1/6/2022, 1:39:16 pm

Nebraska Soybean Board
FINAL Research/Extension Education Report Form

Note: Submit this report no later than 60 days after the NSB-funded project officially terminates.

This post-project 60-day time-frame will allow the Lead PI/Extension Educator time to complete any final data analysis and a final technical report, plus the drafting of any articles for submission to scientific journals.
This completed report will be provided to the National Soybean Checkoff Research Database: soybeanresearchdata.com.

Project # and Title:

#1743 Assessing management options to enhance seed protein

PI / Extension Educator:

Patricio Grassini

Co-PI's / Co-Extension Educator's:

Nicolas Cafaro La Menza (PostDoc)

Project Date ***(Including No-Cost Extension)*****:** 10/1/19 **to** 9/30/21

Total Budget for Project: $ 162,400

1. Briefly State the Rationale for the Research.

Identifying options to increase yield and seed protein concentration is crucial to stop or, at least, lessen the observed decline in soybean seed protein concentration over time. In turn, these crop management options will help soybean processors to ensure a high protein soybean meal and better position NE and US soybean in the global market.

2. Research Objectives: (copy from original proposal, but keep in a brief bullet format).

The goal of the proposed project is to determine the influence of management practices on seed protein concentration.

3. General Approach Used and (if applicable) the Nebraska Test Location.

With the help of 17 UNL Extension Educators and NSB members, we collected soybean seed samples during the 2019 and 2020 harvest seasons. We provided sampling kit boxes (1-3 per producer) with six labeled plastic jars, pencils, and a survey for assessing crop management options that enhance seed protein. Each soybean producer collaborating with this project was asked to submit three soybean seed samples per field and a minimum/maximum of one/three irrigated and one/three dryland fields. Together with the seed samples, producers were requested to provide the field location and associated management practices (planting date, cultivar, fertilizer application, etc). The surveyed fields represented well the soybean production area distribution within the state and the associated range in weather, soil, and management practices. Soybean test weight and seed moisture content were determined upon sample arrival. Then, seed protein and oil concentrations were determined with NIR. Samples were shipped to the University of Minnesota seed quality lab for amino acid and fatty acid profile analysis. Each field was mapped using Google Earth and associated climate and soil properties were retrieved from the nearby weather stations and the SSURGO soil database. A crop simulation model (SOYSIM) was used to estimate dates for key phenological stages (R1, R3, R5 and R7) in each soybean field. Statistical analysis was used to (i) evaluate differences in seed parameters between irrigated and dryland fields, and (ii) to understand the factors influencing the magnitude of the differences between irrigated and dryland fields.

4. Describe Deliverables & Significance Attained for Each Research Objective.

A continuous increase in U.S. soybean yield due to better genetics and agronomic practices has been accompanied by a continuous decline in seed protein concentration. This is becoming a problem for soybean processors aiming to produce a high-protein soybean meal. We found that, in Nebraska, besides higher yield (+10 bu/ac), irrigated fields exhibited higher seed protein concentration (+0.32%) than dryland fields, with slightly lower oil (-0.18%). There was no difference in the test weight between irrigated and dryland fields. However, the average test weight (57 lb/bu) was 3 lb per bushel lower than the standard soybean test weight of 60 lb/bu. Amino acids concentration followed the same trend as protein concentration in 15 out of 18 amino acids analyzed, that is, a higher concentration in irrigated versus dryland fields. In contrast, the water regime did not affect the concentration of the following amino acids: tryptophan, isoleucine, and phenylalanine. There was no significant difference in fatty acid concentration between irrigated and dryland fields but total carbohydrates were lower in irrigated versus dryland fields because of lower raffinose concentration. To summarize, NE irrigated producer produce high soybean yields with high protein concentration. This is an important discovery because nearly half of soybean production takes place under irrigation in Nebraska. Although growers are currently not paid by the protein content in their soybeans, this may become a factor as countries that import soybeans from the United States demand soybean with greater seed protein concentration. Aside from economic considerations, this result is also interesting from a scientific perspective as irrigation seems to be a practice that breaks the typical trade-off that one would expect between yield and seed protein (i.e., a lower protein with higher yield).

