NO-TILLAGE EFFECTS ON INFILTRATION, RUNOFF, AND WATER CONSERVATION ON DRYLAND

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ABSTRACT. *Dryland crops produce limited amounts of residue, thus the water conservation benefits of no-tillage (NT) may be reduced. We compared infiltration, runoff, and water conservation effects of NT with stubblemulch (SM) tillage at Bushland, Texas, in the semiarid southern Great Plains. From 1981 to 1992, we cropped six field-sized (2 to 4 ha) graded-terraced watersheds in a dryland, three-year, winter wheat (*Triticum aestivum L.*)-sorghum [*Sorghum bicolor (L.) Moench*]-fallow (WSF) sequence. There were three pairs of watersheds in the sequence, each with NT and SM treatments maintained on the same watersheds each year. Runoff was measured with H-flumes from each watershed beginning in 1984. Infiltration differences were measured with a rainfall simulator in 1990 and 1991. We compared soil water storage during fallow to evaluate the water conservation effectiveness of tillage treatments. Terminal infiltration rates were similar for both tillage systems; however, infiltration rates declined much more rapidly with NT than with freshly tilled SM, primarily due to surface sealing even though residue coverage exceeded 50% on NT. Cumulative infiltration after 2 h of simulated rainfall was 90% greater on SM than on NT for tests conducted during fallow after sorghum, and 26% greater during fallow after wheat. Infiltration was greater on SM because tillage destroyed the consolidated surface crust, decreased bulk density, and increased surface roughness and depression storage capacity. The first artificial rainfall application compacted and smoothed the surface on the SM treatment; thus, infiltration during subsequent tests was similar for both tillage systems. Storm runoff measured with H-flumes averaged 25.5 and 40.1 mm/year for eight cycles of WSF for SM and NT treatments, respectively, with most runoff occurring during fallow periods. Despite greater surface runoff from the NT system than from the SM system, NT management resulted in improved water conservation due to reduced evaporation. Total plant available soil water storage during fallow after sorghum was 18% greater with the NT treatment and 10% greater during fallow after wheat than for soil water storage obtained with the SM treatment. More intensive cropping with less fallow appears possible on drylands by using NT management.* ***Keywords.*** *Tillage, Residue management, Water conservation.*

Stubblemulch (SM) and no-tillage (NT) residue management systems were developed for the southern Great Plains to protect the soil from wind and water erosion. More than 75% of conservation farm plans for highly erodible lands (HEL), developed in the United States in response to compliance provisions of the 1985 and 1990 farm bills, use variations of mulch-till, no-till, or ridge-till residue management systems to control erosion (Conservation Tillage Information Center, 1993). Stubblemulch tillage, which uses sweeps or blades to undercut the soil surface at a 10 to 15 cm depth, leaving 75 to 80% of residues on the surface after each operation, was developed by a coordinated effort at several Great Plains research stations. Stubblemulch tillage controls wind erosion and improves water conservation and crop yields in comparison to clean (disk) tillage systems (Johnson and Davis, 1972). However, due to low rainfall, residue production is limited on drylands of the southern Great Plains. Most residues have been incorporated and have disappeared from the soil surface by planting time when the SM system is used, especially with fallow where 4 to 5 tillage operations are required to control weeds during an 11-month fallow. In regions where adequate amounts of crop residues are produced, the NT system has the potential to increase infiltration, reduce runoff, and improve water conservation through reduced evaporation (Allmaras et al., 1985). When crop residues from NT are not adequate to protect the surface from the kinetic energy of rainfall, as is often the case with dryland cropping in semiarid areas, then soil crusting can occur. Soil crusts can reduce infiltration, increase surface runoff, and reduce water conservation on drylands (Morin and Benyamini, 1977; Lindstrom and Onstad, 1984; Unger, 1992; Steiner, 1994).

Our objective was to compare the effects of NT and SM management systems on infiltration, runoff, and water conservation for dryland grain production to determine if

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NT is an improved tillage system for water conservation in a semiarid climate.

