100 Bushels or Bust!
Winter Wheat Management Considerations

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N 7 P 15 K 19
Greater yield in the field
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Seed Variety Selection

- May be the most important decision
  - MI varieties: 18 bu/A difference in yield
  - Strengths/Weaknesses across all
- Yield Potential
  - 3 years data
  - Locally adapted varieties

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Seed Variety Selection

- Disease Resistance
  - High levels of resistance
    - MI: Fusarium head blight #1
    - Integrate variety resistance and fungicide for best management
    - Moderately resistant and low DON levels
    - Don't forget about other disease management: such as powdery mildew, stripe rust, Septoria

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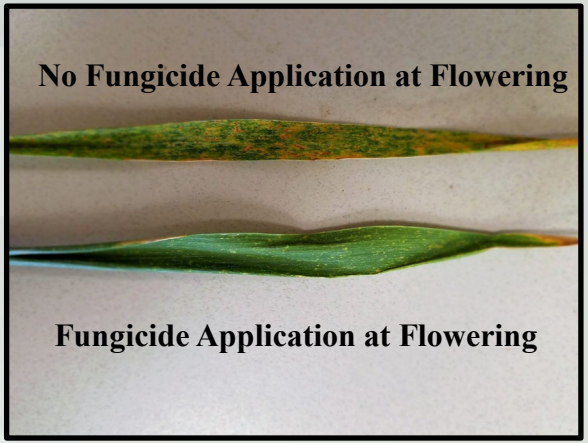
Seed Variety Selection



- Maturity
  - Flowering
    - May differ ~6 days between early and late var.
      - Difficult to time fungicide with uneven maturity
    - Staggered maturities can increase window for fung. application (spread risk out)
- Height
  - Don't underestimate this characteristic
  - 12-inch difference
  - Will impact management (PGR, straw production, lodging risk)

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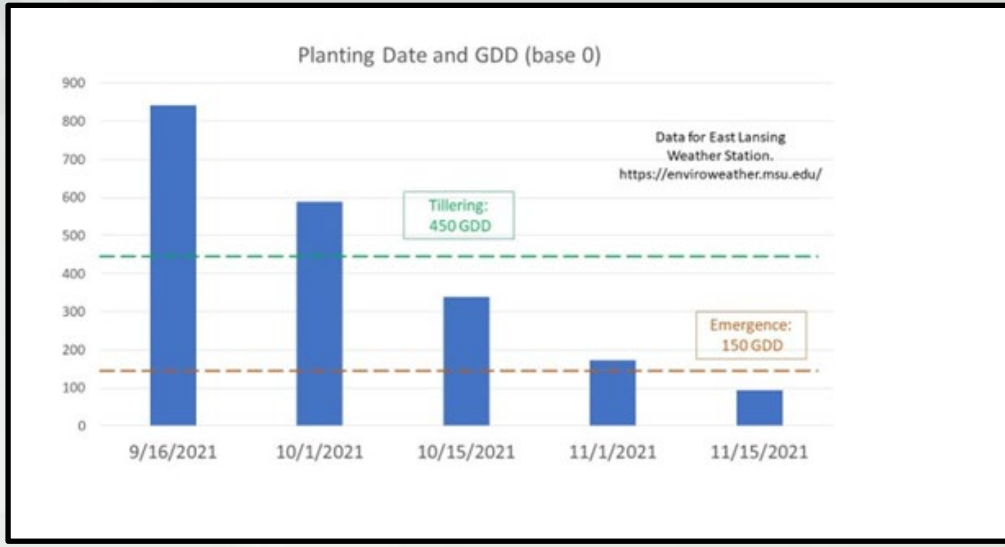
Planting Date

- High yield potential begins in autumn
  - 2-3 tillers before dormancy
  - GDD's essential
    - 150 – emergence
    - 450 – tillering
  - Wheat GDD's
    - (High temp (C) +Low temp (C)) / 2 for individual days
  - Hessian fly date still useful reference



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Winter Wheat Yield Declines with Delayed Planting Across 3 Seasons

- Losses will vary due to climate variability
  - 0.6 bu/day after 10/1
    - 0.3 bu/day after 10/15
- Mid-Oct.
  - 14-20% losses
- Late-Oct. into Nov.
  - 21 – 46% losses (10/25 crop insurance)
- Consider grain yield and winter injury

