Boots on the Ground:
Validation of benchmarking process through an integrated on-farm partnership
FINAL REPORT

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IN A BEAN POD:

- Region-specific improved management treatments, which were developed by analyzing producer survey data, were tested between 2019 to 2021 across the US NC region.
- Between 2019 to 2021, the improved management treatment netted soybean producers an average of 5.5, 3.2, and 3.7 bu/ac yield increase respectively.
- The additional profit of the improved treatment was 51, 31 and 53$/ac in 2019, 2020, and 2021 respectively.
- Economic analysis should be conducted yearly to account for the variable input cost and soybean price.
- Growers should consider improving their soybean management by fine tuning planting date, maturity group, seeding rate, and foliar fungicide and insecticide application.

PROJECT BACKGROUND

Analysis of producer survey data performed during our previous 3-year NCSRP-funded benchmarking project revealed: (1) an average yield gap of 20-30% between current farmer yield and potential yield as determined by climate, soil, and genetics, and (2) a number of agronomic practices that, for a given soil-climate context, can be fine-tuned to close the gap and improve soybean producer profit.

GOALS

This project focused on using the producer survey database to identify and strategically evaluate management changes in on-farm research settings across the US North Central region. In each state, a suite of specific agronomic practices was identified to have the greatest potential for increasing yield and profit for a given combination of climate and soil (a "technology extrapolation domain [TED]"). Those 'improved' practices were tested against the typical practices followed by producers (called 'reference' management) between 2019 and 2021. This evaluation demonstrated how individual producers can increase on-farm soybean yield, input-use efficiency, and net profit by fine tuning current management practices.

EXECUTION

In 2021, 49 replicated on-farm trials in seven states were initiated to compare an "improved" treatment versus the "reference" producer practices, which added up to other 101 on-farm trials carried out in the two previous years (48 in 2019 and 53 in 2020). The "improved' management was specifically designed for each TED in each state by fine tuning planting date, and usually involves earlier planting, lower seeding rate, insecticide and fungicide application, and, in some cases, fine tuning cultivar maturity group based on previous analysis of the survey data (Table 1).

Table 1. The recommended "improved" management treatment in each state.

State	Recommended "improved" treatment
IA	Early planting* + longer MG (> 3.6) + foliar fungicide AND insecticide** + 130K/ac seeding rate
OH	Early planting* + foliar fungicide AND insecticide** + intermediate seeding rate (around 130K/ac)
ND	Early planting* + longer MG (>0.2)** + 150K/ac seeding rate
MI	Early planting* + foliar fungicide AND insecticide** + 130K/ac seeding rate
WI	Early planting* + intermediate seeding rate (around 130K/ac)
NE	Early planting* + foliar fungicide AND insecticide** + 130K/ac seeding rate

* Early planting refers to end of April or early May, always using treated seed, AND early and late (control) plantings should be apart by at least 3 weeks.
** Application around R3 stage (beginning of pod setting).

Replicated trials were established through each University with the assistance of growers, extension personnel, retailers, and county-based agencies, in collaboration with the on-farm experimentation network in each state. Figure 1 provides the geographical reference of the trials and Table 2 indicates the specific treatments of the various trials in each of the states in 2021. A total of 49 trials were successfully conducted during 2021; each trial consisted of a side-by-side comparison of the improved versus reference management. The locations and specific treatments in the two previous years can be seen here. (2019 Report; 2020 Report)

Table 2. Reference (R) and improved (I) treatments actually applied in each state in 2021.