4. Describe Deliverables & Significance Attained for Each Research Objective. (continued)

5. List where the Project Research Results/Findings were Publicized.

We mailed a report to each of the soybean producers who submitted seed samples for the project and also wrote a CropWatch article summarizing the results from the project (https://cropwatch.unl.edu/2021/what-have-we-learned-about-soybean-seed-constituents-irrigated-and-dryland-producer-fields).

Results were also presented at NE Extension and International conference events:

Cafaro La Menza N., Specht J., SL Naeve, and Grassini P., 2020. Soybean Seed Protein and Oil Concentration in Irrigated Vs. Dryland Fields in Nebraska. ASA-CSSA-SSSA annual meeting, November 9-13, 2020, Phoenix, AZ, USA. Oral Presentation.

Cafaro La Menza N., 2021. What can we learn about soybean seed constituents in irrigated vs rainfed field?. 2021 Annual Meeting of Crop Science Society of Hubei Province and International Workshop on Crop Ecophysiology, October 15 to 17, 2021, Wuhan, Hubei, China. Oral Presentation.

Cafaro La Menza N., Specht J., SL Naeve, and Grassini P., 2021. Soybean Seed Protein and Oil Concentration in Irrigated Vs. Dryland Fields in Nebraska. ASA-CSSA-SSSA annual meeting, November 7-10, 2021, Salt Lake City, USA. Oral Presentation.

Grassini P,m 2020. Learning from Your Fields to Improve Nebraska's Soybean Yield and Quality. Nebraska Soybean Day & Machinery Expo. ENREC. Dec, 2020.

We are also working on a journal article to be submitted to Field Crops Research journal in early 2022.

Note: The Final Report comprised of the above listed items must be kept to THREE PAGES.

A Technical Report of no more than TEN PAGES (preferably fewer) can be appended to this report.

Submit the form with the following file name format: #XXX_FINAL_Project Title_LastName

Please submit this completed form with attached files to the Agriculture Research Division, jmcmahon10@unl.edu, based on the reporting schedule given to you.

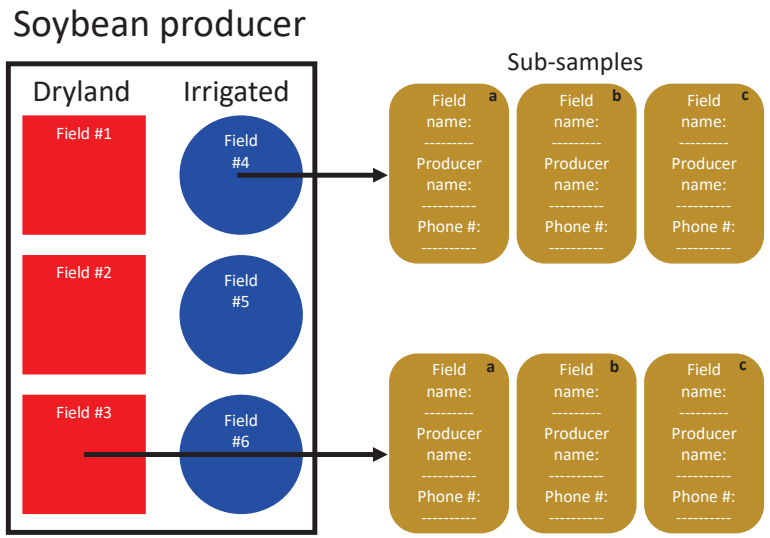
If you have any questions, please call Jen McMahon at the Agricultural Research Division (402) 472-7082.

