Proceedings of

IX International Congress of Plant Protection

Washington, D.C. U.S.A.

August 5-11, 1979

Volume I
Plant Protection: Fundamental Aspects

Editor
Dr. Thor Kommedahl
Department of Plant Pathology
University of Minnesota

7.4 Soil and Water Conservation with Minimum Tillage in the Semiarid Central Great Plains[1]

D. E. Smika

Central Great Plains Research Station
P.O. Box K, Akron, CO 80720 USA

The climate of the semiarid Central Great Plains of the US is characterized by erratic precipitation patterns, variable amounts of precipitation that average less than 400 mm annually, and nearly constant wind movement. These conditions make the practice of fallow a necessity for stable economic winter wheat production in the area. Although the use of fallow has stabilized production, the practice has been criticized for inefficient use of water and for exposing the soil to a greater wind erosion potential. These criticisms, however, are based on management common before 1960. Results from modern technology have shown that these criticisms are not justified because wheat grown after fallow under modern management utilizes water more efficiently than continuously grown wheat [1], and the wind erosion hazard is greater with continuously grown wheat than with wheat grown on fallow [2]. Conservation of both soil and water resources is equally important. Use of good water conservation

1 Contribution from Soil, Water, and Air Sciences, USDA

practices provides a large part of the measures needed for soil conservation. Therefore, the conservation of water will be discussed first and at greater length than conservation of soil.

Water Conservation

Weed control during fallow is of utmost importance. During a 6-week period in July and August after harvest, weeds can use up to 7.6 cm of water. Weeds can be controlled effectively with various tillage machines, some of which destroy crop residue totally and others only to a limited extent. Residue should be maintained on the soil surface—for every 1000 kg of residue/ha on the soil surface, soil water storage can be expected to increase 0.83 cm. The position of the residue is important for water conservation [3]. Standing residue helps soil water storage by trapping and holding snow. Snow water storage exceeds 70% every year and in some years exceeds 100%, because of the snow that is trapped from adjacent areas. During the hot, dry period of the year, standing wheat residue reduces the atmospheric evaporative demand from the soil by reducing wind movement at the soil surface. When standing wheat residue is 38 cm tall, the wind has to exceed 28 km/hr before wind movement occurs at the soil surface. Reducing wind movement at the soil surface reduces water vapor exchange with the atmosphere and decreases soil water evaporation potential. The standing stubble also cools the soil surface, thereby decreasing soil water loss (Table 1).

Implements that destroy stubble in the process of killing weeds are to some extent defeating their purpose. Also, tillage itself tends to dry the soil to the depth of tillage; those implements that destroy the greatest amount of residue also cause greater soil water loss (Table 2).

Continued frequent measurement of soil water content over a 34-day period in 1-cm increments of the tillage layer (0- to 15-cm) of a silt loam soil revealed that the tilled soil continued to lose water until it became dry to the depth of tillage. Nontilled soil, however, lost water only to the 3- to 5-cm depth and did not dry to deeper depths. This drying pattern occurred because in tilled soil there is much more air movement within the tillage depth. Moist air is continually brought to the surface to meet the evaporative demand of the atmosphere. In the nontilled soil, air moves within the soil, but not as rapidly nor as deeply as in tilled soil, and, therefore, less water is lost.

Table 1. Effect of position of wheat residue on soil surface temperature and soil water loss

Position of residue	Soil surface temperature (°C)	Water loss per day (mm)
Standing	32.2	0.43
Flat	41.7	0.56
Bare soil	47.8	0.66

Table 2. Effects of different tillage implements on residue reduction and soil water loss 1 and 4 days after tillage

Tillage Implement	Residue reduction per operation (%)	Soil Water Loss in the 0- to 12-cm depth (cm) 1 day	4 days
Oneway disk	50–60	0.84	1.30
Chisel	10–15	0.74	1.22
Sweep plow	10–15	0.23	0.36
Rodweeder	15–20	0.10	0.56

When weeds are controlled with herbicides, the wheat stubble can be left standing, and the accelerated breakdown of the stubble due to mechanical tillage is avoided. Thus, the advantages of standing residue is reflected in increased soil water storage. Nine years' of data showed an average soil water storage of 19.8 cm with no-till management, 14.7 cm with minimum tillage, and 12.8 cm with conventional stubble mulch tillage. These quantities of water represent storage efficiencies of 52, 38, and 33% respectively.

