Deep ripping fall-planted wheat after fallow to improve infiltration and reduce erosion

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ABSTRACT. Water runoff and soil loss from fall-sown wheat (Triticum aestivum L.) fields are often severe during the winter when rain or snow melt occurs on frozen soils in the inland Pacific Northwest (PNW). In a 2-year field study near Benge, WA, we tilled planted wheat plots on slopes > 40% in late fall to a depth of 25 or 60 cm with shovels spaced 3.7 or 6.0 m apart. In a dry winter, no soil loss was measured in ripped plots compared to 3.0 t ha⁻¹ soil loss for the control. Soil drying occurred near the tillage channels in ripped plots, reducing over-winter soil water storage. In a winter with higher than average precipitation and frozen soil conditions, soil loss was 6.4 and 20.2 t ha⁻¹ for ripped and control treatments, respectively. Ripping significantly improved water infiltration into the soil to a depth of 180 cm as far as 90 cm downslope from the tillage channel. In both years, grain yield was reduced in the row most disturbed by the tillage shank, but was increased in adjacent rows. On a whole-plot basis, there were no differences in grain yield between ripped and control treatments either year. Results suggest that deep ripping planted wheat fields in late fall is an effective soil and water conservation practice that does not reduce grain yield.

Water erosion is often severe during winter in the dryland winter wheat production areas of the inland Pacific Northwest (PNW). Precipitation in this region varies from 200 to 600 mm and characteristically 60% occurs between November and March. A winter wheat-fallow rotation is practiced on more than 2 million ha receiving < 400 mm annual precipitation (Douglas et al. 1992).

Water erosion in the wheat-fallow rotation is most severe during the winter of the crop year because of the winter precipitation pattern, long steep slopes, very little ground cover from crop residue or wheat seedlings, and low water infiltration rates through frozen soil. Soil freezing may occur to depths of 10 cm several times during the winter with occasional freezing to 40 cm (Papendick and McCool 1994). Partial or complete soil thawing frequently occurs between freezing events. Soil loss from water erosion can be especially high when snowmelt or rain occur on thawed soil overlying a subsurface frozen layer. In north-central Oregon, Zuehl et al. (1982) reported that 80% of soil erosion on winter wheat was caused by rapid snowmelt or rainfall on thawing soil. Water infiltration rates of the silt loam soils in this region are about 15 mm/hour, but approach zero when the soils are frozen (Zuehl and Pikul 1987). Infiltration rate into frozen soil decreases with increasing soil water content at the time of freezing (Willis et al. 1961).

Erosion control practices in wheat-fallow areas include tillage, crop residue management, strip cropping, contouring, and terracing. Even the best management plans are often not sufficient to control soil erosion during events of rain and/or melting snow on frozen soil (McCool 1990). Inclement weather conditions frequently limit the amount of crop residue available for erosion control. Dry seed zone soil conditions in the fall often result in partial or complete residue requiring additional treatment to make the seed zone available for tillage.

Interpretive summary

Water erosion from fall-planted wheat fields is a frequent problem during winter in the Pacific Northwest. Ground cover from crop residue and wheat seedlings is often inadequate to prevent runoff. Soil loss is most severe when rain or snow melt occurs on thawed soil overlying a frozen subsurface layer. We reduced soil loss and increased infiltration into frozen soil by creating deep tillage channels on contour on steep slopes.

Key words: fallow, frozen soils, infiltration, Pacific Northwest, ripping, steep slopes, water erosion, wheat.

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Zuzel (1994). Although this technique of tilling when the soil is frozen is successful, there is a narrow window of time when tillage can be performed. Wilkins and Zuzel (1994) tilled when there was 5- to 10-cm of frozen soil. If the frozen layer is thin it will not support the tractor, and ruts are formed and the soil compacted. The other extreme is to till when there is a thick layer of frozen soil that requires excessive power to fracture, and large chunks of soil are uprooted causing difficulty at harvest.

Another approach for providing tillage channels through frozen soil in wheat fields is to plant in the fall, wait for rain, and then make channels with deep tillage shanks prior to soil freezing. Fall rains moisten and firm the loose dry surface mulch created during summer fallow.

