Paper No. 96-2095
An ASAE Meeting Presentation

TILLING SEEDED WHEAT FIELDS FOR EROSION CONTROL

by

D.E. Wilkins
Agricultural Engineer
USDA-ARS Pacific West Area
Pendleton, OR

J.F. Zuzel
Retired Hydrologist
USDA-ARS Pacific West Area
Pendleton, OR

J.D. Williams
Hydrologist
USDA-ARS Pacific West Area
Pendleton, OR

**Written for Presentation at the
1996 ASAE Annual International Meeting
Sponsored by ASAE**

**Phoenix Civic Plaza
Phoenix, Arizona
July 17, 1996**

Summary:

Contour ripping frozen soil in fields seeded to winter wheat enhanced infiltration, reduced soil loss and did not influence grain yield.

Keywords:

Erosion, Frozen Soil, Runoff, Tillage, Wheat

Tilling Seeded Wheat Fields For Erosion Control

D.E. Wilkins, J.F. Zuzel, and J.D. Williams

USDA-ARS, Pendleton, OR

INTRODUCTION

Frozen soil, steep slopes, and low infiltration in fields with little residue cover seeded to winter wheat (*Triticum aestivum* L.) leads to severe soil erosion in the Nez Perce Palouse Prairie and Columbia Plateau Major Land Resource Areas. Average annual soil losses range from 5 to 50 tonnes per ha (McCool et al., 1976). Zuzel et al. (1982) showed that 86 percent of the soil erosion on winter wheat in north-central Oregon was caused by snowmelt, rainfall, or a combination of both on thawing soil.

Erosion control practices in this region include conservation tillage, crop residue management, strip cropping, green cover (crop cover), contouring, grass waterways and terracing. Combining these into best management practices often is not sufficient to control erosion during runoff events associated with frozen soil (McCool, 1990). Additional management practices are needed to combat soil erosion events associated with frozen soil. This is especially true when the amount of crop residue is limited because of drought, pests or harvest fire.

A management technique that has potential for erosion control for frozen soil runoff events is to form tillage channels. These channels extend through the frozen soil and provide a means for intercepting runoff and storing it below the frost layer. Slot mulching (Saxton et al., 1981) and contour ripping (Pikul et al., 1996, Schillinger and Wilkins, 1996) are practices that have been shown to increase water infiltration and water storage when soil is frozen.

Slot mulching consists of making tillage slots 5 to 10 cm wide and 20 to 25 cm deep and compacting crop residue into the slots prior to seeding. Crop residue in excess of that needed for erosion control can be managed by placing it in the tillage slots. For this practice to be successful, the slots need to remain open to the surface. This restricts subsequent tillage and seeding operations.

Pikul et al. (1996) and Schillinger and Wilkins (1996) found that contour ripping in the fall prior to formation of frozen soil reduced runoff. Pikul et al. (1996) created tillage channels with a single chisel or parabolic subsoiling shank operated 20 to 30 cm deep. When soil was frozen, infiltration was increased from 1 to 11 mm/hr by contour ripping. Schillinger and Wilkins (1996) ripped 25 to 60 cm in the late fall and found that infiltration was significantly increased to a depth of 2 m and as far as 1 m down slope.

Wilkins et al. (1991) contour ripped in seeded wheat fields when the soil was frozen 5 to 10 cm deep. Tillage channels were formed with a narrow shank followed by a rotary subsoiler spider. Infiltration was significantly higher in plots with a tillage channel compared to no tillage. Although frozen soil tillage uprooted and destroyed wheat plants, grain yield was not reduced.

The number of natural soil erosion events was very limited and soil was tilled in a non-frozen state in the studies by Schillinger and Wilkins (1996), and Pikul et al. (1996). There is a need to quantify the reduction in soil loss and runoff due to contour ripping. The objective of this research was to evaluate soil erosion control and infiltration benefits of forming tillage channels in frozen soil.

METHODS AND MATERIALS

Tests were conducted near Pendleton, Oregon during the winters of 1993 and 1994 in winter wheat fields that were seeded with a John Deere HZ deep furrow drill on September 29, 1992 and October 14, 1993. Furrows were oriented parallel with the slope that ranged from 9 to 11 percent and 12 to 14 percent, respectively in 1992 and 1993. The soil was Walla Walla silt loam (coarse-silty, mixed, mesic Typic Haploxerolls) that was well drained and deep (1.5 m to basalt).

