CROP INSIGHTS

High Yield Soybean Production in the Western Corn Belt

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Summary

- A survey of soybean management practices was conducted in Nebraska and Kansas from 2013 through 2016 to determine management practices associated with high yield irrigated and non-irrigated soybean production.
- In addition to evaluating management practices already being employed in high-yield production, participants were encouraged to test an additional new management practice in an attempt to raise yields even further.
- Many participants achieved soybean yields between 70 and 90 bu/acre, with four entries exceeding 100 bu/acre.
- Some management practices, such as timely planting and the use of a full seed treatment package were common among participants.
- Many other management practices, such as tillage, seeding rate, and foliar fungicide and insecticide use varied widely among participants, emphasizing the lack of a one-size-fits-all solution for higher soybean yields.

Introduction

Soybean yields have increased dramatically over the past 40 years, essentially doubling from a U.S. average of 26.1 bu/acre in 1976 to 52.1 bu/acre in 2016 (USDA-NASS 2017). Despite this increase, there remains a widespread perception among growers of underperformance with regard to yield gains in soybean, particularly in relation to corn, which has had a higher rate of gain over the same time period. One factor that has likely contributed to this difference is a different approach to management between the two crops. In a corn-soybean rotation, corn has typically been the more intensively managed crop, with soybean historically serving as a lower-input rotational crop. Soybeans are often planted later than corn and rely on soil nutrients left over from the previous corn crop.

This approach to soybean management has begun to shift in recent years with the development of newer soybean varieties with greater genetic yield potential and the publicity surrounding several new record-setting soybean contest yields. This has resulted in increased interest in evaluating and implementing management practices that will contribute to higher soybean yields.

High Yield Soybean Challenge

A survey of soybean management practices, referred to as the Pioneer® GrowingPoint® Agronomy High Yield Soybean Challenge, was conducted across a total of 698 locations in Nebraska and Kansas from 2013 through 2016 (Figure 1). The purpose of this survey was to determine management practices associated with high yield irrigated and non-irrigated soybean production. In additional to evaluating management practices already being employed, participants were encouraged to test an additional new management practice in their high yield challenge entry in an attempt to raise yields even further.

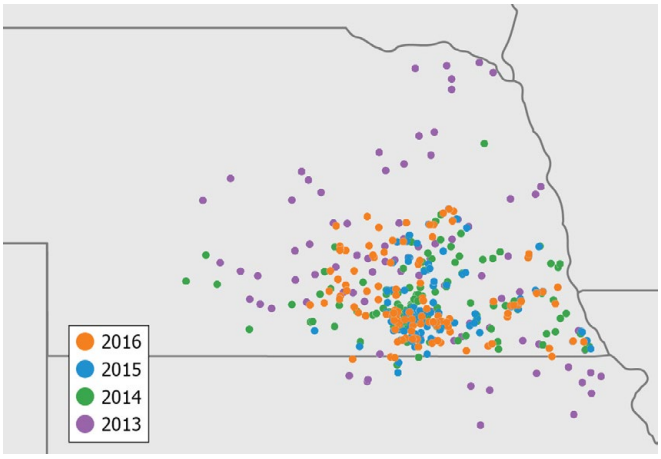

Figure 1. Locations of Pioneer GrowingPoint Agronomy High Yield Soybean Challenge fields, 2013-2016.

All entries consisted of a minimum of 1.25 acres and were planted to a Pioneer® brand soybean variety. Yield and agronomic management data were collected for each location.

Yield Results

Most of the high yield challenge entries (637 of 698) were under full irrigation. Yields under irrigation were typically 10-20 bu/acre more than in non-irrigated entries. Average yields of both irrigated and non-irrigated entries increased from 2013 to 2016 (Figure 2).

