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1. **Project Code** (as per contract): AP-2316a.
2. **Project Title:** Biological enhancement in pulses.
3. **Introduction** (background and rationale for the project – include references to original research projects where necessary):

Over the past decade, the landscape of biological product registration in Canada has shifted significantly. Previously, companies were required to conduct at least two years of field testing to demonstrate product efficacy before obtaining registration. However, changes made by the Canadian Food Inspection Agency (CFIA) removed this requirement, allowing products to enter the market based solely on human safety compliance. As a result, an influx of biological treatments with various performance claims—ranging from biological nitrogen fixation to plant growth promotion and phosphorus solubilization—has become available to producers.

Modern inoculant formulations are no longer limited to rhizobium species for symbiotic nitrogen fixation. Instead, they often include additional biological components such as plant growth-promoting rhizobacteria, lipochitooligosaccharides, phosphate-solubilizing microbes, mycorrhizal fungi, and biological fungicides. While these products are widely promoted, independent and unbiased performance data are limited. Growers attending agricultural trade shows frequently encounter these products but lack comprehensive, field-based comparisons to assess their effectiveness under real-world conditions.

This study aims to address this gap by providing a side-by-side comparison of granular biological treatments intended to enhance pulse crop growth. Rather than attempting to prove or disprove product efficacy, this trial focuses on evaluating product performance under typical field conditions, acknowledging that responses may vary based on environmental factors such as soil nutrient levels and disease presence. Beyond yield assessment, this project serves as a platform for Saskatchewan producers to observe plant development firsthand, fostering knowledge exchange between primary producers and agricultural researchers.

4. Objective(s):

Biological products are an increasingly prominent component of pulse crop production, yet independent field evaluations of their effectiveness remain limited. This study provides a comparative assessment of granular biological treatments designed to promote agronomic improvements in pulse crops. The trial evaluates commercially available formulations, including traditional rhizobial inoculants and enhanced biological blends containing plant growth-promoting rhizobacteria, phosphate-solubilizing microbes, and biological fungicides.

The purpose of this project 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.
5. **Materials & Methods** (experimental design, methods used, details of growing season, materials used, sites and site design, statistical analysis used):

The trials were conducted in a randomized complete block design (RCBD) with four replications. All inoculants used in the study were granular and applied in-furrow. Supplemental macronutrients, including phosphorus (P), potassium (K), and sulfur (S), were applied based on soil test recommendations to ensure

optimal nutrient availability. The table below shows the list of products evaluated in this study (Table 1).

Table 1. Table 1. List of treatments (products) evaluated for their effectiveness in improving agronomic performance in pulse crops.

Treatment	Product	Company	Active Microorganism	Technology
1	Control			
2	AgTIV® Thrive	Premier Tech (Taurus)	<i>R. leguminosarum</i> + <i>Glomus intraradices</i>	R + MF
3	Cell-Tech® Pea	Nexus BioAg	<i>R. leguminosarum</i>	R
4	AgTIV® Fuel G	AgTiv	<i>R. leguminosarum</i> (dual strains)	R
5	Nodulator® Duo SCG	BASF	<i>R. leguminosarum</i> + <i>Basillus subtilis</i>	R + GP
6	Primo GX2 Pulse	Verdisian	<i>R. leguminosarum</i> + <i>Azospirillum</i>	R + PGPR
7	Launcher	Brett Young	<i>R. leguminosarum</i>	R
8	TagTeam® BioniQ®	Novozymes	<i>R. leguminosarum</i> + <i>Penicillium bilaiae</i> + <i>Basillus amyloliquefaciens</i> + <i>Trichoderma virens</i> + <i>lipochitooligosaccharide</i>	R + P + PGPR + LCO
9	LALFIX Start	Lallemand Plant Care	<i>Rhizobium leguminosarum biovar viciae</i> + <i>Mezorhizobium cicero</i> + <i>Bacillus velezensis</i>	R + GP
10	BOS NutriAg	NutriAG	<i>Rhizobium leguminosarum biovar viciae</i> + <i>Pseudomonas</i>	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.

Soil samples were initially collected in the spring to assess nutrient levels at depths of 0-15 cm, 15-30 cm, and 30-60 cm, or alternatively at 15-60 cm. Fertilizer was then applied based on the soil test recommendations. During the plant growth phase, data including emergence, plant density, plant height, days to maturity, and canopy development at the 3-node and R2 stages were recorded for each treatment in every plot. At the early seed filling stages, plant biomass was measured by collecting two 1-meter row sections from the front and back of the plot. Days to maturity were recorded as Julian days. Yield was determined by cleaning the seed and adjusting it to 16% for pea and 13% moisture for lentils. Seed protein content was analyzed by ICDC for all cooperating sites, and seed size was assessed by measuring the weight (g) of 1,000 seeds (TKW). Data analysis was conducted using SAS software, applying a randomized complete block design (RCBD) with four replicates. When significant differences were detected, a post-hoc LSD test was performed for mean separation.