	% Decline (after mid-Sept)		
Plant date	2019-20	2020-21	2021-22
Mid-Sept.	--	--	--
End-Sept.	13.5	--	--
Mid-Oct.	14.7	19.9	20.0
End-Oct.	27	33.3	34.0
Mid-Nov.	21	45.8	43.6

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Seed Rate and Depth

- 1.2 million – 2 million seeds/A
  - Within 1 week of Hessian fly date
    - Lower end of range
  - Late-Oct and after
    - At least 1.8 million seeds/A or greater
  - Risk at lower rates?
- Depth, Method
  - 1 – 1.5 inch allows faster emergence and tillering, moisture
  - Drill vs b-cast

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Relating Seed Size to Seed Rate

Target seeding rates (millions of seeds per acre)						
Seeds per pound	1.2	1.4	1.6	1.8	2	2.2
Seed size	Actual pounds of seed required per acre*					
9,000	133	156	178	200	222	244
10,000	120	140	160	180	200	220
11,000	109	127	145	164	182	200
12,000	100	117	133	150	167	183
13,000	92	108	123	138	154	169
14,000	86	100	114	129	143	157
15,000	80	93	107	120	133	147
16,000	75	88	100	113	125	138

*Target seeding rate divided by seeds per lb = required pounds of seed per acre.

Seeding Rate (millions/ac)	Seeds per foot of row
1.2	17.2
1.4	20.1
1.6	23
1.8	25.8
2	28.7
2.2	31.6

7.5 inch row spacing

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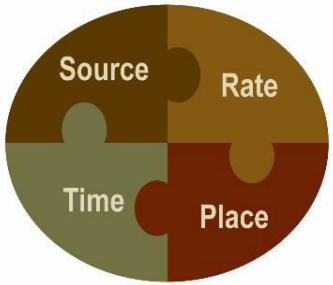
Wheat N Management

- Wheat N strategies must answer 2 questions:
  - 1) Can we deliver N to the plant timely?
    - Early vs late vs too late
  - 2) Can we reduce opportunities for N loss?
    - April
- 4R Nutrient Management
- Wheat is *NOT* corn!
  - Growth period
  - Planting dates can greatly impact

Adapted from https://www.ipni.net



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N Rate and Risk Management

- Although you may want to be 100% certain of N sufficiency, being that certain is not necessarily most profitable
  - Lower N rates risks decrease in profitability due to lost yield
  - Greater N rates risks increase lodging, decrease profitability and yield, and environmental concerns due to unneeded N
    - Too much spring N can increase leaf growth and decrease tillering
  - How much and how long are you willing to manage?

N Rates for Wheat

- Starting point:
  - N Rec. = -13 + (1.33 x YP)
  - Must have realistic yield potential
    - Unrealistic expectations will ALWAYS result in OVER application
  - Tiled?
  - Red vs White
- Weather highly influential
  - Dry years: 0.9 lb N/bu
  - Wet years: 1.2 lb N/bu

- How long are you planning to manage?
- When did you plant?
- Planting dates can have tremendous influence on production