Materials and Methods

The research was conducted on contour-farmed graded-terraced watersheds located on Pullman clay loam (fine, mixed, thermic Torrertic Paleustoll) at Bushland, Texas. The semiarid climate, gently sloping topography, and slowly permeable soils are typical of 2.6 million hectares in the Texas and Oklahoma Panhandles and in eastern New Mexico. Average annual precipitation at Bushland is 466 mm and average 0.5-year (April through September) evaporation from a 1.2-m class A evaporation pan is 1270 mm. The six field-sized watersheds (fig. 1), described by Hauser et al. (1962), were cropped in a three-year winter wheat-grain sorghum-fallow (WSF) sequence with NT management on three of the watersheds and SM management on the other three watersheds. Each phase of the sequence was present each year. The WSF sequence (fig. 2) produces 2 crops in 3 years with an 11-month fallow (noncropped) period preceding each crop. All watersheds were cropped in a SM-tilled WSF sequence for more than 30 years prior to establishing the NT treatment on three of the watersheds in 1981.

On NT watersheds, weeds were controlled with herbicides and the only soil disturbance involved seeding the crops with a single exception described below. The weed control program for NT was:

Fallow After Wheat:

3.36 kg ha^{-1} atrazine [2-chloro-4-(ethylamino)-6(isopropylamino)-s-triazine] and 0.84 kg ha^{-1} 2,4-D [(2,4-dichlorophenoxy) acetic acid] applied immediately after wheat harvest.

Sorghum:

0.56 kg ha^{-1} glyphosate [N (phosphonomethyl) glycine] + surfactant applied just prior to sorghum planting and 1.68 kg ha^{-1} propazine [2-chloro-4,6-bis(isopropylamino)-s-triazine] applied pre-emergence.

Fallow After Sorghum:

23 to 35 g ha^{-1} chlorsulfuron [(2-chloro-N-[[(4-methoxy-6-methyl-1,3,5-traizin-2-yl)amino]carbonyl] benzenesulfonamide] + surfactant and 0.56 kg ha^{-1} 2,4-D applied in February after sorghum harvest the previous November.

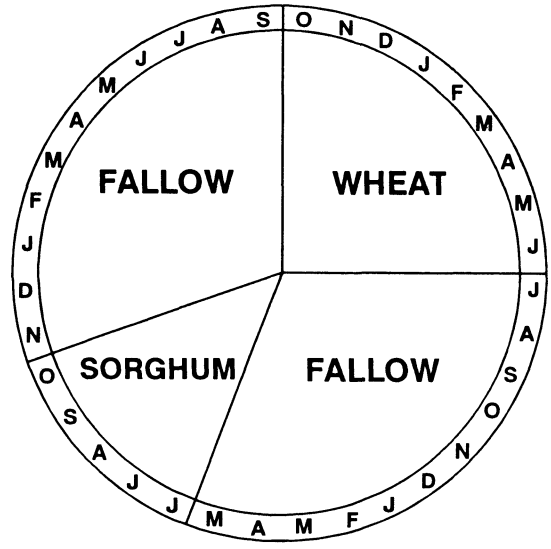
Wheat:

0.56 kg ha^{-1} glyphosate + surfactant applied a few days prior to wheat planting.

In the later years of the experiment (after 1987), glyphosate rates were increased to 0.75 kg ha^{-1} to control grassy weeds, primarily tumblegrass [*Schedonnardus paniculatus* (Nutt.) Trel.] and tumble windmillgrass (*Chloris verticillata* Nutt.). Weed escapes during fallow were controlled with additional applications of glyphosate. In June 1990, the NT watershed scheduled for sorghum was tilled once with V-blades to control tumblegrass and pricklypear (*Opuntia* sp.).

Weeds were controlled and seedbeds prepared on SM watersheds with a 4.6-m-wide sweep machine equipped with three (1.8-m) V-shaped blades with a mulch treader usually attached. The first tillage after crop harvest was about 13 cm deep with the mulch treader detached. Subsequent tillage was at shallower depths, usually just deep enough to control weeds (8 to 10 cm) and with the mulch treader attached. Five tillage operations were usually required during fallow periods in the WSF sequence. The first post-harvest tillage operations were usually performed in July for fallow after wheat and in April for fallow after sorghum. Chemical weed control on SM consisted of 1.68 kg ha^{-1} propazine applied pre-emergence after sorghum planting and 0.56 kg ha^{-1} 2,4-D applied on growing wheat in late February during some years to control flixweed [*Descurainia sophia* (L.) Webb ex Prantl].

