Nitrogen Cycling from Pea Forage to Wheat in No-Till Systems

Perry Miller[1], Dave Wichman[2], and Rick Engel[1]
[1]Dept. of LRES, MSU-Bozeman, Montana, [2]Central Ag. Research Center, Moccasin, MT

Fertilizer Facts
Fertilizer √off
February 2008
Number 51

Introduction

Pea forage could provide an economic incentive for a summer fallow alternative (Miller et al., 2007). However, farmers need to know how different pea forage management practices affect: 1) forage yield and quality, 2) yield and quality of a subsequent wheat crop, and 3) the nitrogen (N) fertilizer equivalent. Our objectives were to measure forage yield and quality differences among winter and spring pea and barley, and to compare cropping sequence effects on wheat in no-till systems. Our goal was to measure the N fertilizer equivalent of pea forage managed under different scenarios.

Methods

Field trials were conducted at Amsterdam (deep silt loam) and Moccasin (variably shallow clay loam) from 2003-2006 at sites previously cropped to wheat under no-till management. Four two-year cropping sequences were compared at each site: winter pea forage-wheat, spring pea forage-wheat, hay barley-wheat, and chemical fallow-wheat. All treatments were conducted under no-till management. Two forage harvest timings (first bloom and plump pod) were compared during the first year of the rotation. Forage barley timing followed the spring pea schedule. Glyphosate was not completely effective at terminating plant stands, even when applied prior to forage harvest. All year-1 crops received 30 lb N/ac except pure hay barley which received 60 lb N/ac. At Amsterdam only, plant available soil water and nitrate samples were taken in early spring and in late summer in year-1. Year-2 treatments included four N rates (0, 45, 89, & 134 lb/ac) on spring (2004) or winter (2006) wheat.

Results

Pea Forage Yield and Quality

Forage yield did not differ consistently among crops. Barley forage yield was the most variable, ranging from 0.3 to 2.2 ton/ac at early harvest and from 0.7 to 3.2 ton/ac at late harvest. Mixing barley with spring pea improved yield consistency somewhat. Pea forage yield at Moccasin (1.3 ton/ac) was 75% of the yield at Amsterdam (1.7 ton/ac) averaged over 2 yr. Pea forage yield at first flower (1.1 ton/ac) was 58% of the yield at plump pod (1.9 ton/ac) averaged over 4 site-yr.

Since forage was harvested fresh and dried in an oven, quality was maximized in the absence of possible weathering damage in the field. Pea forage was very high quality, with a Relative Feed Value consistently > 151. Averaged over 4 site-yr, winter pea forage delivered 90% greater (i.e. nearly double), and spring pea 64% greater, total protein yield than hay barley. In this study, the proportion of pea forage in a targeted 50:50 pea:barley ratio varied from 27 to 46% and increased forage quality importantly. Nitrate content in all barley forage was very low.

Soil Water Effects (Amsterdam only)

Forage crop soil water use was compared with chemical fallow as the 'control'. Soil water use due to forage production averaged 2.5, 2.8, and 3.0 in. for winter pea, spring pea, and barley, respectively. Harvesting early at the first bloom stage used 2.5 in. of soil water compared with 3.1 in. when forage harvest was delayed until plump pod (approx. 3 wk). The most water conservative strategy was winter pea harvested at first bloom with 2.1 in. of soil water use.

Wheat Yield Response to Previous Crop

At Moccasin, wheat yields were not affected by the year-1 forage treatments, and were equal to the chemical fallow control on those shallow soils. However, several interesting effects occurred on the deeper soils at Amsterdam. There, in both years, wheat yield was affected by the previous crop, forage harvest timing, and N fertilizer rate. The yield of wheat on pea was superior to on barley at both forage harvest timings (Fig. 1). This cropping sequence response has been commonly observed in the semiarid northern Great Plains whereby wheat yield on pea stubble was intermediate between yields on fallow and cereal stubble. Under early forage harvest management and a low N fertilizer rate (i.e. 45 lb N/ac), yield of wheat increased to 59 bu/ac following winter pea, nearly equal with chemical fallow (63 bu/ac: Fig. 1).

Grain protein is an important factor

MONTANA STATE UNIVERSITY EXTENSION SERVICE
Extension Service
Agricultural
Experiment Station

for wheat value. In this study the barley forage treatments consistently produced the lowest protein wheat, and winter pea forage treatment the highest. The winter pea early forage harvest produced 0.9% greater wheat protein than fallow, and 1.2% greater protein than wheat following hay barley (Fig. 2).

When harvested at first bloom, the winter pea forage treatment likely had less plant available water than chemical fallow because there was a small yield reduction (Fig. 1) accompanied by a higher grain protein concentration (Fig. 2), and equal total grain N yield.

