GLACIER farmmedia

DISCOVERY FARM

2021 FIELD REPORT

Contents

Executive Summary

Discovery Farm stands as a hub for applied research, demonstration projects and knowledge transfer initiatives – all with the vision of discovering practical solutions for Canadian farmers. Discovery Farm Langham is a 610-acre site and home of Ag in Motion, Western Canada's premier outdoor farm expo, which brings together over 450 exhibitors and 30,000 guests in attendance to learn and network.

Discovery Farm is becoming the agriculture destination for the Canadian farming community – all year round. During the 2021 growing season at Discovery Farm Langham, over 20 research and demonstration projects took place on-site and in the field. The key findings from farmer-led research are projected to unveil solutions to challenges unique to Saskatchewan's agricultural landscape. A number of partners have joined on the quest to discover how their product or equipment will make a difference through in-field trials and demonstrations of innovation. This report outlines the successes and challenges that were faced with Discovery Farm's internal research as well as partner initiatives.

Introduction

This report provides an opportunity to highlight and explore the applied research and demonstration projects conducted at Discovery Farm Langham in 2021. Without a doubt, the 2021 growing season had an impact on crop harvest, with lack of moisture severely limiting crop yield. However, while it may be tempting to write off the season as lost due to extreme drought conditions, important observations can be drawn from data collected under extreme conditions. Primarily, the most prominent outcome in 2021 was the variability in soil moisture status across the landscape as influenced by topography and soil characteristics, and the resultant impact on crop productivity. Through the extreme growing conditions we experienced this year, we were able to understand how agronomic practices may be used every year to manage marginally productive soils impacted by limitations such as salinity or soil prone to low moisture. While all projects conducted on-site this year are listed in the report, an in-depth analysis and interpretation of data collected from certain projects is presented in this report.

Growing Season Conditions

Simply put, 2021 was a challenging growing season over much of the Canadian Prairies, with comparisons made to the historic drought of 1936. These challenges were evident in the conditions at Discovery Farm Langham, as shown in Table 1 below. The severity of the drought at the Langham site relative to other areas across the Canadian Prairies can also be seen (Figure 1). A comparison of 2021 to 2020 growing seasons reveals 2021 precipitation totals to be 44% of what was received on-site in 2020. Spring 2021 soil moisture levels were sub-optimal from low precipitation over the fall and winter, leading to risk of poor germination and crop emergence. Fortunately, a significant precipitation event of 42 mm occurred on May 24, 2021, which aided in crop establishment. Low rainfall combined with high daily max temperatures in June and July severely limited crop yield potential. Late season rains received in August did not contribute to the yield of annual grain crops on-site, but did support re-growth of forages on-site following July cutting events.

Month	2020 Precipitation (mm)	2020 Days Max Temp >30C	2021 Precipitation (mm)	2021 Days Max Temp >30C
May	75	0	42	1
June	132	1	28	9
July	49	6	11	17
August	30	8	45	7
Total	**286**	**15**	**126**	**34**

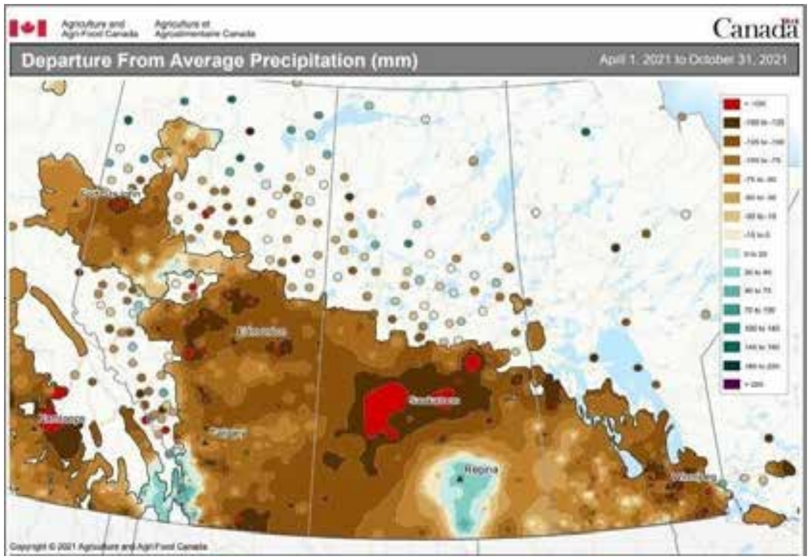


FIGURE 1. Departure from average precipitation (mm) across the Canadian Prairies. Graphic courtesy of Agriculture and Agri-Food Canada.

Field of Excellence

SITE OVERVIEW

The Field of Excellence site is located at E ½ 15-39-8 W3M on the Discovery Farm Langham property. For the 2021 season, the project was conducted across approximately 180-acre split between flax and wheat as shown in Figure 2 at right. Soils at the site are predominantly classified as Elstow Dark Brown soils having a loam texture and gently undulating topography with slopes ranging from 0.5% to 2%. Lower-slope soils on portions of the site consist of Bradwell saline soils, with loamy lacustrine materials found above a layer of gravelly fluvial material (Acton and Ellis, 1978). The entire site has been mapped by SWAT Maps to measure underlying soil properties, both physical and chemical, and topography has been modelled. Collectively, these parameters form the basis of the delineation of 10 soil management zones identified by the colours in Figure 2 at right, and to which unique rates of crop inputs may be applied in a variable-rate program.

FIGURE 2. Map of Discovery Farm Langham with Field of Excellence project site outlined in red boundary (left) and field layout overlain on SWAT Map (right).

PAN-CANADIAN SMART FARM NETWORK

Summer of 2021 served as the first field season of the Pan-Canadian Smart Farm Network (PCSFN), an ecosystem of Smart Farms including Olds College and Lakeland College in addition to Discovery Farm Langham. This network was established in large part due to the support of the Canadian Agri-Food Automation and Intelligence Network (CAAIN) with an overarching goal to "build a collaborative framework among Canada's Smart Farm initiatives for sharing of data and expertise to help farmers, industry and technology developers better understand, utilize, and develop smart agriculture technologies and systems". Through a partnership with METOS Canada, a common suite of data collection hardware and sensors was installed at each of the three Smart Farms. The focus of these sensors is largely to understand variation in soil moisture across the study site through the use of soil moisture and temperature probes as well as above-ground precipitation gauges. Additional hardware in the suite includes cameras to track crop growth stage development along with insect traps equipped with cameras which are able to identify certain species. Data from all three sites is shared and publicly accessible through the on-line FieldClimate platform. Screenshots of the platform showing the location of the three Smart Farm sites and the instrument cluster installed at Discovery Farm Langham are shown in Figure 3 on next page.

In addition to network establishment and sensor installation, the PCSFN has a mandate to develop, test and validate technologies and practices as well as subsequently disseminate project findings for the purpose of assisting growers in overcoming challenges facing the industry. At Discovery Farm Langham, projects which support this objective include the Water Management Project and Field of Excellence. The Field of Excellence is a field-scale demonstration project conducted annually at Discovery Farm Langham with an overarching goal of demonstrating and validating agricultural

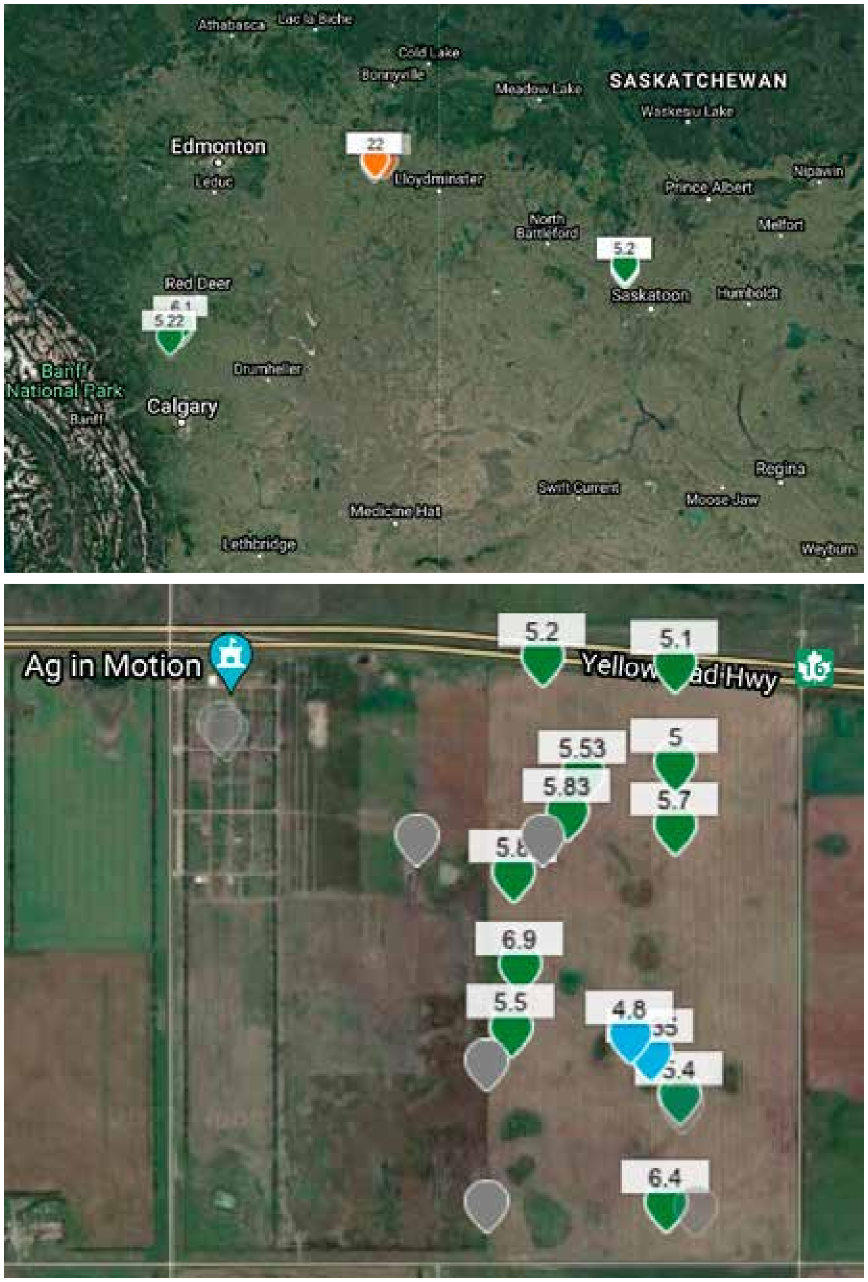


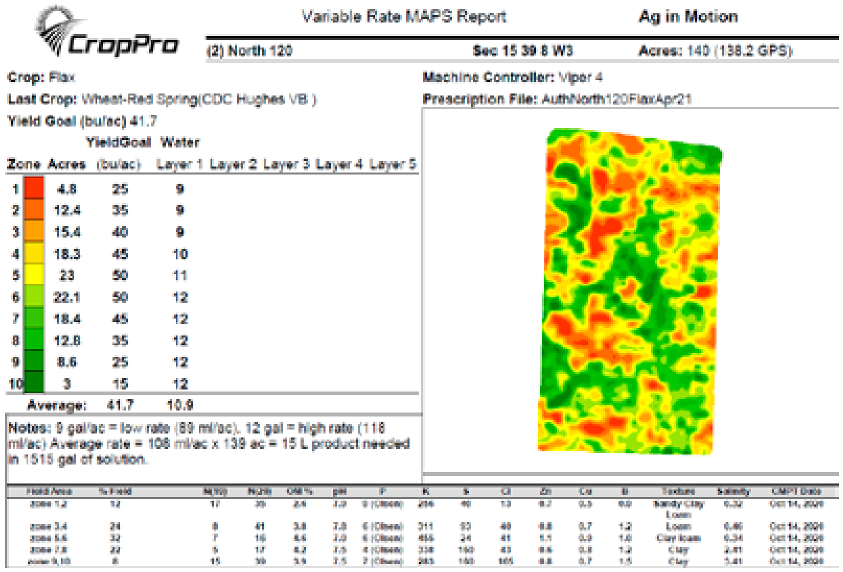
FIGURE 3. Screenshots of FieldClimate data-sharing platform showing all three Smart Farms (top) and sensor cluster installed at Discovery Farm Langham (above).

technologies and practices which seek to address prevailing challenges facing the industry. Industry partners representing the diversity of the agricultural supply chain including crop inputs, agtech, equipment, and product handling and storage companies bring their collective expertise to address these challenges. Focus areas for the 2021 project include managing moisture variability across the landscape and employing Integrated Pest Management (IPM) techniques to address challenging weed species.

Field Operations

WEED CONTROL

Weed control was achieved through a combination of pre- and post-emergent herbicide applications. For the portions of the site seeded to flax, a variable-rate prescription was developed to apply a unique rate of Authority 480 (Sulfentrazone) to each of the 10 soil management zones, as shown in Figure 4 below. Similarly, Authority 480 was applied in an "on/off" variable-rate prescription in the wheat field, where the product was applied at a constant rate to approximately 46% of the field and not applied to approximately 54% of the field where application was not deemed to be economically justified due to minimal weed pressure. Additionally, glyphosate was applied at label rates to the entire field in a separate pre-emergent application. All pre-emergent herbicide application on the Field of Excellence was conducted on May 30, 2021. In-crop herbicide application consisted of bromoxynil, MCPA, and clethoim along with a foliar fertilizer Awaken applied at label rates on June 24, 2021. For the wheat, pinoxaden and MCPA was applied on June 18, 2021 at label rates.


CropPro — Variable Rate MAPS Report — Ag in Motion

(2) North 120 — Sec 15 39 8 W3 — Acres: 140 (138.2 GPS)

Crop: Flax
Last Crop: Wheat-Red Spring(CDC Hughes VB)
Yield Goal (bu/ac) 41.7

Machine Controller: Viper 4
Prescription File: AuthNorth120FlaxApr21

Zone	Acres	YieldGoal (bu/ac)	Water Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
1	4.8	25	9				
2	12.4	35	9				
3	15.4	40	9				
4	18.3	45	10				
5	23	50	11				
6	22.1	50	12				
7	18.4	45	12				
8	12.8	35	12				
9	8.6	25	12				
10	3	15	12				
Average:		41.7	10.9				

Notes: 9 gal/ac = low rate (89 ml/ac). 12 gal = high rate (118 ml/ac) Average rate = 108 ml/ac x 139 ac = 15 L product needed in 1515 gal of solution.

