2019 – 2020 Report

For The

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

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Project Identification

1. **Project Title:** Dry Bean Inoculant and Fertilizer Strategies for Solid Seeded Production
2. **Project Number:** 20180454
3. **Producer Group Sponsoring the Project:** Irrigation Crop Diversification Corporation (ICDC)
4. **Project Location(s):**
    - Irrigation Crop Diversification Corporation (ICDC) – Outlook, SK
    - Western Applied Research Corporation (WARC) – Scott, SK
    - South East Research Farm (SERF) – Redvers, SK
    - East Central Research Foundation (ECRF) – Yorkton, SK
    - Indian Head Agricultural Research Foundation (IHARF) – Indian Head, SK
5. **Project start and end dates (month & year):** April 2019 – February 2020
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

The objective of this study is:

- To demonstrate the efficacy of commercial dry bean inoculant formulations alone or in conjunction with fertilizer nitrogen and

- To evaluate the potential for solid seeded dry bean production under dry land conditions in the non-irrigated areas of Saskatchewan.

8. **Project Rationale:**

Inoculation of pulse crops is widely accepted as a sound agronomic practice. Further, a multitude of trials conducted across western Canada, and globally, have demonstrated the benefit of rhizobia inoculants. For most pulses a wide selection of inoculation formulations (eg. peat, liquid, granular, encapsulated) are available and commonly used. Agronomists recommend the use of inoculants as standard agronomic practice for field pea, lentil, chickpea, soybean and faba bean in Saskatchewan.

The outlier within the pulse crop types with respect to inoculant use occurs with dry bean. If an inoculant formulation which is easy to apply, and available, a portion of dry bean producers have been willing to treat their dry bean seed. Others have simple bypassed inoculants in favor of using commercial fertilizer to meet their crops nitrogen demands (Hnatowich – personal observations and experience). The reason for this is that field dry bean (Phaseolus vulgaris L.) is considered a poor di-nitrogen fixer (N-fixation) and unable to meet crop demand for N to obtain optimal yield through this means. Because of the inconsistency and uncertainty of inoculant response fertilizer nitrogen additions in dry bean production are recommended. In Saskatchewan the current recommendation for non-irrigated dry bean production is to inoculate the crop and also use 55 kg/ha (50 lb/acre) starter nitrogen, broadcast or side-banded (Government of Saskatchewan).

The large multinational inoculant companies have been inconsistent in producing a dry bean inoculant for western Canada due to limited acreage and market demand. Recently, the leading Canadian inoculant manufactures have discontinued manufacturing dry bean inoculant; therefore, Saskatchewan dry bean producers would be entirely reliant upon N fertilizer additions to meet crop demands. However, a USA manufacturer has indicated a willingness to provide dry bean inoculant formulations for exploratory evaluation as to its efficacy under Saskatchewan conditions.

At present, virtually all Saskatchewan dry bean production occurs within a confined area associated to the Lake Diefenbaker region. This production occurs under irrigation and is produced using wide row production. This type of production requires specialized equipment and in-field operations (ex. access to irrigation, row planters, inter-row cultivation, under-cutters, bean combines). This defined production system has developed because historic dry bean varieties produced pods that developed very low on the plant that prevented direct combining, or swathing, such as occurs in other pulse crops. This obviously has restricted acreage expansion of this commodity. However, the Crop Development Centre at the University of Saskatchewan recently released a Black market class dry bean, CDC Blackstrap. This variety tends to produce pods higher on the plant that may be suitable for direct combining, is small seeded so adaptable to existing on-farm seeders, and is high yielding and early maturing. Therefore it may be adaptable for solid seeded production under dry land conditions.

Methodology and Results

9. Methodology:

Trials were established five Agri-ARM facilities in Saskatchewan – ICDC (Outlook), WARC (Scott), SERF (Redvers), ECRF (Yorkton) and IHARF (Indian Head). Each trial was established in a factorial RCBD design with four replications. The factors evaluated were inoculation and N fertilization. Dry Bean inoculant formulations were obtained from Verdisian Life Sciences based in Cary, North Carolina. They included a peat formulation (N Charge, intended for on-seed applications) and a granular formulation (PRIMO GX2, applied in-furrow at seeding). All inoculant treatments were applied without fertilizer N additions or with fertilizer N additions such that total N (soil test N + fertilizer N applications) equaled 80 lbs N/ac.

Trail treatments are shown in Table 1. All inoculants were applied at the manufactures recommended rates. The N Charge peat had a guaranteed titre of 2 x 10e8 cfu/gm and applied for all on-seed treatments at 3.1 gm/kg of seed. The peat formulation contained a self-sticking agent but a damp application method of inoculation was used such that 2 ml of water was applied to each kg seed to assist adhesion. With the molasses application a dilute solution of 60 ml molasses mixed with 240 ml water and then 2 ml of solution was used in substitution for the 2 ml water for damp application. Seed applied inoculant treatments, applied on-site, were treated immediately prior to seeding, allowing sufficient time to dry in order to prevent seed bridging while planting. The polymer was applied with the N Charge utilizing a commercial applicator, application occurred on May 10. The granular inoculant PRIMO GX2 had a guaranteed titre of 1 x 10e8 cfu/gm and was applied at either 4.8 kg/ha (25 cm or 10" row spacing) or 4.0 kg/ha (30 cm or 12" row spacing). Granular treatments were applied with the seed in-furrow.

Times of the various field operations and crop assist products used at each trial location are shown in Table 2. CDC Blackstrap, a Black market class dry bean, was used at all trial locations. A target plant population of 35 plants/m^2 was attempted, with seeding rate adjusted to account for 99% seed germination, seed size and an assumed 90% emergence. Soil test N results from each site are shown in Table 3. Fertilizer N applied at each trial location was determined on the basis of the soil test N results. Plant population (where obtained) was determined after such a time that no further plants were observed emerging. Maturity was deemed at 90% pod colour change. *Sclerotinia* (white mold) was evaluated at maturity using the following rating;

0 – no symptoms apparent
1 – 1-3 small independent lesions on leaf or stems
2 – At least 1 coalescence of lesions with moderate mycelial growth
3 – Mycelial development or wilt involving up to 25% of foliage
4 – Extensive mycelial growth or wilt involving up to 50% of foliage
5 – Plant death

At all locations dry bean plants were directly harvested with small plot combines. Plot grain samples were cleaned and yields adjusted to 16% moisture.

