FIELD TESTING OF "ON THE GO" CHANGES IN FERTILIZER APPLICATION RATES

Robert J. Bens and J. W. Hamm*

1.0 INTRODUCTION

The main objective of research and development carried out by Agro-Tech Systems Inc. is to determine the appropriate agronomic models and technical configuration necessary for remotely controlled rate variation system for crop inputs under Prairie conditions.

The initial focus has been on fertilizer management strategies under three main areas of concern. They are

1. Translocation of soils due to cultivation and erosion has altered the spatial characteristics within field units. Fertilizer strategy designed to compensate for this represents erosion mitigating technology which would counter the effect of soil degradation on individual farms.

2. New crop system technology requires uniform growth characteristics within fields. A system for continuous variation in fertilizer rates could help to discourage rank growth and lodging in nutrient rich areas and encourage more growth on eroded or upslope areas. This would represent new crop

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system technology consistent with long term soil management objectives and goals for development of new technology for Saskatchewan Agriculture.

3. The short term payoff from fertilizer is important for farm management decisions. What are the conditions under which a variable rate system can meet the first two objectives, and at the same time maintain or increase the immediate payoff from using fertilizer?

2.0 METHODOLOGY

The first objective for the project was to modify actual farm scale equipment by development and installation of an experimental variable rate mechanism remotely controlled by the operator from the tractor cab. Procurement and modification of available control equipment was completed by Novametric Engineering Inc. The system was installed on a John Deere 8440 4WD tractor and a John Deere 655 airseeder and underwent extensive lab and field testing.

The second objective was to identify and test a system of variable rates for variable soils which would be more profitable than a system of fixed rates for Variable Soils. Six case study sites were selected, 2 each in the Brown, Dark Brown and Thin Black Soil Zones. Air photos, erosional history, soil tests,topography and moisture conditions were used to develop a system of variable rates for each field.

Four summerfallow and two sites averaging 10 acres were selected in the Brown and Dark Brown Soil Zones and 2 sites totalling 70 acres in the Thin Black Soil Zone. Fertilizer was deepbanded prior to seeding in 1986 with variable rate and fixed rate applications on alternate passes. The direction of travel was strategically designed so as to allow paired-row sampling on field positions with one slope dimension.

For fixed rates, a standard rate and N/P ratio was applied at all slope positions. For variable rates, the mix and rate was changed continuously according to slope position. This was accomplished by two different operational strategies.

For summerfallow fields a mix of phosphate fertilizer (12-48-0) was carried in one tank of the airseeder. The second tank carried a mix of N:P. The rate from this second tank was controlled from the tractor according to the predetermined fertilizer map prepared for each field. For the Brown Soil sites, this mix was 2.2 N:1 P and for the Dark Brown the mix was 3.5 N:1 P.

For the stubble fields, a mix of 3 N:1 P was carried in both tanks.

Yield samples consisted of 1.5 square meters per treatment. Each sample was made up by taking six random drops at .25 square meters per sub sample.

3.0 RESULTS

The results of the field testing of the remote control and the variable speed actuator were extremely positive. Only minor modifications were required in the field to achieve satisfactory performance.

Yield responses were very good at all sites. There is no doubt that the response reflect the excellent growing conditions at all sites in 1986. The rate systems responsible for the yield increases are given in Table 1.

Table 1: Application Rates for Field Tests*

Case Study Sites	Fixed Rate NO :P O lb/ac	Variable Rate NO :P O lb/ac
Brown		
Downslope	5:20	5:20
Midslope	5:20	32:32
Upslope	5:20	50:41
Dark Brown		
Downslope	5:20	5:20
Midslope	5:20	37:29
Upslope	5:20	59:36
Thin Black		
Downslope	60:20	42:14
Midslope	60:20	60:20
Upslope	60:20	96:32

* Sites in each soil zone were on similar soils with similar moisture conditions and the same rate strategy was applied to both sites in each soil zone. Sites in the Brown and Dark Brown were summerfallow, and sites in the Thin Black were stubble.

Table 2: Results From Brown Soil Sites

Position	Treatment	Yield			Yield Increase Over Check	
		No. heads (%)	g/hd (g)	bu/ac (bu)	bu/ac (bu)	NO3 + P2O5 (lb/bu)
Site 1*						
Midslope	check	100	1.27	48	-	-
	FR	107	1.29	49	1	25.0
	VR	124	1.26	59	11	5.8
Upslope	check	100	1.29	41	-	-
	FR	155	.93	46	5	5.0
	VR	165	1.15	61	20	4.6
Site 2*						
Midslope	check	100	.71	39	-	-
	FR	114	.72	45	6	4.2
	VR	124	.79	54	15	4.3
Upslope	check	100	.71	41	-	-
	FR	126	.79	57	16	1.6
	VR	155	.77	69	28	3.3

