considered available. For both winter wheat and spring wheat, 2.5 inches of available moisture was required just for vegetative growth (Fig. 1).

For winter wheat, each inch of available soil moisture in fallow at time of planting provided 6.7 bushels of grain. For each inch of water stored in the soil during the winter (beyond what was present at time of planting), 7.9 bushels of grain was produced. Each inch of rain in April, May, and June accounted for 4.4, 7.6, and 12.2 bushels of grain, respectively (Fig. 1). Each inch of available soil moisture at the time of planting recrop spring wheat provided 5.4 bushels of grain whereas April, May, and June rainfall generated another 1.4, 6.4, and 5.7 bushels, respectively (Fig 1).

Our analysis shows that winter wheat makes much more efficient use of both stored soil moisture and growing season rainfall than does spring wheat. April rainfall is less beneficial to both winter wheat and spring wheat grain yield compared to rain in May and June. The main objective of this work is to provide farmers a decision tool, based on available soil moisture in the spring and historic growing-season rainfall, to determine when to plant spring wheat, or instead make summer fallow. This tool may also be useful for farmers who produce hard red winter wheat to help determine the quantity of nitrogen to topdress in the spring to meet grain protein requirements. A full write up of our findings will be published and available to farmers in the near future.

On-Farm Testing to Adopt No-Till Fallow Winter Wheat Production in the Dryland Cropping Region of Eastern Washington

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WSU Lincoln-Adams Extension on-farm testing helps improve farm profitability in a manner that reduces erosion and improves air quality. Winter wheat (WW) (*Triticum aestivum* L.) production on tillage based summer fallow systems has been a standard practice in the dryland cropping region (14 inches precipitation annually) of eastern Washington for generations. This has been profitable; but it comes at a cost, including soil loss through wind and water erosion. Producers have examined alternative methods including no-till systems for increasing profitability and reducing soil erosion. An on-farm test was established in 2003 examining WW established under three treatments; 'conventional' tillage fallow system, 'no-till early', or seeded at the same time as the conventional treatment, and 'no-till late', or planting was delayed one month. Conventional tillage fallow methods include a chisel sweep and cultiweeding for weed control. No-till fallow methods include chemical applications for weed control. The test is a RCBD with 5-replication. Plots are one acre in size, and seeded, maintained, and harvested by the producer. No difference in soil moisture has been detected between treatments. Grain yield differences were not detected between conventional and no-till early treatments averaging 79-bu/acre, but the no-till late treatment reduced yield 19%. Economic return above variable costs were greater with the no-till early and conventional treatments averaging \$143 and \$137/acre respectively, compared to only \$104/acre with the no-till late treatment. Overall larger agronomic and economic differences were detected between the two no-till treatments, and little differences were detected between conventional and no-till early treatments.

Fall Fertilization for Spring Wheat Production in the Dryland Cropping Region of Washington

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Producers throughout the dryland cropping region (8-14 inches precipitation) of Washington continue to adopt conservation tillage leading to increased spring wheat (SW) (*Triticum aestivum* L.) production. Fall applied nitrogen for SW production is of interest to manage workload, capture historically lower fertilizer prices, and improve grain protein in hard wheat. At risk is leaching nitrogen lower in the soil profile below the root zone costing producers and the environment. A series of on-farm tests were completed examining 'fall' vs. 'spring' applied nitrogen for SW production. Aqua nitrogen was applied with a low disturbance coulter applicator. Fall applied nitrogen was applied after soil temperatures fell below 50ºF to inhibit movement. Seeding was completed in one-pass with starter fertilizer being applied. The tests were carried out over three years at two sites in a RCBD with four replications. Fall applied nitrogen remained in the top foot of the soil profile at the time of seeding.

Differences in grain yield were detected between years and sites but were not detected between treatments with an average of 28.3 bu/ac. Similar results were discovered in grain protein and test weight. Economic return over nitrogen costs were greater with the fall treatment averaging $79.80/ac compared to $72.50/ac with the spring treatment due to lower fall fertilizer prices. Overall fall nitrogen applied late had no negative impact on yield and grain quality, giving producers opportunities to improve time management and capture lower fertilizer prices with limited nitrogen movement below the root zone.

Phosphorus and Seeding Rate Management to Improve Yields of Late-Planted Winter Wheat in the Low Rainfall Zone

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Dryland wheat growers in the low rainfall zone of eastern Washington commonly employ winter wheat-tillage fallow rotations. Annual cropping or chemical fallow reduces wind erosion in this susceptible area. However, late seeding is often required in these situations due to a lack of seed zone moisture at normal planting times. The objective of this study was to determine if phosphorus (P) and/or seeding rates could be altered to improve late seeded wheat yield in recrop or chemical fallow situations. Winter wheat was grown at three locations in eastern Washington in 2004-05 and two locations in 2005-06. One site was chemical fallow and the others winter wheat stubble (recrop) at the time of seeding. Seeding rates of Eltan winter wheat were 40 and 70 lb/acre. Phosphorus rates were 0, 20, 40, 60, and 80 lb P_2O_5/acre in 2004-05, and 0, 10, 20, 40, and 60 lb P_2O_5/acre in 2005-06. The chemical fallow site also had both early and late seeding dates. There was a small but uneconomical increase in grain yield with P application, and no positive effect of increasing seeding rates, at recrop sites. At the chemical fallow site there was a 9.6 bushel/acre (25%) yield response to 20 lb P_2O_5/acre in 2004-05 and a linear response (7 lb P_2O_5/bushel yield increase) to applied P at the 40 lb/ac seed rate, but no response at 70 lb seed/ac, in 2005-06. Responses to P fertilizer occurred in chemical fallow even though soil test P levels were marginal or adequate. Increasing the seed rate from 40 to 70 lb/acre increased yield by 3 bu/acre regardless of planting date at the chemical fallow site. Overall, results indicate a potential to improve wheat yields with P application and, to a lesser extent, increased seeding rates, in chemical fallow regardless of early or late seeding date. The ability to increase yields with P fertilizer or higher seeding rates in an annual cropped system are limited.

Soil Acidity and Lime Responses in Eastern Washington

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Soil quality and conservation is improved with minimum or no-tillage farming practices. Soils of the Palouse region of Washington, Oregon, and Idaho have developed stratified layers of acidity when tillage is reduced or eliminated. Some soil pHs have become relatively acidic (pH < 5.0) in the surface 6 inches; however, it is not known whether this acid layer is impacting crop yields. The objective of this research was to determine the influence of lime rate on wheat, pea, and other rotational crop yields and, if necessary, to develop lime recommendations for cropping systems in the Palouse region. On-farm studies were established in fields under continuous no-till or reduced-tillage management. Treatments include a non-treated control, elemental sulfur application at 2,000 lb/acre (to accelerate acidification), and applications of pelletized lime at rates of 2,000, 4,000 and 10,000 lb/acre. Initial soil samples were collected at depths of 0 to 6 and 6 to 12 inches, and in ½-inch increment to a depth of 6 inches to characterize initial soil pH conditions. Soil pH (0 to 6-inch depth) ranged from 4.9 to 5.6. Detailed sampling indicated an acidic band at the 1 to 3-inch depth in no-till systems. Soil pH in this acidic band is as low as 3.9 at some locations. Even though soil pH is apparently below critical levels for crops grown in the Palouse area, yield responses to lime have been inconsistent. Recent evidence suggests this may be due to high organic matter levels in reduced tillage systems that reduce the incidence of aluminum toxicity associated with low soil pH. Monitoring of these long term trials is ongoing.