The same sorghum planter or wheat drill was used on both SM and NT watersheds. DeKalb sorghum hybrid 'DK-46' was seeded with a 6-row, John Deere Max-emerge planter with 0.76-m row spacing at 76,000 seeds ha^{-1}, while winter wheat variety 'TAM 107' was seeded at 36 kg ha^{-1} using a high-clearance hoe-press grain drill with 0.3-m row spacing.


FALLOW
WHEAT
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The graded-terraces (0.05% channel slope) drain into a grassed waterway with all runoff from each watershed measured through 0.76- or 0.91-m H-flumes equipped with stage recorders. Flumes were individually calibrated (Hauser and Jones, 1991). Runoff charts for 1984 to 1989 were analyzed using the breakpoint method while 1990 to 1992 charts were analyzed with the horizontal summation method (Brakensiek et al., 1979). Precipitation was measured with one weighing and recording gage and two standard gages.

Infiltration rates were measured near the end of the fallow periods with a rotating-disk rainfall simulator that closely approximates the kinetic energy of natural rainfall (Morin et al., 1967). The test dates were a few days prior to sowing wheat in 1990 (which ends the fallow after sorghum phase) and a few days prior to planting of sorghum in 1991 (which ends the fallow after wheat phase). Cistern-stored rainwater was applied at a rate of 48 mm h^{-1} to 1.5-m^2 areas enclosed by a metal frame designed to capture runoff. The frames extended approximately 10 cm above and below the soil surface to control runoff. Infiltration rate was calculated as the difference between water application rate and runoff rate. Infiltration rates were measured at two to three sites on each watershed.

The initial infiltration test at each site was with dry soil surface conditions (dry run) with a second test (wet run) conducted after one day of drying. Infiltration tests were sequenced so that site 1 dry-run tests on both SM and NT watersheds were applied on the same day; site 2 dry-run and site 1 wet-run tests were applied on the second day; and site 3 dry-run and site 2 wet-run tests were applied on the third day. Natural rainfall did not occur on any of the infiltration test dates. Approximately one week prior to conducting the initial (dry run) infiltration tests, the SM watersheds were sweep-tilled 10 cm deep, thus for initial tests, SM watersheds had a rough noncrusted surface, while on NT watersheds the surface was smooth and crusted as a result of prior rainstorms.

In addition to infiltration rates, soil characterization measurements taken at or near each rainfall simulation site included:

- Dry aggregate size distribution of top 2 cm of soil by rotary sieving on samples taken before water application (Kemper and Rosenau, 1986).
- Water-stable aggregate size distribution of top 2 cm of soil by wet sieving samples taken before water application (Kemper and Rosenau, 1986).
- Organic matter concentration to a 15 cm depth (Jackson, 1958).
- Random roughness of soil surface before and after applying water (Allmaras et al., 1966).
- Percent residue cover by determining the number of residue "hits" with the same pins as used for measuring random roughness (maximum of 400 hits m^{-2} possible).
- Soil bulk density and gravimetric soil water content to a 0.90 m depth by 0.10-m increments with a 5.40 cm inside diameter slotted tube and a tractor-mounted hydraulic sampler (Richards, 1954).
- Soil penetration resistance taken before and after water application to a 0.30 m depth using a hand-operated penetrometer with a conical point 20 mm long and 12.7 mm in diameter.

The effect of each tillage system on water conservation was evaluated by comparing measured soil water contents at planting of sorghum and wheat, which was also the end of the fallow after wheat and fallow after sorghum phases, respectively. Soil water contents to a 1.8 m depth were determined in 30-cm increments using the neutron method (6 access tubes per watershed) from 1982 to 1985 and gravimetric sampling (12 cores/watershed) from 1986 to 1992. Gravimetric contents were converted to volumetric contents using soil bulk density values from Taylor et al. (1963) which correspond closely to values obtained by Unger and Pringle (1981).

Differences in runoff between tillage treatments were analyzed with a paired "t" test (SAS, 1986). Cumulative infiltration and soil physical data taken in conjunction with infiltration tests were analyzed using a randomized complete block one-way analysis of variance comparing tillage treatments (SAS, 1990). When depths were included, data for each depth were analyzed separately.

