**Optimizing Yield and Quality of High-Oleic Soybeans**

209206 FINAL REPORT

Shaun Casteel, Purdue University

Indiana Soybean Alliance

 c/o Aly Wells

Project Period: 05/01/2016 to 04/30/2017

**OBJECTIVES**

We want to enable growers to make the best management decisions, to optimize their return/risk tradeoff, associated with high-oleic soybeans. Specifically, our **objectives** are to ***optimize oleic oil production and determine oleic stability across:***

1. ***Seed Rates x Planting Date,***
2. ***Foliar Protection and Foliar Feeding,***
3. ***Water Supply.***

**SEED RATE x PLANTING DATE EFFECTS ON OLEIC VARIETIES**

Two oleic varieties (P29T40, P37T51) were planted in May 22, 2016 and June 13, 2016 at five seed rates (50, 100, 150, 200, and 250 thousand seeds per acre). These 20 treatments were replicated four times at West Lafayette (ACRE) in 2016. Weekly growth staging and canopy closure analyses (digital camera and crop reflectance) were conducted. Stand counts were taken early and at harvest. Grain subsamples were taken for quality analyses (protein, oil, fatty acid profile).

***Yield.*** Varieties yielded ~70 bu per acre at the May 22nd planting with no response to seeding rate. Whereas, both varieties responded to seeding rate at the later planting. The optimal harvest stand was ~150,000 plants per acre for both varieties for the June 13th planting. These yields plateaued near 60 bu per acre. Example of these yield responses in Figure 1.

**Figure 1.** Yield response of P29T40 (oleic variety) planted May 22 and June 13 (late) across five seed rates (50, 100, 150, 200, and 250 thousand seeds/ac) near West Lafayette, IN 2016.

***Quality.*** Seed quality was largely unresponsive to planting date and seed rate combinations for seed size, protein, and oil. P29T40 averaged 16.3 g per 100 seeds, 35.8% protein, and 20.5% oil. P37T51 averaged 18.8 g per 100 seeds, 34.5% protein, and 20.4% oil.

**INTENSE FOLIAR MANAGEMENT EFFECTS ON OLEIC VARIETIES**

Two oleic varieties (P31T96, P33T34) and two standard varieties (AG3334, P28T33) were planted May 22 near West Lafayette (ACRE) and May 23 near Wanatah (Pinney PAC) in 2016. Five management regimes were imposed across the four varieties to total 20 treatments that were replicated four times. The management regimes were untreated control, intense foliar protection from insects at R3 + R5, intense foliar protection from diseases at R1 + R3 + R5, intense foliar feeding at R1 + R3 + R5, and the combination of the latter three regimes. Applications at ACRE were June 19 for R1, July 23 for R3, and Aug 22 for R5. Applications at Pinney PAC were June 30 for R1, July 26 for R3, and Aug 23 for R5. Weekly growth staging and general observations of insect and disease pressures were noted. Stand counts were taken at harvest and grain subsamples were taken for quality analyses (protein, oil, fatty acid profile) from the 80 plots at each location.

***Wanatah 2015 Summary:***

Four varieties (2 oleic + 2 standard) were planted in the previous year on May 19, 2015 near Wanatah (Pinney PAC) under the same management treatment regime. As a quick summary with a few additional details, variety type influenced yield, seed size, and protein in the 2015 trial (Table 1). Management did have an impact on yield pooled across variety type. Protein was influenced by management within the oleic type, but oleic composition did not differ based on management.

**Table 1.** Variety Type x Management ANOVA summary for Wanatah (Pinney PAC) 2015.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Wanatah 2015** | **Yield** | **Seed Size** | **Protein** | **Oil** | **Oleic** |
| Type | \*\*\* | \*\*\* | \*\*\* | NS | . |
| Management | X | NS | NS | NS | NS |
| Type x Mgt | NS | NS | NS | NS | . |
|  |  |  |  |  |  |
| **Standard** |  |  |  |  |  |
| Management | NS | NS | NS | NS | . |
|  |  |  |  |  |  |
| **Oleic** |  |  |  |  |  |
| Management | \* | NS | \*\* | NS | NS |

Significance at P ≤ 0.10, 0.05, 0.01, ≤ 0.001 is denoted by X, \*, \*\*, and \*\*\*, respectively; NS, not significant within full and partitioned ANOVA.

