



# Determination of isoflavone (genistein and daidzein) content, total oil content and fatty acid composition of soybean as affected by environment and management inputs

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**Introduction:** Soybean grain samples were collected from five Michigan site-years. Each location had 16 different field applied management input treatments with 4 replications. Samples were analyzed for various quality traits: isoflavone levels, total oil content, and fatty acid profile. Isoflavones are a group of phytochemicals in some legumes that contribute to the healthful effects of soybeans in human and animal diets. Daidzein and genistein are isoflavone aglycones that are commonly found in soybeans. The major five fatty acids that are produced in soybeans are palmitic, stearic, oleic, linoleic and linolenic acid.

**Objective:** The objectives of this study were to determine the isoflavone (genistein and daidzein) content, total oil content and fatty acid composition of Michigan grown soybean using high performance liquid chromatography, accelerated solution extraction followed by gas chromatography.

## Collection of samples

- Field experiments were established in 2012, 2013, and 2014 in Breckenridge, MI and in 2013 and 2014 in East Lansing, MI.
- Each study consisted of 4 replications of each treatment in a randomized complete block design, with entries random within reps.
- There were 16 different agronomic treatments in this study which are shown below

## Description of Treatments

Treat#	Product Application footnote	Seed applied			Foliar applied							
		Fungicide Seed	Insecticide Seed	LCO Seed	LCO Va-Vb	Nitrogen W	Defoliant Va	Fertilizer R1	PGR R3	Fungicide R3	Insecticide R3	
1	UTC	-	-	-	-	-	-	-	-	-	-	-
2	Bio-Forge	-	-	-	-	-	-	-	-	-	-	-
3	Fung ST	+	-	-	-	-	-	-	-	-	-	-
4	Fung+Insect ST+Biologicals	+	+	-	-	-	-	-	-	-	-	-
5	Fung+Insect+Biologicals+LCO ST+LCO	+	+	+	+	-	-	-	-	-	-	-
6	Foliar fertilizer	-	-	-	-	-	-	+	-	-	-	-
7	Defoliant	-	-	-	-	-	-	+	-	-	-	-
8	Foliar Fung	-	-	-	-	-	-	-	-	+	-	-
9	Foliar Insect	-	-	-	-	-	-	-	-	-	+	-
10	Foliar Insect+Fung	-	-	-	-	-	-	-	-	-	+	+
11	Nitrogen	-	-	-	-	+	-	-	-	-	-	-
12	SOYA Complete (does not include Cobra)	+	+	+	+	+	+	+	+	+	+	+
13	SOYA plus Defoliant	+	+	+	+	+	+	+	+	+	+	+
14	SOYA minus Nitrogen	+	+	+	+	+	+	+	+	+	+	+
15	SOYA minus Foliar Fung at R3	+	+	+	+	+	+	+	+	+	+	+
16	SOYA minus [Foliar Fung+Insect at R3]	+	+	+	+	+	+	+	+	+	+	+

UTC: Untreated control  
 F: Fungicides  
 I: Insecticides  
 B: Biologicals  
 LCO: Growth promoter  
 ST: Seed treatment  
 a) Acceleron fungicide seed treatment  
 b) Imidacloprid at 2.1 ml/kg and Poncho/Votivo at 0.13 mg ai/seed  
 c) Optimize at 1.84 ml/kg  
 d) Ratchet at 292 ml/hectare  
 e) 34 kg of urea with Agrotan at 2.8 liters/90.7 metric tons, and 34 kg of ESN/acre  
 f) Cobra at 877 ml/hectare with 1% crop oil concentrate  
 g) TaskForce 2 at 4.7 l/hectare  
 h) BioForge used as a Plant Growth Regulator (PGR) 1.2 l/hectare  
 i) Headline was used in 2012 and 2013 at 438 ml/hectare, Prioxx was used in 2014 at 584 ml/hectare  
 j) Warrior was used in 2012 and 2013 at 140 ml/hectare, Endigo was used in 2014 at 292 ml/hectare

