SASKATCHEWAN pulse Growers

SPG Applied Research & Demonstration Report Format

2023 Final Report
for the
Saskatchewan Pulse Crop Development Board

Project Title: Biological Enhancement in Pulses
(Project #AP-2316a)

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1. **Project Code (as is in contract):** AP-2316a.

2. **Project Title:** Biological enhancement in pulses.

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5. **Introduction**

Approximately a decade ago, the Canadian Food Inspection Agency (CFIA) allowed changes to the registration process for biological products. Prior to this change, companies were required to conduct at least two years' worth of field testing to scientifically prove that the product performed to its intended claim (i.e. biological nitrogen fixation, plant growth promotion, phosphorus solubilization) to obtain registration. This system gave producers confidence that the product would provide its advertised benefit(s). With the changes that occurred, proof of efficacy is no longer required, and products can be registered for sale as long as they meet human safety requirements. Consequently, a high number of products have entered the market place with performance claims that may or may not be achievable. Further, inoculant formulations are no longer comprised solely of *rhizobium* species for symbiotic nitrogen-fixation. The industry has moved to add components to their inoculant

formulations, including plant growth promoting rhizobacteria, lipochitooligosaccharides, phosphate solubilizing, mycorrhizal fungi and biological fungicides. Producers have experienced this deluge of products, as anyone attending popular trade shows like the Crop Production Show or Ag In Motion can attest. There is limited unbiased public information for growers on the performance of these products in the field compared to regular granular rhizobial products.

This demonstration does not intend to prove or disprove product efficacy but compares all the granular products available to growers. Yield will be assessed, but product response may be lacking, not from efficacy, but rather from non-occurrence of conditions expected for a result. For example, if diseases are not present, the lack of a disease suppression inoculant would not be unexpected. If soils are high in phosphorous, there may not be a response to the phosphate-solubilizing biologicals. However, of high relevance is to offer Saskatchewan agricultural producers the opportunity to witness plant growth and development in response to these products at test locations. It provides an opportunity to exchange information and knowledge between primary producers and Agri-ARM investigators/SPG – which is mutually beneficial.

6. Objective(s) or purpose of the project

The objective of this study is to provide a side-by-side comparison of biological treatments that promote an agronomic improvement in the growth of pulse crops. Its purpose is to:

1. Evaluate granular formulations of biological containing pulse inoculants,
2. Allow producers the opportunity to view the selected growth-enhancing product in side-by-side comparisons and,
3. Be a stage for information exchange concerning biological supplements.

7. Materials and Methods

Field trials were established at six locations within the major grain producing regions in Saskatchewan. Two sites were in the Brown soil zone (WCA-Swift Current, ICDC-Outlook), one trial in the Dark Brown soil zone (WARC-Scott) and four locations were in the Black soil zone (NARF-Melfort, ECRF-Yorkton, IHARF-Indian Head, CLC-Prince Albert). The ICDC-Outlook location was irrigated, all other locations were conducted under dryland production.

All trials were established in a randomized complete block design with four replications. Seeding equipment and general crop management varied across locations, depending on equipment and other factors (i.e., test crop, environment). The plots were seeded into cereal stubble. Trials were seeded between May 5 and May 25, 2023. Supplemental fertilizer was applied according to soil test recommendations. Weeds were controlled using a combination of pre-emergent and in-crop herbicides. In-crop fungicides and/or insecticides were applied at some locations. Similarly, some locations utilized pre-harvest desiccation products for harvest management. All trials were harvested between August 8 and August 18, 2023.

Treatment inoculant products, their component organisms and technology/mode of action are shown in Table 1.

Table 1. Granular pulse inoculation products evaluated in 2023.

Trt#	Product	Company	Active Microorganism	Technology*

1	Control			
2	AgTIV® Thrive	Premier Tech (Taurus)	*R. leguminosarum* + *Glomus intraradices*	R + MF
3	Cell-Tech® Pea/Lentil	Nexus BioAg	*R. leguminosarum*	R
4	AgTIV® Fuel G	Premier Tech (Taurus)	*R. leguminosarum*	R
5	Nodulator® Duo SCG	BASF	*R. leguminosarum* + *Basillus subtilis*	R + GP
6	Primo GX2 Pulse	Verdisian	*R. leguminosarum* + *Azospirilium*	R + PGPR
7	Launcher	BrettYoung	*R. leguminosarum*	R
8	TagTeam® BioniQ®	Novozymes	*R. leguminosarum* + *Penicillium bilaiae* + *Basillus amyloliquefaciens* + *Trichoderma virens* + lipochitooligosaccharide	R + P + PGPR + LCO
9	LALFIX Start	Lallemand Plant Care	*Rhizobium leguminosarum biovar viciae* + *Mezorhizobium cicero* + *Bacillus velezensis*	R + GP
10	BOS NutriAg	NutriAG	*Rhizobium leguminosarumbiovar viceae* + *Pseudomonas*	R + PGPR+ GP

