Targeting Input Responses and Returns on Intensively-Managed Soft Red Winter Wheat

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Introduction

- Michigan wheat (*Triticum aestivum* L.) producers continue to rank in the top five nationally with recent state record yield averages of 81 and 89 bu A^{-1} produced during the 2015 and 2016 growing seasons.
- Increased awareness of climatic variability has further motivated producers toward adopting an intensive wheat management system.
- Intensive wheat management systems commonly involve prophylactic applications of multiple inputs recommended as risk insurance.
- In contrast to intensive management, traditional management justifies input applications utilizing university recommended integrated pest management (IPM) practices.
- Few studies exist examining wheat yield response and economic profitability to multiple inputs applied individually and in combination across traditional and intensive management systems.

Objective

Investigate soft red winter wheat grain yield response and economic profitability to high-N fertilizer management, urease inhibitor, nitrification inhibitor, plant growth regulator, fungicide, and foliar micronutrient applications across intensive (i.e. multiple-input) and traditional (i.e. individual-input) production systems.

Materials and Methods

- Field trial initiated on 29 Sept. 2015 and 23 Sept. 2016 in Lansing, MI.
- Soft red winter wheat 'Sunburst' seeded in 7.5 in. rows to a population of 1.8 million seeds A^{-1}.
- Inputs evaluated: two N rates (90 lbs N A^{-1} and 108 lbs N A^{-1}), urease inhibitor (UI), nitrification inhibitor (NI), plant growth regulator (PGR), fungicide, and foliar micronutrients.
- Conv. tillage following corn (*Zea Mays* L.) silage, 6.4 - 7.0 pH, 27 - 47 ppm P, 85 - 94 ppm K, 0.6 - 2 ppm B, 36 - 37 ppm Mn, and 0.4 - 2.1 ppm Zn.
- Omission trial design (Table 1) arranged as a randomized complete block with four replications with individual plots measuring 8 ft. x 25 ft.
- Grain yield harvested from center 3.8 ft. of each plot on 11 Jul. 2016 and 9 Jul. 2017 and adjusted to 13.5% moisture.
- Economic profitability was assessed from input cost estimates of US$39-47.00, $5.40-6.40, $11.70, $15.84, $14.00, and $17.94 A^{-1} in 2016 and $36.81-44.17, $5.10-6.10, $11.99, $13.27, $12.75, and $17.51 A^{-1} in 2017 for N fertilizer, UI, NI, PGR, foliar micronutrient, and fungicide, respectively. An additional application cost of $7.50 and $7.00 A^{-1} for 2016 and 2017, respectively was added for N fertilizer, PGR, foliar micronutrient, and fungicide.
- Net return calculated by subtracting treatment application cost from total revenue ($3.75 - 4.10 bu^{-1} grain price received x grain yield).
- Statistical analyses performed using the PROC GLIMMIX procedure of SAS at α=0.1. Single degree of freedom contrasts were used to determine treatment mean separations. Factors removed from the intensive management system were contrasted to only the intensive management control and a factors added into the traditional management system was contrasted to only the traditional management control.

Table 1. Overview of omission trial design, treatment names, and inputs applied in 2016 and 2017.

Treatment	Treatment Name	Agronomic Input Applied					
		UI†	NI‡	PGR§	Fungicide¶	Micro#	High-N††
1	Intensive (I)	Yes	Yes	Yes	Yes	Yes	Yes
2	I without UI	No	Yes	Yes	Yes	Yes	Yes
3	I without NI	Yes	No	Yes	Yes	Yes	Yes
4	I without PGR	Yes	Yes	No	Yes	Yes	Yes
5	I without Fungicide	Yes	Yes	Yes	No	Yes	Yes
6	I without Micro	Yes	Yes	Yes	Yes	No	Yes
7	I without High-N	Yes	Yes	Yes	Yes	Yes	No
8	Traditional (T)	No	No	No	No	No	No
9	T with UI	Yes	No	No	No	No	No
10	T with NI	No	Yes	No	No	No	No
11	T with PGR	No	No	Yes	No	No	No
12	T with Fungicide	No	No	No	Yes	No	No
13	T with Micro	No	No	No	No	Yes	No
14	T with High-N	No	No	No	No	No	Yes
15	Check	No	No	No	No	No	No

† Urease inhibitor (UI) applied at a rate of 1 qt ton^{-1} UAN at F3 growth stage.
‡ Nitrification inhibitor (NI) applied at a rate of 37 oz A^{-1} at F3 growth stage.
§ Plant growth regulator (PGR) applied at a rate of 12 oz A^{-1} at F6 growth stage.
¶ Fungicide applied at a rate of 8.2 oz A^{-1} at F10.5.1 growth stage.
# Foliar micronutrient fertilizer containing Zn, Mn, B applied at a rate of 64 oz A^{-1} at F6 growth stage.
††High-nitrogen applied at a rate of 108 lbs N A^{-1} at F3 growth stage.

