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2017 Soft Red and White Winter Wheat Soil Fertility and Plant Nutrition Systems (14-09-05-CS)

2017 Report to the Michigan Wheat Program

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Location: Lansing, MI	**Tillage**: Conventional
Planting Date: Sept. 29, 2015 and Sept. 23, 2016	**Nitrogen Rates**: 90 & 108 lbs. N/A
Soil Type: Capac Loam; 6.4 - 7 pH, 27 - 47 ppm P, 85 - 94 ppm K	**Population**: 1.8 million seeds/A
Variety: Sunburst (SRWW)	**Replicated**: 4 replications

Location: Richville, MI	**Tillage**: Conventional
Planting Date: Oct. 1, 2015 and Oct. 10, 2016	**Nitrogen Rates**: 120 & 144 lbs. N/A
Soil Type: Tappan-Londo Loam; 6.6 - 7.8 pH, 23 – 46 ppm P, and 124 – 150 ppm K	**Population**: 1.8 million seeds/A
Variety: Jupiter (SWWW)	**Replicated**: 4 replications

Soft Winter Wheat Response to Urease Inhibitor, Nitrification Inhibitor, Plant Growth Regulator, Fungicide, Micronutrients, and High N Management

Introduction:

Michigan wheat production continues 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, respectively (NASS, 2017). Increased awareness of climate variability combined with localized yield limitations has further motivated producers to maximize wheat yield and adopt more intensive wheat management systems (Swoish and Steinke, 2017). Intensive wheat management commonly involves prophylactic applications of multiple inputs recommended as a form of risk insurance (Mourtzinis et al., 2016). In contrast, a traditionally managed system justifies input applications utilizing university recommended integrated pest management (IPM) practices (Mourtzinis et al., 2016). Recent studies have examined wheat response to commonly marketed inputs including additional nitrogen (N) fertilizer, urease inhibitor, nitrification inhibitor, plant growth regulator, foliar micronutrients, and fungicide (Knott et al., 2016; Mohammed et al., 2016; Paul et al., 2010; Swoish and Steinke, 2017; Wang et al. 2015). However, few studies exist examining wheat yield and profitability response to multiple inputs individually and in combination across traditional and intensive management systems.

Objective: Investigate soft red and white winter wheat grain yield response and economic net return 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.

Our *working* hypothesis is that an intensive (i.e., multiple-input) management system will increase grain yield and return on investment as compared to traditional (individual-input) management.

Methods and Procedures:

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

		Agronomic Inputs Applied					
Treatment	Treatment Name	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 applied at a rate of 1 qt ton^{-1} UAN at F3 growth stage.
‡ Nitrification inhibitor applied at a rate of 37 oz A^{-1} at F3 growth stage.
§ Plant growth regulator 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 and 144 lbs N A^{-1} at F3 growth stage.

An omission treatment design was used to evaluate two management systems and determine specific input responses (Table 1). An omission design utilizes two treatment controls, one containing all applied inputs (intensive management strategy) and one containing none of the applied inputs (traditional management strategy). To evaluate individual input effects, inputs removed from the intensive management system were compared only to the intensive management control and inputs added to the traditional management system were only compared to the traditional management control.

Results and Discussion:

Environmental Conditions

Table 2. Monthly cumulative precipitation totals for the winter wheat spring growing season at Lansing, MI and Richville, MI, 2016-2017.

Precipitation†	Location	March	April	May	June	July	Total
		---------------------------in------------------------------					
2016	Richville	3.99	1.30	0.63	1.59	3.47	10.98
2017	Richville	1.90	5.79	1.97	4.83	1.10	15.59
30-yr avg.	Richville	1.93	3.19	3.29	3.53	3.10	15.04
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	3.53	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).

Spring climatic variability was evident in Michigan. May and June 2016 cumulative rainfall was 68% and 60% below the 30-yr mean for Richville and Lansing, respectively, and likely reduced wheat yield potential (Table 2). Above average April rainfall was observed during 2017 at both locations causing greater potential N loss (leaching and/or denitrification). Site-specific soil spatial variability, later planting, and winter injury likely contributed to below average grain yields and a yield coefficient of variation (CV) of 42 % at Richville in 2017 (Table 3). High yield variation observed at Richville in 2017 likely contributed to the overall lack of significant input responses during this single site-year (Table 3 and 6). However, despite variability and low grain yields no additional N loss, micronutrient deficiency symptoms, disease, or plant lodging were observed.

