The impact of row width and plant population density on soybean yield, seed mass and seed size variability

September 23rd, 2014

Personal Background

- Raised in southwest Iowa near the small town of Creston
- Youngest of three siblings
- Family moved to the farm when I was very young, this sparked my love of agriculture
- Raised on a small cow-calf, hay and row crop operation
- Bachelors from Iowa State majoring in Agricultural Studies and minor in Agronomy (2000-2003)
- Began at DuPont Pioneer immediately after college
  - 3 years in seed corn production (Reinbeck, IA)
  - 4 years in soybean research (Dallas Center, IA)
  - 4 years in continuous improvement supporting production locations (Johnston)

Our family (wife Michelle, son Ty) live in Waukee

Introduction

- Purpose

  - DuPont Pioneer announced in 2012 that all soybean seed would be sold by count starting in 2013. In 2010 Monsanto and Syngenta also announced this change

  - The ability to reduce seed size variability is increasingly important when selling by count to ensure accurate seed counts in all units while managing discard rates in production

Introduction (cont.)

- Significance
  - 2011 soybean acres were estimated at 75 million acres in the United States **(Soy Stats, 2012)**
  - DuPont Pioneer, Monsanto and Syngenta comprise approximately 70% of the United States soybean market share **(Schafer, 2012)**
  - Changes how production facilities fill units, specifically increases the importance of accurate average seed mass (seeds per pound) measurements
  - The objective of this study is to evaluate the impact that a range of plant population densities and wide and narrow row widths will have on grain yield, seed mass, and seed size variability for several soybean cultivars.

Literature Review- impact of row width on grain yield

- Positive yield responses can be attained in row widths of less than 50cm vs greater than 50cm (Cooper, 1977; Beatty et. al, 1982)
- A positive response was not observed for all cultivars, indicating a cultivar by row width interaction.
- Ethredge et. al (1989) reported increased yields from two cultivars to decreasing row widths, however, the level of response was not the same across cultivars
- In a study conducted in 2008, one cultivar was tested across multiple locations at 38cm and 76cm. Results indicated that 38cm row spacing resulted in greater yield, indicating that the response to row spacing of a single cultivar may remain constant across locations. (De Bruin and Pedersen, 2008)

Literature Review- impact of plant population density (PPD) on grain yield

- Soybean yields increase with increasing PPD up to an optimum PPD and uniform distribution, then yields level (Wiggans, 1938).
- These results are consistent with results from later studies that indicated yield was positively impacted by increasing PPD (Cooper, 1977).
- Much like row width, the optimum PPD is dependent upon environment and cultivar.

Literature Review- impact of row width and PPD on seed mass

- De Bruin and Pederson (2008) indicated an interaction was observed when evaluating the seed mass of one cultivar across 3 locations and narrow and wide row spacing.
  - Locations were in western, central and eastern Iowa, row spacing was 38cm and 76cm.

- Two cultivars with differing growth habits were tested In a 3 year study at one irrigated location, Egli (1994) found no difference in seed mass for either cultivar as a result of PPD when each cultivar was tested in rows as well as equidistant plant spacing.

Literature Review- seed size variability

- Yield is nearly always the most important factor in commercial grain production.
- Customers also consider the seed mass (seeds per pound)
- Customers look to purchase seed with certain characteristics, such as a desirable oil trait, specific herbicide resistance, or specific seed quality characteristics, in addition to seed size and yield mentioned previously.
- The move to selling seed by count, will increase awareness of seed size variability within a lot not only for DuPont Pioneer but also for our customers.

Literature Review- seed size variability

- Studies indicate that the seeds within a population from the same field will vary in dimension when measured by the proportion of seed remaining on different sizes of round hole screens (Burris et. al, 1973). Similar results were reported by Egli et. al (1987) indicating a range of 40-80% of the seed in a lot stayed on one screen.

- These findings are significant as the use of screens in the conditioning process is very common and it serves as the primary method for determining the range of seed sizes within a finished product.

Literature Review- seed size variability

- Screens are used to separate seeds based on dimension.
- The seed lot will pass over larger round hole screens
  - Removes extremely large seed , other large material and debris.
- Seed then moves to smaller slotted screens to remove smaller than desired seed, split seed and other fine material.
- Variability in the finished product may take place if proper screen size selection does not occur.
- Variability can cause challenges accurately filling units
  - Impractical , today to physically count 140,000 seeds
  - Unit filled based on a target unit weight determined from the average seed mass from the desirable portion.

Objective of this study

- Previously mentioned works focused on the impacts of row width and PPD on yield while other work focused on factors impacting seed mass and seed size variability within a seed lot. Little data are available to indicate how row width, PPD would impact seed mass, seed size variability, and grain yield.

- The objective of this study is to evaluate the impact that a range of plant population densities and wide and narrow row widths will have on grain yield, seed mass, and seed size variability for several soybean cultivars.

Materials and Methods- Locations

- Study conducted in 2013
- 2 locations
  - Johnston, IA- Wiota silty clay loam soil type
    - Planted May 17th
  - Champaign, IL- Drummer silty clay loam soil type
    - Planted May 30th

Table 1. Average Temperature and Precipitation for Johnston, IA and Champaign, IL for June 2013 through September 2013 expressed as departure from 30 year average for each location.

	Johnston, IA		Champaign, IL	
	Avg. Temp	Avg. Precip	Avg. Temp	Avg. Precip
June	0.8	-1.71	0.0	-0.92
July	-0.3	-3.45	-1.4	0.69
August	3.1	-3.15	0.4	-3.36
September	5.8	-0.69	3.9	-2.73

Data summarized from http://www.nws.noaa.gov/climate/index.php?wfo=dmx

Materials and Methods-Cultivars

- Six cultivars were selected from a relative maturity range adapted for each location.