Tillage channels formed with these soil conditions may tend to stay open during the winter when frozen soil runoff occurs. It is also more practical than tilling frozen soil, allowing growers a longer time period in late fall to create the tillage channels. Harold Clinessmith, the grower co-operator for our study, reports he has reduced soil erosion for many years on his farm by fall tilling planted wheat fields with a ripper fabricated in his shop.

The objectives of this research were to determine the effects of deep ripping fall-sown wheat on steep slopes prior to soil freezing on: soil loss, water infiltration into the soil, and grain yield components and crop characteristics.

**Materials and methods**

A 2-year on-farm experiment was conducted during the 1993-1994 and 1994-1995 crop cycles on the Harold Clinessmith farm near Benge, Washington. The farm receives an average of 360 mm an-

| Table 1. Monthly precipitation (mm) during the 1993-1994 and 1994-1995 crop seasons compared with the 20-year average at Benge, WA |
|----------------------------------|---------|---------|---------|---------|
| Month                            | 1993-94 | 1994-95 | 20-year |
| September                        | 2       | 7       | 16      |
| October                          | 9       | 46      | 31      |
| November                         | 17      | 82      | 46      |
| December                         | 37      | 44      | 47      |
| January                          | 36      | 44      | 37      |
| February                         | 4       | 36      | 34      |
| March                            | 9       | 59      | 39      |
| April                            | 27      | 31      | 31      |
| May                              | 28      | 15      | 30      |
| June                             | 16      | 58      | 23      |
| July                             | 7       | 21      | 14      |
| August                           | 0       | 10      | 12      |
| 12-month total                   | 192     | 453     | 360     |

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nual precipitation and cropping pattern is a wheat-fallow rotation. Soil was a Walla Walla silt loam (Typic Haploxeroll, coarse-silty, mixed, mesic) overlying basalt bedrock. The experimental design was a randomized complete block with six replications of two treatments: ripped and control. For the 1993-1994 crop cycle, the experimental site was a 41% north-facing slope 58 m long by 156 m wide. In 1994-1995, the site was 47 m long by 255 m wide on a 43% north-facing slope. Individual plots were 58 m long by 13 m wide in 1993-1994 and 47 m long by 21 m wide in 1994-1995. At both sites, soil was 90-to-120-cm deep along the backslope and extended to depths >180 cm towards the base of the hill.

**Planting and ripping operations.** In 1993, soft white winter club wheat (cv. Hyak) was planted on 22 September in 0.4 m rows with deep furrow split-packer drills at a rate of 62 kg ha⁻¹ along the contour of the hillside. Uniform wheat
seedling emergence and plant establishment was attained. On 13 December, ripped plots were established by tillling unfrozen soil ≈ 28 cm deep with a single 2-cm wide shank with attached rotary subsoil spider. This implement was designed to rip the soil and create a series of pock marks along the tillage channel (Wilkins et al. 1991). Contour tillage slots were established at 6 m intervals along the slope. The ripper, pulled by a small crawler tractor, was lifted out of the soil when crossing control plots.

Seed zone soil water was insufficient for early fall planting in 1994. Planting was conducted on 7 November after fall precipitation had wet the soil surface. Soft white winter common wheat (c.v. Eltan) was planted in 0.15 m rows with double-disc drills at a rate of 90 kg ha⁻¹. Ripped plots were contour tilled 60 cmdeep with 4-cm thick shanks at 3.7 m intervals along the slope on 11 November. The tillage implement was a subsoiler which was modified by removing all but the end shanks. The implement was pulled with Clinemysters crawler tractor. Wheat seedlings had not yet emerged at the time of the ripping operation.

### Water infiltration, soil loss, and yield component measurements

Soil water content was measured within 3 days of the ripping operation and periodically thereafter throughout both winters. Volumetric water content of the 30- to 180-cm soil depth was measured in 15-cm increments with a neutron probe. Water content of the 0- to 30-cm soil depth was measured gravimetrically, as described by Gardner (1986), in two 15-cm core samples. In 1993, neutron probe access tubes were installed 30, 90, and 150 cm down-slope of a tillage channel near the base of the hill. In 1994, four access tubes were placed in each plot: in the tillage channel, and 30, 90, and 150 cm down-slope of the tillage channel. Access tubes were placed in the same general lateral locations in control plots, i.e., where the tillage channel would have been if the ripper had not been lifted out of the soil when crossing control plots.

