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Crop Rotation and N Rate Effects on Net Returns and Soil pH

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INTRODUCTION

Farmers in north central Montana (aka 'Golden Triangle') have questions about risks of cropping intensity and nitrogen (N) fertilizer strategies under low precipitation. A 10-yr study in wetter southwestern Montana demonstrated superior economic resilience provided by pea in rotation with wheat under contrasting available N fertility rates and uncertain wheat protein discount/ premium schedules (Miller et al. 2015). A daughter study was initiated west of Big Sandy, MT, to investigate whether this long-term economic response is also observed in a drier climate. Our objectives were to compare winter wheat yield and quality, agronomic efficiency of fertilizer use, and economics of four alternative crop rotations managed with four different N fertility rates (0, 75%, 100%, 150% of recommended).

METHODS

This plot-scale study began in 2012 at Big Sandy (sandy clay loam), managed as low-disturbance no-till (disk drill), and included four cropping treatments in rotation with winter wheat, ranging from low to high drought risk: 1) Chem fallow, 2) Cover crop (herbicide-terminated, except hayed in 2018), 3) Pulse crop harvested for grain, and 4) Spring wheat (Table 1).

All wheat varieties were considered sawfly-tolerant and rotations were managed with four target N availability levels for wheat ranging from no fertilizer applied to 150% of a 3 lb available N/bu rate. The 3 lb N/bu rate is midway between winter wheat and spring wheat MSU guidelines (Jacobsen et al. 2023).

Soil nitrate N was measured 3 ft deep prior to wheat planting and additional legume credits were used for pulse crops harvested for seed (9 to 13 lb/ac) and for pea manure (18 to 26 lb/ac). Target wheat yields after fallow were set to reflect a high potential yield for that field (50 bu/ac); wheat target yields after fallow and cover crop were set equal while the continuous wheat yield goal was reduced by 33%. The yield goal for the pulse–wheat rotation was set at 10% greater than continuous wheat, thus requiring correspondingly greater available N. But rarely was more N fertilizer needed due to the N provided by the pulse rotation.

Net returns to land and management were calculated ignoring crop insurance or USDA Farm Program payments. Fertilizer prices were set as a 2-yr average based on actual fertilizer prices monitored bi-annually by the Montana Department of Agriculture, while pesticide/ adjuvant and custom machinery rates were taken from NDSU sources. Seed and rhizobial inoculants were based on farmer-reported costs in similar situations. The base price for pulse crops was set at a 24-month average for publicly offered prices in Montana centered on harvest. The base price for wheat was set at a 36-month average from July prior to wheat harvest until June two years after wheat harvest. Hay price for the cover crop in 2018 was considered $45/ton 'on the stump'. Protein discount/ premium schedules were applied in two ways based on data collected from 40 Montana grain elevators from 2001-2012. During those 12 years, 'Steep' discount schedules occurred in five years and a 'Flat' market response in seven years. Equations were generated to reflect the average of the 'Flat' and 'Steep' response scenarios.

In mid-September 2019, two top 3-inch soil cores were collected with a hydraulic probe in each subplot and mixed for laboratory pH analysis (1:1 water:soil by volume).

All treatment differences are reported with 95% confidence ($P < 0.05$).

RESULTS

Pulse- and fallow-wheat rotations had the highest (and similar) net returns. Pulse-wheat had higher net returns than fallow when no N was applied under Flat protein discounts (Fig. 1A) and with no added N and 100% N for Steep protein discounts (Fig. 1B). Cover-wheat and continuous wheat rotations had similarly lower net returns. Continuous wheat had net loss when no N was added during Flat protein discounts (Fig. 1A) and when less than 100% recommended N was supplied during Steep protein discounts (Fig. 1B).

Table 1. Cropping sequences for each of four rotational systems, Big Sandy, MT, 2012 – 19.

Year	Fallow	Cover crop	Pulse	Continuous wheat
2012	Chem fallow	*Arvika* forage pea	*CDC Impress* lentil	*Choteau* SWht
2013	*Genou* WWht	*Genou* WWht	*Genou* WWht	*Genou* WWht
2014	Chem fallow	*Arvika* forage pea	*Stirling* green pea	*Duclair* SWht
2015	*Warhorse* WWht	*Warhorse* WWht	*Warhorse* WWht	*Warhorse* WWht
2016	Chem fallow	*Arvika* forage pea	*Stirling* green pea	*Duclair* SWht
2017	*Warhorse* WWht	*Warhorse* WWht	*Warhorse* WWht	*Warhorse* WWht
2018	Chem fallow	Barley, Faba, Radish mix*	*Orion* chickpea	*Duclair* SWht
2019	*Warhorse* WWht	*Warhorse* WWht	*Warhorse* WWht	*Warhorse* WWht

* A mix of *Hays* hay barley, *Felix* black fababean, and VNS tillage radish replaced *Arvika* forage pea due to excess soil N accumulation.