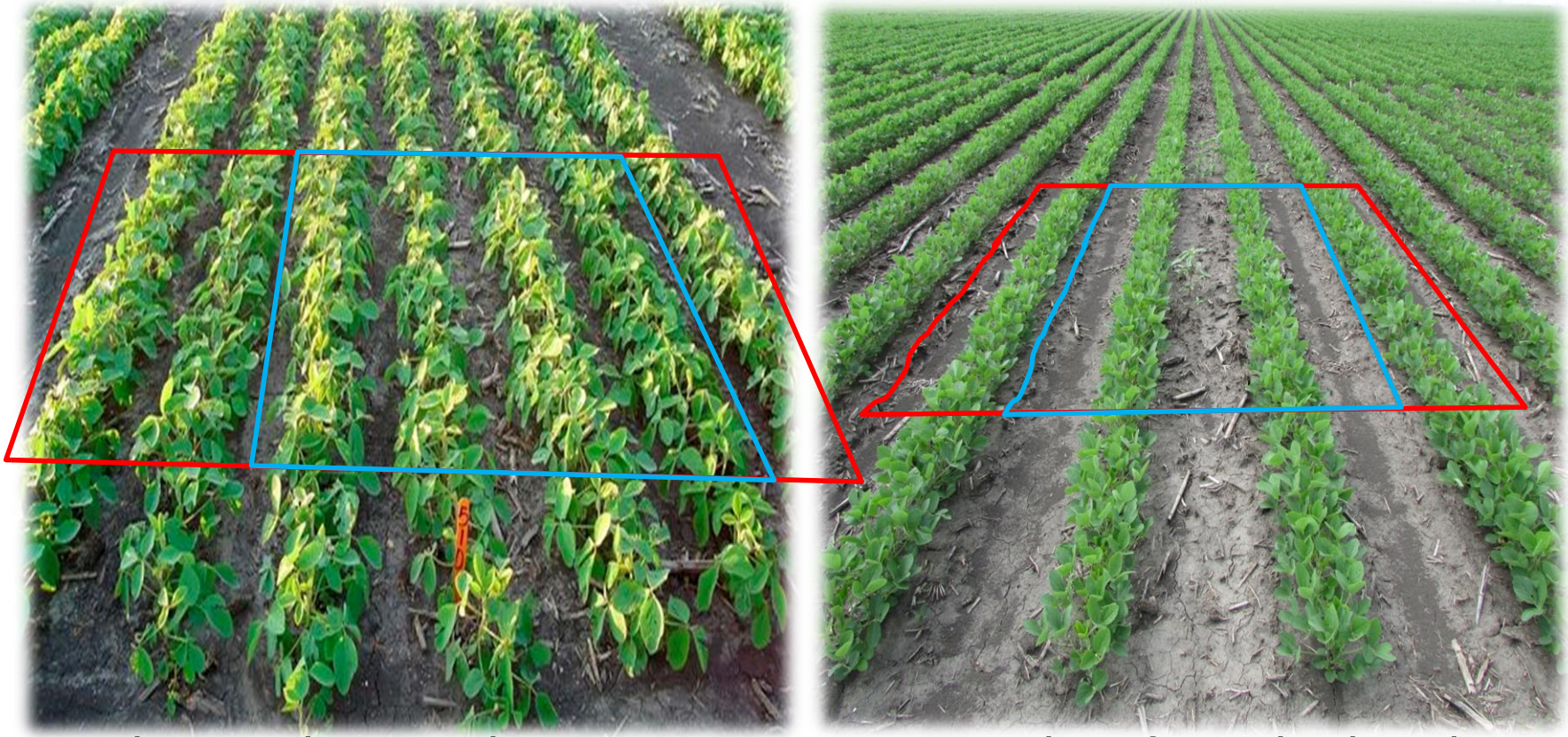
- The locations differ in relative maturity range suitability; therefore, cultivars were not duplicated at both locations.

- As a result 12 different cultivars were tested
  - Johnston ranged from 2.5- 3.2 relative maturity
  - Champaign ranged from 3.5-4.2 relative maturity.

Materials and Methods – Experimental Design

- Four PPD levels of 75,000, 125,000, 175,000 and 225,000 plants per acre.
- All PPDs planted in 30 inch rows and 15 inch rows.
- Total width of each plot was 10 feet wide and 17.5 feet long
- Randomized complete block design with a factorial treatment arrangement.
- Replications were blocked, and blocks consisted of each cultivar, population and row width combination randomly placed within each block.

Row Width Illustrated



- Observations and measurements were taken from the interior two rows (rows 2 and 4) of the 30 inch plots and from the interior four rows (rows 3, 4, 5 and 6) in the 15 inch plots.

Materials and Methods – Data Analysis

- Individual analysis of the Johnston and the Champaign locations was completed because location and cultivar were confounded.

- Yield, seed mass, and seed size variability were analyzed by the analysis of variance using Minitab (Minitab Inc., State College, PA, USA).

- Plot weights and moistures were collected using ALMACO (ALMACO, Nevada, Iowa, USA) SPC40 research combine harvester with weight and moisture measurement capabilities.

Materials and Methods – Data Analysis (Cont.)

- Plots were subsampled at the time of harvest via a sampling probe located below the weigh hopper and each subsample was retained for further lab analysis.

- Samples measured to collect seed mass for all cultivar, PPD and row width combinations.

- Seed mass, expressed as grams per 100 seeds, was calculated by measuring the weight, in grams, of three replications of 100 seeds for each sample.

Materials and Methods – Data Analysis (Cont.)

- Samples from Johnston, IA were evaluated for seed size variability measured by weight and seed count retained on a calibrated set of round hole and slotted hand screens.

- Total weight and count of seeds remaining on each of the screens was recorded and utilized to calculate the percent of seed that remained on each screen.

- Seeds and other material that passed through the 10/64th by ¾ inch slotted screen were considered unusable seed and were not included in the analysis.

- Seed Size variability was not measured on Champaign, IL location samples

Screens for processing

Left to right: Round hole screen, slotted screen, screens stacked smallest to largest ready to process sample

