Crop and Soil Nitrogen Dynamics of Nine Rotation Systems During the Transition and Certified Organic Phases of Dryland Grain Production

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Introduction

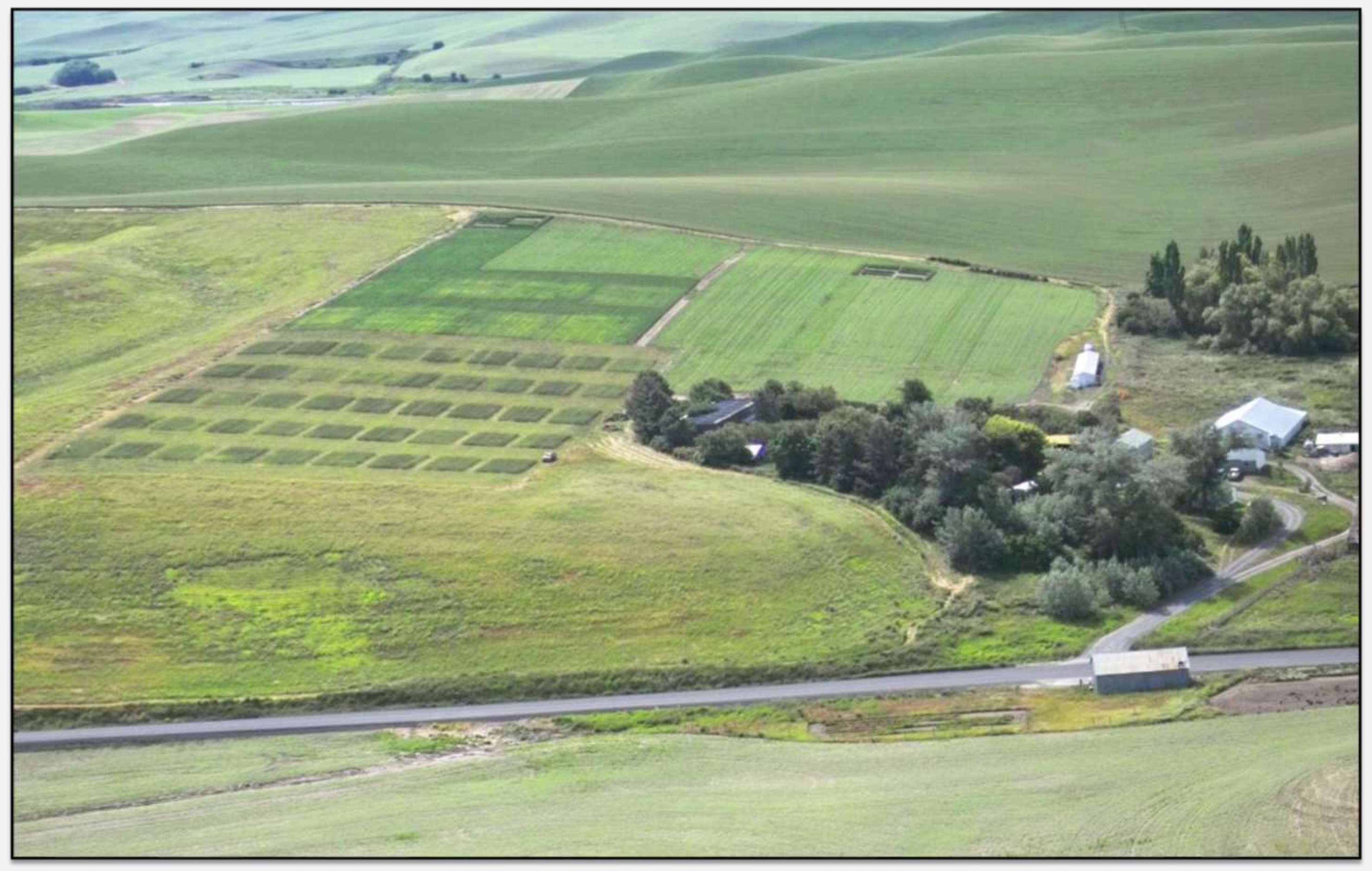
The dryland region of Eastern Washington is ideal for producing small grain cereal crops that have some of the highest yields in the nation. However, despite consumer demand and higher price incentives for growers, producing certified organic cereal crops is difficult. One main challenge is the limited availability of manure or other inexpensive sources of nutrients in this region. As a result, growers must rely on legume-based rotations to meet the nitrogen (N) needs of organic cereal crops. A long-term research study was initiated in 2003 in Pullman, WA (46° 45 min 1.6 sec N; -117° 4 min 55.1 sec W), to evaluate nine rotation systems designed to transition dryland cereals from conventional to organic production.