Results and Discussion

Infiltration Tests

Cumulative infiltration on SM sites was 62% greater than on NT sites at the end of 1 h of water application during the initial (dry) run on the fallow after sorghum watershed and 90% greater than on NT sites after 2 h (table 1). However, after 1 day of drying, a second (wet) run showed no significant difference in cumulative infiltration at the end of 0.5 h, which was the time required to attain near terminal infiltration rate. Infiltration rates during the dry runs on the fallow after wheat watershed did not decrease as quickly on NT sites as they did for the fallow after sorghum watershed (figs. 3 and 4), indicating that wheat residues are more effective in maintaining infiltration rates than are sorghum residues. Stover production for the crop preceding the infiltration test periods was 4.5 Mg ha^{-1} for wheat and 6.2 Mg ha^{-1} for sorghum. Infiltration rates on the NT fallow after wheat watershed decreased sharply after 30 mm of rainfall was applied. After 2 h, cumulative infiltration on SM exceeded infiltration on NT sites by 26%. Only one site on the fallow after wheat watershed received a second (wet) application, but infiltration rates and cumulative infiltration were similar to the wet runs for fallow after sorghum. A tendency toward greater cumulative infiltration on NT sites

Table 1. Tillage effects on mean cumulative infiltration into Pullman soil after 1 and 2 h of water application at 48 mm h^{-1} with a rainfall simulator*

Condition	Rainfall Simulator Infiltration Test	Elapsed Time (h)	SM† (mm)	NT† (mm)	ANOV N	ANOV Prob > F
Fallow after sorghum	Dry run	1	42.9	26.5	3	0.012
	Dry run	2	66.4	35.0	3	0.014
	Wet run	0.5	7.0	9.1	2	0.071
Fallow after wheat	Dry run	1	44.0	42.0	2	0.213
	Dry run	2	73.4	58.2	2	0.007
	Wet run	0.5	7.4	10.3	1	‡

* Infiltration measurements were taken in 1990 and 1991, near the end of fallow periods and a few days before crop planting.
† Tillage treatments: SM = Stubblemulch; NT = No-tillage.
‡ For the wet run, rainfall simulator was operated only at one site on each tillage treatment.

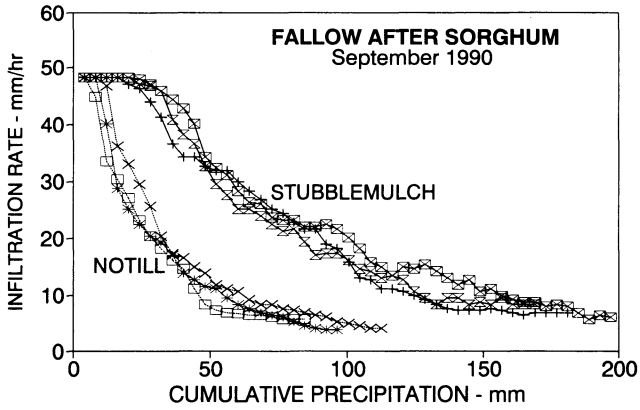

Figure 3–Tillage effects on infiltration rate measured by rainfall simulator during dry runs on fallow after sorghum. Rainfall simulator application rate was 48 mm h^{-1} at three sites on each watershed.

in comparison to SM sites on wet runs indicated a benefit of maintaining residues on the surface.

Some soil parameters showed large measurement differences due to tillage treatment (table 2). Dry aggregate mean weight diameter (MWD) was significantly greater on SM than on NT. This probably results from the mixing of organic material with soil during tillage which potentially increases infiltration rate. Water-stable aggregate MWD, however, was greater on the NT treatment for fallow after sorghum than for SM, but there was no significant difference for fallow after wheat. Since infiltration rates for NT declined more quickly than for SM on fallow after sorghum, we conclude that water stable aggregate size did not control infiltration.