Results and Discussion- Yield Champaign

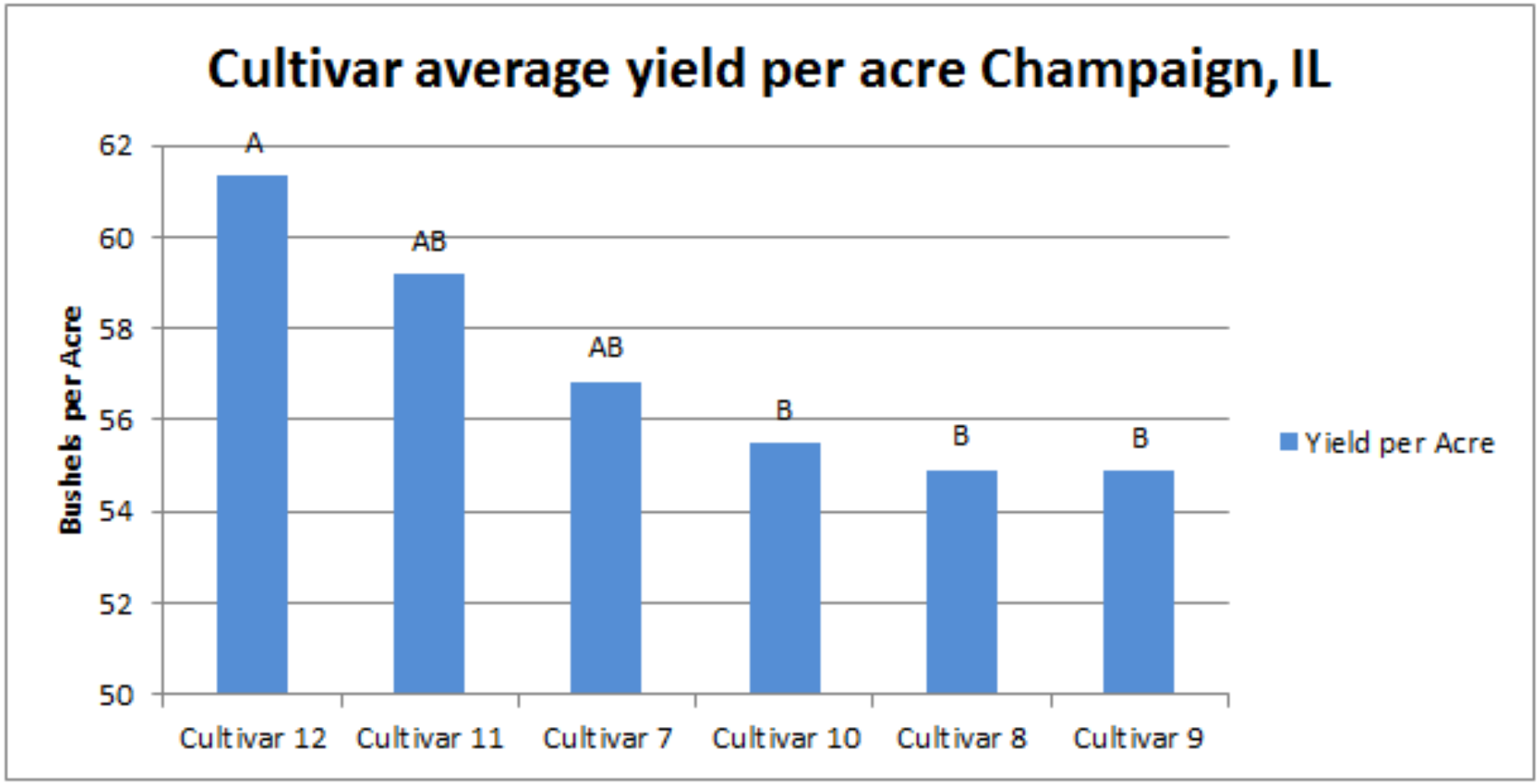
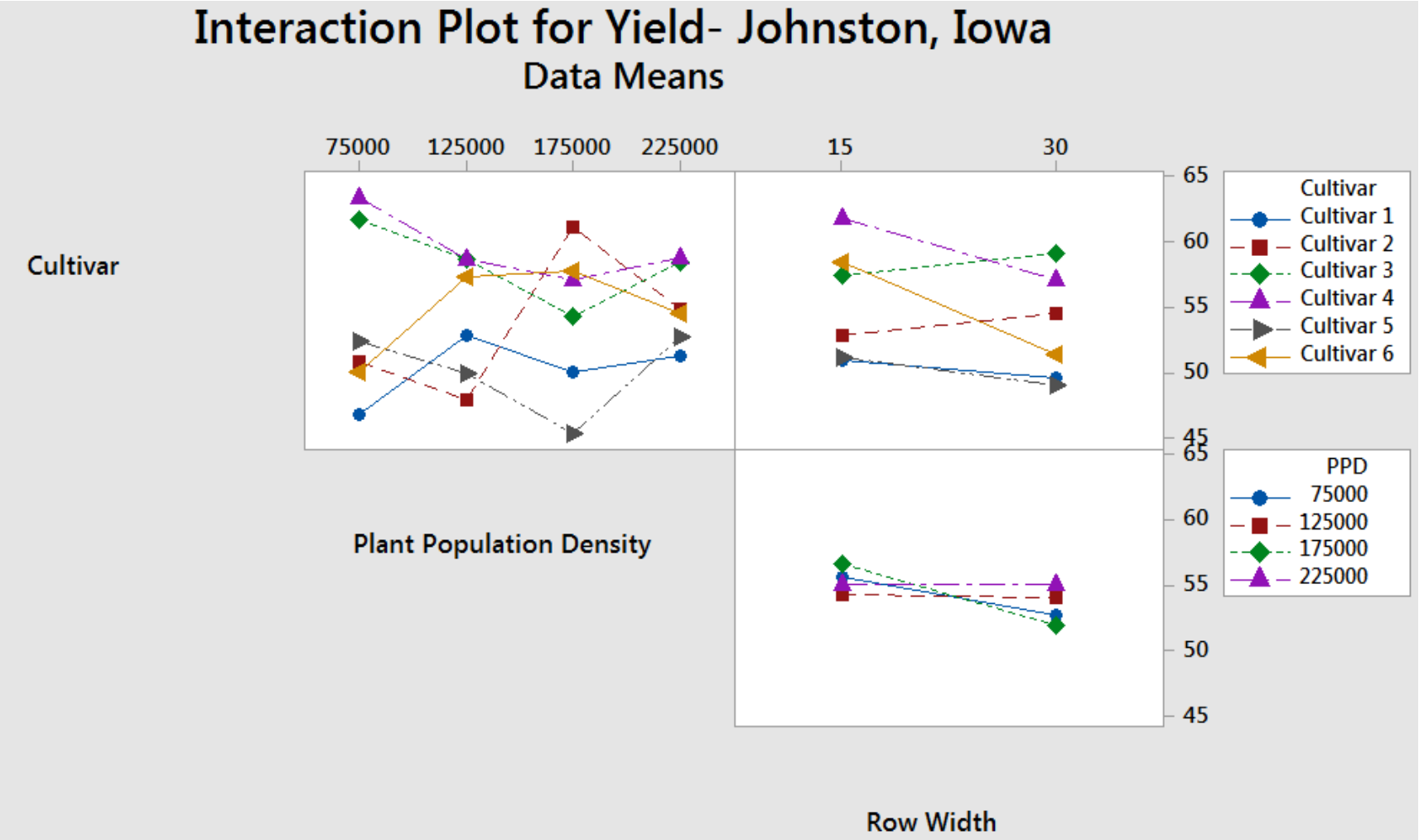


Figure 1. Cultivar average yield per acre averaged across all population and row width treatments at Champaign, Illinois. Levels not connected by the same letter are significantly different at $P < 0.05$.

