Soybean Quality Mapping: New Sensing Technologies and Big Data

Soybean composition quality has received increased attention recently among farmers, agronomists and commodity traders. Higher nutritional content of U.S. soybeans can help in marketing efforts and increase the economic value of each bushel. In the past, measuring soybean protein and oil content required the collection of soybean seed samples and laboratory analyses. With recent innovations in sensor technologies, it is now possible to map soybean protein and oil on-the-go during soybean harvest.

This is a preliminary summary of a joint project between the Iowa Soybean Association (ISA), the Iowa State University (ISU) Agricultural and Biosystems Engineering Department and John Deere Co. The project is partially funded by a grant from the United Soybean Board.

In the preliminary stage of the project, the objective was to test whether calibrated temporal imagery of soybean canopy can be used to detect changes in soybean protein and oil before the grain harvest. ISA staff selected 70 sampling areas from 80-acre soybean fields in Story County (Figure 1) and had a commercial lab analyze the samples for oil and protein content. The University of Minnesota Stupar Lab analyzed the samples for essential amino-acid content. The fields were flown every 10-15 days and the imagery was calibrated using ground-based imagery calibration reflectance tarps.

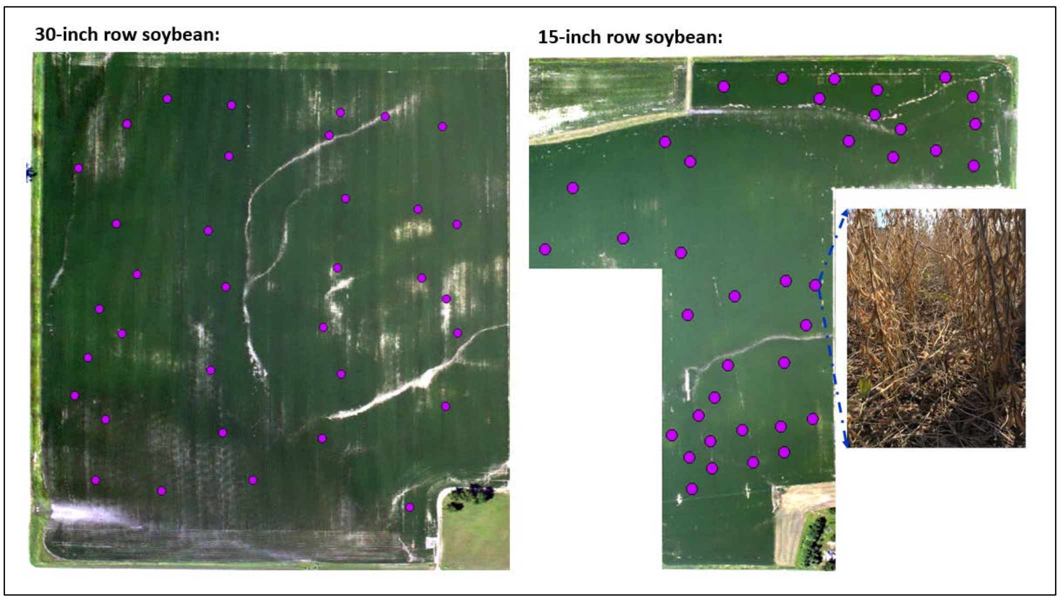


Figure 1: Purple dots indicate sample locations in 30-inch and 15-inch rows of soybean fields planted on the same day. Aerial imagery was taken at the same time to test whether calibrated temporal imagery NDVI can detect yield, protein and oil zones.

The calibrated temporal NDVI values reached their maximum by mid-July (Figure 2), indicating that both wide and narrow rows reached the canopy closure almost at the same time. There was more variation in NDVI values for the 30-inch row soybeans than the 15-inch rows. The two highest protein and oil categories were easily separated on the graph by their blue and green colors, 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, then this information can help farmers in harvest planning and soybean marketing.

