Adding Value to Field Peas: Understanding the Rotation Benefit

Patrick M. Carr, Glenn B. Martin, Burt. A Melchior
North Dakota State University Dickinson Research Extension Center

Research Summary

Field pea (*Pisum sativum* L.) is the most widely grown annual, cool-season pulse crop in North Dakota, in part because of perceived benefits to subsequent crops that result when pea is inserted into rotations. The objectives of this project were to determine the benefit of pea to hard red spring wheat (HRSW; *Triticum aestivum* L. emend. Thell.) in a HRSW-pea rotation, and quantify the relative contribution of pea on plant nutrient availability, plant available water, soil temperature, diseases and weeds to the rotation benefit. Dry conditions in 2004 and widespread infection by *Fusarium* head blight compressed differences over this 3-yr study, but grain yield still was elevated by an average of over 15% when HRSW followed peas compared with a continuous HRSW monoculture over this 3-yr study (2090 vs. 1800 kg/ha; P < 0.05). Likewise, larger kernels resulted when HRSW was grown following peas compared with a monoculture. A consistent effect of rotation on grain test weight and crude protein concentration of HRSW were not detected. Plant N yields were greater for HRSW following pea compared with a continuous wheat monoculture, indicating that the rotation benefit pea also results from a positive effect on the soil N pool. However, the impact of pea on soil N are complex and not fully understood, although soil samples still are being processed and analyses of these additional data may allow a cause and effect relationship of pea on soil N and subsequently HRSW performance to be established. Consideration of root disease incidence, soil temperature, and soil water content failed to explain rotation benefits provided by pea to HRSW consistently. Results of this research will be summarized and published over the next 12-mo period.

Introduction

The benefit of field peas when rotated with spring wheat and other small grain crops to cereal grain yield is documented. Grain yield increases of more than 20% have occurred when wheat or barley followed field peas rather than small grains in the prairie region of Canada (Wright, 1990; Stevenson and van Kessel, 1996) and eastern North Dakota (Meyer, 1987). Yield increases ranging from 17 to 34% have resulted when spring wheat followed field peas rather than wheat in an ongoing study at Dickinson, depending on the year (unpublished data). Assigning an economic value to the rotation benefit of field peas has been elusive, in part because the reason[s] for the rotation benefit are not understood completely.

Work on the impact of field peas in crop rotations has focused almost exclusively on determining the fertilizer replacement-value of field peas (Gardner, 1992). Canadian research suggests that biological N-fixation fails to explain a majority of the rotation benefit from field peas to spring wheat and other crops (Stevenson and van Kessel, 1996). A few studies have considered the impact of field peas on soil water content in North Dakota, but much of this work was limited in duration and none of the results were published. The impact of field peas on disease in subsequent crops was considered at Mandan in a 2-yr study (J. Kuprinsky, personal communication, 2001). However, the duration of the study limits application of the results to environments like those that existed during the single year that the crops followed field peas.

No effort has been made to quantify the various factors that together explain the benefit provided by field peas to subsequent crops in North Dakota. The lack of research on the non-N rotation benefits of field peas is surprising; field pea growers have identified research on the impact of field peas on subsequent crops as among the top ten priority areas of research in surveys conducted by the North Dakota Dry Pea and Lentil Association. Our objectives were to determine the rotation benefit of peas to hard red spring wheat (HRSW) for yield and quality, and to determine the relative contribution of peas on plant nutrient availability, plant available water, soil temperature, diseases and weeds to the rotation benefit.

Materials and Methods

A 3-yr study was conducted during 2003, 2004, and 2005 in plots managed under conventional-tillage (CT), reduced-tillage (RT), and no-tillage (NT) methods since 1993. Beginning in 1999, both a HRSW-pea rotation along with a continuous HRSW monoculture were established and maintained across the three tillage environments. Treatments were in a randomized complete block design with a split-plot arrangement. Tillage treatments comprised whole plots and cropping system comprised subplots. All phases of both cropping systems occurred each year.

Results and Discussion

Precipitation was 75% of the l00-yr average of 243 mm during the growing season (01 Apr. through 31 July) in 2003, 56% of the average in 2004, and 142% of the average in 2005. Temperatures during the growing season were near the long-term average of 13°C. Water stress conditions developed and persisted during both 2003 and 2004, whereas relatively wet conditions favored the development of *Fusarium* head blight in HRSW during 2005.

Grain yield averaged 2090 kg/ha for HRSW following field peas compared with 1800 kg/ha in the monoculture across the 3-yr. Decreases in tillage also enhanced HRSW grain yield; yield averaged 1690 kg/ha under CT and 2330 kg/ha under NT. The combined effects of rotation and tillage elimination were additive and elevated grain yield by 55% in the wheat-pea rotation under NT compared with the continuous HRSW monoculture under CT.

Larger kernels were produced by HRSW in a HRSW-pea rotation compared with a continuous wheat monoculture. However, grain test weight and crude protein concentration were not affected consistently by rotation. In contrast, crude protein was over 10 g kg^{-1} lower in NT compared with CT plots, even though enough fertilizer N was applied in each plot for a 3360 kg ha^{-1} yield goal based on soil test results. Grain N yield (the product of grain yield and N concentration) was greater for NT than CT, so the lower grain protein concentration under NT probably resulted from a yield-induced N deficiency. Still, these data suggest that fertilizer recommendations may need adjustment when CT is replaced with NT for grain protein content to be maintained, even after 10 or more years after moving to NT.

Consideration of soil N (nitrate, ammonium, total) following pea did not explain the grain yield elevations for HRSW consistently, but some soil samples collected during the late summer and fall in 2005 were not analyzed prior to writing this report. Inclusion of these soil samples into the data set along with additional analyzes could make the impact of pea on the soil N pool easier to understand. The additional soil samples may also help explain why no differences in soil N levels across tillage treatments were detected.

Soil water content was unaffected by cropping system in this study. Conversely, preliminary analyses indicate that an additional 22 mm of soil water occurred in the 0- to 30-cm soil depth under NT compared with CT. Likewise, soils under NT were cooler during and for several weeks after planting. The combination of cooler soil temperatures and greater soil water content may explain partially the elevated grain yields for HRSW under NT compared with CT in this study.

This study demonstrated a positive rotation effect from pea to HRSW in southwestern North Dakota that averaged over 15%. Much of this benefit may result from result from the impact of pea on available soil N, although the mechanisms involved are unknown. Preceding HRSW with pea seems to have little if any impact on soil water content and soil temperature compared with preceding HRSW with HRSW. These results suggest that future research on the rotation benefits of pea and other pulses should focus on the N-fixing ability of the legume species and how this affects the soil N pool.

The positive benefits resulting from replacing CT with NT in southwestern North Dakota were demonstrated in this study. Grain yield increases of almost 40% were demonstrated for HRSW, suggesting that the yield benefits may justify the additional equipment expenses that must be incurred when switching tillage systems. Results of this research demonstrated that much of the benefit occurs because of the conservation of soil water which results as crop residue is left on the soil surface and not incorporated.

More thorough summaries of this study will be prepared by the end of 2006.

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