Accepted for publication 10 November 2011. Published 23 December 2011.

One-pass Tillage for Summer Fallow Under Arid Summer Conditions

Stewart B. Wuest, Soil Scientist, USDA-ARS, Columbia Plateau Conservation Research Center, PO Box 370, Pendleton, OR, 97801; and **Mary K. Corp,** Professor, Oregon State University, 2411 NW Carden, Umatilla Hall, PO Box 100, Pendleton, OR 97801

Corresponding author: Stewart B. Wuest. stewart.wuest@ars.usda.gov

Wuest, S. B., and Corp, M. K. 2011. One-pass tillage for summer fallow under arid summer conditions. Online. Crop Management doi:10.1094/CM-2011-1223-03-RS.

Abstract

Millions of acres of cropland with as low as 6 inches annual precipitation are used for production of winter wheat (*Triticum aestivum* L.) in the Pacific Northwest of the USA. Despite soil conservation advances, soil erosion continues to be a problem. This on-farm study analyzed seed-zone soil water under farmer-implemented fallow tillage practices to find out if very low-disturbance systems are possible. A low-disturbance, wide-blade undercutter sweep treatment was similar or superior to the farmer's more intensive conventional tillage system. A subsequent test at four paired no-till-conventionally-tilled summer-fallow sites demonstrated that a single pass of an undercutter sweep in the no-till field could preserve seed-zone moisture comparable to the more intensive multiple-pass conventional tillage. Despite conventional wisdom, summer-fallow soil mulches do not need to be finely pulverized or repeatedly tilled to be effective.

Introduction

Winter wheat in rotation with tilled summer fallow continues to be the most important production system in the driest regions of the inland Pacific Northwest (5). Similar to other areas of the world with a Mediterranean climate, the cool, wet winters and warm, dry summers make production of cool-season cereals more profitable than summer annuals in the absence of irrigation. Much of the Pacific Northwest has deep silt loam soil capable of storing enough winter precipitation to bring fall-seeded winter wheat to acceptable yields at harvest even in years without substantial spring rainfall.

A key feature of the winter wheat-fallow system is establishment of the crop before temperatures drop in the fall (1,4,7). In higher precipitation zones of the Pacific Northwest, sufficient rain can be expected in October or November when there are still sufficient growing degree days for the wheat plants to establish crowns and tillers and become freeze tolerant. In the lowest rainfall areas, however, fall precipitation may not be sufficient to germinate and establish the crop before the onset of freezing weather (6).

Summers in the Pacific Northwest are hot and dry, so unlike some other wheat producing areas of the United States and Canada, rainfall rarely has a substantial effect on the continuous progression of evaporation starting in June or July and lasting through September and sometimes October (3,9). Early in the history of the region it was found that a tilled soil mulch of three to six inches would preserve high water content levels near the surface throughout the hot, dry summer and on into September or beyond (5). Seeding equipment was developed to seed into the moist soil below the dry soil mulch to establish winter wheat without waiting for fall rains. This system is still used today because it has proven reliable and profitable. The major undesirable feature of the tilled summer fallow system is its vulnerability to wind and water erosion.

Over recent decades there has been gradual progress in reducing tillage and retaining crop residues on the soil surface for soil conservation. Lacking a good understanding of the physics of how a soil mulch reduces evaporation, changes have been in small increments, with the prevailing belief that finely pulverized soil favored in early practices produces the best result. The studies outlined here are part of an effort to measure whether coarse, cloddy mulches might be effective at reducing evaporation, paving the way for a better understanding of summer fallow options.

Analyzing Seed-Zone Soil Water Under Fallow Tillage

Our first experiment analyzed soil water profiles from an on-farm test near Helix, OR, where the farmer's current summer fallow tillage practice was compared to a reduced-tillage practice and to no-till. The average precipitation during the four years of the study was 14 inches. There were four summer-fallow treatments. All plots were sprayed with non-selective herbicide in April, followed by the treatments:

(i) *No-till*. Non-selective herbicide sprayed as necessary to control weeds.

