Cropping Sequence Effect of Pea and Pea Management on Spring Wheat

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Introduction

Producers have questions about the effect of pea harvest management on soil N contribution in no-till systems. For example, pea forage could provide an economically viable summer fallow alternative but it is crucial to know how forage removal affects N contribution. Previous studies of annual legume green manures in the semiarid Northern Plains were done in tilled systems. Our objectives were to compare cropping sequence effects of pea with fallow and other crops in no-till systems. Specifically, the goal was to measure the effects of pea harvest timing and shoot biomass presence on soil water use, soil N contribution, yield, and grain quality of subsequent wheat.

Methods

Cropping sequence experiments were conducted in 1999-2001 at Amsterdam, Denton, and Havre. All trials began in wheat stubble fields with at least 3 years of no-till management. The sites received normal to below normal annual precipitation. Treatments included year-1 crops (pea, mustard, & spring wheat) plus chem fallow, harvest timing (early flower or maturity), biomass presence or absence, and four N rates (0, 20, 40, & 80 lb/ac) on a spring wheat crop (year-2). Harvest timing for all crops matched pea. At the mid-season harvest, crops were sprayed with glyphosate and biomass left in place or removed. Similarly, at maturity, each crop was harvested for grain and the straw was left on the plot or removed.

Plant available soil water (PASW) and nitrate-N (NO_3-N) soil samples were taken at seeding and after harvest in year-1, and before seeding in year-2. Soil depth varied among sites; 2 ft at Denton, 3 ft at Havre, and 4 ft at Amsterdam. In year-1, N fertilizer was applied to mustard and wheat plots to achieve 60-80 lb/ac of total available N (soil + fertilizer N). Although N levels were modest, wheat grain protein was consistently greater than 13.4%, indicating that N did not limit wheat yield (Engel et al., 1999). Fertilizer P, K, and S, were also applied.

Results

Year-1 Crop Management Effects

The effects of year-1 crop and pea management on soil N were inconsistent among sites. At seeding of year-2 wheat, no soil N differences occurred among crops at Amsterdam or Denton. However, at Amsterdam early termination of pea increased soil N by 26 lb/ac. At Havre, spring soil NO_3-N levels were greater under pea than for mustard, wheat stubbles, and chem fallow. Soil under the chem fallow treatment was saturated in early spring and substantial N losses probably occurred as a result of denitrification. This was shown by the fact that spring soil N levels were significantly lower ($P<0.05$) than the preceding fall. Soil N was measured in the 2 to 3-ft soil layer to see if measurable N leaching occurred from upper to lower soil layers and this was not found.

Striking soil water effects were observed under the droughty conditions at Havre. For the mature harvest, pea held 0.75 in. greater PASW than mustard (data not shown), but 2.25 in. less PASW than chem fallow. However, early harvest of pea conserved an additional 1.5 in. of PASW (Figure 1). At Amsterdam only minor differences were observed among crops and chem fallow, however early harvest of pea conserved an additional 0.75 in. of PASW. Neither year-1 crop differences nor pea management affected PASW in the shallow soil at Denton.

Year-2 Wheat Test Crop

Spring wheat yield in the chem fallow control ranged from 28 to 43 bu/ac among all sites. At Denton, there were no treatment effects on soil N or PASW. Wheat following wheat that was harvested for grain with straw 'present', yielded 38% less than chem fallow due to disease localized within those plots.

At Havre, the previous crop and harvest timing affected both soil N and PASW; a drought from 2 June to 5 July made water the key limiting factor. The results highlight the benefit of using pea for an early forage crop instead of harvesting as a seed crop. Pea harvested for forage during early flower resulted in a similar soil water status as chem fallow (Figure 1), which mirrored closely the year-2 wheat yield (Figure 2).

Adequate PASW and growing season rainfall made soil N the key limiting factor at Amsterdam. Grain N uptake by year-2 wheat was greatest following pea or chem fallow, and lowest following mustard or wheat (P<0.01; data not shown). Averaged over management treatments and N fertility rates, year-2 wheat took up 7 lb N/ac more in its grain when following pea, compared with mustard or wheat treatments. Early termination of pea resulted in 12 lb greater N uptake in the grain compared with pea grown to maturity.

How large was pea's soil N contribution?

