Winter Legumes to Increase Water-Use-Efficiency in No-Till Systems?

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Our Story

In 1998 and 2000, Mike Greytak, a highly diversified no-till farmer in southeastern Montana, organized well attended no-till conferences in Billings. Much discussion at these farm conferences centered around stable management questions for soil water management. Mike challenged us to develop a project that studied crop water-use-efficiency (WUE) in continuous, diversified dryland cropping systems in Montana. Our belief was that knowledge about maximizing WUE would lead to increased sustainability of Montana farming systems by increasing profitability and building healthier soils and biological diversity.

Western SARE seemed a logical source of funding for this type of sustainable agriculture research. We first applied for a research grant in 2000, and after our 3rd application in 2002, we were awarded 20% of our request. That was insufficient funding to conduct our planned project but we'd since become very interested in the potential for winter lentil and pea to help intensify winter wheat-based systems, and together with funding from the USDA Cool Season Food Legume program we planned a project to investigate the effects of wheat stubble management on winter survival, yield, and water use of winter lentil and pea. In 2001, Mike Greytak harvested two field plots of Austrian winter pea on his farm. His September seeding date yielded 22 bu/ac while a March seeding date yielded only 7 bu/ac. We were quite excited about the questions for winter legumes to be a “game changer” in diversifying fallow – wheat/winter systems in a water-use-efficient manner.

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Experimental Parameters

Adjacent pea and lentil sites were established on representative no-till farm fields for 3 years. After wheat harvest, stubble was cut short (4 inches) or left tall (12 – 16 inches) for main plot treatments within each crop: pea and lentil. Early and late September seeding dates X two winter genotypes plus two high-yield spring cultivars were randomized as six subplots within the stubble height main plots. Experimental winter pulse breeding lines were referred to as Mortau and ’79’ for lentil, and ’760’ (tall) and ’726’ (short) for pea. The controls were spring cultivars, Brewer and Richlea lentil, and Delia and Mozart pea. Plots were 6 x 40 ft. Additionally, one seeding line each of winter pea (’726”) and lentil (’79”) was seeded at four plant densities in early September in tall stubble only. Data collection included phenological development rates, stand density, grain productivity and quality, and soil water extraction.

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Questions

1) How do winter lentil and winter pea compare for winterhardiness and are there genetic differences within pea or lentil for winterhardicess?
2) How do winter lentil and winter pea seed yield and WUE compare with spring lentil and pea?
3) How would cereal stubble height affect winter survival, and subsequent yield formation?
4) How early would winter lentil and pea have to be seeded to reduce the risk of everwinter stand loss?
5) Would optimal plant densities for winter lentil and pea be the same as their familiar spring counterparts?

Field Site

A field site was chosen at Amsterdam, MT, to represent the cold dry winter climate typical of the Rocky Mountain Frost region. Long-term average annual precipitation is 14.1 inches (360 mm). This area grows winter wheat predominantly in a fallow – wheat cropping sequence.

Answers

1) Lentil vs. Pea Winterhardiness?

- Pea has consistently shown greater winter survival in this and other studies at this location, possibly due to larger seed size tolerant of deeper seeding. In Rocky Mountain frost environments it is very likely that the top growth of fall-emerged winter lentil and pea will be frozen off during snow-free periods in the winter, or during cold periods following spring snow melt. Pea and lentil must then re-emerge from below ground nodules. Frozen tissue damage may extend below the soil surface depending on the intensity and duration of the cold period, and shallower seeded lentils will suffer proportionally greater tissue damage.

Figure 1. 1971-2000 average monthly precipitation, September to August, at Amsterdam, MT (annual total = 14.1 inches or 360 mm).

Figure 2. 1971-2000 average monthly minimum and maximum temperatures, September-August, at Amsterdam, MT.

2) Winter vs. Spring?

- Winter lentil and pea flowered 10 and 7 days earlier than early-sown spring counterparts. Lentil matured 6 days earlier than spring counterparts but pea matured 4 days later than spring counterparts, indicating genetic improvement needed for the rate of seed fill in winter pea.

- Winter pea and lentil yielded equal or lower than high yielding modern spring cultivars in 2002 and 2003 at Amundelsen; in 2004, persistent dry fall soil conditions resulted in no full establishment and complete stand failure for all winter lentil and winter pea treatments, highlighting need for moist soil conditions in September. In related research in central Montana winter lentil yielded equal or greater than spring lentil, by as much as 76% (Chen et al., 2006). Limited farmer experience in Montana has since shown increased yield potential with Montana winter lentil.

- Winter pea has consistently shown faster biomass accumulation within the growing season highlighting potential for high quality forage production, or as a green manure (Miller et al., 2008). Biological N fixation has begun sooner in the winter, resulting in greater N fixation by a given calendar date or when the season is terminated by early summer drought. However, the depth of soil water extraction did not differ between winter and spring types of pea or lentil, with no water use observed below 3 ft.

- Tall stubble was reported to increase WUE in spring pea and lentil (Cutforth et al., 2001). Stubble height effects on winter pea and lentil were inconsistent in this study. In fall 2002, precipitation was delayed until Oct 11, followed by cool growing conditions. Establishment, survival, and yield was superior in the warmer short stubble micro-environment. In fall 2003, September precipitation was insufficient to germinate pea and lentil, and no precipitation was received in Oct or Nov, resulting in zero survival for all winter pea and lentil plots. The farmer’s spring pea field yielded 30% greater in the tall stubble plots.

- In a related study in central Montana, with taller stubble conditions associated with much lower wheat yield potential, stubble height increased winter lentil yield consistently by 2.5 bu/acre; but not winter pea (Chen et al., 2006). Yield increase in winter lentil was associated with increased WUE and improved harvestability due to 1-inch taller plants. In subsequent observations, winter pea and lentil establishment and survival was optimized under light cereal residue conditions consistent with wheat yields of 30 bu/acre or less, or higher yields with straw removal.

- Winter lentil in tall stubble at Amsterdam, MT, June 16, 2003. Seeding date = Sep 13, variety = Exp Line ’79. (best case winter lentil)

- Spring lentil in tall stubble at Amsterdam, MT, June 16, 2003. Seeding date = Apr 9, variety = Richlea. (best case spring lentil)

- Citations


The authors gratefully acknowledge funding support from the USDA Cool Season Food Legume Program and farmer collaboration with Matt Fikkema, Belgrade, MT. Technical expertise was capably provided by Jeff Holmes, Mike Sill, and Marty Mathisen.