<u>Growing Season Weather</u>

Mean monthly temperatures and precipitation amounts for trial locations are listed in Table 4 and 5. The 2019 season was cooler than the long-term average at all sites. Rainfall was below average for all sites except Scott. Irrigation applied to the Outlook site included 8 mm in May, 27.5 mm in June, 45.5 mm in July and 12.5 mm in August.

Table 1. Inoculant and fertilizer treatments.

Trt #	Inoculant	Formulation	Total N (soil + fertilizer)
1	Control	n/a	0 lbs N/ac
2	N Charge	Peat on-seed	0 lbs N/ac
3	N Charge	Peat on-seed + molasses	0 lbs N/ac
4	N Charge	Pretreated Polymer Peat on-seed	0 lbs N/ac
5	PRIMO GX2	Granular	0 lbs N/ac
6	N Charge + PRIMO GX2	Peat on-seed + Granular	0 lbs N/ac
7	Control	n/a	80 lbs N/ac

8	N Charge	Peat on-seed	80 lbs N/ac
9	N Charge	Peat on-seed + molasses	80 lbs N/ac
10	N Charge	Pretreated Polymer Peat on-seed	80 lbs N/ac
11	PRIMO GX2	Granular	80 lbs N/ac
12	N Charge + PRIMO GX2	Peat on-seed + Granular	80 lbs N/ac

Table 2. Times of operations and crop input products utilized by location.

	Location				
Activity	**Outlook**	**Scott**	**Redvers**	**Yorkton**	**Indian Head**
Pre-seed Herbicide Application	NA	May 19 Glyphosate 540 (0.7 L/ac) + AIM (35 ml/ac)	May 23 Glyphosate 540 (1 L/ac) + AIM (35 ml/ac)	NA	May 27 Roundup Weathermax 540 (0.67 L/ac)
Seeding	May 23	May 24	May 27	May 23	May 17
Row Spacing	25 cm (10”)	25 cm (10”)	30 cm (12”)	30 cm (12”)	30 cm (12”)
Emergence Counts	June 11	June 5	NC	June 14	July 4
In-crop Herbicide Application	June 26 Viper ADV (400 ml/ac) + Basagran Forte (145 ml/ac) + UAN	June 26 Viper ADV (400 ml/ac) + Basagran Forte (145 ml/ac) + UAN	June 6 Centurion (75 ml/ac) + Amigo (200 ml/ac) July 1 Viper ADV (400 ml/ac)	May 24 Roundup Transorb (0.5L/ac) June 26 Centurion (150 ml/ac) + Amigo July 2 Viper ADV (400 ml/ac) + Basagran Forte (145 ml/ac) + UAN	July 12 Viper ADV (400 ml/ac) + Basagran Forte (145 ml/ac) + UAN + Equinox (100 ml/ac + Merge)
In-crop Fungicide Application	July 27 Priaxor (180 ml/ac)	NA	NA	July 22 Acapela (350 ml/ac)	NA
Harvest	Sept 20	Oct 7	Sept 17	Oct 7	Oct 12

NA = not applied

NC = observation not captured

Table 3. Soil test results from each trial location.

Nitrate Levels (lbs NO_3-N/ac)	Outlook	Scott	Redvers	Yorkton	Indian Head
0-15cm (0-6in)	10 lb/ac	12 lb/ac	20 lb/ac	14 lb/ac	12 lb/ac
15-30cm (6-12in)	7 lb/ac				
15-60cm (6-24in)	12 lb/ac	30 lb/ac	24 lb/ac	15 lb/ac	15 lb/ac
Total 0-60cm (0-24in)	29 lb/ac	42 lb/ac	44 lb/ac	29 lb/ac	27 lb/ac

Table 4. Mean monthly temperatures vs long-term (30 year) means for the 2019 growing seasons at Saskatchewan Trial Locations.

Location	Year	May	June	July	August	Avg. / Total
		-----------------------------*Mean Temperature (°C)* -------------------				
Outlook	2019	9.9	16.0	18.0	16.2	15.0
	Long-term	***11.5***	***16.1***	***18.9***	***18.0***	***16.1***
Scott	2019	*9.1*	*14.9*	*16.1*	*14.4*	*13.6*
	Long-term	***10.8***	***14.8***	***17.3***	***16.3***	***14.8***
Redvers	2019	9.5	16.3	18.5	16.6	15.2
	Long-term	***12***	***16***	***19***	***18***	***16.3***
Yorkton	2019	8.6	16	18.3	16.1	14.8
	Long-term	***10.4***	***15.5***	***17.9***	***17.1***	***15.2***
Indian Head	2019	8.9	15.7	17.4	15.8	14.4
	Long-term	***10.8***	***15.8***	***18.2***	***17.4***	***15.6***

Table 5. Precipitation amounts vs long-term (30 year means for the 2019 growing seasons at Saskatchewan Trial Locations.

Location	Year	May	June	July	August	Avg. / Total
		-------------------------------- *Precipitation (mm)* ---------------------				
Outlook	2019	13.2	90.2	43.8	39.6	186.8
	Long-term	***42.6***	***63.9***	***56.1***	***42.8***	***205.4***
Scott	2019	12.7	97.7	107.8	18	236.2
	Long -term	***38.9***	***69.7***	***69.4***	***48.7***	***226.7***
Redvers	2019	18.0	79.0	54.0	88.0	239
	Long-term	***60***	***91***	***78***	***64***	***293***
Yorkton	2019	11.1	81.6	49.1	32.2	174

	Long-term	***51***	***80***	***78***	***62***	***272***
Indian Head	2019	13.3	50.4	53.1	96.0	212.8
	Long-term	***51.7***	***77.4***	***63.8***	***51.2***	***241.4***

10. Results

Individual site treatment agronomic results and associated statistics for each treatment are shown in the Appendix. For clarity of data interpretation, results of factorial analyses for each trial location are presented in Tables 6 through 10.

