ISRC Project Report, June 2025

1) About the project

- **Project Title:** Optimizing Continuous Soybean Production
- **Lead PI and Co-PIs:**

Principal Investigator

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- *Projects years:* 2023, 2024, 2025 (on going)
- *Total amount of funding:* $215,710

2) Project summary

Objectives: the main research questions we answer with this study are:

- What is the magnitude of the soybean-soybean yield penalty and how does it vary from year to year?
- Can management practices such as use of cover crops close the yield gap of continuous soybeans?
- Does the pest/disease pressure build up in the soybean monocropping systems?
- Is continuous soybean a profitable cropping system?
- How does the continuous soybean system impacts soil hydrology, N cycling, soil carbon, and overall sustainability in the long term?

Benefit to Soybean Farmers: Iowa soybean farmers could potentially benefit economically from planting soybeans after soybeans (with/without rye cover crop in between) in time periods when input prices are high or in the scenario of higher soybean demand to meet crushing capacity. Soybeans require no N fertilizer inputs and have a lower cost of production compared to corn. Also, current policies that aim to offset the cost of increasing biodiesel production while adopting conservation practices (e.g. 45Z) could increase demand for more soybean production. There are risks associated with introducing a new cropping system, so it is important to test and optimize the management of the continuous soybean system, and quantify its risks, benefits, and economics at the university level before it is implemented in farmers' fields.

3) Progress update

Field experiment establishment

The continuous soybean project was established in 2023 in two IA locations, Boone and Sutherland. It explores 7 cropping system treatments (plot), with 2 soybean cultivars (PI88788 and Peking resistance, subplots), each replicated 4 times. Plots are 16 rows by 100ft to allow for extensive data collection and collaboration across multiple labs. The cropping systems explored are: 1) soy-soy in 30" rows, 2) soy-soy in 15" rows, 3) soy-rye cover crop-soy, 4) soy-rye cover crop-soy + manure, 5) corn-corn, 6) corn-soy, and 7) soy-corn. The data collected covers a wide range of agronomy research areas, from drone imagery, hydrology to crop physiology, soil, and soybean pathology. The Continuous Soybean experiment is currently ongoing in year 2025, we will carry similar data collection as in the 2024 experimental year to build capacity and gain confidence on conclusions and recommendations.

Field experiments results

There was no yield gap associated with growing third year soybeans in 2024 (Fig. 1). In both locations, we observed a trend of increase in soybean cyst nematode (SCN) pressure in plots of continuous soybean. There is large variability in the measurements, and this trend was not statistically significant (Fig. 2). Studies of the hydrology data obtained from the sensors in this study have given us important information on the importance of water tables to crop production, and patterns of water use for both corn and soybeans. Through measurements of volumetric soil water content at different depths and times of the growing season, we observed that in 2024 crops relied on water stored at the top 90cm of the soil profile, with similar uptake amounts and pattern for corn and soybeans (Fig. 3).

Modelling study results

Data from field experiments also support modelling studies for long-term assessments of cropping systems' performance. We have calibrated and validated the APSIM cropping systems model in the continuous soybean plots and already performed a systems evaluation in collaboration with ISA personnel (Freitas et al., 2025). Some highlights of our findings are:

- Intensifying soybean-based systems offers the opportunity for higher and more stable yields (Fig. 4)
- Inclusion of a winter rye cover crop to soybean-based systems improved system nitrogen use efficiency, and reduced N_2O emissions (Fig. 6)
- Water use efficiency can be improved through management compared to current soybean management practices (Fig. 6)
- Soybean systems had similar profitability to maize monoculture using current production cost estimates and market prices (Fig. 5)

Freitas, C., Hart, C., Litch, M., Hubber, I., Castellano M., Helmers M., McClure, J., Herman, M., Grassini, P., Northrup D., & Archontoulis, SV. (2025). Economic and environmental evaluation of soybean-based cropping systems in the US Midwest. Agricultural Systems Journal – in-review