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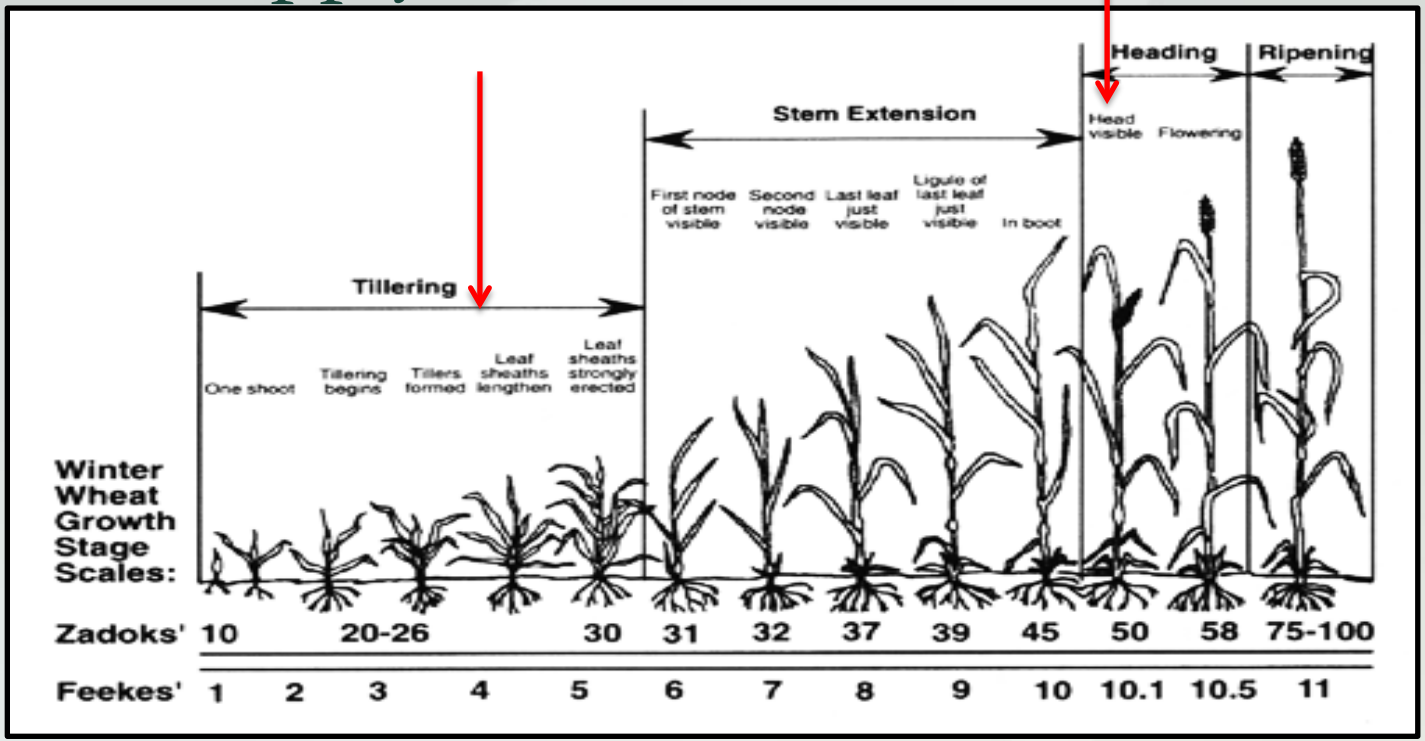
When to Apply N?



- 60% of N taken up between Feekes 4 and 10.1 (stem elongation to head emergence)

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When is N at the Greatest Potential for Loss?

1) Wet, warm conditions

2) Soil nitrate present without active crop growth

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Green-Up vs. F5 vs. Split N Application

	Wheat yield (bu/A)			
Year	Green-Up	Feekes 5	50% Green-Up 50% Feekes 5	April rainfall (inches)
2013	83 b[2]	95 a	92 ab	8
2014	97 a	97 a	94 a	1
2015	109 a	109 a	110 a	0.8
2016	91 a	90 a	91 a	2.9

- 90 lb N/A, Soft red varieties
- Wet = split or delayed assist; Dry = poor use of split or delayed N
- Tillering may help determine GU vs. F5

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Alternative N Application Technologies for Soft Red Winter Wheat

- Stream Jet Nozzles (GU)
- Streamer Bars (GU)
- Flat Fan Nozzles (GU)
- Broadcast Urea (GU)
- Spoon-Fed N
  - Weekly starting at GU and lasting for 7 weeks after GU (8 total)
- (All 100 units N)

Alternative N Application Technologies for Soft Red Winter Wheat (2018)

Treatment	Grain Yield (bu A^{-1})
Check	64 d
Stream Jet Nozzles	86 ab
Streamer Bars	93 ab
Flat Fan Nozzles	67 cd
Broadcast Urea	80 bc
Spoon-Fed N	96 a
P>F	0.04 (15.1 LSD)

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Alternative N Application Technologies for Soft Red Winter Wheat (2019)