Field Area	% Field	N(0)	N(20)	OM %	pH	P	K	S	Cl	Zn	Cu	B	Texture	Salinity	CMPT Date
zone 1,2	12	17	35	2.6	7.0	9 (Olsen)	256	40	13	0.7	0.5	0.0	Sandy Clay Loam	0.32	Oct 14, 2020
zone 3,4	24	8	41	3.8	7.8	6 (Olsen)	311	53	40	0.8	0.7	1.2	Loam	0.46	Oct 14, 2020
zone 5,6	32	7	16	4.6	7.0	6 (Olsen)	455	24	41	1.1	0.9	1.0	Clay loam	0.34	Oct 14, 2020
zone 7,8	22	5	17	4.2	7.5	4 (Olsen)	338	160	43	0.6	0.8	1.2	Clay	2.41	Oct 14, 2020
zone 9,10	8	15	30	3.9	7.5	7 (Olsen)	283	160	105	0.8	0.7	1.5	Clay	3.41	Oct 14, 2020

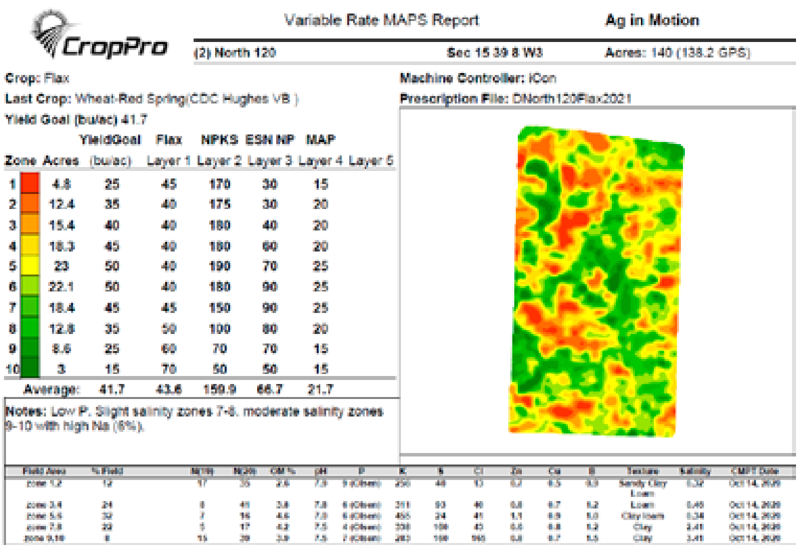
FIGURE 4. Variable-rate prescription for pre-emergent Authority 480 application by SWAT zone in flax field.

SEEDING

Seeding operations were completed with an 80 ft wide Vaderstad toolbar with a Vaderstad 980 air cart. The toolbar has independently-controlled openers on 12 inch spacing, with seed and fertilizer delivered in a double-shoot and side-band configuration.

Flax (var. Westlin 72) was seeded on May 30, 2021 and Hard Red Spring Wheat (var. CDC Ortona) was seeded on June 1, 2021. Seed and fertilizer were applied according to variable-rate prescriptions developed for each field as shown in Figures 5 and 6 below.

For each seed and fertilizer layer applied, rates are shown in lbs per acre.



CropPro — Variable Rate MAPS Report — Ag in Motion

(2) North 120 — Sec 15 39 8 W3 — Acres: 140 (138.2 GPS)

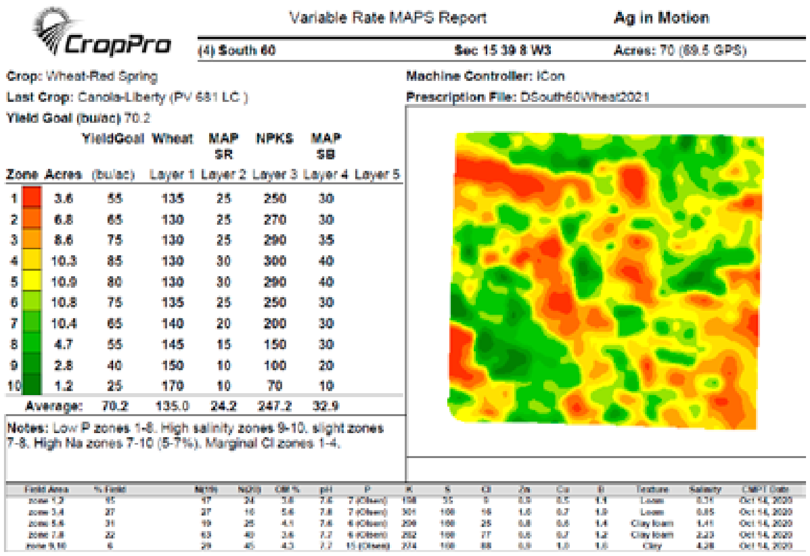
Crop: Flax
Last Crop: Wheat-Red Spring(CDC Hughes VB)
Yield Goal (bu/ac) 41.7

Machine Controller: iCon
Prescription File: DNorth120Flax2021

Zone	Acres	YieldGoal (bu/ac)	Flax Layer 1	NPKS Layer 2	ESN NP Layer 3	MAP Layer 4	Layer 5
1	4.8	25	45	170	30	15	
2	12.4	35	40	175	30	20	
3	15.4	40	40	180	40	20	
4	18.3	45	40	180	60	20	
5	23	50	40	190	70	25	
6	22.1	50	40	180	90	25	
7	18.4	45	45	150	90	25	
8	12.8	35	50	100	80	20	
9	8.6	25	60	70	70	15	
10	3	15	70	50	50	15	
Average:		41.7	43.6	159.9	66.7	21.7	

Notes: Low P. Slight salinity zones 7-8. moderate salinity zones 9-10 with high Na (6%).

FIGURE 5. Variable-rate prescription showing rates of seed and fertilizer applied to each SWAT zone in flax field.



CropPro — Variable Rate MAPS Report — Ag in Motion

(4) South 60 — Sec 15 39 8 W3 — Acres: 70 (69.5 GPS)

Crop: Wheat-Red Spring
Last Crop: Canola-Liberty (PV 681 LC)
Yield Goal (bu/ac) 70.2

Machine Controller: iCon
Prescription File: DSouth60Wheat2021

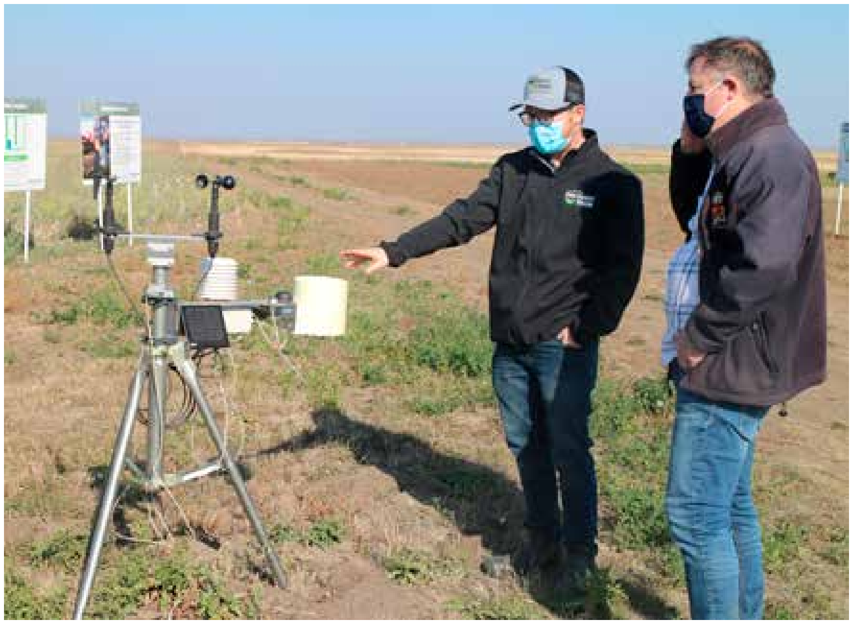
Zone	Acres	YieldGoal (bu/ac)	Wheat Layer 1	MAP SR Layer 2	NPKS Layer 3	MAP SB Layer 4	Layer 5
1	3.6	55	135	25	250	30	
2	6.8	65	130	25	270	30	
3	8.6	75	130	25	290	35	
4	10.3	85	130	30	300	40	
5	10.9	80	130	30	290	40	
6	10.8	75	135	25	250	30	
7	10.4	65	140	20	200	30	
8	4.7	55	145	15	150	30	
9	2.8	40	150	10	100	20	
10	1.2	25	170	10	70	10	
Average:		70.2	135.0	24.2	247.2	32.9	

Notes: Low P zones 1-8. High salinity zones 9-10. slight zones 7-8. High Na zones 7-10 (5-7%). Marginal Cl zones 1-4.

FIGURE 6. Variable-rate prescription showing rates of seed and fertilizer applied to each SWAT zone in wheat field.

METOS HARDWARE INSTALLATION

In partnership with METOS Canada, a suite of data collection hardware and sensors were installed at the project site. Specifically, 16 ECO D3 devices consisting of an above-ground precipitation gauge coupled with a 120 cm soil moisture probe installed below ground were installed throughout the study site. Additional instruments installed include two iScout insect traps, which are equipped with a camera and software to identify certain insect species and two CropView cameras, which track crop growth stage through automatically taking pictures at a pre-defined interval. The hardware was installed following seeding from the period of June 1 to 11, 2021. Working in consultation with Croptimistic Technology Inc., ECO D3 devices were strategically installed in zones 1, 5, and 8 for the purpose of measuring the soil moisture spectrum throughout the project site. In each zone, soil samples were collected at four depth increments and soil textural analysis was conducted for interpretation of soil volumetric moisture content.



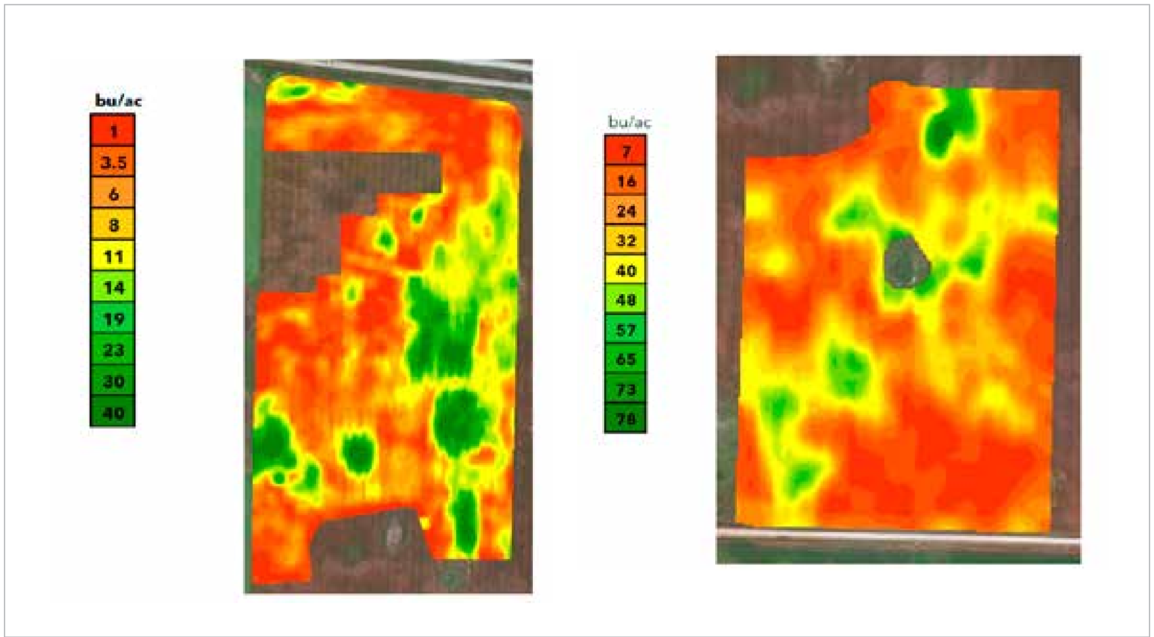


FIGURE 7. Yield map for the flax (left) and wheat (right) fields.

CROP HARVEST

Crop harvest was conducted in partnership with CLAAS of America and Canada West Harvest Centre using a CLAAS 780 TT combine. The wheat field was harvested on September 14, 2021 and the flax field was harvested on September 30, 2021. Yield data was collected on a Trimble TMX-2050 monitor and calibrated using a crop weight recorded by a grain cart scale from a known harvested area. Crop moisture was determined on sub-samples using a Shore Model 920 Moisture Tester from Shore Measuring Systems. Yield and maps for each crop are shown below (Figure 7) as well as average values for each SWAT zone.

ECONOMIC ANALYSIS AND DISCUSSION

Crop yield by management zone and a resulting economic analysis is presented for flax and wheat in Tables 2 and 3 respectively below. Data is presented for each zone along with a weighted average for each variable. Crop input costs considered seed, fertilizer, and pesticides, while operations costs consisted of expenses for field operations based on published rates for custom field work (Government of Saskatchewan, 2020). For both crops, yields reflect the poor growing season conditions, with lack of moisture severely limiting yield. An examination of surface soil characteristics analyzed from post-harvest soil samples reveals high residual nitrate and sulfate, providing evidence that the growing crop was not able to access available nutrients due to lack of moisture. Low residual phosphate across all zones suggests that P fertility will be an important consideration for the 2022 growing season.

While crop yields were well below historical averages, significant variation in yield was observed across the soil management zones for both crops, with the highest yields found in low-lying areas. In flax, zone 8 (13.7 bu/ac) yielded nearly four times that of zone 1 (3.5 bu/ac). For the wheat field, average yield of zone 7 was nearly 250% of the zone 1 average (12.8 vs 5.2 bu/ac). This yield variation is not surprising given the stark contrast in Plant Available Water (PAW) measured across the landscape, as seen in Figure 8 below. While physical re-distribution of water across the landscape was likely to play a role in this variation, perhaps the more important role given the lack of run-off over the growing season was the improved water holding capacity of low-lying areas compared to the up-slope areas as primarily influenced by soil texture and organic matter (Table 4). The slight yield reduction in zones 9 and 10 relative to the highest yielding areas was likely due to the yield-limiting impacts of salinity, even though PAW was greatest in these zones.

TABLE 2. Flax yield and economic analysis by SWAT zone.

SWAT Zone	Acres	Yield (bu/ac)	Crop Price ($/bu)	Gross Revenue ($/ac)	Crop Input Cost ($/ac)	Operations Cost ($/ac)	Cost of Production ($/ac)	Profit ($/ac)
1	3.6	3.5	$35.49	$124.22	$144.78	$59.13	$203.91	-$79.69
2	9.1	4.1	$35.49	$145.51	$144.43	$59.13	$203.56	-$58.05
3	11.6	5.1	$35.49	$181.00	$150.13	$59.13	$209.26	-$28.26
4	14.5	6.4	$35.49	$227.14	$159.95	$59.13	$219.08	$8.06
5	18.7	8.2	$35.49	$291.02	$170.60	$59.13	$229.73	$61.29
6	18.5	10.6	$35.49	$376.19	$177.40	$59.13	$236.53	$139.66
7	16.0	11.7	$35.49	$415.23	$171.30	$59.13	$230.43	$184.80
8	10.8	13.7	$35.49	$486.21	$153.15	$59.13	$212.28	$273.93
9	7.0	11.7	$35.49	$415.23	$144.90	$59.13	$204.03	$211.20
10	2.3	11.0	$35.49	$390.39	$137.30	$59.13	$196.43	$193.66
Total	**112.1**	**8.9**	**$35.49**	**$314.38**	**$162.16**	**$59.13**	**$221.43**	**$64.85**

TABLE 3. Wheat yield and economic analysis by SWAT zone.