Three frozen soil tillage treatments were randomized in a Latin Square design. Treatments included no-tillage (NT), tilling with a shank (S) and tilling with a shank plus a rotary subsoiler spider (SR). The tillage tool was designed to create a channel in frozen soil with minimum soil disturbance (Wilkins et al., 1991). The shank was 56 cm long and 2 cm wide. One treatment used a spider wheel from a Calkins model SR-3-00 rotary subsoiler that followed directly behind the shank to make small reservoirs. These reservoirs were intended to intercept runoff and facilitate in moving water into the tillage channels. Soil was tilled on January 11, 1993 and February 7, 1994 to a depth of 25 to 30 cm in soil that was frozen 5 to 8 cm and 13 to 15 cm deep, respectively in 1993 and 1994.

Simulated precipitation was applied to two replications of each treatment on February 18 and 19 in 1993 and February 10, 1994. Runoff was simulated with four flat fan spray nozzles mounted on a frame and placed 1 m up slope from the tillage channel with each nozzle directly over a furrow (fig. 1). These nozzles were calibrated and operated to simulate runoff from a storm intensity of 2.5 mm/h on an area four rows wide (1.6 m) by 23 m long. Supply water temperature was 5 C in 1993 and 1 C in 1994. Runoff was collected 1 m down slope from the tillage channel, and measured and sampled for sediment concentration every 5 minutes.

The impact of frozen soil tillage on crop production was evaluated by measuring grain yield. Samples were taken by hand harvesting plants from 1.5 m^2. The harvest area in each plot was 0.6 by 2.5 m. The 0.6 m dimension was parallel to the tillage channel and the 2.5 m dimension was centered over the tillage channel and extended across tracks made by the tractor pulling the tillage tool. In 1993, harvest samples were taken from an adjacent companion experiment that included the same tillage treatments in a randomized complete block design with 4 replications.

RESULTS AND DISCUSSION

The proportion of applied water that infiltrated non-tilled soil in 30 minutes was about the same both years (45 and 40 percent respectively in 1993 and 1994) but the percentage of applied water that infiltrated tilled soil was about 40 percent greater in 1994 as compared to 1993. (85 percent in 1994 and 60 percent in 1993) (fig. 2). Figures 3 and 4 show the mean cumulative infiltration in 1993 and 1994. Frozen soil tillage increased infiltration both years but the magnitude of effect was much greater in 1994.

The infiltration differences between 1993 and 1994 in the tilled plots were probably due to the tillage channels silting in between the time of tillage and runoff tests. Figure 5 shows the 5 cm soil temperature and precipitation for the period between tillage and runoff tests. In 1993, there was 25 cm of snow on the ground at the time of tillage and an additional 40 mm of precipitation, mostly in the form of snow, accumulated prior to the runoff tests. A natural runoff event initiated by melting snow and rain that occurred between tillage and simulated runoff tests in 1993 moved sediment into the tillage channel. This sediment in the channel reduced the efficiency of the channel to conduct water into soil below the frozen layer. Schillinger and Wilkins (1996) found that the effectiveness of contour ripping seeded wheat fields for erosion control prior to freezing decreased with each runoff event. In 1994, runoff tests were conducted three days after tillage and there were no natural runoff events between tillage and runoff tests.

There was no advantage for tilling with a shank plus rotary subsoiler for erosion control in 1993. Sediment delivery was similar for NT and SR plots (Fig. 6) but tilling with only a shank reduced soil loss by 50 percent during the first 30 minutes. It is possible that the small reservoirs created by the rotary subsoiler spider aided in sealing the tillage channel during the natural runoff event after tillage and prior to simulated runoff tests. In 1994, there was almost no sediment loss during the first 30 minutes. Both frozen soil tillage treatments, S and SR conserved soil similarly during the first 50 minutes of runoff in 1994.