(ii) *Conventional tillage*. Plots disked in April, and cultivated in May with a straight-point chisel/narrow-blade sweep combination. Rodweeded if necessary to control weeds in June, and again in July at about 4 to 5-inch depth.

(iii) *Sweep, coil pack*. Five-foot-wide V-blade sweeps used to undercut plots at about 4-inch depth in May, with attached coil-type soil packer. The packer was used in 2005 and 2006 because the farmer felt that the undercutting operation left the soil too loose and deep to seed into. Non-selective herbicide used to control weeds during remainder of fallow.

(iv) *Sweep, rod*. In 2007 and 2008, the packer was not used and the herbicide was replaced by a rod-weeding in July at about 4-inch depth.

The treatments were replicated in four randomized blocks. Surface soil samples were taken in late August of each year to 12-inch depth. (The first increment was 0 to 3 cm, then 2-cm increments down to 15, and 5-cm increments down to 30 cm.) Because different tillage treatments result in different surface bulk density, all data were corrected to equivalent mass-depths for analysis (8). We used a mixed model with years considered as incomplete blocks (2), to accommodate the change in sweep treatment in years 3 and 4.

Feasibility of Very Low-Disturbance Systems

Figure 1 shows the mean soil water content from 4 to 11-inch depth. As expected, the surface of the no-till fallow dried more over the summer than the tilled treatments. The single pass of the sweep and coil packer resulted in a very similar water profile to the more intensive conventional tillage. When the sweep was not packed, but followed later by a rodweeding, it produced slightly better soil water than any of the other treatments. Soil samples taken before planting in 12-inch increments to five feet all four years indicated that the only difference between treatments in water gained over the fallow period (from harvest to planting) was reduced moisture in no-till in the top foot ($P > F = 0.0012$). This was the same reduced soil water seen in the seed-zone samples of Figure 1.