*R = rhizobium for nitrogen fixation; GP = growth promotion; PGPR = plant growth promoting rhizobacteria; MF = mycorrhizae fungi; P = phosphate solubilizer; LCO = signal molecule

All inoculant products were applied in-furrow at the time of seeding at the manufacturer's recommended rate of application. Trials located at IHARF-Indian Head, WARC-Scott and WCA-Swift Current were seeded with CDC Impulse, a small red lentil. Remaining trials were seeded with the Yellow field pea variety AAC Profit except at the CLC-Prince Albert location which was seeded with the Yellow pea variety CDC Spectrum.

Data were collected over the course of the growing season and from the harvested grain samples. Plant height measurements were obtained from random plants within plots post-flower. Biomass samples were collected by collecting above-ground plant growth from two 1m lengths of differing rows from both the front and back of each plot at early pod-fill growth stage. Canopy cover, defined by the % of the soil surface covered by vegetation, was obtained utilizing the Canopea app developed by Oklahoma State University. Canopy cover observations were conducted at herbicide application timing (3 node) and again at fungicide timing application (R2). Seed protein contents and seed size determinations were obtained from harvest grain samples.

Mean monthly temperatures and total precipitation amounts were compiled from the nearest Environment and Climate Change Canada or privately owned weather stations.

Selected agronomic information and dates of operations for individual trials are provided in Table 3 in the Appendix.

8. Results & Discussion

Weather

Mean monthly temperatures and precipitation amounts for each location are presented relative to the long-term (30 years) averages for the 2021 growing season (May-August) in Tables 2 and 3, respectively.

Table 2. Mean monthly temperatures along with long-term (30 years) averages for the 2023 growing season at IHARF (Indian Head), NARF (Melfort), ICDC (Outlook), CLC (Prince Albert), WARC (Scott), WCA (Swift Current), and ECRF (Yorkton), Saskatchewan.

Location					
Year	**May**	**June**	**July**	**August**	**May-Aug**
	---------- Mean Temperature (°C) ----------				
IHARF (2023)	14.0	19.4	16.7	17.7	17.0 (+1.4)
Long term average	10.8	15.8	18.2	17.4	15.6
NARF (2023)	14.1	19.2	16.9	17.3	16.9 (+1.7)
Long term average	10.7	15.9	17.5	16.8	15.2
ICDC (2023)	15.2	19.5	18.5	18.7	18.0 (+1.9)
Long term average	11.5	16.1	18.9	18.0	16.1
CLC (2023)	14.4	18.8	16.6	17.1	16.7 (+1.6)
Long term average	10.4	15.3	18.0	16.7	15.1
WARC (2023)	14.9	17.2	17.1	17.4	16.7 (+1.9)
Long term average	10.8	14.8	17.3	16.3	14.8
WCA (2023)	14.8	17.7	18.4	18.8	17.4 (1.6)
Long term average	11.0	15.7	18.4	17.9	15.8
ECRF (2023)	13.8	19.7	16.7	17.8	17.0 (+1.8)
Long term average	10.4	15.5	17.9	17.1	15.2

Overall, the 2023 growing season was considerably warmer than the long-term average over the growing season. Across all locations mean growing season temperatures were 111% higher than historic averages. Precipitation amounts were below average at all locations; however, the severity of the drought varied from location to location. Paradoxically the WCA (Swift Current) location, historically the region receiving the least annual precipitation, received the most in 2023. This

location also was the closest to achieving historic means. The ICDC location received the least natural precipitation at 46% of historic however, it obtained an additional 279 mm of irrigation water which off-set the severity of the drought. Black soil zone locations on the eastern portion of Saskatchewan (IHARF, NARF, ECRF), typically those receiving the greatest precipitation, were among the driest in 2023. Each of these sites received ≤ 50% of historic precipitation.

Table 3. Mean monthly precipitation amounts along with long-term (30 years) averages for the 2023 growing season at IHARF (Indian Head), NARF (Melfort), ICDC (Outlook), CLC (Prince Albert), WARC (Scott), WCA (Swift Current), and ECRF (Yorkton), Saskatchewan.

