Field testing, evaluation, and demonstration of small, light-weight, autonomous planter used to plant soybeans

Update Report by Salin 247, Inc.

for the

Iowa Soybean Association

June 10, 2022

Project goals

As a reminder, the goals of the "Field testing, evaluation, and demonstration of small, light-weight, autonomous planter used to plant soybeans" are:

- Field test planting capabilities of the **Salin 247** small, autonomous farm machinery platform
- Demonstrate the feasibility of using small, light-weight, autonomous planters
- Quantify and evaluate the mechanical and economic performance of the planting capability of the platform
- Gather feedback and critique from pilot growers
- Communicate the project work and findings with soybean growers and the soybean industry
- Develop a plan for working with the ISA Research Center for Farm Innovation (RCFI) field research team as well as a plan for collaborating with the On-farm Research Network in conducting on-farm research

Status of project tasks

The status of key project work tasks is summarized here:

Broad tasks	Key tasks	Status
2022 Pilot Planning	Grower meetings & enrollment	Charles City meeting with eight growers Ames meeting with eight growers
	Grower feedback & pilot protocol updates	Grower feedback collected and incorporated some of the grower ideas
	Field setup	Completed
	Planting scheduling plan	Planting scheduled originally for 8 farms and 10 fields in IA (also two in TN)
Planter preliminary field testing	Southern field test site identification	Decided not to go south for testing. Did all of our testing in Ames test field
	Take Salin 247 Planter to southern test site	Decided not to go south for testing. Did all of our testing in Ames test field
	Conduct preliminary Planter field testing and data collection	Of the 10 original fields (7 soybean fields) for testing, we ultimately only planted four
Pilot implementation	Plant pilot fields	Started planting trials on May 13 and ended on June 2
	Soil compaction data collection	Penetrometer data collected on the 4 planted fields
	Planter performance data collection	Precision Planting 20/20 data collected on all 4 test fields
	Navigation performance data collection	Navigation data collected on all 4 test fields
	Pilot field monitoring	TBD this summer
	Grower field day	Likely to be scheduled in July An ISA group will be coming to the Salin 247 office for a field day stop on Aug 4
	Grower feedback data collection	In progress
	Data analysis	In progress
	Project findings & conclusions	TBD
Communicate project work & findings	Semi-annual reporting	Completed June 10
	Website information	Launched new Website
	Social media channels	Set up Twitter account
Next steps defined	Define ISA/Salin 247 field research collaboration ideas	Met with Theo Gunther March 11 to discuss ideas for Year 2 research

Salin 247 prototype planter

The Salin 247 prototype autonomous planter is a 4-row, 30” row planter powered by a 10-kwh Lithium Iron Phosphate battery. The prototype has four tracks, each with a 5-kw electric motor, a 20-1 gearbox, and controller. The machine has a hydraulic system for raising and lowering the planter and also has an air compressor for air bag down force. The machine is guided using software and RTK GPS. We have a custom-made base station that we bring to each field.

Status of field tests

During the winter of 2022, Salin 247 met with and signed up eight growers who agreed to have Salin 247 field test a prototype autonomous planter on 10 fields. The plan was to start field tests as soon as soil conditions were suitable for planting. Initially, we thought we could be planting in mid-April.

Because of the cool, wet early spring weather followed by warmer but wet weather in late April and early May, none of our test fields were suitable for planting until mid-May. Because of the late date and growers wanting to get their fields planted, we canceled field tests on six of our 10 fields including all three corn fields and three soybean fields. We also reduced the number of acres planted on the four fields that were planted by our planter. Below is a summary of the test fields signed up and those that were actually planted.

Salin 247 2022 Field Test Locations

Farm location	Dates	Crop	Previous crop	Tillage type	Row width	Field size	Acres planted
					inches	*acres*	*acres*
Luther, IA	May 13-17	Soybeans	Corn	Reduced till	30	40	30
Griswold, IA	May 22-23	Soybeans	Corn	No-till	15**	20	12
West Liberty, IA	May 30	Soybeans	Soybeans	No-till	30	20	8
Plainfield, IA	June 2	Soybeans	Corn	No-till, fall VT	30	37	8
Plainfield, IA	Canceled*	Soybeans	Corn	No-till, fall VT	30	37	0
Plainfield, IA	Canceled*	Soybeans	Corn	No-till, fall VT	30	90	0
Thor, IA	Canceled*	Corn	Soybeans	Strip-till	30	10	0
Clarion, IA	Canceled*	Corn	Soybeans	Strip-till	30	3	0
Vincent, IA	Canceled*	Corn	Soybeans	Reduced till	30	5	0
Eagle Grove, IA	Canceled*	Soybeans	Corn	Reduced till	30	6	0

*Canceled due to weather

**Planted plot twice

Planter performance data

We are still in the process of analyzing data and collecting grower feedback. However, below is some of the data that has been collected relative to planter performance.

