

Agronomic Management Practices to Maximize Yield of Ohio Soybean

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Introduction

Soybean [*Glycine max* (L.) Merr] is one of the world's most important crops, supplying approximately half of the global demand for vegetable oil and protein (Oerke, 2006). In 2013, Ohio had a record high soybean yield of 3.29 Mg ha⁻¹ (NASS, 2014). However, further yield increases are critical to meet the growing food and bio-based product demand. Yield increases occur due to a combination of genetic and agronomic factors. Improvements on agronomic management practices increase soybean grain yield by 0.060 to 0.015 Mg ha⁻¹ yr⁻¹ (Specht et al., 1999). Agronomic inputs may be applied alone or in combination with other practices to attain increased yields.

Objectives: Therefore, the objective of this study was to evaluate five common agronomic inputs (*Rhizobia* inoculant, fungicide, insecticide, Mn foliar fertilizer, and gypsum) on soybean grain yield and determine whether:

1. Inputs decrease yield when omitted from an enhanced soybean production system.
2. Inputs increase yield when added to a traditional production system.

Materials and Methods

- Field study conducted in 2013 in nine Ohio counties:
 - Clark, Clinton, Delaware, Erie, Henry, Mercer, Preble, Wood, and Wayne
- Omission trial, randomized complete block design with four replications (Table 1)
- ASGROW 3231 seed, 3.2 maturity group, metalaxyl, pyraclostrobin, fluxapyroxad, and imidacloprid seed treatment (Acceleron®)
- Planted at 358,000 seeds ha⁻¹ in 38 cm rows
- Plots 8.5 to 9.1 m long (depending on site)
- Application of inputs:
 - Rhizobia* inoculant (0.06 ml kg⁻¹ of seed) at planting
 - Pelletized gypsum (4.47 Mg ha⁻¹) at VC
 - Pyraclostrobin fungicide (439 ml ha⁻¹) at R3
 - Lambda-cyhalothrin insecticide (117 ml ha⁻¹) at R3
 - Mn foliar fertilizer (4.67 L ha⁻¹) at R3
- Protein and oil content analyzed with Tecator Infratec whole grain analyzer calibrated with the Composition Systems Calibration.
- Analyzed with PROC MIXED in SAS at $\alpha = 0.05$. Single degree of freedom contrasts used to compare 'Enhanced (E)' to 'E - Input' or 'Traditional (T)' to 'T + Input' or 'E' to 'T'.

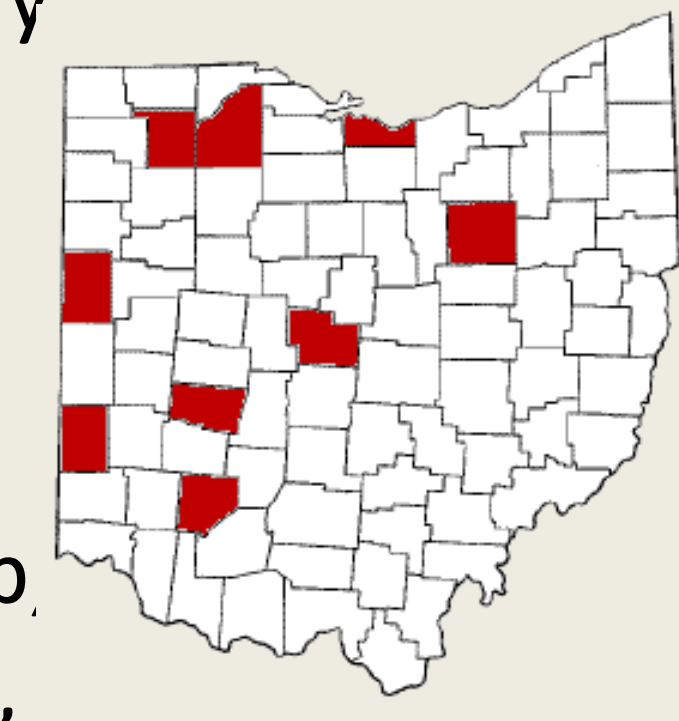


Table 1 Trial Treatments.

Trt Name	Inoculant	Gypsum	Fungicide	Insecticide	Mn ²⁺
Enhanced (E)	Yes	Yes	Yes	Yes	Yes
E - inoculant	No	Yes	Yes	Yes	Yes
E - gypsum	Yes	No	Yes	Yes	Yes
E - fungicide	Yes	Yes	No	Yes	Yes
E - insecticide	Yes	Yes	Yes	No	Yes
E - manganese	Yes	Yes	Yes	Yes	No
Traditional (T)	No	No	No	No	No
T + inoculant	Yes	No	No	No	No
T + gypsum	No	Yes	No	No	No
T + fungicide	No	No	Yes	No	No
T + insecticide	No	No	No	Yes	No
T + manganese	No	No	No	No	Yes

Table 2 Soybean grain yield in 2013. Yield is shown for Enhanced (E) and Traditional (T) treatments. Change in yield shown for all other treatments.