Results and Discussion-Yield Johnston



Results and Discussion- Seed Mass Champaign

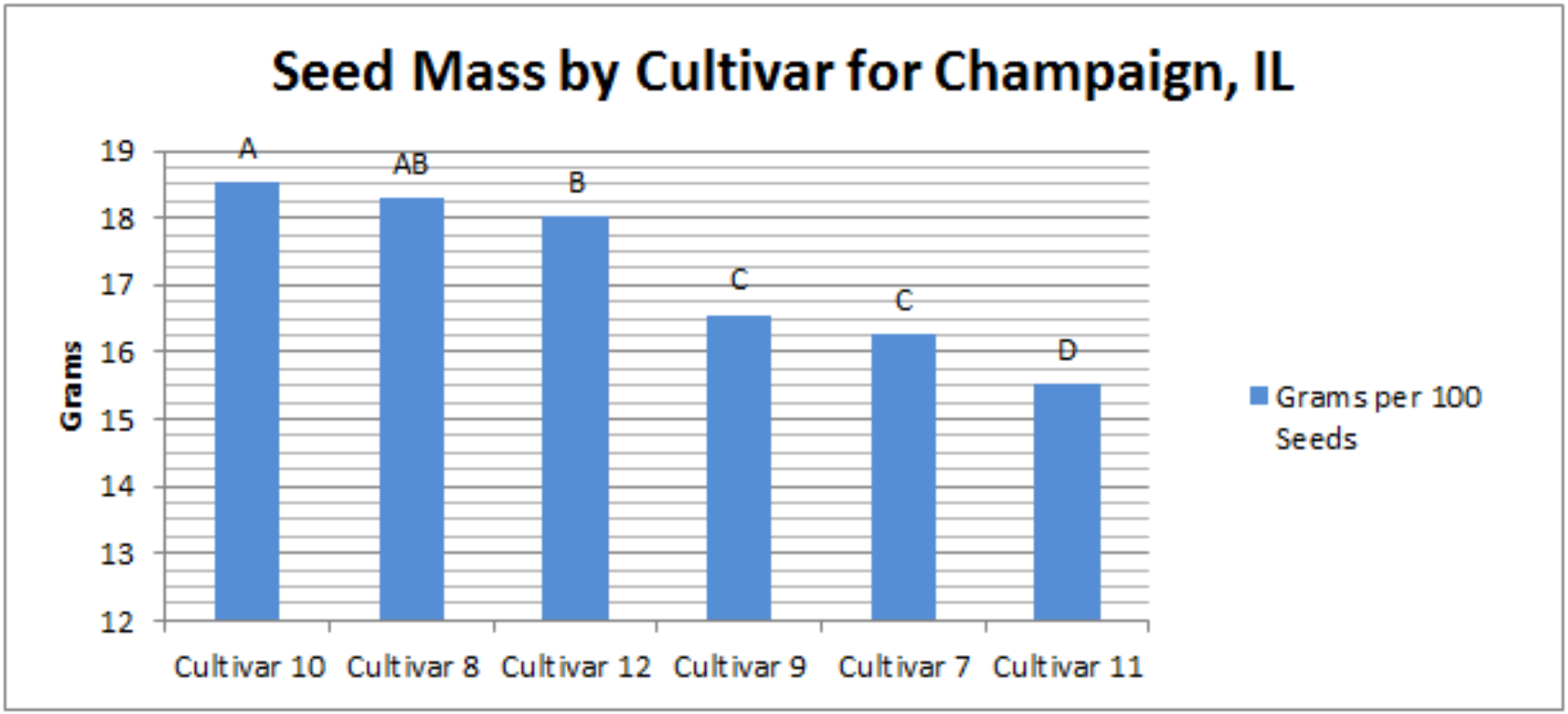


Figure 3. Seed mass by cultivar averaged across all population and row width treatments at Champaign, Illinois. Levels not connected by the same letter are significantly different at $P < 0.05$

Results and Discussion- Seed Mass Champaign

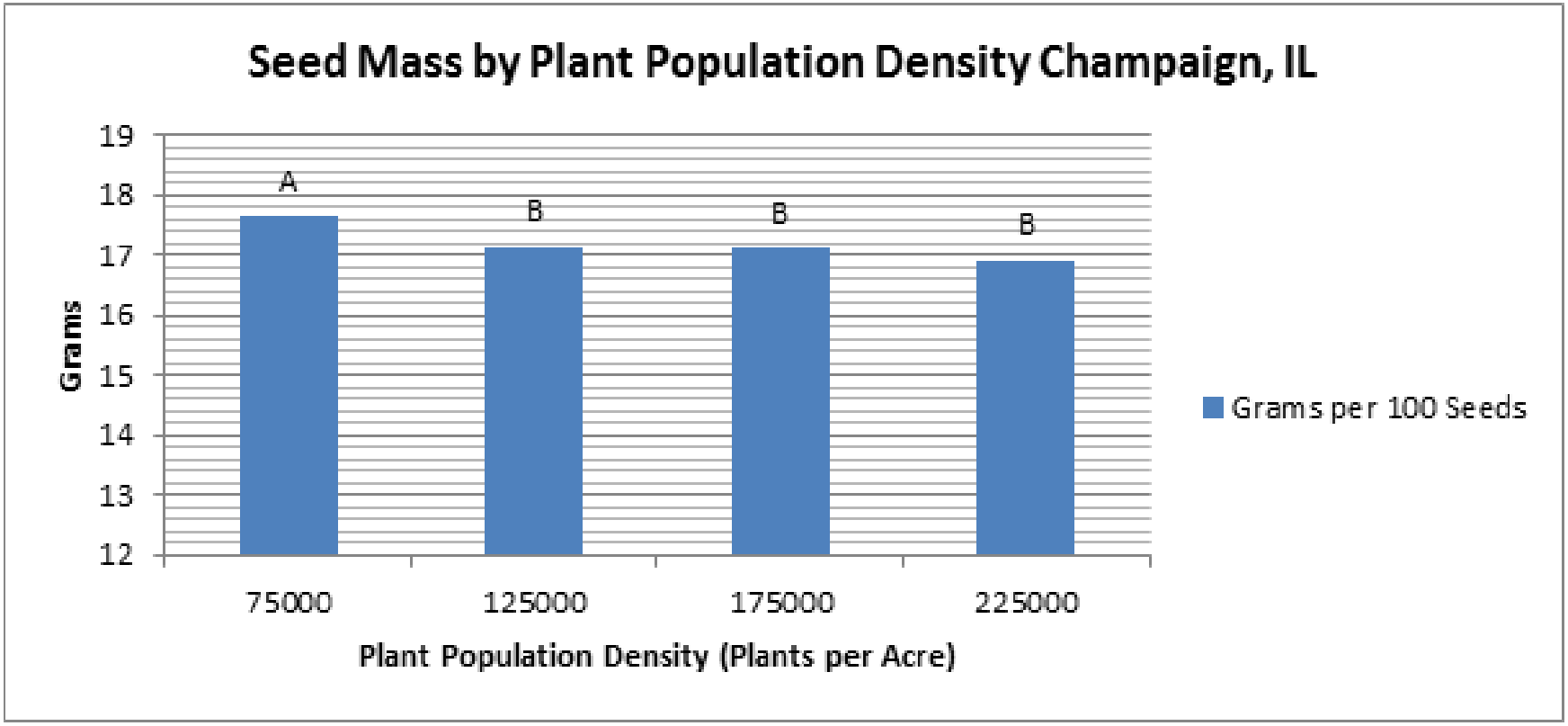


Figure 4. Seed mass by PPD (plants per acre) averaged across all cultivar and row width treatments at Champaign, Illinois. Levels not connected by the same letter are significantly different at $P < 0.05$