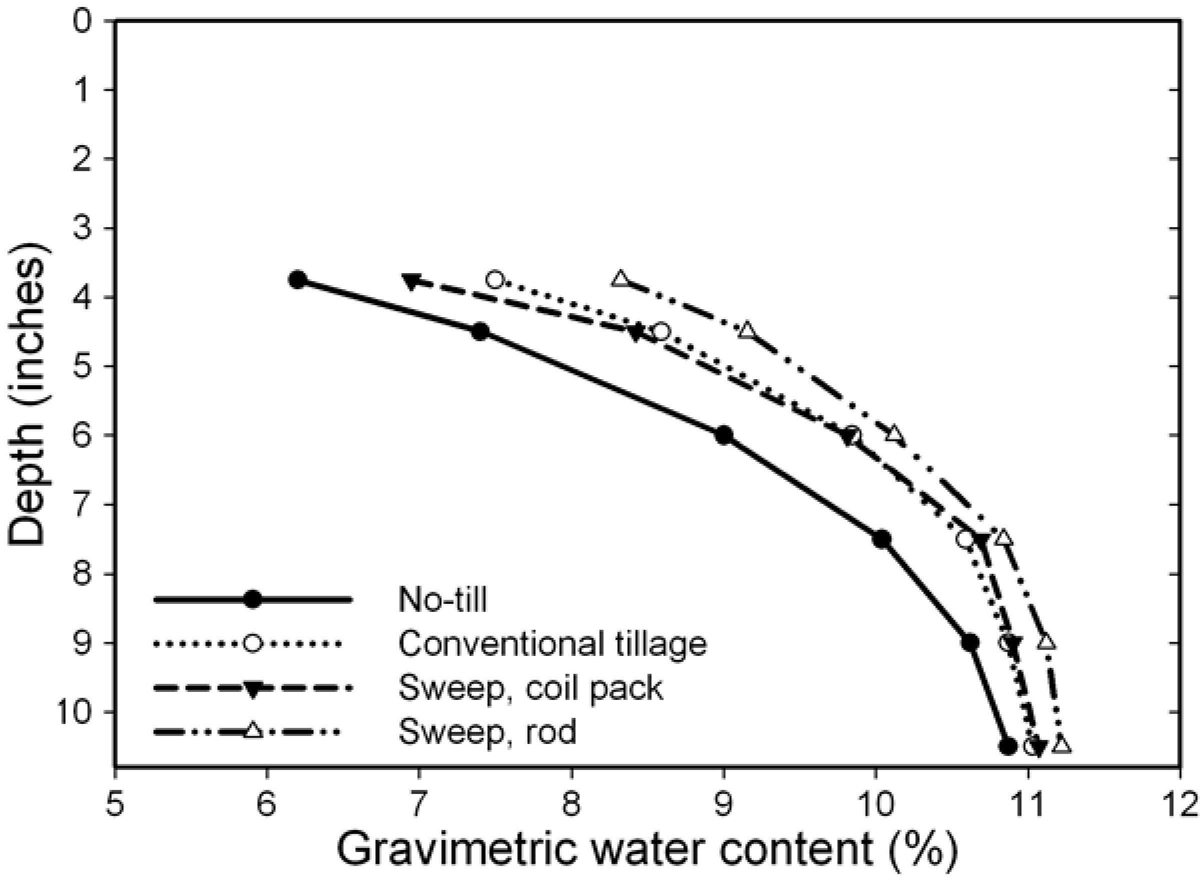

Fig. 1. Water content profiles produced by four summer fallow management treatments. The samples were taken in the fall before planting. No-till and the other treatments are significantly different at 4- to 8-inch depths ($P > F = 0.05$). Sweep rod has greater moisture than sweep coil pack at 4 and 5 inches ($P > F = 0.05$).

A second study was performed in 2010 at four sites near Moro, OR. We chose fields in no-till fallow that were adjacent to fields under tilled fallow and where we could take soil samples "across the fence" in four places with similar landscape aspects and soil conditions. The tilled fallow fields were tilled at different times and with different methods according to the normal practices of the four farmers, but all started earlier than June and used several tillage passes. After spring rains stopped, which was about 1 July in 2010, we tilled four small areas in each no-till field using an undercutter sweep similar to that used in the first study. Figures 2 and 3 show soil conditions typical of the conventional tillage fields and the single-pass sweep tillage plots. On 7 September and again on 29 September we sampled the seed zone at all sites and replicate treatments. Figure 4 shows the 7 September results. At site 1 it appears that the conventional tillage was performed so early that it reduced infiltration of the later spring rains. At the other three sites the single sweep tillage gave results that were similar to the more intensive conventional tillage.

Fig. 2. Typical soil condition produced by conventional summer fallow tillage.

Fig. 3. Soil condition produced by one pass of a low-disturbance undercutter sweep.