Table 2. Monthly cumulative precipitation totals for the soft red winter wheat spring growing season in Lansing, MI during 2016 and 2017.

Year	Location	March	April	May	June	July	Total
		-------------------- in --------------------					
2016	Lansing	3.98†	2.94	2.06	0.71	3.78	13.47
2017	Lansing	2.98	5.22	2.59	3.29	2.65	16.73
30-yr avg.	Lansing	2.06	3.36	8.53	3.45	2.84	14.74

† Precipitation data was collected from Michigan State University Enviro-weather (https://enviroweather.msu.edu/). 30-yr means were obtained from the National Oceanic and Atmospheric Administration (https://www.ncdc.noaa.gov/cdo-web/datatools/normals).

Table 3. Soft red winter wheat grain yield and net return values for 2016 and 2017. Mean grain yield and net return of intensive and traditional control treatments displayed with remaining treatments showing change in grain yield or net return from the respective intensive or traditional control.

Treatment	2016	2017	2016	2017
	------bu A^{-1}------		------US$ A^{-1}------	
Intensive (I)	**77.88**	**99.56**	**156.13**	**280.88**
I w/o UI†	+5.70	-7.80*	+27.78	-25.89
I w/o NI	+2.28	+5.17	+20.23	+33.16*
I w/o PGR	-0.42	+4.71	+14.25	+32.58*
I w/o Fungicide	+0.35	+0.76	+27.27	+28.13
I w/o Micro	+9.83	+2.90	+50.32*	+24.10*
I w/o High-N	-8.43	-2.18	-22.59	-0.57
Traditional (T)	**81.03**	**100.10**	**257.34**	**366.59**
T w/ UI‡	-2.88	-7.52*	-16.18	-35.93*
T w/ NI	+3.35	-3.03	+0.86	-24.41
T w/ PGR	+1.10	-4.26	-19.73	-38.31*
T w/ Fungicide	+10.78*	+1.00	+14.45	-20.91
T w/ Micro	+7.23	-6.05	+5.59	-44.57*
T w/ High-N	+4.05	+0.94	+7.19	-3.51
I vs. T	ns§	ns	*	*
Check¶	66.95	47.73	251.06	195.66

* Significantly different at α=0.1 using single degree of freedom contrasts.
† Values in I w/o input rows indicate a yield (bu A^{-1}) or net return (US$ A^{-1}) change from respective intensive (I) treatment.
‡ Values in T w/ input rows indicate a yield (bu A^{-1}) or net return (US$ A^{-1}) change from respective traditional (T) treatment.
§ Non-significant
¶ Untreated check containing no fertilizer or additional inputs was not included in statistical analysis.

Table 4. Influence of Feekes 10.5.1 fungicide on foliar disease presence, 3 weeks after application in 2016 and 2017.

Year	Treatment			
	Intensive (I)	I w/o Fungicide†	Traditional (T)	T w/ Fungicide‡
	---------- % leaf area affected ----------			
2016	6.78	+11.34*	21.75	-14.98*
2017	0.0§	0.0	0.0	0.0

* Significantly different at α=0.1 using single degree of freedom contrasts
† Values in I w/o fungicide column indicate a leaf area affected (%) change from respective intensive (I) treatment.
‡ Values in T w/ fungicide column indicate a leaf area affected (%) change from respective traditional (T) treatment.
§ Years containing all values of 0.0 did not receive foliar disease pressure.

Figure 1. Differences in flag leaf foliar disease development following fungicide application at F10.5.1 during the 2016 growing season.

Results and Discussion

- Due to minimal N losses (volatilization, leaching, and/or denitrification), a lack of plant lodging, and few micronutrient deficiencies, NI, PGR, foliar micronutrients, and a 20% increase in N rate did not significantly affect grain yield across site-years (Table 3).
- Urease inhibitor significantly increased grain yield by 7.7 bu A^{-1} within the intensive system and significantly decreased grain yield by 7.6 bu A^{-1} within the traditional system in 2017 (Table 3). Inconsistent response across management systems was likely a function of urea hydrolysis rate, N fertilizer rate, and UI application with or without NI.
- Due to significant foliar disease pressure caused by the pathogen stripe rust (*Puccinia striiformis* f. sp. *tritici*.), fungicide application significantly increased grain yield by 10.8 bu A^{-1} in 2016 (Table 3). Removal of fungicide from the intensive system resulted in a 11.3% increase in foliar disease presence. Conversely, addition of fungicide to the traditional management system reduced foliar disease presence 15%.
- Despite some increases in overall grain yield, no single input resulted in a significant positive return on investment following the 2016 and 2017 growing seasons (Table 3). In addition, traditional management produced comparable grain yields to intensive management and significantly increased net return per acre by an average of $93 A^{-1}.
- Even in the presence of adverse climatic conditions warranting input applications, results in this study suggested little potential for improved grain yields and/or net returns from simply adopting an intensive management system.
- Producers may want to consider greater emphasis on profit loss rather than yield loss when choosing to incorporate intensive management.

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