Results and Discussion- Seed Mass Champaign

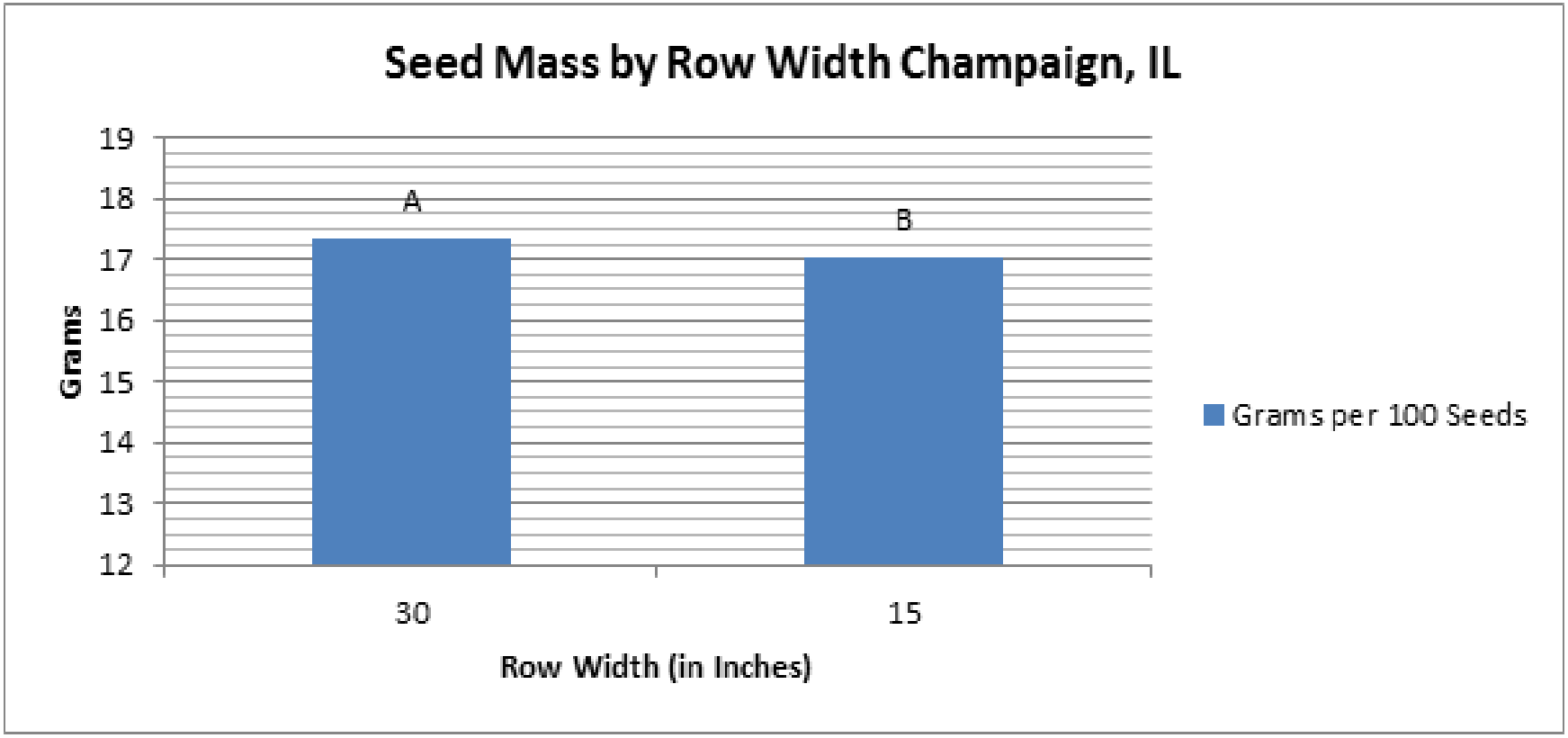


Figure 5. Seed mass by row width (in inches) averaged across all cultivar and population treatments at Champaign, Illinois. Levels not connected by the same letter are significantly different at $P < 0.05$