These results show that frozen soil tillage can enhance infiltration and reduce sediment loss for runoff events associated with frozen soil. Pikul et al (1992) indicated that the 20 year return interval of rain on snow when the soil is frozen is 6 mm/hr with a storm intensity of 3 h or a total of 18 mm of precipitation. Assuming that each meter of tillage channel (including 1 m either side of the channel) would infiltrate 1 mm the first half hour (fig. 4) and 1 mm/h for each additional hour (fig. 3) of water from a 23 m length of slope, in 3 hours a total of 3.5 mm of precipitation would infiltrated into one tillage channel. To accommodate the 18 mm of precipitation 5 channels per 23 m or one tillage channel every 4.6 m would be required. This does not account for infiltration 1 m beyond the tillage channel in the non-tilled frozen soil. Figure 3 shows that after 30 minutes there was some infiltration in the non-tilled plots (positive slope of cumulative infiltration curve). The infiltration rate into frozen soil is primarily determined by soil water content at the time of freezing (Kane, 1980). Zuzel and Pikul, 1987) showed that air-filled macropores in frozen soil can provide important water flow paths. The assumption that the tillage channel will continue to infiltrate at 1mm/h (steady state condition) after 30 minutes is an extrapolation of the data. Wilkins et al. (1994) found in other tests in Walla Walla soil that infiltration in the tillage channel was 3 mm/h after 60 minutes. In 1993, the infiltration rate stabilized at 0.7 mm/h (slope of cumulative infiltration curve fig. 3) but at the end of the 30 minutes in 1994 the infiltration rate was 1.2 mm/h.

Frozen soil tillage increased infiltration and potentially provided more water for plant growth but in the tillage process wheat plants are uprooted and damaged. Grain yield measurements were taken to assess the impact of tillage on yield. Frozen soil tillage for enhanced water infiltration did not significantly influence grain yield (Table 1). This is consistent with previous studies for contour ripping in seeded wheat fields for water conservation (Wilkins and Zuzel, 1994, Schillinger and Wilkins, 1996). Plant injury due to tillage was probably offset by increased stored soil water by infiltration through the tillage channel.

Table 1. Effect of frozen soil tillage on winter wheat yield.

Tillage	1993	1994
	---------------- kg/ha	---------------
None	5420 a*	5370 a
Shank	5390 a	5270 a
Shank + Subsoiler	5340 a	5400 a

* Values followed by the same letter do not differ significantly (0.05).

CONCLUSIONS

Forming contour tillage channels in seeded wheat fields with 5 to 15 cm of frozen soil, enhanced water infiltration, reduced soil erosion and did not reduce yield. The effectiveness of the tillage channel was diminished after a single runoff event. This technique has potential for erosion control in the Inland Pacific Northwest dryland winter wheat farming region where rain on snow and melting snow occur on frozen soil.

REFERENCES

Kane, D. L. 1980. Snowmelt infiltration into seasonally frozen soils. Cold Regions Sci. and Tech. 3:153-161.

McCool, D. K. 1990. Crop management effects on runoff and soil loss from thawing soil. p 171-176. *In* K. R. Cooley (ed.) Frozen soil impacts on agricultural, range, and forest lands. Proc,. International Symposium. Spokane, WA. 21-22 Mar. 1990. CRREL Special Report 90-1. US Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, Hanover, NH.

McCool, D. K., R. I. Papendick and F. L. Brooks. 1976. The universal soil loss equation as adapted to the Pacific Northwest. *In* Proc., Third Federal Interagency Sedimentation Conf. U.S. Geol. Sur., Denver, CO. pp. 135-147.

Pikul, J. L., Jr., D.E. Wilkins, J. K. Aase, and J .F. Zuzel,. 1996. Contour ripping: A tillage strategy to improve water infiltration into frozen soil. J. Soil and Water Conserv. 51(1):76-83.

Pikul, J. L., Jr., J. F. Zuzel, and D. E. Wilkins. 1992. Infiltration into frozen soil as affected by ripping. Trans. Amer. Soc. Agric. Engr. 35(1):83-90.

Saxton, K. E., D. K. McCool and R. I. Papendick. 1981. Slot mulch for runoff and erosion control. J. Soil and Water Conserv. 36:44-47

Schillinger, W.F. and D.E. Wilkins. 1996. Deep ripping seeded wheat fields to improve water infiltration and reduce soil loss. J. Soil and Water Conserv. (in press).

