 1 show both NW and NE gained soil water in the upper part of the profile, but the change in soil water below 30 inches was much greater for NE than NW. The lysimeter tanks, which protrude 0.5 inches above the soil surface, may have enhanced soil water infiltration on NE by retarding runoff. However, results are similar to data reported by Deibert et al. (E.J. Deibert, submitted to J. of Soil and Water Cons.) where soil covered by standing wheat stubble stored about 50 percent of the non-growing season precipitation at Minot and Williston, ND.

Springtime Evaporation

The lysimeter readings during April and May 1982 were evaluated to determine effects of stubble on evaporation. The period from April 1 to May 9 was much drier than normal with only 0.48 inches of precipitation. The evaporation from NW and NE was nearly identical during this period, totaling 1.04 and 1.05 inches, respectively (Table 2). This nominal evaporation rate, averaging only 0.027 inches per day, indicates primarily stage three evaporation on both lysimeters. Under these conditions evaporation is controlled more by soil properties than surface conditions or meteorological factors, resulting in similar rates of water loss. With 0.48 inches of precipitation during this period, there was a net loss in soil water of 0.56 inches and 0.57 inches on NW and NE, respectively.

The situation changes with intermittent rainy periods beginning May 10. There were 13 days with measurable precipitation from May 10 through May 31. The evaporation from NE was 0.31 inches less than from NW during this period. Cumulative evaporation for May is illustrated in Figure 2. The frequency of

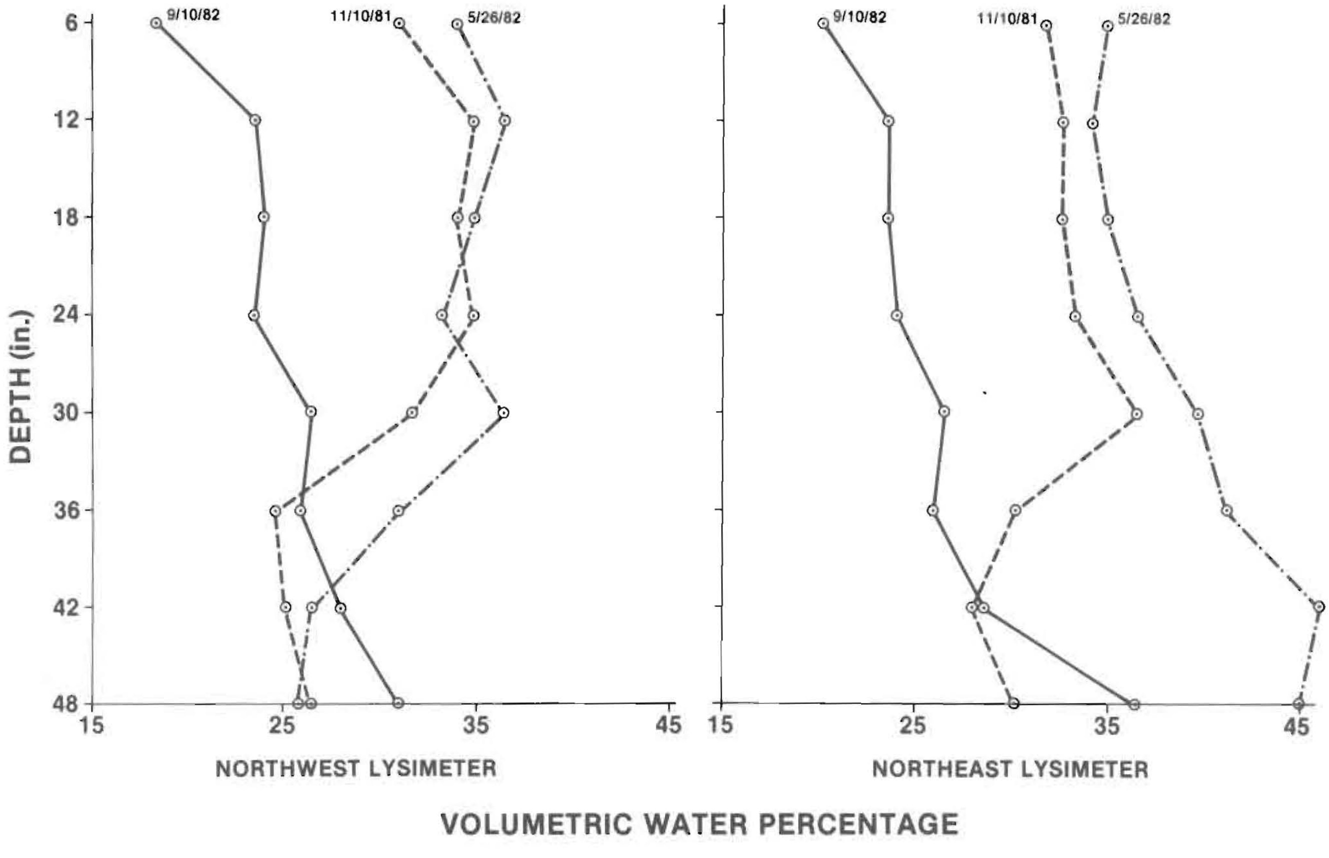

Figure 1. Soil water profiles for Northwest and Northeast Lysimeters.