Results and Discussion- Seed Mass Johnston

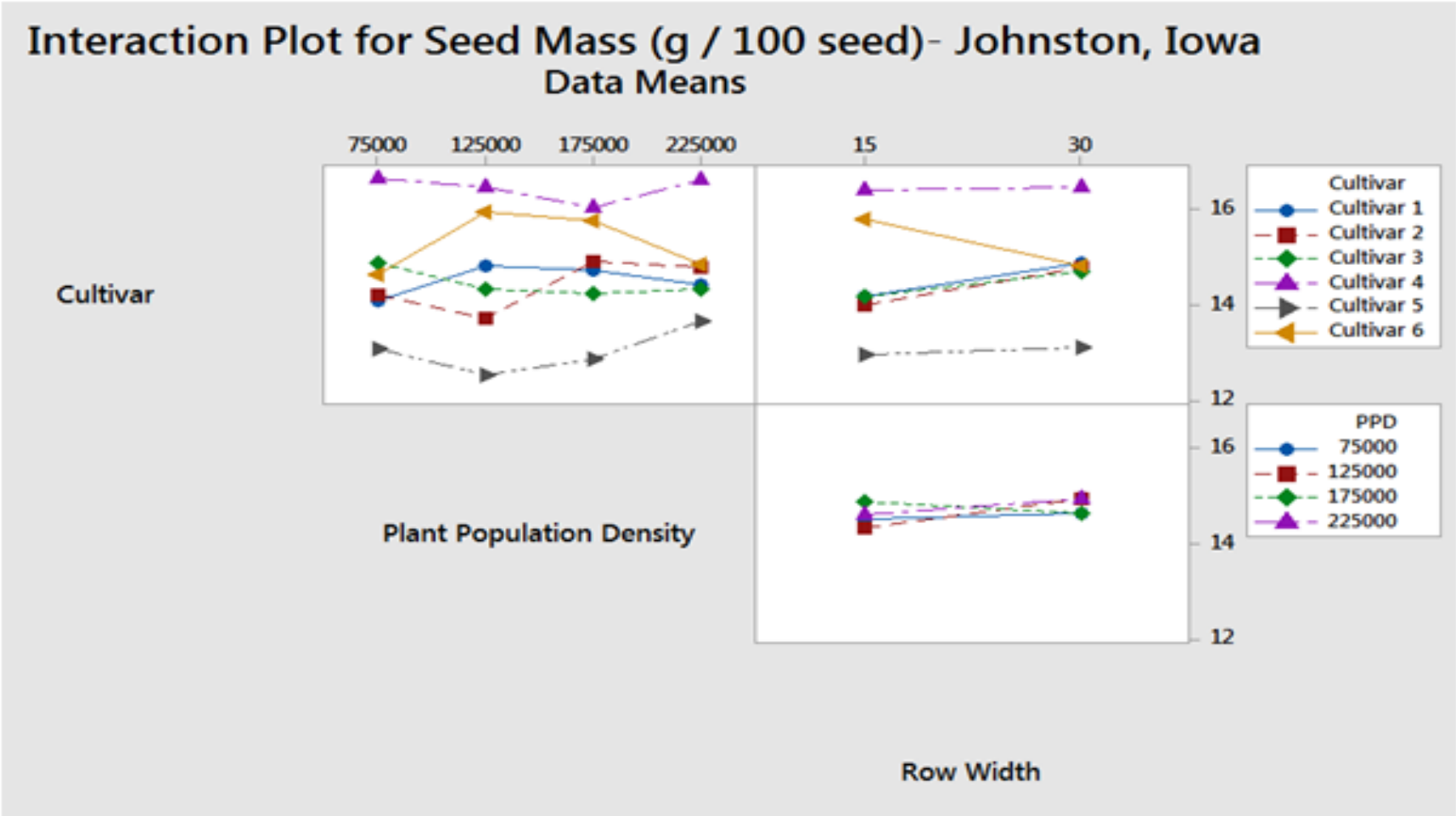
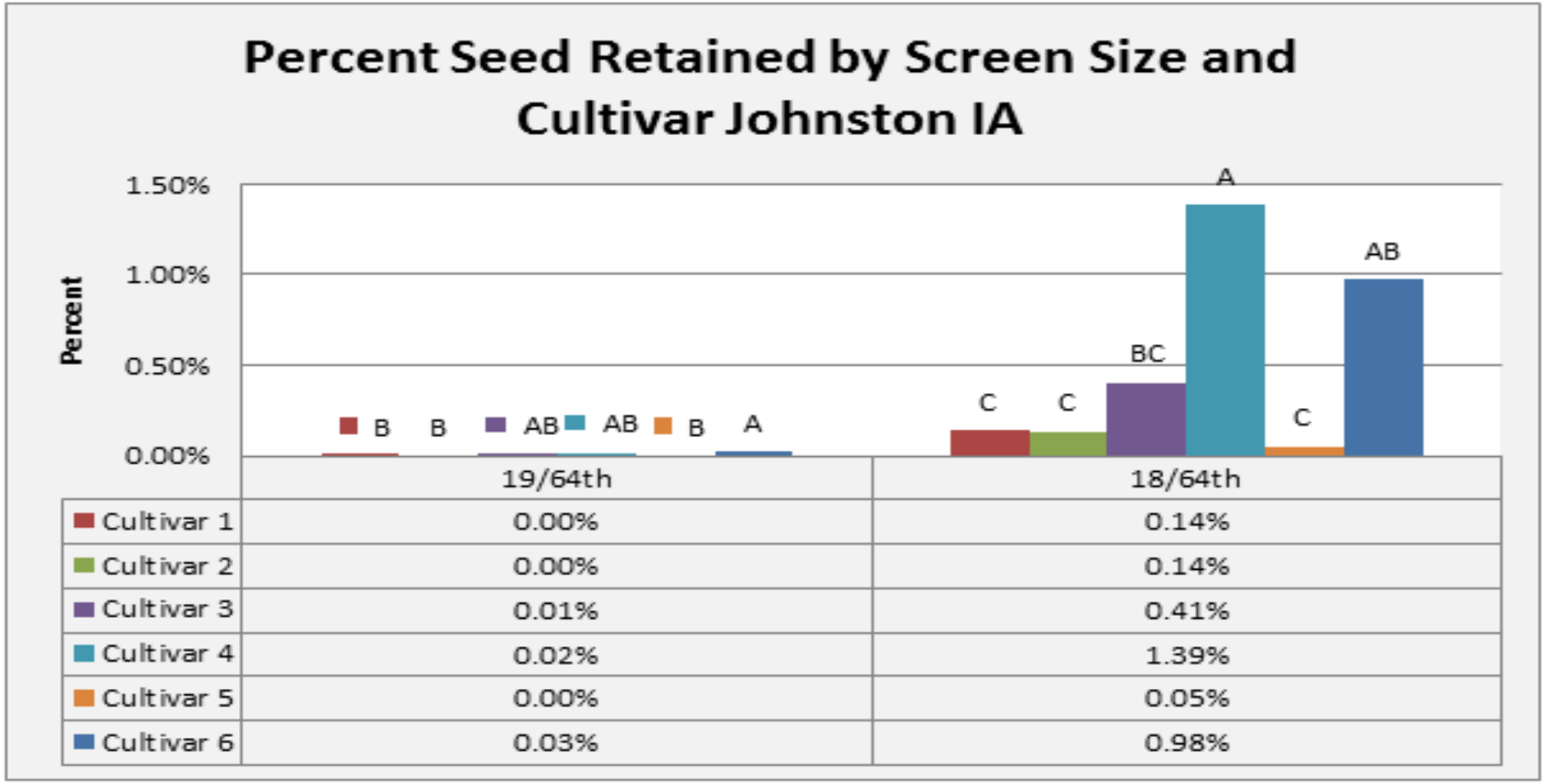


Figure 6. Cultivar by PPD by row width interactions for Seed Mass at Johnston, Iowa.