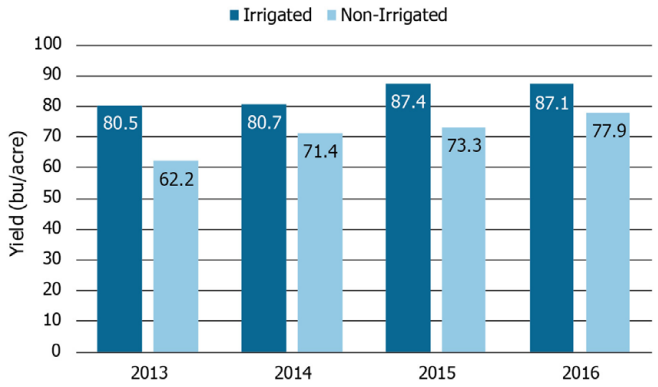

Figure 2. Average yield of irrigated and non-irrigated high yield soybean entries, 2013-2016.

This positive yield trend was likely a result of new high yield potential soybean varieties, as well as management and growing conditions. Over the four years of the survey there was nearly a complete turnover from older M and Y series varieties to newer Pioneer® brand T series soybean varieties, going from 4% of entries planted to T series soybean varieties in 2013 to 100% in 2016 (Figure 3). Entries planted to T series soybean varieties were 6.3 bu/acre higher yielding on average and accounted for most of the highest yields achieved in the survey, including 78% of entries over 95 bu/acre and 100% of entries over 100 bu/acre.

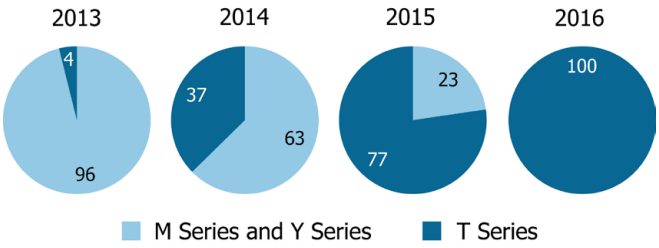

Figure 3. Variety series of Pioneer brand soybean varieties used in high yield soybean entries, 2013-2016

Yield levels of individual entries are shown in Figure 4. The majority of high yield challenge entries (72%) yielded between 70 and 90 bu/acre, with 14% of entries above 90 bu/acre. A total of four entries over the four years of the survey topped 100 bu/acre. Yield, Pioneer brand soybean variety, name, location, and management details of top-yielding entries are shown at right.

Pioneer® GrowingPoint® Agronomy High Yield Soybean Challenge Entries over 100 bu/acre (2013-2016):

101.9 bu/acre Pioneer® variety P27T59R

Mark Koperski – Farwell, NE

- **Planting Date:** May 9, 2016
- **Previous Crop:** Corn
- **Tillage:** Ridge-Till
- **Irrigation:** Limited
- **Seeding Rate:** 170,000 seeds/acre
- **Row Spacing:** 36 inches
- **Pioneer Premium Seed Treatment offering:** Yes
- **Foliar Fungicide:** No
- **Foliar Insecticide:** No
- **Harvest Date:** September 30, 2016

101.5 bu/acre Pioneer® variety P27T59R

Matthew King – Central City, NE

- **Planting Date:** April 30, 2016
- **Previous Crop:** Corn
- **Tillage:** Ridge-Till
- **Irrigation:** Full
- **Seeding Rate:** 200,000 seeds/acre
- **Row Spacing:** 30 inches
- **Pioneer Premium Seed Treatment offering:** Yes
- **Foliar Fungicide:** Yes
- **Foliar Insecticide:** Yes
- **Harvest Date:** October 18, 2016

101.5 bu/acre Pioneer® variety P27T91PR^

Keith Bankson – Hordville, NE

- **Planting Date:** May 6, 2016
- **Previous Crop:** Corn
- **Tillage:** Strip-Till
- **Irrigation:** Full
- **Seeding Rate:** 162,000 seeds/acre
- **Row Spacing:** 30 inches
- **Pioneer Premium Seed Treatment offering:** Yes
- **Foliar Fungicide:** Yes
- **Foliar Insecticide:** Yes
- **Harvest Date:** October 14, 2016