Treatment	Grain Yield Site								
	Clark	Clinton	Delaware	Erie	Henry	Mercer	Preble	Wayne	Wood
Enhanced (E)	4.72	5.00	3.20	2.48	4.07	3.75	4.33	4.03	4.21
E minus inoculant†	-0.13	-0.24	-0.52	-0.36	-0.04	+0.29	+0.14	+0.08	-0.07
E minus fungicide	-0.12	-0.79*	+0.13	+0.32	-0.35*	+0.05	+0.39	-0.11	-0.21*
E minus insecticide	+0.05	-0.27	-0.55	-0.20	-0.01	+0.50*	+0.24	-0.01	-0.14
E minus manganese	+0.03	+0.13	-0.28	+0.01	-0.05	+0.17	+0.25	+0.06	-0.16
E minus gypsum	+0.53*	-0.11	+0.46	+0.39	+0.06	+0.06	+0.16	-0.04	-0.13
Traditional (T)	4.78	4.76	2.72	2.57	3.88	3.92	4.58	3.87	3.98
T plus inoculant‡	-0.47	+0.06	-0.35	-0.32	+0.08	-0.14	-0.02	+0.11	-0.01
T plus fungicide	+0.10	-0.14	+1.01	+0.43	+0.19	+0.07	-0.27	+0.16	+0.07
T plus insecticide	-0.50	0	-0.01	+0.37	-0.06	-0.14	+0.01	-0.09	+0.08
T plus manganese	+0.19	+0.08	-0.21	+0.20	-0.09	-0.37	+0.06	-0.19	-0.01
T plus gypsum	-0.08	-0.57*	+0.20	-0.41	-0.23	-0.26	+0.12	+0.10	0
E vs. T	ns	ns	ns	ns	ns	ns	ns	ns	*

† Yield values in 'E minus input' rows signify a change in yield (Mg ha⁻¹) from the respective 'Enhanced (E)' treatment
‡ Yield values in 'T plus input' rows signify a change in yield (Mg ha⁻¹) from the respective 'Traditional (T)' treatment
* Significantly different at $P \leq 0.05$ using single degree of freedom contrasts

Table 3 Soybean protein content in 2013. Protein content is shown for Enhanced (E) and Traditional (T) treatments. Change in protein content shown for all other treatments.

Treatment	Protein Content Site								
	Clark	Clinton	Delaware	Erie	Henry	Mercer	Preble	Wayne	Wood
Enhanced (E)	34.9	34.6	34.9	35.3	35.6	34.6	34.3	35.4	34.5
E minus inoculant†	+0.2	-0.1	+0.1	-0.2	-0.3	0	-0.1	+0.2	0
E minus fungicide	+0.3	+0.3	+0.5*	+0.4*	-0.2	-0.3	+0.1	+0.5*	+0.3
E minus insecticide	+0.2	-0.3	0	-0.1	-0.1	-0.2	-0.1	-0.1	+0.2
E minus manganese	0	-0.4	+0.3	-0.1	0	-0.4	0	0	+0.2
E minus gypsum	+0.4	-0.1	0	+0.1	0	+0.2	0	+0.1	-0.1
Traditional (T)	35.0	34.7	35.6	35.2	35.8	34.7	34.4	35.5	34.7
T plus inoculant‡	+0.1	+0.2	0	0	+0.1	+0.1	-0.2	0	-0.1
T plus fungicide	+0.1	-0.1	-0.8*	+0.3	-0.7*	-0.4	-0.3	-0.4	-0.4
T plus insecticide	+0.1	0	-0.1	+0.1	-0.2	-0.6*	-0.1	+0.1	-0.1
T plus manganese	-0.4	-0.2	-0.2	+0.2	-0.2	+0.2	-0.1	-0.1	-0.2
T plus gypsum	+0.1	0	0	+0.2	-0.1	-0.3	0	+0.4	0
E vs. T	ns	ns	*	ns	ns	ns	ns	ns	ns

† Protein values in 'E minus input' rows signify a change in protein (%) from the respective 'Enhanced (E)' treatment
‡ Protein values in 'T plus input' rows signify a change in protein (%) from the respective 'Traditional (T)' treatment
* Significantly different at $P \leq 0.05$ using single degree of freedom contrasts

Table 4 Soybean oil content in 2013. Oil content is shown for Enhanced (E) and Traditional (T) treatments. Change in oil content shown for all other treatments.