Please click to attach technical reports, etc. Attach files Please check your information before submitting the form. Submit by Email

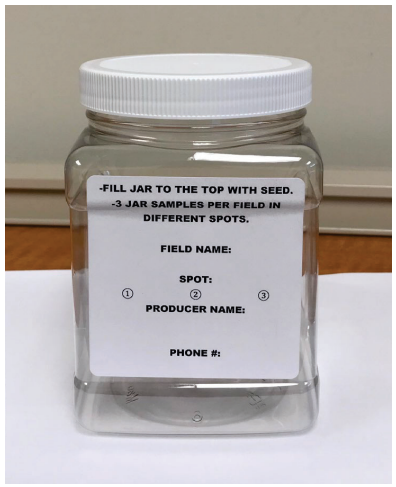
Please note: Attach files button may not work in some versions of Acrobat Reader. You may need to save a copy of this form and then attach files to the copy.

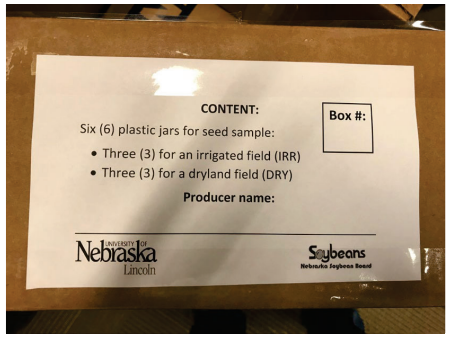
Sample collection

We worked with 17 UNL Extension Educators, and Nebraska Soybean Board members to collect samples across the state.



Total 32 Oz jars collected from this example: <u>18 (6 fields*3 sub-sample per field)</u>



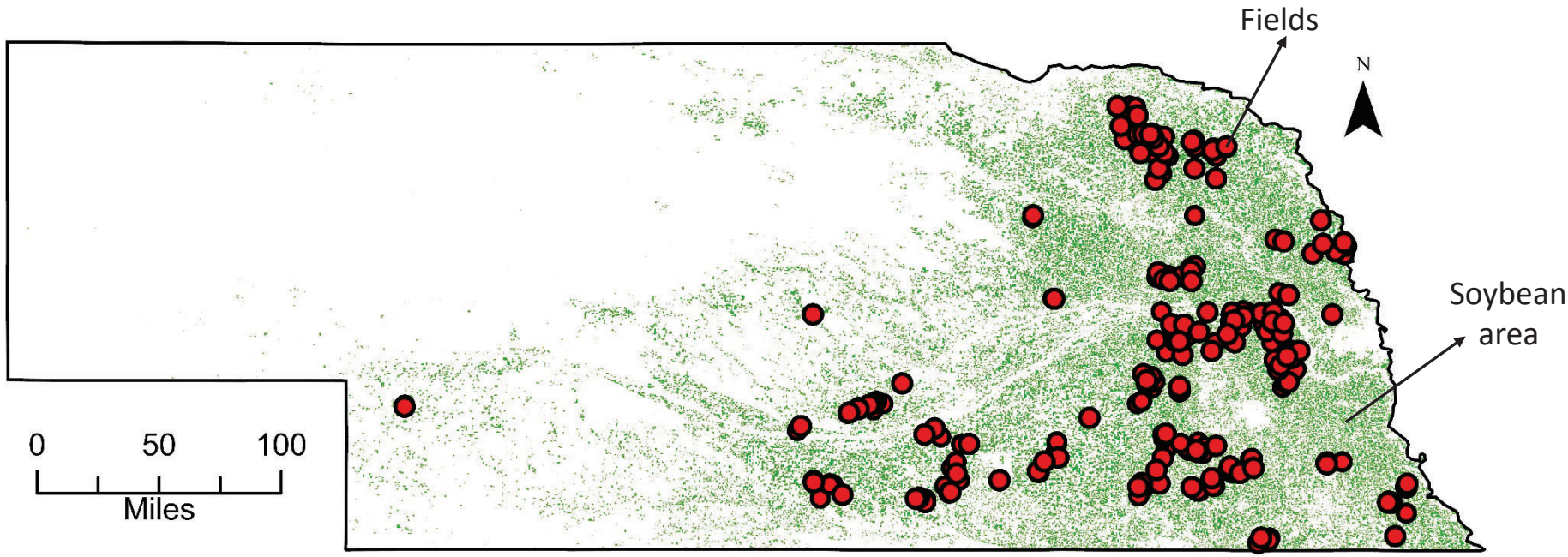


Seed sample analysis

Samples were labeled upon arrival. We measured the test weight (with Winchester, and DICKEY-John) and seed moisture content. Then seed protein, oil, fiber, and moisture concentrations were determined with NIR. Samples were shipped to the Minnesota lab for amino and fatty acid profile analysis.