Objective

To design and evaluate alternative strategies for the mandatory three-year transition phase from conventional to organic cereal production in Eastern Washington. The intent of this poster is to present data on an N balance constructed for the transition years and crop performance data for the certified organic years.

Hypotheses

- Legume intensive systems will contribute higher N for the following cereal crop than cereal intensive systems.
- Residual soil N will be higher following the transition from legume intensive systems than from cereal intensive systems.
- Cereals need a legume for optimal N contribution when other nutrient sources are unavailable.



Materials and Methods

Nine cropping systems (Table 1) were evaluated ranging from intensive cereal production to intensive legume production for forage or green manure, as well as systems with alternating cereal grains and legumes. The experimental design was a Randomized Complete Block Design with five replications. Additional inputs from commercial organic fertilizers [Biogro® + gypsum (7 lbs N, 15 lbs P, K, S)] were included in small grain crop systems in 2003-04. The entire study was planted to certified organic spring wheat in 2006 (Split plots: Hard Red 'Tara 2002' and Soft White 'Alpowa') and winter wheat in 2006-07 (Soft White 'Madsen'). Samples of soil (1.5 meter depth; Fine-silty, mixed, superactive, mesic Pachic Ultic Haploxerolls), cover crop, weed and cash crop biomass were collected annually from each system and tested for inorganic and total N. These data were used to construct an N budget. Nitrogen inputs, net gains or losses, and soil inorganic N during the transition and certified organic phases were compared for each rotation system.

Table 1. Nine Cropping Systems Ranging from Intensive Cereal production to Intensive Legume production for the Transition Phase and Certified Organic Phase for Small Grain Production

	Transition Phase†			Certifiable Organic Phase§	
	Year				
System	2003	2004	2005	2006	2007
	Control Rotation				
1	Spring Wheat	Winter Wheat	Spring Barley	Spring Wheat	Winter Wheat
	3 yr of Grain Cropping				
2	Spring Pea	Winter Wheat	Spring Pea	Spring Wheat	Winter Wheat
3	Spring Pea	Spring Wheat	Spring Pea	Spring Wheat	Winter Wheat
	2 yr of Grain Cropping + 1 yr Green Manure				
4	Spring Pea	Winter Wheat	Winter Pea GM	Spring Wheat	Winter Wheat
5	Spring Pea	Spring Wheat	Winter Pea GM	Spring Wheat	Winter Wheat
	1 yr of Grain Cropping + 2 yr Green Manure				
6	Bean GM	Winter Wheat	Winter Pea GM	Spring Wheat	Winter Wheat
7	Bean GM	Spring Wheat	Winter Pea GM	Spring Wheat	Winter Wheat
	3 yr Green Manure				
8	Bean GM	Winter Pea GM	Winter Pea GM	Spring Wheat	Winter Wheat
	Legume/Grass Forage				
9	Alfalfa + Oat/Pea	Alfalfa + Oat/Pea	Alfalfa + Oat/Pea	Spring Wheat	Winter Wheat

†GM = green manure, flail mowed; alfalfa established poorly in 2003, but supplemented with oat + pea in 2003-2005.
§ Each spring wheat plot was split equally to a hard red (cv. 'Tara 2002') and soft white (cv. 'Alpowa') wheat variety.