Treatment of dry bean seed with *rhizobium* inoculant generally failed to provide a yield response at any trial location excepting Indian Head (Table 10). At Indian Head some treatments appeared to be influencing yield, with or without fertilizer N additions. However no clear explanation of response is apparent. The N Charge peat is statistically higher yielding than the control but N Charge + molasses and N Charge polymer treatments are not. It is not thought that the addition of a sugar source or the commonly adopted polymer technology should adversely affect the *rhizobium* inoculant. The granular and dual inoculant treatments also appear to positively influence yield. Treatment effects on yield for Indian Head are illustrated in Figure 1. It is apparent that the yields obtained at Indian Head were very low and statistical analyses indicated a high coefficient of variation (CV). A higher CV in dry bean trials in Saskatchewan, compared to other pulse, cereals or oilseed crops, is not unusual. These results exhibit a variability between inoculant treatments and their variation may be a result of the very low yields obtained. Yield obtained may also be a reflection of differing plant populations between treatments. Indian Head results have not been rejected, as a consequence of its higher CV, based on personal experience in dry bean trials and because of the strong significant influence of fertilizer N additions. This site location exhibits the same N fertilizer response as all other locations and Figure 1 clearly illustrates that fertilizer N applications increase and influence yield to a far greater extent than did inoculation.

Inoculation of dry bean failed to positively influence dry bean yield at any remaining trial location. The reason for the inability of the inoculant to influence dry bean yield cannot be definitively answered within the limited observations/measurements undertaken within the scope of this trial. Given the inherent soil N fertility as revealed by soil testing procedures it is not thought that the N levels at any site would be sufficiently high to inhibit *rhizobia* infection and possible N-fixation. However the author suggests that the following are possible reasons;

1. *Rhiobia* strain specificity is known to occur within dry bean. Meaning that it is possible that the strain of *rhizobium leguminosarum bv. Phaseoli* simply failed to form a symbiotic relationship with CDC Blackstrap dry bean. While developing commercial inoculant formulations the author did experience this phenomena. A specific *rhizobium* strain might generally work in one market class type of dry bean but not in others. Further, specificity was also found within market classes such that the strain might result in acceptable N-fixation in one variety but not others.

2. The *rhizobium* within the inoculants may not have been adaptable to Saskatchewan soil conditions. This regional adaptability is also known and is the reason inoculant companies often screen soils for effective indigenous *rhizobium* strains to be used within their sales market region and where

production of the pulse commodity is highest.

Inoculation may have failed to influence dry bean yield in 2019 but the application of fertilizer N certainly did. All trial locations obtained significant yield responses to the addition of fertilizer N. This response highlights the inefficiency of the inoculant formulations evaluated. With respect to seed yield, results from all sites indicate that supplemental fertilizer N is required to optimize dry bean yield. At Outlook, the trial was irrigated and yields obtained at this location generally doubled those obtained at the remaining dry land locations. The Outlook location has a long-term history of dry bean production with the field on which the trial was conducted having had dry beans produced numerable times. Though not part of the trial protocol, plant roots were exhumed from all unfertilized and fertilized control treatments and nodules were found on all. Moreover, the red colour exhibited upon cutting nodules suggest they were performing active biological N-fixation. These bacteria were from indigenous populations likely built up from previous dry bean production and likely contributed to the high unfertilized yield obtained at Outlook. However, even these indigenous populations did not suffice to provide maximum yields and a fertilizer N response occurred.

In general, inoculation did not directly influence any other agronomic measurement, at any trial location. Nitrogen fertilizer additions tended to decrease individual seed weight and increased plant height. *Sclerotinia* (white mold) was not an issue at any site in 2019

The result of inoculation and N fertilizer additions on dry bean yield averaged across all 5 trial locations is shown in Figure 2.

A summary of the combined all site analyses, and for the 4 dry land trials alone, for CDC Blackstrap seed yield is presented in Table 11. Yield results indicate that, for all sites, the average yield response to N fertilizer was 521 kg/ha (464 lb/ac). However, an objective of this project was to demonstrate dry bean production away from the traditional irrigated production and into dry land production. Therefore if we exclude the Outlook site the average yield response to N fertilizer increases to 690 kg/ha (614 lb/ac). Presently, Black dry beans are being purchased at $0.75/kg ($0.34/lb) so the gross return of the fertilizer additions is approximately $518/ha or $209/ac, easily an economic return for the fertilizer investment. The result of inoculation and N fertilizer additions on dry bean yield averaged across only the 4 dry land trial locations is shown in Figure 3.

Some general observations and thoughts regarding the dry land production trials can be made;

- All sites were solid seeded and direct combined. While harvest loss assessment was beyond the scope of the study (given the finances), all sites report that harvest losses were deemed minimal.
- Direct combining of dry beans is likely only possible at this time with the Black market class variety CDC Blackstrap which is a Type II plant structure with pods that may initiate high enough on the plant stem to facilitate direct combining or swathing.
- Seed weights obtained at WARC (Scott) were very low and might limit market acceptance, additional work should be conducted in this region in order to ascertain if this is a function of the trialing season or potentially problematic to the region.
- It is reasonable to believe rolling of the dry beans after seeding will assist harvest management by

facilitating pod clearance. On heavy textured, such as at Indian Head, rolling can be a challenge for dry bean. Seed bed conditions need be ideal and packing pressure be light enough to minimize possible compaction issues.

Table 6. ICDC (Outlook) Dry Bean Yield & Agronomic Observations as Influenced by N Fertilizer and Inoculant.