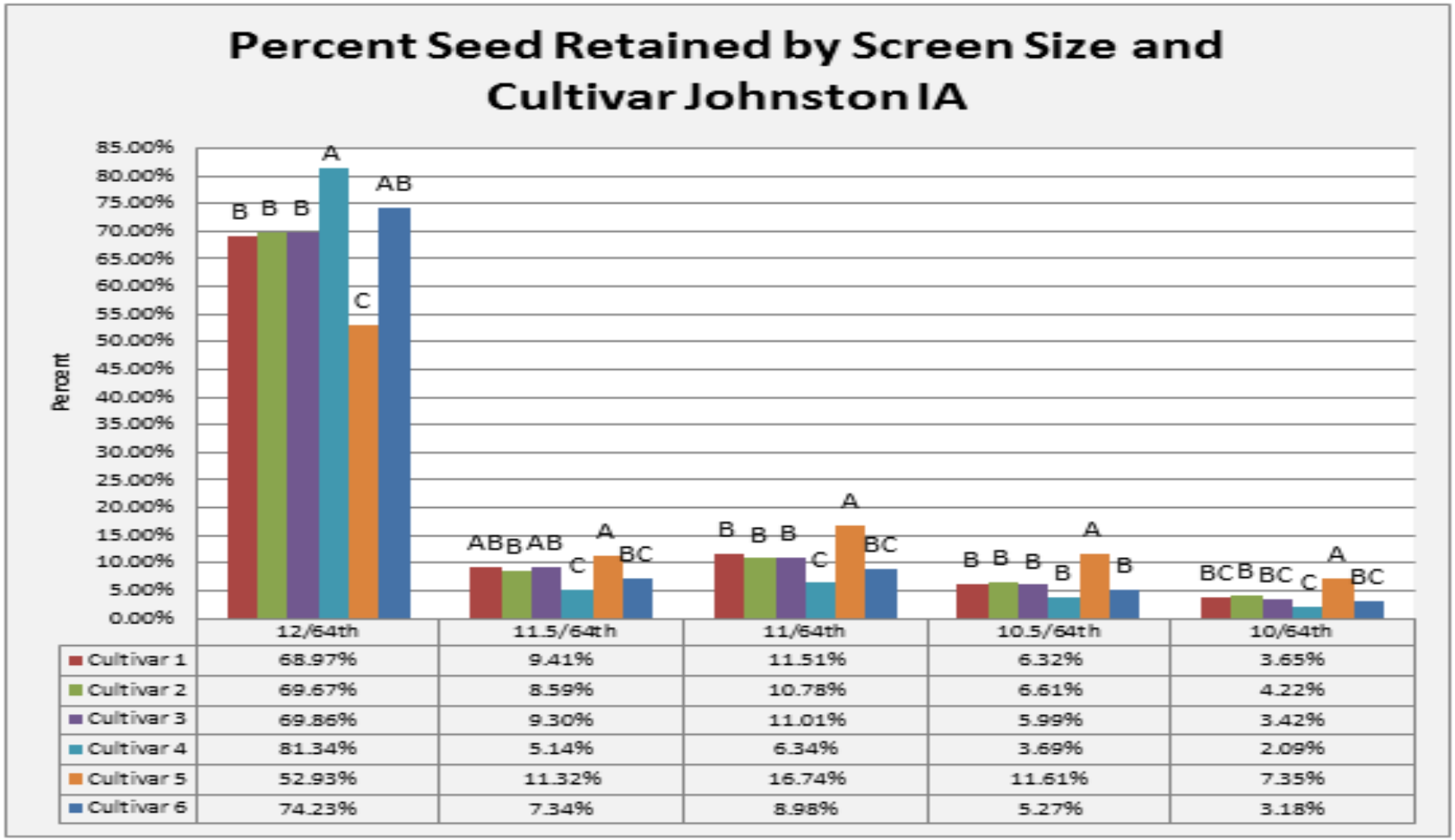
Seed Size Variability- Johnston



	19/64th	18/64th
Cultivar 1	0.00%	0.14%
Cultivar 2	0.00%	0.14%
Cultivar 3	0.01%	0.41%
Cultivar 4	0.02%	1.39%
Cultivar 5	0.00%	0.05%
Cultivar 6	0.03%	0.98%

Figure 7. Percent seed remaining on the 19/64th and 18/64th round hole screens by cultivar averaged across all treatments, Johnston, IA. Levels not connected by the same letter are significantly different at $P < 0.05$

Seed Size Variability- Johnston



	12/64th	11.5/64th	11/64th	10.5/64th	10/64th
Cultivar 1	68.97%	9.41%	11.51%	6.32%	3.65%
Cultivar 2	69.67%	8.59%	10.78%	6.61%	4.22%
Cultivar 3	69.86%	9.30%	11.01%	5.99%	3.42%
Cultivar 4	81.34%	5.14%	6.34%	3.69%	2.09%
Cultivar 5	52.93%	11.32%	16.74%	11.61%	7.35%
Cultivar 6	74.23%	7.34%	8.98%	5.27%	3.18%

Figure 8. Percent seed remaining on 12/64th to 10/64th slotted screens by cultivar averaged across all treatments, Johnston, IA. Levels within the same screen size not connected by the same letter are significantly different at $P < 0.05$

