# Evaluating the potential of an algorithm-based (A.I.) decision-making tool to increase farmers' profitability in Wisconsin

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## IN A BEAN POD:

- Soybean A.I.-based cropping systems were, in general, successful in increasing yield and profit compared to typical systems
- Across all locations, following soybean A.I. recommended systems would have increased mean yield by ~7 bu/ac and mean profit by ~$40/ac compared to typically used cropping systems
- The potential of corn A.I.-based cropping systems to increase yield and profit was not clear
- The corn A.I. tool recommended systems resulted in either increased or similar profit with typical systems by applying 19-223% lower nitrogen fertilizer rate

## INTRODUCTION

Substantial crop yield variability arises from the wide range of optimal to sub-optimal management observed in farmers' soybean and corn fields. Replicated field experiments have been used to identify best management practices for several decades. Most commonly, the effectiveness of up to three management factors and their interactions are evaluated in a single location due to practical constraints (e.g., cost, logistics). It is assumed that background management practices are optimal or at least relevant to what most farmers use in the region, which in fact may not be realistic for many farmers.

Given all the well-known deficiencies of current agricultural research methods, an AI-tool, which leverages the power of artificial intelligence algorithms, claims that it has the potential to identify, among thousands of possible cropping systems a farmer can choose from in a single field, optimum cropping system for greatest yield and for greatest profitability. The AI-tool, using a combination of methods, estimates yield and projected profit by accounting for field location, soil type, weather conditions and several management practices and associated costs. Eventually, the cropping systems with highest probability of success are recommended to the farmer. The spatial coverage of the AI-tool is extensive and coincide with the region where most of corn and soybean are grown across the US (Figure 1).

The objective of the presented work is to compare yield and profitability of UW-recommended soybean and corn cropping systems with AI-recommended systems in WI in three growing seasons (2021, 2022 and 2023). Here we present results of the first year.

## RESULTS

### Soybean

Five experiments in five locations across WI were conducted to evaluate the effectiveness of algorithm-recommended (A.I.) cropping systems to increase yield and profit

