

Practical Farm Research (PFR) - Study

August 5, 2019



ROGO



BECK'S

Overview

Goal: How much error exists simply based on how it's sampled?

- 1 Field x 14 Sample Sites
- Same Protocol Each Time
- Humans Sampled 3 times
- Rogo Sampled 3 times

Error: Swing In Nutrient Levels as % of Average



Takeaway #1: Robot eliminates nutrient errors!

14% Error



5% Error



~10% Error Reduction



Lab



Collection



Takeaway #2: Robot eliminates fertilizer bill swings

P, K, Lime Bill - Yearly Average (\$/Acre)

\$85

\$63



+/- \$22
(25%)

\$107



ROGO

\$76

+/- \$9
(10%)

\$94

Summary



ROGO

Nutrient
Error

14% +

5%

Fertilizer Bill
Swing

+/- \$22
(25%)

+/- \$9
(10%)

Accountability

Sampler in the
right field?

Location & depth
of every core

The Study Details

- The Test: Humans with hand probes and Rogo's SmartCore robot sampled the same field multiple times in the same day, and the variance error was compared.
- Important Note: Humans knew they were being measured and did their best. This is best case scenario for humans.
- Details:
 - Samples taken on Randomly Selected, Conv. Till Field, 35 acres
 - 2.5 ac grid, 14 sample points, 8x 6-in cores per sample, 9 Trials



Detailed Results

- Rogo decreased total soil testing error from 14% to 4.9%,
almost a 10% reduction in error
- Rogo reduced soil collection error from 12% to 2.5%,
equalling the lab analysis in precision
- Rogo decreased the Tri-state recommendation error (**fertility bill swing** based only on sampling error) on \$85/ac of P,K,Lime
 - **from +/- 25%, or +/- \$22**
 - **to +/- 10%, or +/- \$9**
- Rogo also eliminated absolute error on depth (humans didn't achieve desired protocol)
- Rogo's ROI for Annual Sampling
 - is **8X + for precision error reduction**
 - 7X for absolute error reduction
- Rogo's robot was **2x as fast** at getting the job done

All results statistically validated.

Soil Testing - Error Types

PRECISION (VARIABILITY)

The difference in soil sampling results if we sample the same field the same way.

ACCURACY (ABSOLUTE)

Did we actually sample the field right?
(Right depth, right location of each core)

Soil Testing Precision Error - Humans vs Robots

The Study:

- Robots vs Humans
- Humans tried their best
- they knew they were being evaluated
- Humans used iPad's & Handprobes
- Trials were tested at A&L Great Lakes
- Trials were timed

SOIL TESTING ERROR

Study by Beck's Hybrids PFR

TODAY

Total Error 14 %		
Human Collection 12 %		Lab 2.5 %
Depth Error 6.4 %	Location Error 5.3 %	Lab 2.5 %

THE FUTURE

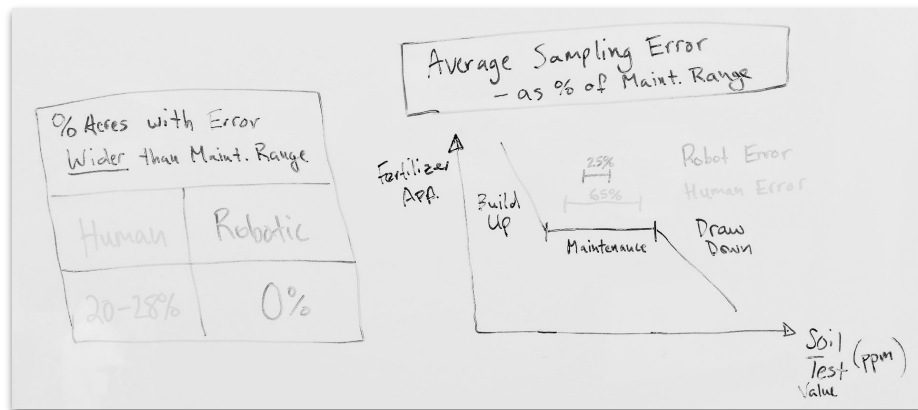
2x Faster	10 % Less Error	5x More Accurate
Robotic Soil Sampling by ROGO's SMARTCORE		

Total Error 5 %	
ROGO Robot 2.5 %	Lab 2.5 %

Notes: Conv. Till Field, 2.5 ac grid, 14 Samples, 8 6-in cores, 9 Trials
Error = Coefficient of Variation. Validated by 90% CI 2-tailed T-test.
Lab Error based on A&L Great Lakes estimate.