6. **Results & Discussion** (results presented and discussed in the context of existing knowledge and relevant literature or comparison to existing recommendations. Detail any major concerns or sources of error. Provide proper statistical significance.):

Results & Discussion

Table 2. ANOVA of treatments by measured variables and locations, Alpha = 0.05.

Measured variable	Source of Variation	P- value							
		Lentil				Pea			
		ISask	IHARF	WCA	WARC	SERF	ECRF	CLC	NARF
Emergence	Treatment	MD	MD	0.02	MD	MD	MD	MD	MD
Height	Treatment	0.56	0.58	0.73	0.98	MD	0.06	M	0.71
Canopy 3-Node stage	Treatment	0.48	0.33	0.02	0.57	MD	0.03	0.5	0.31
Canopy R2 stage	Treatment	0.99	0.22	0.64	0.35	0.24	0.1	0.44	0.82
Plant Density	Treatment	0.67	0.42	0.02	MD	MD	MD	0.2	MD
Maturity	Treatment	NA	0.03	MD	0.12	0.67	0.95	0.11	NA
Dry Weight	Treatment	0.5	0.42	0.65	0.75	0.2	0.9	0.3	0.26
Seed Yield	Treatment	0.83	0.57	0.06	0.04	0.66	0.62	0.57	0.35
Protein	Treatment	0.95	MD	MD	MD	MD	0.008	MD	MD
TKW	Treatment	0.53	0.6	0.63	0.1	0.46	0.13	0.86	0.01

NA: Indicates that there is no variation in the data for the measured variable. (Analysis not applicable).
MD: missing data. Pulse planted: Lentil: ICDC (Outlook), Indian Head (IHARF), Swift Current (WCA) and Scott (WARC); Pea: Redvers (SERF), Yorkton (ECRF), Prince Albert (CLC) and Melfort (NARF).

Emergence

Emergence data was available only for the WCA site, where a statistically significant effect ($P = 0.02$) was observed (Table 1). The mean separation test indicated that inoculant treatments 9 (LALFIX Start) and 6 (Primo GX2 Pulse) had the greatest impact on lentil seedling emergence (Figure 1). This finding aligns with previous studies (Gan et al., 2005), which reported varying responses to microbial inoculants in seedling emergence, depending on the microbial strains and environmental conditions.

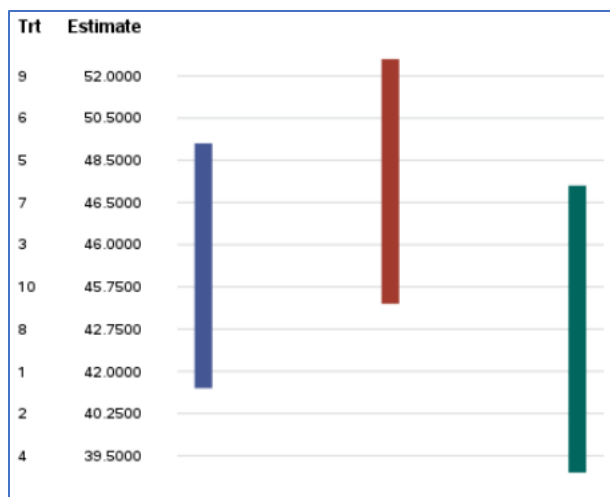


Figure 1. Effect of inoculant treatments on seedling emergence at the Swift Current (WCA) site. Trt: Treatments; Estimate: treatment means. Means covered by the same bar are not significantly different (Alpha = 0.05; LSD = 7.24)

Plant Height

Plant height data did not show any significant differences ($P > 0.05$) across all locations in both lentil and pea (Table 2). While inoculants have been reported to influence plant growth, particularly through enhanced nutrient uptake via plant-microbe interactions (Gan et al., 2005; Laishram et al., 2024), the results of this study indicate no statistically significant differences in plant height. This lack of effect may be attributed to site-specific biotic and/or abiotic factors that likely influenced plant growth more strongly than the microbial inoculants.