Treatment	Oil Content Site								
	Clark	Clinton	Delaware	Erie	Henry	Mercer	Preble	Wayne	Wood
Enhanced (E)	18.3	18.5	18.2	17.5	17.7	18.3	18.6	17.9	18.1
E minus inoculant†	-0.3*	0	0	+0.1	+0.1	+0.1	0	-0.1	0
E minus fungicide	-0.4*	-0.2	-0.2	-0.1	+0.2*	+0.1	0	-0.1	-0.1
E minus insecticide	0	+0.1	0	+0.1	+0.1	+0.2	0	0	-0.1
E minus manganese	-0.1	+0.1	-0.1	+0.1	+0.1	+0.1	+0.1	+0.1	0
E minus gypsum	-0.2	0	0	0	0	0	+0.1	-0.1	+0.1
Traditional (T)	18.2	18.4	18.0	17.7	17.8	18.3	18.7	17.9	18.0
T plus inoculant‡	0	0	+0.1	0	-0.2	0	+0.1	0	+0.1
T plus fungicide	-0.1	0	+0.2*	-0.2	+0.1	+0.1	+0.1	+0.1*	+0.2
T plus insecticide	0	0	0	-0.1	0	+0.1	-0.1	0	0
T plus manganese	+0.1	+0.1	0	-0.1	-0.1	0	+0.1	0	+0.2
T plus gypsum	-0.1	0	-0.1	-0.2	-0.1	+0.1	0	0	+0.1
E vs. T	ns	ns	ns	ns	ns	ns	ns	ns	ns

† Oil values in 'E minus input' rows signify a change in protein (%) from the respective 'Enhanced (E)' treatment
‡ Oil values in 'T plus input' rows signify a change in protein (%) from the respective 'Traditional (T)' treatment
* Significantly different at $P \leq 0.05$ using single degree of freedom contrasts

Table 5 Frogeye leaf area affected for the top third of the soybean canopy in 2013 at four weeks after fungicide application.

Site	Frogeye Leaf Area Affected Treatment						
	Enhanced (E)	E - fungicide	Δ	Traditional (T)	T + fungicide	Δ	E vs. T†
Clinton	0.2	1.9	+1.7*	1.6	0.1	-1.5	ns
Delaware	0.3	0.9	+0.6*	0.7	0.2	-0.5*	*
Henry	0.3	3.4	+3.1*	6.4	1.2	-5.2*	*

Δ Change in percent leaf area affected between 'Enhanced (E)' and 'E - fungicide' or the change between 'Traditional (T)' and 'T + fungicide' treatments.
† Single degree of freedom contrast used to compare 'Enhanced (E)' treatment to 'Traditional (T)' treatment
* Significantly different at $P \leq 0.05$ using single degree of freedom contrasts

Results

Grain Yield: When fungicide was omitted from the enhanced production system, soybean yield decreased at 3 of 9 locations. When fungicide was added to the traditional production system, no significant yield effects were observed. No beneficial yield responses were observed for the inoculant, gypsum, insecticide, and manganese foliar fertilizer inputs (Table 2).

Protein Content: When fungicide was omitted from the enhanced production system, protein content was increased in two of nine locations and protein content was decreased in one of nine locations. When fungicide was added to the traditional production system, protein content was decreased in one of nine locations. The inoculant, manganese foliar fertilizer, and gypsum inputs had no effect on soybean protein content (Table 3).

Oil Content: When fungicide was omitted from the enhanced production system, oil content was decreased in one of nine locations and increased in one of nine locations. When fungicide was added to the traditional production system, oil content was increased in two of nine locations. When inoculant was omitted from the enhanced production system, oil content was decreased in one of nine locations. The insecticide, manganese foliar fertilizer, and gypsum inputs had no significant effects on oil content (Table 4).

Conclusions

Omission of pyraclostrobin fungicide from an enhanced production system reduced yield in three out of nine locations by 0.21 to 0.79 Mg ha⁻¹, but addition of the fungicide to a traditional system did not result in a yield increase. It is possible tank mixing with lambda-cyhalothrin insecticide resulted in synergistic effects. During 2013, with established corn/soybean rotations, no sulfur or manganese deficiencies, and limited insect pressure, there was no beneficial effect of inoculant, gypsum, insecticide, and manganese foliar fertilizer on grain yield. Regular scouting is useful to identify inputs that will increase soybean yield.

Although statistically significant differences were observed for protein and oil content, these differences varied only by 0.4 and 0.8% for protein and 0.1 to 0.4% for oil. These differences may not be biologically significant.

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