Figure 1. Cumulative nitrogen gain or loss for each cropping system over the three-year transition phase (2003-05)

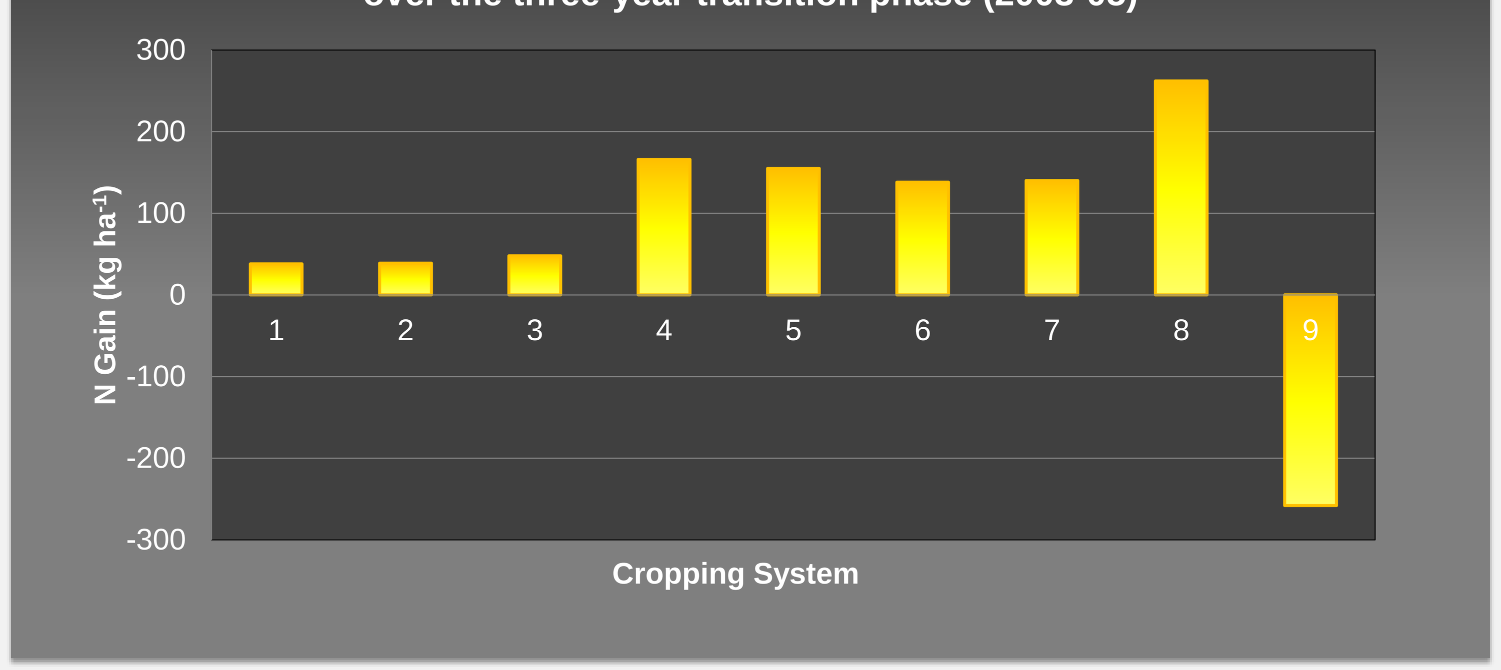


Figure 2. Residual soil inorganic nitrogen in spring 2006 following the transition to organic grain production