**Figure 1.** Crop hectareage across the US. Adapted from Mourtzinis and Conley, 2017.

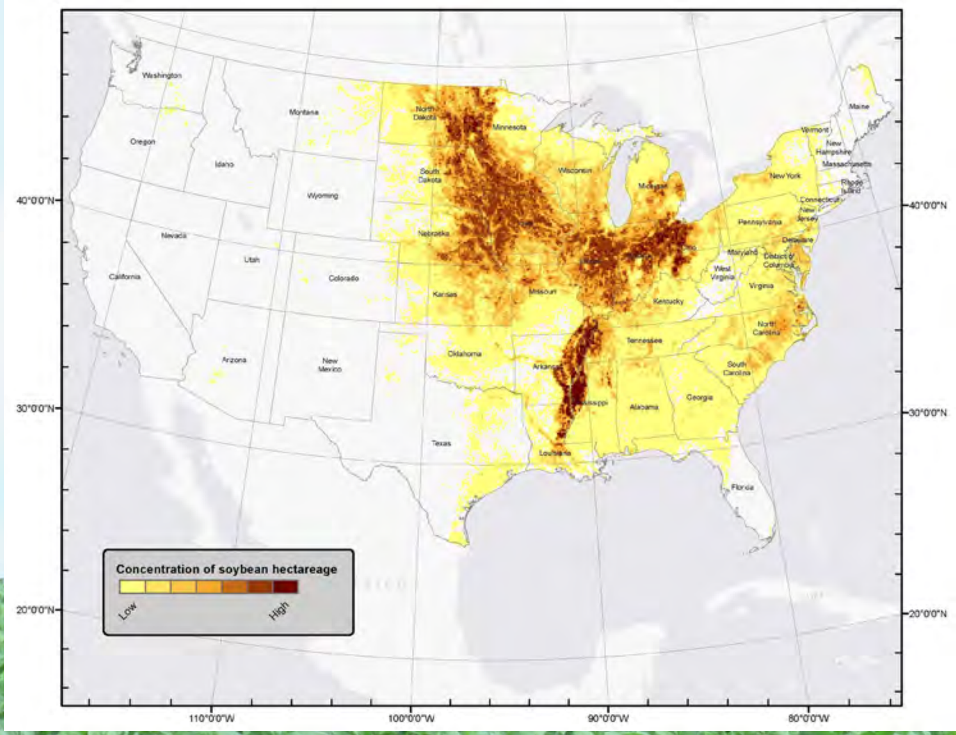



**Table 1.** A.I. recommended and typical cropping systems used in each location.

| Location | Name | Planting date (2021) | Seeing rate (seeds/ac) | Variety | RM | Fungicide | Pre-plant nitrogen (N) |
|---|---|---|---|---|---|---|---|
| ARL | Typical | 11-May | 140,000 | S23-G5X(T) | 2.3 | 0 | 0 |
| ARL | A.I. Yield | 29-Apr | 160,000 | AG26X0(T) | 2.6 | MiravisNeoR3 | 0 |
| ARL | A.I. Profit | 29-Apr | 160,000 | AG26X0(T) | 2.6 | 0 | 0 |
| PLT | Typical | 27-Apr | 140,000 | S23-G5X(T) | 2.3 | 0 | 0 |
| PLT | A.I. Yield | 27-Apr | 240,000 | AG26X0(T) | 2.6 | MiravisNeoR3 | 50 lbs N/a |
| PLT | A.I. Profit | 27-Apr | 160,000 | AG26X0(T) | 2.6 | 0 | 0 |
| HAN | Typical | 30-Apr | 140,000 | AG20X9(T) | 2 | 0 | 0 |
| HAN | A.I. Yield | 30-Apr | 240,000 | S23-G5X(T) | 2.3 | MiravisNeoR3 | 50 lbs N/a |
| HAN | A.I. Profit | 30-Apr | 165,000 | S23-G5X(T) | 2.3 | 0 | 0 |
| MAR | Typical | 7-May | 140,000 | AG14X8(T) | 1.4 | 0 | 0 |
| MAR | A.I. Yield | 7-May | 240,000 | AG14X8(T) | 1.4 | MiravisNeoR3 | 50 lbs N/a |
| MAR | A.I. Profit | 7-May | 160,000 | AG14X8(T) | 1.4 | MiravisNeoR3 | 0 |
| SPO | Typical | 15-May | 140,000 | AG10X9(UT) | 1 | 0 | 0 |
| SPO | A.I. Yield | 20-Apr | 200,000 | AG10X9(UT) | 1 | MiravisNeoR3 | 50 lbs N/a |
| SPO | A.I. Profit | 20-Apr | 160,000 | AG10X9(UT) | 1 | 0 | 0 |

compared to UW-recommended systems (typical). The A.I. approach provided maximum yield ("A.I. yield") or maximum profit ("A.I. profit") cropping systems depending on the objective (Table 1).

Among the five locations, A.I. increased yield (Fig. 2) and profit (Fig. 3) in two locations whereas no differences were observed in the rest three locations. Across all locations, A.I. significantly increased both, yield and profit compared to typical. In cases where a farmer has multiple fields (five in our exercise), following A.I. recommended systems would have increased mean yield by ~7 bu/ac and mean profit by ~$40/ac compared to typically used cropping systems.

**Figure 2.** Soybean yield comparison among algorithm-recommended (A.I.) cropping systems for maximum profit (A.I. profit), for maximum yield (A.I. yield) and UW-recommended systems (typical). In bars with the same letter yield was not significantly different at alpha=0.05. Errors represent standard error of the mean.