Treatment	Grain Yield (bu A^{-1})
Check	77 c
Stream Jet Nozzles	104 ab
Streamer Bars	101 ab
Flat Fan Nozzles	103 ab
Broadcast Urea	103 ab
Spoon-Fed N	111 a
P>F	< 0.01 (12.3 LSD)

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Nitrogen Stabilizers or Extenders

- Inhibitors or Extenders – added to "conventional" N sources such as anhydrous ammonia, urea, or UAN
  - **Nitrification Inhibitors (leaching and denitrification)**
    - Nitrapyrin (ex. N-Serve, Instinct)
    - Dicyandiamide (DCD) {ex. Guardian}
    - Pronitridine (ex. Centuro) UAN and AA only
  - **Urease Inhibitors (volatilization)**
    - NBPT (ex Agrotain)
    - Duromide and NBPT (ex. Anvol)
  - **Nitrification and Urease Inh. (Protect against 3 forms N loss)**
    - DCD and NBPT
      - Ex. Super U, Agrotain Plus SC
    - DCD and Pronitridine
      - Ex. Tribune

Urease Inhibitors

- Urea is an organic compound that must be hydrolyzed in the presence of a specific enzyme (urease) in order to ultimately produce ammonium-N

- The first product of the reaction is ammonia (volatile)

Nitrification Inhibitors

- Nitrification is the conversion of ammonium-N into nitrate-N
  - The reaction occurs relatively quickly, but it is a function of:
    - Ammonium concentration
    - Soil pH
    - Oxygen availability
    - Soil moisture
    - Temperature

Wheat Response to N Inhibitors 2013 - 2017

Wheat yield (bu/A)				
Year	90N	90N with UI[2] + NI	90N with UI only	April rainfall[4] (inches)
2013	83 a[3]	96 a	87 a	8
2014	97 a	103 a	100 a	1
2015	109 a	108 a	107 a	0.8
2016	91 a	96 a	92 a	2.9
2017	82 a	78 a	79 a	5.2

[1] Adapted from K. Steinke. 2013-2017, Michigan Wheat Research Reports
[2] UI, Urease inhibitor; NI, Nitrification inhibitor
[3] Values in a row followed by the same lowercase letter are not significantly different at ? = 0.10
[4] Mean April total rainfall for Lansing is 2.9 inches

- Why varied performance?
  - MOISTURE (2015 photo)

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Intensive Management
Yes, No, or Maybe?

2016-2017 Intensive Winter Wheat Mgmt Study - Inputs Evaluated

Input	Product Name	Rate Applied
Nitrogen	UAN	120 lbs/A, 144 lbs/A (White) 90 lbs/A, 108 lbs/A (Red)
Urease Inhibitor	Agrotain Advanced	1 qt/ton UAN
Nitrification Inhibitor	Instinct II	37 oz/A
Plant Growth Regulator	Palisade EC	12 oz/A
Foliar Micronutrients	Max-IN Ultra ZMB	2 qt/A
Fungicide	Prosaro	8.2 oz/A

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Grain Yield (bu/A) Changes from Respective Enhanced or Traditional System

Lansing (Red)			
Treatment	**Grain Yield (bu/A) Change**		**Treatment**
Enhanced (E)	**77.9**	**81**	**Traditional (T)**
E w/o Urease Inhibitor	5.7	-2.8	T w/Urease Inhibitor
E w/o Nitrification Inhibitor	2.2	3.4	T w/Nitrification Inhibitor
E w/o Plant Growth Regulator	-0.5	1.1	T w/Plant Growth Regulator
E w/o Fungicide	0.3	10.8*	T w/Fungicide
E w/o Foliar Micronutrients	9.8	7.2	T w/Foliar Micronutrients
E w/o Increased Nitrogen Rate	-8.4	4.1	T w/Increased Nitrogen Rate