Canopy Development (3-Node Stage)

At several locations, the treatments did not significantly affect canopy development at the 3-node stage ($P > 0.05$). However, significant effects were observed in lentils at the WCA site ($P = 0.02$) and in peas at the ECRF site ($P = 0.03$). The mean separation test indicated that treatment 2 (AgTIV® Thrive) promoted early canopy development in both crops at both sites (Figure 2 and 3), likely through enhanced nutrient cycling. At the WCA site, interestingly, treatment 1 (control) showed the lowest canopy development at the 3-node stage, and the other nine treatments had no significant difference among each other (Figure 2).

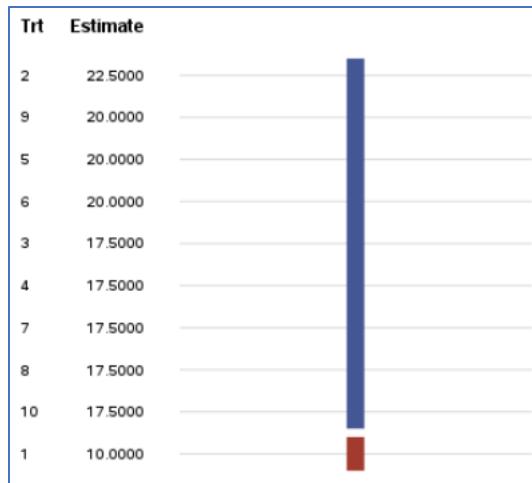


Figure 2. Effect of inoculant treatments on lentil canopy development (3-Node Stage) at the Swift Current (WCA) site. Trt: Treatments; Estimate: treatment means. Means covered by the same bar are not significantly different (Alpha = 0.05; LSD = 5.8).

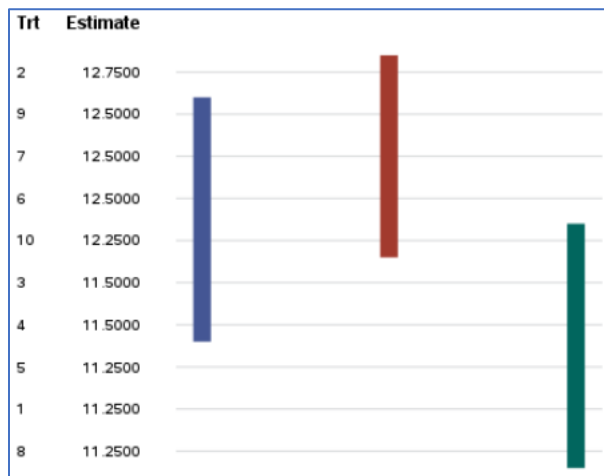


Figure 3. Effect of inoculant treatments on pea canopy development (3-Node Stage) at the Yorkton (ECRF) site. Trt: Treatments; Estimate: treatment means. Means covered by the same bar are not significantly different (Alpha = 0.05; LSD = 1.14).

Canopy Development at R2 Stage

Unlike the 3-node stage, canopy development at the R2 stage showed no significant treatment effects in across all the locations in both crops ($P > 0.05$), Table 2.

Plant Density

Plant density showed a statistically significant effect on lentils at the WCA site ($P = 0.02$) (Table

2). The mean separation test indicated that treatments 9 (LALFIX Start) and 6 (Primo GX2 Pulse) resulted in the highest lentil plant density, with no significant difference compared to treatments 5 (Nodulator® Duo SCG), 7 (Launcher), 3 (Cell-Tech® Pea), and 10 (BOS NutriAg) (Figure 4). However, this effect was not observed at other locations in both lentils and peas ($P > 0.05$).

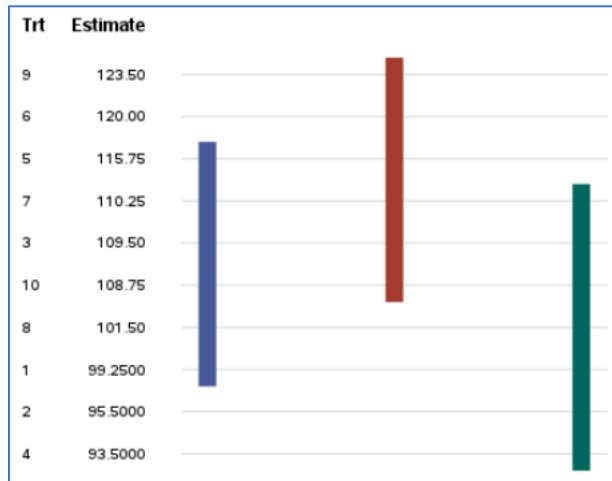


Figure 4. Effect of inoculant treatments on lentil plant density at the Swift Current (WCA) site. Trt: Treatments; Estimate: treatment means. Means covered by the same bar are not significantly different ($\text{Alpha} = 0.05$; $\text{LSD} = 17.4$).