Location Year	**May**	**June**	**July**	**August**	**May-Aug**
	---------- Total Precipitation (mm) ----------				
IHARF (2023)	12.9	49.6	15.9	40.8	119 (49%)
Long term average	51.8	77.4	63.8	51.2	244
NARF (2023)	17.9	26.4	16.4	50.0	111 (49%)
Long term average	42.9	54.3	76.7	52.4	226
ICDC (2023)	17.2	15.3	15.5	46.6	95 (46%)
Long term average	42.6	63.9	56.1	42.8	205
Irrigation amounts	-	117	120	43	279
CLC (2023)	22.8	52.8	40.8	51.2	168 (67%)
Long term average	44.7	68.6	76.6	61.6	252
WARC (2023)	16.6	81.1	29.7	31.7	159 (70%)
Long term average	38.9	69.7	69.4	48.7	227
WCA (2023)	41.0	32.9	63.3*	42.1	179 (95%)
Long term average	42.1	66.1	44.0	35.4	188

ECRF (2023)	16.8	67.9	18.0	33.3	136 (50%)
Long term average	51.3	80.1	78.2	62.2	272

Soil Testing Results

Soil test results for each location are summarized in Table 4. Supplemental fertilizer was applied according to soil test recommendations as to not limit yield. Nitrogen (N) fertilizer was applied at some locations, generally being provided as a component of other macronutrient fertilizer sources. Soil nitrate nitrogen (NO_3-N) was generally low at the majority of sites such that soil N levels would not inhibit or negate biological N-fixation from *R. leguminosarum* within the granular treatment products. Soil N levels at the CLC location were at levels approaching those that might limit biological N-fixation during the early portion of the growing season.

Table 4. Selected soil test analyses result at IHARF (Indian Head), NARF (Melfort), ICDC (Outlook), CLC (Prince Albert), WARC (Scott), WCA (Swift Current), and ECRF (Yorkton) in 2023. Unless otherwise indicated, all measurements represent the 0-15 cm (0-6 inches) soil profile.

Parameter	IHARF	NARF	ICDC	CLC	WARC	WCA	ECRF
pH	8.1	6.6	7.9	5.7	6.5	6.6	6.8
Organic Matter (%)	4.3	7.8	2.6	5.2	3.3	2.6	7.8
CEC (meq)	49.3	-	22.2	-	15.2	18.9	27.4
NO_3-N (kg/ha) [a]	12.3	37.4	11.2	45.2	24.6	25.7	37.0
Olsen-P (ppm)	3.0	14.0	5.0	7.0	13.0	10.0	16.0
K (ppm)	444.0	401.0	277.0	193.0	205.0	224.0	353.0
kg S/ha (kg/ha) [a]	44.8	80.0	118.0	51.5	38.0	55.0	51.5

Results Across Locations

Individual location data analyses for observations obtained are presented in Tables 5-11. Typically, a discussion for a final report would include the results of combined site statistical analyses and, possibly, a review of individual location results. For the purposes of this final report, data were not combined across locations primarily due to the consistency of results obtained at all locations.

Results obtained within Tables 5-11 are striking in their uniformity. No statistical difference occurred for any agronomic measurement gathered at any location! Yields obtained were lower than would be historically obtained at most test locations. This is certainly the case for lentil yields at WCA-Swift Current which was impacted by hail damage in early July. Pea yields at CLC-Prince Albert, WARC-Melfort, ECRF-Yorkton and IHARF-Indian Head were lower than typical, but surprisingly good considering the extreme drought experienced. Lentil yields at WARC-Scott were very good and irrigated pea yield at ICDC-Outlook, while lower then normal, were certainly acceptable. At no location did treatment granular biological enhancement products provide a yield enhancement. Some of these biologicals had microorganisms intended to enhance crop growth which this study failed to agronomically identify or confirm. All products tested contained *R. leguminosarum*, and although quantification of biological N-fixation was beyond the scope of this study, results suggest

N-fixation had no influence on elevating seed yield. Undoubtably results obtained for all agronomic observations were influenced, to some degree, by the extreme weather and poor growing conditions experienced in 2023.

For lentil yields at WARC-Scott and pea yield at ICDC-Outlook natural rainfall and/or irrigation produced acceptable yields yet without any apparent benefit from treatment biological products. Soil available NO3-N was low at both sites and in-season mineralization improbable to release sufficient N for the yields obtained.

As indicated, no biological inoculant had a statistical influence on plant in-season biomass, canopy cover, plant height, plant maturity and seed protein and seed size at any location.