Outreach

Throughout the year 2024, we had opportunities to disseminate results gained from the continuous soybean project. During July 2024 we hosted ~60 farmers and Iowa Soybean Association (ISA) staff on the experiment site in Boone, IA during the ISA Field Day and the ISA Experience Class. Also in July, we welcomed a group of ~20 scientists who were attending the APSIM workshop. Throughout the month of August, we hosted at the plots ~65 soybean producer farmers from Brazil and Argentina who were attending the Farm Progress Show. Insights from modelling studies, supported by the field data collected at the continuous soybean trials, were presented at the 2024 Tri-Societies Meeting held in San Antonio -TX on November 10th and summarized in a scientific article currently under review.

4) Supporting attachments

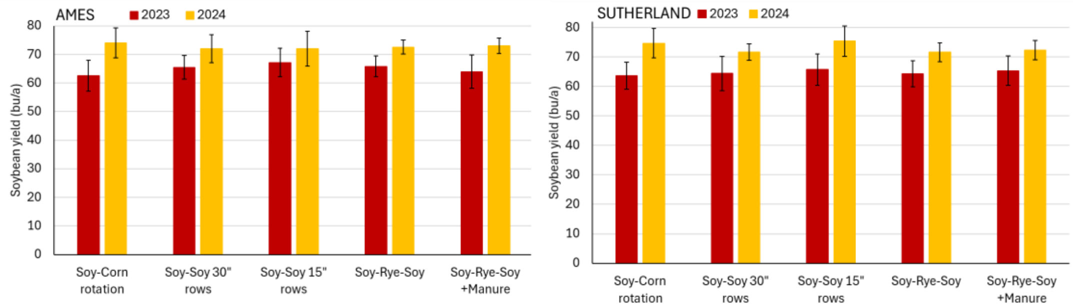

Figure 1 - Soybean yields (bu/a) for Boone, IA and Sutherland, IA experiments for each cropping system treatment.

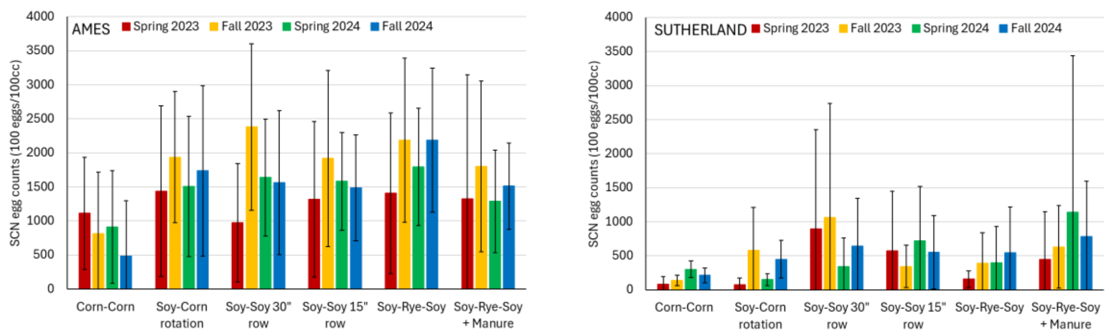

Figure 2 - Soybean Cyst Nematode egg counts (100 eggs/100cc) for Boone, IA and Sutherland, IA experiments for each cropping system treatment.