* Site 1: NW-11-29-17-W3; Hr:1; summerfallow durum; 5 acres
Site 2: NW-21-29-16-W3; Hr:1-Ec:1; summerfallow wheat; 10 acres

Table 3: Results From D. Brown Sites

Position	Treatment	Yield			Yield Increase Over Check	
		No. heads (%)	g/hd (g)	bu/ac (bu)	bu/ac (bu)	$NO_3 + P_2O_5$ (lb/bu)
Site 1*						
Midslope	check	100	.80	39	-	-
	FR	112	.95	51	12	2.1
	VR	127	1.10	67	28	2.4
Upslope	check	100	.61	25	-	-
	FR	133	.74	40	15	1.7
	VR	176	.71	50	26	3.7
Site 2*						
Midslope	check	100	.95	28	-	-
	FR	131	.92	36	8	3.1
	VR	140	.97	41	12	5.5
Upslope	check	100	.96	29	-	-
	FR	115	1.00	34	6	4.2
	VR	162	1.04	47	18	5.3

* Site 1: NW-12-34-15-W3, Ec-Ec:l. summerfallow wheat, 5 acres
Site 2: SW-14-34-14-W3, Ec:l., summerfallow wheat, 20 acres

Table 4: Results From Thin Black Sites

Position	Treatment	Yield: No. heads (%)	Yield: g/hd (g)	Yield: bu/ac (bu)	Yield Increase Over Check: bu/ac (bu)	Yield Increase Over Check: NO3 + P2O5 (lb/bu)
Site 1*						
Downslope	check	100	.47	32	-	-
	FR	115	.55	42	10	8.0
	VR	153	.54	56	24	2.3
Upslope	check	100	.36	15	-	-
	FR	166	.45	31	16	5.0
	VR	169	.47	34	19	6.7
Site 2*						
Downslope	check	100	1.09	60	-	-
	FR	125	1.19	82	22	3.6
	VR	110	1.38	83	23	2.4
Upslope	check	100	1.10	44	-	-
	FR	163	.95	61	23	3.5
	VR	182	1.33	96	52	2.2

* Site 1: NE-16-39-14-W3; W:1-0:1 stubble wheat, 40 ac
Site 2: SE-16-39-14-W3; W:1-0:1 stubble barley, 30 ac

Table 5: Economic Comparisons Brown Soil Sites

Rates	Position	Returns bu x $4 x ac	Fert. Cost lb x $.26 x ac	Net
Site 1*				
FR	Midslope	1 x 4 x 50 = $ 200	25 x .26 x 50 = $ 325	$ (125)
	Upslope	5 x 4 x 50 = 1,000	25 x .26 x 50 = 325	675
		$1,200	$ 650	$ 550
VR	Midslope	11 x 4 x 50 = 2,200	64 x .26 x 50 = 832	1,368
	Upslope	20 x 4 x 50 = 4,000	91 x .26 x 50 = 1,183	2,817
		$6,200	$2,015	$4,185
Site 2*				
FR	Midslope	6 x 4 x 50 = $1,200	25 x .26 x 50 = $ 325	$ 875
	Upslope	16 x 4 x 50 = 3,200	25 x .26 x 50 = 325	2,875
		$4,400	$ 650	$3,750
VR	Midslope	15 x 4 x 50 = 3,000	64 x .26 x 50 = 832	2,168
	Upslope	28 x 4 x 50 = 5,600	91 x .26 x 50 = 1,183	4,417
		$8,600	$2,015	$6,585

* Results extrapolated to 150 ac field for analysis with 100 acres subject to comparison between FR and VR

* Both sites moderately rolling; 33% upslope, 33% midslope, 33% downslope

Table 6: Economic Comparisons Dark Brown Soil Sites

Rates	Position	Returns bu x $4 x ac	Fert. Cost lb x $.26 x ac	Net
Site 1*				
FR	Midslope	12 x 4 x 60 = $2,880	25 x .26 x 60 = $ 390	$2,490
	Upslope	15 x 4 x 45 = 2,700	25 x .26 x 45 - 293	2,407
		$5,580	$ 683	$4,897
VR	Midslope	28 x 4 x 60 =$ 6,720	66 x .26 x 60 = $1,030	$5,690
	Upslope	26 x 4 x 45 = 4,680	95 x .26 x 45 = 1,112	3,568
		$11,400	$2,142	$9,258
Site 2*				
FR	Midslope	8 x 4 x 60 = $1,920	25 x .26 x 60 = $ 390	$1,530
	Upslope	6 x 4 x 45 = 1,080	25 x .26 x 60 = 293	787
		$3,000	$ 683	$2,317
VR	Midslope	12 x 4 x 60 = $2,880	66 x .26 x 60 = $1,030	$1,850
	Upslope	18 x 4 x 45 = 3,240	95 x .26 x 45 = 1,112	2,128
		$6,120	$2,142	$3,978