*Significantly different at α=0.1

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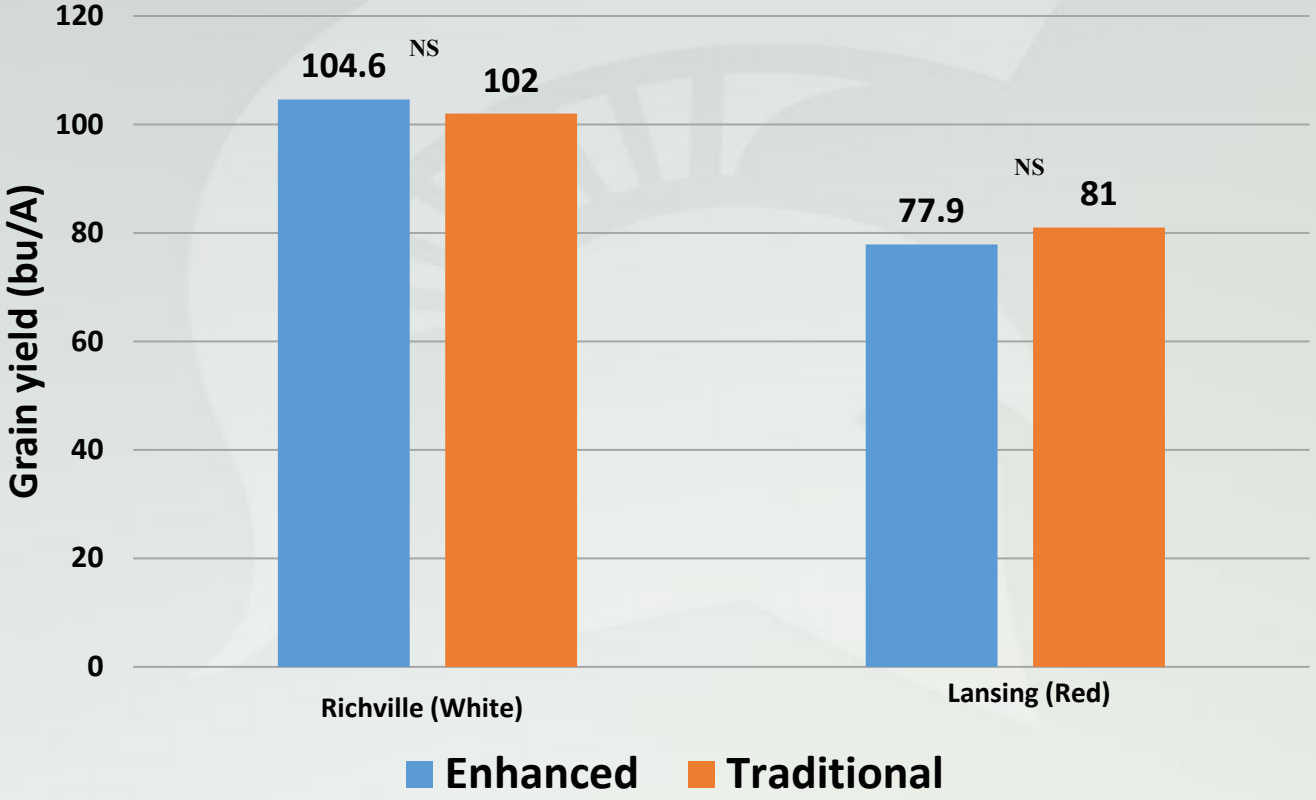
Grain Yield (bu/A) Comparison of Enhanced vs. Traditional



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2018-2019 Intensive Winter Wheat Mgmt Study – Inputs Evaluated

Input	Product Name	Rate Applied
Seeding Rate	Starburst	1.8 million seeds A^{-1} 0.9 million seeds A^{-1}
Autumn Starter Fertilizer	12-40-0-10S-1Zn	250 lbs A^{-1}
Weekly N	UAN 28%	12.5 lbs N A^{-1}
Fungicide	Prothioconazole + Tebuconazole	8.2 oz A^{-1}
Plant Growth Regulator	Trinexapac-ethyl	12 oz A^{-1}
High N Rate	UAN 28%	133 lbs N A^{-1}