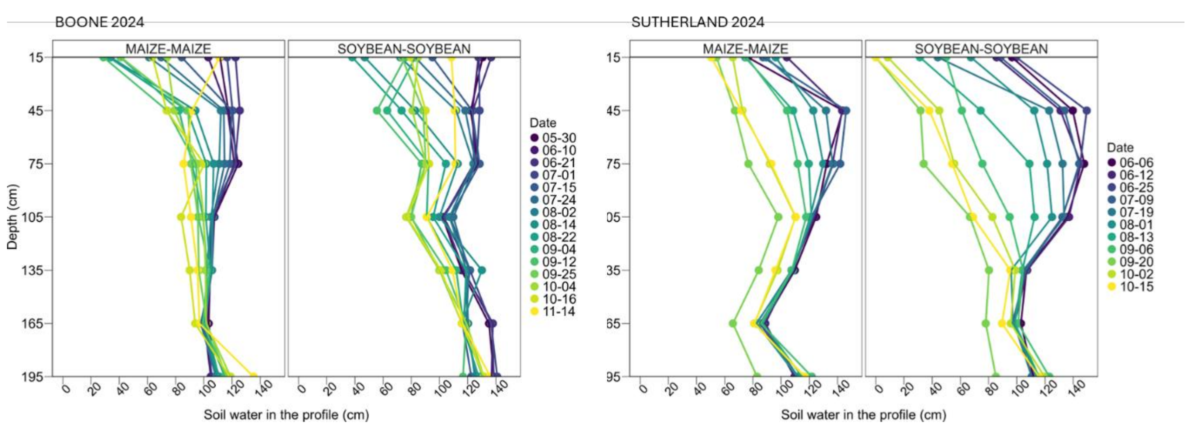

Figure 3 - Measured volumetric water content by depth (15 to 195cm) at 15 timepoints (Boone , IA) and 11 timepoints (Sutherland , IA).

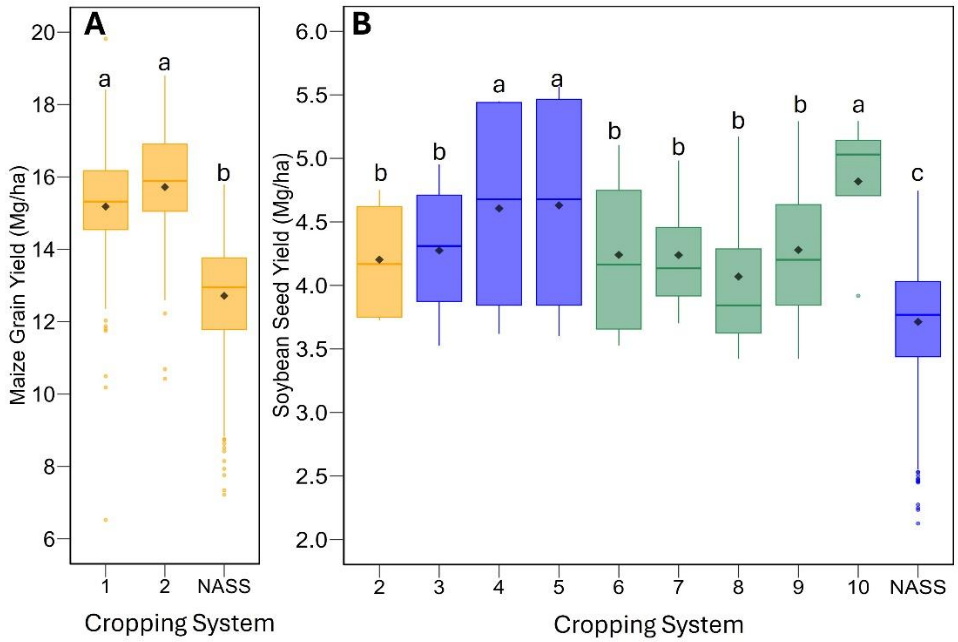

Figure 4 – Simulated grain yield across four locations and 30 years and NASS Iowa county level maize and soybean grain yields. Panel A illustrates maize grain yields and Panel B illustrates soybean seed yields. System 1 is maize-maize, system 2 is maize-soybean, systems 3–5 continuous soybeans with various intensification levels, and systems 6–10 are soybean-winter rye-soybean systems. The letters above boxplots represent statistically significant differences among cropping systems at α=0.05.