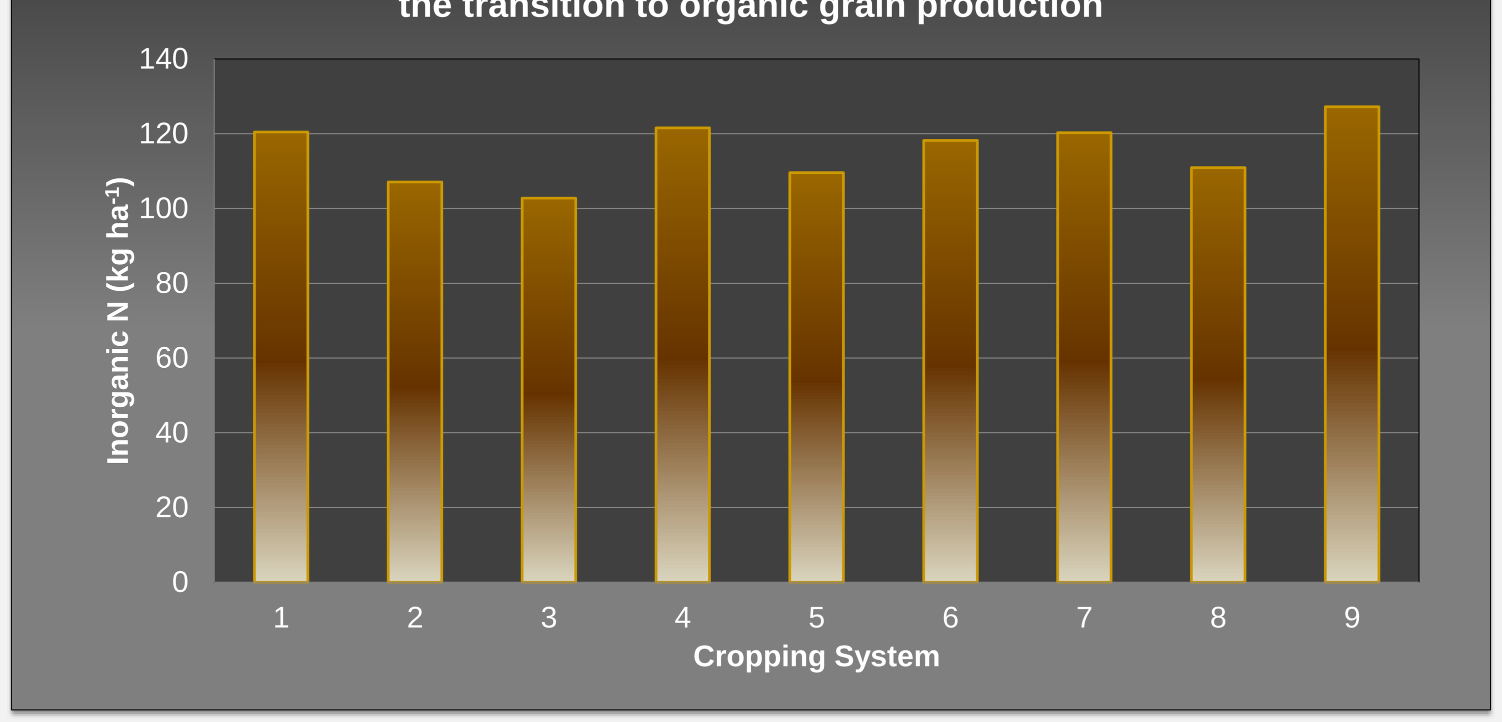


Figure 3. Average grain yield and protein content for hard red and soft white spring wheat in the first year of organic production in 2006