2022 Field Test Preliminary Planter Performance Results

Farm	Luther, IA	Griswold, IA	Griswold, IA	West Libery, IA	Plainfield, IA
		First pass	*Second pass*		
Crop	Soybeans	Soybeans	Soybeans	Soybeans	Soybeans
Acres	30	5	5	8	8
Previous crop	Corn	Corn	Corn	Soybeans	Corn
Tillage system	Reduced-till	No-till	No-till	No-till	No-till, fall VT
Row width	30	30	30	30	30
Clean furrow (%)					
Mean	93.90%	92.73%	91.53%	96.03%	95.24%
Standard deviation	2.35%	2.24%	2.28%	2.42%	2.10%
Down force margin (PSI)					
Mean	51.6	3.57	3.35	2.48	7.49
Standard deviation	26.4	5.33	4.4	6.31	10.17
Furrow quality (%)					
Mean	87.70%	65.32%	69.68%	93.05%	88.47%
Standard deviation	9.30%	16.12%	15.51%	7.74%	9.77%
Ground contact (%)					
Mean	98.30%	66.74%	61.46%	60.09%	66.33%
Standard deviation	4.84%	21.88%	24.99%	19.50%	21.66%
Population (1000 seeds/acre)					
Mean	138.8	69.99	70.54	138.89	139.45
Standard deviation	4.10	6.08	5.69	3.98	4.35
Productivity (acres/hr.)					
Mean	2.75	2.54	2.55	2.63	2.95
Standard deviation	0.28	0.23	0.23	0.337	0.65
Singlation (%)					
Mean	99.00%	99.69%	99.66%	99.59%	98.99%
Standard deviation	1.30%	0.15%	0.14%	1.43%	0.57%
Skips (%)					
Mean	0.86%	0.18%	0.21%	0.25%	0.63%
Standard deviation	1.32%	0.92%	0.11%	1.40%	0.29%
Soil moisture (%)					
Mean	25.40%	25.70%	25.21%	35.33%	33.70%
Standard deviation	3.50%	3.95%	3.25%	4.56%	3.50%

Navigation performance

We are still processing our navigation performance data but preliminary data as well as field observations reveals some navigation performance degradation when the prototype is moving faster than about three mph. We are still looking into this issue and testing some theories. We will have better information by the end of the project.

Soil compaction data

We are still processing the soil compaction data that was collected in the field planted fields. We also plan to collect additional data during the growing season. The results of soil compaction learnings will be available at the end of the project.

Key learning so far

The following is a summary of some of our observations and key learnings so far from the field tests.

- The prototype planter did a very good job of planting (in terms of population, singulation, doubles, skips, depth, etc.) when field conditions were in good shape and there was minimum soil compaction
- In areas of the fields where soil compaction was high, keeping the gauge wheels on the ground and the double disk openers in the ground was a challenge due in part to the light weight of the prototype planter.
    - As a result, we had to add weight to the left and right back of the machine as well as to the left front
    - Adding additional weight helped but did not completely solve the problem on some of them most compacted soil
- Related to the above issue, we learned that weight balance (front to back and left to right) are important for our planter. When planting, a large portion of the weight of the machine is on the front tracks. As a result, when using high downforce, the back tracks loose some traction. However, on turns when the planter is raised, a large portion of the weight is on the back tracks which occasionally causes the front tracks to spin.
- We need to determine why we have navigation degradation at higher speeds (i.e., above 3 mph).
    - We have observed and data collection has shown that the machine does not converge to the AB line at higher speeds
    - We are looking into reasons including uneven left to right weight balance
- Energy use for planting with the prototype is somewhat higher than our original estimates.
    - To address this issue in the short-run, we installed a generator on the machine to keep the batteries charged. This may or may not be a permanent solution.
- We burned up the electric motor to our vacuum system twice. Our theory is that dust is getting into the motor bearings and causing trouble. We have a short-term work-around solution but need to address the ultimate cause of the problem.
- We generally feel very positive about the performance of the prototype planter. When we solve the weight balance, energy use, and navigation issues, we will have an impressive machine for autonomous planting.
- Our final report will go into more detail relative to project results and conclusions. In the meantime, we will be making videos and other information available through our Website and other channels. We will also be holding a Field Day for sometime in July.