101.3 bu/acre Pioneer® variety P28T08R

Willoughby Farms – Wood River, NE

- **Planting Date:** May 9, 2016
- **Previous Crop:** Corn
- **Tillage:** Minimum Tillage
- **Irrigation:** Full
- **Seeding Rate:** 175,000 seeds/acre
- **Row Spacing:** 30 inches
- **Pioneer Premium Seed Treatment:** Yes
- **Foliar Fungicide:** No
- **Foliar Insecticide:** Yes
- **Harvest Date:** September 27, 2016

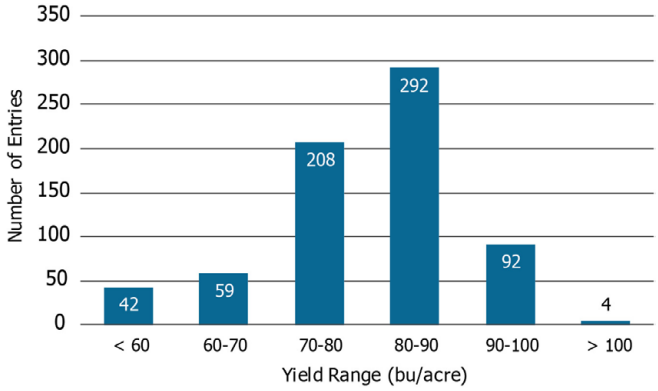

Figure 4. Yield range of high yield soybean entries, 2013-2016.

Yields of high yield challenge entries were generally well-above average for their geography. Average yields of both irrigated and non-irrigated entries were around 20 bu/acre greater than their respective county average yields for irrigated and non-irrigated production (Figure 5).

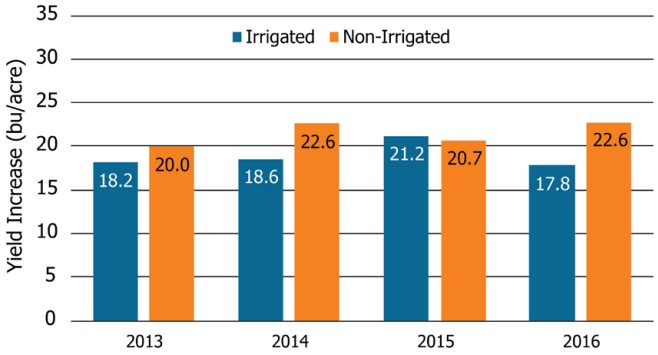

Figure 5. Irrigated and non-irrigated high yield soybean entries difference from respective county average soybean yields.

Management Practices

Tillage

The most common tillage system used in the high yield soybean challenge was no-till, accounting for nearly half of all entries, followed by ridge-till and conventional tillage (Figure 6).

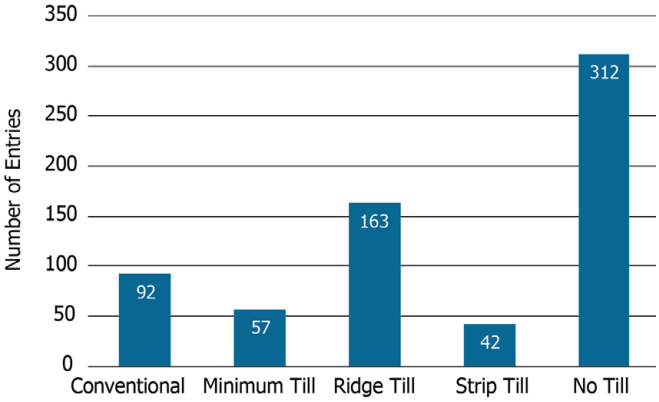

Figure 6. Tillage used in high yield soybean entries.

The average yield of no-till entries was lower than that of entries that included some kind of tillage – no-till entries averaged 76 bu/acre, while other tillage systems averaged between 81 and 85 bu/acre. The impact of excessive residue in no-till is likely a contributing factor to this difference in yield. Challenges with managing residue in no-till have been observed in the survey area. Improved nutrient placement in tilled systems may also be a contributing factor.

