Crop Diversity Effects on Productivity and Economic Returns Under Dryland Agriculture

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Introduction

Increasing crop diversity has been identified as a method to improve long-term sustainability of crop production. However, understanding the economic viability of diverse cropping system is important if producers are to adopt these systems. In this study, crop productivity and economic net returns were evaluated for different levels of crop diversity in a long-term , field-scale, no-till cropping system study conducted at the Area IV Soil Conservation Districts Research Farm near Mandan, North Dakota.

Methods and Materials

Long-term crop rotation treatments were implemented over time on fields at the Area IV Farm. Crop rotation treatments included: Small grain –fallow (SG-Fallow); spring small grain – winter wheat – sunflower (SG-WW-Sun); pea-corn-soybean-spring wheat-winter wheat (Five Year); and a dynamic rotation where crop choices are made annually (Dynamic). The SG-Fallow and SW-WW-Sun rotations were established in 1984, Five Year was established in 2009, and Dynamic was established in 2001. Before 2009, fields included in the Five Year treatment were managed as a dynamic system with crop choices made annually. Field sizes range from 5 to 34 acres, are all predominantly on Temvik-Wilton silt loam soils, and were farmed with field-scale equipment. For the fixed rotations, each crop in each rotation was grown each year. All treatments were managed as no-till systems. Rotations are not replicated, except the SG-WW-Sun rotation, which has two replicates.

Data from 2004-2013 were used for this analysis. Yield data were collected from entire fields with all grain from each field weighed using a weigh-wagon. All management operations, and all seed, fertilizer, and pesticides were recorded annually for each field. Crop enterprise budgets were constructed for each field based on observed yield and management, using 2014-2015 input and machinery costs, and North Dakota annual crop prices (Zollinger et al., 2014; Swenson and Haugen, 2014; Lazarus, 2014 ; and USDA-NASS, 2015). Statistical analyses were conducted using mixed models in JMP 11.0, with crop or rotation modeled as a fixed effect and year as a random effect, with a significance level $\alpha=0.10$.

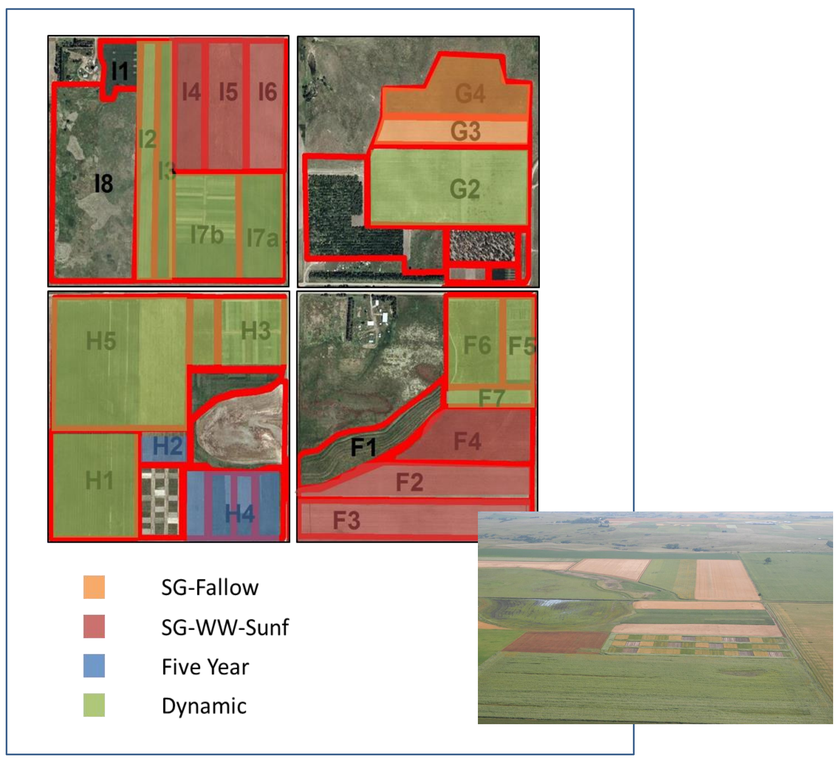

Figure 1. Area IV Research Farm Fields included in each rotation

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Results and Discussion

Crop diversity can improve economic performance in two main ways: 1) By improving productivity and reducing costs to produce the primary crops, and 2) by adding more profitable crops to the rotation.

Effects on primary crop:

Spring wheat and winter wheat are the predominant crops grown in the region.

- *Average spring wheat yield was significantly higher in SG-Fallow than the other rotations (Fig. 2a). However, only one crop is produced every two years in this rotation*
- *Average spring wheat yield increased numerically as crop diversity increased from SG-WW-Sun to Five Year to Dynamic. However, differences were not significant.*
- *No significant differences in winter wheat yields were detected (Fig. 2a)*
- *No significant differences in wheat production costs were detected (Table 1)*
  - ➢ *Average spring wheat net returns were highest for SG-Fallow, but this does on include the cost of the rotational fallow year when no income is generated (Fig. 2b).*
  - ➢ *Spring wheat net returns showed an increasing trend as crop diversity increased from SG-WW-Sun to Five Year to Dynamic. No significant differences were detected among winter wheat net returns.*

Table 1. Average annual spring wheat and winter wheat production costs for each crop rotation.