* Results extrapolated to 150 ac field for analysis, with 105 acres subject to comparison between FR and VR
* Both sites strongly rolling; 30% upslope, 40% midslope, 30% downslope

Table 7: Economic Comparisons Thin Black Soil Sites

Rates	Position	Returns bu x $4 x ac	Fert. Cost lb x $.26 x ac	Net
Site 1*				
FR	Downslope	10 x 4 x 45 = $1,800	80 x .26 x 45 = $ 936	$ 864
	Upslope	16 x 4 x 45 = 2,880	80 x .26 x 45 = 1,944	1,944
		$4,680	$1,872	$2,808
VR	Downslope	24 x 4 x 45 = $4,320	56 x .26 x 45 = $ 655	$3,665
	Upslope	19 x 4 x 45 = 3,420	128 x .26 x 45 = 1,498	1,922
		$7,740	$2,153	$5,587
Site 2*		bu x $2 x ac		
FR	Downslope	22 x 2 x 38 = $1,672	80 x .26 x 38 = $ 794	$ 878
	Upslope	23 x 2 x 37 = 1,702	80 x .26 x 38 = 794	908
		$3,374	$1,588	$1,786
VR	Downslope	23 x 2 x 38 = $1,748	56 x .26 x 38 = $ 553	$1,195
	Upslope	52 x 2 x 37 = 3,848	128 x .26 x 38 = 1,265	2,583
		$5,596	$1,818	$3,778

* Site 1: stubble wheat Site 2: stubble barley
* Results extrapolated to 150 ac field for analysis
* Site 1 strongly rolling, 30% upslope, 40% midslope, 30% downslope. Comparisons apply to 90 ac out of 150
Site 2 moderately rolling 25% upslope, 50% midslope, 25% downslope. Comparisons apply to 75 ac out of 150

Table 8: Summary of Net Returns Comparison

Summerfallow Groups		Net Return/ Quarter ($/150 ac. crop)	Net Return to Fert. $* (%)
1)	FR	550	85
	VR	4,185	208
2)	FR	3,750	576
	VR	6,585	326
3)	FR	4,897	717
	VR	9,258	432
4)	FR	2,317	339
	VR	3,978	186
Stubble Crops			
5)	FR	2,808	150
	VR	5,587	260
6)	FR	1,786	112
	VR	3,778	207

* Differences in net return per $ fertilizer do not indicate differencies in "efficiency" between one system and another for individual sites. In order to make "efficiency" comparisons, observations of input/output relationships are required over a range of input levels wide enough to generate the appropriate production surfaces for individual fields.

Table 9: Summary of Effect Density and Height

Summerfallow Crops		Density % of check*	Height % of check*	D X H % of check
1)	FR	129	100	129
	VR	142	120	170
2)	FR	120	110	132
	VR	140	125	175
3)	FR	121	110	133
	VR	149	120	179
4)	FR	123	100	123
	VR	151	115	174
Stubble Crops				
5)	FR	134	100	134
	VR	155	100	155
6)	FR	141	120	168
		141	140	197

* Density determined by actual count of heads in the harvested samples. Comparisons on height of crop are based on estimates of the average height of plants in the harvested samples.

NOTE: Crops 1) through 5) are wheat, crop 6) is barley.

Table 10: Summary of Return to Investment & Density x Height

Summerfallow Crops**	Return to Invest VR/FR	Density x Height* VR/FR
1)	2.4	1.3
2)	.6	1.3
3)	.6	1.3
4)	.6	1.4
Stubble Crops***		
5)	1.7	1.2
6)	1.8	1.2

* The density x height comparisons are based on density (as % of check) x height (as % of check)

** midslope plus upslopes

*** downslopes plus upslopes

4.0 CONCLUSIONS

1. A system of "on the go" adjustments in fertilizer rates was successfully tested. The mechanical system developed is a satisfactory prototype for further development.
2. A variable rate system was successfully tested. The performance of the system was positive for important objectives.
   - encouraged growth and yield to be more even across the fields
   - encouraged greater production of straw and grain on upslope positions
   - increased the short term payoff from fertilizer
3. A manually controlled variable rate system can represent "erosion mitigating technology" for farms with variable soils.
4. Additional tests over several years are required to confirm the agronomic potential of variable rate strategies for individual fields. The results of this study indicate that this potential is likely to be very field specific and general recommendations will be difficult if not impossible.
5. Research is required to develop suitable fertilizer rate mapping techniques for individual fields. The mapping problem involves estimating the combined impact of variables like soil test data, soil moisture and slope position on rate requirements. The objective should be to produce maps suitable for applying price information, so that farms have a rational base for rate variation decisions.