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Treatment	Agronomic Inputs					
	Decreased Seeding Rate (D.S.)	Fungicide	Plant Growth Regulator	Autumn Starter	Weekly N	High N Rate
Enhanced (E) –D.S.	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
E w/o D.S.	**No**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
E w/o Fungicide	**Yes**	**No**	**Yes**	**Yes**	**Yes**	**Yes**
E w/o PGR						**Yes**
E w/o Autumn starter						**Yes**
E w/o Weekly N	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**Yes**
E w/o High N	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**No**
Traditional (T) –I.S.	**No**	**No**	**No**	**No**	**No**	**No**
T w/ D.S.	**Yes**	**No**	**No**	**No**	**No**	**No**
T w/ Fungicide	**No**	**Yes**	**No**	**No**	**No**	**No**
T w/ PGR						**No**
T w/ Autumn starter						**No**
T w/ Weekly N	**No**	**No**	**No**	**No**	**Yes**	**No**
T w/ High N	**No**	**No**	**No**	**No**	**No**	**Yes**
Untreated Check	**No**	**No**	**No**	**No**	**No**	**No**

$N\ Rate = 133\ lbs\ N\ A^{-1}$

$N\ Rate = 100\ lbs\ N\ A^{-1}$

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Input Intensive Management Study

- Autumn Starter
  - 10 – 25 bu A^{-1} increase with addition
  - 15 – 37 bu A^{-1} decrease with removal
  - Steinke et al. 2021….Integrating multiple inputs for soft red and white winter wheat
- What about the straw?
  - Identify the impact of autumn starter fertilizer and spring N on wheat grain yield, straw production, and grower profitability in short and tall- statured varieties

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Looking Beyond Grain Yield: Winter Wheat Autumn Starter Fertilizer Treatments 2020-2021

Fertilizer Rates: Soft Red Winter Wheat			
Autumn Starter: 12-40-0 10S 1Zn		28% Nitrogen	
No Starter Fertilizer	0 lb/A	Low Spring N	50 lb/A
Mid Autumn Starter	125 lb/A	Base Spring N	100 lb/A
High Autumn Starter	250 lb/A	High Spring N	150 lb/A

'Flipper' and 'Red Dragon'

Fertilizer Rates: Soft White Winter Wheat			
Autumn Starter: 12-40-0 10S 1Zn		28% Nitrogen	
No Starter Fertilizer	0 lb/A	Low Spring N	60 lb/A
Mid Autumn Starter	125 lb/A	Base Spring N	120 lb/A
High Autumn Starter	250 lb/A	High Spring N	180 lb/A

'Jupiter' and 'AC Mountain'