SWAT Zone	Acres	Yield (bu/ac)	Crop Price ($/bu)	Gross Revenue ($/ac)	Crop Input Cost ($/ac)	Operations Cost ($/ac)	Cost of Production ($/ac)	Profit ($/ac)
1	0.83	5.2	$11.15	$57.98	$155.52	$59.13	$214.65	-$156.67
2	3.76	6.3	$11.15	$70.25	$160.92	$59.13	$220.05	-$149.80
3	5.87	7.9	$11.15	$88.09	$168.87	$59.13	$228.00	-$139.91
4	7.21	10.1	$11.15	$112.62	$175.17	$59.13	$234.30	-$121.68
5	7.24	10.3	$11.15	$114.85	$187.99	$59.13	$247.12	-$132.27
6	6.18	11.9	$11.15	$132.69	$171.54	$59.13	$230.67	-$97.98
7	4.34	12.8	$11.15	$142.72	$154.99	$59.13	$214.12	-$71.40
8	1.95	9.4	$11.15	$104.81	$138.44	$59.13	$197.57	-$92.76
9	0.87	11.7	$11.15	$130.46	$118.79	$59.13	$177.92	-$47.46
10	0.27	8.8	$11.15	$98.12	$110.09	$59.13	$169.22	-$71.10
Total	**38.5**	**9.9**	**$11.15**	**$110.73**	**$168.65**	**$59.13**	**$227.90**	**-$117.18**

TABLE 4. Selected surface (0-15 cm) soil properties reported by grouped SWAT zones.

Soil Parameter	SWAT Zone				
	1-2	3-4	5-6	7-8	9-10
	Flax Stubble				
NO3- (lbs/ac)	113	93	60	120	53
OM (%)	2.6	3.8	4.6	4.2	3.9
pH	7.9	7.8	7.0	7.5	7.5
PO4- (ppm)	9	6	6	4	7
SO4- (lbs/ac)	160	29	160	64	160
E.C. (dS/m)	0.32	0.46	0.34	2.41	3.41
Texture	Sandy Clay Loam	Loam	Clay Loam	Clay	Clay
	Wheat Stubble				
NO3- (lbs/ac)	95	121	56	145	99
OM (%)	3.0	5.6	4.1	3.6	4.3
pH	7.6	7.8	7.6	7.7	7.7
PO4- (ppm)	7	7	6	6	15
SO4- (lbs/ac)	160	160	160	160	160
E.C. (dS/m)	0.31	0.85	1.41	2.23	4.28
Texture	Loam	Loam	Clay Loam	Clay Loam	Clay

Poor crop yields also had a significant impact on the economic analysis. Aside from the portions of the flax field where moisture was severely limiting, net profitability was observed. In terms of profitability across all zones, the impact of poor yields was overcome in part by high commodity prices ($35.49/bu). A net loss was observed in the upper zones due to low gross revenue from poor yields. Profitability was highest in zone 8 due to the impact of highest gross revenue combined with low crop input costs relative to mid zones. Low crop input costs came as a result of a reduction in fertilizer application rate to account for residual soil nutrients. Profitability was reduced in the highest zones from a reduction in gross revenue due to the yield-limiting impacts of salinity.

For wheat, a net economic loss was observed across all sites largely due to the poor crop yields. Further, while the weighted average cost of production for wheat was similar to that of flax ($227.90 vs $221.43 per acre) the sale price of wheat did not have the same ability to overcome the poor yield as flax did. However, the profitability trend in wheat was similar to that of flax - the lowest net loss was observed in the upper zones, where crop yields were highest combined with relatively low crop input costs from a reduction in fertilizer application rates relative to mid-zones.

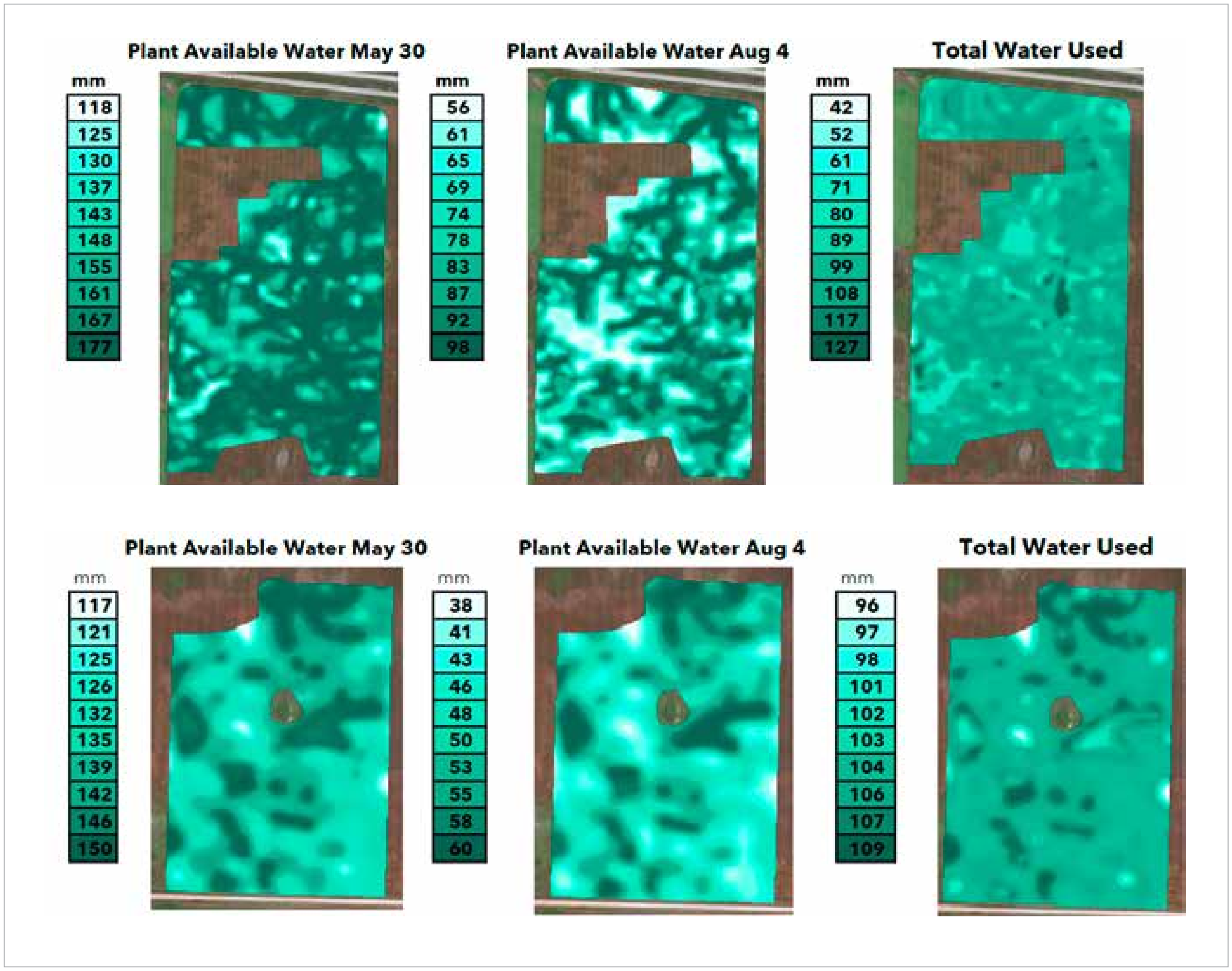


FIGURE 8. Plant available water and total water use for the flax (top) and wheat (bottom) fields.

CAAIN
Canadian Agri-Food Automation and Intelligence Network

This project is funded by Canadian Agri-Food Automation and Intelligence Network in partnership with:

Water Management Project

Much of the landscape of the Canadian Prairies and a significant portion of the north-central United States comprises the largest wetland landscape in North America, an area termed the Prairie Pothole Region (PPR). In total, the PPR encompasses roughly 780,000 km2 and contains between 5 and 60 wetlands per km2 (Biswas et al., 2012). These wetlands often create challenges for farmers, due to logistical (e.g. lost time due to operational inefficiencies) or economic (e.g. poor productivity of wetland soils due to periodic flooding) reasons. As such, certain farmers have justifiably long had a keen interest in managing agricultural waters on their fields, using both surface and subsurface drainage techniques. While this strategy may address the above challenges within a given field, potential adverse impacts include increasing both the volume and nutrient load of the run-off water to the terminal collection point downstream from the point of drainage. When a wetland is drained, the drained basin may continually release accumulated nutrients in the soil to the water that is leaving the drained basin.

In response, the Agricultural Water Management Strategy was implemented in 2015 by the Saskatchewan Water Security Agency with the goal of assisting producers in developing responsible drainage works by balancing the producer's need to manage water on their landscape while limiting potential adverse impacts to land downstream and the environment (Water Security Agency, n.d.). In striking this balance, consideration is currently given to approving the construction of certain drainage works with required engineering controls, while retaining certain wetlands within the landscape as deemed necessary. While it has largely remained unexplored in the PPR, another consideration in the development of a responsible water management plan could be the implementation of BMP's (Beneficial Management Practices) intended to reduce nutrient load in runoff water to counteract the increased volume of water exiting the landscape through the surface channel. Also unknown is the impact that topography within the landscape has on influencing the BMP's effectiveness in achieving its intended goal.

PROJECT DESCRIPTION

Working in consultation with technical and regulatory experts from the Saskatchewan Water Security Agency, this field site is located at the Glacier FarmMedia Discovery Farm Langham, located west of Langham, Saskatchewan (E ½ 15-39-8 W3M). Eight independent watersheds, henceforth referred to as basins, consisting of wetlands of varying classes and covering a cumulative area of approximately 16 hectares (ha) were identified in a single field having a common management history. In fall of 2020, surface ditches were constructed to channel water from each basin to an approved adequate outlet. The field site and construction plan for the comprehensive water management strategy is shown in Figure 9 below. Surface ditches were constructed using the equipment that can be seen in Figure 10. In spring of 2021, snowmelt run-off water samples were collected by hand from each basin over a four-day period during peak run-off and were analyzed for soluble and particulate N and P concentrations to determine baseline water quality characteristics prior to treatment initiation. Additionally, in spring 2021, surface (0-10 cm) soil samples were collected from six locations in a transect across each basin and were analyzed for baseline physical and chemical properties. Each location will be sampled and analyzed again in fall of 2021 and fall of 2022.

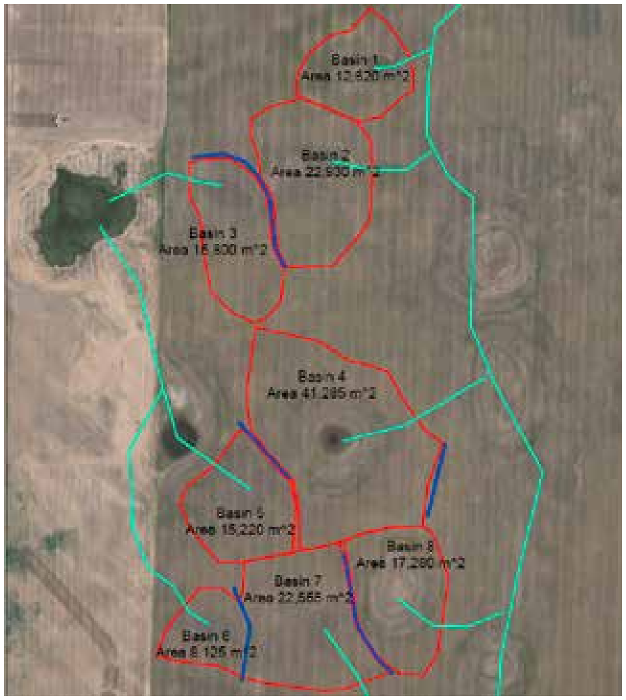


FIGURE 9. Site overview showing eight basins (red polygons) and constructed surface ditches (teal lines).

FIGURE 10. Pull dozer style plow used for construction of surface ditches to channel water from basins.

Three treatments of agricultural management practices along with a control treatment of standard farming practices will be evaluated in a two-year field study beginning in 2021. The four treatments are outlined below:

1) Variable-rate (VR) fertilizer application: Rates of N and P varied according to prescription developed for each unique management zone delineated within the basins. The VR prescription seeks to achieve acceptable crop yield goals while reducing nutrient application rates compared to standard practices by accounting for residual and plant-available nutrients often found accumulated in low-lying areas within the field as assessed through spring soil sampling and analysis. Crop uptake of residual nutrients is anticipated to result in reduced nutrient export in run-off water compared to the control treatment.

2) Crop residue management: An industry-accepted residue management practice (e.g. shallow tillage) was conducted following crop harvest to lightly incorporate crop residue into the soil profile. As previous research has shown crop residue to be an appreciable source of soluble reactive P (SRP), incorporation of crop residue into the surface soil profile seeks to reduce interaction of surface crop residue with snowmelt run-off water, thereby reducing the removal of SRP from the residue in run-off.

3) Poly-cropping of annual forages: A blend of annual forage species including N-fixing legumes. As salt-affected soils tend to manifest in low-lying areas of the landscape due to water tables periodically near the soil surface, cropping of annual forage species which are relatively more salt-tolerant than annual grain species, is increasing in popularity as a targeted BMP.

Annual forage species of diverse composition and with specific traits such as salt tolerance are anticipated to have increased uptake of residual soil nutrients and soil water use compared to annual grain species. Further, with the inclusion of legumes within the forage species blend, reduced fertilizer N application at the time of seeding is needed compared to annual cereal or oilseed crops to achieve acceptable crop yields.

4) Control: A control treatment of standard farming practices including fixed fertilizer application rates and no post-harvest residue management.

Following seeding a flume was installed at the location where the surface ditch exits each basin to allow for measurement of run-off water volumes. Each year at the six transect locations within each basin, square metre crop samples will be collected and the yield and uptake of N and P in the grain and straw measured to determine nutrient removal. Samples of residue on the soil surface remaining after harvest (and initiation of treatment 2 above) will be analyzed for soluble N and P. Snowmelt run-off water in spring of 2022 and 2023 will be measured for volume and collected and analyzed for soluble and particulate N and P concentrations. At each of the six transect points from each basin, anion exchange sandwiches will be conducted from surface (0-15 cm) soil samples to determine the influence of the treatment on potential supply and release of surface soil phosphate and nitrate to water. Soil samples collected in the fall will be used for NIR assessment using a handheld device that is then related to measurements of N and P that are made on the soil samples. NIR assessment in the field will also be evaluated. NIR assessments will also be related to the N and P measured in run-off water.

SITE MAPPING

The entire project area was mapped on August 25, 2021 using a Quantum Trinity Remotely Piloted Aircraft System (RPAS) equipped with a Yellowscan Qube 240 LiDAR. Resultant data was used to create a high-resolution Digital Elevation Model (DEM) of the site, which will be used to detect micro-variation in topography across the site (Figure 11). This information will be used during the simulated snowmelt run-off experiment, where the exact slope angle from where the soil slab was extracted in the field will be replicated in the lab.