Soil loss from rill erosion during the winter was measured using the voided rill method (Everts and Riehle 1980). Total cross-sectional area of rills near the top, middle and base of each plot were averaged to determine soil loss on a whole-plot basis. Precipitation, minimum-maximum air temperature, and soil temperature at 5-, 10-, 20-, and 30-cm depths were recorded hourly throughout the study period at a weather station placed < 1 km from the experimental site. Spike density was measured from hand-cut samples obtained from 1-m row sections near each access tube in all plots at harvest in August. Clean grain yield, kernels per spike¹, 1000 kernel wt, and dry matter were determined from these samples.

An analysis of variance was conducted for water content in 15 cm depth increments and for the total 180-cm soil profile on each sampling date, soil loss from rill erosion on each sampling date, and yield components and crop characteristics. Treatments were considered significantly different if the P-value was < 0.05. Treatment means were separated by Fisher’s protected least significant difference.

### Results and discussion

#### Water infiltration

The 1993-1994 winter was dry (Table 1 and Figure 1) and water recharge into the soil was low. There were only 3 days from mid-December through February where precipitation exceeded 5 mm (Figure 1). In March, the
soil 30 cm from the tillage channel was significantly drier than in control plots but there were no differences in soil water content 90 cm down-slope of the tillage channel (Figure 2).

Precipitation was greater than average and frequently occurred when the soil was frozen during the 1994-1995 winter (Table 1 and Figure 3). By late January, treatment differences in water infiltration within 30 cm of the tillage channel were measured to soil depths of 150 cm (Figure 4). By late February, highly significant differences in soil water content were measured to 180 cm depth within 90 cm from the tillage channel (Figure 5), but there were no differences in water content 150 cm from the tillage channel. Soil water differences between treatments were slightly less pronounced in late March (Figure 6), because March precipitation fell on unfrozen soils. Ripping does not generally improve water infiltration when the soil is unfrozen (Pikul et al. 1992). At harvest in August, available soil water was depleted in control plots but still present within 30 cm of the tillage channels, especially at deeper depths (Figure 7). We were surprised to find these differences because winter wheat is an efficient water extractor, and speculate that diminished plant stand near the tillage channel reduced water demand.

**Soil loss.** Ripping significantly reduced soil loss by rill erosion during both dry and wet winters. In 1994, most soil loss occurred during a 3-day period in early January when 27 mm of rain fell on thawed soil overlying a frozen layer extending to 10 cm depth (Figure 1 and Table 2). The remainder of the 1994 precipitation occurred on unfrozen soil (Figure 1), causing little soil loss. In March, there were no measurable rills in the ripping treatment compared to a modest soil loss of 3.0 t ha\(^{-1}\) in control plots (Table 2).

Recurrent precipitation on frozen soils during the 1994-1995 winter produced cumulative soil loss from rill erosion (Figure 3 and Table 2). Ripping significantly reduced soil loss throughout the winter compared to control treatments (Table 2). Tillage channels generally stopped rills, whereas many rills extended the entire length of the hillside in control plots. No precipitation occurred on frozen soils after February. Rate of soil loss in rilled plots, which remained low throughout the winter, had increased by early spring (Table 2), perhaps because the surface soil was saturated and tillage channels had filled with sediment by this time.

**Yield components and crop characteristics**

Ripping decreased grain yield in the row closest to the tillage channel both years by reducing spike density (Table 3 and Table 4). However, yield in adjoining rows as far as 90 cm from the tillage channel was increased compared to control plots (Table 3 and Table 4). Ripping had no effect on grain yield 150 cm from the tillage channel either year. On a whole-plot basis, ripping did not significantly affect any yield component or crop characteristic either year (Table 3 and Table 4).

**Conclusion**

Creating deep tillage channels on contour in planted wheat on steep slopes in the fall had the following effects: (i) reduced soil loss by retarding rill erosion during both dry and wet winters; (ii) increased water infiltration during the wet winter; and (iii) did not reduce or increase overall grain yield either year.

In areas of the PNW where soil freezing is common, growers routinely rip wheat stubble after harvest to reduce the risk of soil erosion and increase water storage during the fallow winter. Our research suggests that growers will benefit by employing the same practice, but with wider shank spacings, during the crop year.

**REFERENCES CITED**