Nitrogen Rate

A significant yield decrease of 14.5 bu A^{-1} occurred at Richville in 2016 when a 20% increase in N rate was reduced down to the university recommended N rate within the intensive management system (Table 3). In contrast, a 20% N rate increase within the traditional management system did not result in a significant yield response across all 4 site-years (Table 3). Results from this trial correspond with previous findings that suggested minimal wheat grain yield increases occur from N rates beyond university recommendations under traditional management (Mourtzinis et al., 2017; Swoish and Steinke, 2017). Additionally, results suggest university recommended N rates supply adequate plant available N to maximize wheat yields when utilizing a traditional management system.

Table 3: Wheat grain yield 2016 - 2017. Mean grain yield of intensive and traditional control treatments displayed. All other treatments display change in grain yield from respective intensive or traditional control, respectively.

	2016		2017	
Treatment†	Richville	Lansing	Richville	Lansing
	---------------------------------- bu A^{-1} ----------------------------------			
Intensive (I)	104.60	77.88	64.58	99.56
I w/o UI‡	-5.95	+5.70	+16.23	-7.80*
I w/o NI	-5.28	+2.28	+22.98	+5.17
I w/o PGR	-8.38	-0.42	+16.55	+4.71
I w/o Fungicide	-8.35	+0.35	-9.33	+0.76
I w/o Micro	-2.80	+9.83	+15.08	+2.90
I w/o High-N	-14.48*	-8.43	+17.23	-2.18
Traditional (T)	102.00	81.03	64.58	100.10
T w/ UI§	+6.23	-2.88	+0.43	-7.52*
T w/ NI	-5.18	+3.35	+1.43	-3.03
T w/ PGR	+4.28	+1.10	-18.08	-4.26
T w/ Fungicide	-0.93	+10.78*	+2.68	+1.00
T w/ Micro	-0.18	+7.23	+1.93	-6.05
T w/ High-N	-0.63	+4.05	-9.93	+0.94
I vs. T	NS¶	NS	NS	NS
Check#	63.18	66.95	41.50	47.73
CV %	11.25	17.51	42.25	24.46

***** Significantly different at α=0.1 using single degree of freedom contrasts.
† Urease inhibitor (UI), nitrification inhibitor (NI), plant growth regulator (PGR), 20% increase in nitrogen fertilizer rate (High-N).
‡Values in I w/o input rows indicate a grain yield (bu A^{-1}) change from respective intensive (I) treatment.
§Values in T w/ input rows indicate a grain yield (bu A^{-1}) change from respective traditional (T) treatment.
¶ Non-significant α=0.1 using single degree of freedom contrasts.
\# Untreated check containing no fertilizer or additional inputs was not included in statistical analysis.

Positive grain yield response from an increase in N rate within the intensive system at Richville in 2016 demonstrates potential greater N fertilizer demand with intensive management (Ruffo et al., 2015) and/or a potential synergistic effect between additional inputs and the greater N rate (144 lbs N A^{-1}) associated with SWWW as compared to the decreased N rate (108 lbs N A^{-1}) associated with SRWW. However, no other input resulted in a significant yield decrease when removed from the intensive system at Richville in 2016, making it difficult to understand which specific input(s) may have resulted in an interaction with the increase in N rate. Previous research has observed significant interactions between fungicide application and high N rates (140 kg N ha^{-1} – 240 kg N ha^{-1}) regardless of disease presence (Brinkman et al., 2014; Mourtzinis et al., 2017), often due to the extended plant photosynthetic period associated with fungicide application (Mourtzinis et al., 2017; Salagado et al., 2017). Application of multiple inputs may have enhanced green flag leaf area and extended the grain fill period resulting in an increase in wheat N requirement (Mourtzinis et al., 2017; Salgado et al., 2017). In addition, previous trials have reported greater individual input responses under intensive management than traditional management suggesting synergy among various technologies (Bluck et al., 2015; Ruffo et al., 2015). University recommended N rates are based off the assumption that wheat response to N is independent of agronomic factors other than yield (Warncke et al., 2009). However, results from this single site year suggest that under specific environmental conditions N rate may be the primary driver of significant input interactions (Mourtzinis et al., 2017) suggesting greater N demand in the presence of intensive management.