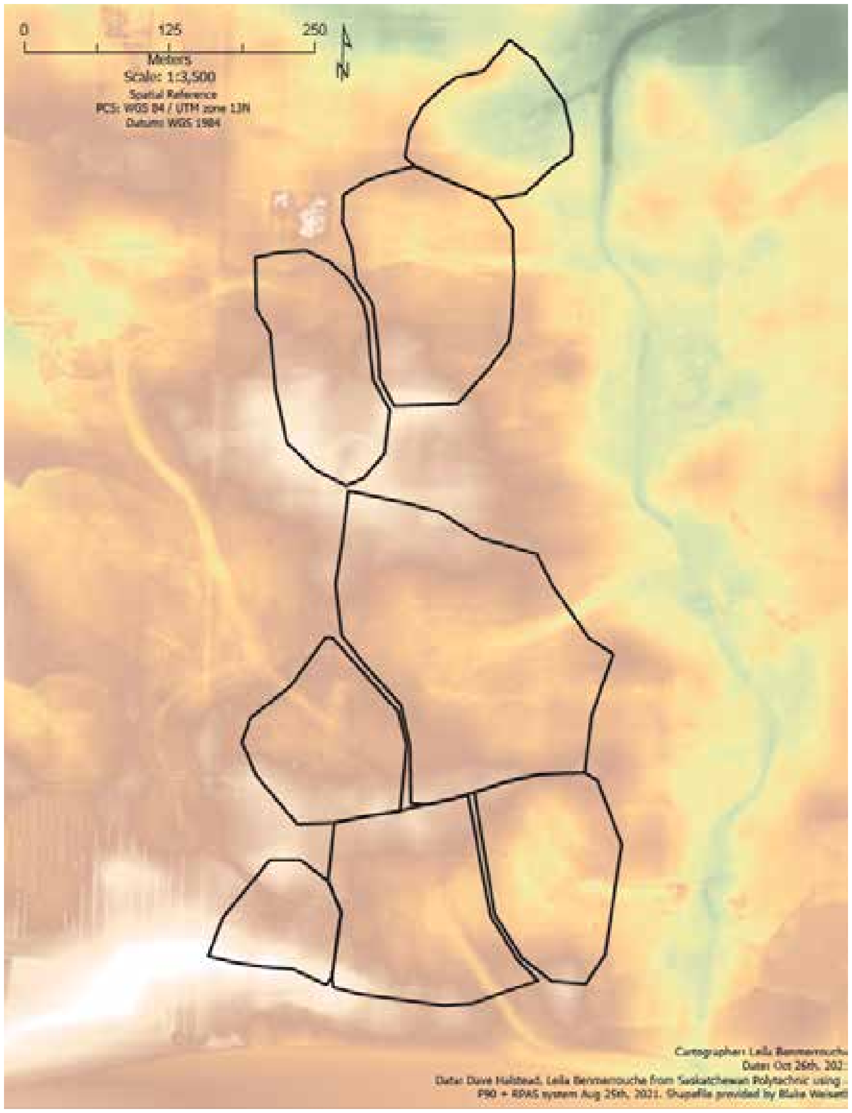


FIGURE 11. DEM of Water Management Project site created with LiDAR data, showing micro-variation in topography across the site.

Field Operations

SEEDING

All seeding operations were conducted by an 80 ft wide Vaderstad toolbar with a Vaderstad 980 air cart. The toolbar has independently-controlled openers on 12 inch spacing, with seed and fertilizer delivered in a double-shoot and side-band configuration. Treatment three was planted on May 28, 2021, with a seed rate of 12 lbs per ac along with fertilizer applied in the side-band at rates of 50 and 25 lbs N and P2O5 per ac respectively. Species in the annual forage mix along with the percentage of each species within the mix is as follows: hps Hairy Vetch (30%), hps Crimson Clover (25%), hps Tillage Radish (25%), and hps Turnips (20%). Treatments one, two, and four were seeded to flax (var. Westlin 72) on May 31, 2021. A fixed rate of seed and fertilizer was applied for treatments two and four, while for treatment one, a unique rate was applied to each of ten soil management zones delineated within the relevant basins. Application rates of seed and fertilizer prescribed for each management zone are shown in Table 5 below. Rates of seed and fertilizer prescribed for soil management zone 5 were applied to the entire basins assigned to treatments two and four. Accounting for the percent area each soil management zone occupies within the basin, weighted average rates of N, P2O5, and seed for basins 3 and 4 are shown in Table 7 below.

TABLE 5. Application rates of seed and fertilizer nutrients by soil management zone.

Zone	Seed (lbs ac-1)	N (lbs ac-1)	P2O5 (lbs ac-1)	K2O (lbs ac-1)	S (lbs ac-1)
1	45	64	29	8	9
2	40	66	32	9	9
3	40	71	35	9	9
4	40	76	40	9	9
5	40	83	46	10	10
6	40	85	51	9	9
7	45	76	48	8	8
8	50	57	39	5	5
9	60	44	31	4	4
10	70	32	25	3	3

TABLE 6. Breakdown of area occupied by each soil management zone across basin 3 and 4.

Zone	Basin 3		Basin 4	
	Area (ac)	(% Area of Basin)	Area (ac)	(% Area of Basin)
1	0.23	5.7	0.38	3.6
2	0.33	8.3	1.31	12.6
3	0.48	12.0	1.07	10.3
4	0.75	18.7	1.09	10.5
5	0.63	15.7	1.33	12.8
6	0.64	16.0	1.78	17.1
7	0.49	12.2	1.72	16.6
8	0.39	9.8	1.29	12.4
9	0.06	1.5	0.44	4.2
10	0	0.0	0	0
Total	**9.90**	**100**	**10.42**	**100**

TABLE 7. Application rates of seed, N, and P for treatment one presented as weighted averages and relative to control treatment.

Basin	Weighted Average Application Rate (lbs ac-1)					
	Flax Seed	% of Zone 5	N	% of Zone 5	P2O5	% of Zone 5
3	42	105.4 %	75	89.4 %	42	90.1 %
4	43	107.8 %	73	87.5 %	42	90.1 %

WEED CONTROL

Weed control of the study area was achieved by chemical means through the application of approved herbicides at label rates. For the basins where treatment three was applied, pre-seed herbicide application consisted of glyphosate, carfentrazone-ethyl, and bromoxynil. For all other treatments, application consisted of sulfentrazone, carfentrazone-ethyl, and glyphosate. In-crop herbicide application for the treatments where flax was seeded consisted of bromoxynil, MCPA, and clethodim. No herbicides were applied in-season for treatment three due to lack of products registered for application on the species included in the poly-cropping mixture. Glyphosate was applied to basins seeded to flax as a pre-harvest aid.

DATA COLLECTION HARDWARE INSTALLATION

On June 2, 2021, an H-flume was installed at the point where the surface ditch exists each basin, as shown in Figure 12 below. Additionally, a single soil moisture probe was installed each in basins 1, 2, 5, and 6. These 120 cm probes measure volumetric soil moisture content in 10 cm depth increments from the surface. Each soil moisture probe is coupled with an above-ground precipitation gauge.

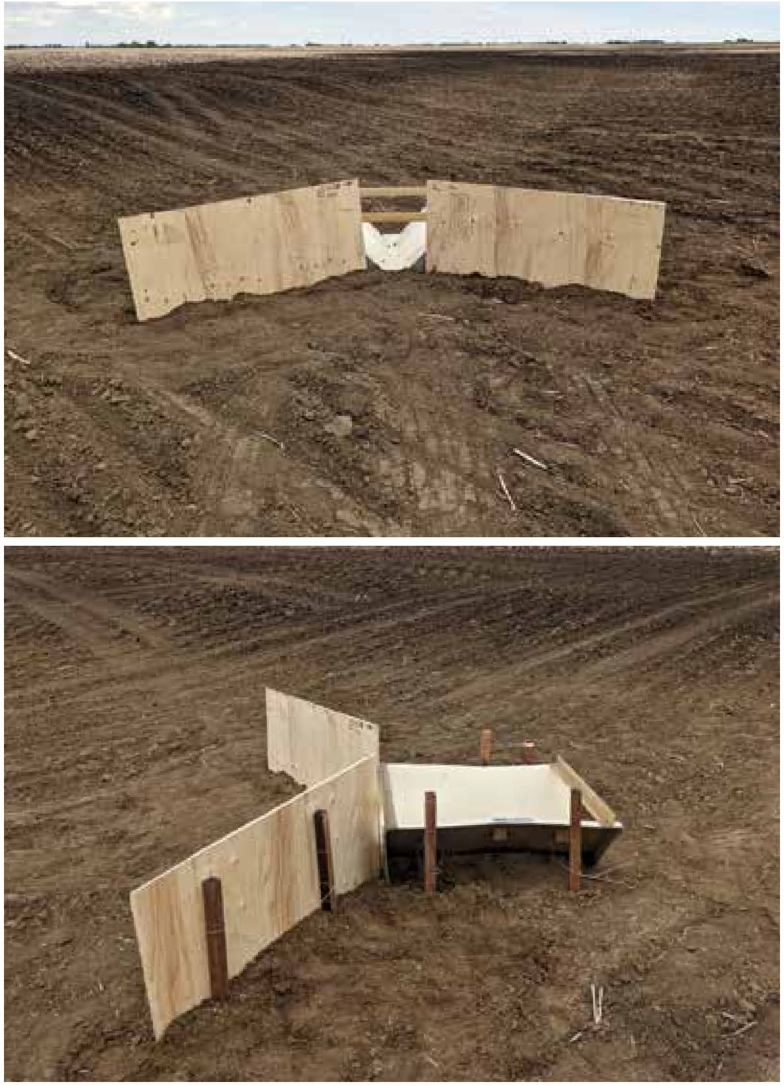


FIGURE 12. Example of H-flume installed at the exit point of the surface ditch from each basin.

FIGURE 13. Apparatus used for intact soil slab extraction.

CROP HARVEST

For treatment three, biomass samples were collected over two events including on July 15, 2021 and September 30, 2021 to account for biomass regrowth following the first cutting. During each cutting event, a single m2 biomass sample was collected from each of the six transect locations and biomass yield was recorded following air drying. Flax samples (treatments 1, 2, and 4) were hand-sampled on August 24, 2021 and air dried until threshing for grain and straw yield determination on October 19, 2021.

SOIL SAMPLING AND POST-HARVEST OPERATIONS

Following crop harvest, crop residue management was conducted on basins receiving treatment two on September 23, 2021. A chisel plow was used to conduct a light tillage operation at an approximate depth of 5 cm. Post-harvest soil sampling was conducted on September 27, 2021. A dutch auger was used to collect 0-5 cm and 0-15 cm samples from each of the 6 transect points per basin. Additionally, a three dimensional in-tact soil slab was collected from each transect point using a square shovel as shown in Figure 13 below. Following extraction, the slabs were placed within an aluminum container and frozen for preparation to conduct a simulated snowmelt run-off event to determine the treatment effect on N and P export in run-off water. Water infiltration measurements were also conducted at each transect point within each basin using a double ring infiltrometer (See Figure 14).

FIGURE 14. Double-ring infiltrometer used for water infiltration assessment.

Results

CROP YIELD

For the flax treatments, average grain yield was 365.1, 385.4, and 549.8 lbs/ac respectively for the variable-rate fertility, control, and crop residue management treatments (6.5, 6.9, and 9.8 bu/ac). A portion of the yield difference between the control and variable-rate fertility treatment was likely due to the reduced fertilizer application rate in the VR treatment relative to the control. As fertilizer application rates of the Crop Residue Management treatment were the same as that of the control, increased yield in the residue management treatment is likely due to micro-environmental impacts and differences in soil characteristics influencing water holding capacity. However, further interpretive power will be possible upon investigation of soil properties from post-harvest samples collected at each transect location for each basin. While the samples were collected following crop harvest, they have not yet been analyzed at time of publication.

Crop yield for each of the four treatments is presented by transect point location in Figure 15. For all basins, significant variability in flax grain or forage biomass yields were observed across the transect locations. In general, transect locations are set across the basin, with fringe locations 1 and 6 located on up-slope locations, and locations 3 and 4 located in basin bottoms. While the variability in yield results across transect locations may be explained with an interpretation similar to what was provided in the Field of Excellence project, interpretive power will be greatly improved with a thorough examination of soil properties analyzed from post-harvest samples.

CHART A.

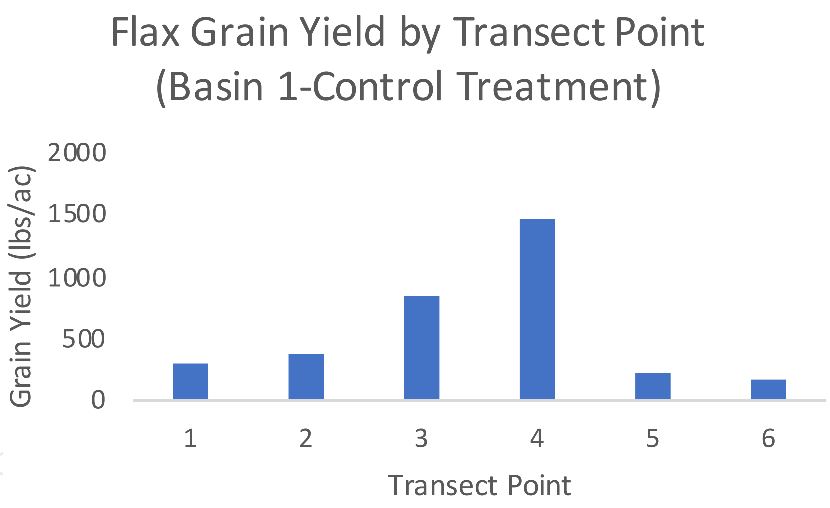
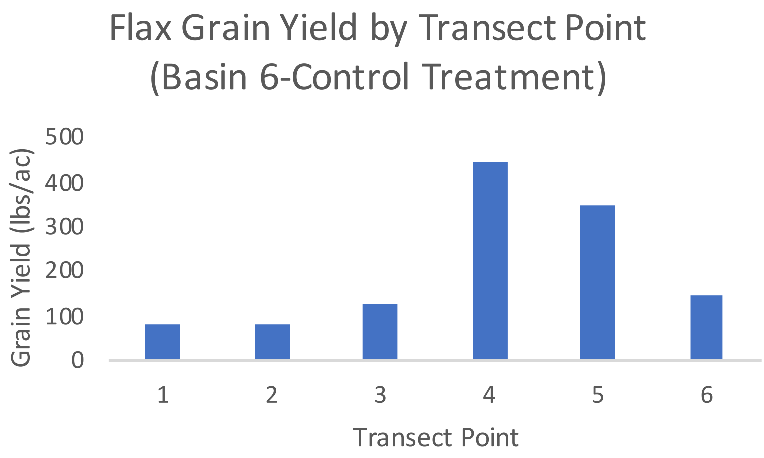


CHART B.



CHARTS A - H. Flax grain yield by transect point location for the control (A and B), residue management (C and D), and variable-rate fertilizer (E and F) treatments along with dry forage biomass yield by transect point for the Forage Polycropping treatment (G and H).

CHART C.

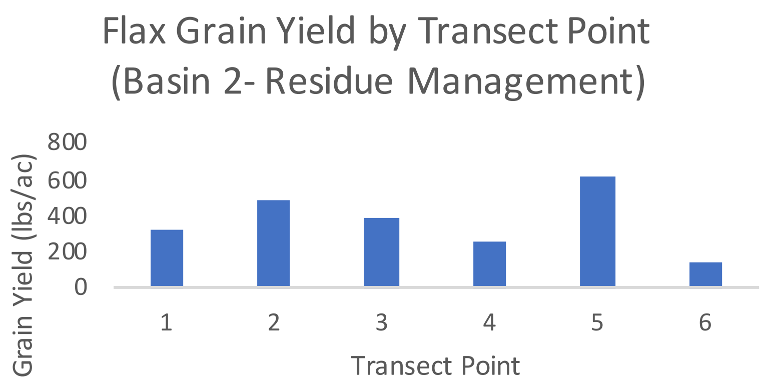


CHART D.