**Correlation and regression of isoflavones (mg/g), total oil (g/g), and fatty acids (%) with soybean grain yield (bu/acre)**

Regression	Pr> t	Slope
Genistein: grain yield	NS	
Daidzein: grain yield	NS	
Total oil: grain yield	*	(-) 0.04
Palmitic acid: grain yield	***	(+) 0.02
Stearic acid: grain yield	***	(-) 0.02
Oleic acid: grain yield	*	(+) 0.03
Linoleic acid: grain yield	***	(-) 0.04
Linolenic acid: grain yield	*	(+) 0.1
Genistein: total oil	NS	
Daidzein: total oil	NS	
Palmitic acid: total oil	NS	
Stearic acid: total oil	NS	
Oleic acid: total oil	NS	
Linoleic acid: total oil	NS	
Linolenic acid: total oil	NS	
Genistein:daidzein 2012 Breck.	***	(+) 2.75
Genistein:daidzein 2013 Breck.	***	(+) 2.88
Genistein:daidzein 2013 E. Lansing	***	(+) 1.06
Genistein:daidzein 2014 Breck.	***	(+) 1.64
Genistein:daidzein 2014 E. Lansing	***	(+) 0.87
Genistein:daidzein All Sites	***	(+) 1.43

## Acknowledgements

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\* = P < 0.05; \*\* = P < 0.01; \*\*\* = P < 0.001

Amount of daidzein and genistein (mg /g) levels in soybean grain with all 16 treatments

Daidzein	All	2012	2013	2014	Genistein	All	2012	2013	2014	
Input Contrast	Sites	Breck	Breck	MSU	Breck	MSU	Breck	MSU	Breck	MSU
Nitrogen vs. no Nitrogen	NS	NS	*(.26)	NS	NS	NS	NS	NS	NS	NS
Lactofen vs. no Lactofen	**(-.3)	NS	NS	**(-1.7)	**(.35)	NS	NS	NS	NS	NS
Foliar Fertilizer vs. no Foliar Fertilizer	*(.14)	NS	**(.38)	NS	*(.13)	NS	NS	NS	NS	NS
Bio-Forge vs. no Bio-Forge	*(.13)	NS	**(.42)	NS	NS	NS	NS	NS	NS	NS
Foliar Fung. vs. no Foliar Fung	**(.17)	NS	**(.44)	NS	*(.12)	NS	NS	NS	NS	NS
Foliar Insecticide vs. no Foliar Insect	*(.13)	**(-.16)	**(.55)	NS	**(.18)	NS	NS	NS	NS	NS
Seed Fung vs. no Seed Fung	NS	NS	*(.12)	**(.40)	NS	NS	NS	NS	NS	**(-.16)
Seed Complete vs. no Seed Comp	NS	NS	**(.40)	NS	NS	NS	NS	NS	NS	NS

Treatment effect of oleic and linoleic acid (%) in soybean grain

Oleic Acid	All	2012	2013	2014	Linoleic Acid	All	2012	2013	2014	
Input Contrast	Sites	Breck	MSU	Breck	MSU	Breck	MSU	Breck	MSU	Breck
Nitrogen vs. no Nitrogen	NS	*(0.60)	NS	NS	NS	NS	NS	NS	NS	NS
Lactofen vs. no Lactofen	*(-0.75)	NS	NS	*(-0.67)	NS	*(-0.15)	NS	NS	**(-0.97)	NS
Foliar Fertilizer vs. no Foliar Fertilizer	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Bio-Forge vs. no Bio-Forge	NS	NS	*(0.77)	NS	NS	NS	NS	NS	NS	NS
Foliar Fungicide vs. no Foliar Fungicide	NS	NS	NS	**(-.82)	NS	NS	NS	NS	**(-0.78)	NS
Foliar Insecticide vs. no Foliar Insecticide	NS	*(0.54)	NS	**(-.67)	NS	NS	NS	NS	**(-0.51)	NS
Seed Fungicide vs. no Seed Fungicide	NS	**(-0.83)	NS	*(-0.45)	*(0.88)	NS	NS	NS	NS	NS
Seed Complete vs. no Seed Complete	NS	**(-0.88)	NS	NS	NS	NS	NS	NS	NS	NS