The greater water stable aggregate MWD found on some NT samples may be due to tillage effects on the distribution of organic matter (OM) in the soil profile. Average OM concentration to a 15 cm depth was not affected by 10 years of NT on dryland (table 2), however, the distribution of OM within the sampling profile was affected. With NT, OM concentration, as might be expected, averaged 3 to 4 g kg^{-1} higher near the surface (0 to 2 cm) than in the rest of the sampling profile.

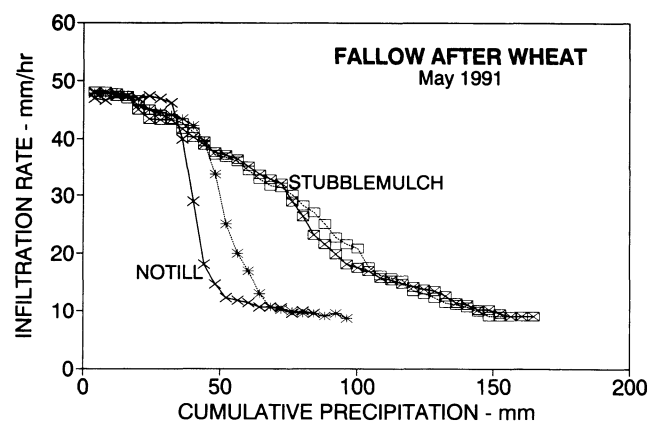

Figure 4–Tillage system effects on infiltration rate measured by rainfall simulator during dry runs on fallow after wheat. Rainfall simulator application rate was 48 mm h^{-1} at two sites on each watershed.

Table 2. Means for soil parameters determined before or after applying simulated rainfall to Pullman clay loam during fallow periods*

Condition	Time of Measurement	Tillage Treat. SM	Tillage Treat. NT	ANOV N	ANOV Prob > F
Dry aggregate size, MWD† (mm)					
Fallow/sorghum	Before dry run	14.76	6.57	4	0.001
Fallow/wheat	Before dry run	7.75	2.56	4	0.001
Water stable aggregate size, MWD (mm)					
Fallow/sorghum	Before dry run	1.24	2.02	4	0.002
Fallow/wheat	Before dry run	0.76	0.66	4	0.29
Organic matter concentration, 0-0.15 m (g kg^{-1})					
Fallow/sorghum	Before dry run	16.3	15.6	4	0.167
Fallow/wheat	Before dry run	15.0	14.2	4	0.226
Soil water content, 0-0.10 m (m^3 m^{-3})					
Fallow/sorghum	Before dry run	0.11	0.17	4	0.13
Fallow/wheat	Before dry run	0.10	0.12	4	0.22
Soil water content, 0-0.91 m (m^3 m^{-3})					
Fallow/sorghum	Before dry run	0.25	0.27	4	0.048
Fallow/wheat	Before dry run	0.27	0.30	4	0.020
Random roughness (mm)					
Fallow/sorghum	Before dry run	15.2	6.3	4	0.001
	After wet run	8.7	6.3	2	0.037
Fallow/wheat	Before dry run	16.7	9.9	4	0.013
	After wet run	12.1	8.8	1	‡
Soil bulk density, 0-0.10 m (Mg m^{-3})					
Fallow/sorghum	Before dry run	0.92	1.21	4	0.005
Fallow/wheat	Before dry run	0.83	1.04	4	0.033
Surface residue cover (%)					
Fallow/sorghum	Before dry run	25.0	56.7	4	0.001
Fallow/wheat	Before dry run	73.1	86.1	4	0.002

* Measurements were taken in September 1990, near the end of fallow after sorghum, and in May 1991, near the end of fallow after wheat.
† Mean weight diameter (MWD).
‡ For the wet run, rainfall simulator was operated only at one site on each tillage treatment.

Soil water contents were low near the surface for both tillage treatments with no significant difference for the 0 to 10 cm depth, although the NT treatment tended toward higher contents (table 2). Deeper in the soil profile, NT had a higher soil water content, but significantly higher soil water contents were below the 0.45 m depth. Thus a higher soil water content on NT probably affects infiltration rate, but not at the beginning of rain.