	Experiment	Treatment	Planting date	Seed treatment	Maturity group	Seeding rate (x1000 seeds/ac)	Foliar Insecticide/ Fungicide
Iowa	IA 1	I	4/15/2021	yes	3.3	140	no/no
		R	5/12/2021	yes	2.9	140	no/no
	IA 2	I	4/24/2021	no	2.9	140	no/no
		R	5/4/2021	no	2.6	140	no/no
	IA 3	I	4/22/2021	yes	2.8	140	no/yes
		R	5/12/2021	yes	2.3	140	no/yes
	IA 4	I	4/26/2021	yes	3.1	140	no/yes
		R	5/12/2021	yes	2.5	140	no/yes
	IA 5	I	5/6/2021	yes	2.6	140	no/no
		R	5/25/2021	yes	2	140	no/no
	IA 6	I	4/13/2021	no	2.5	175	no/yes
		R	5/13/2021	no	1.8	175	no/yes
	IA 7	I	4/23/2021	yes	3	160	no/yes
		R	5/14/2021	yes	2.5	160	no/no
	IA 8	I	4/23/2021	yes	2.6	140	no/yes
		R	5/11/2021	yes	2	140	no/no
	IA 9	I	4/21/2021	no	3.7	140	no/yes
		R	6/1/2021	no	3.1	140	no/no
	IA 10	I	4/28/2021	yes	2.6	120	no/n.r.
		R	5/12/2021	yes	2.3	120	no/n.r.
	IA 11	I	4/29/2021	yes	3	140	no/yes
		R	5/13/2021	yes	2.7	140	no/yes
	IA 12	I	5/6/2021	yes	3.3	140	no/no
		R	5/19/2021	yes	2.5	140	no/no
	IA 13	I	4/30/2021	yes	3.1	140	no/no
		R	5/13/2021	yes	2	140	no/no
	IA 14	I	4/20/2021	yes	3	140	no/no
		R	5/6/2021	yes	2.7	140	no/no
Ohio	OH 1	I	5/20/2021	yes	2.8	135	yes/yes
		R	6/4/2021	yes	2.8	156	no/no
	OH 2	I	5/19/2021	yes	3.1	130	yes/yes
		R	6/7/2021	yes	3.1	160	no/no
	OH 3	I	4/27/2021	yes	3.5	130	no/yes
		R	5/27/2021	yes	3.5	160	no/no
	OH 4	I	4/19/2021	yes	3.3	130	yes/yes
		R	5/14/2021	yes	3.3	160	no/no
	OH 5	I	4/26/2021	yes	3	130	yes/yes
		R	5/24/2021	yes	3	160	no/no
	OH 6	I	4/19/2021	yes	3.6	130	yes/yes
		R	5/21/2021	yes	3.6	160	no/no
	OH 7	I	4/17/2021	yes	3.1	130	no/yes
		R	5/15/2021	yes	3.1	160	no/no
	OH 8	I	4/19/2021	yes	n.r.	130	yes/yes
		R	5/15/2021	yes	n.r.	160	no/no

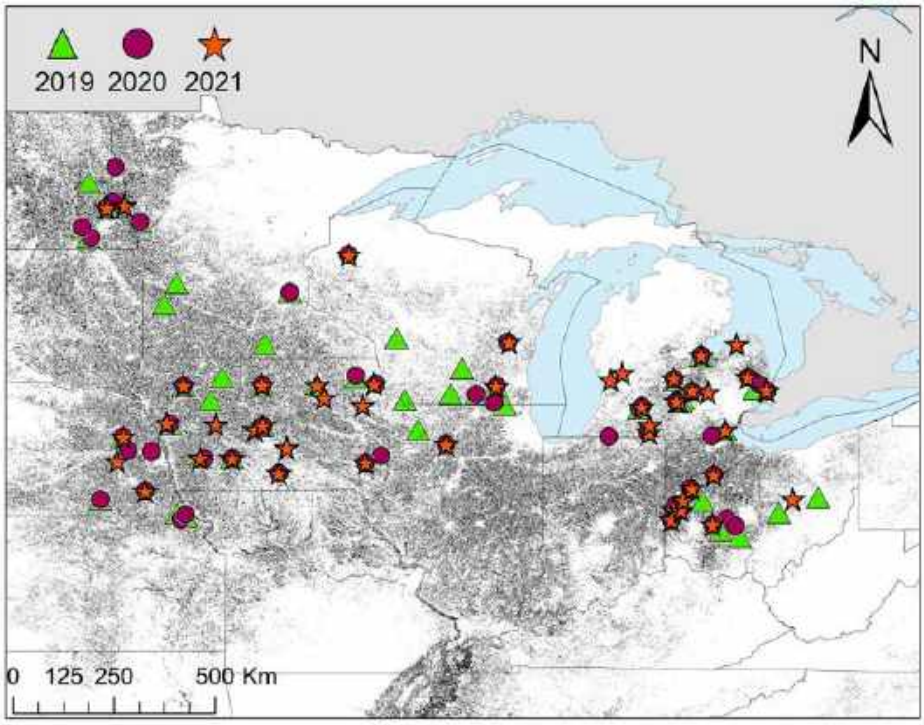
n.r.: not reported; information is still being collected.