Treatment	ICDC						
	Yield		Seed weight (gm/1000)	Maturity (days)	White Mold (0 – 5)	Height (cm)	Plant Stand (plants /m^2)
	kg/ha	lb/ac					
Nitrogen Fertilizer Application (lbs N/ac)							
0	2651	2365	225	105	0	37	29
80	3142	2802	225	107	0	39	31
Fertilizer LSD (0.05)	247	220	NS	0.4	NS	1.7	NS
CV (%)	14.5	14.5	2.0	0.6	0	7.4	22.1
Inoculant							
Control	2829	2523	225	106	0	38	30
N Charge peat	3008	2683	225	106	0	39	29
N Charge peat + molasses	3046	2717	225	106	0	38	31
N Charge polymer	2868	2558	226	106	0	39	29
PRIMO GX2 granular	2782	2481	224	106	0	37	29
N Charge + PRIMO GX2	2846	2538	228	106	0	38	31
Inoculant LSD (0.05)	NS	NS	NS	NS	NS	NS	NS
Nitrogen Fertilizer x Inoculation							
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS

NS = not significant

Table 7. WARC (Scott) Dry Bean Yield & Agronomic Observations as Influenced by N Fertilizer and Inoculant.

Treatment	WARC						
	Yield		Seed weight (gm/1000)	Maturity (days)	White Mold (0 – 5)	Height (cm)	Plant Stand (plants /m^2)
	kg/ha	lb/ac					
Nitrogen Fertilizer Application (lbs N/ac)							
0	1324	1181	169	103	0.04	27	18
80	1983	1768	161	99	0.25	34	14
Fertilizer LSD (0.05)	112	100	2.7	1.0	0.2	2.0	2.8
CV (%)	11.5	11.5	2.8	1.7	229	11.1	30.6
Inoculant							
Control	1666	1486	168	102	0.25	29	18

N Charge peat	1617	1442	165	101	0.13	31	15
N Charge peat + molasses	1663	1483	164	101	0.13	30	15
N Charge polymer	1686	1503	164	101	0.13	34	17
PRIMO GX2 granular	1674	1493	165	102	0.25	30	13
N Charge + PRIMO GX2	1613	1439	165	101	0	30	17
Inoculant LSD (0.05)	NS	NS	NS	NS	NS	NS	NS
Nitrogen Fertilizer x Inoculation							
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS

NS = Not Significant

Table 8. SERF (Redvers) Dry Bean Yield & Agronomic Observations as Influenced by N Fertilizer and Inoculant.

Treatment	**SERF**						
	Yield		**Seed weight (gm/1000)**	**Maturity (days)**	**White Mold (0 – 5)**	**Height (cm)**	**Plant Stand (plants /m^2)**
	kg/ha	**lb/ac**					
Nitrogen Fertilizer Application (lbs N/ac)							
0	1381	1229	198	97	0	28	25
80	1746	1554	191	96	0	31	28
Fertilizer LSD (0.05)	121	108	5.2	NS	NS	1.2	NS
CV (%)	13.2	13.2	4.6	1.4	0	7.1	24.7
Inoculant							
Control	1695	1509	197	97	0	30	30
N Charge peat	1570	1397	199	96	0	29	25
N Charge peat + molasses	1558	1386	196	96	0	29	29
N Charge polymer	1593	1418	195	97	0	29	24
PRIMO GX2 granular	1450	1290	189	95	0	30	23
N Charge + PRIMO GX2	1514	1348	193	97	0	29	27
Inoculant LSD (0.05)	NS	NS	NS	NS	NS	NS	NS
Nitrogen Fertilizer x Inoculation							
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS

NS = Not Significant

Table 9. ECRF (Yorkton) Dry Bean Yield & Agronomic Observations as Influenced by N Fertilizer and Inoculant.

Treatment	**ECRF**						
	Yield		**Seed weight (gm/1000)**	**Maturity (days)**	**White Mold (0 – 5)**	**Height (cm)**	**Plant Stand (plants /m^2)**
	kg/ha	**lb/ac**					
Nitrogen Fertilizer Application (lbs N/ac)							
0	973	866	200	105	0	41	32

80	1885	1677	210	105	0	46	39
Fertilizer LSD (0.05)	166	148	3.6	NS	NS	2.3	4.5
CV (%)	19.8	19.8	3.0	1.5	0	8.9	21.4
Inoculant							
Control	1372	1221	203	105	0	44	35
N Charge peat	1447	1288	207	105	0	44	30
N Charge peat + molasses	1266	1127	206	104	0	41	34
N Charge polymer	1341	1194	204	104	0	43	39
PRIMO GX2 granular	1454	1294	205	105	0	43	40
N Charge + PRIMO GX2	1694	1508	206	105	0	48	39
Inoculant LSD (0.05)	NS	NS	NS	NS	NS	3.9	NS
Nitrogen Fertilizer x Inoculation							
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS

NS = Not Significant

Table 10. IHARF (Indian Head) Dry Bean Yield & Agronomic Observations as Influenced by N Fertilizer and Inoculant.

Treatment	**IHARF**						
	Yield		**Seed weight (gm/1000)**	**Maturity (days)**	**White Mold (0 – 5)**	**Height (cm)**	**Plant Stand (plants /m^2)**
	kg/ha	**lb/ac**					
Nitrogen Fertilizer Application (lbs N/ac)							
0	174	155	220	110	0	22	22
80	998	890	224	113	0	30	23
Fertilizer LSD (0.05)	70	62	NS	0.2	NS	1.0	NS
CV (%)	20.3	20.3	12.9	0.4	0	6.3	19.9
Inoculant							
Control	484	432	228	110	0	25	20
N Charge peat	620	553	214	111	0	26	26
N Charge peat + molasses	533	475	211	111	0	26	23
N Charge polymer	526	469	227	112	0	27	18
PRIMO GX2 granular	641	572	215	112	0	27	21
N Charge + PRIMO GX2	712	635	239	112	0	25	27
Inoculant LSD (0.05)	121	108	NS	0.4	NS	NS	4.5
Nitrogen Fertilizer x Inoculation							
LSD (0.05)	S	S	NS	NS	NS	NS	NS

S = Significant

NS = Not Significant

Table 11. Dry Bean Combined Site Yields: Effect of Inoculation and N Fertilization, 2019.