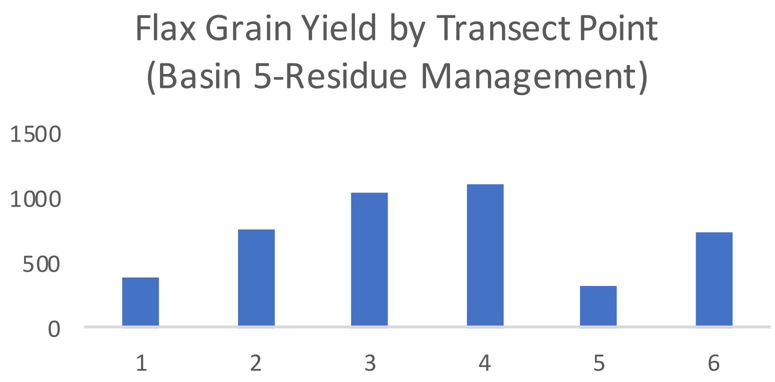


CHART E.

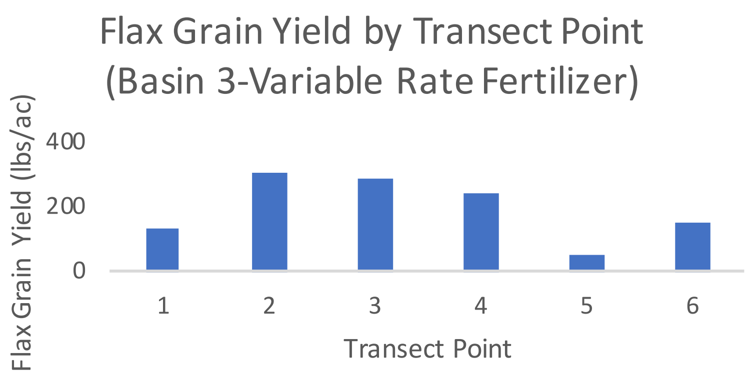


CHART F.

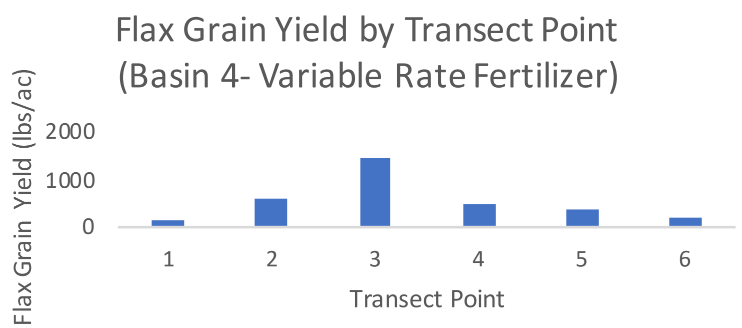


CHART G.

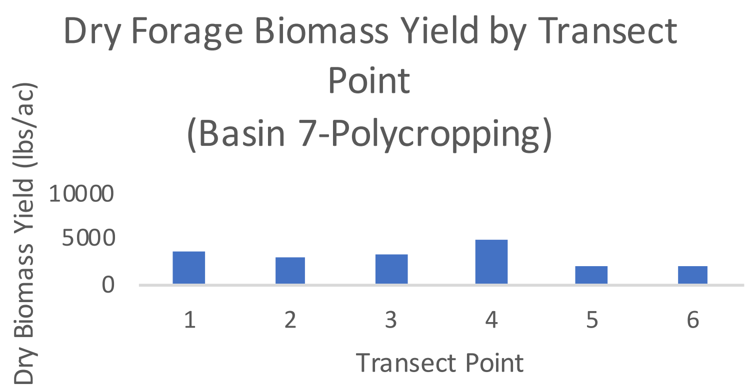
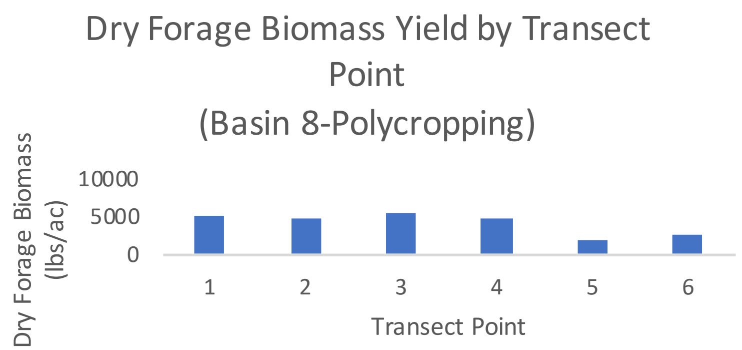


CHART H.



DISCUSSION

While the focus of the results presented above has been on crop grain and biomass yield due to availability of data at time of publication, conclusions on the effectiveness of a given BMP should not be made based on this data alone. Indeed, the overall objective of the project is to assess the ability of each management practice to optimize water use efficiency across variable landscapes through limiting N and P export in run-off water. The simulated snow-melt run-off experiment along with in-field measurement of snowmelt run-off water flow rates and quality will be critically important in assessing the overall validity of a given BMP. Further, the degree to which the treatment influences water infiltration rates will also be important along with crop yield in assessing the treatment's impact on water use efficiency across the landscape.

An economic assessment has purposefully not yet been completed on the given project at this time, given the nature of its objectives. For example, while gross revenue and total costs can be calculated similarly to what was done in the Field of Excellence Project above, this would result in an incomplete economic assessment that does reflect the value of limiting nutrient losses in run-off water. While easy to conceptualize, these values are difficult to quantify and are something which certainly require further investigation. Additionally, while market signals do not exist to the authors knowledge, such as a premium paid for sustainability metrics related to water and nutrient use efficiency, these factors would certainly impact a producer's decision of whether or not to adopt a management practice based on return on investment.

This project is a collaborative effort with Dr. Jeff Schoenau of the University of Saskatchewan College of Agriculture and Bioresources, Dr. Jane Elliott with Environment and Climate Change Canada and the Global Institute of Water Security, as well as the following partners:

Water Security Agency
Saskatchewan Soil Conservation Association
Saskatchewan Stock Growers Association
V-WING
CropPro Consulting
Nutrien Ag Solutions
Proven Seed
VÄDERSTAD

Salinity Project

Though especially prevalent under drought conditions, the use of targeted practices to manage salt-affected soils is an approach that is best considered every year and over the long-term. For example, when surveyors mapped the soils at the Salinity Project site over 40 years ago, it was noted that mid-slope soils are prone to be impacted by salinity, with the potential for moderate to severe limitations to crop productivity, depending on the extent of salinity. When looking at the agricultural capability that was assigned to this soil, 50% of the soil in this map unit is deemed to have a moderate limitation to productivity due to lack of moisture, while the other 50% is deemed to have a severe limitation due to the impacts of salinity (Acton and Ellis, 1978).

These capability limitations are manifested in poor productivity when annual crops are grown at this site noted by the presence of intense weed pressure of salt-tolerant species like kochia (Bassia scoparia) and foxtail barley (Hordeum jubatum). Fortunately, only a small portion of the soils at the entire Discovery Farm Langham site are classed in this way, as seen in Figure 16 below. The management approach that was chosen to address these limitations and manage a portion of this marginally productive soil was the establishment of salt-tolerant perennial forage species to achieve aboveground productivity, with important consideration given to the economic feasibility of this approach and an assessment of its ability to remediate the soil over time.

PROJECT DESCRIPTION

With an overall goal of assessing the initial establishment and overall productivity of perennial forage species on salt-affected soil, a two-acre site with soils impacted by various degrees of salinity was identified at Discovery Farm Langham (SE 15-39-8 W3M). Three treatments of perennial forages were seeded on May 19, 2020. A description of the treatments is shown in Table 8 below. Each treatment was seeded in three replicates and randomized throughout the project site (see Figure 17 below). Weed control in the establishment year was achieved using strategic mowing events with timing prescribed to prevent return of weed seeds to the seed bank. Two mowing events were conducted in 2020, including on July 6th and August 4th. During the August 4th event, each experimental plot was divided in half and subjected to two mowing heights of 5 and 15 cm to determine what impact, if any, this may have on treatment establishment and overwinter survival.

FIGURE 16. Satellite image showing soil map units at Discovery Farm Langham. Dot on map shows location of Salinity Project.

TREATMENT LIST:
A= Halo Alfalfa, B= Salinemaster, C= AC Saltlander

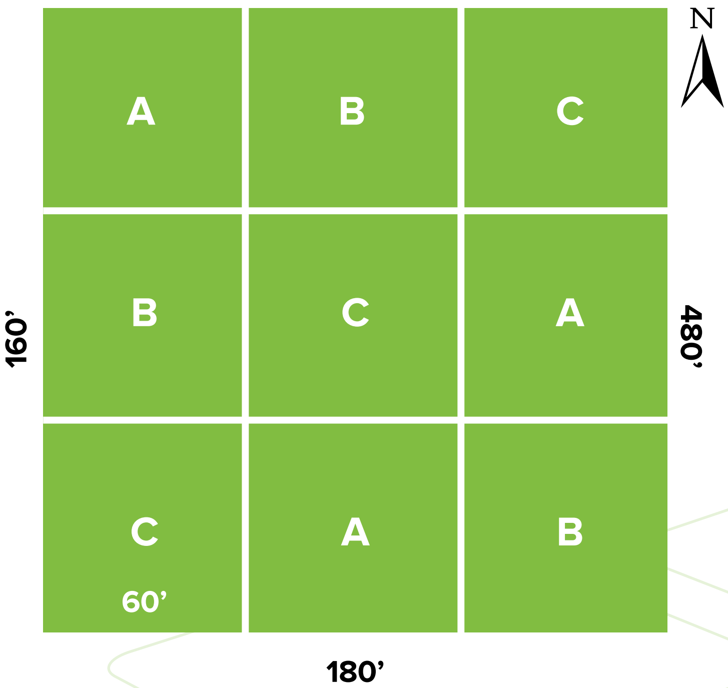


FIGURE 17. Salinity Project site overview showing treatment list and randomization.

TABLE 8. Percent species composition for each treatment in the Salinity Project.

Treatment Name	Treatment Species Composition	
	Species Name	Percent Composition
Halo2	Halo2 Alfalfa	100 %
Salinemaster	AC Saltlander Green Wheatgrass	40 %
	Barolex Tall Fescue	30 %
	AC Rocket Smooth Bromegrass	20 %
	Revenue Slender Wheatgrass	10 %
AC Saltlander	AC Saltlander Green Wheatgrass	100 %

Results

BIOMASS YIELD

Square meter biomass samples for dry yield determination were collected on July 5, 2021. Six replicate samples were collected from each experimental plot, including three within each cutting height assessed. Average dry biomass yield reported on a kilogram (kg) per hectare (ha) basis is shown in Figure 18 below. AC Saltlander green wheatgrass was shown to be the most productive treatment followed closely by Halo 2 alfalfa (2051 and 1742 kg ha-1 or 1825 and 1550 lbs ac-1 respectively) and yield of these two treatments was shown to be significantly higher ($p<0.001$) than yield of the Salinemaster blend (1167 kg ha-1 or 1039 lbs ac-1). Cutting height in the year prior did not significantly impact biomass yield (Figure 19).

SOIL PROPERTIES

Select soil properties from surface (0-15 cm) samples collected in the fall of 2020 (year of establishment) and 2021 are presented in Table 9 below. Soil samples were collected from benchmark locations in the furthest south treatment block of the project site and samples will continue to be collected from these locations in future project years. For all treatments, plant-available P concentrations were lower in Fall 2021 relative to Fall 2020. For treatments where the soil was rated as severely saline in Fall 2020 based on EC values (Halo 2 and AC Saltlander), a reduction in EC was observed when these same locations were sampled in Fall 2021.

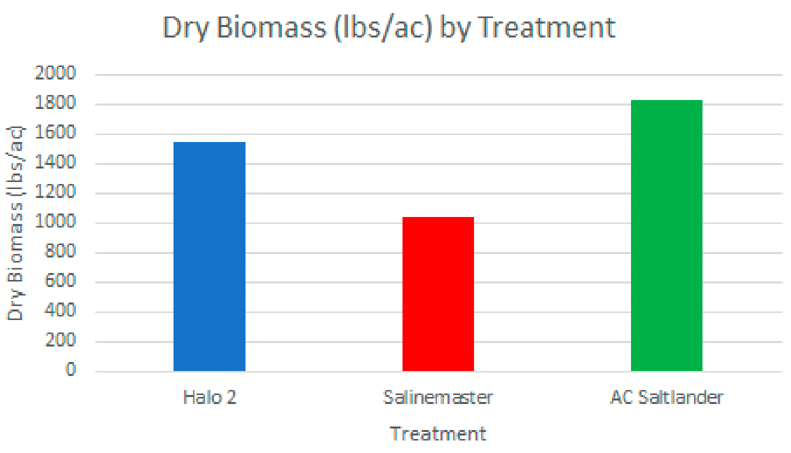


FIGURE 18. Dry biomass yield according to each forage treatment.

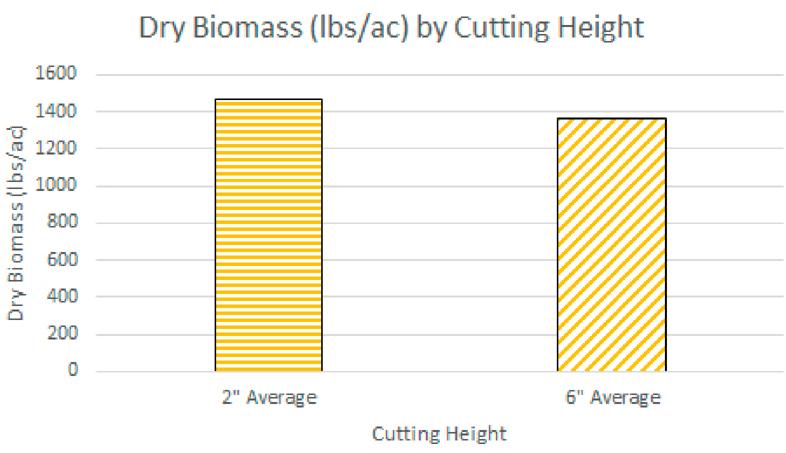


FIGURE 19. Dry biomass yield as impacted by cutting height during mowing on August 4, 2020.

TABLE 9. Select soil properties from surface (0-15 cm) samples collected from the same location in Fall 2020 and Fall 2021.