Row Spacing

The most common row spacing in high yield challenge entries by far was 30-inch rows (Figure 7). While much more common in other soybean producing areas, 15-inch and narrower row spacings accounted for less than 20% of entries.

In a recent DuPont Pioneer summary of soybean row spacing studies, 15-inch and drilled soybeans yielded around 4 bu/acre greater than soybeans in 30-inch rows (Jeschke and Lutt, 2016). However, studies included in this summary were all located in the central and eastern Corn Belt, where solar radiation during reproductive growth tends to be more of a limiting factor and narrower rows would be expected to provide an advantage. Results of the high yield soybean challenge clearly show that high yields are attainable in 30-inch rows in Nebraska and Kansas. All four of the entries that exceeded 100 bu/acre were planted in 30-inch or wider rows.

The popularity of ridge- and strip-till systems has likely contributed to soybean acres staying in or moving to 30-inch rows. The ability to cover acreage more quickly using a larger 30-inch row planter is likely a factor as well. Even if one assumes a slight yield reduction with 30-inch rows compared to narrower rows, this could be offset by the yield benefit of more timely planting.

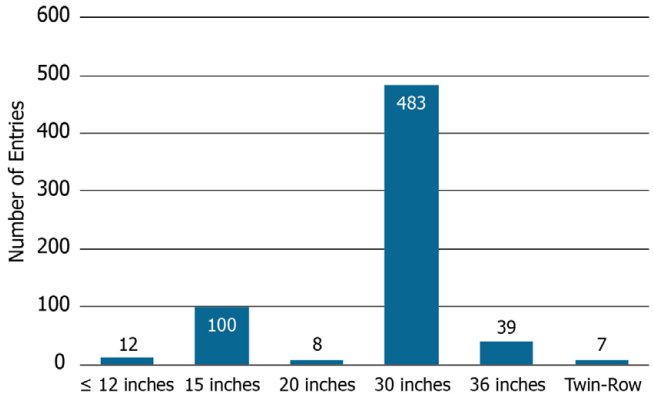

Figure 7. Row spacings used in high yield soybean entries.

Pioneer Premium Seed Treatment Offering

Nearly all high yield soybean challenge entries used seed with the Pioneer Premium Seed Treatment offering (Figure 8). Pioneer Premium Seed Treatment offering helps emerging soybean plants ward off early season insect & disease issues, particularly when planting earlier into cool, wet soils or high residues. In DuPont Pioneer research trials conducted in 2013 and 2014, the Pioneer Premium Seed Treatment offering

increased soybean yield by 4.5 bu/acre versus non-treated soybean varieties in responsive environments.

Foliar Fungicide and Insecticide

Foliar fungicides and foliar insecticides were both used on close to half of the entries (Figure 8). A total of 42% of entries included both treatments, with 6% receiving a fungicide only, 6% an insecticide only, and 46% receiving neither. The average yield of soybeans receiving both treatments was 3.3 bu/acre greater than entries receiving no treatment. A survey of DuPont Pioneer on-farm side-by-side comparisons from 2007-2011 showed an average yield response of 5.3 bu/acre, with similar results observed in Pioneer small-plot research trials (Jeschke and Ahlers, 2015).

High yield soybean challenge results from 2013-2015 showed a 4.2 bu/acre advantage of the full fungicide + insecticide treatment. In 2016, insect and disease pressure in soybeans were generally lower and fewer entries had a foliar treatment applied, which reduced the 4-year average yield advantage of the full treatment. Insecticide application should not necessarily be a routine treatment. Treatment decisions should be based on insect thresholds evaluated from a combined insect number perspective, rather than any single insect species.