Urease Inhibitor

Utilization of a urease inhibitor (UI) resulted in a significant grain yield response in 1 of 4 site-years (Table 3). Grain yield was significantly decreased by 7.8 bu A^{-1} when UI was removed from the intensive management system and significantly increased by 7.5 bu A^{-1} when UI was added to the traditional management system at Lansing in 2017 (Table 3). In all 4 site-years UAN was applied to minimal residue, low temperature soils, with rainfall occurring within 5 days following N fertilizer applications (data not shown). Previous observations regarding similar environmental conditions present in all 4 site-years of this trial suggest response to UI application should not have occurred due to a lack of potential N loss caused by volatilization (Warncke et al., 2009; Franzen, 2017). In addition, UAN+UI response is often lacking compared to urea + UI due to UAN composition of only 50% urea (Hendrickson, 1992).

Inconsistent grain yield response to UI was observed across the different management systems at Lansing in 2017. A positive yield response occurred within the intensive management system (i.e., yield loss when removed) and a negative yield response occurred within the traditional system (i.e., yield loss when added). The 2017 growing season produced April rainfall totals 1.5 x greater than the 30-yr mean in Lansing (Table 2) potentially resulting in N loss (leaching and/or denitrification) conditions. Therefore, results suggest intensive management practices including a combined inhibitor application with a 20% increase in N rate provided greatest reduction of multiple N-loss risks through inhibited transformation of N and thus greater synchrony between N availability and crop N demand (Mohammed et al., 2016).

In contrast to a positive yield response within the intensive management system, UI application significantly decreased grain yield within the traditional management system at Lansing in 2017. Similar yield reductions from UI applications have been observed in corn (Hendrickson, 1992; Fox and Piekielek, 1993; Murphy and Ferguson, 1997). Lansing produced above average April rainfall following N fertilizer application in 2017 (Table 2) with 2.62 in. cumulative rainfall occurring within 1 week of N application (data not shown). Above average rainfall suggested high potential for fertilizer N to be transported further beneath the soil surface reducing the rate of urea hydrolysis. UAN+UI when transported beneath the soil surface may reduce urea hydrolysis to NH_4 increasing the risk for urea to be transported beyond the root zone and decreasing plant availability. In addition, the Lansing traditional management N rate of 90 lbs N A^{-1} was the lowest among all SRWW and SWWW treatments allowing for smaller N losses to have a greater potential reduction of plant available N. Due to the high frequency of

Michigan's spring rainfall events often coinciding with wheat N fertilizer top-dress timings, UI application is unlikely to provide a benefit under traditional management.

Nitrification Inhibitor

Nitrification inhibitor (NI) did not significantly impact grain yield across all 4 site-years (Table 3). Lack of significant grain yield response in 2016 was likely due to below 30-yr average cumulative April rainfall following N fertilizer application at both locations resulting in decreased risk of N leaching and/or denitrification (Table 2). Results support previous research conclusions suggesting positive NI responses are not expected during climatic conditions producing below average rainfall following N applications (Franzen, 2017; Steinke and Bauer, 2017).

Unlike 2016, above average April rainfall following N fertilizer application was observed at both locations in 2017 (Table 2). April rainfall following N fertilizer application was 81% and 71% higher than the 30-yr average at Richville and Lansing, respectively, suggesting a potential for N-loss due to leaching and/or denitrification. Mean soil temperatures at Richville and Lansing 1 week following N application were < 48°F and < 57°F in 2017, respectively (data not shown) and may have slowed bacterial conversion of NH_4 to NO_3 further contributing to the lack of NI response (Barker and Sawyer, 2017). In addition to cool soil temperatures, specific nitrapyrin formulation of the NI product (Instinct II; Dow Agrosciences, Indianapolis, IN) used in this trial may have contributed to the lack of response. Nitrapyrin microencapsulation of this product has been shown to delay release and reduce the concentration of nitrapyrin at any one time during N application potentially inhibiting any positive effects from product application (Franzen, 2017).

Plant Growth Regulator

Table 4: Impact of plant growth regulator (PGR) and foliar micronutrient applications on wheat Feekes 10.5.4 mean plant height in 2016 and 2017.