Treatment	Fall 2020				Fall 2021			
	EC 1:1 (dS/m)	OM (%)	Na+ (ppm)	PO4- (lbs/ac)	EC 1:1 (dS/m)	OM (%)	Na+ (ppm)	PO4- (lbs/ac)
Halo 2	3.5	3.8	202	43	2.6	3.3	116	33
Salinemaster	1.7	4.1	79	32	2.5	3.2	142	15
AC Saltlander	4.1	3.8	228	77	3.5	3.1	191	31

ECONOMIC ANALYSIS AND DISCUSSION

An examination of Figure 18 above shows that all treatments were able to establish well on salt-affected soils, as shown by their productivity in their second year of establishment in the midst of a severe drought. An economic analysis of each perennial forage treatment was also conducted and is presented in Table 10 below. Following the trend of yield, net profit was highest for the AC Saltlander treatment ($172.33/ac). Despite the challenging growing season conditions, net profit was achieved on the Salinemaster blend, largely due to a limited cost of production. Interestingly, yield difference between AC Saltlander and Halo 2 were not statistically different, showing that while alfalfa is typically categorized as a forage crop tolerant to moderate levels of salinity, the Halo2 variety was able to perform as well as AC Saltlander, bred specifically for high salinity tolerance, among other traits (Kayter et al., 2020). Therefore, given the nitrogen-fixing capability of alfalfa and demonstrated subsequent yield benefits of annual grain crops following alfalfa in rotation in other studies (Rehemuti, 2014), alfalfa may be a favorable option for annual grain farmers exploring the use of annual forages as a tool to manage salt-affected soils. The biomass yield from each treatment also indicates that strategic mowing in the year of establishment can be an effective weed control tool to allow the forages to compete against the salt-tolerant weeds.

Beyond assessment of establishment and above-ground productivity of the treatments, this study also seeks to understand what impact if any perennial forage establishment has on influencing surface (0-15 cm) properties of salt-affected soils. Evidence of utilization of residual nutrient levels is seen by examining the reduction in extractable P concentrations in fall 2021 relative to fall 2020. In contrast to the site's prior management of being seeded to annual grain crops resulting in the dominance of salt-tolerant weed species, soil nutrients were exported from the field in the form of the baled biomass rather than being returned annually to the soil in the form of weed biomass. Therefore, perennial forages may be an important tool to prevent nutrient accumulation in surface soil layers, which in the case of P may be prone to off-site losses in snowmelt run-off water and lead to adverse impacts on surface water quality.

For benchmark soil samples rated as "severely saline" in Fall 2020, a reduction in EC was observed in Fall 2021. This observation is likely due to a lowering of the water table height in 2021 due to drought conditions. Conditions required for surface salt accumulation include a water table close enough to the soil surface to allow upward movement of water by capillary flow, which, while dependent on soil texture, is generally 2 m and evaporative losses of water from the soil surface exceeding the amount of water entering the profile due to rainfall. In this way, perennial forage establishment is achieving its intended goal in managing salt-affected soils by managing the water table height in the discharge area. An established forage stand will utilize water at depth and prevent evaporative losses and subsequent salt accumulation at the soil surface. Salts will continue to be flushed downward in the soil when water infiltration exceeds evaporation.

TABLE 10. **Economic analysis for each perennial forage treatment.**

Treatment	Yield (lbs/ac)	Gross Revenue ($/ac)	Cost of Production ($/ac)	Net Profit ($/ac)
Halo 2	1550a	$186.61	$47.13	$139.48
Salinemaster	1039b	$124.87	$47.13	$77.74
AC Saltlander	1825a	$219.46	$47.13	$172.33

Note: Cost of production is calculated based on published custom machinery rental rate guides and includes costs associated with cutting and baling forages. Gross revenue is based on an assumption of a price of baled hay of $0.12/lb. Superscript letters indicate significantly different mean yields by treatment at the p<0.01 significance level.

This project is a collaborative effort with the following partners:

Ducks Unlimited Canada — Conserving Canada's Wetlands

Proven SEED

Nutrien Ag Solutions

4R Phosphorus Project

This three-year project was initiated in spring 2021, with one site located at Discovery Farm Langham (SE 15-39-8 W3M) and an additional two sites near Central Butte, Saskatchewan. The overarching goal of this project is to assess the affect that management practices related to 4R nutrient stewardship have on influencing agronomic productivity (i.e. nutrient uptake and yield) and environmental fate of applied nutrients in snowmelt run-off water. The nutrient of interest in this study is phosphorus (P) and how treatments implemented reflect the four Rs of nutrient stewardship including the “Right Source”, “Right Rate”, “Right Place” and “Right Time”. Specifically, eight P fertilizer formulations are applied at a low and high rate (18 and 36 lbs P2O5 ac-1) and with two placement methods (in the seed-row and broadcast followed by incorporation immediately prior to seeding), along with an unfertilized control. Treatment response was evaluated on wheat in 2021 and will be investigated on pea and canola in 2022 and 2023 respectively.

This project is being conducted in collaboration with Dr. Jeff Schoenau from the University of Saskatchewan with financial support from Western Grains Research Foundation, Saskatchewan Pulse Growers, Saskatchewan Wheat Development Commission, and Saskatchewan Canola Development Commission. As data was not available at time of publication, it is omitted from this report. Analysis and interpretations will be presented when available through another medium.

Upslope Central Butte site at crop harvest.

Nutrien Ag Solutions Innovation Acres

Nutrien Ag Solutions Innovation Acres is a showcase of innovative yet practical solutions for western Canadian farmers. It is 40 acres made up of four 10-acre fields in a 4-year lease. These fields follow proper rotation practices and allow Nutrien Ag Solutions to demonstrate the newest technology under proper recommendations. In 2021 and ongoing years, the focus on the acres will be to showcase premium product technology from both Proven® Seed and Loveland Products, Echelon™ for variable rate, data aggregation and field tracking software, all while being enrolled in Nutrien's Carbon Credit pilot program. Crop Protection and other products used on the acres were ordered using Nutrien Ag Solutions' Digital Hub. Knowledge gained this year will be utilized in decision making plans for the 40 acres for 2022, along with sharing of the learnings internally and externally.

Seeding choices are the first crucial steps in planning the 40 acres. Half the acres were on wheat stubble, the other half on canola stubble. Planning a proper crop rotation is important for soil health and disease management. All four fields were seeded on June 1st. WestLin 60 flax was the seed of choice for the flax acres. In WestLin 60, Proven Seed has provided a flax that has an early maturity rating, earliest on the market, which is a perfect fit for northern areas of the prairie provinces. It is a high-yielding brown flax that showcased great standability in 2021, along with less straw material. It ended up being about 7 days earlier than the standard WestLin 72. This may not always be the case, but the early maturing WestLin 60 was prominent in 2021.

The canola chosen was a pre-commercial TruFlex™ Roundup Ready® variety from Proven Seed. This choice was important on these acres because this canola holds clubroot resistance, has a strong blackleg rating, and has the harvest management piece which allowed us to decide late in the season to swath instead of strait cutting. Having that flexibility on a year like this with unprecedented weather conditions was important. There was minimal shelling or pod drop observed after swathing. The canola was ripe when swathed but maintained integrity.

Our feed barley choice was Altorado, which is an early maturing awned barley that produces high quality grain with a best-in-class disease package. This was shown in the sample taken which yielded a 47.5bu weight. Although 2021 was a dry year, minimal disease was seen, with strong standability. The wheat variety selected was AAC Broadacres. This variety has a very good lodging rating, excellent yield potential, and has wheat midge resistance. These traits are important when selecting a wheat variety to minimize spraying insecticides and to hold up to increased rates of fertilizer. This variety performed well on the farm, stood well with minimal disease, and ended up grading #2 with 15.7% protein. The variety held up grade even though it was rained on multiple times prior to harvest. Harvest of wheat, barley, and canola was on September 9th, and flax on September 30th. Yield averages were 16.5bu/acre on wheat, 20 bu/acre barley, 9.5 bu/acre canola, and 8.6 bu/acre flax. This was average and aligned with yield results in the area due to minimal in-season moisture.

One of Nutrien Ag Solutions' priorities is around implementation of sustainable practices. In 2021, a carbon pilot project was announced by Nutrien with limited acre enrollment. The Innovation Acres was a great place to implement carbon reduction practices. Being enrolled in the carbon pilot helped drive decisions on the field acres including fertilizer choice and rate, and use of Echelon's variable rate technology. No till is practiced on these acres which on dry years is important for improved soil productivity by supporting soil health in conservation of moisture and nutrients and overall productivity. A 4R plan was created, utilizing a nutrient balance calculator and soil tests to create fertilizer recommendations. Fertilizer actuals were a 79-30-0-25 for flax, 100-40-0-20 for canola, 84-43-0-16 for barley, and 89-43-0-16 for wheat acres. Because the farm acres are classed by Saskatchewan Soil Information System (SKSIS) as having a limiting factor that includes the potential to be 50% too wet, having ESN (slow-release urea) as part of the blend at 30% of total N was important.

The phosphorus fertilizer source was MAP+MST which is monoammonium phosphate with micronized sulfur technology in one prill. The micronized portion of the prill is 15 microns in size which means it will oxidize in the crop year it is placed. Because the micronized sulfur is elemental in source, the application of an additional available sulfur source in the form of AMS (Ammonium Sulfate) was placed in a blend to ensure that early season sulfur was accessible to the growing crop. The acres have varying pH levels from 7.6 to 8. This is higher on the alkalinity scale which means that nutrients like phosphorus may be less accessible. Due to this, the use of Loveland's Atlas® XC fertilizer product was important.

Atlas XC is a liquid fertilizer additive to dry phosphorus and potassium fertilizer sources at 1 litre per tonne completed at a retail or plant. This liquid additive is not a live organism so it can be applied up to one year in advance. This product helps to breakdown the phosphorus fertilizer faster

so that the nutrients are available sooner and longer for plant uptake before they are tied up by calcium and magnesium in high pH soils. This was noted in the exceptional plant vigour out of the ground right after seeding as well as even maturity across all fields. Fall soil tests indicate that the phosphorus levels remaining were slightly higher than the uptake/removal nutrient calculator estimates. This follows the trend with other Atlas XC treated fields where the amount of phosphorus in the soil was higher following application due to more being released from the prill. 2022 recommendations in fertilizer application and placement will be guided by fall 2021 soil tests, uptake and removal calculator, and best 4R and carbon reduction practices.

Decisions on fertilizer placement was done using Echelon's variable rate technology. Echelon utilizes satellite NDVI imagery, along with historical data, to analyze variability within the field. Each crop type had an individual average N and P rate which was varied with respect to low, average, and high producing areas and matching low, average, high rates of fertilizer. N rates were maxed at 90 lbs and 100 lbs N on barley and wheat respectively. Phosphorus rates were maxed out at seed safe rates on all crop types. In placing fertilizer using variable rate, the nutrients applied match the potential of the crop yield. This eliminates the over application in under-producing areas while maximizing profit on the other areas. All fields had even maturity and yield data collected indicated that the high fertility areas produced the largest yields in the fields. 2021 showcased extreme variations in the field due to soil type, stubble material etc., so placing fertilizer with this variable rate methodology was profitable in utilizing fertilizer best on the acres while following 4R practices.

Herbicide product selection and use was important in the 2021 cropping year. The Innovation Acres project was challenged by the common weeds of kochia, foxtail barley, dandelions, and volunteer canola among others. With kochia being the top problematic weed on the acres, product selection with control on kochia was important. Flax received an application of Authority® 480, a rain activated soil residual with labelled control on kochia, along with an in-crop application of Buctril M and clethodim. In-crop herbicide was applied with a tank mix of Loveland's Awaken® foliar. Awaken is a 16-0-2 with boron, copper, iron, manganese, molybdenum, zinc, and chloride. This product lessens the effects of herbicide on the crop which is beneficial to a sensitive crop like flax and this positive effect was seen after spraying in 2021. Other herbicide application products for wheat and barley include Convex and Startup® glyphosate for a pre-burn and Sentrallas™ with MCPA and Trondus™ for in-crop. Both these products work well on weeds like kochia and wild oats and this was observed in post-application scouting.

Canola received a pre-seed application of Octagon and Startup glyphosate which also has control over kochia. Wheat, barley, and canola all received an application of 60-acre rate Radiate® at time of in-crop herbicide application. This plant growth product contains indole-3-butyric acid (IBA) and cytokinen in ratios that drive root growth and plant vigor. This was seen in healthy root growth and helped drive the plants to search for nutrients and moisture in a low soil moisture year. It was observed that applying these additional plant health products to all crops was beneficial in a drought year to help plants deal with the extreme heat and drought. Drought conditions brought grasshoppers later in season to the four fields. The damage being done on flax warranted an insecticide spray application. Coragen® was chosen due to its pre harvest interval and minimal effects to any beneficial insects. No in-season fungicide applications were made due to minimal moisture and very low risk. Flax did receive a preharvest glyphosate application in September which was needed due to regrowth after late August rains. Conditions after the late August rains resulted in volunteer canola flushes across the cereal stubble as well as second growth on canola stubble stems. Fall kochia flushes were abundant. An application of Heat® LQ plus glyphosate was applied third week in September and this worked well to set back the weed flushes to conserve soil moisture and nutrient reserves. This will create a clean seed bed for spring 2022 with no re-cropping restrictions.

Taurus Ag Discovery Plot Challenge

LOWER SEEDLING MORTALITY, HIGHER FERTILIZER RATES, INCREASED EMERGENCE

Seedling mortality rate is often caused by salt in fertilizer and toxicity to seed. We know higher fertilizer rates are applied to increase yield, but we also know this practice sacrifices emergence. Our seed safety knock-out challenges the accepted seedling mortality rate to show it is possible to increase fertilizer and increase emergence with seed safe products.

On our Discovery Plots, we applied high rates, to showcase how seed safe innovations can decrease seed mortality and improve soil biology.