All trial sites used within this study have an extended history of pulse production, either with field pea and/or lentil. *R. leguminosarum* bacteria are able to infect pea, lentil and faba bean and provide biological N-fixation to occur, it is conceivable, that with extended pulse inclusion within rotations, the background endemic "indigenous" levels of *R. leguminosarum* in these soils is now high. Consequently, endemic rhizobia populations might result in diminishing yield responses to annual inoculant applications. It appears there is growing evidence supporting this proposition. In an Alberta study Lopetinski et. al. (2014) failed to obtain a faba bean yield response to inoculation in a six site-year study. In field pea McKenzie et. al., 2001 found an inoculant yield response in field pea at only 9 of 22 sites in Alberta. Vessey (2004) in a review of inoculant applications in the Northern Great Plains found positive yield responses occur from one third to one half the time. Hnatowich et. al. (2018) found that faba bean inoculation resulted in a yield enhancement in only 2 of 15 trials. Although these results suggest that indigenous populations of *R. leguminosarum* may now be high, through an extended history of pulse production in Saskatchewan, no commercial test is presently available to measure soil rhizobium levels and predict the likelihood of an inoculation response. Consequently, agronomists will be averse to recommending producers forego fresh inoculant application to pulses. However, consideration could be made to suggest producers seek to utilize lower cost rhizobia inoculant formulations compared to higher priced granular formulations. Results of this study also suggest that a multi-year, multi-location evaluation of inoculant benefits within Saskatchewan is warranted.

Table 5. Main effect means for Yield, plant biomass (dry matter), protein, thousand kernel weight, Canopy cover (using Canopea app.), Plant height and days to maturity for different biological treatments in pea at **ECRF (Yorkton)**. Values within a column followed by the same letter do not significantly differ (Least Significant Difference, P ≤ 0.05).

Treatment	**Yield**	**Biomass**	**Protein**	**TKW**	**Canopy cover1**	**Canopy cover2**	**Height**	**Maturity**
	(kg/ha)	*(kg/ha)*	*(%)*	*(g/1000 seeds)*	*R/G and B/G ratios[2]*		*(cm)*	*(days)*
Control[1]	3684 a	7157 a	20.4 a	250.5 a	-	58.0 a	54.5 a	81.8 a
AgTIV® Thrive	3792 a	6960 a	20.6 b	252.1 a	-	57.4 a	52.1 a	80.8 a
Cell-Tech®	4099 a	8153 a	20.3 a	251.4 a	-	62.5 a	58.1 a	83.3 a
AgTIV® Fuel G	3874 a	7665 a	20.3 a	248.0 a	-	59.1 a	56.0 a	81.8 a
Nodulator® Duo SCG	3755 a	6956 a	20.4 a	254.0 a	-	57.2 a	54.6 a	82.8 a
Primo GX2 Pulse	3951 a	8178 a	20.4 a	255.9 a	-	57.4 a	53.8 a	82.5 a
Launcher	4019 a	8112 a	20.4 a	247.1 a	-	59.9 a	54.8 a	82.5 a
TagTeam® BioniQ®	3813 a	6525 a	20.4 a	246.1 a	-	58.8 a	52.6 a	82.3 a
LALFIX Start	3419 a	6525 a	20.3 a	246.3 a	-	54.7 a	53.6 a	81.3 a
BOS NutriAg	3654 a	7058 a	20.4 a	246.2 a	-	55.0 a	52.1 a	82.3 a
P-value	NS	NS	0.052	NS		NS	NS	NS
CV	11.45	12.76	0.56	2.12		7.9	9.5	0.96

NS: nonsignificant

[1]Control: no inoculant applied at seeding.

[2]R/G: red to green & B/G: blue to green.

Canopy cover1: recorded at three nodes stage.

Canopy cover2: recorded at R2 stage.

Table 6. Main effect means for Yield, plant biomass (dry matter), protein, thousand kernel weight, Canopy cover (using Canopea app.), Plant height and days to maturity for different biological treatments in lentil at **WARC (Scott)**. Values within a column followed by the same letter do not significantly differ (Least Significant Difference, P ≤ 0.05).