Forage pea's soil N contribution

Compared with hay barley, forage pea averaged 18 lb/ac of additional N uptake in the harvested grain of wheat, and ranged from 11 to 29 lb N/ac. Grain N uptake was 24 lb N/ac greater following winter pea and 13 lb N/ac greater following spring pea than grain N yield following hay barley. It typically takes about 2 lb of fertilizer N to increase wheat grain N uptake by 1 lb, suggesting that N fertilizer savings may be even higher than these N uptake differences

Effect of early forage harvest of pea on available N

In this study, grain N uptake by subsequent wheat increased by 4 lb N/ac (spring pea) to 12 lb N/ac (winter pea) with early forage harvest. This response was partially related to conserved soil water.

Fertilizer Facts:

- Winter pea was a superior forage pea due to better synchrony of crop growth with rainfall.
- Nitrogen contribution from pea forage to the next crop in no till systems was substantial when compared with hay barley on deep soils.

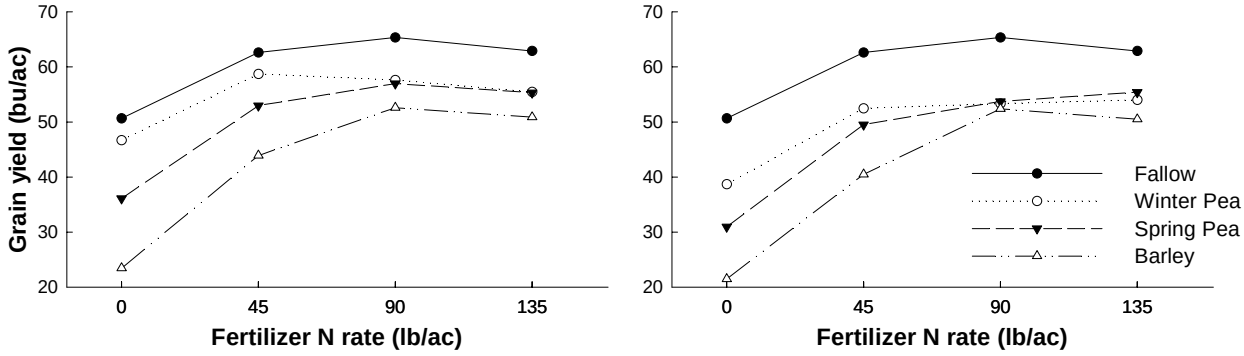

Figure 1. Wheat grain yield following chemical fallow, winter pea, spring pea, and barley forage at first bloom (left) and plump pod (right), Amsterdam, MT, 2004 and 2006.

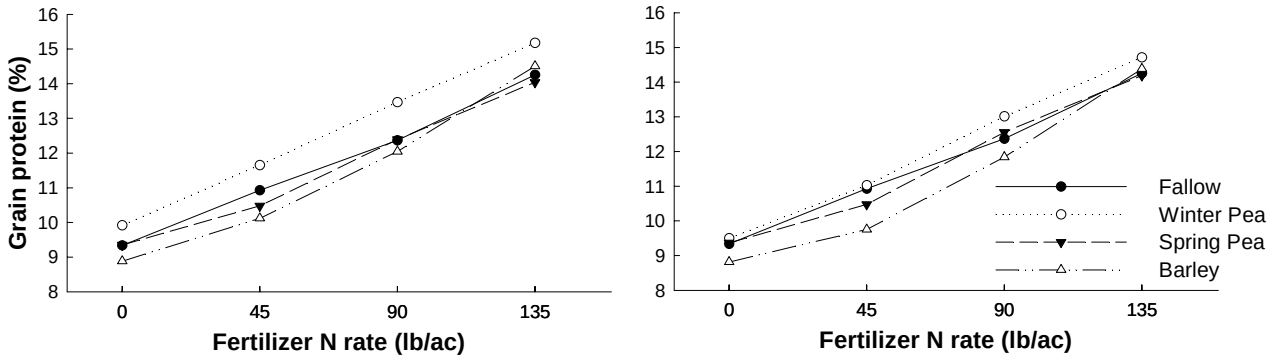

Figure 2. Wheat grain protein following chemical fallow, winter pea , spring pea, and barley forage at first bloom (left) and plump pod (right), Amsterdam, MT, 2004 and 2006.

Reference:

Miller, P., R. Engel, and J. Holmes. 2007. Cropping sequence effect of pea and pea management on spring wheat. Fertilizer Fact No. 45. MSU Extension Service, Bozeman, MT.

Acknowledgements:

This research was funded by MFAC and MAES. Invaluable farm field access was provided by Matt Flikkema at Amsterdam.

Edited by Clain Jones, Extension Soil Fertility Specialist, and Elizabeth D'Imperio, Research Associate