Maturity

Maturity showed significant treatment effects on lentils at IHARF ($P = 0.03$, Table 2). The mean separation test indicated that lentils treated with treatment 8 (TagTeam® BioniQ®) took statistically longer date to maturity. No statistical difference was found when compared to treatments 7 (Launcher), 2 (AgTIV® Thrive), and 4 (AgTIV® Fuel G) (Figure 5).

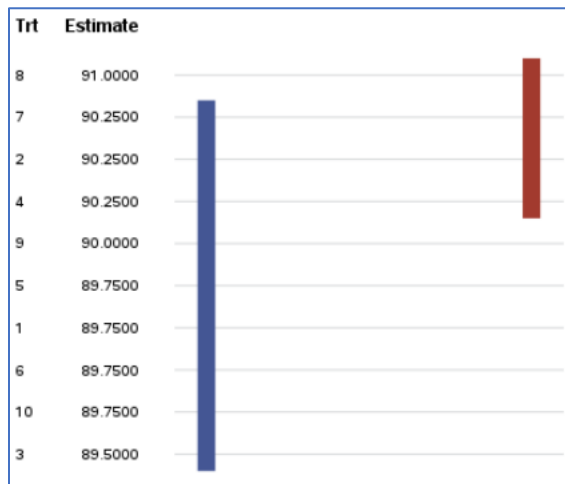


Figure 5. Effect of inoculant treatments date to maturity of lentils at the Indian Head (IHARF) site. Trt: Treatments; Estimate: treatment means. Means covered by the same bar are not significantly different (Alpha = 0.05; LSD = 0.78).

Dry Weight

Dry weight, a key indicator of biomass accumulation, did not show significant treatment effects at any location in both crops ($P > 0.05$) (Table 2). This suggests that the microbial inoculants did not provide notable biomass advantages under the prevailing soil and climatic conditions.

Yield (Kg/ha)

Yield, a critical measure of the economic success of the treatments, did not show significant differences at most locations ($P > 0.05$), except for lentil at WARC ($P = 0.04$, Table 2). The mean separation test indicated that treatments 2 (AgTIV® Thrive), 5 (Nodulator® Duo SCG), and 8 (TagTeam® BioniQ®) resulted in the highest seed yield, while treatment 3 (Cell-Tech® Pea) yielded the lowest compared to all other treatments (Figure 6). At WARC, inoculant treatments led to a significant improvement in lentil yield, likely due to enhanced nutrient uptake facilitated by microbial inoculation, as supported by Cordeiro et al. (2019) and Sign et al. (2018).

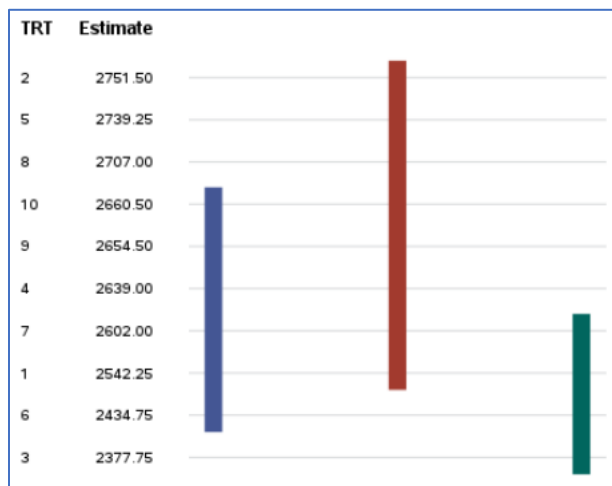


Figure 6. Effect of inoculant treatments on lentil yield at the Scott (WARC) site. Trt: Treatments; Estimate: treatment means. Means covered by the same bar are not significantly different (Alpha = 0.05; LSD = 233.7).

Protein Content

Pea protein content was significantly affected at the ECRF location ($P = 0.008$, Table 2). The mean separation test indicated that treatment 2 (AgTIV® Thrive) resulted in the highest protein content at this site (Figure 7). This suggests that microbial treatments can enhance the nutritional quality

of peas, possibly through improved nitrogen fixation or nutrient uptake (Granada Agudelo et al., 2023).