Treatment	**Yield**	**Biomass**	**Protein**	**TKW**	**Canopy cover1**	**Canopy cover2**	**Height**	**Maturity**
	(kg/ha)	*(kg/ha)*	*(%)*	*(g/1000 seeds)*	*R/G and B/G ratios*[2]		*(cm)*	*(days)*
Control[1]	3431 a	2523 a	24.4	53.9 a	11.2 a	90.0 a	40.2 a	81 a
AgTIV® Thrive	3464 a	2351 a	24.7	53.8 a	10.6 a	88.6 a	40.3 a	81 a
Cell-Tech®	3535 a	2574 a	24.7	54.3 a	11.1 a	87.8 a	40.4 a	81 a
AgTIV® Fuel G	3471 a	2547 a	25.0	54.0 a	10.4 a	89.5 a	40.9 a	81 a
Nodulator® Duo SCG	3424 a	2305 a	24.6	53.1 a	10.9 a	84.8 a	40.1 a	81 a
Primo GX2 Pulse	3348 a	2461 a	24.9	53.8 a	10.9 a	82.3 a	40.4 a	81 a
Launcher	3434 a	2454 a	24.3	53.7 a	9.0 a	86.0 a	40.6 a	81 a
TagTeam® BioniQ®	3491 a	2429 a	24.7	53.9 a	10.1 a	87.0 a	38.9 a	81 a
LALFIX Start	3546 a	2502 a	24.8	53.8 a	9.5 a	86.9 a	41.4 a	81 a
BOS NutriAg	3393 a	2396 a	24.9	54.3 a	9.8 a	84.0 a	40.0 a	81 a
P-value	NS	NS	NS	NS	NS	NS	NS	NS
CV	6.12	7.39	2.23	1.14	13.34	4.18	2.66	0.35

NS: nonsignificant

[1]Control: no inoculant applied at seeding.

[2]R/G: red to green & B/G: blue to green.

Canopy cover1: recorded at three nodes stage.

Canopy cover2: recorded at R2 stage.

Table 7. Main effect means for Yield, plant biomass (dry matter), protein, thousand kernel weight, Canopy cover (using Canopea app.), Plant height and days to maturity for different biological treatments in lentil at **WCA (Swift Current)**. Values within a column followed by the same letter do not significantly differ (Least Significant Difference, P ≤ 0.05).

Treatment	**Yield**	**Biomass**	**Protein**	**TKW**	**Canopy cover1**	**Canopy cover2**	**Height**	**Maturity**
	(kg/ha)	*(kg/ha)*	*(%)*	*(g/1000 seeds)*	*R/G and B/G ratios[2]*		*(cm)*	*(days)*
Control[1]	766 a	1909 a	27.3 a	46.1 a	-	-	29.6 a	74 a
AgTIV® Thrive	799 a	1986 a	27.0 a	46.0 a	-	-	29.4 a	74 a
Cell-Tech®	772 a	2010 a	27.4 a	46.5 a	-	-	29.5 a	75 a
AgTIV® Fuel G	844 a	1790 a	26.9 a	45.8 a	-	-	29.9 a	74 a
Nodulator® Duo SCG	801 a	1623 a	27.3 a	46.9 a	-	-	28.9 a	75 a
Primo GX2 Pulse	891 a	2058 a	27.7 a	46.1 a	-	-	30.1 a	74 a
Launcher	785 a	1998 a	26.6 a	44.3 a	-	-	29.3 a	74 a
TagTeam® BioniQ®	883 a	1676 a	27.4 a	46.5 a	-	-	31.6 a	75 a
LALFIX Start	863 a	2219 a	27.9 a	46.2 a	-	-	30.4 a	74 a
BOS NutriAg	923 a	1861 a	27.3 a	47.6 a	-	-	30.5 a	74 a
P-value	NS	NS	NS	NS			NS	NS
CV	13.3	17.4	2.0	1.9			6.0	1.0

NS: nonsignificant

[1]Control: no inoculant applied at seeding.

[2]R/G: red to green & B/G: blue to green.

Canopy cover1: recorded at three nodes stage.

Canopy cover2: recorded at R2 stage.

Table 8. Main effect means for Yield, plant biomass (dry matter), protein, thousand kernel weight, Canopy cover (using Canopea app.), Plant height and days to maturity for different biological treatments in pea at **CLC (Prince Albert)**. Values within a column followed by the same letter do not significantly differ (Least Significant Difference, P ≤ 0.05).