OSTARA Crystal Green® 5-28-0-10Mg SUL4R-PLUS® Polysulphate

TAURUS AG PRODUCTS

CRYSTAL GREEN® (CG)
5-28-0+10Mg

SUL4R-PLUS® (S4P)
0-0-0+21CA+17S

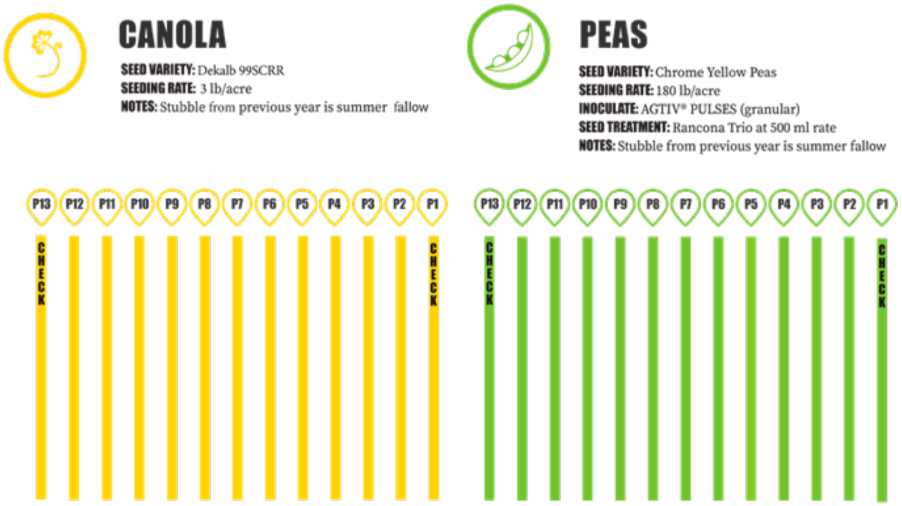
POLYSULPHATE® (POLY)
0-0-14+12.2Ca+3.6Mg+19.2S

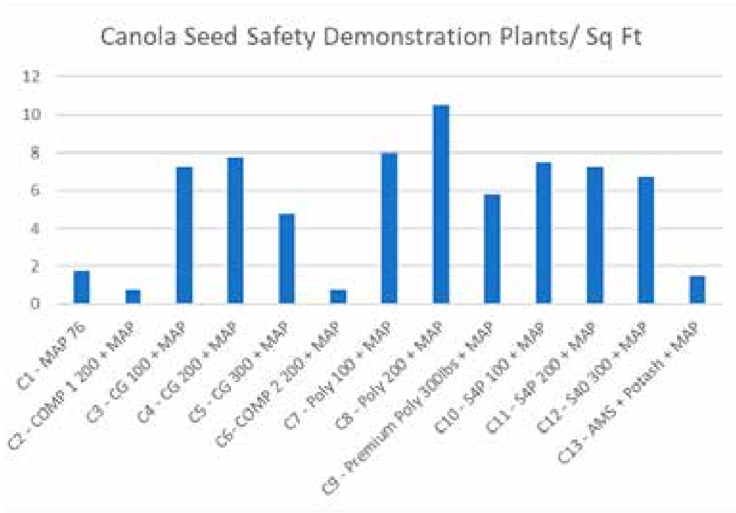
COMPETATIVE OPTIONS

COMPETITOR 1
14-24-0+10S

COMPETITOR 2
8–29–5+10S+10CA

Plot Design





Canola Seed Safety Demonstration

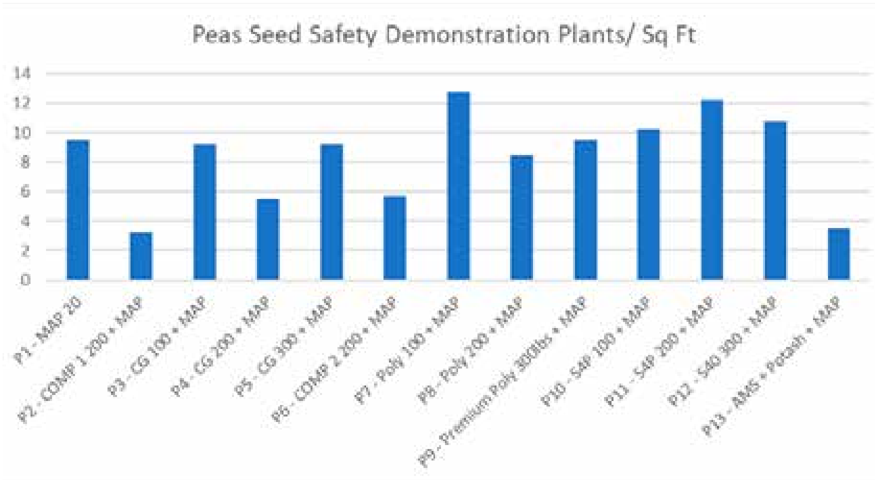
Treatment	TOTAL NUTRIENT VALUE APPLIED
C1 - MAP 76	76 Lb of P205
C2 - COMP 1 200 + MAP	68Lb of P205 + 20S
C3 - CG 100 + MAP	48 Lb of P205
C4 - CG 200 + MAP	76 Lb of P205
C5 - CG 300 + MAP	103 Lb of P205
C6- COMP 2 200 + MAP	78 Lb of P205+K10+ S20+Ca20
C7 - Poly 100 + MAP	20 Lb of P205+ S19+K14+Ca12
C8 - Poly 200 + MAP	20 Lb of P205+ S38+K28+Ca24
C9 - Premium Poly 300lbs + MAP	20 Lb of P205+S57+K42+Ca36
C10 - S4P 100 + MAP	20 Lb of P205+S17+Ca21
C11 - S4P 200 + MAP	20 Lb of P205+S34+Ca42
C12 - S40 300 + MAP	20 Lb of P205+S51+Ca63
C13 - AMS + Potash + MAP	20 lb of P205 + AMS38+K28

CANOLA PLOT DETAILS AND FINDINGS

- Canola is an extremely sensitive seed as increased rates of traditional fertilizer are used. As such, in the 2021 Discovery Plot, Taurus chose to look for alternatives for Canola.
- This plot showed valuable information on seed safe applications of Phosphate, Potassium and Sulphate with new products that Taurus is bringing to the marketplace.
- As suspected, high rates of MAP, AMS and Potash in the seed row show extensive seed mortality.
- Crystal Green® (CG) showed excellent seed safety at 100 and 200 lb/ac rates. Slight reduction at the 300 lb rate
- Both competitors had similar seed safety to the high rate of MAP
- Polysulphate is showing great seed safety at all 3 rates. Very encouraging as this product allows for seed safe application of Sulphate and Potash which has not been available to the Canadian Farmer.
- As we suspected along with Crystal Green®, Sul4R-Plus® is an extremely seed safe product with excellent handling characteristics.

Peas Seed Safety Demonstration

Treatment	Actual Nutrient of P K S Applied
P1 - MAP 20	76 Lb of P205
P2 - COMP 1 200 + MAP	68Lb of P205 + 20S
P3 - CG 100 + MAP	48 Lb of P205
P4 - CG 200 + MAP	76 Lb of P205
P5 - CG 300 + MAP	103 Lb of P205
P6 - COMP 2 200 + MAP	78 Lb of P205+K10+ S20+Ca20
P7 - Poly 100 + MAP	20 Lb of P205+ S19+K14+Ca12
P8 - Poly 200 + MAP	20 Lb of P205+ S38+K28+Ca24
P9 - Premium Poly 300lbs + MAP	20 Lb of P205+S57+K42+Ca36
P10 - S4P 100 + MAP	20 Lb of P205+S17+Ca21
P11 - S4P 200 + MAP	20 Lb of P205+S34+Ca42
P12 - S40 300 + MAP	20 Lb of P205+S51+Ca63
P13 - AMS + Potash + MAP	20 lb of P205 + S38+ K28



PEA PLOT DETAILS AND FINDINGS

- Peas are slightly less sensitive than canola to increased rates of traditional fertilizers.
- This plot also showed valuable information on seed safe applications of phosphate, potassium and sulphate with new products that Taurus is bringing to the marketplace.
- Plot 1 consisted of only 20 lbs of P2O5 to show a standard practice stand establishment.
- Higher rates of AMS and Potash in the seed row show the increased mortality over the Taurus exclusive fertilizers.
- Crystal Green® showed excellent seed safety at all rates. Noting 103 lbs of P2O5 applied in the seed row, with good seed safety, opens new doors to fertility.
- Both competitors had similar seed safety to the high rate of MAP.
- Again, Polysulphate showed great seed safety at all 3 rateswhich was very encouraging as this product allows for seed safe application of Sulphate and Potash which has not been available to the Canadian Farmer.
- Sul4R-Plus® is an extremely seed safe product with excellent handling characteristics. Peas demand high amount of Ca and Sul4R-Plus® can supply they Ca require.

Other Industry-Led Projects

Yara Incubator Farm 2021 Trial Report

COMPLETE NUTRITION WITHOUT COMPLEXITY

Yara leased 80 ac from the Discovery Farm to conduct field scale trials in conjunction with industry partners. The trials challenge current rates, practices, and technology to improve efficiencies and production at a field level.
All products are applied with full scale field equipment.

In 2021, 40 acres of wheat and 40 acres of canola were seeded. In each crop there were two treatments. A Grower Standard Practice (GSP) was compared to a Yara Complete Nutrition Program (Yara).

The fertility programs were designed with Fertilizer Canada's 4R Nutrient Stewardship (Right Source @ the Right Rate, Right Time, and Right Place®) in mind. The best management practices, combined with the 4R stewardship attributes are utilized to minimize environmental impact while maximizing production.

TREATMENT DESCRIPTIONS

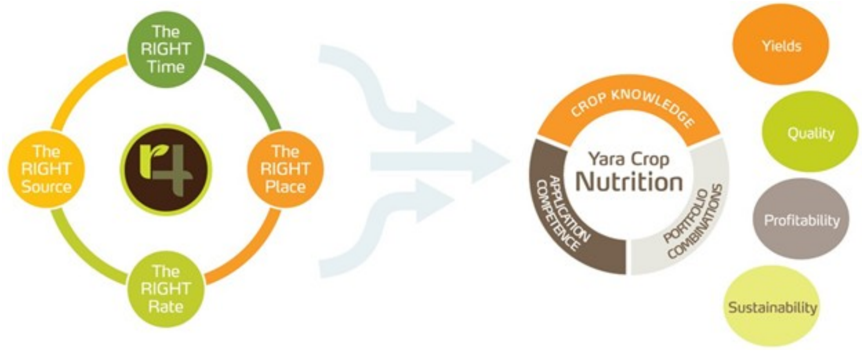
Seeding Date: May 23, 2021 (80 foot SeedHawk drill)
Dry fertilizer was placed in the sideband due to the dry conditions.

Yara Wheat Program: Designed to showcases the flexibility of YaraVera AMIDAS (65% applied at seeding 35% top dressed with a spin spreader on June 23, 2021.)

- YaraVita Procote BCMZ & Procote Cu on phosphate/potash blend (addressing micronutrient deficiencies, provide that complete nutrition package.
- YaraVita FLEX applied with herbicide (nutrition boost in a high demand growth period).
- YaraVita LAST N applied with fungicide (promote protein development).

Yara Canola Program: Designed to highlight the nutrient use efficiency benefits of YaraVera AMIDAS (unique homogeneous nitrogen/sulphur pearl). A slightly lower rate of nitrogen and sulfur were applied at seeding timing with Fertilizer Canada's 4R concept in mind.

- YaraVita Procote package was applied as in the wheat program.
- June 23, frost event. To aid the canola in recovery, an application of YaraVita FLEX was applied. (supplying much needed nutrients aiding in recover from an injury event)
- YaraVita FLEX applied with the fungicide (addressing any hidden hungers)



YARA LARGE SCALE CANOLA RESEARCH TRIAL

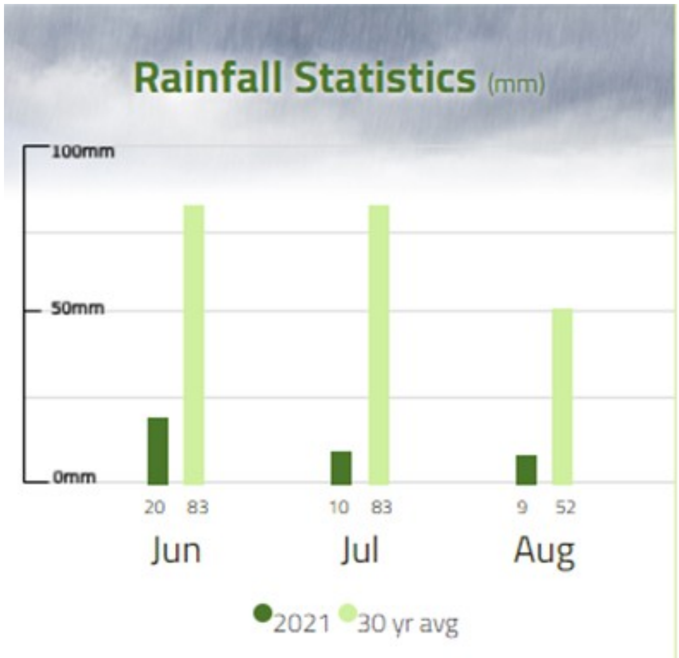
Grower Standard Practice (GSP)	Yara Complete Nutrition Program
Urea & Ammonium Sulphate	YaraVera AMIDAS (40-0-0-5.5)
Monammonium Phosphate (MAP) & Potash (MOP)	Monammonium Phosphate (MAP) & Potash (MOP)
	YaraVita PROCOTE BCMZ (3L/t on MAP/MOP)
	YaraVita PROCOTE Cu (1L/t on MAP/MOP)
	YaraVita FLEX (post frost event) (1L/ac)
	YaraVita FLEX with herbicide (1L/ac)
Total Program (N P K & S) 100-50-15-25S	**TotalProgram (N P K & S) 95.50-15-11S + micros**

YARA LARGE SCALE WHEAT RESEARCH TRIAL

Grower Standard Practice (GSP)	Yara Complete Nutrition Program
Urea & Ammonium Sulphate	YaraVera AMIDAS (40-0-0-5.5) (65% @ seeding, 35% top dressed @ flag leaf stage)
Monammonium Phosphate (MAP) & Potash (MOP)	Monammonium Phosphate (MAP) & Potash (MOP)
	YaraVita PROCOTE BCMZ (3L/t on MAP/MOP)
	YaraVita PROCOTE Cu (1L/t on MAP/MOP)
	YaraVita FLEX with herbicide (1L/ac)
	YaraVita Last N with fungicide (1L/ac)
Total Program (N P K & S) 95-50-15-11S	**TotalProgram(NPK& S)95-50-15-11S + micros**

DROUGHT, WATER USE AND COMPLETE NUTRITION

In collaboration with Crop Intelligence, part of the initial protocol was to observe water use by treatment in each crop. Soil moisture probes were installed in each of the treatments a few days after seeding. Soil moisture conditions were considered fair until mid-late June. Conditions deteriorated through the rest of the season.



All of Western Canada experienced extremely dry conditions in the 2021 growing season. The site of the Yara Incubator Farm was no exception with only 15% of the 30-year average rainfall. The Crop Intelligence weather stations recorded the rainfall and temperature statistics.

Temperature Statistics (celcius)

Mos	Min	Max	Days >28c	Days <0c	GDD	30YR GDD
Jun	0	36.8	12	1	363.7	318.7
Jul	5.2	40.3	22	0	501	425.4
Aug	8.3	38.4	8	0	268.4	227.3
Total	0	40.3	42	1	1133.1	971.4

In the month of July there were 22 days above 28 degrees Celsius.

Temperature Statistics (celcius)

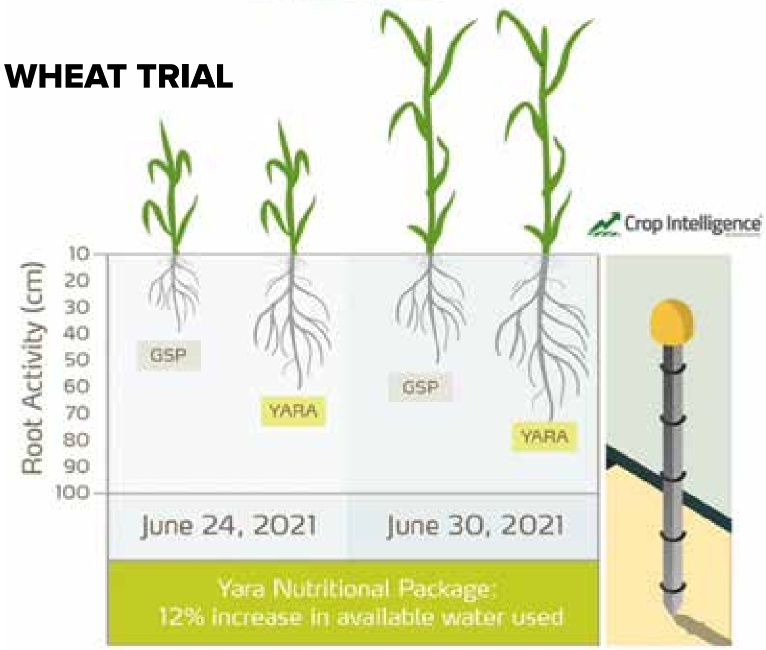
Mos	Min	Max	Days >29c	Days <0c	GDD	30YR GDD
Jun	0	36.8	9	1	363.7	318.7
Jul	5.2	40.3	17	0	501	425.4
Aug	8.3	38.4	8	0	249.8	202.5
Total	0	40.3	34	1	1114.5	946.6

Looking at the number of days above 29 degrees Celsius, there were 17 for the month of July.