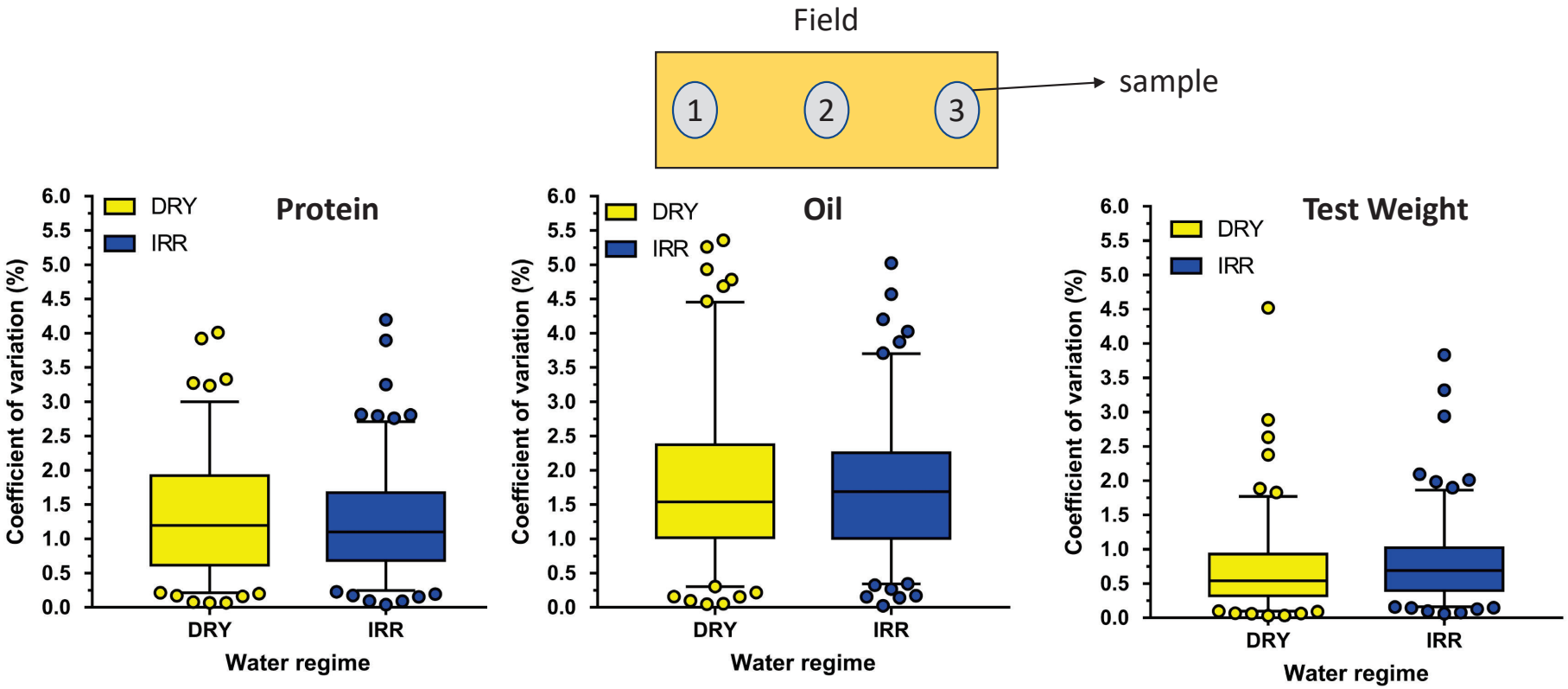
Soybean seed sample collection on fall 2019 & 2020

