Conservation Farming in the Low-Precipitation Zone of the Inland Pacific Northwest

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I. Overview

The low-precipitation (<12 inches average annual) dryland cropping region in east-central Washington and north-central Oregon covers 3,846,000 acres, and is by far the largest cropping zone in the Western USA. About 1,013,000 acres is currently enrolled in the Conservation Reserve Program (USDA-FSA, 2000) where land is removed from crop production and farmers are paid an average of $50/acre per year to grow perennial grasses and shrubs for environmental and soil conserving benefits. This land is under contract for ten years during which tillage or harvest are not allowed.

Most soils in the dryland cropping areas are formed from a thick deposit of windblown silt, called 'loess', that in some locations is 250 ft deep overlying basalt rock (Busacca, 1989). Deposits along with natural soil erosion from wind and water have formed a gently rolling topography in the low-precipitation region. Wind erosion from excessive tillage is a greater threat than water erosion. Loess and related sand dunes originated from wind reworking sediments deposited by cataclysmic glacial outburst floods that occurred about 15,000 years ago (Busacca, 1991).

Pre-agricultural vegetation was sagebrush-steppe (Daubenmire, 1970). Soils under dryland crop production have developed mainly in post-glacial loess under perennial bunchgrass vegetation. In areas receiving less than 9 inches annual precipitation, soils are low organic matter desert soils or Aridisols, with Entisols on active and recently stabilized dunes. The pH of topsoil is generally neutral to alkaline in the low precipitation region.

Soil texture is predominantly silt loam but with higher sand content in the lower precipitation areas such as the Horse Heaven Hills in Benton County, Washington. With intensive cultivation grain farming for 120 years, many soils have lost 40 to 50% of their original content of organic matter from topsoil erosion and oxidation. Presently, organic matter content in the surface four inches of cultivated dryland soil is 1.2% or lower in the low precipitation region. Soils are generally permeable and in most areas deep enough to adequately store winter precipitation (Papendick, 1996). Some soils in north-central Oregon and central Washington are shallow and have considerably less water storage capacity, but still are sufficient for profitable crop production.

II. Cropping Systems

A single family operates most farms and average farm size is 3500 acres. Family farms of 6,000 acres or larger are common, especially in areas that receive less than 10 inches annual precipitation, where grain yield and profit per acre are relatively low compared to higher precipitation areas. Since land was broken out of native grassland and sage in the 1880s, farming has been almost exclusively a tillage-based wheat-fallow system, where only one crop is grown every two years. Today, winter wheat-summer fallow is practiced on 90% of cropland. Average long-term winter wheat grain yield after summer fallow ranges from 20 to 50 bu/a.

The main purpose of summer fallow is to store a portion of over-winter precipitation to enable successful establishment of winter wheat planted into moist soil in late summer or early fall. Fallow also helps to ensure economic crop yields and reduces risk of crop failure from drought. Between 60 to 75% of precipitation received during winter months after wheat harvest is stored in the soil up to April. However, precipitation that occurs after April, as well as a considerable quantity of water stored in the soil, is lost during late spring and summer (Leggett et al. 1974). By the end of the fallow cycle, an average of only 30% of precipitation received during the 13-mo period is stored in the soil. The processes of water loss and seed zone water retention from summer fallow under PNW conditions have been described by Papendick et al. (1973) and Hammel et al. (1981).

A 3-yr winter wheat-spring cereal-fallow rotation is practiced on about 10% of the cropland. In general, farmers will consider planting a spring cereal, primarily wheat or barley, if over-winter water recharge occurs to a soil depth of 3 ft and at least 5 inches of plant available water is stored in the soil. Continuous annual cropping is practiced on less than 1% of land. Average grain yield of spring wheat and spring barley after winter wheat range from 600 to 2200 lbs/acre. Winter wheat after summer fallow is the dominant rotation as it provides relatively stable grain yields and is less risky compared with spring wheat or barley. However, farmers are increasingly interested in spring wheat due to recent release of high yielding cultivars. Many farmers also want to increase intensity of cropping (i.e., decrease frequency of fallow) and reduce or eliminate tillage. Both practices help to control wind and water erosion and, in the long-term, improve quality of dryland soils (Kennedy, 1998). Reduction in price of some non-selective herbicides, such as glyphosate, and recently introduced no-till drills that fertilize and plant in one pass through the field leaving ample residue cover, has sparked interest in more intensive cropping systems. Experience of researchers and farmers with a wide array of alternative crops such as peas, canola, condiment mustard, safflower, sunflower, and flax has not yet revealed a crop that can compete agronomically or economically with cool-season cereals. There is strong interest and support for research on new crops and for more diverse rotations in the low precipitation environment, but the ongoing drought from 1999 through 2004 has not proven favorable for annual cropping.

