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 peas (*Pisum sativum* L.) are the most widely grown annual, cool-season pulse crop in North Dakota, in part because of perceived benefits to subsequent crops that result when peas are inserted into rotations. The objectives of this project are to determine the benefit of peas to hard red spring wheat (HRSW; *Triticum aestivum* L. emend. Thell.) in a HRSW-pea rotation, and quantify the relative contribution of peas on plant nutrient availability, plant available water, soil temperature, diseases and weeds to the rotation benefit. Dry conditions developed and persisted during the growing season in 2004, shrinking the difference in grain yield when HRSW followed peas compared with a continuous HRSW monoculture that existed in 2003. Still, grain yield was elevated following peas (1759 vs. 1578 kg/ha; $P < 0.05$). Likewise, larger kernels resulted when HRSW was grown following peas (37 kernels/g) compared with a monoculture (35 kernels/g), but differences were not detected for grain protein concentration or test weight. Consideration of soil N (nitrate, ammonium, total) and water levels failed to explain the pea rotation benefit to HRSW, but there was a non-significant trend for more discoloration of the subcrown internode ($P = 0.07$) of HRSW plants in a monoculture. These data along with data collected in 2003 suggest that the rotation benefit from peas partially may result from suppression of root rot pathogens. This work will continue in 2005.

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when spring wheat followed field peas rather than wheat in an ongoing study at Dickinson, depending on the year (unpublished data).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. The objectives of this research are: (1) determine the rotation benefit of peas to hard red spring wheat (HRSW) for yield and quality; and (2) quantify the relative contribution of peas on plant nutrient availability, plant available water, soil temperature, diseases and weeds to the rotation benefit.

Materials and Methods
The study is located in conventional-, reduced-, and no-till plots at the Dickinson Research Extension Center so that both the N non-N rotation benefits from field peas can be determined across a range of soil temperature and moisture environments. The tillage plots were established in 1993. Continuous wheat and wheat-pea rotations were established in the plots in 1998 and 1999, respectively, so both cropping systems already have been in place for several years. Plots are arranged in a randomized, complete block design in a split plot arrangement. Tillage system comprises whole plots and cropping system comprises subplots. Whole plots are 4500 ft^2 (90 by 40 ft). Subplot dimensions are 30 ft by 40 ft.

Whole and subplot treatments are replicated four times.

Each whole plot and subplot treatment is established and maintained using commercial-scale equipment following recommended agronomic procedures for optimum production of field peas and spring wheat. Soil temperature and water data are collected from subplots in two replicates. Wheat vegetative (stand counts, tiller development, spike and kernel density, and foliar and root pathogen incidence) and reproductive (grain yield, test weight and kernel weight) growth data are collected in each subplot in all four replicates. Crude protein concentration of wheat grain are determined each year, as are the economic returns for both the continuous spring wheat monoculture and the spring wheat-pea rotation. Field pea plant growth (stand counts, nodule production, days to flowering and flowering period, biomass production) are determined in field pea subplots. Plant N content is determined in field pea and wheat subplots in 2 blocks at 30-, 60-, and 90 days after sowing. Weed biomass production is determined in each plot at these same times.

Soil N content (total, nitrate, and ammonium) is determined at the 0- to 2-ft depth in the fall, prior to sowing plots in the spring, and at 30 and 60 days after planting. Soil N content also is determined at the 2- to 4-ft soil depth in the fall.

Data within the experiment is analyzed using PROC GLM available from SAS. Tillage environments and crop rotations are considered fixed effects, while replications and years are considered random effects. Mean comparisons are made with a protected LSD where *F*-tests indicate that significant differences exist between treatments ($P \leq 0.05$).

Results and Discussion

Objective 1. Dry conditions developed and persisted during the growing season (April through August) in 2004, when only 56% of the 30-yr average of 284 mm of precipitation was received. Grain yield averaged 1759 kg/ha for HRSW following field peas compared with 1578 kg/ha in the monoculture (an 11% yield increase due to rotation). Decreases in tillage also enhanced HRSW grain yield; yield averaged 1310 kg/ha under CT and 2117 kg/ha under NT (a 62% yield increase due to eliminating tillage). The combined effects of rotation and tillage elimination were additive and elevated grain yield by 73% in the wheat-pea rotation under NT compared with the continuous HRSW monoculture under CT. Analyses of the data collected in 2004 along with data collected in 2003 indicate a consistent positive effect of peas on HRSW grain yield in a HRSW-pea rotation compared with a continuous HRSW monoculture.

Likewise, differences in grain protein concentration ($P = 0.08$), test weight ($P = 0.53$), and kernel weight ($P = 0.09$) were not detected between tillage systems. These results along with those collected from this study in 2003 fail to indicate a trend in grain quality for HRSW rotated with peas.

Objective 2. Soil N (nitrate, ammonium, total) levels did not explain the grain yield elevations for HRSW when rotated with peas compared with a continuous HRSW monoculture. Similarly, soil water content was similar between HRSW plots seeded previously with peas compared with HRSW. Conversely, an additional 16 mm of soil water occurred in the 0- to 15-cm soil depth under NT compared with CT, and may explain the superior plant stand that developed under NT (data not provided). Improvements in crop stand may help explain the elevated grain yield that occurred under NT. Consistent trends in soil N content were not detected across the tillage systems. There was a non-significant trend ($P = 0.07$) for greater discoloration of the subcrown internode among HRSW plants in a continuous monoculture compared with plants in the HRSW-pea rotation. Discoloration of the subcrown internode can indicate the prevalence of root pathogens. Likewise, depressed crown and seminal root numbers may indicate root pathogen prevalence, but differences in root numbers between HRSW plants following peas and in a monoculture were not detected for crown roots ($P = 0.76$) and seminal roots ($P = 0.09$). Crown root numbers were depressed in the monoculture compared with the wheat-pea rotation in 2003, but seminal root numbers were unaffected. The 2003 and 2004 results suggest that rotating HRSW with peas may reduce the incidence of root rot pathogens in HRSW, although the impact of peas on HRSW root disease is inconsistent.

Soil temperature was cooler under NT than CT at the time of seeding and for several weeks thereafter in 2004. Likewise, colder soil temperatures occurred in plots in continuous HRSW plots compared with plots where peas preceded HRSW. As a result, stand establishment was slower in the monoculture than in the HRSW-pea rotation. Earlier establishment generally favors grain yield and quality in southwestern North Dakota, and the faster establishment of HRSW plants because of warmer soil temperatures may have contributed to the rotation benefit provided by peas.

Literature Cited

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