Snow Water Management for Crop Production in the Central Great Plains

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ABSTRACT

The importance of snowmelt water for crop production has received attention only in recent years. We are reporting on research conducted at the Central Great Plains Research Station which shows that management of crop residue for trapping and holding snow is important for the success of the winter wheat-fallow and winter wheat-corn-fallow rotations used in the area. In both rotations the no-till system resulted in the highest production and water use efficiency. The overwinter storage of snowmelt water was as much as 22% greater with no-till compared to conventional tillage. The winter wheat-corn-fallow rotation utilizes 10% more of the precipitation for crop production than the winter wheat-fallow rotation but both are dependent on the storage of snowmelt water to be successful.

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INTRODUCTION

Snowfall in the semiarid central Great Plains varies greatly from season to season as well as distribution within the snowfall season at any one location. There is also a difference in snowfall expectancy from south to north in response to decrease in temperature, increase in elevation, and change in latitude. As a result of these differences, the average snowfall near the southern edge of the Central Great Plains (southern Colorado and Kansas borders) is 38 cm (15 in.), contributing only 10% of the total annual precipitation. Near the northern edge of the area (northern Nebraska and Wyoming borders) the average annual snowfall is 117 cm (46 in.), contributing 30% of the total annual precipitation. This snowfall amounts to 698 million hectare cm (679 million ac. ft.) of water that is potentially available per year from snow in the area (Greb, 1975b). If the snow were uniformly distributed there would be approximately 9.3 cm (3.7 in.) of water for every hectare (2.5 ac.). This estimate excludes losses due to evaporation, sublimation, runoff, and deep percolation or gains from deposition of drifting snow.

Snow management to harvest water for crop production is of utmost importance throughout the area, but research in this area has occurred only in recent years (Greb, 1979). The importance of snowmelt water for crop production in the central Great Plains has been conclusively demonstrated by Greb (1971, 1975a, 1975b). Numerous barrier-types, both vegetative and artificial, and their effectiveness were used in these studies. The storing of snowmelt water for crop production was always greater than 50%, and in some instances 100%. On the other end, the storing of rainfall never exceeded 25% and was frequently less than 10%.

The scope of the information presented herein is to demonstrate the necessity of good snow management for successful crop production in the dryland winter wheat-fallow and winter wheat-corn fallow cropping systems used in the central Great Plains.

CROPPING SYSTEMS

Winter Wheat-Fallow

The winter wheat-fallow rotation has been the predominant cropping system used in the central Great Plains since the practice of fallow was almost universally adopted in the 1930's (Greb, 1979). This cropping system has demonstrated stable economical production (Smika, 1970). The success of the system relies on total weed control and the storage of soil water which comes largely from snowmelt water, because average rainfall alone during the crop growth period is insufficient to meet the water-use requirements of winter wheat (Figure 1). The overwinter storage of snowmelt water in the soil to a depth of 180 cm (6 ft.) averages 80% with no-till and 59% with conventional stubble mulch tillage (Table 1). Soil water storage during the total fallow period averages nearly 50% with no-tillage and 35% with conventional tillage (Table 2).

There are several factors which contribute to snow water storage in winter wheat stubble. Those envoked by nature cannot be controlled (wind, temperature during storm, and storm duration), but wheat stubble height can be managed to some extent which then provides some management of wind near the soil surface and, thus, management of the snowpack. Research at the Central Great Plains Research Station has shown that the optimum height of wheat stubble is 38 cm (15 in.) for consistently storing the greatest amount of snowmelt water. Wheat stubble shorter than 38 cm frequently cannot be maintained full of snow following snowstorms which come with