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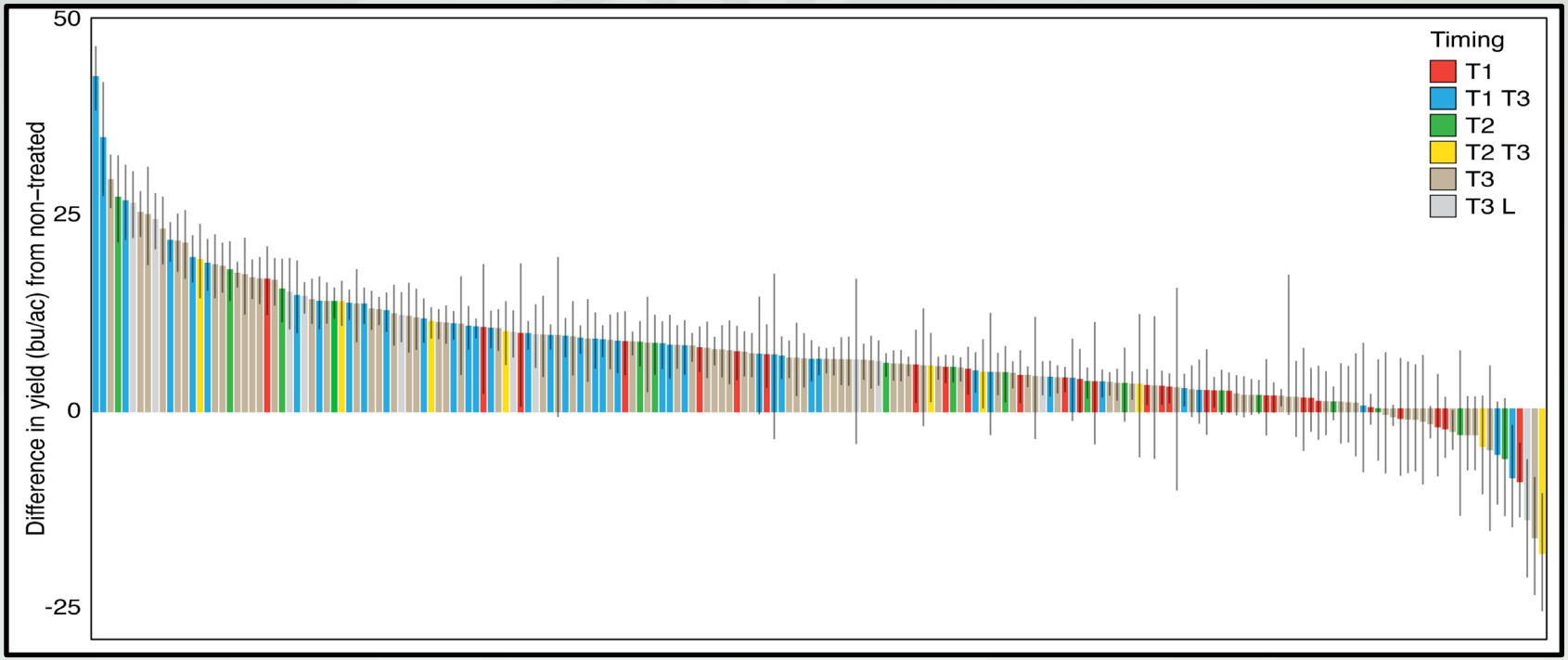
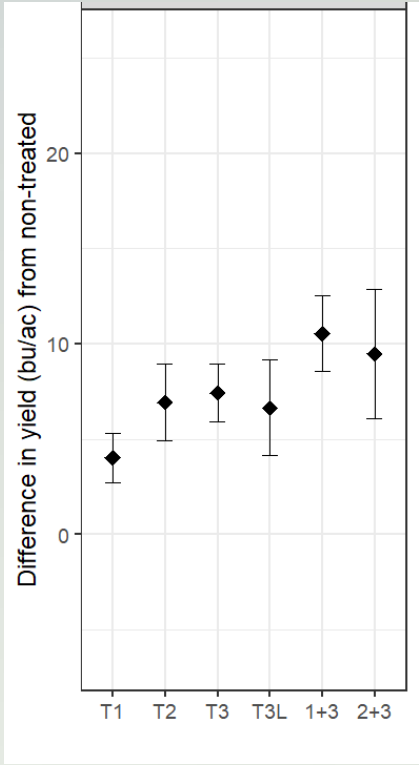
Summary

- Autumn practices are NOT only tied to grain yield
  - Straw production also influenced
  - Grain and straw yield reductions with treatments containing no autumn starter also had N:S ratios > 12:1
- High spring N did not compensate for lack of autumn starter
  - Varietal (stature) differences
- Plant height increased with autumn starter across all varieties
  - Direct impact on variety selection for straw production
  - Short stature did not limit straw
  - Increases in tiller count and plant height with autumn starter
- Pre-plant soil test levels crucial to determining plant response

Meta-analysis of 93 individual studies on difference in grain yield between fungicide treated and non-treated wheat



Timing	Yield response bu/ac ($\overline{D}_t$)	Among-study variance $\hat{\sigma}^2$
T1	4.01 A	8.65
T2	6.93 B	37.16
T3	7.41 B	40.79
T3_L	6.65 B	31.72
T1_T3	10.53 C	60.76
T2_T3	9.48 CB	64.14



- On average, all application timings provided significant yield benefit
- T1 provided the least benefit
- Combination treatments provided highest benefit on average, but also largest variance

Breunig et al., 2022. Meta analysis of yield response to applications of fungicide made at different crop growth stages in Michigan winter wheat. Plant Health Prog. 23:300-307

Experimental Treatment & Design

- **Three-level factorial structure with four replications**

  (84 plots per site)

  - Autumn starter fertilizer
  - Fungicide timing applications
  - Late-applied Nitrogen
  - Check plot

LeeAgra Avenger with Kincaid cobra plot sprayer attachment controlled by HarvestMaster

Preliminary Results

- **Grain & Straw Yield**
  - Autumn starter improved grain yield by **36.03%.**
  - Late-applied N increased grain yield by **4.83%.**
  - **Straw w/ autumn starter only = straw w/ autumn starter + late-applied N.**
  - Fungicide Timing = NS
- **Tiller Production**
  - Autumn starter increased tillers by **13.74%**.
- **Fractional green canopy coverage (FGCC) and normalized difference vegetation index (NDVI)**
  - Autumn starter enhanced wheat's canopy coverage and greenness across growth stages.
- **Head count, head length & plant height**
  - Autumn starter and late-applied N increased headcount by **46.67% and 5.56%**, respectively.
  - Interaction of autumn starter and late-applied N increased head length.