At the most N responsive site (Amsterdam) pea stubble caused 7 lb/ac greater grain N uptake in subsequent wheat, compared with mustard and wheat stubbles. It is likely that an added small amount of N would have been contributed to grow the straw portion of the year-2 wheat, possibly another 3 lb of plant N uptake, for a total N contribution of 10 lb. This value may be equal to 20 lb of N fertilizer, assuming a 50% N fertilizer uptake efficiency. At Denton, no N contribution was associated with pea, and at Havre, the N contribution of pea was strongly confounded with effects on soil water.

Does early harvest of pea affect available N?

In this study, harvesting pea at flowering resulted in greater (approx. double) N contribution to a subsequent wheat crop than when harvested for pea seed. The soil processes by which this occurs are not well understood.

Did pea biomass have to be present for rotational N benefits?

Not at any site or harvest timing did soil N contribution increase by leaving green or mature pea biomass on the soil. This finding speaks only to short term effects which may not hold true in the long term. Research is needed to investigate long term effects of pea biomass removal on soil N contribution.

Fertilizer Facts:

- Annual pea N contribution to the soil in no till systems is dependent on current soil N levels and PASW.
- Harvesting annual pea early conserved more water than harvesting at maturity and increased available N for subsequent crops.
- In this two-year study, leaving green or mature pea biomass on the surface did not contribute to increased soil N levels. Long term research is needed to measure the long term N benefits from peas within dryland cropping systems.

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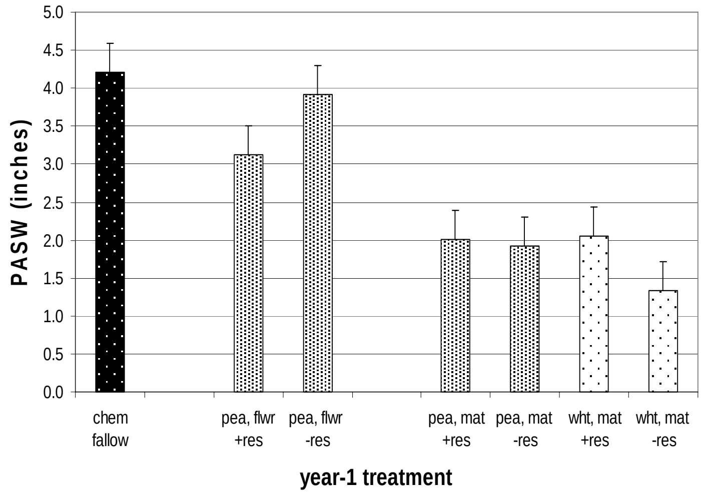

Figure 1. Plant-available soil water (PASW) at seeding April of year-2 spring wheat crop following year-1 crop management treatments, Havre, MT, 2000. (flwr-terminated at flowering; mat-harvested at maturity; res–residue).

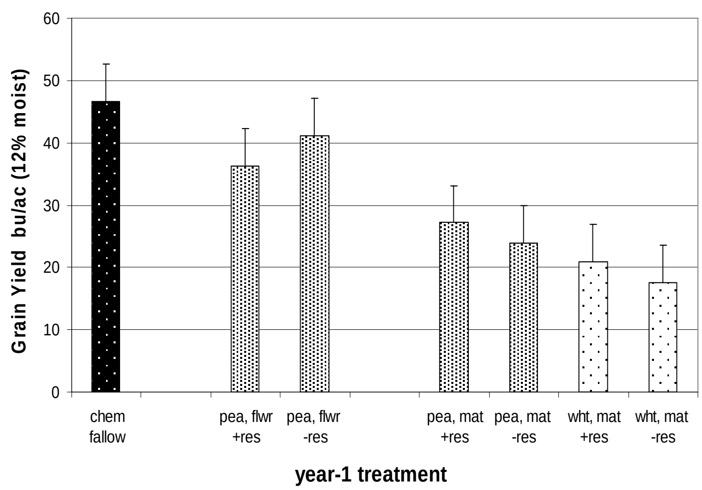

Figure 2. Year-2 spring wheat yield (fertilizer N rate, 40 lb/ac) following year-1 crop management treatments, Havre, MT, 2000.

Reference:

Engel R.E., D.S. Long, G.R. Carlson, and C. Meirer. 1999. Method for precision N management in spring wheat: I. Fundamental relationships. Prec. Agric. 1:327-338.

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