Treatment effect on soybean grain yield (bu / acre)

Grain Yield	All	2012	2013	2014							
Input Contrast	Sites	Breck	MSU	Breck	MSU	Breck					
Nitrogen vs. no Nitrogen	**	(3.38)	NS	**	(7.61)	**	(2.95)	**	(2.6)	**	(1.96)
Lactofen vs. no Lactofen	**	(-2.19)	NS	NS	**	(-1.31)	NS	**	(-3.65)	NS	NS
Foliar Fertilizer vs. no Foliar Fertilizer	**	(2.84)	NS	**	(4.18)	**	(2.7)	**	(2.56)	**	(2.80)
Bio-Forge vs. no Bio-Forge	**	(2.81)	NS	**	(5.12)	**	(1.76)	**	(2.62)	**	(2.90)
Foliar Fungicide vs. no Foliar Fungicide	**	(3.37)	*(3.07)	**	(4.36)	*(1.39)	**	(3.19)	**	(4.44)	NS
Foliar Insecticide vs. no Foliar Insecticide	**	(3.04)	NS	**	(4.31)	**	(2.07)	**	(2.84)	**	(3.66)
Seed Fungicide vs. no Seed Fungicide	**	(1.74)	NS	NS	*(1.13)	**	(2.03)	*(1.81)	NS	NS	NS
Seed Complete vs. no Seed Complete	**	(3.15)	NS	**	(5.42)	**	(1.87)	**	(2.9)	**	(3.30)

## Results and conclusions

### Isoflavones

- Agricultural inputs did not always impact isoflavone levels (daidzein 15 of 48 observations and genistein (10 of 48 observations) but when a response was observed to management inputs it generally resulted in an increase in isoflavone levels (21 of 26 observations).
- This study supports previous research showing high variability in soybean grain isoflavone levels.
- The research confirms a significant interaction of soybean isoflavone levels with the field environment. During one particular site year, Breckenridge 2013, all management practices, with the lone exception of the defoliant, increased daidzein and genistein levels.
- Over all 5 site years, daidzein was more responsive to agricultural management inputs than genistein.

### Total oil and fatty acid profile

- Common agronomic practices that were used in this study did not significantly increase or decrease total oil levels.
- In general, management inputs were not consistent in altering the fatty acid profile of soybean oil.
- Averaged across all site years, application of a defoliant (lactofen) decreased oleic acid levels and increased linoleic acid levels. However, the relationship was greatly influenced by one particularly responsive site-year (Breckenridge '13).
- There were significant differences in all five fatty acids in relation to agronomic practices in individual site years but the effects were not consistent between sites.
- Oleic and linoleic acid levels showed the largest response to management inputs.

Treatment effect on soybean grain oil content (g /g)

Oil Content	All	2012	2013	2014			
Input Contrast	Sites	Breck	MSU	Breck	MSU	Breck	
Nitrogen vs. no Nitrogen	NS	NS	NS	NS	NS	NS	0.97
Lactofen vs. no Lactofen	NS	NS	NS	*(3.52)	NS	NS	0.64
Foliar Fertilizer vs. no Foliar Fertilizer	NS	NS	NS	NS	NS	NS	0.50
Bio-Forge vs. no Bio-Forge	NS	NS	NS	NS	NS	NS	0.71
Foliar Fungicide vs. no Foliar Fungicide	NS	NS	NS	NS	NS	NS	*(-1.33)
Foliar Insecticide vs. no Foliar Insecticide	NS	NS	NS	NS	*(1.11)	*(-1.33)	NS
Seed Fungicide vs. no Seed Fungicide	NS	NS	NS	NS	NS	NS	0.57
Seed Complete vs. no Seed Complete	NS	NS	NS	NS	NS	NS	0.31