We sampled a total of **288** Irrigated (IRR) and Dryland (DRY) soybean fields across Nebraska



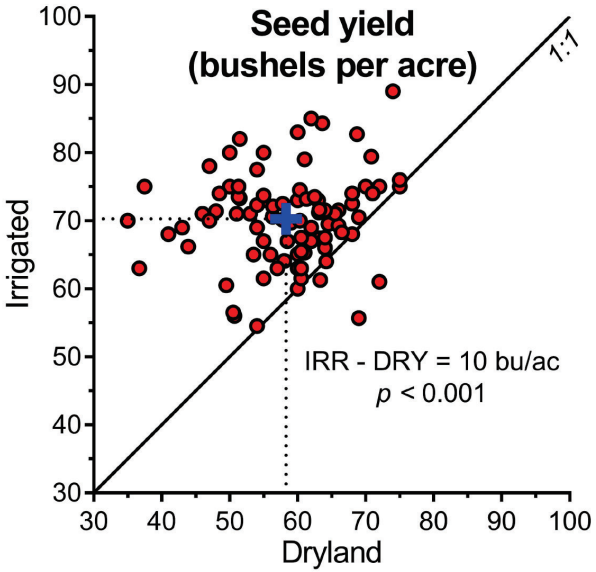
Within-field variation in Irrigated (IRR) and Dryland (DRY) fields

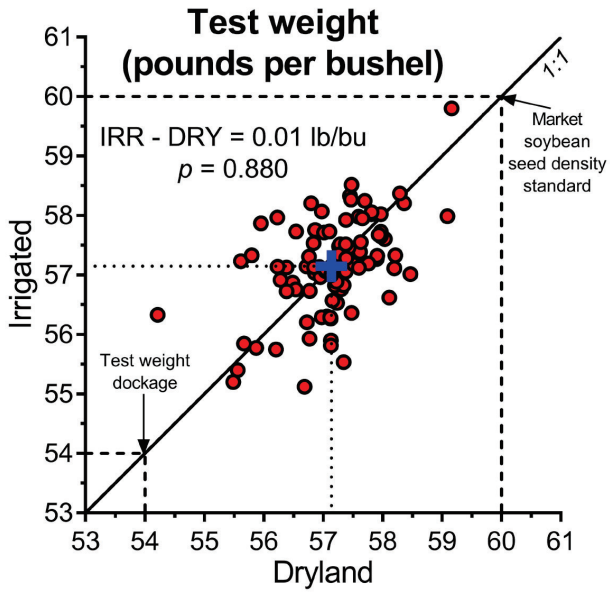
Within-field variability was *ca.* 1.5 % or less for most of the variables.



Irrigated (IRR) vs Dryland (DRY) comparison: seed yield and test weight*

Yield was 10 bu ac^{-1} higher in IRR *versus* DRY fields. There were no differences on Test Weight between water regimes. Average Test Weight from IRR and DRY fields in the pooled data from 2019 & 2020 was 57 lb bu^{-1} which is *ca.* 3 lb per bu^{-1} lower than the standard soybean test weight of 60 lb bu^{-1}.