Crops are sensitive to both dry conditions and excess heat. When these conditions are experienced at the same time for an excessive time-period, the results can be devastating on pollination and therefore yield.

Under these extreme conditions, the Yara Nutritional Program showed earlier root development and the roots accessed stored soil water sooner and at greater depths than the GSP. Resulting in improved water use. Being able to maximize the amount of water used by the plant is critical under stressful conditions such as drought.

WHEAT TRIAL



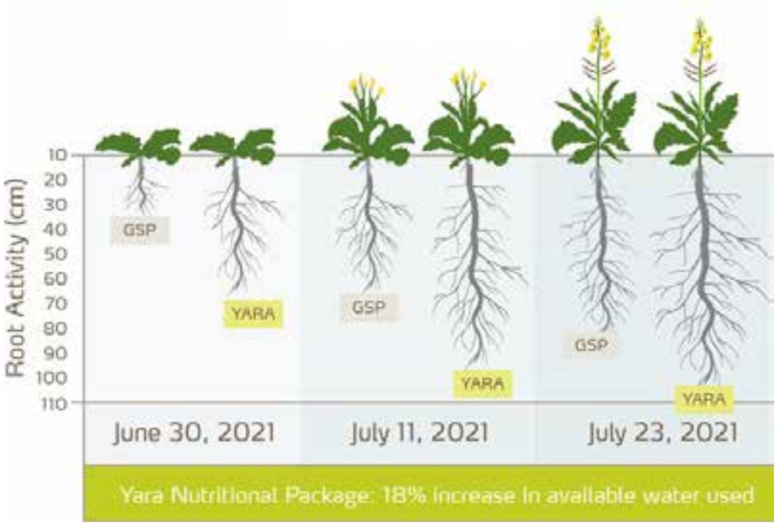
Yara treatment accessed the soil moisture at depths earlier than the GSP.

50 cm depth: Yara showed root activity on June 24th

GSP did not show activity until July 2, (8 days later)

70 cm depth: Yara showed root activity on June 30th GSP never reached the 70 cm depth

CANOLA TRIAL

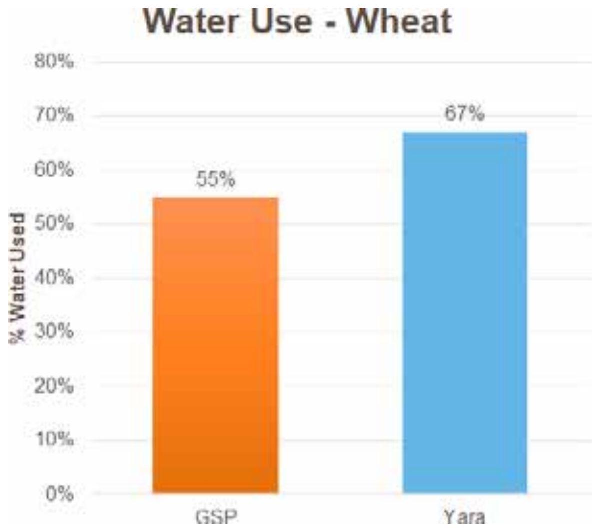


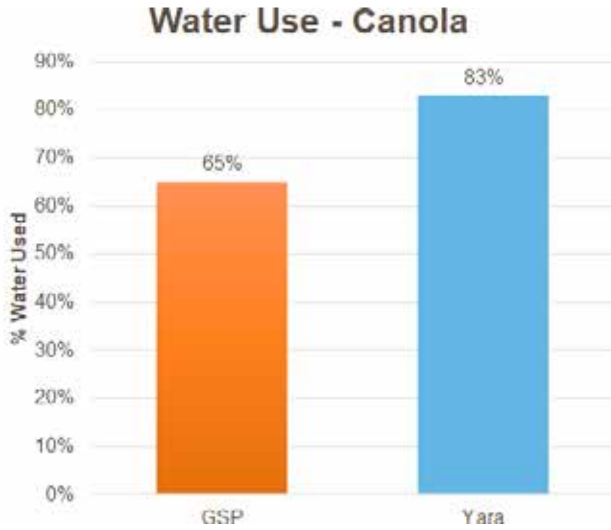
Yara treatment accessed the soil moisture at depths earlier than GSP. 70 cm depth: Yara showed root activity on June 30th

GSP did not show activity until July 12, (8 days later)
100 cm depth: Yara showed root activity on July 11th

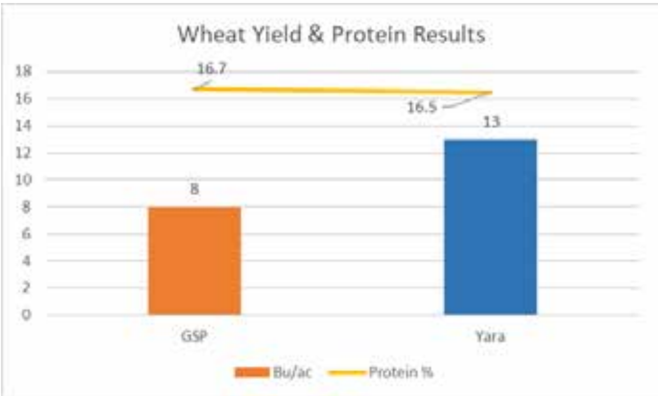
GSP did not show root activity until July 23rd (12 days later)

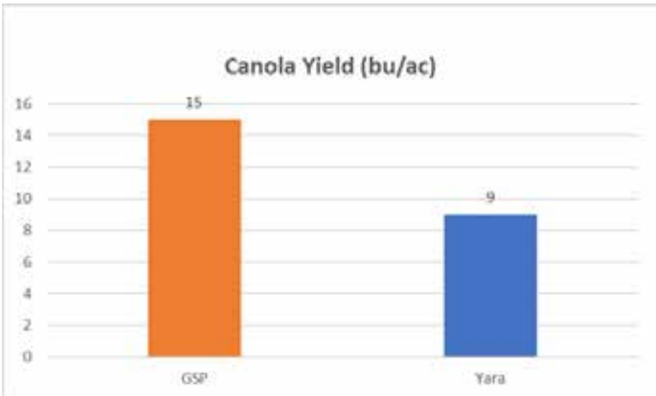
(GSP) Grower Standard Practice





The amount of water used by each treatment was calculated. In the wheat treatment, the Yara Complete Nutrition Program was able to utilize 12% more of the available water. In the canola treatment the Yara Complete Nutrition Program was able to utilize 18% more of the available water in the growing season. The increased amount of water uptake is directly related to having an improved root structure. Having a root structure that can utilize the available water is critical. Nutrients are carried in the soil's solution, therefore water uptake is directly proportional to nutrient uptake.





Yield differences by treatment was heavily affected by lack of moisture. The Yara program in the canola trial did not produce a yield improvement compared to the GSP. The reduction of yield is likely a factor of timing of reproductive stage in the Yara treatment. The month of July received 22 days above 28 degrees Celsius and received no rainfall. In these conditions flower blast would have been significant. Being that the Yara treatment had access to moisture, it would have entered the reproductive phase later than the GSP, therefore more flower blast was likely to occur.

The ability to provide complete nutrition to any crop starts with understanding what the crop needs for nutrition in any growing season. Micronutrients provided by YaraVita® PROCOTE™ aid in the early development of root systems which improves the root's ability to explore for nutrients and water. Foliar applied micronutrients as found in YaraVita® FLEX™ have significant effect on crop yield and water use efficiency (WUE), particularly under drought stress conditions. Soil test, tissue tests as well as visual assessments from previous years are all tools to utilize in making fertility decisions. Choosing the right product that can provide the best nutritional value can not only improve water and nutrient uptake, but also provide handling efficiencies.

Discovery Farm Knowledge Transfer

Groundbreaking new findings in the world of agriculture are coming to life not only in the field, but also in the hands of Canadian farmers thanks to a wide range of knowledge transfer activities. Supported by the expertise and resources of our parent company Glacier FarmMedia, Discovery Farm offers partners the ability to connect with their customers through knowledge transfer and dissemination events.

Through an array of Glacier FarmMedia's publishing, digital, conference and event platforms, as well as in-person interactive learning in the field, Discovery Farm is connecting farmers to innovation that will benefit their unique farming practice for years to come.

WEBINARS

- Easy Wins in Precision Ag December 16, 2020
  Discovery Farm Langham's Applied Research Lead Blake Weiseth was joined by panelists Wes Anderson of Crop Pro Consulting, Lorne Grieger of PAMI and Bryce Moore of Prestige Agronomic Consulting for the Easy Wins in Precision Ag webinar. During this session, examples of precision ag that have been implemented in the field were shared to offer insight on just how easy it is to get started. Those with a base of precision ag experience as well as those looking to explore it from scratch took in a wealth of information from these experts who shared easy wins that may not have been considered before.
- The Story Behind the Data February 16, 2021
  In today's day and age, we have the ability to collect enormous amounts of data, but what can be done with it, and how can it be put into context of what's being observed in the field? Joined by special guest Guy Ash of METOS Canada, Blake Weiseth discussed in this webinar how data can be a powerful tool to inform management decisions on-farm and how it has been used at Discovery Farm Langham.
- Managing Salinity on your Farm
  Implementing new management practices on-farm can be risky. Challenges such as seeding perennial forages on saline soil can lead to poor establishment in the first year due to weed competition. Special guest Dr. Bart Lardner, principal investigator at the Livestock and Forage Centre of Excellence, shared in this webinar his expertise on forage production in soil saline conditions.

INDUSTRY EVENTS

- **Discovery Farm Langham Spring Kick Off April 16, 2021**
  With seeding right around the corner, the team at Discovery Farm Langham took this opportunity to join industry partners in an online networking event to unveil the 2021 growing season activities and important happenings at the farm. This event is where exciting plans, partnerships and progress are shared through meet-and-greet style interactions where we discuss how we are unearthing possibilities this year at Discovery Farm.
- **FCL Equipment Internal Training Day August 5, 2021 –**
- **Equipment Training Day**
- **FCL Agronomy Internal Training Day June 29, 2021 and July 21, 2021**
- **Belchim Internal Training Day July 15, 2021**
- **Harvest Celebration October 7, 2021**
  Discovery Farm Langham staff, partners and friends headed into the Thanksgiving weekend thankful as ever for all who took part in the 2021 growing season. Many celebrations were had at the harvest wrap-up event to acknowledge all that we are achieving together.
- **AGI Coffee Talk October 22, 2021**
  Discovery Farm's Kaitlyn Kitzan and Blake Weiseth sat down with Laura Handke of AGI during the AGI SureTrack CoffeeTalk to chat all things Discovery Farm from partnerships, research, farmer outreach and more.

MEDIA EVENTS

- **Pan Canadian Smart Farm Network June 17, 2021**
  On June 17, 2021, the Canadian Agri-Food Automation and Intelligence Network (CAAIN) announced funding towards the Pan-Canadian Smart Farm Network– a project in collaboration with Lakeland College, Olds College and Discovery Farm Langham. The goal of the Pan-Canadian Smart Farm Network is to build a collaborative framework among Canada's Smart Farm initiatives for sharing of data and expertise to help farmers, technology developers and industry stakeholders access new ideas, information and infrastructure to better understand smart agriculture technologies and systems.

  On this day, the great news was shared through a media conference and a virtual kickoff presentation among project partners and stakeholders hosted by Principal Investigator Dr. Joy Agnew, Associate Vice-President, Applied Research at Olds College, Josie Van Lent, dean of Agriculture Technology and Applied Research at Lakeland College and Blake Weiseth, applied research lead with Glacier FarmMedia Discovery Farm and agriculture research chair at Saskatchewan Polytechnic.

MEDIA RELEASES

Discovery Farm Langham distributed 8 media releases throughout the growing season in response to the successful collaborations and innovation taking place on the farm.

- Discovery Farm Langham sees growth in industry partnerships as focus on research continues - April 19, 2021
- Discovery Farm content enriches Saskatchewan Polytechnic Agricultural Equipment Technician program - April 22, 2021
- Discovery Farm Langham announces in-person VIP Experience for June 2021 - May 10, 2021
- Olds College Launches Pan-Canadian Smart Farm Network with Glacier FarmMedia Discovery Farm and Lakeland College, funding from CAAIN - June 17, 2021
- Day one of Discovery Farm VIP Experience wraps up - June 23, 2021
- Discovery Farm VIP Experience returns July 20, 21, 22 & 23 - July 8, 2021
- Discovery Farm Harvest underway with CLAAS & AGI - September 14, 2021
- New grain tracking and testing solutions deployed at Discovery Farm - September 27, 2021
- Complete nutrition in a drought: What Yara learned in 2021 - November 18, 2021

FARMER-FOCUSED EVENTS

Farmers get a hands-on learning experience with events designed specifically for in-field interactive demonstrations. Discovery Farm has hosted a variety of field days, learning clinics and workshops that allow the farmer to see first-hand the latest innovation that will benefit their farming practice.

- Discovery Farm VIP Experience: June 23 & 24 and July 20-23
- The Discovery Farm VIP Experience was designed to connect Canadian farmers with practical ag solutions amid a pandemic year through safely guided, small-scale tours. Farmers took in one full day of networking, prizes and exclusive programming while enjoying fun, interactive stations with industry partners.
- Vaderstad Product Launch: July 12-16
- AgSmart Panel: August 9 & 10
- Livestock Days: August 20 & 21
- Canadian Foodgrains Bank: September 2

Tours What's happening in the dirt at Discovery Farm? Those who joined us for a tour this growing season were able to find out. Our team hosted small-scale guided tours that allowed researchers, agronomists and other industry stakeholders to ask questions one-on-one and see our field projects up close in a personalized manner.

- Keesekoose Site Tour: August 3
- Stakeholder Day: August 17
- University and Industry Consortium: October 5

Our Social Network

584
FOLLOWERS

33K
POST IMPRESSIONS

505
PAGE LIKES

15.3K
POST REACH

TOP POSTS

- AgExpert Video Topics: Entering and Tracking Inputs
- Saskatchewan Ag Month: Meet Jordan and Jennifer Lindgren
- Meet our summer students Luke and Brooklyn
- Discovery Farm VIP Experience promotional video
- METOS contest winner from Discovery Farm VIP Experience

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Our Partners

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