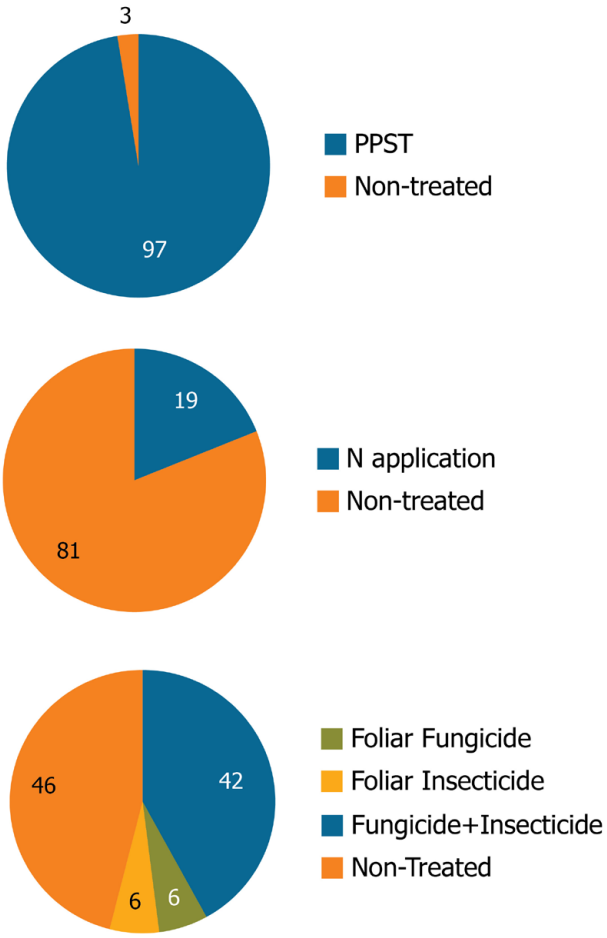

Figure 8. Frequency of use of Pioneer Premium Seed Treatment offering, foliar fungicide, foliar insecticide, and supplemental nitrogen in high yield soybean entries.

Supplemental Nitrogen

Of the 354 entries with nitrogen management practices reported, nearly 19% included a supplemental nitrogen application (Figure 8). Around half of these entries had nitrogen applied prior to planting; the other half had an in-season application. The average yield of entries that received supplemental nitrogen was slightly greater than that of non-treated entries; however, results did not indicate that supplemental nitrogen would likely provide an economic benefit. These results align with those of previous Pioneer and university research that indicate economic benefit of supplemental nitrogen on soybeans is unlikely outside of low organic matter soils or poor nodulation situations (Schmidt, 2013).

Planting Date

Over the four years of the high yield soybean challenge, the average planting date was May 11th. Irrigated locations were planted 3-7 days earlier on average than non-irrigated locations (Table 1).

Table 1. Average planting dates, 2013-2016.

Year	Irrigated	Non-Irrigated
2013	May 15	May 19
2014	May 7	May 11
2015	May 5	May 12
2016	May 10	May 13

Yields tended to decline with later planting. The average yield with early May planting (May 1-10) was 84.5 bu/acre, compared to 78.1 bu/acre with late May planting (May 21-30). However, yields exceeding 90 bu/acre were achieved over a wide planting window – from April 5 through May 24 (Figure 9). The four entries over 100 bu/acre were planted between April 30 and May 9, all in 2016. Optimum planting date changes with annual weather conditions, however planting in the early portion of the planting season generally maximizes yield. Several Pioneer studies have shown the value of planting as early as practical with a full-season soybean variety. It is possible to plant too early every year and associated risks must be considered, such as residue management, SDS management, and late freeze risk.

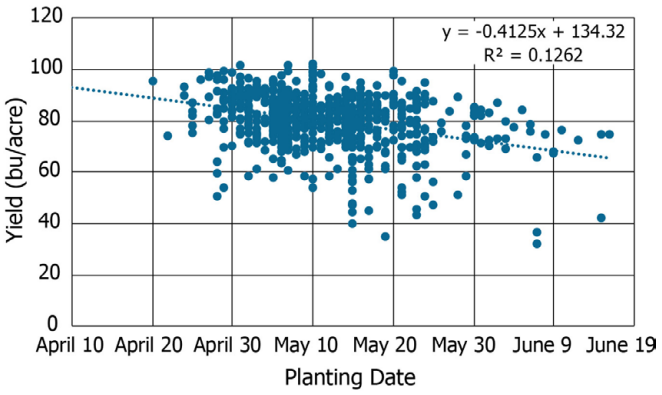

Figure 9. Soybean yield by planting date of high yield soybean entries.