Both soft white and hard red winter and spring wheat cultivars are grown. In general, available cultivars have excellent yield potential, disease resistance, winter hardiness, and end-use quality. However, farmers in the low-precipitation zone have not been able to take full advantage of the extensive progress in soft white winter wheat development because all cultivars, except one, released in the past 35 years are semidwarfs that carry dwarfing genes (Allan, 1980). Semidwarfs have short coleoptiles and length of coleoptile is correlated with ability of winter wheat to emerge from the soil when planted deep to moisture. Stand establishment of winter wheat on summer fallow is a crucial factor affecting grain yield (Bolton, 1983). Farmers in this zone need cultivars that emerge rapidly (7-10 days) with limited moisture and up to 6 inches of dry soil covering the seed (Schillinger et al., 1998). In response to the expressed needs of farmers, breeding of standard height and tall soft white winter wheat lines with good emergence potential has recently been included in breeding objectives for low-precipitation areas.

III. Tillage and Planting

Farmers in the winter wheat-summer fallow production areas typically conduct eight or more tillage operations during fallow. Timing and extent of tillage varies depending on quantity of surface residue, weed infestations, soil type, potential for water runoff on frozen soils, and individual preference.

With traditional practices, the first tillage may occur just after wheat harvest when a V-shaped sweep implement is used to kill weeds such as Russian thistle, if present, by severing the taproot. After surface soil has been moistened by fall rain, fields at higher elevations and latitudes are generally chiseled in

November to a depth of 10 inches or more to create channels open to the subsoil to aid infiltration of runoff when soils are frozen (Pikul et al., 1992). In late winter a nonselective herbicide may or may not be used to control winter grass weeds. Initial spring tillage is conducted from mid-March though April and commonly consists of one or two operations with a duck-foot cultivator plus attached harrow or a single operation with a tandem disk. Spring tillage disrupts soil capillary continuity to create a dry surface-tillage mulch that retards evaporation of stored water during dry summer months (McCall, 1925). Aqua or anhydrous NH3-N is injected into soil with shanks in April or May. To control Russian thistle and other weeds, and to set the seed zone moisture line (break between disturbed soil on top and non-tilled soil below), 3 to 5 secondary tillage operations with rodweeders [a 1-in. square rotating rod operated up to 4 inches below the soil surface are carried out in spring and summer.

Intensive tillage operations during fallow often bury surface crop residue, pulverize soil clods, and reduce surface roughness (Schillinger and Papendick, 1997). Blowing dust from excessively tilled fields leads to major soil losses and reduces air quality. Therefore, many farmers are converting to minimum and delayed conservation tillage methods, using herbicides instead of tillage whenever feasible to reduce tillage to as few as three operations during fallow. Long-term research at Lind, Washington, showed that minimum and delayed conservation tillage significantly increased surface residue and clod retention for controlling erosion with no adverse agronomic (Schillinger, 2001) or economic (Janosky et al., 2002) effects compared to conventional tillage. Water content in the seed zone at the end of fallow was not affected by tillage treatment, suggesting that finely divided soil particles in tillage mulch are not as important for retarding evaporative water loss during the summer as previously thought. Rather, creating an abrupt break between the tilled and non-tilled layer with initial spring tillage, which severs capillary channels from the subsoil to the surface, appears to be the dominant factor regulating over-summer evaporative water loss. In addition, initial spring tillage could be delayed until mid-May because late winter application of a nonselective herbicide provided excellent weed control for several months.