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Preliminary Results

- **Fusarium head scab**
  - Interaction of autumn starter and late-applied N reduced FHB severity and index.
- **Flag leaf nutrient concentration**
  - Interaction of autumn starter and late-applied N improved plant N.
  - Addition of late-applied N increased plant P.
  - Addition of autumn starter increased plant S.
- **Grain nutritive quality**
  - Addition of autumn starter and fungicide reduced protein content.
  - Application of late N improved protein content.

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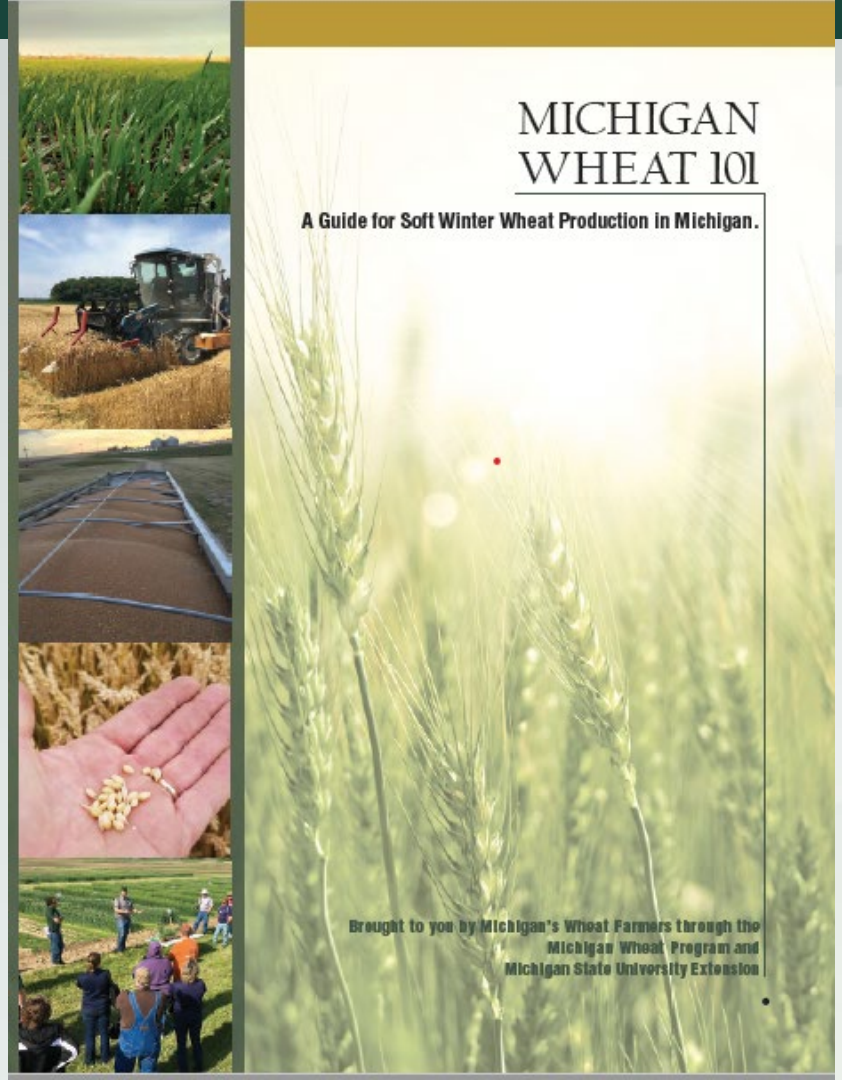

- Be sure to check out recent wheat production bulletin
- soil.msu.edu
  - Resources
    - Bulletins, Articles, Papers
      - Michigan Wheat 101

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Thank you!

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Greater yield in the field
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