Seeding Rate

Seeding rate of high yield soybean challenge entries ranged from 120,000 to 210,000 seeds/acre, with an average seeding rate of 174,000 seeds/acre. The majority of entries had seeding rates between 160,000 and 190,000 seeds/acre (Figure 10). Data from the high yield soybean challenge show that higher seeding rates are used with higher yield level production practices. Seeding rates in the high yield soybean challenge were generally greater than typical soybean seeding rates in the western Corn Belt according to results of a 2015 DuPont Pioneer survey. Yields in the high yield soybean challenge were also generally around 20 bu/acre above average. Establishing an adequate stand is critical to maximizing soybean yield potential.

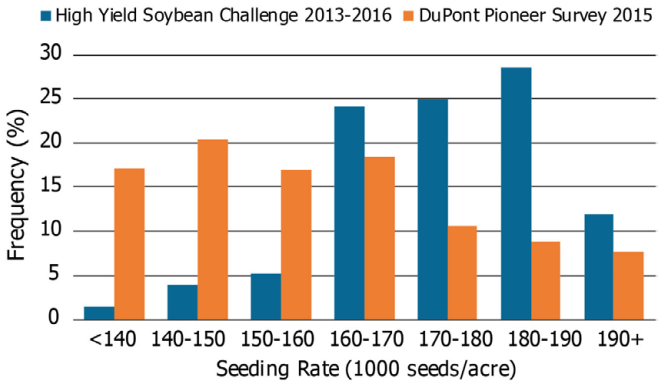

Figure 10. Seeding rate distribution on entries in the high yield soybean challenge (2013-2016) and by percent of soybean acres planted in the Western U.S. Source: 2015 DuPont Pioneer brand concentration survey.

Soybean yields tended to increase with seeding rate, although yields over 90 bu/acre were achieved over a wide range of seeding rates – from 140,000 to 210,000 seeds/acre (Figure 11). Establishing healthy, uniform stands is import-ant to maximize soybean profitability, even though soybeans respond to reduced stands better than many other crops. Because there are many factors that affect soybean stand establishment, optimum seeding rates vary considerably by region, cropping practice, and field.

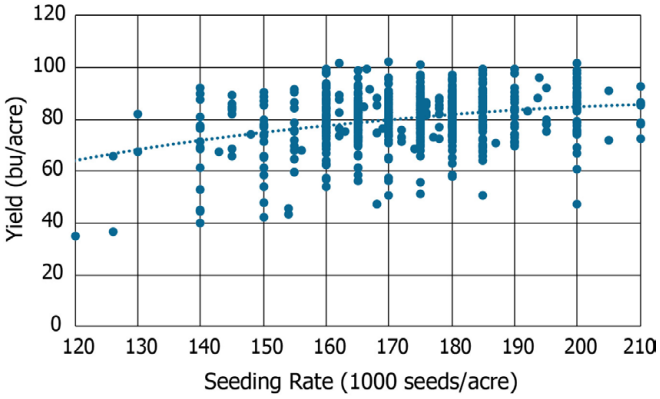

Figure 11. Soybean yield by seeding rate of high yield soybean entries.

Agronomic advantages of maintaining moderate to high seeding rates:

- Higher seeding rates enable quicker canopy closure, which can be a benefit in drought and/or heat prone environments. High levels of heat reflected from the soil surface can reduce early vegetative growth.
- Thicker seeding rates can enhance plant and pod height, which is especially important on sandy soils or with late-planted soybeans that tend to have shorter plants.
- Quicker canopy closure due to higher seeding rates can also benefit weed control by providing shade to slow down or inhibit weed emergence and early growth.
- Higher seeding rates can provide a buffer against the need to replant due to light to moderate stand reduction events, such as hail.