Protein tended to be higher with higher yield (positive correlation of 0.30) in the 30-inch row field (data not shown). In the 15-inch row field, with higher yield protein decreased below 55 bu/acre, and then it increased with higher yield above 55 bu/acre. Oil content slightly decreased with higher protein (negative correlation of -0.32) in the 15-inch row field while protein did not correlate with oil in the 30-inch row field.

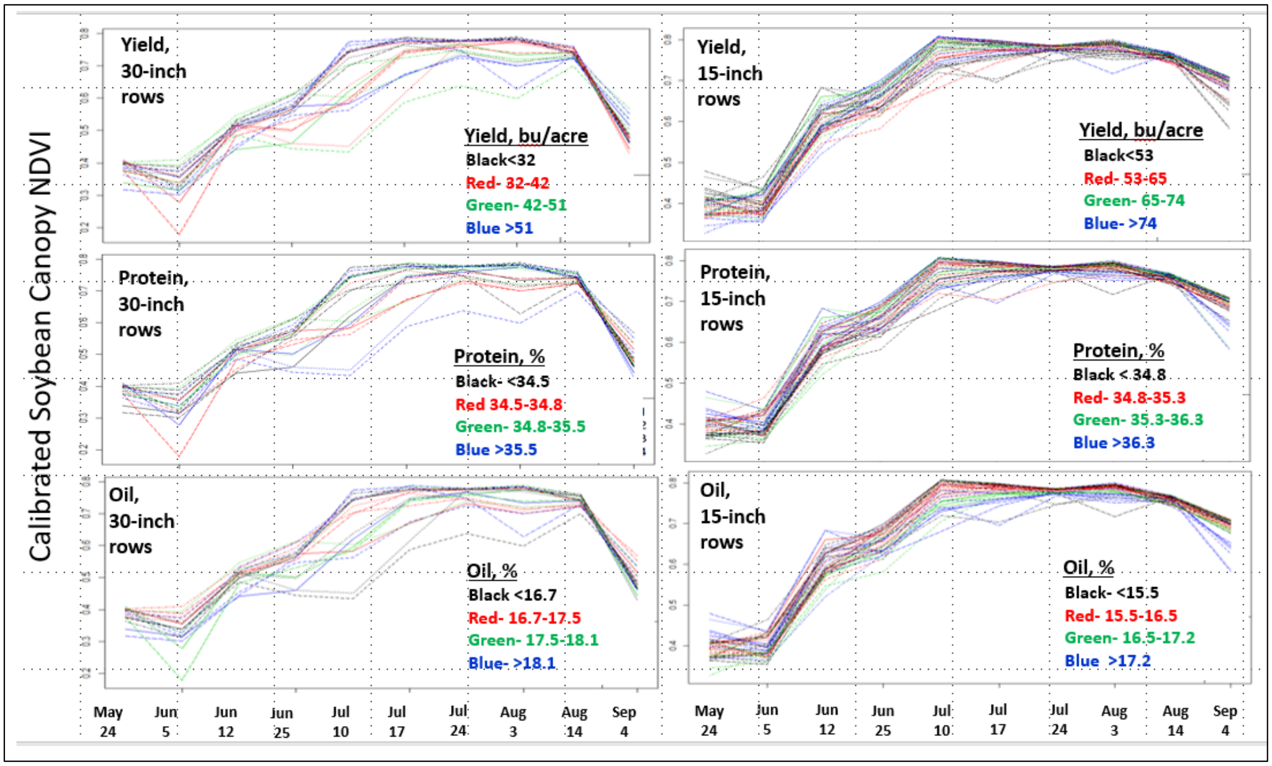
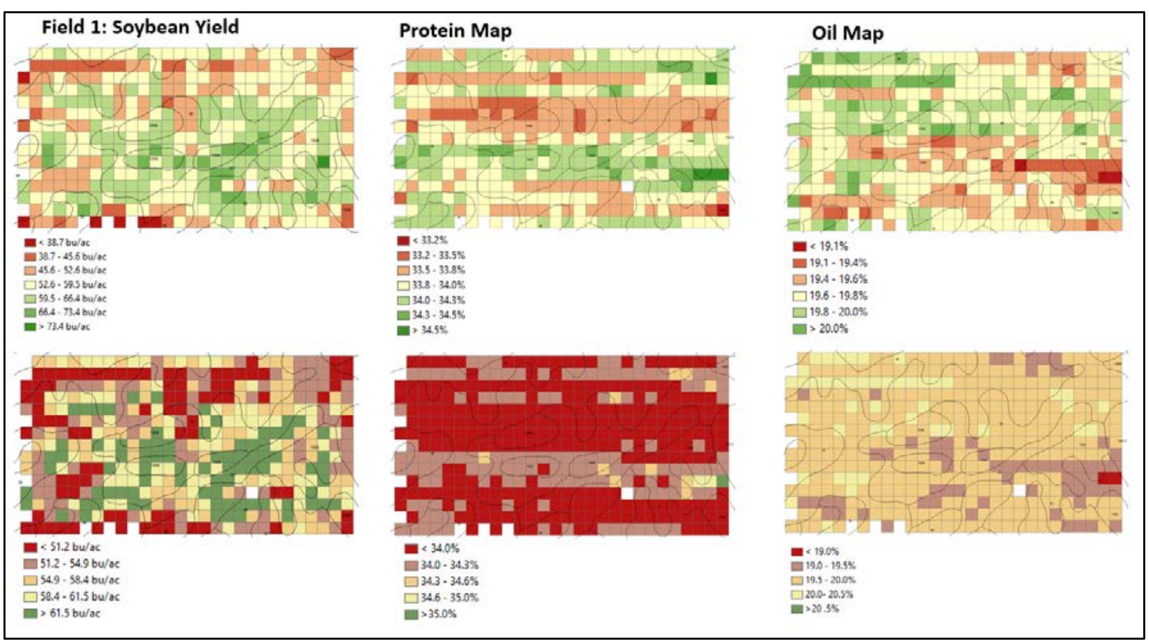