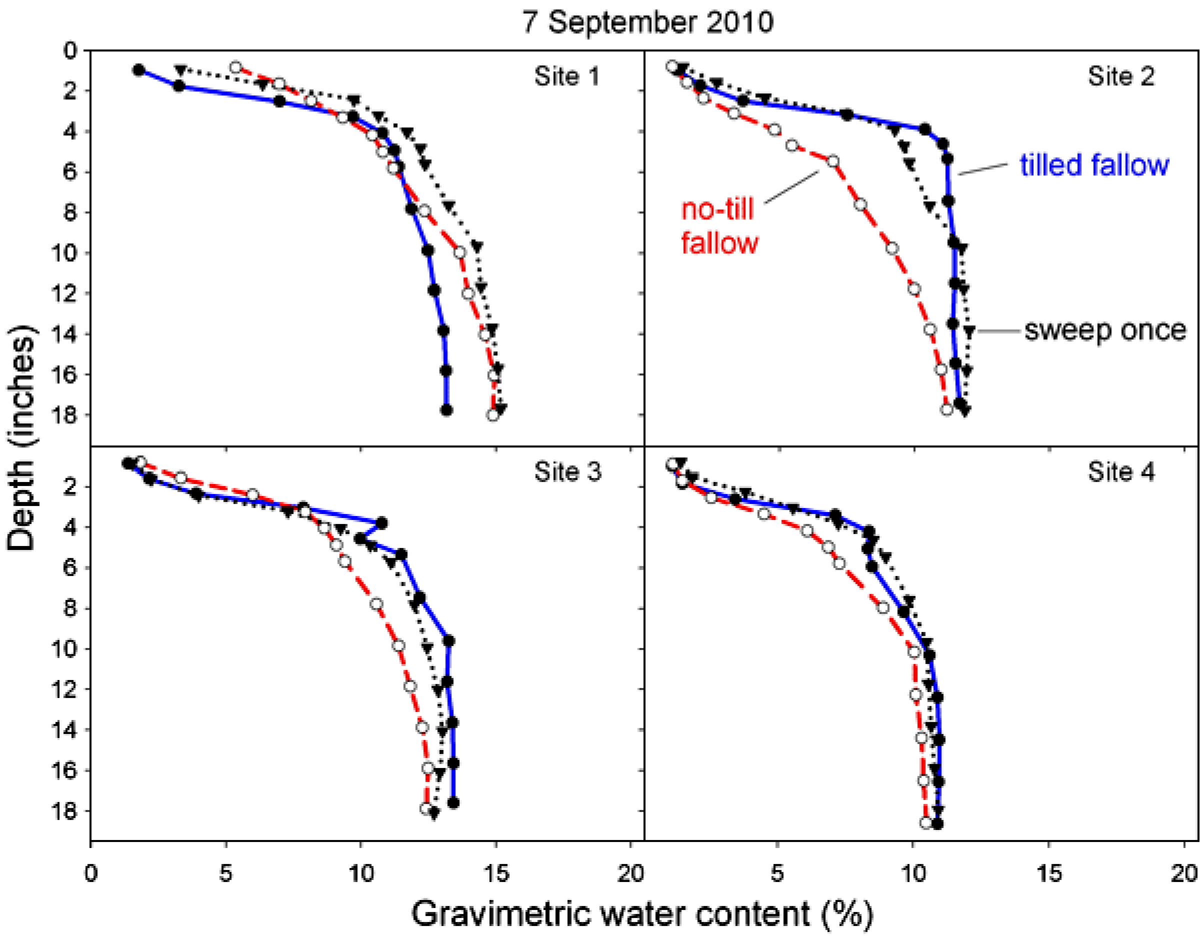

Fig. 4. Water content profiles produced by conventional multiple-pass tillage, no-till, and a single pass of a low-disturbance undercutter sweep at four sites. Over all sites, no-till has significantly less moisture at 4 to 6-inch depths (*P* > F = 0.01).

This is an important finding because it indicates that, despite the progress in tillage reductions over the past few decades, we can develop systems that are even more effective at erosion protection while preserving soil water over summer. Conventional thought has been that it takes several passes to create an effective soil mulch, but our data shows this is not true. Soil does not need to be extensively tilled into fine particles to provide a barrier to evaporation. This is an important concept for the development of more sustainable systems for summer fallow. The cloddy high residue surface left by a single pass of an undercutter (Fig. 3) is very resistant to wind and water erosion. The reduction in soil inversion also allows for stratification of organic matter near the soil surface where it increases soil aggregation, reducing crusting and improving water infiltration (10). The 29 September sampling shown in Figure 5 was taken after some early fall rain. The sweep treatment in the second experiment tended to absorb water more similarly to the no-till, and better than the conventional tilled fallow. The same response to first fall rains was observed in the first study (*data not shown*).