Crop Rotation

Nearly half of the high yield soybean challenge entries were in a corn-soybean rotation. Another 30% had a crop other than soybeans in the field the prior two seasons and 25% were planted to a different crop for three years or more. Yield tended to be greater in entries with more than one season between soybean crops – a 7.1 bu/acre increase compared to entries rotated away from soybeans for a single season (Figure 12).

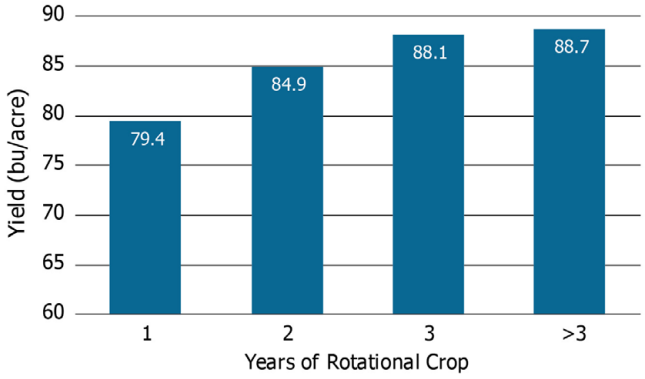

Figure 12. Yields of high yield soybean entries according to number of prior consecutive years planted to a crop other than soybean.

Multiple university studies have shown that soybean yields tend to be greater when a field is rotated away from soybeans for more than one consecutive season. However, results of a University of Nebraska-Lincoln study suggested that the yield benefit of extended rotations may diminish as productivity levels increase (Grassini et al., 2017).

Soil Fertility

A subset of high yield soybean entries reported soil test levels for phosphorus (101 entries) and potassium (50 entries). In nearly all cases, fertility levels were at or above recommended levels for soybean production. University of Nebraska guidelines indicate that soybean yield response to fertilization is unlikely at phosphorus levels above 12 ppm (Bray P1) and potassium levels above 124 ppm (Shaver, 2014). However, soil fertility guidelines are commonly based on crop needs

and removal rates at yield levels below those achieved in the high yield soybean challenge and may be insufficient for high yield production.

Table 2. Soil test range for phosphorus (Bray P1) and potassium for entries reporting soil fertility data.

Phosphorus		Potassium	
Range	Entries	Range	Entries
ppm	number	ppm	number
< 15	5	0-100	0
15-20	16	101-150	1
21-25	26	151-250	8
26-30	26	251-350	20
> 30	28	> 350	21

Nebraska soils typically do not require additional potassium for soybean production. Fertilizer applications in high yield soybean entries were generally focused on insuring adequate levels of phosphorus. A total of 99 entries indicated a pre-plant fertilizer application of monoammonium phosphate (11-52-0), Microessentials® SZ™ (12-40-0-10S-1Zn), or other similar phosphorus containing fertilizer blend.

Harvest Timing and Grain Moisture

Grain buyers pay growers for soybeans based on a weight of 60 pounds per bushel and a grain moisture level of 13%. Delivering soybeans below or above that level reduces profits. Soybeans over 13% moisture can be docked for being too wet. Soybeans below 13% moisture result in fewer effective bushels for which the grower is paid. For example, delivering soybeans at 10% moisture rather than 13% would be equivalent to a 3.3% reduction in yield.

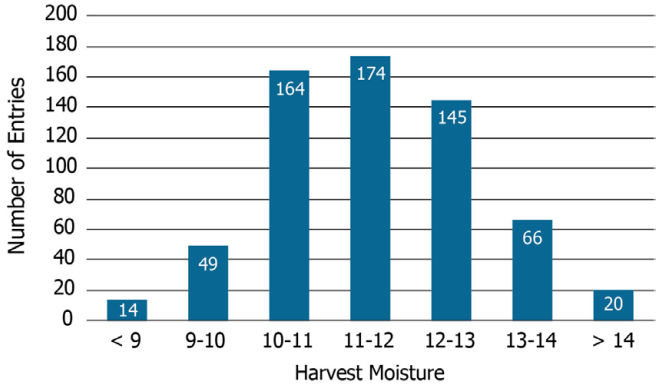

Figure 13. Harvest moisture of high yield soybean entries.