Wilkins, D. E., J. L. Pikul, Jr., J. F. Zuzel and R. W. Smiley. 1991. Tillage tool for enhancing water infiltration through frozen soil. p 393-398. *In* T. J. Gish, and A. Shirmohammadi (ed.) Preferential Flow. Proc. National Symposium. Chicago, IL. 16-17 Dec. 1991. Amer. Soc. Agric. Engr., St. Joseph, MI.

Wilkins, D. E., and J. F. Zuzel. 1994. Tillage to enhance water infiltration through frozen soil. p 459-464. *In* H. E. Jensen, P. Schjonning, S. A. Mikkelsen, and K. M. Madsen (eds.) Soil Tillage for Crop Production and Protection of the Environment. Proc. International Soil Tillage Research Organization Conference. Aalborg, Denmark. 24-29 July 1994.

Zuzel, J.F., R.R. Allmaras, and R.N. Greenwalt. 1982. Runoff and soil erosion on frozen soil in northeastern Oregon. J. Soil and Water Conserv. 37(6):351-354.

Zuzel, J.F. and J.L. Pikul, Jr. 1987. Infiltration into a seasonally frozen agricultural soil. J. Soil Water Cons. 42:447-450

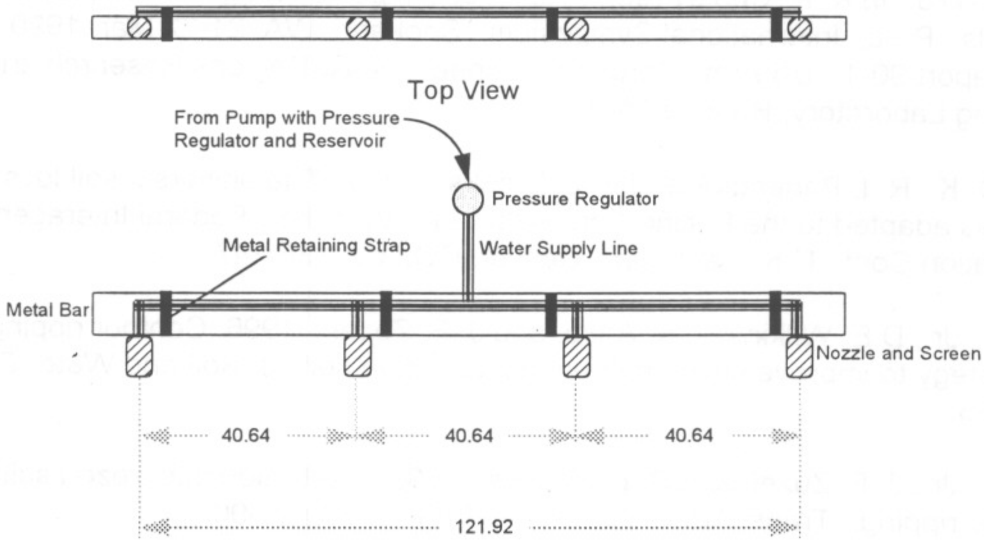

Figure 1 Schematic of the apparatus used to simulate upslope runoff.