Treatment	**Yield**	**Biomass**	**Protein**	**TKW**	**Canopy cover1**	**Canopy cover2**	**Height**	**Maturity**
	(Kg/ha)	*(kg/ha)*	*(%)*	*(g/1000 seeds)*	*R/G and B/G ratios[2]*		*(cm)*	*(days)*
Control[1]	2469 a		21.6 a	253.0 a	27.7 a	82.0 a	46.6 a	76
AgTIV® Thrive	1995 a		21.8 a	251.6 a	26.1 a	78.6 a	46.5 a	76
Cell-Tech®	2454 a		21.5 a	254.2 a	27.4 a	82.2 a	47.9 a	75
AgTIV® Fuel G	2723 a		21.9 a	249.9 a	27.0 a	82.1 a	49.3 a	75
Nodulator® Duo SCG	2418 a		21.3 a	250.4 a	25.1 a	79.3 a	45.2 a	75
Primo GX2 Pulse	2919 a		21.3 a	251.8 a	26.1 a	77.7 a	44.2 a	76
Launcher	2375 a		21.3 a	250.1 a	24.4 a	77.9 a	42.9 a	78
TagTeam® BioniQ®	2921 a		21.4 a	250.0 a	26.2 a	80.5 a	48.2 a	78
LALFIX Start	2506 a		21.2 a	250.7 a	21.6 a	80.6 a	43.7 a	75
BOS NutriAg	2615 a		21.2 a	251.3 a	25.9 a	78.5 a	44.6 a	76
P-value	NS		NS	NS	NS	NS	NS	-
CV	22.0		2.7	2.1	14.7	5.7	10.3	-

NS: nonsignificant

[1]Control: no inoculant applied at seeding

[2]R/G: red to green & B/G: blue to green.

Canopy cover1: recorded at three nodes stage.

Canopy cover2: recorded at R2 stage.

Table 9. Main effect means for Yield, plant biomass (dry matter), protein, thousand kernel weight, Canopy cover (using Canopea app.), Plant height and days to maturity for different biological treatments in pea at **NARF (Melfort)**. Values within a column followed by the same letter do not significantly differ (Least Significant Difference, P ≤ 0.05).

Treatment	**Yield**	**Biomass**	**Protein**	**TKW**	**Canopy cover1**	**Canopy cover2**	**Height**	**Maturity**
	(Kg/ha)	*(kg/ha)*	*(%)*	*(g/1000 seeds)*	*R/G and B/G ratios[2]*		*(cm)*	*(days)*
Control[1]	2805 a	7002 a	20.6 a	238.6 a	15.9 a	70.3 a	51.6 a	76 a
AgTIV® Thrive	2899 a	6576 a	20.5 a	239.8 a	12.8 a	66.5 a	53.5 a	76 a
Cell-Tech®	2907 a	6622 a	20.5 a	239.4 a	13.0 a	68.2 a	53.4 a	76 a
AgTIV® Fuel G	2843 a	7036 a	20.6 a	238.5 a	14.5 a	66.6 a	50.5 a	76 a
Nodulator® Duo SCG	2901 a	6881 a	20.6 a	238.6 a	14.2 a	68.7 a	54.6 a	76 a
Primo GX2 Pulse	2946 a	7414 a	20.3 a	239.9 a	15.1 a	69.8 a	55.4 a	76 a
Launcher	3239 a	6735 a	20.4 a	239.9 a	13.1 a	70.5 a	51.4 a	76 a
TagTeam® BioniQ®	2961 a	6699 a	20.4 a	239.8 a	13.2 a	69.5 a	55.4 a	76 a
LALFIX Start	2856 a	6409 a	20.3 a	239.9 a	13.7 a	65.3 a	53.8 a	76 a
BOS NutriAg	2999 a	5738 a	20.4 a	240.2 a	13.0 a	68.4 a	54.4 a	76 a
P-value	NS	NS	NS	NS	NS	NS	NS	-
CV	8.9	9.9	0.9	1.1	12.6	6.5	7.3	-

NS: nonsignificant

[1]Control: no inoculant applied at seeding

[2]R/G: red to green & B/G: blue to green.

Table 10. Main effect means for Yield, plant biomass (dry matter), protein, thousand kernel weight, Canopy cover (using Canopea app.), Plant height and days to maturity for different biological treatments in lentil at **IHARF (Indian Head)**. Values within a column followed by the same letter do not significantly differ (Least Significant Difference, P ≤ 0.05).

