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| Project Number:  | **USB Project #1920-172-0201-B** |
| Project Title:  | **Use of High Density Protein Maps and Remote Sensing to Understand Protein Levels in U.S. Produced Soybeans** |
| Organization:  | Iowa Soybean Association |
| Principal Investigator Name: | Scott Nelson and Peter Kyveryga |
| **National Soybean Checkoff Research Database** [**https://www.soybeanresearchdata.com/**](https://www.soybeanresearchdata.com/) **(visible to public)****Please choose one option (if no option is selected, this report will be posted to the website):**[x]  I agree to allow the information contained in this report to be published in its entirety.[ ]  I have included, at the end of this report, a brief non-technical report that can be posted to the website.[ ]  I DO NOT agree to allow the information contained in this report to be published. |
| Project Status - What key activities were undertaken and what were the key accomplishments during the life of this project? Please use this field to clearly and concisely report on project progress. The information included should reflect quantifiable results (expand upon the KPIs) that can be used to evaluate and measure project success. Technical reports, no longer than 4 pages, may be included in this section.  |
| The objective of this pilot project was to calibrate and deploy new on-the-go NIR sensor technology to map soybean protein within production fields. The project was conducted by Iowa Soybean Association (ISA), On-Farm Network and Analytics teams in collaboration with Dr. Matt Darr’s research group at Iowa State University, Department of Biosystems and Agricultural Engineering, and the John Deere Advanced Management Solution Group, Urbandale, IA. The project had two components: (1) exploratory focused on whether vegetation indices from calibrated digital aerial imagery can predict protein within fields from on-the-ground dense sampling (Iowa Soybean Association imagery calibration sites) and (2) on-the-go NIR sensor calibration and mapping soybean protein and oil content in farmer fields in closed proximity to the Iowa State University research farm in Ames. In the exploratory stage of the project in 2018, ISA team tested whether calibrated temporal imagery of soybean canopy can be used to detect changes in soybean protein and oil before the grain harvest. 70 sampling areas were selected from 80-acre 30-ich and 15-inch row spacing fields in Story County and had a commercial lab analyze the samples for oil and protein content. The fields were flown every 10-15 days and the imagery was calibrated using ground imagery calibration reflectance tarps or panels. Calibrated vegetative indices of the soybean canopy were produced for each aerial image.There was more variation in NDVI values for the 30-inch than the 15-inch row soybean. The two highest protein and oil categories were easily separated by calibrated NDVI, starting from mid-July for the 15-inch soybean but not for the 30-inch rows. If oil and protein can be predicted before the harvest in 15-inch soybean, then this information can help farmers in harvest planning and soybean marketing.In the fall of 2018, five farmers’ fields around the ISU research farm were mapped by a John Deere grain combine with an on-the-go NIR sensor. The sensor readings were calibrated to corresponding laboratory data and on-the ground samples. In addition to crude protein, the sensor data also were converted to oil and fiber content. ISA staff aggregated all spatial variables and imagery at 75x75-foot grids.In general, field areas with higher protein had lower oil but this relationship was not consistent across all fields. Two of the seven fields had relatively large areas (up to 60 and 70 %) with protein content lower than 34%. Three fields had 80 to 95 % areas with oil content lower than 19 %. Soybean seeds with protein lower than 34 percent and oil lower than 19% can put the U.S. at a disadvantage in international trade. Variation in both oil and protein for these fields was relatively low, not exceeding 5% as a coefficient variation. Within-field protein variability was relatively small. Neither soil type or other soil characteristics could explain much variation in protein. We observed better prediction of protein than oil using soil and aerial imagery. Early and late-season digital imagery were the most useful in predicting protein and oil. In two fields, oil tended to be higher with higher soil potassium and phosphorus content.  |
| Did this project meet the intended Key Performance Indicators (KPIs)? List each KPI and describe progress made (or not made) toward addressing it, including metrics where appropriate.  |
| * Calibrated and processed spatial spectral NIR sensor data and developed accurate protein and oil maps of 5 fields, each about 80 acres. *Completed.*
* Analyzed relationship between protein, soil attributes, terrain and imagery. *Completed.*
* Presented at the ISA Farmer Tour Meetings at 3 locations in Iowa with about 350 farmer crop consultants and industry agronomists. *Completed.*
* Raised awareness among farmers about the issue of declining soybean protein and quality at ISA District Advisory Meetings at 7 locations during the 2019 summer. About 250 farmers attended the meetings and asked questions. *Completed.*
* NIR sensor deployment and calibration by farmers in 2019. All on the ground soybean samples are already collected before the harvest. Using two commercial JD Harvest Lab sensors two farmers will map at least in 12 soybean fields in 2019. Sensors have already been installed and data are being collected. *In process, as planned.*
* Since the collection of the 2019 yield from farmers’ fields is delayed due to late planting, we will develop a scientific publication describing the relationship between remotely sensed images and soybean protein for predictive marketing later in 2020. *Will be completed due to the need for second year of data and delayed planting.*
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| Expected Outputs/Deliverables - List each deliverable identified in the project, indicate whether or not it was supplied and if not supplied, please provide an explanation as to why. |
| * **Sensor calibration and accurate NIR sensor mapping ability at field scale**

The study illustrated that soybean protein and oil can be mapped during the harvest at the same time as collecting yield monitor data. Lab calibration curves and on-the ground observations are needed for on-the-go NIR sensor calibration for producing accurate maps. * **Farmer friendly communication and outreach**

Presentations from the 2019 ISA Farmer Tour meetings are posted online.<https://www.iasoybeans.com/upl/downloads/publications/2019-frt-analytics-soybean-quality-mapping.pdf>ISA Research Annual Research report<https://www.iasoybeans.com/upl/downloads/publications/2018-analytics-soybean-quality-mapping-new-sensing-technologies-and-big-data.pdf>.US Soy.org “Sensor Ing A Change” article. <https://ussoy.org/sensor-ing-a-change/>.* **Establishing relationship between protein and spatial variables.**

We did not establish a reliable relationship across all fields since protein and oil variability were low and the number of soybean fields mapped was not enough from one year. A larger sample of farmers’ fields will be mapped in 2019, with diverse soybean genetics and field management. |
| Describe any unforeseen events or circumstances that may have affected project timeline, costs, or deliverables (if applicable.) |
| The new on-the-go NIR sensor technology requires on-the-ground calibration data. On-the-go automatic sampling methods and calibration are being developed by private industry. Some lab protein and oil calibration datasets are proprietary.  |
| What, if any, follow-up steps are required to capture benefits for all US soybean farmers?Describe in a few sentences how the results of this project will be or should be used. |
| Similar to GPS-enabled yield mapping technologies used by farmers today, the new on-the-go NIR soybean quality mapping technology should help farmers in the future to separate areas within fields with specific protein or oil content to better market their soybean bushels in the domestic and international markets.  |
| **List any relevant performance metrics not captured in KPI’s.** |
| Anticipating that the NIR sensor technology may not available to farmers soon, or that it may be too expensive for wide adoption, we included digital aerial imagery component in this project. This component is promising for development soybean quality maps without the need for NIR sensors or improved calibration of NIR sensor. Since the imagery was calibrated using on-the-ground imagery calibration targets or tarps, we were able to do time series analyses and identify the best timing or soybean growth stage to capture the imagery to predict protein and oil during the growing season.  |
| **Non-technical report (this information will be posted to website in place of above report):** |
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