A 2016 University of Nebraska-Lincoln study of soybean deliveries to elevators in Hamilton and York county, NE found that soybeans delivered at 1 to 4 points below target moisture were common (Pryor et al., 2016). Data from the high yield soybean challenge showed very similar results, with over half of entries reporting harvest moisture between 10 and 12% (Figure 13). Yields tended to decline with later harvest dates (Figure 14), and with lower harvest moisture.

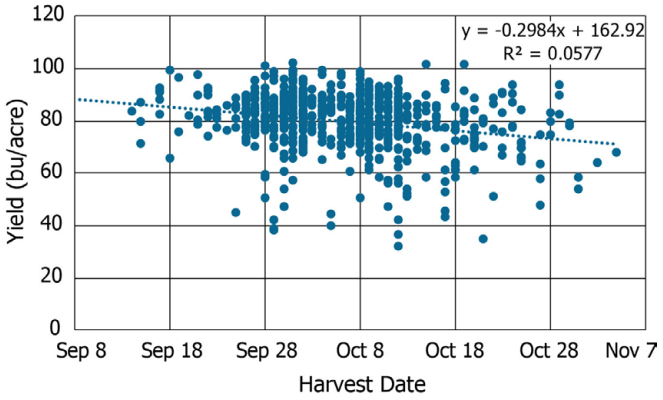

Figure 14. Soybean yield by harvest date of high yield soybean entries.

The observed decline in yield with lower harvest moisture, however, was greater than what would be expected purely due to lower grain weight alone. (Table 3). This suggests that other factors associated with later harvest may also have contributed, such as pod shattering and grain loss at harvest.

Table 3. Expected and observed soybean yield reduction associated with sub-optimum grain moisture at harvest.

Harvest Moisture	Yield Reduction (%)	
	Expected	Observed
12	1.1	2.6
11	2.3	5.4
10	3.3	8.5
9	4.4	11.9

Summary of Management Trends

Variety Selection – Adoption of new, high yield potential soybean varieties likely contributed to the 8.6 bu/acre increase in average yield from 2013 to 2016.

Seed Treatment – Nearly all growers (97%) used soybean varieties treated with Pioneer Premium Seed Treatment offering

Planting Date – May 11 was the average planting date over four years. Soybeans planted in early May yielded 6.4 bu/acre higher on average than those planted in late May.

Seeding Rate – Seeding rates were generally higher than typical for the western Corn Belt, with an average seeding rate of 174,000 seeds/acre.

Crop Rotation – Yield tended to be greater in entries with more than one season between soybean crops – a 7.1 bu/acre increase compared to entries in a corn-soybean rotation.

Tillage – Around half of the entries were in no-till, but those with some form of tillage tended to be higher yielding.

Foliar Fungicide and Insecticide – Around half of the entries used a foliar fungicide and/or insecticide. Entries treated with both yielded 3.3 bu/acre greater on average.

Harvest Timing and Grain Moisture – Yields tended to decline with later harvest dates and with lower harvest moisture.

References

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All Pioneer products are varieties unless designated with LL, in which case some are brands.

Components under the Pioneer Premium Seed Treatment offering for soybeans are applied at a DuPont Pioneer production facility or by an independent sales representative of Pioneer. Not all sales representatives offer treatment services, and costs and other charges may vary. See your Pioneer sales representative for details. Seed treatment offering exclusive to DuPont Pioneer and its affiliates.

Always follow grain marketing, stewardship practices and pesticide label directions. **Varieties with the Glyphosate Tolerant trait** (including those designated by the letter "R" in the product number) contain genes that confer tolerance to glyphosate herbicides. Glyphosate herbicides will kill crops that are not tolerant to glyphosate.

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