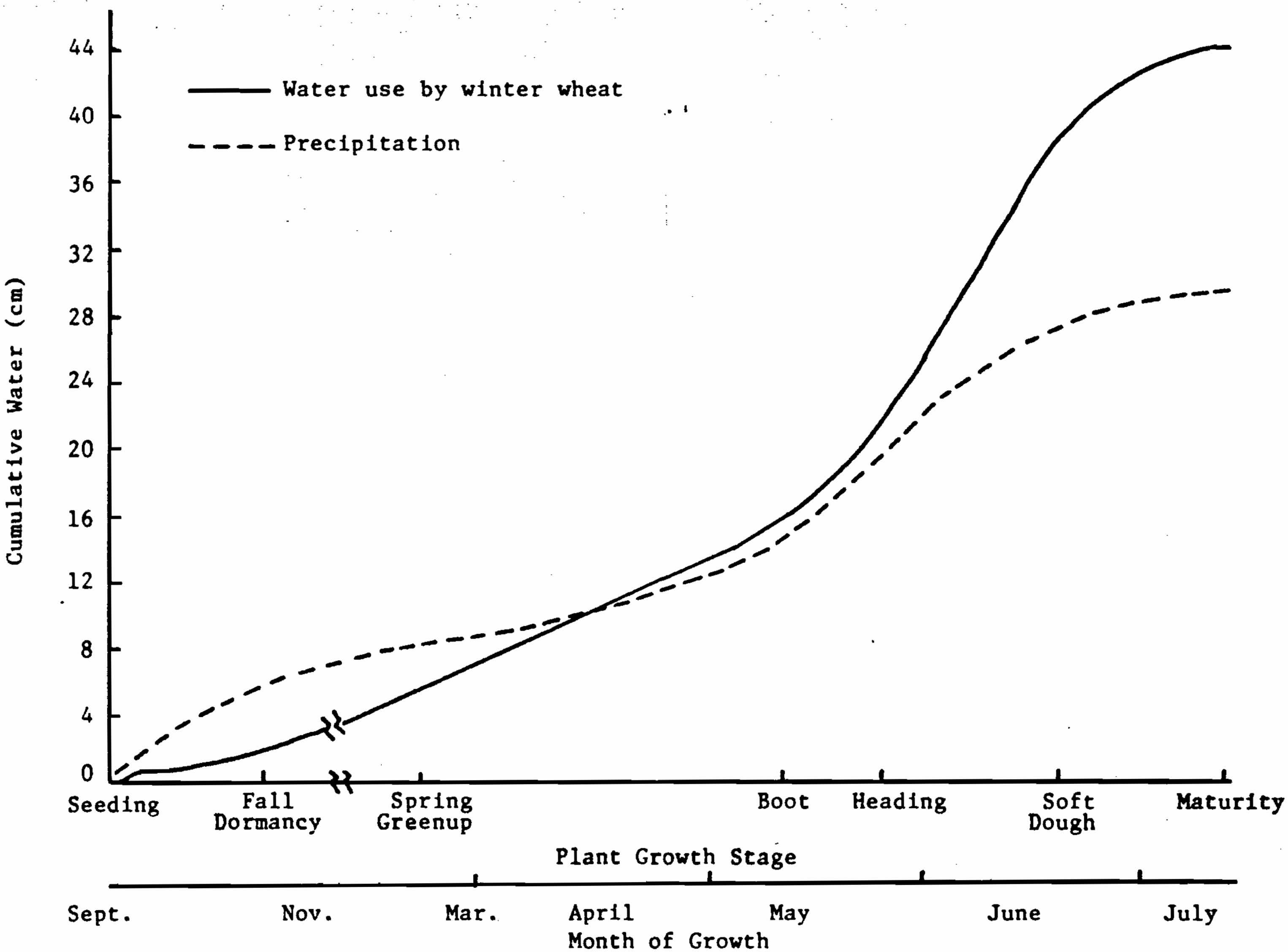

Figure 1. Water use by winter wheat in relation to growing season precipitation.

Table 1. Overwinter (Nov. 15 - Mar. 1) soil water storage of snowmelt water, Akron, Colorado, 1974-1985.

Winter season	Tillage Practice			
	No-tillage		Conventional stubble mulch	
	cm	%1/	cm	%
1974-75	6.9	123	2.8	50
1975-76	12.7	119	10.4	98
1976-77	4.1	80	2.8	55
1977-78	2.8	79	2.0	57
1978-79	5.8	79	4.1	55
1979-80	19.3	84	14.0	61
1980-81	17.0	131	15.5	120
1981-82	0.5	15	0.3	8
1982-83	4.8	43	3.6	31
1983-84	4.4	45	3.3	28
1984-85	3.6	82	2.5	59
Average	7.5	80	5.6	57

1/ Percent of overwinter precipitation as soil water storage.

Table 2. Soil water storage and storage efficiency as influenced by tillage treatment, 8-year average, Akron, Colorado.