		Treatment					
Location	Year	Intensive (I)	w/o PGR†	w/o Micro	Traditional (T)	w/PGR‡	w/Micro
		-- in --					
Richville	2016	28.31	+0.49	+0.46	29.04	+1.48	+0.63
Richville	2017	25.16	+4.56*	+3.48*	27.59	-1.70	+1.38
Lansing	2016	27.76	+1.84	+3.41*	30.48	-0.52	+0.23
Lansing	2017	28.25	+4.14*	+2.79*	31.96	-2.26*	+0.13

* Significantly different at α=0.1 using single degree of freedom contrasts

† Values in w/o input column indicate a plant height (cm) change from respective intensive (I) treatment.

‡ Values in w/input column indicate a plant height (cm) change from respective traditional (T) treatment.

Plant growth regulator (PGR) application did not result in a significant yield response during all 4 site-years (Table 3). In addition, plant height reductions were inconsistent when PGR was applied alone in the traditional system, resulting in only one significant plant height reduction of 2.26 in at Lansing in 2017 (Table 4). In contrast to traditional management, significant plant height increases were observed in 2 of 4 site years from the removal of the PGR from the intensive system and in 3 of 4 site years from the removal of the foliar micronutrient from the intensive system, suggesting a synergistic response between both inputs (Table 4). Foliar micronutrient (Max-IN®; Winfield United, St. Paul, MN) used in this trial contained a monosaccharide adjuvant utilized to increase plant uptake. Addition of specific adjuvant likely allowed an elevated and more consistent plant uptake of the PGR resulting in a greater plant height response.

Plant lodging did not occur in any of the 4 site-years across both soft winter wheat varieties and management systems including N rates up to 144 lbs. N A^{-1}. Both SWWW and SRWW varieties used in this trial contain short-strawed, high stem strength (Siler et al., 2017; Michigan Crop Improvement Assoc.) physical characteristics that likely contributed to the lack of lodging occurrence and lack of positive grain yield response to PGR application. Results correspond to recent Michigan research by Swoish and Steinke (2017) determining yield increases from PGR application only tend to occur in the presence of lodging, which is more consistent of a taller, weaker structured cultivar rather than incorporation of elevated N rates. Results suggest producer motive for applying a PGR should depend on cultivar structure, susceptibility to lodging, and average plant height data which are readily accessible through university variety trials (Siler et al., 2017) rather than management intensification (Knott et al., 2016; Swoish and Steinke, 2017).

Fungicide

Table 5: Impact of Feekes 10.5.1 fungicide on wheat foliar disease presence, 3 wk. after application in 2016 and 2017.

		Treatment			
Location	Year	Intensive (I)	I w/o Fungicide†	Traditional (T)	T w/ Fungicide‡
		------------------------------ % leaf area affected --------------------------------			
Richville	2016	0.0§	0.0	0.0	0.0
Richville	2017	0.0	0.0	0.0	0.0
Lansing	2016	6.78	+11.34*	21.75	-14.98*
Lansing	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 and locations containing all values of 0.0 indicate years and locations that did not receive foliar disease pressure.

Addition of the fungicide to the traditional management system resulted in a significant yield increase of 10.8 bu A^{-1} in 1 of 4 site-years (Table 3). Removal of the fungicide from the intensive system did not significantly affect grain yield at either location in 2016 or 2017 (Table 3). Fusarium head blight incidence did not occur in any of the 4 site-years. Below average May rainfall was observed in all 4 site-years (Table 2), specifically during the period of wheat growth stage Feekes 10.5.1 (anthesis), decreasing risk of infection. Lansing 2016 was the only site-year to experience significant foliar disease pressure predominantly caused by the foliar pathogen stripe rust (*Puccinia striiformis* f. sp. *tritici*.).

Visual assessment of percent leaf area affected showed removal of fungicide from the intensive system at Lansing in 2016 resulted in an 11.3% increase in foliar disease presence (Table 5). Conversely, addition of the fungicide to the traditional management system reduced foliar disease presence by 15%. Reason for the non-significant yield response to fungicide in the presence of disease, despite significant visual control within the intensive system at the Lansing location was unclear. Disease suppression from inputs other than fungicide may have occurred including foliar applied Mn and B both of which have previously shown to decrease rust (*Puccinia* spp.) incidence in wheat (Huber and Wilhelm, 1988; Datnoff et al., 2007). Overall, results suggested greatest fungicide impact occurred only in a high disease, minimal input environment, but further research may be needed to understand the impact of various inputs other than fungicide on disease occurrence.