The grain yields associated with no-till, minimum tillage, and conventional tillage fallow practices were 32.9, 30.2, and 25.6 quintals/ha, respectively.

Soil Conservation

Soil erosion by wind is a potential threat on cultivated soils in the Great Plains when the soil is loose, dry, and finely divided; vegetative cover is sparse or absent; and wind velocity is great enough to initiate soil movement. Conditions are most conducive to wind erosion during February, March, and April, after the long period of weathering degradation of both vegetative material and soil aggregates. During this time, peak wind velocity probabilities are high and vegetation is dormant.

Soil erosion can be controlled by creating a soil surface resistant to erosion, by protecting the erodible-sized particles from the wind, or by a combination of both. The resistance of soil to erosion is increased by increased surface roughness, vegetation, barriers, and crop residue. Surface roughness can be increased by ridging the soil surface or by increasing the quantity of soil aggregates resistant to wind erosion. A soil aggregate more than 0.84 mm in diameter is considered to be resistant to wind erosion, and at least 67% of the aggregates on the soil surface must be 0.84 mm or larger to protect the soil surface from wind erosion [4]. Crop residue has been used to increase resistance of soil to erosion through conventional stubble mulch tillage. The practice leaves an average of 1000 kg of residue/ha on the soil surface at the end of fallow. This quantity of residue provides only marginal protection for loam and silt loam soils and inadequate protection for sandy soils. Minimum tillage increases the quantity of straw residue on the soil surface to 1880 kg/ha at the end of fallow, which is probably enough residue for protection of nearly all soils. No-till management has resulted in 2050 kg of residue/ha on the soil surface at the end of fallow, which would adequately protect all soils.

A second benefit from straw residue on the surface is that the formation of nonerodible-sized aggregates is closely related to the quantity of residue on the soil surface [5]. Determination of soil aggregate sizes in the surface soil at the end of fallow showed that under conventional stubble mulch tilage, 64% of the aggregates were nonerodible greater than 0.84 mm in diameter. Under minimum tillage, 68% of the aggregates were greater than 0.84 mm, and with no-till, 69.5% of the aggregates were greater than 0.84 mm. These percentages of nonerodible aggregates were highly correlated with the quantity of straw on the soil surface ($r^2 = 0.990^{**}$).

The 64% nonerodible aggregates left by conventional stubble mulch tillage is not enough to provide a soil surface resistant to wind erosion. In contrast, both minimum tillage and no-till treatments left nonerodible aggregate percentages that exceeded the 67% considered the minimum needed for soil protection. Thus, the resultant aggregate formation with minimum tillage and no-till fallow practices would provide an erosion-resistant soil surface, and, along with the nearly 2000 kg of residue/ha on the soil surface, would provide a dual mechanism for wind erosion protection. The additional straw residue left on the soil surface at the end of fallow after fewer tillage operations was a direct result of practices that increased soil water storage. Therefore, as stated earlier, good water conservation practices provide a large part of the measures needed for soil conservation.

Literature Cited

1. Smika, D. E. 1970. "Summer fallow for dryland wheat in the semiarid Great Plains." *Agron. J.* 62:15-17.
2. Greb, B. W., D. E. Smika, C. J. Whitfield, and N. P. Woodruff. 1974. Summer fallow in the Central Great Plains. p. 51-85. In Summer fallow in the western United States. *USDA Conserv. Res.* Rept. No. 17.
3. Smika, D. E. 1976. Mechanical tillage for conservation fallow in the semiarid Central Great Plains. *Proc. 6th Gt. Plains Conserv. Till.* Workshop Publ. No. 77. pp. 78-92.
4. Woodruff, N. P., Leon Lyles, F. H. Siddoway, and D. M. Fryrear. 1972. How to control wind erosion. *USDA Agr. Info. Bull.* 354, 22 pp.
5. Smika, D. E., and B. W. Greb. 1975. Nonerodible aggregates and concentration of fats, waxes, and oils in soils as related to wheat straw mulch. *Soil Sci. Soc. Am. Proc.* 39:104-107.