Tillage treatment	Begin fallow	Fall	Spring	End fallow	Total storage	Storage efficiency1/
	cm					%
Conventional tillage	7.62	10.16	16.03	23.62	16.00	34.4
No-tillage	7.37	11.35	20.73	28.88	21.26	48.0

1/ Soil water gain divided by total precipitation times 100.

strong winds (velocities >14 m/s). Wheat stubble taller than 38 cm, especially taller than 46 cm (18 in.) is frequently flattened with the first storm in the fall and is thereafter less effective for trapping and holding subsequent snow. These initial storms usually produce snow that has a high percentage of water (as great as 20%). This heavy wet snow adheres to the straw which eventually bends and breaks the straw at the soil surface because of the added weight of the wet snow.

Efficient utilization of the stored soil water by crops is of utmost importance if snow management practices to increase the actual storage of water are to be feasible. Otherwise there is little value in trying to achieve a high soil water storage efficiency. With the wheat-fallow rotation, with total weed control, the use of no-tillage compared to conventional stubble mulch tillage resulted in more total dry matter production (grain plus straw), a water-use-efficiency increase of 18 kg/cm (21 lb./in.) of water used with only a 6.4 cm (2.5 in.) increase in total water (Table 3). The overall total precipitation-use-efficiency was 8% greater for no-tillage when compared to conventional stubble mulch tillage. The no-till system accounted for 59% of the total precipitation during the two-year period.

Winter Wheat-Corn-Fallow

The advent of improved herbicides which provide more options for better weed control and improved soil water storage has offered greater opportunity for more frequent cropping. The winter wheat-corn-fallow cropping system has been successful when a minimum of 10 cm (4 in.) of soil water is available at corn planting time, because water-use by corn exceeds precipitation by approximately that amount (Figure 2). This soil water