Surface random roughness and bulk density of the 0 to 10 cm depth were factors most affected by tillage and appear responsible for much of the difference in infiltration between SM and NT treatments (table 2). Differences in bulk density due to tillage treatments were also reflected in soil penetrometer resistance measurements (fig. 5). After large amounts of rainfall or a high intensity storm, the soil surface of both SM and NT treatments becomes smoothed and consolidated or crusted. However, when tillage is performed on SM to control weeds, the soil surface is loosened, soil crusts are destroyed, and porosity, surface roughness, and depressional storage capacity are increased. Thus infiltration rate and cumulative infiltration are increased and runoff is reduced. Since sweep-tillage was

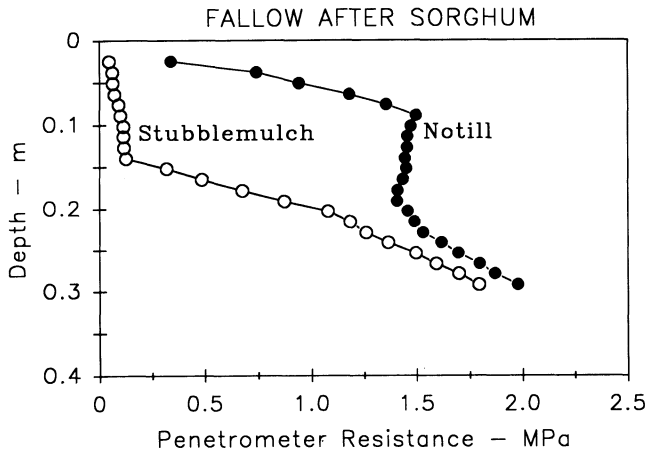

Figure 5–Tillage effects on cone penetrometer resistance measurements taken prior to rainfall simulator tests on fallow after sorghum watersheds, September 1990. Each point is the mean of 18 measurements.

performed four to five times during fallow periods on SM treatments, higher average infiltration rates were maintained on SM than on NT where the surface remained smooth and consolidated after rainstorms.

Yields of dryland crops were excellent throughout the experimental period. Surface coverage with residues exceeded 50% on NT (table 2), however, surface smoothing and soil crusting still occurred because the Pullman clay loam Ap soil horizon (0 to 15 cm) has a high silt content (17% sand, 53% silt, and 30% clay) and is very susceptible to crusting (Unger and Pringle, 1981). Also, possibly in response to a crusted surface and the dry climate, earthworm activity is low, thus macropore influence on infiltration is reduced, at least in comparison to macropore effects reported with NT in more humid areas (Edwards et al., 1988).

Runoff – Growing Season

Runoff was much lower (table 3) during wheat and sorghum phases than during either of the fallow phases because the periods were shorter, crop canopies protected the soil, and growing crops dried the soil. Thus infiltration was enhanced and runoff was reduced. Runoff from growing wheat was much lower than from growing sorghum because most high-intensity storms occurred during May and June near the end of the wheat growing season when the soil profile was depleted of water and cracked, and the wheat provided excellent ground cover. Near the end of crop growing seasons, soil cracks extended as much as 0.5 m deep on both wheat and sorghum. Thus infiltration rates were high and little runoff occurred with either tillage system on maturing crops. Sorghum was planted in June when most severe storms occur, so profile soil water content was high and crop canopy was small, thus producing more runoff.

Growing season runoff from the NT treatment was usually equal to or greater than runoff from the SM treatment for both wheat and sorghum. The only major reversal of that trend was on sorghum in 1990 when the NT field scheduled for sorghum received a one-time mid-June tillage with sweeps to control tumblegrass and pricklypear. Thus, runoff from NT was less from SM because weeds had dried the profile and the soil surface was loosened and roughened by tillage.

Table 3. Precipitation (PPT) and field measured runoff from stubblemulch (SM) and no-tillage (NT) management systems for the four phases of a WSF sequence, 1984-1991