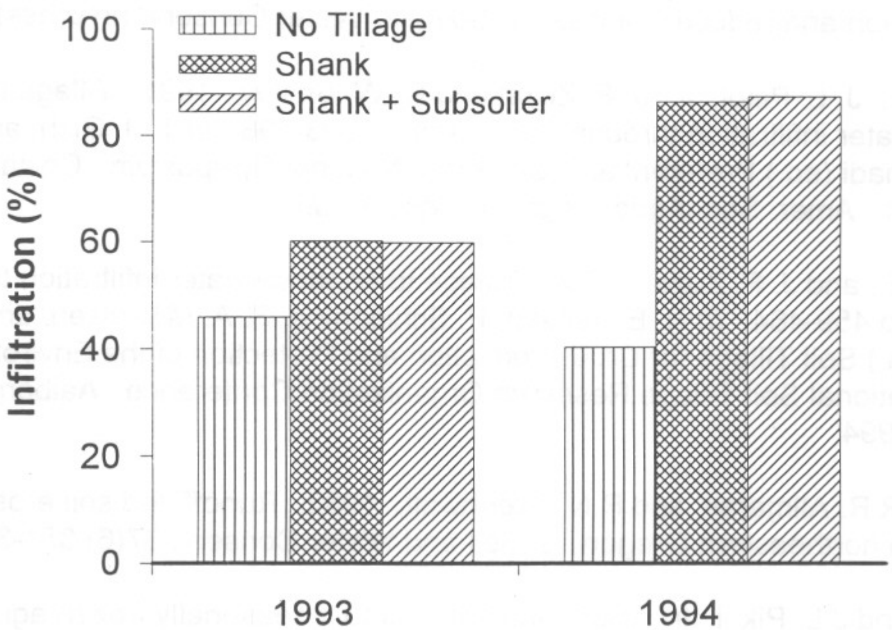

Figure 2 Proportion of water infiltrated in 30 minutes.

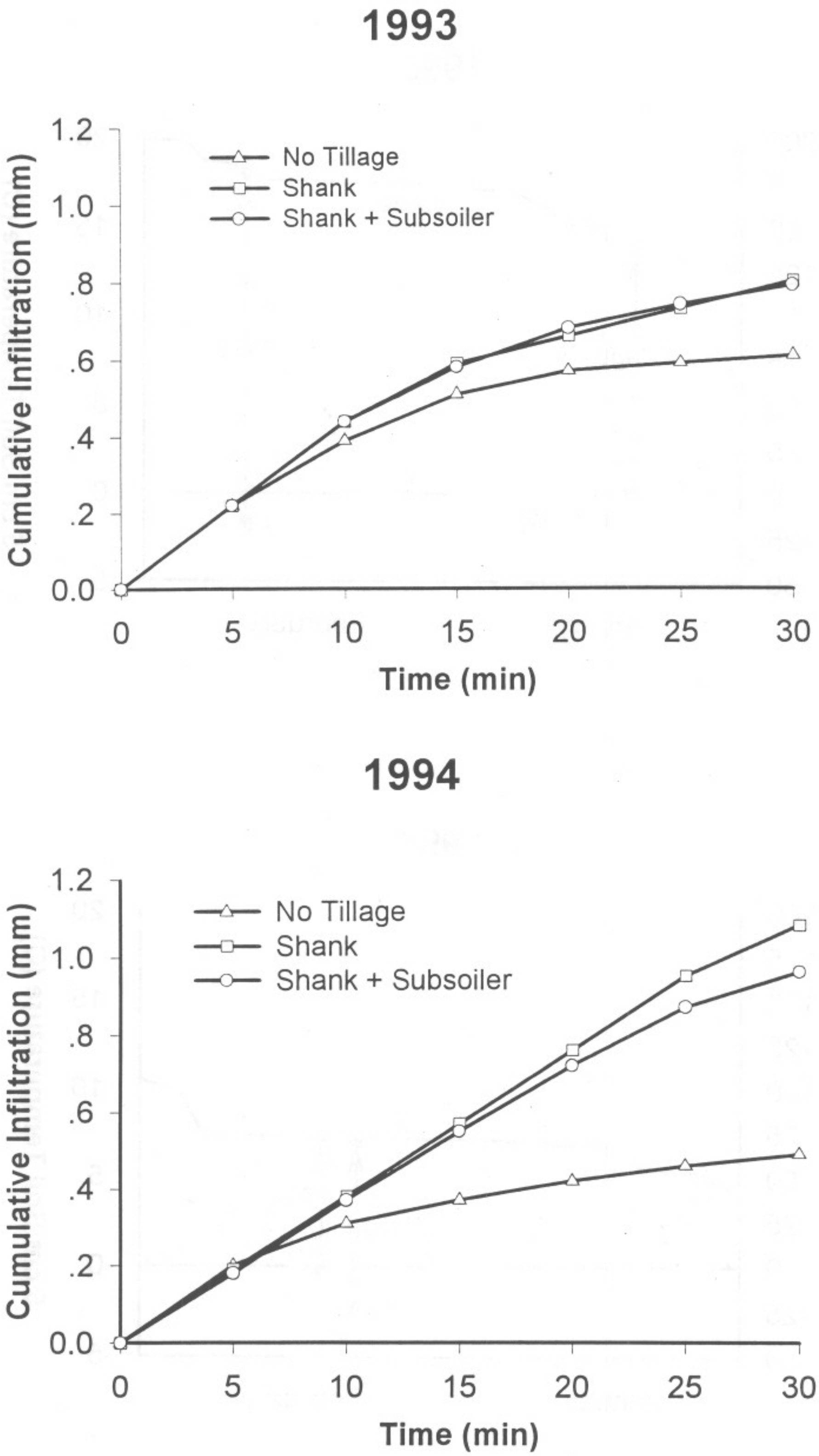

Figure 3 Effect of frozen soil tillage on mean cumulative infiltration.