Location/Treatment	**All 5 Sites**	**4 Dry Land Sites Only**
	Yield	**Yield**

Trial Site	kg/ha	lb/ac	kg/ha	lb/ac
ICDC – Outlook	2896	2583	-	-
WARC – Scott	1653	1475	1653	1475
SERF – Redvers	1563	1391	1563	1391
ECRF – Yorkton	1429	1272	1429	1272
IHARF – Indian Head	586	523	586	523
Location LSD (0.05)	113	101	92	144
CV (%)	17.4	17.4	15.5	15.5
Nitrogen Fertilizer Application (lbs N/ac)				
0	1365	1217	963	858
80	1886	1681	1653	1472
Fertilizer LSD (0.05)	72	64	81	72
Inoculant				
Control	1589	1416	1305	1162
N Charge peat	1620	1444	1314	1170
N Charge peat + molasses	1616	1440	1255	1118
N Charge polymer	1568	1398	1286	1146
PRIMO GX2 granular	1675	1493	1305	1162
N Charge + PRIMO GX2	1686	1502	1383	1232
Inoculant LSD (0.05)	NS	NS	NS	
Location x Nitrogen Fertilizer Application Interaction				
LSD (0.05)	S	S	S	S
Location x Inoculant Interaction				
LSD (0.05)	NS	NS	NS	NS
Nitrogen Fertilizer Application x Inoculant Interaction				
LSD (0.05)	NS	NS	NS	NS
Location x Nitrogen Fertilizer Application x Inoculant Interaction				
LSD (0.05)	NS	NS	NS	NS

S = Significant

NS = Not Significant

Figure 1. Dry Bean Yield Response to Inoculation & N Fertilization – Indian Head, 2019

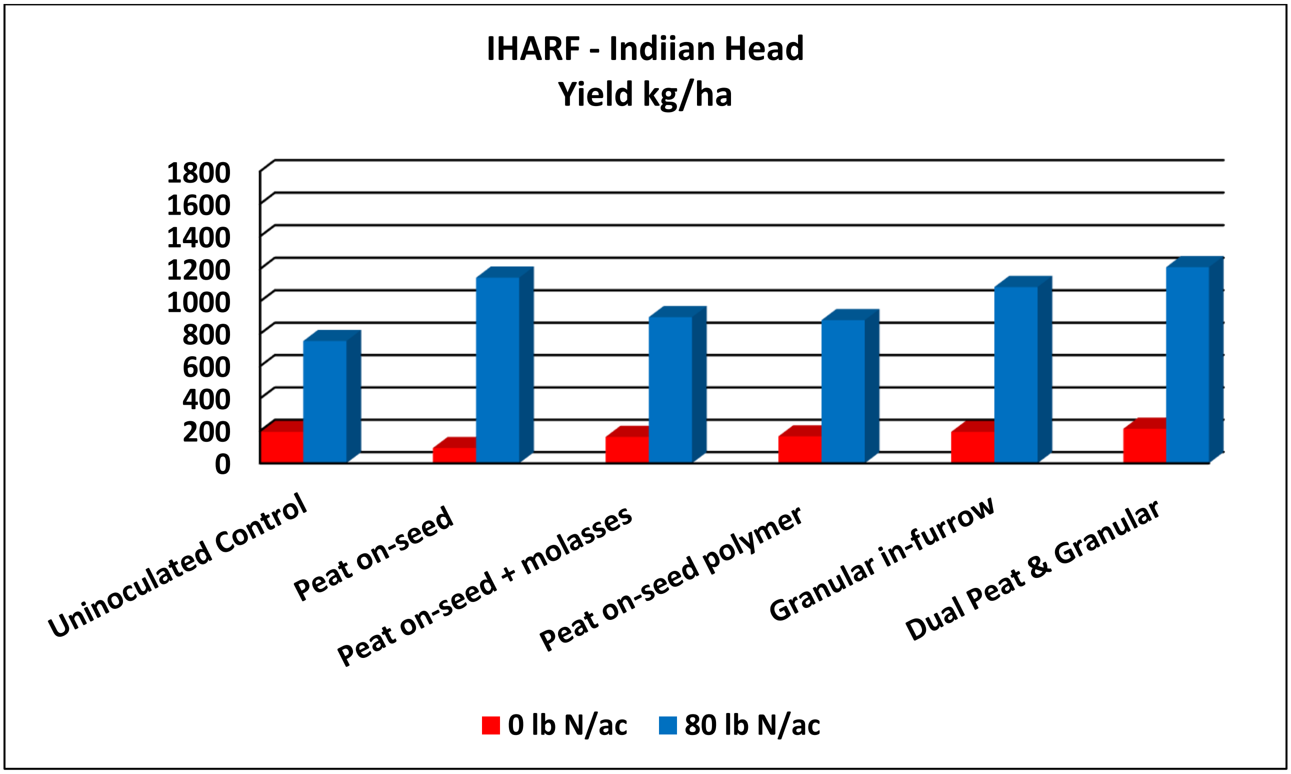


Figure 2. Combined 5 Site Dry Bean Yield, Effect of Inoculation and N Fertilization, 2019.