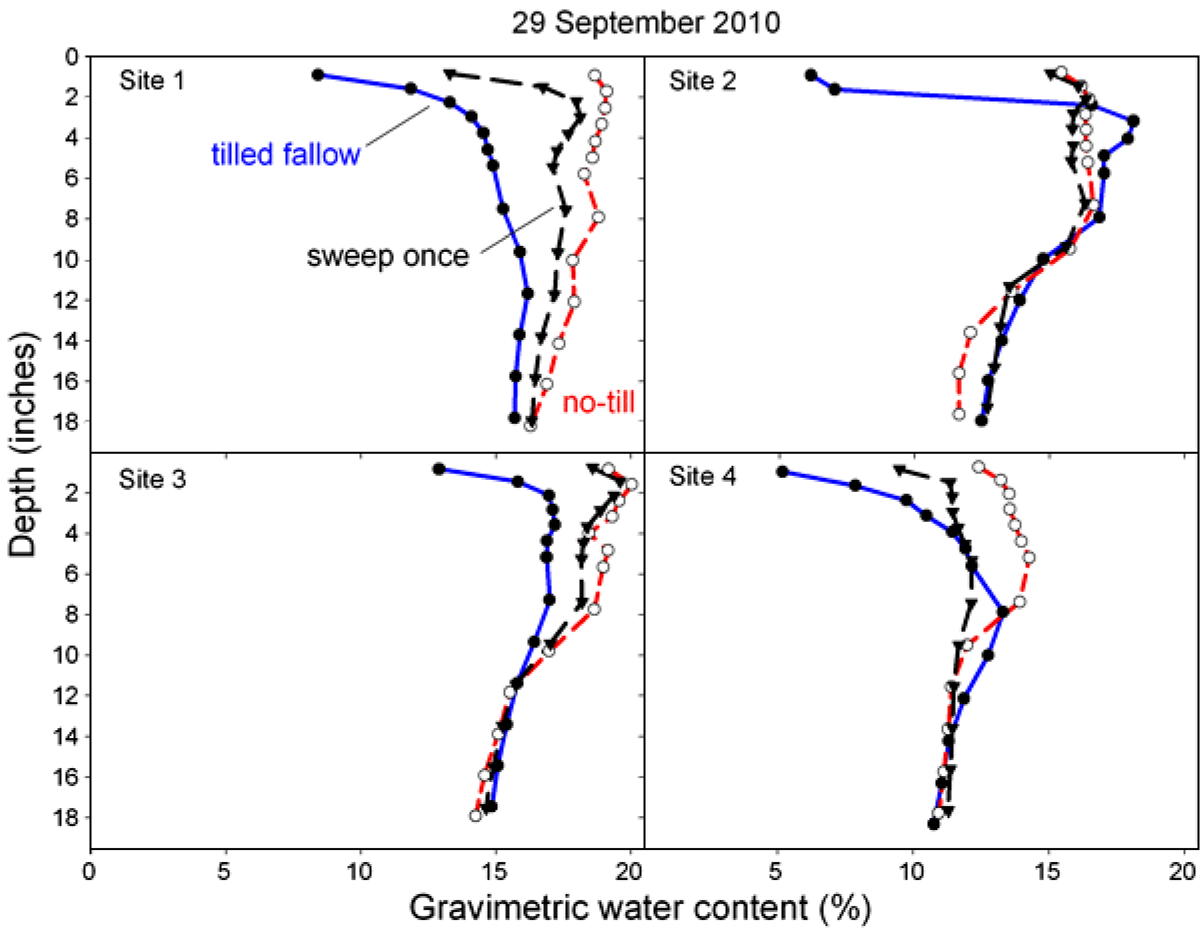

Fig. 5. Water content profiles at same sites and treatments as Figure 4, after some early precipitation events. Such rainfall is unusual at this location, but show superior retention by no-till and low-disturbance tillage.

In the first two years of the first study, coil packing recompressed the soil mulch created by the sweep, and was done because the farmer was uncertain how to successfully seed into the conditions created by the sweep. From a soil physics perspective, the soil mulch might be expected to perform better without the packing operation because it contains more air and increases the distance between the surface and stored soil water. In the sweep-rod treatment the soil mulch was not packed after sweeping, and it appears in Figure 1 that it outperformed the conventional tillage treatment. Our data indicates that sweep-rod or sweep without packing may be superior to conventional tillage in preserving seed zone water.