Foliar B, Mn, and Zn

Table 6: Summary of pre-plant soil (0-8 in.) and Feekes 9 flag leaf tissue B, Mn, and Zn concentrations taken from untreated check plots.

		Soil Concentration†			Tissue Concentration‡		
Year	Location	B	Mn	Zn	B	Mn	Zn
		------------------ ppm	---------------		------------------ ppm	-------------------	
2016	Richville	6	43	1.2	2	20	16.5
	Lansing	2	35.5	0.4	5	44	19.5
2017	Richville	0.5	16	3.6	3.3	21.8	19.8
	Lansing	0.6	37	2.1	9.3	22	15

† B boron (hot-water extraction); Mn manganese (0.1 M HCl extraction); Zn zinc (0.1 M HCl extraction).
‡ B boron (ICP mass spectroscopy); Mn manganese (ICP mass spectroscopy); Zn zinc (ICP mass spectroscopy)

Foliar application of Zn, Mn, and B did not result in a significant yield response across all 4 site-years (Table 3). Pre-plant soil test data showed deficiencies in B in 2 of 4 site years, Zn in 3 of 4 site years, and no Mn deficiencies across all 4 site-years (Table 6) (Warncke et al., 2009). Furthermore, tissue samples from the uppermost leaf at Feekes 9 showed deficiencies in B (< 6 ppm) in 3 of 4 site years, Zn (< 21 ppm) in 4 of 4 site years, and no deficiencies in Mn (< 20 ppm) across all 4 site-years (Table 6) (Vitosh et al., 1995). Soil and tissue nutrient analysis suggested need and anticipated response from foliar application of B and Zn (Vitosh et al., 1995). However, despite soil and tissue deficiencies of B and Zn plant deficiency symptoms were not observed across all 4 site-years (data not shown).

University recommendations for micronutrient applications are not solely based on soil or tissue test levels but also incorporate crop sensitivity to a response (Vitosh et al., 1995; Warncke et al., 2009). Crops categorized as sensitive to specific micronutrients have a high likelihood of response to application once soil and tissue nutrient levels drop below sufficiency ranges, while crops categorized as being non-sensitive do not (Vitosh et al., 1995; Warncke et al., 2009). University nutrient recommendation guidelines define wheat as being non-sensitive to B and Zn, yet highly sensitive to Mn (Vitosh et al., 1995; Warncke et al., 2009). University guidelines and results from this trial suggest positive response from a combined foliar application of Zn, Mn, and B on wheat is likely to occur only in the presence of a Mn deficiency, which was not present in all 4 site-years. Trial results suggest micronutrient application may only be warranted once crop-sensitive micronutrients drop below sufficiency ranges, stressing not only the importance of soil and tissue testing, but also the use of university fertilizer guidelines before incorporating a micronutrient application.

Intensive vs. Traditional

Across different years, locations, and varieties, grain yield was not significantly different between the intensive management control containing all inputs and the traditional management control containing only a university recommended rate of N fertilizer (Table 3). Minimal and inconsistent input responses were observed across all site-years likely due to an overall lack of adverse environmental conditions including N loss, micronutrient deficiency symptoms, plant lodging, and disease pressure during the 2016 and 2017 growing seasons. Results from this trial are consistent with previous research and support university recommended IPM principles which have concluded that positive grain yield responses are not associated with specific input applications without the presence of yield-limiting factors (Paul et al., 2010; Wegulo et al., 2012; Knott et al., 2016; Swoish and Steinke, 2017; Rajkovich et al., 2017; Barker and Sawyer, 2017; Steinke and Bauer, 2017).