Seed Size Variability- Johnston

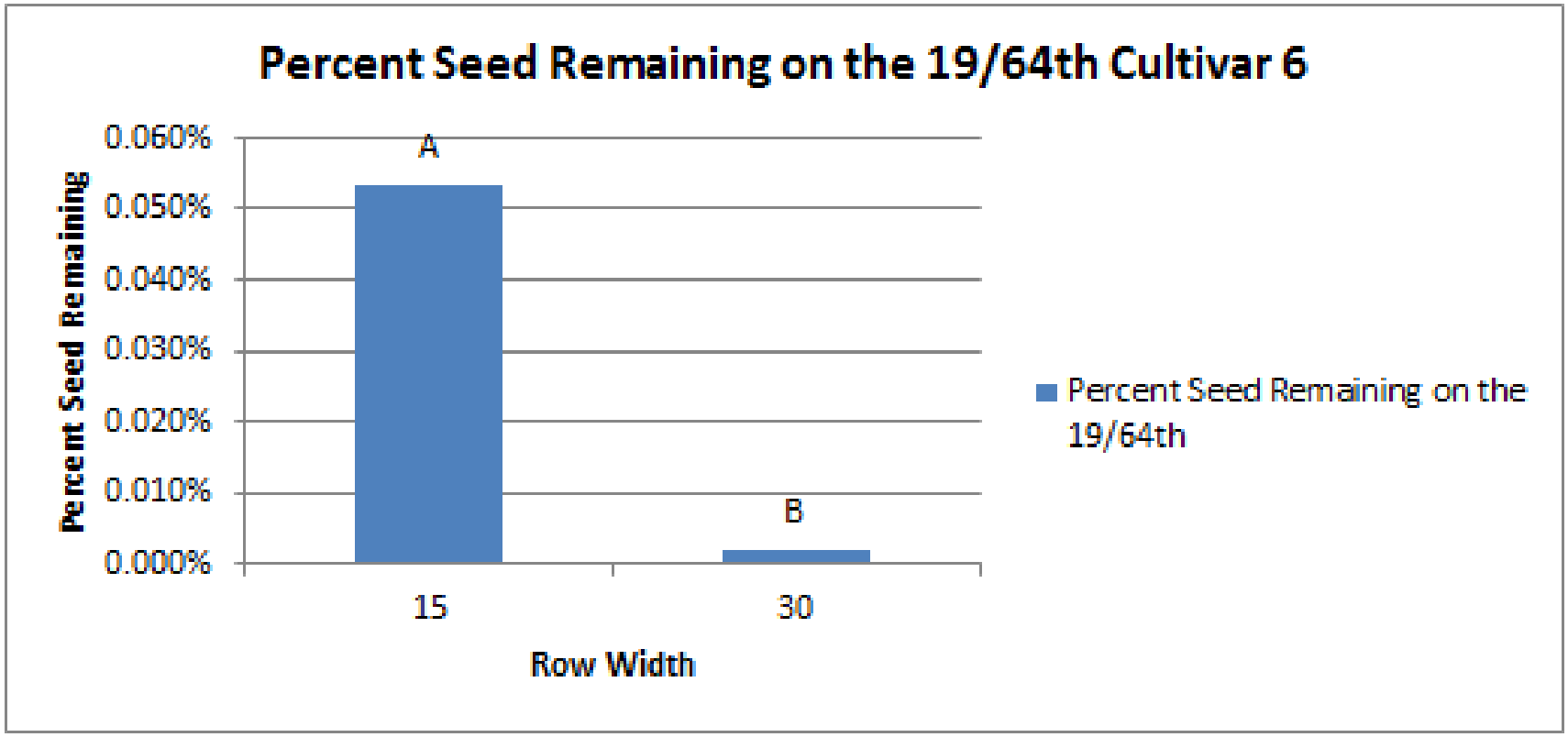


Figure 9. Percent Seed Remaining on the 19/64th screen for cultivar 6 by row width. Levels within the same screen size not connected by the same letter are significantly different at $P < 0.05$

Seed Size Variability- Johnston

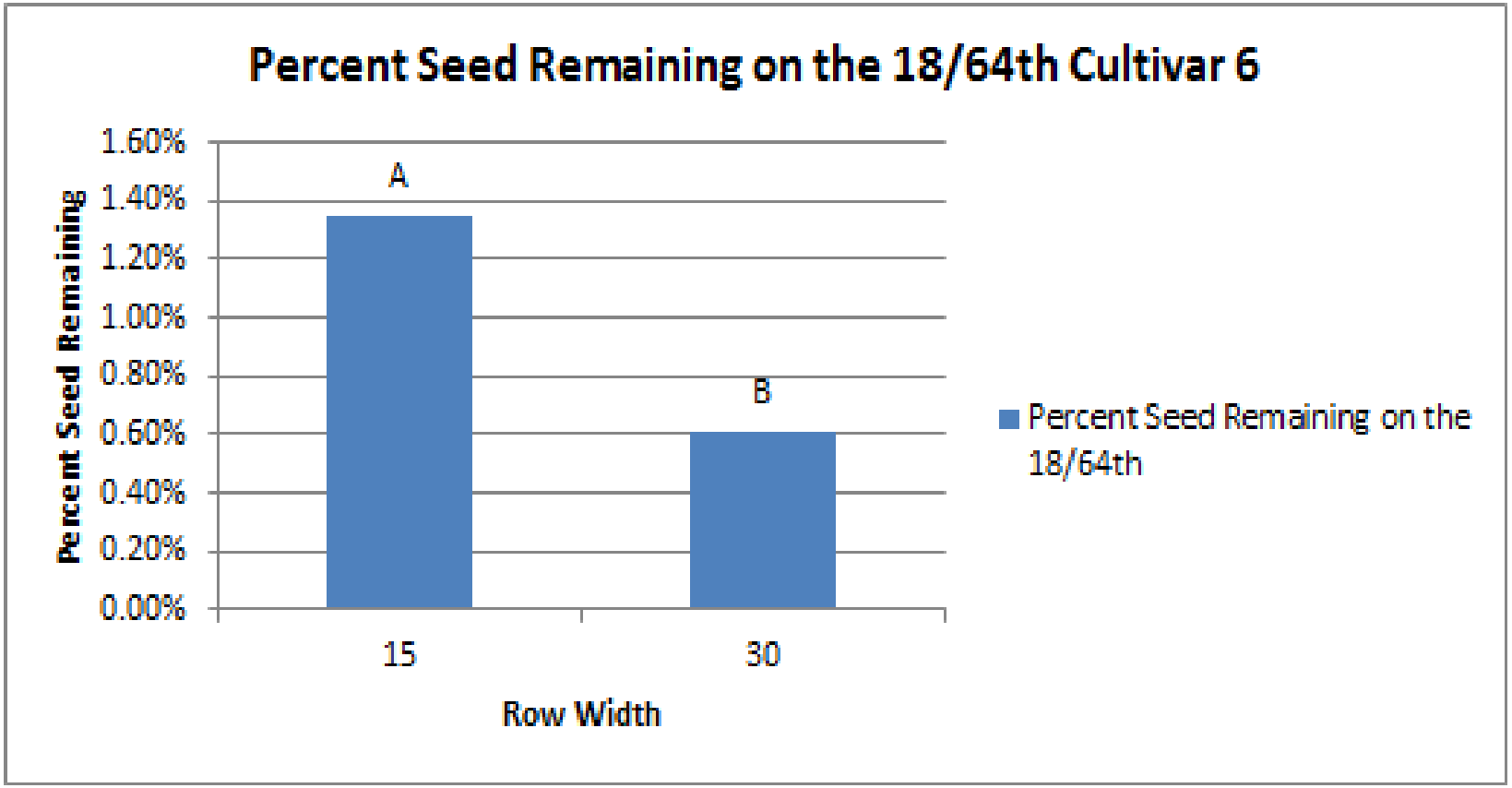


Figure 10. Percent Seed Remaining on the 18/64th screen for cultivar 6 by row width. Levels within the same screen size not connected by the same letter are significantly different at $P < 0.05$

Summary and Conclusion

- Champaign results indicate that cultivars differ in yield and seed mass
  - Yield Impacted by Cultivar
  - Seed mass at Champaign impacted by cultivar, PPD and row width
- Johnston location results and 3 way interactions observed make it difficult to arrive at any clear conclusion
- Seed size variability was impacted by Cultivar but not impacted by PPD
  - Cultivar 6 indicated a row width impact when evaluating seed size variability
- Recommend additional data

Acknowledgements

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  - DuPont Pioneer for providing the resources to conduct this trial
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