	Wheat			Fallow/Wheat			Sorghum			Fallow/Sorghum		
		Runoff			Runoff			Runoff			Runoff	
Year*	PPT (mm)	SM (mm)	NT (mm)	PPT (mm)	SM (mm)	NT (mm)	PPT (mm)	SM (mm)	NT (mm)	PPT (mm)	SM (mm)	NT (mm)
1984	242	0	0	487	4.3	8.1	245	0.5	0	591	75.9	57.1
1985	218	0	1.3	566	47.5	68.8	357	59.7	57.9	415	26.9	53.1
1986	368	10.9	30.0	554	32.3	65.3	273	0.8	4.1	620	21.3	96.5
1987	266	0	0.5	526	1.5	32.0	350	2.5	8.4	491	32.7	86.4
1988	285	9.9	8.1	509	88.6	93.5	303	19.3	35.3	550	35.0	74.2
1989	134	0	0	413	9.6	37.1	293	15.7	21.8	280	0.3	7.9
1990	246	0	10.2	344	0.3	1.0	226	38.6	14.2	383	1.8	2.8
1991	481	7.1	14.5	613	35.8	38.9	269	1.8	2.0	681	31.3	31.2
AVG	280	3.5	8.1	502	27.5	43.1	290	17.4	18.0	501	28.2	51.1
% of PPT		1.2	2.9		5.4	8.6		6.0	6.2		5.6	10.2

* The year the crop was planted or the fallow period began.

Runoff – Fallow Phases

Most runoff from the WSF system occurred during the two fallow phases (table 3). Runoff was increased during fallow because (1) land in WSF was fallow 64% of the time and (2) the soil usually had a high soil water content during the latter part of fallow periods. Average runoff was nearly equal for the two fallow periods with SM tillage; however, NT resulted in a substantial increase in runoff over SM for both fallow after wheat and fallow after sorghum phases. The largest average increase in runoff due to NT was 81% (22 mm) which occurred on fallow after sorghum because sorghum residues provide less protection to the soil surface than do wheat residues. Factors responsible for increased runoff on NT in comparison to SM are as reported earlier in the infiltration section, namely a smooth consolidated soil surface that seals quickly, and higher soil water content on NT deeper in the soil profile. The smooth, undisturbed surface on NT resulted in more frequent occurrence and larger volumes of runoff from storms than were measured on SM. Measurable runoff (≥ 0.12 mm) occurred on an average of 47.1 day/fallow period from NT watersheds, versus 27.8 day/fallow period from SM watersheds. The 16 fallow periods averaged 347 days each.

Runoff – Three-year WSF Sequence

Field measured runoff, expressed as percentage of rainfall, ranged from a minimum of 1.2% on SM wheat to a maximum of 10.2% for NT fallow after sorghum (table 3). Total runoff for the 3-year WSF sequence averaged 77 mm from SM (25.5 mm year^{-1}) and 120 mm (40 mm year^{-1}) from NT, a 56% increase in runoff from NT over SM. Paired "t" test analysis of all runoff events showed that runoff increases on NT were highly significant. We conclude that NT management on Pullman clay loam results in increased runoff in comparison to SM management as evidenced by: (1) the consistency of the increase in runoff on NT from storm to storm and year to year, (2) visual and video observations of watershed surfaces during runoff events, (3) the greater number of runoff events occurring on NT, and (4) results of rainfall simulator infiltration tests.

Water Conservation

Conservation of water during fallow is extremely important in dryland crop production. For example, every millimeter of plant available soil water stored at planting above the threshold value of 50 mm will produce an average of 17 kg ha^{-1} of sorghum (Jones and Johnson, 1983). Average total soil plant available water (0 to 1.8 m depth) was 33 mm greater with NT than with SM at sorghum planting (end of fallow after wheat) (fig. 6), and 18 mm greater with NT at wheat planting (end of fallow after sorghum) (fig. 7). Although more runoff occurred on NT than on SM, significantly more soil water was stored with NT, indicating greatly reduced evaporation with NT in comparison to SM management. The difference in evaporation between NT and SM can probably be attributed to a combination of the following: (1) reduced porosity and increased diffusion resistance to vapor flow due to consolidation and crusting of the NT surface (Jalota and Prihar, 1990); (2) reduced wind speed and vapor movement due to more standing surface residues with NT (Smika and Unger, 1986); (3) increased albedo and reduced temperature at the soil surface with NT (Smika, 1983; Steiner, 1994); and (4) increased evaporation on SM due to tillage (Smika and Unger, 1986).

We found that NT management on dryland in a harsh semiarid climate with limited crop residue production resulted in improved water conservation during fallow as evidenced by substantially higher soil water contents at planting of sorghum and wheat in a WSF system. Wheat residues were more effective in reducing evaporation than were sorghum residues.