***Yield.*** The standard varieties out-yielded the oleic varieties by 4 bu when comparing the untreated controls of each pair of soybean varieties (61.9 vs. 57.9 bu). Foliar management regimes had limited impact on the overall yield of these varieties and soybean types. Foliar fertilizer, foliar insecticide, and foliar fungicide regimes did not increase yield above the untreated control (UTC) within each respective soybean type (standard vs. oleic). The foliar fungicide and foliar ALL added about 2 bu when compared to UTC within the standard, but only differed from foliar insecticide. The foliar ALL added 3.7 bu in the oleic varieties compared to UTC, which seemed to build on the foliar components that only added ~1 to 1.5 bu when applied individually.

***Quality.*** Protein averaged 33.7% and oil averaged 19.6% in the standard varieties across the five management regimes. Oleic varieties were higher in protein than standard type (35.4 vs. 33.7%, respectively). Though, protein was ~0.5% lower in the treatments that included an insecticide and/or fungicide in the management regime for oleic varieties (Figure 3). Oleic varieties averaged 19.5% oil. Oleic composition averaged 80.5% and did not differ based on management.

c

bc

c

ab

a

**Figure 3.** Protein concentrations (%) as influenced by intense foliar management across two standard and two oleic varieties in 2015 season at Wanatah IN. Means are averaged across the two respective varieties for each type of soybean. Differences due foliar treatments are denoted by different letters (Standard = UPPERCASE; Oleic = lowercase) at alpha = 0.05.

***Wanatah 2016 Summary***:

Seed size and protein differed based on variety type in 2016 trial in Wanatah (Table 2). Management and Management x Type did not impact yield, seed size, protein, oil, or oleic composition.

Standard varieties averaged 63.5 bu/ac, and oleic varieties averaged 62.2 bu/ac with no management effects (Table 2, Fig. 4). Oleic varieties had bigger seeds at harvest than standard varieties (20.1 vs. 16.8 g/100 seeds, which is 2258 vs. 2757 seeds/lb). Protein was also higher for oleic varieties compared to standard varieties (36.1 vs. 34.9%), but oil did not differ ~19.6%. Finally, oleic composition was high for the oleic varieties (~82.5%) and was not influenced by foliar management.

**Table 2.** Variety Type x Management ANOVA summary for Wanatah (Pinney PAC) 2016.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Wanatah 2016** | **Yield** | **Seed Size** | **Protein** | **Oil** | **Oleic** |
| **Type** | NS | \*\*\* | \*\*\* | NS | . |
| **Management** | NS | NS | NS | NS | NS |
| **Type x Mgt** | NS | NS | NS | NS | . |
|  |  |  |  |  |  |
| **Standard** |  |  |  |  |  |
| Management | NS | NS | NS | NS | . |
|  |  |  |  |  |  |
| **Oleic** |  |  |  |  |  |
| Management | NS | NS | NS | NS | NS |

Significance at P ≤ 0.10, 0.05, 0.01, ≤ 0.001 is denoted by X, \*, \*\*, and \*\*\*, respectively; NS, not significant within full and partitioned ANOVA.

**Figure 4.** Yield as influenced by intense foliar management across two standard and two oleic varieties in 2016 season at Wanatah IN. Means are averaged across the two respective varieties for each type of soybean. No differences were detected among management or variety type.

***West Lafayette 2016 Summary***:

Variety type influenced yield, seed size, and protein in 2016 trial near West Lafayette (Table 3). Yield was also impacted by Management and the interaction of Management x Type. No other treatment effects were noted including oleic composition.

**Table 3.** Variety Type x Management ANOVA summary for West Lafayette (ACRE) 2016.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **W. Lafayette 2016** | **Yield** | **Seed Size** | **Protein** | **Oil** | **Oleic** |
| **Type** | \*\*\* | \*\*\* | \*\*\* | NS | . |
| **Management** | X | NS | NS | NS | NS |
| **Type x Mgt** | \* | NS | NS | NS | . |
|  |  |  |  |  |  |
| **Standard** |  |  |  |  |  |
| Management | \*\* | NS | NS | NS | . |
|  |  |  |  |  |  |
| **Oleic** |  |  |  |  |  |
| Management | NS | NS | NS | NS | NS |

Significance at P ≤ 0.10, 0.05, 0.01, ≤ 0.001 is denoted by X, \*, \*\*, and \*\*\*, respectively; NS, not significant within full and partitioned ANOVA.