Table 2. (continued)

Experiment	Treatment	Planting date	Seed treatment	Maturity group	Seeding rate (x1000 seeds/ac)	Foliar Insecticide/ Fungicide
North Dakota						
ND 1	I	5/6/2021	yes	0.8	165	yes/no
	R	5/26/2021	yes	0.5	185	yes/no
ND 2	I	5/6/2021	yes	0.8	165	yes/no
	R	5/26/2021	yes	0.5	185	yes/no
ND 3	I	5/6/2021	yes	0.8	165	yes/no
	R	5/26/2021	yes	0.5	185	yes/no
Michigan						
MI 1	I	5/2/2021	yes	2.2	130	no/no
	R	5/19/2021	yes	2.2	130	no/no
MI 2	I	4/26/2021	yes	2.4	140	no/no
	R	5/17/2021	yes	2.4	140	no/no
MI 3	I	4/26/2021	yes	2	120	no/no
	R	5/15/2021	yes	2	120	no/no
MI 4	I	4/7/2021	yes	3.1	160	no/no
	R	5/16/2021	yes	3.1	160	no/no
MI 5	I	4/8/2021	yes	3.1	140	no/no
	R	5/5/2021	yes	3.1	140	no/no
MI 6	I	4/22/2021	yes	3	126	no/no
	R	5/15/2021	yes	3	126	no/no
MI 7	I	5/10/2021	yes	2.1	130	no/no
	R	5/28/2021	yes	2.1	170	no/no
MI 8	I	4/23/2021	yes	1.6	140	yes/yes
	R	5/11/2021	yes	1.6	140	no/no
MI 9	I	4/24/2021	yes	1.5	130	no/yes
	R	5/15/2021	yes	1.5	130	no/no
MI 10	I	4/18/2021	yes	2.4	130	yes/yes
	R	5/18/2021	yes	2.4	130	no/no
MI 11	I	4/24/2021	yes	1.8	120	no/no
	R	5/17/2021	yes	1.8	120	no/no
MI 12	I	4/27/2021	yes	2.6	160	yes/yes
	R	5/19/2021	yes	2.6	160	no/no
MI 13	I	5/2/2021	yes	2.1	130	no/no
	R	5/18/2021	no	2.1	130	no/no
MI 14	I	5/1/2021	yes	2.1	135	no/no
	R	5/25/2021	yes	2.1	165	no/no
MI 15	I	5/5/2021	yes	2	130	yes/no
	R	5/24/2021	yes	2	140	no/no
MI 16	I	4/18/2021	yes	2.6	140	no/yes
	R	5/18/2021	yes	2.6	140	no/no
Wisconsin						
WI 1	I	5/1/2021	yes	2	139	no/no
	R	5/18/2021	yes	2	139	no/no
WI 2	I	4/30/2021	yes	2.8	140	no/no
	R	5/22/2021	yes	2.8	140	no/no
WI 3	I	4/30/2021	n.r.	1	139	no/no
	R	5/24/2021	n.r.	1	139	no/no
WI 4	I	5/1/2021	n.r.	2.2	128	no/no
	R	5/26/2021	n.r.	2.2	125	no/no
WI 5	I	4/23/2021	yes	1.8	140	yes/yes
	R	5/12/2021	yes	1.8	140	yes/yes
Nebraska						
NE 1	I	4/22/2021	no	4.1	130	no/no
	R	5/23/2021	no	4.1	150	no/no
NE 2	I	5/3/2021	no	2.9	145	yes/yes
	R	5/13/2021	no	2.9	160	no/no
NE 3	I	5/12/2021	yes	2.9	130	yes/yes
	R	5/15/2021	yes	2.9	160	no/no

n.r.: not reported; information is still being collected.