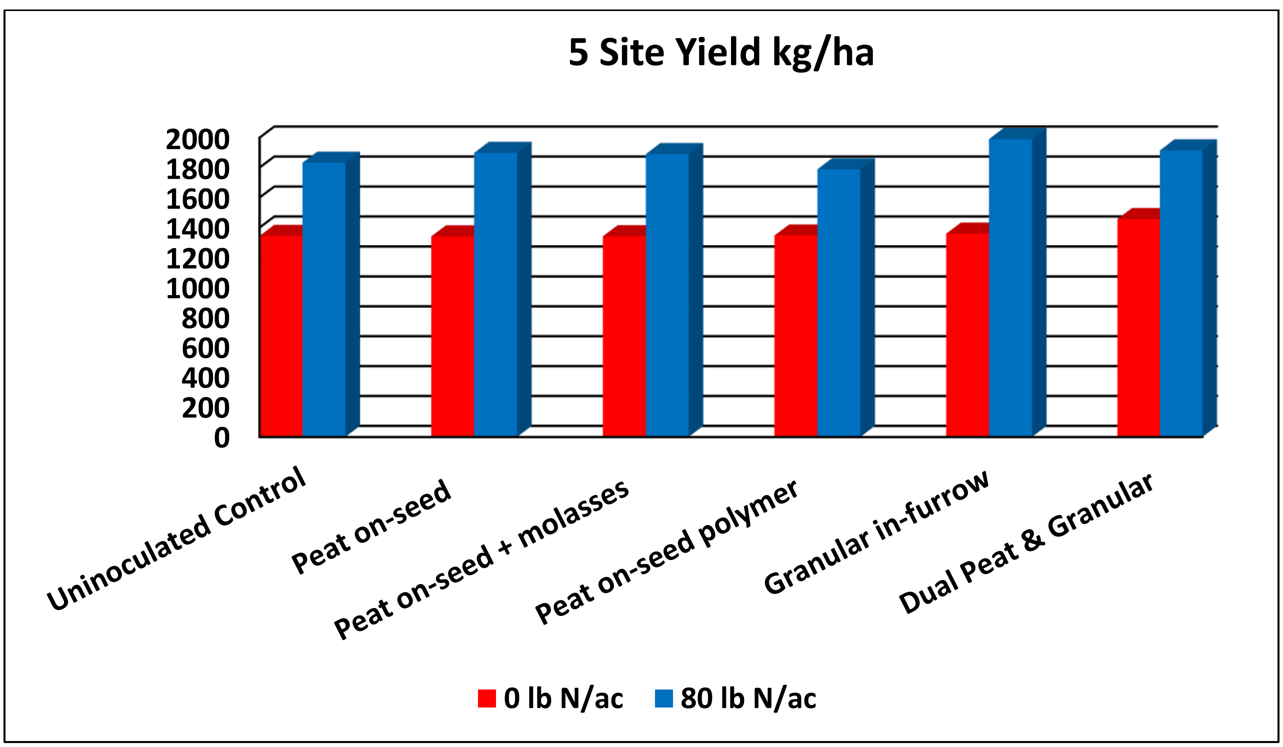
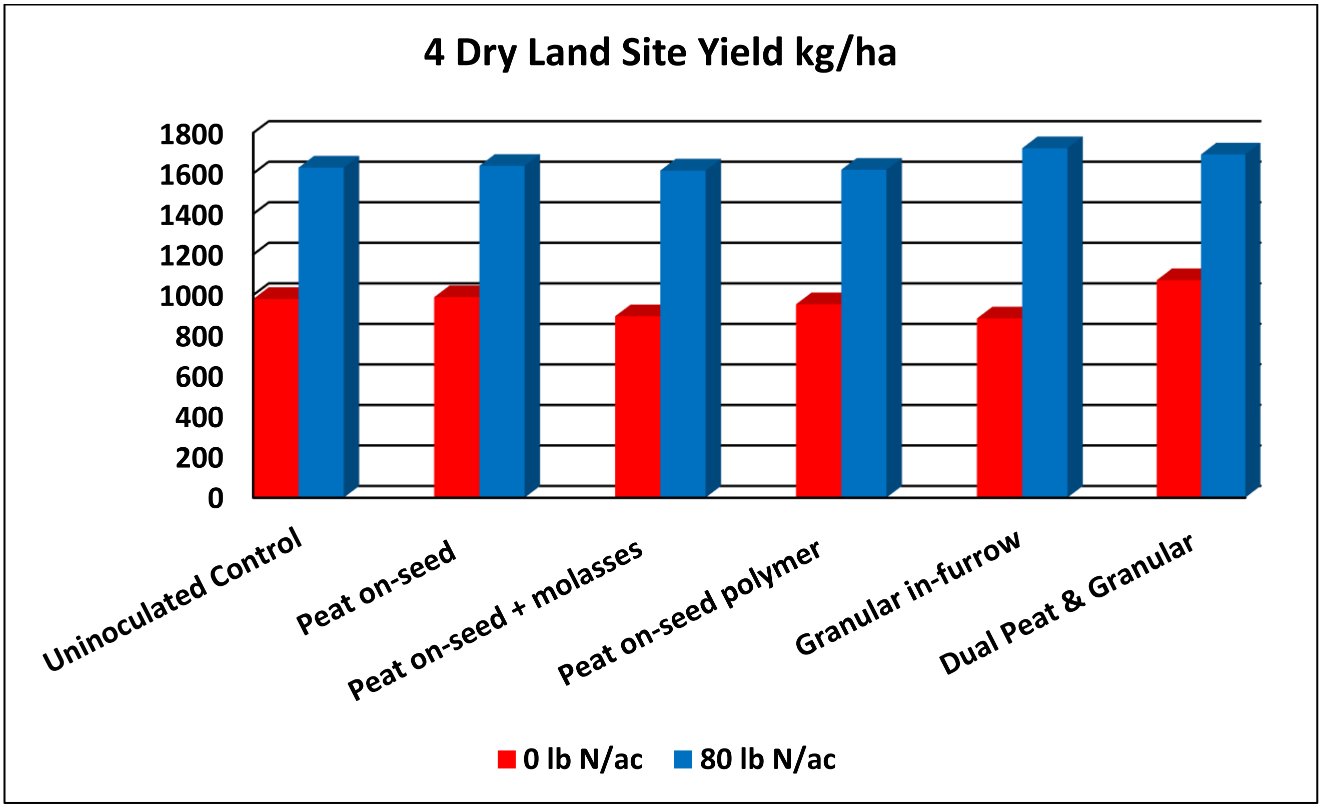


Figure 3. Combined 4 Dry Land Site Dry Bean Yield, Effect of Inoculation and N Fertilization, 2019.