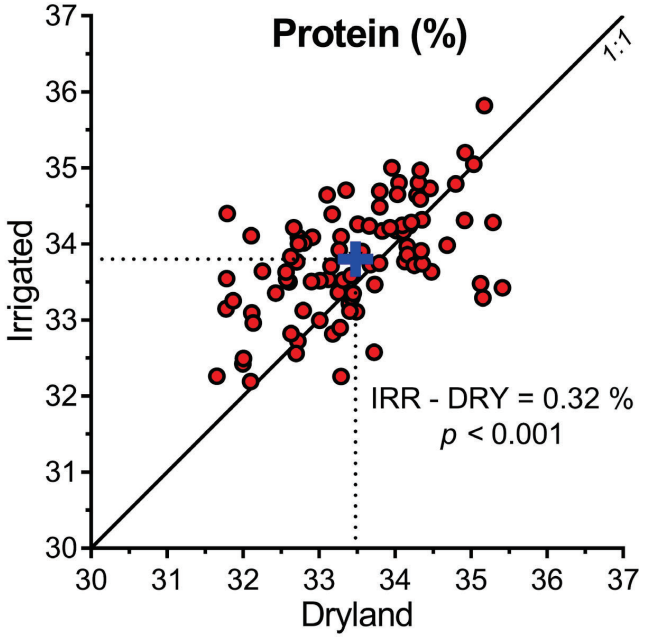


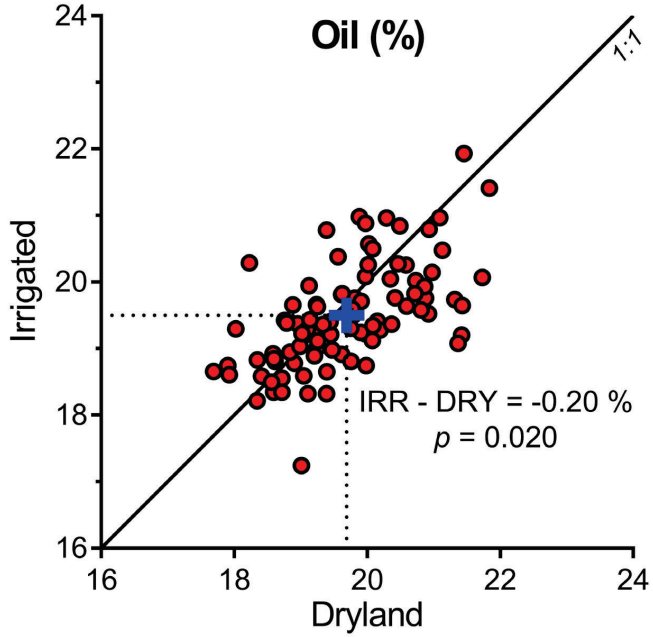


*Total paired IRR-DRY comparisons: 91. Each paired comparison represents one soybean producer, with at least one IRR and one DRY field (but no more than three for each water regime). Three subsamples were collected from each field.

Irrigated (IRR) vs Dryland (DRY) comparison: protein, and oil*

Despite higher seed yield in IRR *vs* DRY fields, IRR fields exhibited 0.3 percentual points higher than DRY on seed protein concentration, while seed oil concentrations were slightly lower in IRR *vs* DRY.