Figure 1. Locations of the 2019-2021 NCSRP validation trials.

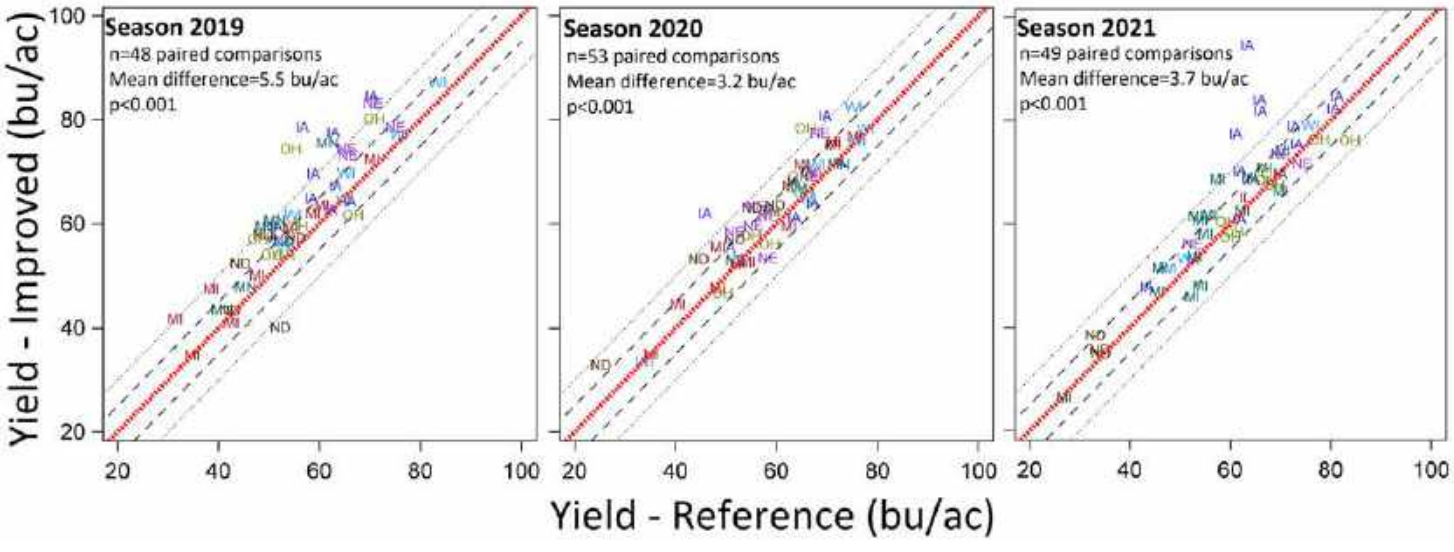


RESULTS

Soybean yield

Yield from the 2021 trials were analyzed as a large group by comparing the "improved" versus "reference" management. Across the 49 trials, an average 3.7 bu/ac yield increase was realized from using the improved management treatment (Figure 2). The yield benefit derived from the improved treatment in 2021 was comparably smaller than the yield increase observed in 2019 (5.5 bu/ac) but greater than 2020 (3.2 bu/ac). During the three years of the study, a 3.9 bu/ac average yield benefit due to the improved treatment when compared to reference was observed.

Figure 2. Yield comparison between reference and improved treatment across 48 farms in 2019, 53 farms in 2020, and 49 in 2021, distributed in seven states. The red dashed line is the 1:1 line of agreement. The dashed and dotted lines show the ±5 and ±10 bu/ac deviation from the 1:1 line of agreement.