***Yield.*** Standard varieties were 4.6 bu/ac better than the oleic varieties in 2016 near West Lafayette (67.2 vs. 62.6 bu/ac, Fig. 5). The management effect was much higher within the standard varieties than the oleic varieties. Foliar fungicide application yielded 71.4 bu/ac within standard varieties, which was 4.7 bu/ac more than UTC. The yields within the oleic type ranged from 61.1 bu/ac (UTC) to 64.2 bu/ac (insecticide) with no differences among the management regimes.

***Quality.*** Oleic varieties produced larger seeds in the trial at West Lafayette, which followed the same trend at Wanatah. Oleic varieties averaged 19.3 g/100 seeds (2368 seeds/lb); whereas, standard varieties averaged 16.1 g/100 seeds (2898 seeds/lb). Protein followed a similar trend between the variety types (36.2% for the oleic varieties vs. 34.7% for standard varieties). Oil did not differ among the variety types and averaged 20.1%. Oleic composition was very good for the oleic type and did not differ among management (83.9 to 84.6% oleic).

**Figure 5.** Yield as influenced by intense foliar management across two standard and two oleic varieties in 2016 season at West Lafayette IN. Means are averaged across the two respective varieties for each type of soybean. Differences due foliar treatments are denoted by different letters at alpha = 0.05, and reported across both soybean types due to interaction effect (Table 3).

AB

B

B

A

A

B

B

B

B

B

**WATER SUPPLY EFFECTS ON OLEIC VARIETIES**

Six varieties (3 oleic + 3 standard) were planted on May 23, 2016 and May 26, 2017 near Wanatah (Pinney PAC) in a Tracy Sand. Each of the variety types were matched in pairs of similar maturity: 2.9 and 2.8, 3.3 and 3.4, and 3.7 and 3.8. Half of the field was dryland and the other half was irrigated once the varieties reached reproductive stages. Supplemental irrigation was supplied based on Purdue Irris Scheduler. We tracked the estimated daily evapotranspiration in order to maintain soil moisture ≥ 60% soil water holding capacity. We applied 4.8 inches of water across August and September in 2016 and only 3 inches in 2017 (Table 4). Stand counts were taken at harvest and grain subsamples were taken for quality analyses (protein, oil, fatty acid profile) from the 48 plots (6 varieties x 2 Water Regimes x 4 reps) in each season.

**Table 4.** Irrigation dates and quantities during the 2016 and 2017 growing season near Wanatah (Pinney PAC) on a Tracy sand. Irrigation was initiated once soybeans reached R3 (first pod) and concluded once R7 (first physiological maturity) began.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **2016 Dates** | **Irrigation** |  | **2017 Dates** | **Irrigation** |
| **August** | inches |  | **August** | inches |
| 08/01 | 0.6 |  |  |  |
| 08/03 | 0.6 |  |  |  |
| 08/09 | 0.6 |  | 08/16 | 0.6 |
| 08/11 | 0.6 |  | 08/31 | 0.6 |
| *Subtotal* | *2.4* |  | *Subtotal* | *1.2* |
| **September** |  |  | **September** |  |
| 09/07 | 0.6 |  | 09/07 | 0.6 |
| 09/14 | 0.6 |  | 09/13 | 0.6 |
| 09/20 | 0.6 |  | 09/18 | 0.6 |
| 09/23 | 0.6 |  |  |  |
| *Subtotal* | *2.4* |  | *Subtotal* | *1.8* |
| **2016 TOTAL** | **4.8** |  | **2017 TOTAL** | **3.0** |

***Wanatah 2016 and 2017 Summary:***

***Yield.*** Standard and oleic varieties did not differ in yield in 2016 and 2017 within water regime (Table 5). Yields were higher under the irrigation regime when averaged across the varieties in 2016 (Dryland: 62.8 bu/ac vs. Irrigation: 66.5 bu/ac) and 2017 (Dryland: 57.0 bu/ac vs. Irrigation: 64.5 bu/ac ).

**Table 5.** Water Supply ANOVA summary for Wanatah (Pinney PAC) in 2016 and 2017.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **IRRIGATION** | **Yield** | **Seed Size** | **Oleic** |  | **DRYLAND** | **Yield** | **Seed Size** | **Oleic** |
| **2016** |  |  |  |  | **2016**  |  |  |  |
| Variety  | NS | \*\*\* | \*\*\* |  | Variety  | NS | \*\*\* | \*\*\* |
| **2017**  |  |  |  |  | **2017**  |  |  |  |
| Variety  | NS | . | \*\*\* |  | Variety  | NS | . | \*\* |

Significance at P ≤ 0.10, 0.05, 0.01, ≤ 0.001 is denoted by X, \*, \*\*, and \*\*\*, respectively; NS, not significant within full and partitioned ANOVA.