Economic Net Return

Across all 4 site-years, the intensive management system had an average treatment cost of \$140 A^{-1} with an average break-even yield of 34 bu A^{-1}, as compared to the traditional management system which had an average treatment cost of \$52 A^{-1} and an average break-even yield of 12 bu A^{-1} (data not shown). In 3 of 4 site-years, traditional management resulted in a significant increase in per acre net return when compared to intensive management (Table 7). Traditional management containing only a university recommended N rate averaged an increase of \$89 A^{-1} across all 4 site-years. A 20% increase in N rate was the only individual management input to result in a significant positive increase in per acre net return in 1 of 4 site-years. However, positive response was only observed within the intensive management system. The intensive treatment containing the increase in N rate only produced an average economic net return of \$278 A^{-1} as compared to \$361 A^{-1} for the traditional treatment at Richville in 2016 (Table 7), which suggests that although an increase in N rate positively impacted net return in an intensive system, utilization of a traditional management system was still more profitable for the producer.

Table 7: Wheat economic net return 2016 - 2017. Mean net return of intensive and traditional control treatments displayed. All other treatments display change in net return from respective intensive or traditional control.

	2016		2017	
Treatment†	Richville	Lansing	Richville	Lansing
	---------------------------------- US\$ A^{-1} ----------------------------------			
Intensive (I)	277.67	156.13	151.65	280.88
I w/o UI‡	-15.73	+27.78	+82.47	-25.89
I w/o NI	-10.03	+20.23	+117.22	+33.16*
I w/o PGR	-18.67	+14.25	+89.07	+32.58*
I w/o Fungicide	-15.40	+27.27	-17.67	+28.13
I w/o Micro	+1.94	+50.32*	+81.27	+24.10*
I w/o High-N	-47.95*	-22.59	+90.07	-0.57
Traditional (T)	360.74	257.34	239.67	366.59
T w/ UI§	+18.55	-16.18	-4.85	-35.93*
T w/ NI	-33.02	+0.86	-18.51	-24.41
T w/ PGR	-6.25	-19.73	-103.57	-38.31*
T w/ Fungicide	-29.77	+14.45	-12.78	-20.91
T w/ Micro	-22.22	+5.59	-10.94	-44.57*
T w/ High-N	-12.58	+7.19	-88.02	-3.51
I vs. T	*	*	NS¶	*
Check#	260.28	251.06	190.07	195.66
CV %	14.99	10.20	61.11	12.84

***** Significantly different at α=0.1 using single degree of freedom contrasts.

† Urease inhibitor (UI), nitrification inhibitor (NI), plant growth regulator (PGR), 20% increase in nitrogen fertilizer rate (High-N).

‡Values in I w/o input rows indicate a net return (US\$ A^{-1}) change from respective intensive (I) treatment.

§Values in T w/ input rows indicate a net return (US\$ A^{-1}) change from respective traditional (T) treatment.

¶ Non-significant α=0.1 using single degree of freedom contrasts.

\# Untreated check containing no fertilizer or additional inputs was not included in statistical analysis.

Other than the single site year positive response to a 20% increased N in 2016, no other input resulted in a significant per acre net return across all 4 site-years. Although fungicide and urease inhibitor applications resulted in significant grain yield increases in 2016 and 2017, respectively, corresponding net return was not increased indicating grain yield increases were not great enough to offset the cost of application. July 2016 and 2017 wheat commodity prices received were the lowest in the last 8 years (NASS, 2017). Results indicate that even in the presence of adverse conditions warranting positive input yield responses (i.e. foliar disease), input applications may still not be profitable to the producer depending upon commodity price. Producers continue to perceive yield loss as a greater risk than profit loss (Rutan and Steinke, 2017). However results suggest producers should place greater emphasis on profitability rather than yield loss protection when choosing to incorporate additional inputs.

Conclusion

The 2016 and 2017 growing seasons produced minimal and inconsistent responses from applications of urease inhibitor, nitrification inhibitor, plant growth regulator, foliar micronutrients, fungicide, and high N management on soft red and soft white winter wheat grain yield. In addition, little evidence was observed that an intensive management system utilizing prophylactic applications of multiple inputs could benefit a producer's economic profitability. Positive yield responses from an increase in N rate, urease inhibitor, and fungicide across site-years did not result in greater economic net return than traditional management utilizing only a university recommended N rate at current year wheat commodity prices. Results appear to provide continued support for the use of university IPM programs that emphasize both grain yield and profitability. Producers should look to incorporate a management system that utilizes specific techniques (i.e. crop scouting, prediction models, varietal selection) to minimize and justify input applications to match specific crop needs and maximize profitability rather than applying a suite of inputs as risk insurance.

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