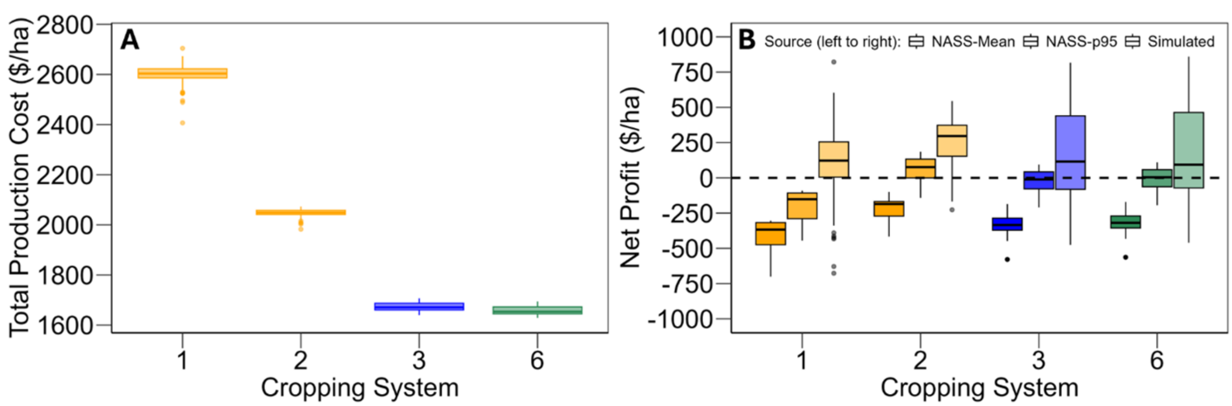

Figure 5 – A) Total production costs ($/ha) and B) Net profit ($/ha) for selected systems from 30 years of simulated yields and farm data costs. System 1 is maize-maize, system 2 is maize-soybean, system 3 is continuous soybean, and system 6 is soybean-winter rye-soybean.

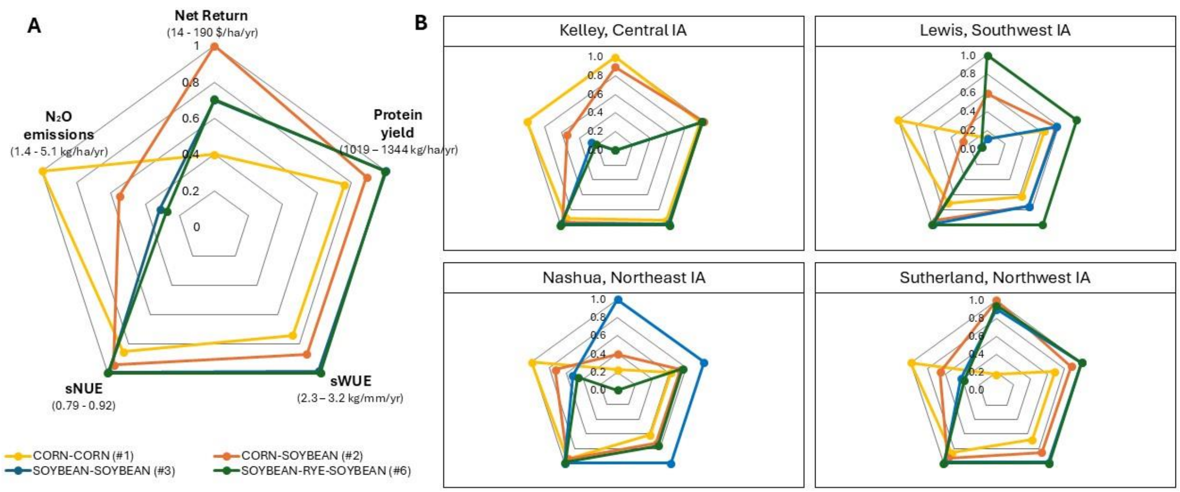

Figure 6 – Five indicators of cropping system's performance using simulated long-term results: net return ($/ha), protein yield (kg/ha), systems water use efficiency (sWUE,kg/mm), systems nitrogen use efficiency (sNUE, 0-1), and N_2O emissions (kg N/ha). Values were scaled (0-1) across cropping systems based on the maximum value of each variable. In parenthesis, ranges are shown. Panel A illustrates average values across locations and panel B data per location.