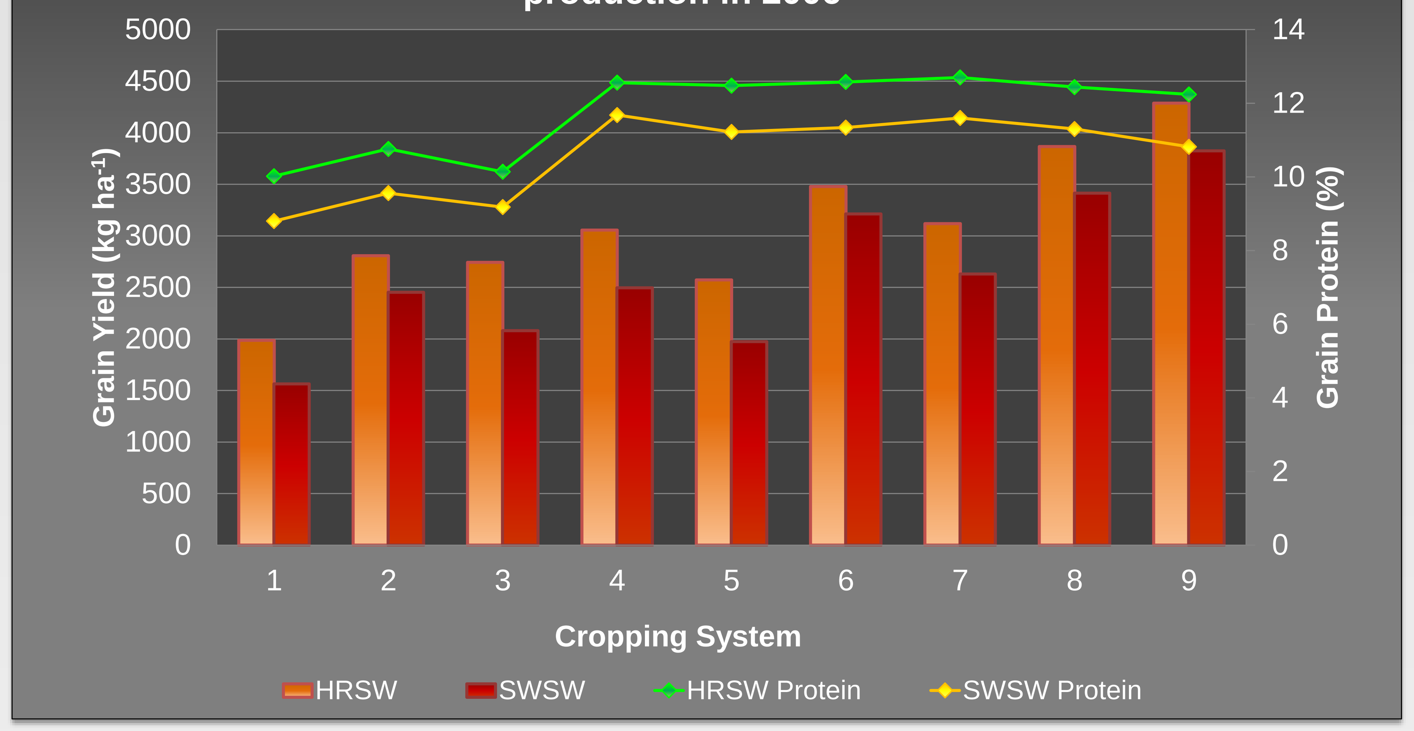
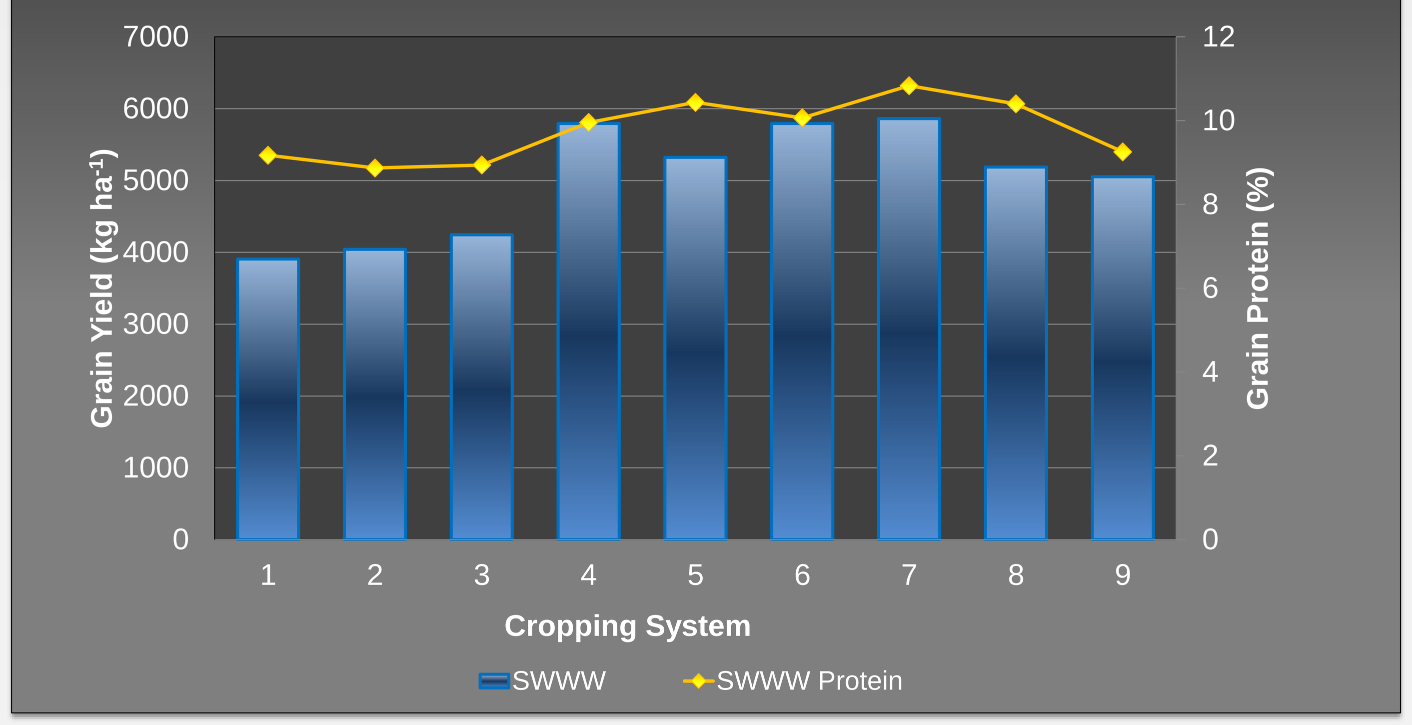