Precision Error vs. Size of Maintenance Band

How many of your acres move between build-up and draw-down simply based on how you sample? (Maint. Band Size)



Percentage of Acres With Variance Greater than Maint Range:		
	Human	Robotic
K	28.57%	0%
P	21.43%	0%

Error as Percentage of Maint Band		
	Human	Robotic
K	66%	41%
P	64%	13%
Average	65%	27%

Precision Error by Fertility Component

	Human + Lab Error	Robot + Lab Error	Improvement
K	11%	7%	160%
P	25%	4%	560%
pH	5%	1%	500%
Avg	13%	4%	330%

OM	14%	7%	210%
CEC	10%	5%	200%
Avg	12%	6%	200%

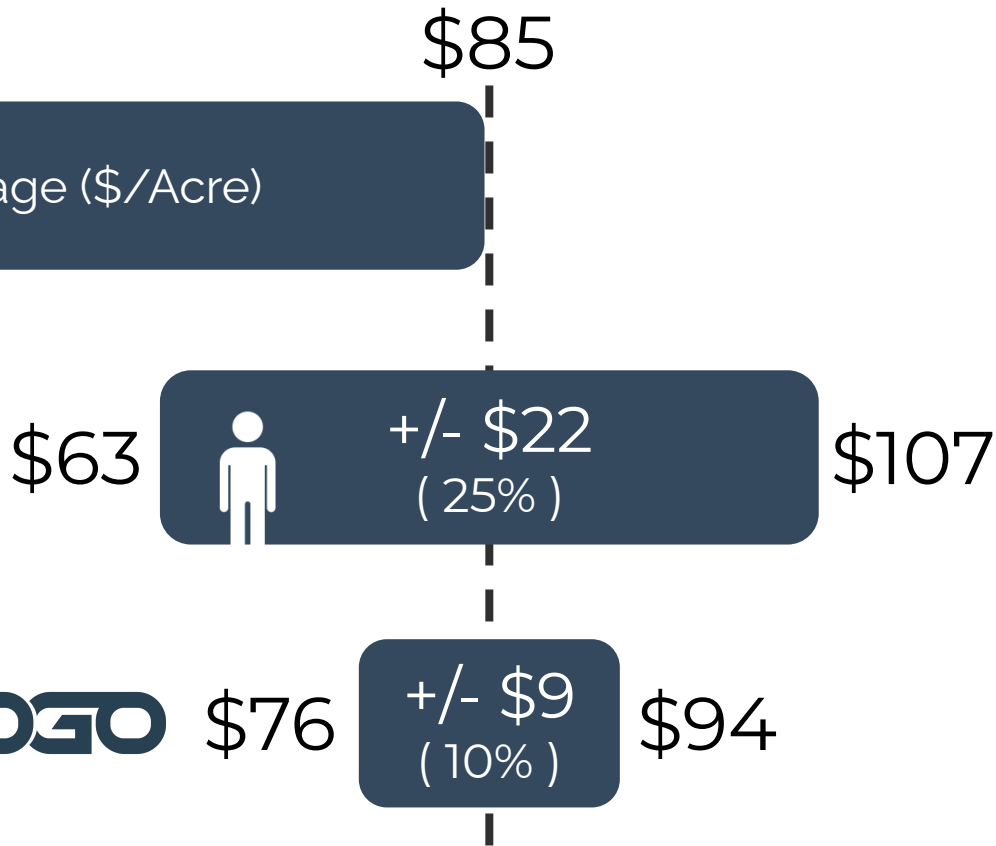
Mg	13%	2%	610%
Ca	14%	6%	230%
S	13%	5%	250%
Zn	10%	3%	340%
Mn	9%	2%	510%
Fe	15%	5%	270%
Cu	16%	2%	820%
B	30%	15%	190%
Avg Micros	15%	5%	290%

TOTAL AVG	14.2%	4.9%	280%
	Human + Lab Error	Robot + Lab Error	Improvement

Precision Economics Graphic - Fertility \$ Swing

P, K, Lime Bill - Yearly Average (\$/Acre)

How much your fertilizer bill swings simply based on how you sample it in a given year!



Precision Economics - Sample Every Year

Corn

Soybeans

Recs Variability Error	Human Sampling	Rogo Robotic Sampling	
<u>Recs Variation Error from Avg (%)</u>			<u>Total App. (lb/ac):</u>
P	22%	7%	77
K	20%	13%	91
Lime	42%	13%	2716
<u>Error Decrease (%)</u>			
P - %		15%	
K - %		7%	
Lime - %		30%	
<u>Variation Error (lbs / ac)</u>			<u>Avg Cost (\$/lb):</u>
P - lbs	17	6	\$0.515
K - lbs	19	12	\$0.321
Lime - lbs	1151	347	\$0.006
<u>Variation Error (\$ / ac)</u>			<u>Total App. (\$/ac)</u>
P - \$	\$9	\$3	\$40
K - \$	\$6	\$4	\$29
Lime - \$	\$7	\$2	\$16
Total Error - \$	\$22	\$9	\$85
Total Error - %	25%	10%	
<u>ROI Analysis Per Acre</u>			<u>Total App. (\$/ac)</u>
Total Error Decrease - \$		\$13	\$85
Total Error Decrease - %		15%	
Additional Rogo Price		\$1.50	
ROI		8.6	