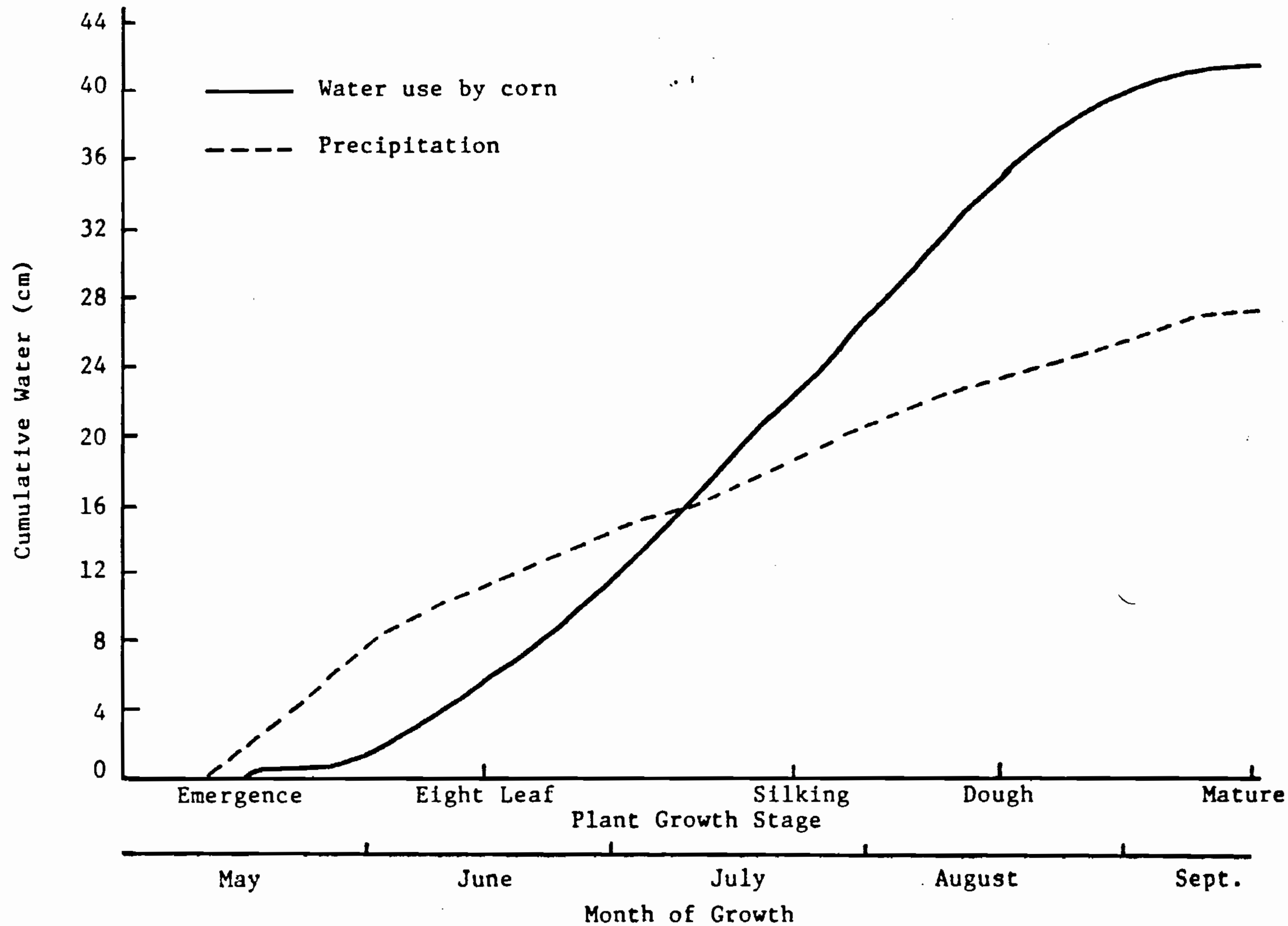

Figure 2. Water use by corn in relation to growing season precipitation.

Table 3. Production and water use in relation to tillage practice and cropping system for a 6-year period, Akron, Colorado.

	Conventional tillage	No tillage
	Winter wheat-fallow rotation	
Total dry matter produced	18,816 kg/ha	25,133 kg/ha
Production efficiency 1/	60 kg/cm	78 kg/cm
Total water used	124.13 cm	130.53 cm
Precipitation use efficiency 2/	51.4 %	59.0 %
	Winter wheat-corn-fallow rotation	
Total dry matter produced	29,187 kg/ha	38,864 kg/ha
Production efficiency	82 kg/cm	94 kg/cm
Total water used	143.76 cm	167.34 cm
Precipitation use efficiency	59.5 %	69.0 %

1/ Kilograms of total dry matter produced per cm of water used.

2/ Percent of precipitation used by crop plus amount stored as soil water.

Table 4. Soil water storage from snowmelt with different crops and management systems, Akron, Colorado.

Crop and/or Mgt. System	Years of data*	Storage Water	Storage Efficiency
		cm	%
Corn stalks - chopped	6	5.61	37.9
Corn stalks - standing	4	4.72	35.6
Forage sorghum - chopped	12	6.76	28.7
Grain sorghum - standing	4	7.52	46.0
Wheat stubble - conv-till	11	7.52	83.9
Wheat stubble - no-till	11	5.54	61.8

* Data collection years are not all consecutive nor concurrent.

usually comes from snow which is dependent on good management of the stubble from the previous wheat crop. The importance of residue management practice is shown in the information presented in Table 4, which covers a 20 year period. Many of the crops were grown in different years, therefore, direct comparisons cannot be made, but difference in both amount and percent of precipitation stored due to crop grown and management of the residue is evident. Chopping corn or sorghum residue near the soil surface influenced snow water storage efficiency by as much as 17%. Millet is another crop that can be grown in the area (data not available) but, because the stubble following harvest is generally only 15 to 20 cm tall, snow water storage similar to that of chopped corn or sorghum would be expected.

Utilization of water for crop production in the wheat-corn-fallow rotation is important to the success of the system. As with the wheat-fallow rotation, no-tillage resulted in the highest total production, production efficiency, and total water-use compared to conventional tillage (Table 2). With the 3-year rotation, precipitation-use-efficiency was 10% greater with no-tillage than with conventional tillage. Of greater importance is the fact that the 3-year rotation had greater production, and precipitation-use-efficiencies than with the 2-year rotation accounting for nearly 70% of the water, or 10% more than with the wheat-fallow rotation.

CONCLUSIONS

No-tillage in a 3-year rotation utilized nearly 70% of the precipitation received for production. This increased water utilization is important, because nearly 20% of the total precipitation received is in amounts of 0.64 cm (0.25 in.) or less which is difficult to store as soil water or get into the plant in any other manner. Further effort should be made to improve the use of the precipitation. Increasing the storage of snowmelt water is obviously one means whereby this can be achieved.

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