If conservation tillage practices, as outlined by Schillinger (2001), were widely practiced in winter wheat-summer fallow production zones, a sharp reduction in wind erosion and suspended dust emissions could be expected, leading to improved air quality with no hardship to the livelihood of farmers. It must be emphasized, however, that no-till summer fallow (chemical fallow) shows limited potential in low precipitation areas because of increased evaporative loss of seed-zone soil water during dry summer months compared with tillage (Lindstrom et al., 1974).

Winter wheat is planted starting in late August in 14-to 18-in. wide rows with deep furrow split-packer drills. These drills are specifically designed to place seed as deep as 8 inches below the pre-planting soil surface into moist soil. Highest winter wheat grain yield is generally achieved and the greatest straw production always occurs with early planting (Donaldson, 1996; Donaldson et al., 2001) despite the increased likelihood of the fungal disease Fusarium foot rot, commonly called dryland foot rot, associated with early planting (Inglis and Cook, 1986). In dry years when seed zone water is inadequate for seed germination and emergence, farmers will either plant shallow (1 to 1.5 inches deep) into dry soil using either hoe or disk type drills with 6-to 12-in. row spacing, delay planting until the arrival of fall rains, or postpone planting until spring.

IV. Highlights of Long-Term Conservation-Till and No-Till Cropping Systems Research in the Low-Precipitation Zone

For the tillage-based winter wheat – summer fallow system: Research has conclusively shown that best management practices are as follows:

- Apply glyphosate herbicide to wheat stubble in early spring.

- Conduct primary spring tillage with a low-disturbance undercutter sweep implement at 5-inch depth. A rotary hoe, spring-tooth harrow, or other secondary implement attached directly behind the undercutter sweep may or may not be needed (depending on soil type) to break up large clods and fill air voids. With simple plumbing, aqua nitrogen can easily be delivered with the undercutter sweep during the primary tillage operation.
- Primary spring tillage may be conducted anytime from mid March until late April with no affect on soil moisture. After you have applied glyphosate to the stubble in late winter or early spring, take your family on a vacation. There is no need to be in a big rush to make summer fallow. The soil moisture will still be there when you come back (all relaxed) from your kids' school spring break.
- Rodweed 2-3 times as needed at the 4-inch depth to control Russian thistle and other weeds during late spring and summer.
- Plant early (late August or early September for most of east-central Washington). Use a non- semidwarf winter wheat cultivar if seed-zone moisture is marginal.
- Consider purchasing a deep-furrow split packer drill that has staggered openers (i.e., on two ranks) so that you can plant winter wheat in high residue conditions. Most farmers still have deep-furrow split-packer drills with all openers in a line. This type of drill cannot pass through high levels of residue and, in my opinion, has been a major constraint to the adoption of conservation tillage by farmers.

Intensive Cropping Using No-Till

In areas of less than 10 inches of annual precipitation, long-term research with current technology shows that:

- Continuous annual soft white and hard red spring wheat produce half the grain yield of winter wheat after summer fallow. This holds true in both (relatively) wet and dry years. Continuous annual cropping is not economically competitive with the winter wheat – summer fallow system.
- Recrop winter wheat will generally produce greater grain yield than recrop spring wheat as long as downy brome is not a major problem.
- For late fall planting, there is no grain yield advantage of planting spring wheat (i.e., facultative spring wheat) compared to winter wheat.
- Spring wheat is a good bet if 5 plus inches of plant available water is stored in the soil by mid March. With less than 5 inches of available soil water, farmers, in the long run, are better off to make conservation tillage summer fallow as described above.

In areas with 11-12 inches of annual precipitation:

- Continuous annual soft white spring wheat is economically competitive with winter wheat – summer fallow, but year-to-year grain yield is highly variable (i.e., risky).
- Rhizoctonia "bare patch" soil fungal disease is a big problem with long-term no-till, especially with low-disturbance disc-type drill openers.
- A 2-year spring wheat – spring barley rotation significantly reduces Rhizoctonia bare patch disease compared to continuous annual spring wheat.
- Alternative crops such as safflower, yellow mustard, canola, narrow-leaf lupine, etc. are not profitable and provide no benefit for control of Rhizoctonia.
- See Papendick (2004) for a comprehensive overview of best management practices for wind erosion and air quality control for dryland cropping on the Columbia Plateau.

References

Allan, R.E. 1980. Influence of semidwarfism and genetic background on stand establishment of wheat. Crop Sci. 20:634-638.