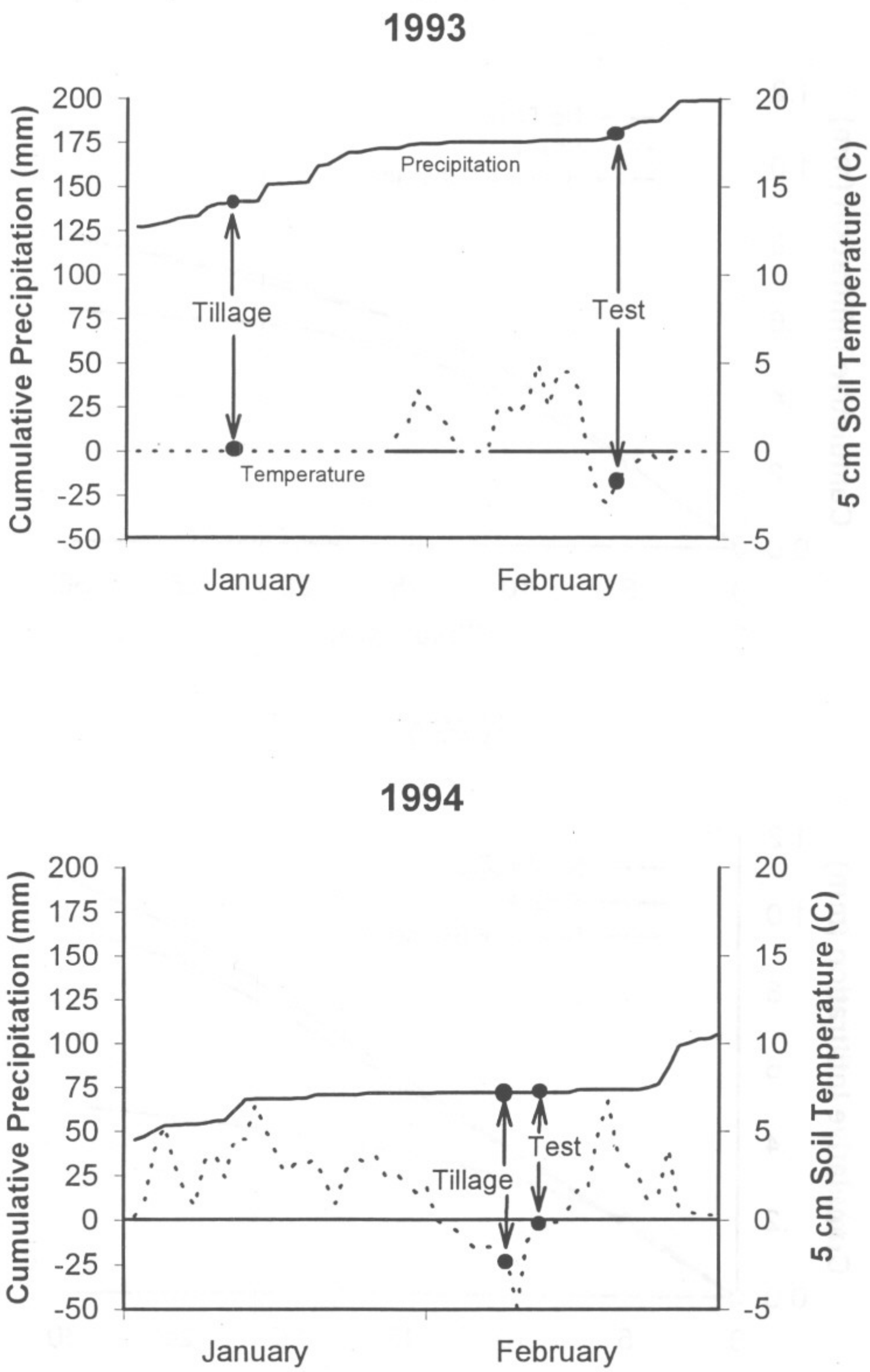

Figure 4 Soil temperature and cumulative precipitation at test sites.