Figure 2: Temporal NDVI value of digital imagery of 30-inch and 15-inch rows of soybean to detect yield, protein and oil zones within fields. The protein and oil zones could be identified in the 15-inch row soybean starting from July until the end of the growing season. Zones with the higher protein and oil content had lower NDVI values.

In the main part of the project, ISU researchers equipped a grain combine with a NIR sensor and collected spatial sensor data from five farmers and ISU research soybean fields. The sensor readings were calibrated to corresponding laboratory data. In addition to crude protein and oil, the sensor data also can be used to predict soybean fiber content. ISA staff aggregated all spatial variables and imagery at 75x75-foot grids.



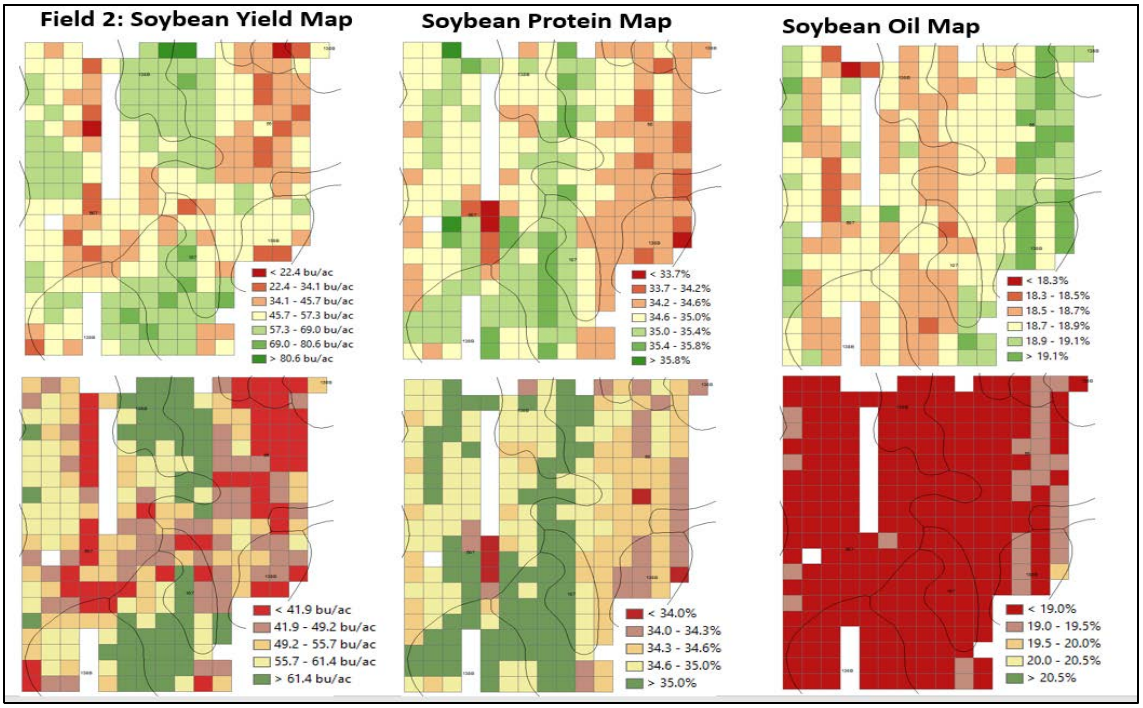


Figure 3: Maps of two ISU soybean fields showing soybean yield, protein and oil content. Protein and oil data were collected using an NIR sensor during harvest. The top row of maps represents yield bu/acre in each grid, percent protein and percent oil classified using standard deviation for each grid. The maps in the bottom row represent show protein and oil classified using 34 percent threshold for low protein and 19 percent threshold soybean oil content.

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 percent) with protein content lower than 34 percent (Figure 3 and Table 1). Three fields had 80 to 95 percent areas with oil content lower than 19 percent. Soybeans with protein lower than 34 percent and oil lower than 19 percent can put the U.S. at a disadvantage in international trade.

Table 1. Percentage of areas with different proten and oil classes within seven soybean fields.

Field	PROTEIN (%)					OIL (%)					SOYBEAN VARIETY	PLANTED DATE	ACREAGE
	< 34.0	34.0 - 34.3	34.3 - 34.6	34.6 - 35.0	> 35.0	< 19.0	19.0 - 19.5	19.5 - 20.0	20.0 - 20.5	> 20.5			
Story Co-ISU-1	31	32	21	13	3	1	3	21	44	30	P28T08	5/23/2018	107
Story Co-ISU-2	73	21	2	3	1	4	33	52	9	1	AG27X7	5/23/2018	63
Story Co-ISU-3	46	27	15	10	2	20	53	22	5	1	ACRESDGE - 22R269	5/18/2018	55
Story Co-ISU-4	2	11	27	28	32	88	11	0	0	0	ACRESDGE - 22R269	5/18/2018	40
Story Co-ISU-5	64	33	2	0	0	0	16	73	11	0	AG27X7	5/22/2018	63
Story Co-ISA-30-inch	9	3	9	15	64	96	0	4	0	0	CB28R58 / FC22R269	5/11/2018	55
Story Co-ISA-15-inch	13	0	5	21	61	89	4	0	3	4	FC22R269	5/11/2018	72

In the next phase of the project, ISA staff members will use different machine learning and analytical methods to identify soybean genetics, soil, management, and weather factors that might drive spatial variability in protein and oil maps. We will also explore the relationship between amino-acid content and different vegetation indices from calibrated aerial imagery.