Bolton, F.E. 1983. Cropping practices: Pacific Northwest. p. 419-426. In H.E. Dregne and W.O. Willis (eds.) Dryland Agriculture. Agron. Monogr. 23. ASA, CSSA, and SSSA, Madison, WI.

Busacca, A. J. 1989. Long Quaternary record in eastern Washington, U.S.A. interpreted from multiple buried paleosols in loess. Geoderma 45:105-122.

Busacca, A. J. 1991. Loess deposits and soils of the Palouse and vicinity. p. 216-228. In Baker, V.R. and others. The Columbia Plateau, Ch. 8, In Morrison, R. B. (eds.) Quaternary Non-Glacial Geology of the United States. Geological Soc. of America Geology of North America, Vol. K-2.

Daubenmire, R. 1970. Steppe vegetation of Washington. Wash. Agric. Exp. Sta. Tech. Bull. 62. Washington State Univ., Pullman, WA. 131 p.

Donaldson, E. 1996. Crop traits for water stress tolerance. Amer. J. Alternative Agric. 11:89-94.

Donaldson, E., W.F. Schillinger, and S.M. Dofing. 2001. Straw production and grain yield relationships in winter wheat. Crop Sci. 41:100-106.

Hammel,, J.E., R.I. Papendick, and G.S. Campbell. 1981. Fallow tillage effects on evaporation and seedzone water content in a dry summer climate. Soil Sci. Soc. Am. J. 45:1016-1022.

Inglis, D. A., and R. J. Cook. 1986. The persistence of chalmydospores of Fusarium culmorum in wheat-field soils of eastern Washington. Phytopathology 76:1205-1208.

Janosky, J.S, D.L. Young, and W.F. Schillinger. 2002. Economics of conservation tillage in a wheat-fallow rotation. Agron. J. 94:527-531.

Kennedy, A.C. 1998. The rhizosphere and spermosphere. p. 389-407. In D.M. Sylvia, J.J. Fuhrman, R.G. Hartel, and D.A. Zuberer (eds.). Principles and Applications of Soil Microbiology. Prentice-Hall, New Jersey.

Leggett, G.E., R.E. Ramig, L.C. Johnson, and T.W. Massee. 1974. Summer fallow in the Northwest. p. 110-135. In Summer Fallow in the United States. U.S. Dept. of Agriculture, Agricultural Research Service, Washington, DC.

Lindstrom, M.J., F.E. Koehler, and R.I. Papendick. 1974. Tillage effects on fallow water storage in the eastern Washington dryland region. Agron. J. 66:312-316.

McCall, M.A. 1925. The soil mulch in the absorption and retention of moisture. J. Agric. Res. 30:819-831.

Papendick, R.I. 2004. Farming with the wind II: Wind erosion and air quality control on the Columbia Plateau and Columbia Basin. Special Report by the Columbia Plateau PM-10 Project. Washington Agric. Exp. Station Rpt. XB 1042, Pullman, WA.

Papendick, R.I. 1996. Farming systems and conservation needs in the northwest wheat region. Amer. J. Alternative Agric. 11:52-57.

Papendick, R.I., M.J. Lindstrom, and V.L. Cochran. 1973. Soil mulch effects on seedbed temperature and water during fallow in eastern Washington. Soil Sci. Soc. Am. Proc. 37:307-314.

Pikul, J.L., Jr., J.F. Zuzel, and D.E. Wilkins. 1992. Infiltration into frozen soil as affected by ripping. Trans. ASAE 35:83-90.

Schillinger, W.F., and R.I. Papendick. 1997. Tillage mulch depth effects during fallow on wheat production and wind erosion control factors. Soil Sci. Soc. Am. J. 61:871-876.

Schillinger, W.F., E. Donaldson, R.E. Allan, and S.S. Jones. 1998. Winter wheat seedling emergence from deep sowing depths. Agron. J. 90:582-586.

Schillinger, W.F. 2001. Minimum and delayed conservation tillage for wheat-fallow farming. Soil Sci. Soc. Am. J. 65:1203-1209.

USDA-FSA. 2000. The conservation reserve program 20th signup. U.S. Dept. of Agriculture – Farm Service Agency, Washington, DC.