Extension Activities

ICDC – Outlook

This trial was mentioned but not viewed during the CSIDC/ICDC Annual Field Day on July 11 and attended by approximately 200 producers, agrologists and company or governmental represetatives. The trial was clearly posted with ADOPT signage. Further, an in-season video outlining the background and objectives of this project was created and can be viewed at ICDC's you tube video page located at https://irrigationsaskatchewan.com/icdc/icdc-research-and-development-program/ A supplimental video highlighting the results of this study will be developed and added to this introductory video during the winter. At present the video has been viewed 42 times. The results were also presented at the 2020 Agri-ARM Update during the Crop Production Show on Jan. 18, 2020, with approximately 30 attendees. The presentation was entitled *"Dry Bean Production: To Inoculate or Fertilize"* and will be posted to the Agri-ARM website. The trial will be discussed at the ICDC Annual Agronomy Update to be held March 5, 2020 in Outlook with expected attendance of approximately 40. Results will also be made available in the 2019 ICDC Field Crops Annual Report and the 2019 CSIDC Annual Report. Trial results will also be made available on the ICDC website http://irrigationsaskatchewan.com/icdc/ Results may also be presented in extension activities when requested.

WARC – Scott

The trial was viewed and discussed during the WARC Annual Field Day held July 10, 2019 and viewed by approximately 150 participants.

SERF – Redvers

The trial was viewed and discussed during the SERF Annual Field Day held July 18, 2019 and viewed by approximately 30 participants.

ECRF – Yorkton

The trial was viewed and discussed on two separate Field Days. The first was the Annual ECRF Field Day held on July 23, 2019 and viewed by approximately 100 participants. The second, an Agratactics Field event took place on August 8, 2019 with approximately 40 participants. ECRF is also intending to produce a video on the project that when completed will be found on their website located at http://www.ecrf.ca/

IHARF – Indian Head

Due to distance this trial was not viewed during the Annual IHARF Field Day, however, it was toured by 35 – 40 Federated Co-Operatives Limited agronomists on July 12, 2019 and then by a small contingent of SPG staff on July 18, 2019. Key results of the study will also be presented at an ICAN (Independent Consulting Agronomist Network) meeting in Regina on February 4, 2020 and during the IHARF Annual Winter Meeting & AGM in Balgonie, February 5, 2020. Expected combined attendance is estimated at 180 – 225 participants.

11. Conclusions and Recommendations

Inoculation failed to provide yield or agronomic benefits to dry beans in this trial. It is suspected that the strain of *rhizobium leguminosarum bv. Phaseoli* provided in the inoculant formulations used in the study were either inefficient in forming an effective symbiotic relationship with the CDC Blackstrap variety used in the study or the strain was unable to thrive and multiply under Saskatchewan soil/climatic conditions. Application of fertilizer N, such that the combination of soil available N (0-60cm depth) plus fertilizer N (nutrient) equaled 80 lb N/ac significantly increased grain yield and tended to produce taller plants which may facilitate harvest management. It is recommended that producers view N fertilizer as their primary nutrient source for dry bean production. An inoculant, if available, can be used as an insurance but is unlikely to provide optimal N-fixation to optimize yield goals.

This study demonstrated the feasibility of producing CDC Blackstrap dry bean under dry land conditions utilizing a solid seeded production system. Should further investigations also demonstrate this potential then dry bean production could expand considerably beyond the present acreage. This pulse could be an alternative for the moister regions of the province where root diseases have impacted other pulse crops.

Additional research projects such as the following are suggested;

- Further N fertilizer studies are warranted, rates should continue beyond those used in this study.

Within these studies *sclerotinia* should be closely assessed, as well as pod clearance.

- Seeding rate trials would have merit and value.
- Seeding date trials should be geographically evaluated with attention to soil temperatures, plant populations and pod clearance.
- Further regional adaptability trials should be considered, certainly the entire black soil zone of Saskatchewan should be assessed.
- As dry beans are poor competitors until canopy closure, weed control options under solid seeded production should be assessed.
- Within all trials where dry bean is either direct combined or swathed, harvest losses and seed quality should be assessed.
- Should dry bean inoculants be made available then;
    - Producers should view such products sceptically unless regional independent third-party efficacy results are provided. Regardless, N fertilizer supplementation will be required.
    - Consideration should be given to secure funding for organizations such as Agri-ARM facilities to maintain an annual pulse inoculant trials for suitable pulses within their local whereby all commercial and pre-commercial inoculant products can be compared for efficacy.
- An economic investigation either by the Ministry of Agriculture or the University of Saskatchewan Ag, Econ., should be undertaken to investigate such aspects as crop insurance/risk management options, lack or perceived lack, of buyer interest within Saskatchewan, production contracts and marketing agreements presently available, market barriers to possible low quality dry bean, accessibility and availability of CDC varieties (closed loop systems?), etc.

Supporting Information

12. Acknowledgements

Financial support was provided by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Canadian Agricultural Partnership (CAP) bi-lateral agreement. Inoculant products were provided in-kind by Verdesian Life Sciences. The Saskatchewan Ministry of Agriculture will be acknowlodged in any written or oral presentations which may arise regarding this study.

13. Appendices

Individual trial location agronomic responses and associated statistical results for individual treatments are shown in Tables 12 through 16.

Table 12. ICDC (Outlook) Dry Bean Yield & Agronomic Observations, RCBD Analyses, 2020.