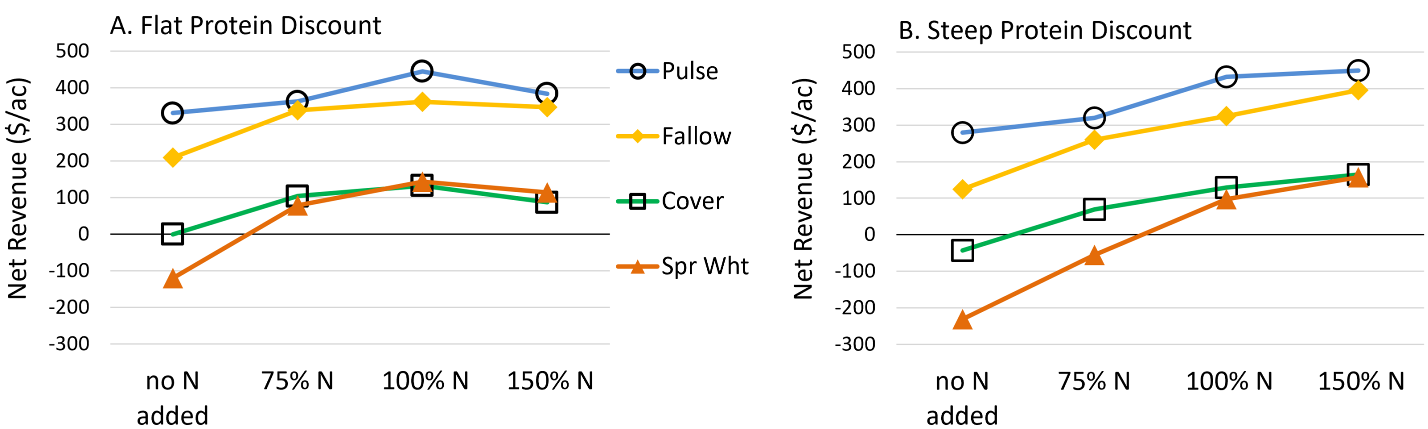

Figure 1. Total net returns after 8 years to land and management under assumed 'Flat' (A) and 'Steep' (B) protein discount schedules. All net returns are different than fallow EXCEPT pulse at 150% N at flat discounts and pulse at 75% N and 150% N at steep discounts.

In all rotations, net returns were greatest at 100% of recommended N under a Flat protein discount, but were greatest at 150% of recommended N under a Steep protein discount. Although this suggests that about 4.5 lb N/bu should be applied to maximize profit when protein discounts are steep, the profit gains between 100% and 150% might not be enough to offset the negative effects of increased soil acidification measured at greater N rates on this sandy loam soil (Fig 2.).

Soil acidification can lead to yield losses and is a growing issue in Montana (Jones et al. 2019; Jones and Olson-Rutz, 2020). Continuous wheat had lower soil pH than the pusle-wheat system (Fig. 3), a result also seen in the wetter Bozeman study (Jones et al. 2022). Fallow-wheat also had lower pH than pulse-wheat at Big Sandy possibly due to greater nitrate leaching, a result not seen at Bozeman. Due to high costs of mitigating low pH with lime, the short-term benefits of greater N rates might be partly or fully erased by liming costs at least on soils where the pH is already low. In addition, applying high N can lose money when discounts are flat.

FERTILIZER FACTS

- 100% of recommended N was most profitable under a Flat protein discount, while 150% of recommended N was most profitable under a Steep' protein discount scenario.
- Pulse-wheat rotations had equal or higher net returns than fallow-wheat systems during this 8-year study.
- Greater N rates led to lower soil pH, which could hurt yield or require lime.

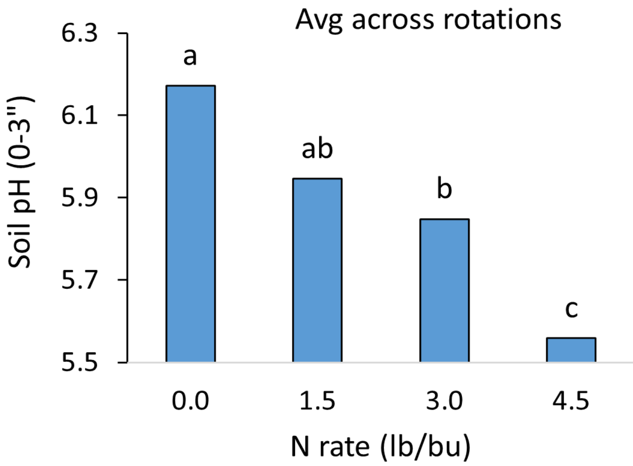

Figure 2. Soil pH after 8 years of different N rates.

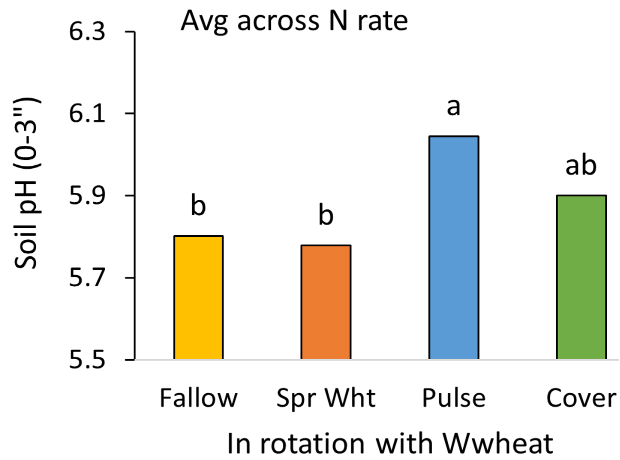

Figure 3. Soil pH after 8 years udner different crop rotations.

ACKNOWLEDGEMENTS

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