Figure 4. Average grain yield and protein content for soft white winter wheat in the second year of organic production in 2007



Summary

- Cumulative N gain was highest following three years of green manure (System 8) and lowest following cereal intensive rotations (Systems 1-3). A cumulative N loss occurred in following three years of forage (System 9; **Figure 1**).
- Little variation was found in residual soil inorganic N between systems following the transition phase (**Figure 2**). This is most likely the result of low production or crop failure in systems 1, 2 and 3 in 2005 and mineralization of residual N. In comparison, winter pea GM (Systems 4-8) grew well in 2005 and most likely contributed high amounts of N.
- Organic wheat yields and protein content were higher after transitioning from more intensive legume rotations compared to more intensive cereal rotations (**Figures 3 and 4**).
- Cumulative N loss occurred following three years of forage (System 9) as a result of forage removal as hay. However, organic wheat yields were highest in this system in 2006 suggesting that more N was mineralized by this system during the certified organic production years (**Figures 1 and 3**).
- Legume green manures and legume/grass forages have the potential to supply a source of N when transitioning from conventional to organic dryland cereal production (**Figures 2, 3 and 4**).

References and Acknowledgements

Gallagher, R.S., D. Pittman, A.M. Snyder, R.T. Koenig, E.P. Fuerst, I.C. Burke and L. Hoagland. 2010. Alternative strategies for transitioning to organic production in direct-seeded grain systems in eastern Washington I: Crop Agronomy. J. Sust. Agric. 34:483-503.
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