Partial economic analysis

An economic analysis of the improved versus the standard treatments was conducted to calculate a profit or loss from applying the recommended improved treatments. Our assumptions for the analysis were:

- Soybean price: $15/bu in 2021 ($11/bu in 2020, $9/bu in 2019)
- Treated seed cost: $60/140k seeds
- Non-treated seed cost: $54/140k seeds
- Foliar insecticide (product only) = $3/ac
- Foliar fungicide (product only) = $10/ac
- Foliar fungicide and/or insecticide application (excluding product cost): $6.50/ac

We found that the yield increase, together with the high soybean price ($15/bu) and the lower costs due to lower seeding rate, resulted on average +$53/ac extra net profit in the "improved" management treatment compared with the "reference" treatment in the 2021 season (Figure 3). The additional profit was higher than in 2019 (+ $51/ha) and 2020 (+$31/ac) due to the high soybean price. The additional profit derived from the "improved" management in 2021 was higher than 10 $/ac in 75% of the cases (compared with 85% of the cases in 2019 and 65% in 2020). The large yield benefits due to the improved treatment in IA, along with the high soybean price, resulted in very large profit difference from the reference treatment that reached $460/ac. In general, one can conclude that the economic impact derived from the improved treatment was high and consistent across farms and years.

The combined analysis of producer-reported data and the spatial framework allowed us to design high yielding and profitable soybean systems for specific climate-soil domains. Our analysis shows that the average positive impact on profit derived from the improved management was consistent across all three years of the study. We note that due to the variability in input costs and soybean price, economic analysis should be performed every year before deciding on the cropping system that will be used. Overall results show that analysis of producer-reported data can help identify management practices that can lead to higher yield and profit for a given climate-soil context.

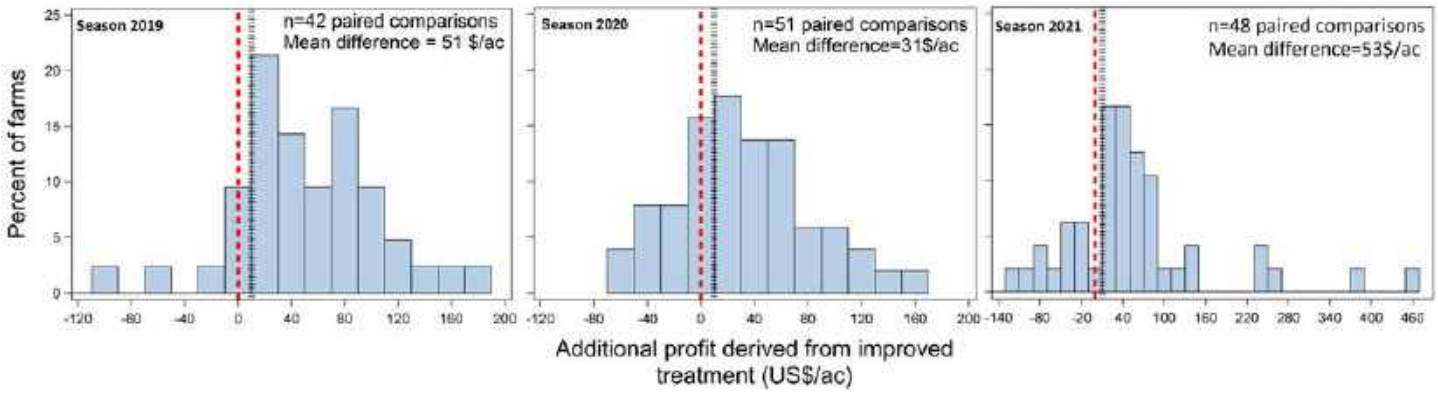


Figure 3. Distribution of partial profit (improved minus reference treatment profits) across 42 farms in 2019, 51 farms in 2020, and 48 in 2021. The red dashed line shows the zero-extra profit threshold and the black dashed line shows the 10 $/ac extra profit threshold.

ACKNOWLEDGMENTS

We thank the North Central Soybean Research Program (NCSRP), Wisconsin Soybean Marketing Board (WSMB), and Nebraska Soybean Board (NSB) for supporting the project and the farmers participating in the project for their excellent fieldwork.