	Spring Wheat				Winter Wheat		
	SG-Fallow	SG-WW-Sun	Five year	Dynamic	SG-WW-Sun	Five year	Dynamic
Costs	---------- $ ha^{-1} ----------						
Machinery	109	127	121	116	122	122	116
Fuel	26	27	27	25	25	27	25
Labor	19	20	19	19	17	21	18
Fertilizer	133	145	138	134	141	158	150
Pesticides	105	105	116	104	102	93	90
Seed	49	55	56	50	44	49	39
Total Cost	441	480	477	448	451	468	439

Rotational crops:

Average net returns were calculated for each crop for all years in which they were grown over the period 2004-2013 (not every crop was grown every year).

- *Many crops had higher average net returns than spring wheat or winter wheat, so including these crops in a diverse rotation helped increase profitability of the rotation. A notable exception are losses during the fallow year (Fig. 3).*

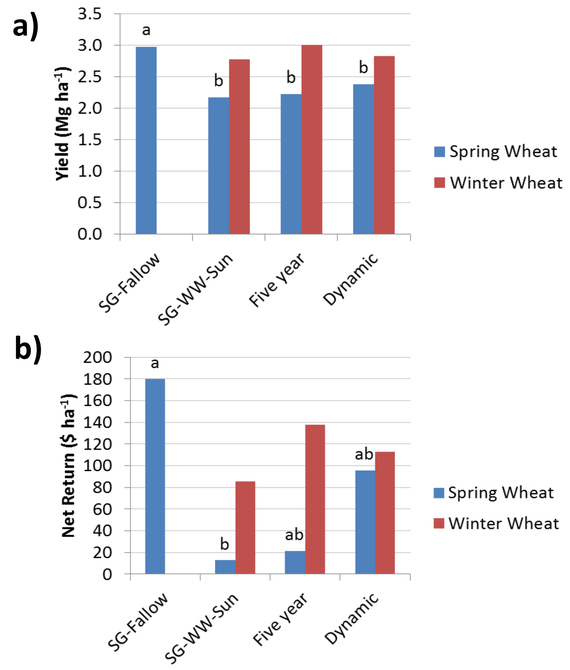

Figure 2. (a)Average spring wheat and winter wheat yields and (b) average spring wheat and winter wheat net returns for each rotation. Different letters within a crop indicate significant differences ($\alpha=0.10$).

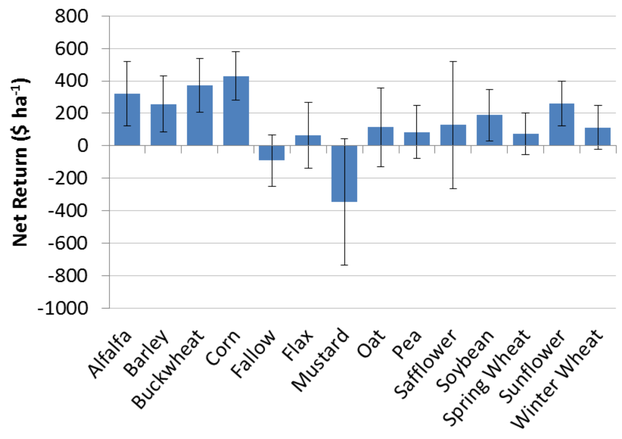

Figure 3. Average net returns for each crop across all rotation and years. Error bars represent 90% confidence interval.

Rotation results:

Average (2004-2013) net returns for each rotation were plotted against the standard deviation of net returns as a measure of risk.

- **Net returns were significantly higher for Dynamic than SG-Fallow (Table 2).**
- **Both risks and returns showed an increasing trend as crop diversity increased.**

Table 2. Average annual gross returns, costs, and net returns for each rotation

	SG-Fallow	SG-WW-Sun	Five year	Dynamic
	---------- $ ha^{-1} ----------			
Gross Returns	309 b	608 a	610 a	633 a
Cost	273 b	474 a	438 a	434 a
Net Return	36 b	134 ab	173 ab	198 a

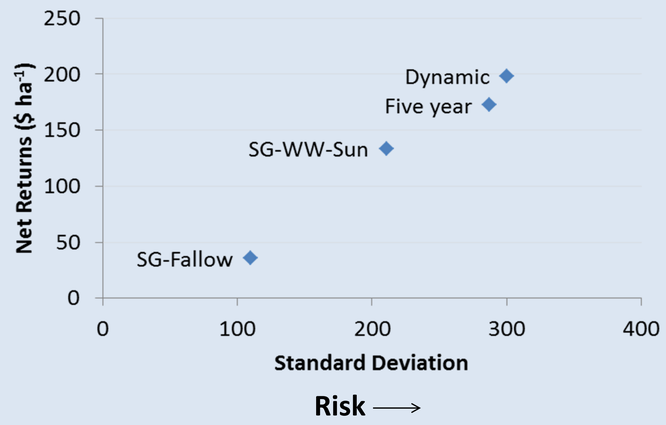

Figure 4. Average net returns versus standard deviation of net returns (risk) for each crop rotation.

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