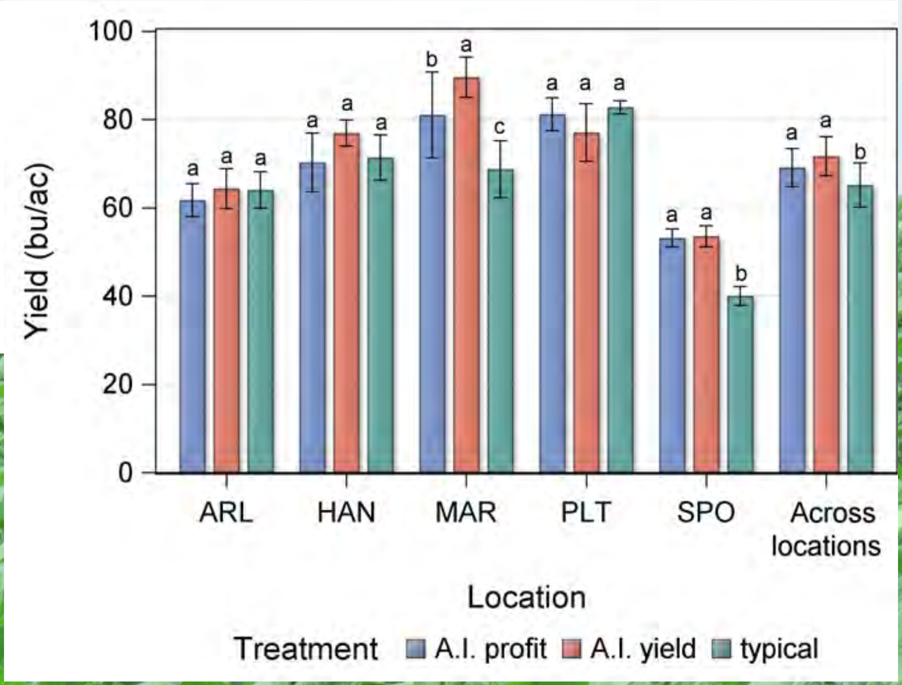
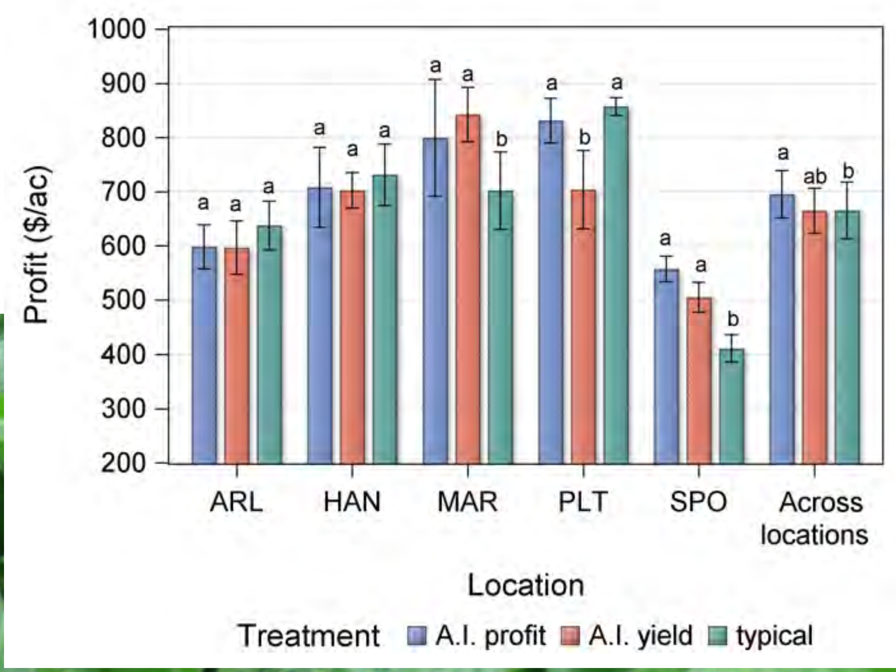



**Figure 3.** Soybean profit comparison among algorithm-recommended (A.I.) cropping systems for maximum profit (A.I. profit), for maximum yield (A.I. yield) and UW-recommended systems (typical). In bars with the same letter yield was not significantly different at alpha=0.05. Errors represent standard error of the mean.



## Corn

Three experiments in three locations in WI were conducted to evaluate the effectiveness of algorithm-recommended (A.I.) corn cropping systems to increase yield and profit compared to UW-recommended systems (typical). Similarly to soybean, the A.I. approach provided maximum yield ("A.I. yield") or maximum profit ("A.I. profit") cropping systems depending on the objective (Table 2).

Among the three locations, "A.I. yield" systems resulted in lower yield in the ARL location by ~15 bu/ac and across locations by 10 bu/ac compared to typical. No significant differences were observed in the rest two locations (Fig. 4). The "A.I. profit" systems resulted in increased profit in the DAL location by $76/ac and no other differences were observed in the rest two locations (Fig. 5). Across the three locations, the difference between "A.I profit" and typical was not significantly different.