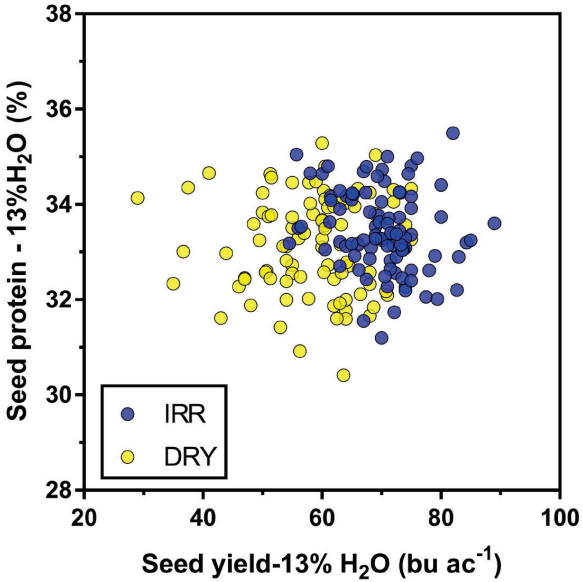


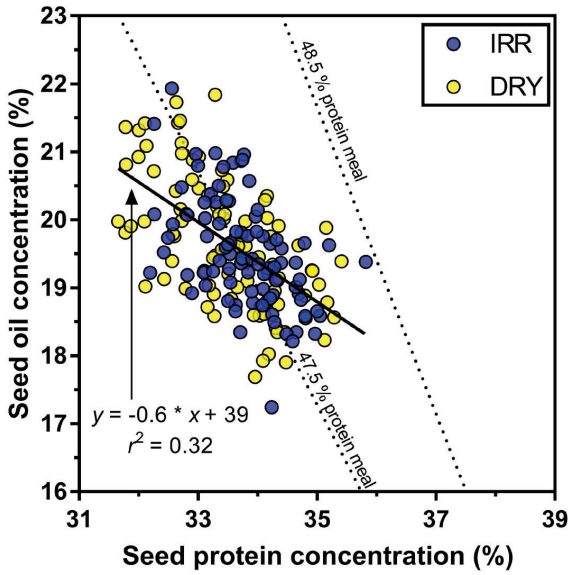


*Total paired IRR-DRY comparisons: 91. Each paired comparison represents one soybean producer, with at least one IRR and one DRY field (but no more than three for each water regime). Three subsamples were collected from each field.

Relationships between seed yield, protein, and oil in Irrigated (IRR) *vs* Dryland (DRY) fields of each producer (n = 91)

There was no clear relationship between seed protein concentration and yield. IRR fields had on average greater seed protein that DRY fields. However, there was a relationship between seed protein and oil concentration that was not affected by the water regime.





*Each datapoint corresponds to the average of irrigated (blue) or dryland (yellow) field for one soybean producer, with at least one irrigated and one dryland field (but no more than three for each water regime). Three subsamples were collected from each field.

Amino acid concentrations in Irrigated (IRR) *vs* Dryland (DRY) fields

Variable	IRR *versus* DRY difference*
Lysine	+0.8%
Cysteine	+2.2%
Methionine	+1.9%
Threonine	+1.1%
Tryptophan	n.s.
Isoleucine	n.s.
Leucine	+0.7%
Histidine	+0.7%
Phenylalanine	n.s.
Valine	+0.5%
Alanine	+0.8%
Arginine	+1.0%
Aspartic acid	+1.1%
Glutamic acid	+1.2%
Glycine	+1.0%
Proline	+1.1%
Serine	+0.9%
Tyrosine	+0.8%

*** Difference between irrigated and rainfed fields, expressed as % of the dryland average value. Differences were statistically significant from zero (P<0.05), unless indicated (n.s.: not significant)**

Amino acids concentration followed the same trends as protein concentration in in 15 out of 18 amino acids analyzed. That is, higher concentration in IRR *vs* DRY fields. In contrast, the following amino acid concentrations were not affected by the water regime: tryptophan, isoleucine, and phenylalanine.

Fatty acid and carbohydrate concentrations in Irrigated (IRR) vs Dryland (DRY) fields

There was no significant difference in fatty acid concentrations in IRR vs DRY fields. Total carbohydrates were lower in IRR vs DRY fields because of lower raffinose concentration.

Variable	IRR versus DRY Difference
Fatty acid	
Linoleic acid	**n.s.**
Linolenic acid	**n.s.**
Oleic acid	**n.s.**
Palmitic acid	**n.s.**
Stearic acid	**n.s.**
Carbohydrates	
Sucrose	**+2%**
Raffinose	**-3.5%**
Stachyose	**n.s.**

*** Difference between irrigated and rainfed fields, expressed as % of the dryland average value. Differences were statistically significant from zero (P<0.05), unless indicated (n.s.: not significant)**

Summary

- Within-field variability on seed quality parameters was less than 1.5% with three subsamples per field.
- Seed yield and protein concentration were higher in IRR *vs* DRY fields.
- There was no difference in test weight between water regimes.
- There was no apparent trade-off between seed yield and protein concentration.
- There was a negative correlation between seed protein and oil concentration.
- Most amino acids concentration (15 out of 18) increased in IRR vs DRY fields; the same trends as protein concentration.
- No significant trend on fatty acid concentrations between IRR vs DRY fields.
- Total carbohydrates were lower in IRR vs DRY fields due to lower raffinose concentration.