Both seed-zone and deep soil samples indicate that the no-till treatments lose more water during the fallow period. If it is true that less water is stored under no-till, this may have a significant bearing on the development of future wheat-fallow systems in areas with marginal rainfall where successful establishment of winter wheat into stored soil water is key to high grain yield potential. On the other hand, where no-till is practiced in the Pacific Northwest over a number of years, surface runoff may be reduced and better long term water storage might be possible compared to tilled soil, especially on sloping land under higher precipitation (10).

Where tilled fallow is required for timely seeding, however, erosion resistant minimal tillage systems can be developed which perform very well in terms of evaporation control. Herbicides are now routinely used to control weeds during the spring so the tillage operation can be delayed until evaporation becomes significant. Weeds germinating after tillage need to be controlled either by herbicides or rodweeding. The extremely cloddy, high-residue surface does present a challenge for seeding operations, and drill modification may be needed.

Conclusions

The data indicate that a low-disturbance wide-sweep tillage was similar in performance to the farmer's more intensive conventional tillage practice. When the sweep was used without being followed by a rolling packer, it appears to have outperformed the conventional practice. A follow-up study at four different sites confirmed that a coarse soil mulch left by a single tillage pass can perform similar to more intensive tillage. This supports further development of low-disturbance systems for improving soil conservation while maintaining agronomic performance.

Acknowledgments

The authors thank Jeff and Bob Newtson of Helix, OR, and Tom McCoy, Doug Bish, Dan Richelderfer, Nate Smith, Ray Smith, Darryl Hart, Bryan Cranston, Josh Hilderbrand, Terry Kaseberg, Bryan Peters, L. P. McClennan, Bob Olsen, and Bryce Coelsch of Sherman Co., OR, for excellent cooperation in the course of this experiment.

Literature Cited

1. Donaldson, E., Schillinger, W. F., and Dofing, S. M. 2001. Straw production and grain yield relationships in winter wheat. Crop Sci. 41:100-106.
2. Littell, R. C., Milliken, G. A., Stroup, W. W., and Wolfinger, R. D. 1996. SAS system for mixed models. SAS Institute Inc., Cary, NC.
3. Papendick, R. I., Lindstrom, M. J., and Cochran, V. L. 1973. Soil mulch effects on seedbed temperature and water during fallow in eastern Washington. Soil Sci. Soc. Am. Proc. 37:307-314.
4. Russelle, M. P., and Bolton, F. E. 1980. Soil temperature effects on winter wheat and winter barley emergence in the field. Agron. J. 72:823-827.
5. Schillinger, W. F., and Papendick, R. I. 2008. Then and now: 125 years of dryland wheat farming in the Inland Pacific Northwest. Agron. J. 100:S166-S182. doi:10.2134/agronj2007.0027c.
6. Schillinger, W. F., and Young, D. L. 2004. Cropping systems research in the world's driest rainfed wheat region. Agron. J. 96:1182-1187.
7. Smiley, R. W. 2009. Water and temperature parameters associated with winter wheat diseases caused by soil borne pathogens. Plant Dis. 93:73-80.
8. Wuest, S. B. 2009. Correction of bulk density and sampling method biases using soil mass per unit area. Soil Sci. Soc. Am. J. 73:312-316.
9. Wuest, S. B., and Schillinger, W. F. 2011. Evaporation from high residue no-till versus tilled fallow in a dry summer climate. Soil Sci. Soc. Am. J. 75:1512-1518. doi:10.2136/sssaj2010.0368.
10. Wuest, S. B., Williams, J. D., and Gollany, H. T. 2006. Tillage and perennial grass effects on ponded infiltration for seven semi-arid loess soils. J. Soil Water Conserv. 61:218-223.