It is interesting to observe the profit comparison between corn A.I. profit and typical systems in every location. When compared to typical cropping systems, the A.I. tool recommended systems that either increased (in DAL) or resulted in similar profit with

**Table 2.** A.I. recommended and typical corn cropping systems used in each location. Note: GM= Genetically modified, RW=rootworm, F=fungicide, I=insecticide.

| Location | Name | Planting date (2021) | Seeding rate (seeds/ac) | Hybrid | RM | Seed Traits | Starter Fert (N-P-K lbs/a) | Pre N lbs/a | Post N lbs N/a |
|---|---|---|---|---|---|---|---|---|---|
| ARL | Typical | 29-Apr | 36,000 | P0720Q | 107 | GM+RW+F+I | 30-76-60 | 0 | 207 |
| ARL | A.I. Yield | 29-Apr | 38,000 | W4196RIB | 105 | GM+F+I | 30-76-60 | 37 | 55 |
| ARL | A.I. Profit | 29-Apr | 34,000 | 199-11VT2PRIB | 99 | GM+F+I | 30-76-60 | 64 | 0 |
| LAN | Typical | 26-Apr | 35,000 | W4246RIB | 105 | GM+F+I | 14-35-45 | 120 | 0 |
| LAN | A.I. Yield | 26-Apr | 40,000 | W4246RIB | 105 | GM+F+I | 14-35-45 | 101 | 0 |
| LAN | A.I. Profit | 26-Apr | 30,000 | W4246RIB | 105 | GM+F+I | 14-35-45 | 101 | 0 |
| DAL | Typical | 15-May | 32,500 | DKC50-64RIB | 100 | GM+RW+F+I | 39-80-60 | 0 | 141 |
| DAL | A.I. Yield | 8-May | 39,000 | P0339Q | 104 | GM+RW+F+I | 39-80-60 | 0 | 176 |
| DAL | A.I. Profit | 8-May | 39,000 | P0339Q | 104 | GM+RW+F+I | 39-80-60 | 0 | 71 |

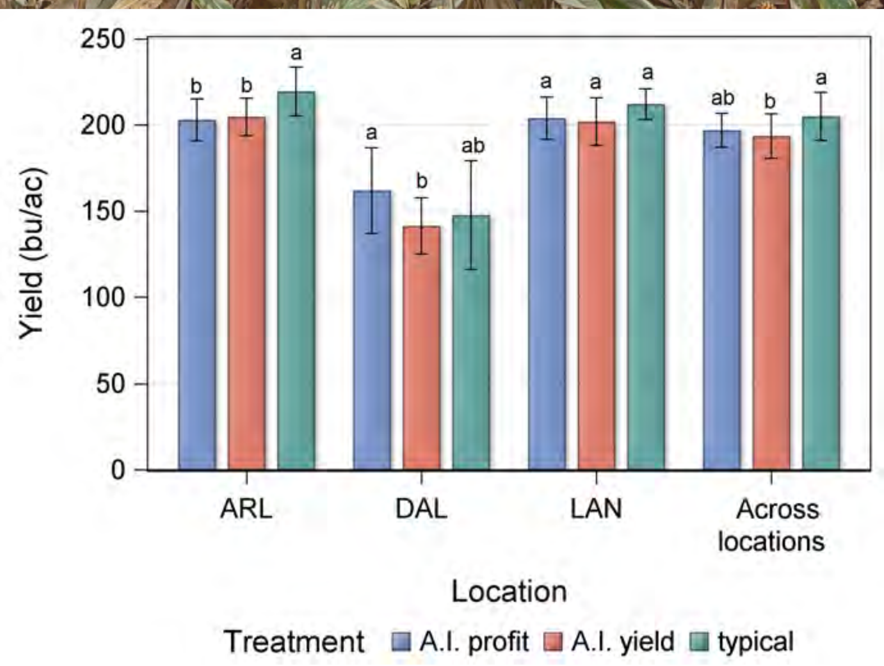



**Figure 4.** Corn yield comparison among algorithm-recommended (A.I.) cropping systems for maximum profit (A.I. profit), for maximum yield (A.I. yield) and UW-recommended systems (typical). In bars with the same letter yield was not significantly different at alpha=0.05. Errors represent standard error of the mean.