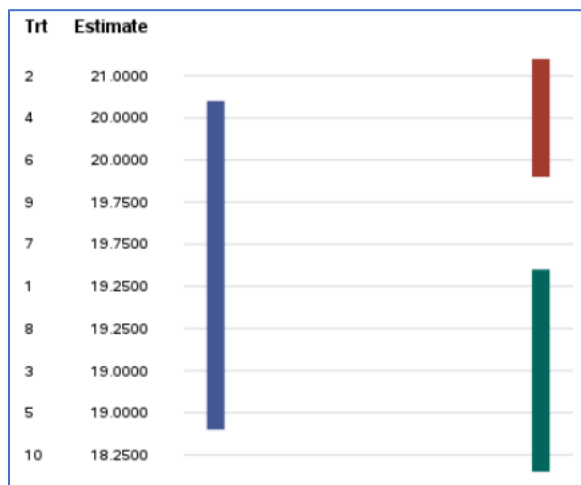


Figure 7. Effect of inoculant treatments on pea protein content at the Yorkton (ECRF) site. Trt: Treatments; Estimate: treatment means. Means covered by the same bar are not significantly different (Alpha = 0.05; LSD = 1.2).

Thousand Kernel Weight (TKW)

Thousand Kernel Weight (TKW) was significantly affected at the NARF site ($P = 0.01$, Table 2). The mean separation test indicated that treatment 8 (AgTIV® Thrive) resulted in the highest Thousand Kernel Weight for pea, although no significant difference was observed when compared to treatments 6 (Primo GX2 Pulse), 7 (Launcher), and 5 (Nodulator® Duo SCG). This significant variation suggests that microbial inoculants may have influenced pea seed size at this location (Figure 8). However, no significant effects were observed at most other locations in lentil or pea. Variations in Thousand Kernel Weight in response to microbial inoculation have been reported in several studies (Gah et al., 2005), but, as with other variables in this study, the effect on TKW appears to be site dependent.

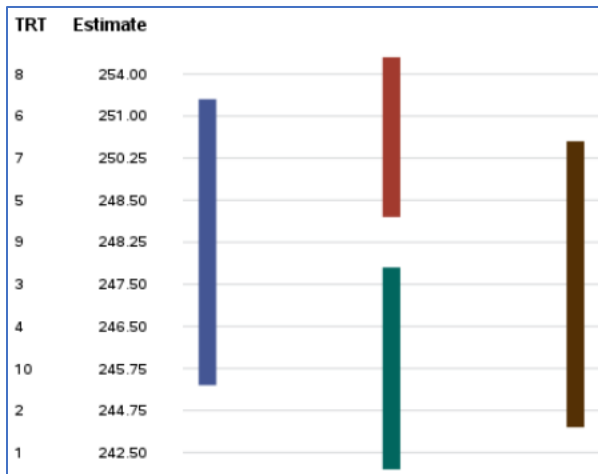


figure 8. Effect of inoculant treatments on pea thousand kernel Weight (TKW) at Melfort (NARF) site. Trt: Treatments; Estimate: treatment means. Means covered by the same bar are not significantly different (Alpha = 0.05; LSD = 5.6).

7. Economic & Practical Implications for Growers:

The study suggests that microbial inoculants can improve seedling emergence, plant density, and yield, but these benefits vary by location. While some treatments showed promise at specific sites, there were no consistent improvements in agronomic parameters. This variability indicates the importance of considering local environmental factors when choosing inoculants. For growers, this means inoculants may be beneficial in certain conditions but not universally effective, requiring site-specific testing for optimal results.

8. Conclusions & Recommendations (how do results relate to original objectives or research that the project is based on? Is there a need to refine current recommendations based on the results from this project?):

The results of this study align with the original objectives by providing a comparative assessment of granular biological treatments, including pulse inoculants and enhanced biological blends. The trial allowed for side-by-side comparisons of various formulations, fulfilling the objective of giving producers insights into the effectiveness of these products under field conditions. The findings revealed that microbial inoculants had varying effects on agronomic parameters, such as seedling emergence, plant density, and yield, depending on location.

However, the inconsistent results across different sites suggest that current recommendations may need refinement. Further research is needed to better understand these variable effects, which could lead to more tailored and precise recommendations for using biological products in pulse crop production.

9. Future Research (did the project identify a need for future research?):

The project identified a need for future research to better understand the variable effects of microbial

inoculants across different locations. Specifically, further studies are needed to explore how environmental factors influence the effectiveness of these products.

10. Technology Transfer Activities (detail any presentations delivered, extension material developed, field days, and articles published):

The findings were presented at the SPG Winter Pulse Meeting; also, at a webinar organized by the Ministry of Agriculture, titled “Home Grown Research: Learn the Latest from AgriARM Research Sites in Your Backyard.

11. Funding Contributions (acknowledge any partners and contributors to the project):

We gratefully acknowledge the support from Saskatchewan Pulse Growers for this project and thank all participants and collaborators for their valuable contributions.

12. Appendices (include any additional, detailed data tables, maps, photos, etc):

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