Table 2. **April through May evaporation as measured by lysimeter readings and changes in soil water content.**

Time Period	Precipitation	Evaporation		Change in Soil Water	
	inches				
		NW	NE	NW	NE
April 1-May 9	0.48	1.04	1.05	−0.56	−0.57
May 10-May 31	2.21	1.53	1.22	0.68	0.99

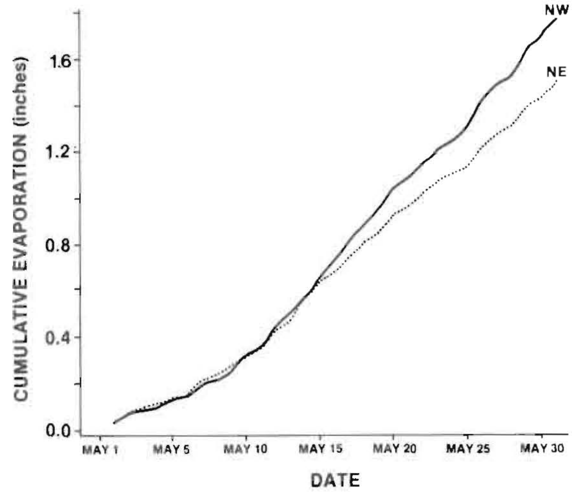

Figure 2. Cumulative evaporation from bare soil (NW) and stubble (NE) during May, 1982.

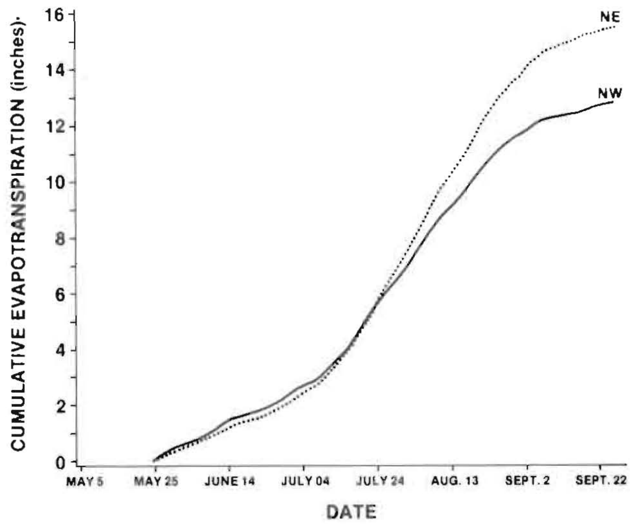

Figure 3. Cumulative growing season evapotranspiration for soybeans on bare soil (NW) and stubble (NE).

precipitation indicates much of the water loss was by evaporation from a wet surface or stage one evaporation. Thus, a major effect of the stubble appears to be reduction in stage one evaporation, complementing the report of Bond and Willis (1969). During this period the net gain in soil water was 0.68 inches on NW and 0.99 inches on NE.

Growing Season Water Use

The cumulative growing season evapotranspiration from NW and NE lysimeter readings is shown in Figure 3. The evapotranspiration from NW was greater than NE from seeding through June (2.36 inches versus 2.09 inches). However, in July the evapotranspiration from NE began to exceed that from NW. The more favorable water status in NE resulted in greater plant growth (Table 3) and thus more water use the rest of the season. From July 1 through September 26 evapotranspiration on NE exceeded that on NW by 2.94 inches. Water use by periods and over the growing season is found in Table 4.

The yield on NE was 41.8 bushels per acre and the yield on NW was 34.0 bushels per acre. The water use efficiency was only slightly higher on NE (2.69 bushels per acre-inch) compared to NW (2.64 bushels per acre-inch). A higher water use efficiency on NE may be due

Table 3. Plant height at various times over the growing season.

Date	Height in inches	
	NW	NE
June 15	2.0	2.0
21	3.5	3.5
July 7	7.5	9.5
12	10.0	13.0
26	21.0	26.0
August 4	30.0	34.0
17	30.0	34.0

Table 4. Water use by periods and over the growing season.

Period	Inches Evapotranspiration	
	NW	NE
May 25 - June 30	2.36	2.09
July 1 - July 31	4.53	5.27
August 1 - August 31	4.81	6.44
September 1-September 26	1.19	1.76
Growing Season	12.89	15.56

to a smaller amount of water lost as evaporation early in the growing season and a more favorable soil water status during the growing season.

SUMMARY

This research supports the value of small grain residue for water conservation. The most significant benefit was from snow trapping and subsequent increase in soil water content. In addition, the stubble reduced stage one evaporation losses during rainy periods. In general the evapotranspiration from NE was less than NW until the first week of July. After this the evapotranspiration from NE became greater because of greater soil water availability for transpiration. The cumulative water use became equal on July 19; however, for the growing season NE used 2.67 inches more water than NW resulting in 7.8 bushels per acre greater soybean yield.

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Continued from page 31

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