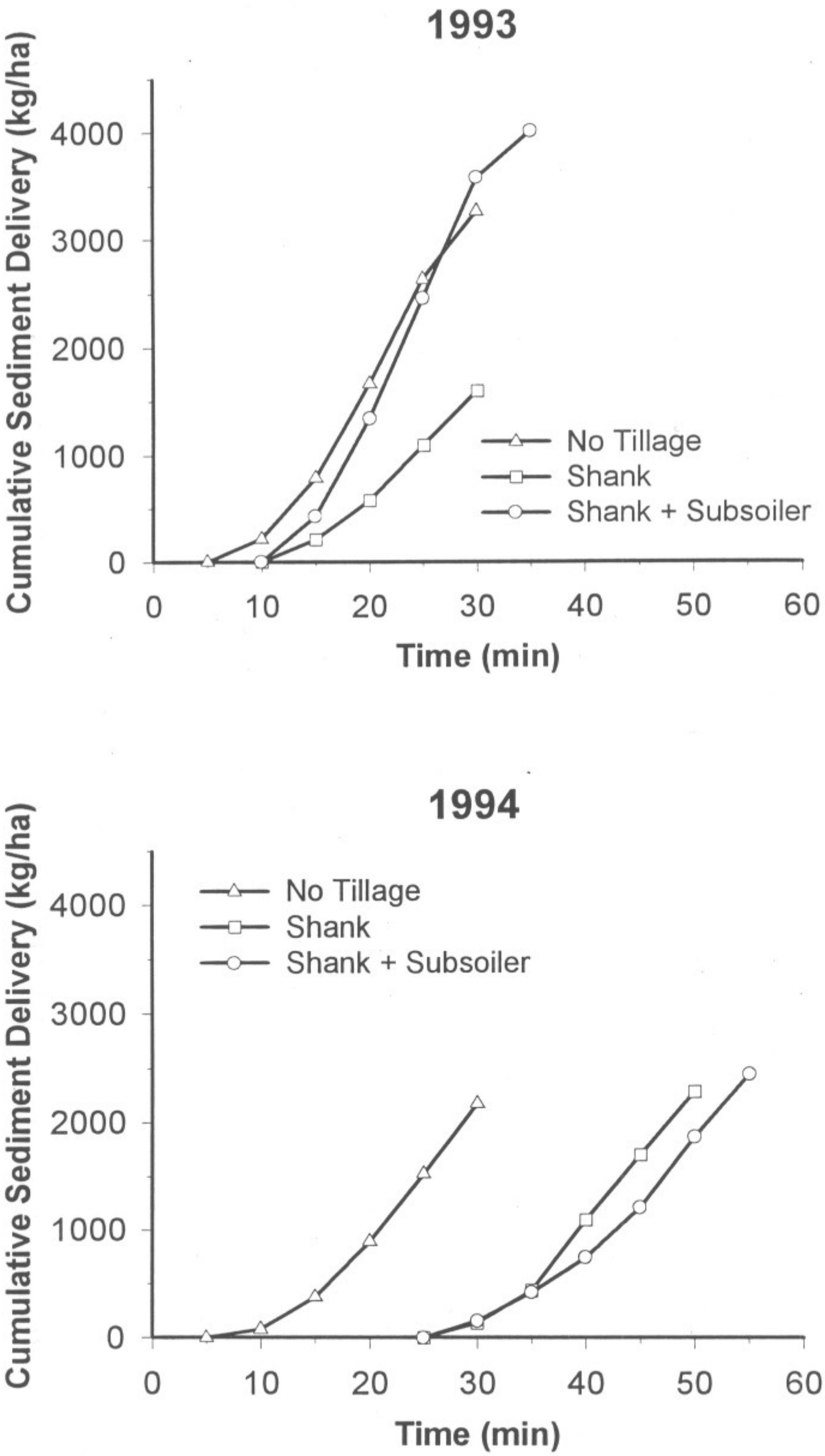

Figure 5 Mean cumulative sediment delivery.