Treatment	**Yield**	**Biomass**	**Protein**	**TKW**	**Canopy cover1**	**Canopy cover2**	**Height**	**Maturity**
	(Kg/ha)	*(kg/ha)*	*(%)*	*(g/1000 seeds)*	*R/G and B/G ratios*[2]		*(cm)*	*(days)*
Control[1]	2645 a	3830 a	24.6 a	53.3 a	32.4 a	61.7 a	37.6 a	80 a
AgTIV® Thrive	2650 a	3706 a	24.9 a	51.6 a	32.5 a	61.1 a	37.3 a	80 a
Cell-Tech®	2785 a	3796 a	25.0 a	52.5 a	32.9 a	60.9 a	37.2 a	81 a
AgTIV® Fuel G	2636 a	3634 a	25.0 a	51.1 a	30.6 a	59.1 a	38.4 a	80 a
Nodulator® Duo SCG	2727 a	3874 a	24.4 a	53.6 a	32.7 a	61.5 a	38.6 a	80 a
Primo GX2 Pulse	2672 a	3853 a	24.5 a	51.4 a	32.9 a	59.3 a	38.3 a	81 a
Launcher	2739 a	3684 a	25.1 a	51.6 a	30.9 a	57.9 a	37.1 a	81 a
TagTeam® BioniQ®	2731 a	3616 a	24.7 a	51.9 a	32.7 a	57.4 a	37.0 a	81 a
LALFIX Start	2733 a	3580 a	24.9 a	52.8 a	33.2 a	59.0 a	38.8 a	81 a
BOS NutriAg	2716 a	3576 a	24.8 a	51.3 a	31.9 a	61.1 a	37.5 a	81 a
P-value	NS	NS	NS	NS	NS	NS	NS	NS
CV	4.1	8.8	1.9	3.4	13.7	8.1	3.8	0.6

NS: nonsignificant

[1]Control: no inoculant applied at seeding.

[2]R/G: red to green & B/G: blue to green.

Canopy cover1: recorded at three nodes stage.

Canopy cover2: recorded at R2 stage.

Table 11. Main effect means for Yield, plant biomass (dry matter), protein, thousand kernel weight, Canopy cover (using Canopea app.), Plant height and days to maturity for different biological treatments in pea at **ICDC (Outlook)**. Values within a column followed by the same letter do not significantly differ (Least Significant Difference, P ≤ 0.05).

Treatment	**Yield**	**Dry Matter**	**Protein**	**TKW**	**Canopy cover1**	**Canopy cover2**	**Height**	**Maturity**
	(kg/ha)	*(kg/ha)*	*(%)*	*(g/1000 seeds)*	*R/G and B/G ratios*[2]		*(cm)*	*(days)*
Control[1]	5608 a	8868 a	23.3 a	225.6 a	30.6 a	92.5 a	83.4 a	95
AgTIV® Thrive	5511 a	9272 a	23.2 a	206.9 a	29.8 a	94.2 a	80.8 a	95
Cell-Tech®	5451 a	10138 a	23.6 a	201.4 a	31.2 a	92.9 a	84.8 a	95
AgTIV® Fuel G	5504 a	7254 a	23.3 a	198.7 a	31.3 a	93.4 a	86.9 a	95
Nodulator® Duo SCG	5266 a	9380 a	23.3 a	207.1 a	28.3 a	92.6 a	84.6 a	95
Primo GX2 Pulse	5483 a	8356 a	23.2 a	214.2 a	29.0 a	93.1 a	92.3 a	95
Launcher	5486 a	9518 a	23.0 a	203.0 a	31.7 a	92.0 a	94.8 a	95
TagTeam® BioniQ®	5468 a	8514 a	23.0 a	185.5 a	27.2 a	92.3 a	89.3 a	95
LALFIX Start	5704 a	9626 a	23.3 a	200.9 a	30.7 a	93.1 a	89.0 a	95
BOS NutriAg	5623 a	10502 a	23.0 a	198.2 a	32.6 a	92.9 a	89.8 a	95
P-value	NS	NS	NS	NS	NS	NS	NS	-
CV	4.0	15.6	1.5	7.4	15.1	1.9	7.9	-

NS: nonsignificant

[1]Control: no inoculant applied at seeding

[2]R/G: red to green & B/G: blue to green.

Canopy cover1: recorded at three node stage.

Canopy cover2: recorded at R2 stage.

9. Economic and Practical Implications For growers

This demonstration does not intend to prove or disprove product efficacy; therefore, no economical assessment of results is contemplated. Nor does the short-term nature of the study offer the development of practical recommendations.

10. Conclusions & Recommendations

Overall, environmental conditions were adverse for pea/lentil production due to widespread drought and heat stress for the majority of trial locations. These conditions certainly contributed to the lack of treatment response obtained. However, lack of treatment response should not solely be attributed to contrary environmental conditions. It is reasonable to suggest that agronomic observations obtained (e.g. yield, biomass) at several location should have seen a benefit due to the application of rhizobium carrying inoculants. Soil testing procedures indicated insufficient NO_3-N levels to achieve the yields obtained. Nor with the prevailing dry conditions experienced would in-season mineralization supply the necessary N required for achieved seed yields.