***Quality.*** Seed size was highly influenced by varieties in both regimes with a similar effect regardless of water regime in 2016 (Figure 6). Seeds were generally larger as the relative maturity increased in both standard (from 14.8 to 21.0 g per 100 seeds) and oleic from (17.6 to 21.2 g per 100 seeds) varieties.

**Figure 6.** Seed weight (g per 100 seeds) of standard and oleic soybean varieties under dryland (brown) and irrigated (blue) regimes in 2016. Means of varieties are separated within each water regime (Dryland = lowercase, Irrigation = UPPERCASE) at alpha = 0. 05.

***Quality – continued.*** Fatty acid analyses were performed on the oleic varieties in 2016 and 2017. Individual variety consistently influenced the proportion of oleic acid within each water regime (Table 5, Figures 7 and 8). Oleic composition was very high in 2016 (>80%) and moderate in 2017 (75 to 82%). In general, the oleic 3.7 variety produced the greatest proportion of oleic acid in both years and water regimes (Figure 7). The other two varieties were still above acceptable levels of oleic production, but marginally lower than oleic 3.7. Irrigation in 2016 marginally suppressed oleic production by 0.5 to 2.1 percentage points. Similar suppression in oleic production was apparent in our previous 2015 trial (decrease of 1.0 to 2.4 percentage points of oleic acid). Whereas, irrigation in 2017 seemed to have the opposite effect with oleic proportions that were 1.8 to 4.6 percentage points higher.

Oleic 3.7

Oleic 2.9

Oleic 3.3

**Figure 7.** Proportion of oleic acid in the oil of oleic soybean varieties under dryland (brown) and irrigated (blue) regimes in 2016. Means of varieties are separated within each water regime (Dryland = lowercase, Irrigation = UPPERCASE) at alpha = 0. 05.

**Figure 8.** Proportion of oleic acid in the oil of oleic soybean varieties under dryland (brown) and irrigated (blue) regimes in 2017. Means of varieties are separated within each water regime (Dryland = lowercase, Irrigation = UPPERCASE) at alpha = 0. 05.

**CONCLUSIONS**

***Seed Rate x Planting Date.*** Optimal plant populations were similar for standard and oleic varieties that were planted timely as well as those planted later than ideal. The effects on quality were not evident and thus, optimizing plant population based on our traditional agronomic yield goals and/or economic returns of investment of seed are appropriate.

***Intense Foliar Management.*** The management effects on yield were mixed within given location and variety type. Oleic varieties were more responsive to the full combinations of intense foliar management at Wanatah in 2015 (3.7 bu/ac), which still would not cover the expense of this management regime. Whereas, the oleic varieties were not responsive to any foliar management regime in 2016 at Wanatah and W. Lafayette. All applications were made prophylactically in the absence of insect and disease thresholds. If thresholds were attained, the yield responsiveness would most likely be present.

Intense foliar management did not influence the oleic composition of the oleic varieties evaluated in 2015 (Wanatah) and 2016 (Wanatah, W. Lafayette). All oleic concentrations were very high (~80%) in these trials that were planted within a normal window without pest pressures or nutrient deficiencies. Within this subset of varieties, the oleic varieties consistently produced larger seeds (~500 more seeds per lb) with greater protein concentration than the standard varieties.

***Water Supply.*** The yield performance of standard and oleic varieties were similar in 2016 and 2017 (additional trial provided in this report). Timely irrigation events to maintain ~60% field capacity provided an additional 2.7 bu in 2016 and 7.5 bu in 2017 when averaged over varieties. The influence of irrigation regime on oleic composition was mixed between 2016 (oleic suppression by 0.5 to 2.1 percentage points) and 2017 (oleic improvement by 1.8 to 4.6 percentage points). Potential sources of oleic variations are likely linked to temperature, solar radiation, and soil moisture supply during pod development and seed fill as well as the duration of seed fill and leaf retention. We are exploring the specific differences during R5 to R7 (first seed to first signs of maturity). Due to these conflicting effects within the water regime, we are repeating these water regime trials in 2018.