The large difference in soil water contents between planting and harvest for the 1.5- to 1.8-m soil depth increment (figs. 6 and 7) indicated some movement of soil water occurring to depths below the normal rooting depth for wheat and sorghum, particularly with NT management. A one-time sampling of soil water and nitrate content on two watersheds in 1990 indicated that considerable leaching was occurring below the root zone with NT management (Eck and Jones, 1992). With increased leaching potential as a result of reduced evaporation and improved water conservation with NT, it appears that a more intensive dryland cropping system with less fallow would be desirable to maximize water use efficiency and minimize environmental impact due to leaching with NT management.

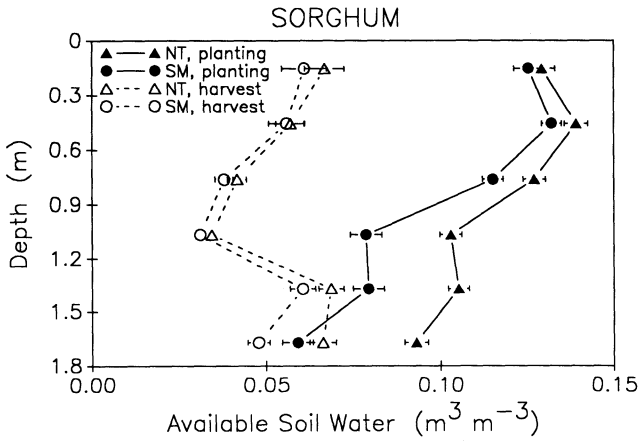

Figure 6–Tillage effects on 1986 to 1992 average plant available (0.03 to 1.5 mPa potential) soil water content at sorghum planting (end of fallow after wheat) and sorghum harvest (beginning of fallow after sorghum). Error bars = standard error of the mean. Each data point is an average of 84 gravimetric samples (12 sites × 7 years).

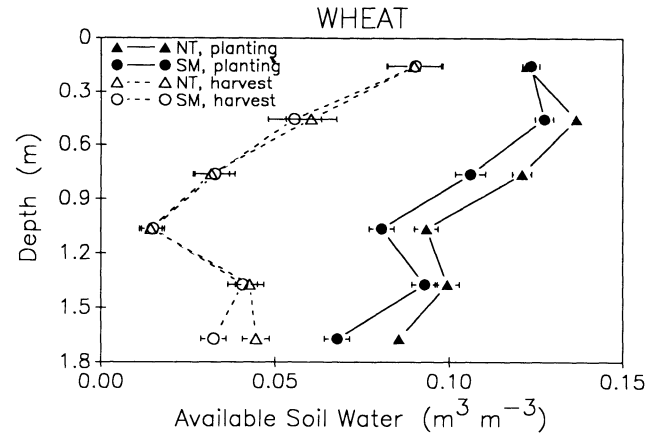

Figure 7–Tillage effects on 1987 to 1992 average plant available (0.03 to 1.5 mPa potential) soil water content at wheat planting (end of fallow after sorghum) and wheat harvest (beginning of fallow after wheat). Error bars = standard error of the mean. Each data point is an average of 72 gravimetric samples (12 sites × 6 years).

Conclusions

Storm runoff measured from no-tilled graded-terraced watersheds cropped in a dryland WSF sequence averaged 56% greater than runoff measured from SM-tilled watersheds on a slowly permeable soil. Infiltration tests with a portable rainfall simulator showed that infiltration rates declined more rapidly with NT management than with SM management and that total infiltration was less on NT because of soil crusting. Infiltration was greater on SM because tillage destroyed the surface crust, decreased bulk density, and increased surface roughness and depression storage capacity.

Dryland crops did not produce sufficient residues to prevent soil crusting with NT management, however, overall water conservation was improved with NT because soil water evaporation was reduced in comparison to evaporation from SM. Total root-zone plant-available soil water contents were 10 to 18% greater at crop planting with NT than with SM management, even though NT had less total infiltration and greater surface runoff. No-tillage is an improved management system for water conservation for dryland in comparison to SM if surface runoff is controlled.

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