It's hypothesized that the lack of yield enhancement from the biological inoculants included in the study could be due to high indigenous soil populations of *R. leguminosarum* achieved from previous pulse production.

11. Future research

The absence of responses to biological enhancing products obtained suggest a longer-term evaluation of inoculant responses in pulses across Saskatchewan should be considered. Particular focus should be on the *R. leguminosarum* activity of inoculants.

12. Technology transfer activities

The trial was highlighted by Meagan Reed at the NARF & AAFC Joint Annual Field Day at the Melfort Research Farm to 70 attendees on July 26th, 2023. At WCA, the trial site was toured by our WCA directors and with SPG Agronomy Manager (Meagen Reed and Michael Brown)

13. Funding contributions – acknowledge partners and contributors to the project.

Financial support for the project was provided exclusively by the Saskatchewan Pulse Crop Development Board and greatly acknowledged by the Agri-ARM affiliates participating in the study. Acknowledgement is also given by those Agri-ARM organizations with working relationships with Agriculture and Agri-Food Canada.

14. Appendices:

Table 3. Selected agronomic information and dates of operations for the 2023 biological enhancements in pulses (pea and lentil) trials at IHARF (Indian Head), NARF (Melfort), ICDC (Outlook), CLC (Prince Albert), WARC (Scott), WCA (Swift Current), and SERF (Yorkton), Saskatchewan.

Activity	IHARF	NARF	ICDC	CLC	WARC	WCA[y]	ECRF
Previous Crop	Wheat	Wheat	Wheat	Oat	Wheat	Wheat	Wheat
Pre-Emergent Herbicide	May 11 (glyphosate)	May 16 (glyphosate)	April 28 (EDGE MicroActiv)	May 12 (glyphosate)	May 08 (glyphosate)	May 12 (glyphosate)	-
Seeding Date	May 10	May 11	May 15	May 27	May 05	May 17	May 11 & 12
kg N-P_2O_5-K_2O-S/ha [x]	28-40-20-20	26-56-0-17	2-20-0-0	9-42-0-0	7-32-0-0	11-52-0-0	6-30-0-0
Variety (crop)	CDC Impulse (small red lentil)	AAC Profit (yellow pea)	AAC Profit (yellow pea)	CDC Spectrum (green pea)	CDC Impulse (small red lentil)	CDC Impulse (small red lentil)	AAC Profit (yellow pea)
Canopy measurements 1	June 14	June 05	June 14	June 14	May 26	n/a	n/a
Canopy measurements 2	June 23	June 27	July 05	July 05	June 28	n/a	June 29
Biomass	July 10	July 19	July 14	August 10	July 24	July 10	July 25
In-crop Herbicide 1	June 06 (Odyssey NXT + Caziva Ultra Q + Merge)	June 10 (Viper)	June 07 (Viper)	June 08 (Poast Ultra)	June 02 (Solo Ultra Q)	June 07 (Solo + Poast)	June 05 (Viper)
In-crop Herbicide 2	June 09 (Centurion)	-	-	-	-	-	June 07 (Centurion + Amigo + AMS)
In-crop Herbicide 3	-	-	-	-	-	-	-
Fungicide Date	June 26 (Dyax)	-	-	-	June 26 (Dyax)	June 22 (Bravo ZNC)	June 27 (Dyax)
Insecticide 1	June 06	June 23	May 30	-	July 07	July 01	-

(grasshoppers)	(Decis)	(Decis)	(Matador)		(Decis)	(Decis)	
Insecticide 2 (grasshoppers)	June 22 (Coregen)	-	June 12 (Matador)	-	-	-	-
Insecticide 3 (grasshoppers)	July 21 (Coregen)	-	-	-	-	-	-
Pre-harvest Herbicide	August 04 (glyphosate) August (Reglone)	-	-	August 08 (Reglone)	August 04 (Reglone)	July 31 (Reglone)	-
Harvest Date	August 17	August 08	August 18	August 18	August 08	Aug-16	August 14

n/a - observations not recorded

[x] Fertility information only includes nutrients provided by phosphorus, potassium, and/or sulfur products applied (i.e., do not include soil residual nutrients)

[Y] Hailstorm at WCA (Swift Current) on July 22, 2023, resulted in an estimated 10-40% seed yield loss.

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