Recs Variability Error	Human Sampling	Rogo Robotic Sampling	
<u>Recs Variation Error from Avg (%)</u>			<u>Total App. (lb/ac):</u>
P	23%	7%	56
K	19%	12%	119
Lime	42%	13%	2716
<u>Error Decrease (%)</u>			
P - %		16%	
K - %		7%	
Lime - %		30%	
<u>Variation Error (lbs / ac)</u>			<u>Avg Cost (\$/lb):</u>
P - lbs	18	6	\$0.515
K - lbs	17	11	\$0.321
Lime - lbs	1151	347	\$0.006
<u>Variation Error (\$ / ac)</u>			<u>Total App. (\$/ac)</u>
P - \$	\$9	\$3	\$29
K - \$	\$5	\$3	\$38
Lime - \$	\$7	\$2	\$16
Total Error - \$	\$22	\$8	\$83
Total Error - %	26%	10%	
<u>ROI Analysis Per Acre</u>			<u>Total App. (\$/ac)</u>
Total Error Decrease - \$		\$13	\$83
Total Error Decrease - %		16%	
Additional Rogo Price		\$1.50	
ROI		8.8	

Precision Economics

Corn/Bean Rotation Sample Every 2 Years

<u>ROI Analysis Per Acre</u>		<u>Total App. (\$/ac)</u>
Total Error Decrease - \$	\$26	\$168
Total Error Decrease - %	16%	
Additional Rogo Price	\$1.50	
ROI	17.4	

Note: ROI would double if sampling every 4 years

Absolute Error Economics - Background

Rogo showed more nutrients in the soil on average than humans. Since Rogo hits depths within $\frac{1}{8}$ inch 100% of time, the humans sampled just plain wrong, showing less nutrient concentration, and applying more.

Note: it just happened that humans sampled too deep. In a different instance, they could also sample too shallow, resulting in underapplication.

Takeaway: Absolute error matters as well as variability error. A human not only has variance in the process, they can also just do it plain wrong.

Absolute Accuracy Economics

Sample Annually

Corn

Recs - lbs/\$ Absolute Error	Human Sampling	Rogo Robotic Sampling
P - lbs/ac avg	77	74
K - lbs/ac avg	91	83
Lime - lbs/ac avg	2716	1637
P - \$/ac	\$39.73	\$38.17
K - \$/ac	\$29.12	\$26.78
Lime - \$/ac	\$16.30	\$9.82
P - Delta \$ per Ac		\$1.56
K - Delta \$ per Ac		\$2.34
Lime - Delta \$ per Ac		\$6.48
	<u>Per Acre:</u>	
Absolute Accuracy Savings		\$10.38
Max Additional Rogo Price		\$1.50
ROI		6.9

Soybeans

Recs - lbs/\$ Absolute Error	Human Sampling	Rogo Robotic Sampling
P - lbs/ac avg	56	54
K - lbs/ac avg	119	111
Lime - lbs/ac avg	2716	1637
P - \$/ac	\$28.64	\$27.93
K - \$/ac	\$38.11	\$35.48
Lime - \$/ac	\$16.30	\$9.82
P - Delta \$ per Ac		\$0.72
K - Delta \$ per Ac		\$2.63
Lime - Delta \$ per Ac		\$6.48
	<u>Per Acre:</u>	
Absolute Accuracy Savings		\$9.82
Max Additional Rogo Price		\$1.50
ROI		6.5

Absolute Accuracy Economics

Corn/Bean Rotation Sample Every 2 Years

<u>ROI Analysis Per Acre</u>		<u>Total App. (\$/ac)</u>
Total Error Decrease - \$	\$20.20	\$168
Total Error Decrease - %	12%	
Additional Rogo Price	\$1.50	
ROI	13.5	

Note: ROI would double if sampling every 4 years

Assumptions

- *Error = Coefficient of Variation = Standard Deviation Divided by Mean*
- *Recs Method: Tri-State Recs*
- *Lab Error is based on estimate by A&L Great Lakes.*
- *All error differences were validated with 90% CI 2-tailed T-Test. (90% of results also validated with 95% CI 2-tailed test).*

Rec Inputs

	Bushel Goal
Corn	200
Beans	60
pH Target	6.5

	\$/ ton
LIME	\$12
MAP	\$536
POTASH	\$385

About

Rogo Ag

Rogo offers robotic soil sampling services that give farmers more accurate soil data so they can make more profitable fertilizer decisions. It does this by collecting and packaging soil samples with complete depth-, pattern-, and location-consistency.

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Beck's PFR

Beck's Practical Farm Research provides farmers with the best farmer-focused research and advisors to add profitability to their farm. We do this by conducting unbiased agronomic research and delivering it to farmers.

beckshybrids.com/PFR/About-PFR



ROGO



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