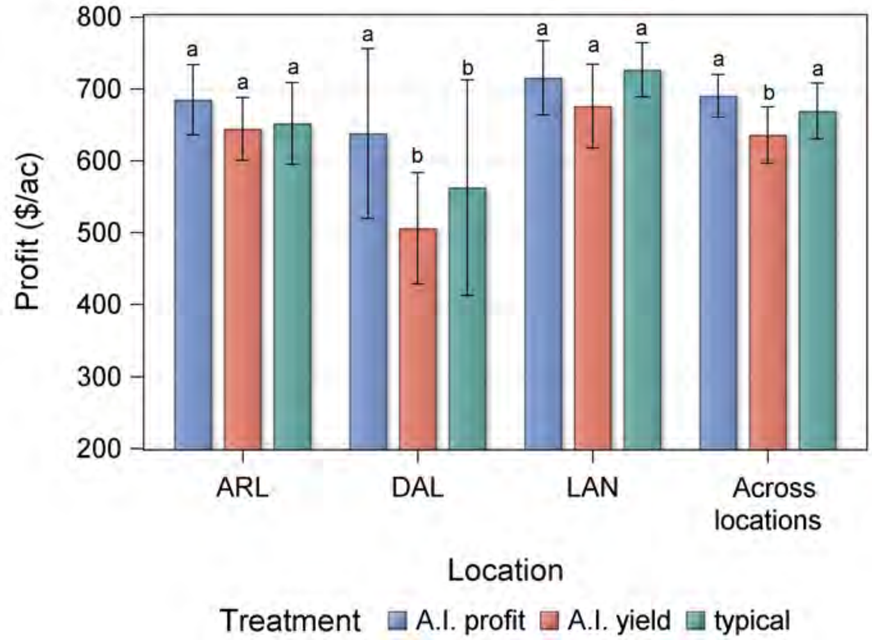



**Figure 5.** Corn profit comparison among algorithm-recommended (A.I.) cropping systems for maximum profit (A.I. profit), for maximum yield (A.I. yield) and UW-recommended systems (typical). In bars with the same letter yield was not significantly different at alpha=0.05. Errors represent standard error of the mean.

typical systems by applying substantially lower Nitrogen fertilizer rate (N reduction by 323% in ARL, 16% in LAN and 50% in DAL). These results suggest the potential of these algorithms to identify and recommend more environmentally friendly cropping systems without compromising farm profitability.

## DISCUSSION

Algorithm-based decision making will likely play an important role in the coming years. Algorithms can capture and quantify complex relationships that can result in more informative decisions with greater probability of success (effectively increase profit) compared to current approaches. Evaluation of such tools in field conditions which involve unexpected and unmanageable yield adversities is important. In this work, soybean A.I.-based cropping systems were in general successful to increase yield and profit compared to typical systems. The potential of corn A.I.-based cropping systems to increase yield and profit though was not clear (Table 3). Additionally, Tar Spot was found and not treated at all three locations. This may have impacted the overall results of the experiment and suggest that the A.I. tool alone cannot account for in-season IPM decisions and should be paired with scouting or other management tools such as TarSpotter.

**Table 3**. Frequency of success/failure of soybean and corn A.I. recommended cropping systems compared to typical among individual locations.

| Crop | Comparison | A.I. success | A.I. failure | Draw | Total |
|---|---|---|---|---|---|
| Soybean | A.I yield vs. typical | 2 | 0 | 3 | 5 |
| | A.I profit vs. typical | 2 | 0 | 3 | 5 |
| Corn | A.I yield vs. typical | 0 | 1 | 2 | 3 |
| | A.I profit vs. typical | 1 | 0 | 2 | 3 |

It should be noted that the typical cropping systems have been developed by UW researchers after years of research in the specific locations and are already optimized. Therefore, identification of even more improved cropping systems is very challenging. We argue that in suboptimal cropping systems, that frequently exist in farmer's fields (Edreira et al., 2017; Mourtzinis et al., 2018), the A.I. approach has potential to increase yield and more importantly profit. The A.I. tool will be further improved and evaluated in more locations in subsequent years.

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