Trt	Description	Yield kg/ha	Yield lbs/ac	Seed Weight (gm/1000)	Maturity (days)	White Mold (0 – 5)	Height (cm)	Plant Stand (plants/m2)
1	Uninoculated – 0 N/ac	2601	2320	224	106	0	37	29
2	N Charge peat – 0 N/ac	2947	2629	224	105	0	36	27
3	N Charge peat + molasses – 0 N/ac	2769	2470	227	105	0	38	28
4	N Charge polymer – 0 N/ac	2531	2258	227	105	0	38	28
5	PRIMO GX2 granular – 0 N/ac	2480	2212	223	105	0	36	30
6	N Charge + PRIMO GX2 – 0 N/ac	2579	2300	227	105	0	38	32
7	Uninoculated – 80 N/ac	3056	2726	226	107	0	38	32
8	N Charge peat – 80 N/ac	3069	2737	226	107	0	42	31
9	N Charge peat + molasses – 80 N/ac	3323	2964	222	107	0	39	35
10	N Charge polymer – 80 N/ac	3205	2859	224	107	0	40	30
11	PRIMO GX2 granular – 80 N/ac	3083	2750	226	107	0	39	28
12	N Charge + PRIMO GX2 – 80 N/ac	3112	2776	228	107	0	38	30
	LSD (0.05)	NS*	NS*	NS	0.0001		NS	NS
	CV (%)	14.5	14.5	2.0	0.6		7.4	22.1

NS = not significant

NS* = not significant at P<0.05 but significant at P<0.10

Table 13. WARC (Scott) Dry Bean Yield & Agronomic Observations, RCBD Analyses, 2020.

Trt	Description	Yield kg/ha	Yield lbs/ac	Seed Weight (gm/1000)	Maturity (days)	White Mold (0 – 5)	Height (cm)	Plant Stand (plants/m2)
1	Uninoculated – 0 N/ac	1334	1190	171	103	0	26	18
2	N Charge peat – 0 N/ac	1298	1157	170	104	0	28	19
3	N Charge peat + molasses – 0 N/ac	1243	1109	169	104	0	26	15
4	N Charge polymer – 0 N/ac	1352	1206	167	104	0.3	32	20
5	PRIMO GX2 granular – 0 N/ac	1325	1182	171	104	0	27	13
6	N Charge + PRIMO GX2 – 0 N/ac	1391	1241	165	102	0	27	20
7	Uninoculated – 80 N/ac	1999	1783	164	100	0.5	32	18
8	N Charge peat – 80 N/ac	1937	1728	160	98	0.3	35	12
9	N Charge peat + molasses – 80 N/ac	2083	1858	160	98	0.3	35	15
10	N Charge polymer – 80 N/ac	2020	1801	161	99	0	35	15
11	PRIMO GX2 granular – 80 N/ac	2023	1804	159	99	0.5	34	13

12	N Charge + PRIMO GX2 – 80 N/ac	1835	1637	165	100	0	34	13
	LSD (0.05)	273	244	6.7	2.5	NS	4.9	NS
	CV (%)	11.5	11.5	2.8	1.7	229	11.1	30.6

NS = not significant

Table 14. SERF (Redvers) Dry Bean Yield & Agronomic Observations, RCBD Analyses, 2020.

Trt	Description	Yield kg/ha	Yield lbs/ac	Seed Weight (gm/1000)	Maturity (days)	White Mold (0 – 5)	Height (cm)	Plant Stand (plants/m2)
1	Uninoculated – 0 N/ac	1525	1357	197	97	0	28	30
2	N Charge peat – 0 N/ac	1371	1221	209	97	0	28	21
3	N Charge peat + molasses – 0 N/ac	1403	1248	199	97	0	29	27
4	N Charge polymer – 0 N/ac	1376	1224	197	96	0	28	23
5	PRIMO GX2 granular – 0 N/ac	1197	1065	189	96	0	28	22
6	N Charge + PRIMO GX2 – 0 N/ac	1415	1260	199	98	0	27	27
7	Uninoculated – 80 N/ac	1866	1661	196	98	0	32	29
8	N Charge peat – 80 N/ac	1769	1574	190	96	0	31	30
9	N Charge peat + molasses – 80 N/ac	1713	1524	193	96	0	30	31
10	N Charge polymer – 80 N/ac	1811	1612	193	98	0	31	26
11	PRIMO GX2 granular – 80 N/ac	1703	1515	189	95	0	31	25
12	N Charge + PRIMO GX2 – 80 N/ac	1613	1436	186	96	0	31	28
	LSD (0.05)	296	264	NS*	NS		3.0	NS
	CV (%)	13.2	13.2	4.6	1.4		7.1	24.7

NS = not significant

NS* = not significant at P<0.05 but significant at P<0.10

NC = observation not captured

Table 15. ECRF (Yorkton) Dry Bean Yield & Agronomic Observations, RCBD Analyses, 2020.

Trt	Description	Yield kg/ha	Yield lbs/ac	Seed Weight (gm/1000)	Maturity (days)	White Mold (0 – 5)	Height (cm)	Plant Stand (plants/m2)
1	Uninoculated – 0 N/ac	851	757	197	104	0	39	32
2	N Charge peat – 0 N/ac	1195	1064	206	106	0	43	23
3	N Charge peat + molasses – 0 N/ac	773	688	204	104	0	38	32
4	N Charge polymer – 0 N/ac	925	823	195	104	0	41	39
5	PRIMO GX2 granular – 0 N/ac	824	733	198	105	0	39	37

6	N Charge + PRIMO GX2 – 0 N/ac	1272	1132	199	104	0	46	32
7	Uninoculated – 80 N/ac	1894	1686	210	105	0	48	37
8	N Charge peat – 80 N/ac	1698	1511	208	105	0	45	37
9	N Charge peat + molasses – 80 N/ac	1759	1566	207	104	0	43	37
10	N Charge polymer – 80 N/ac	1757	1564	212	103	0	45	39
11	PRIMO GX2 granular – 80 N/ac	2084	1855	211	105	0	48	43
12	N Charge + PRIMO GX2 – 80 N/ac	2116	1883	213	106	0	50	39
	LSD (0.05)	408	363	8.7	NS		5.6	NS*
	CV (%)	19.8	19.8	3.0	1.5		8.9	21.4

NS = not significant

NS* = not significant at P<0.05 but significant at P<0.10

Table 16. IHARF (Indian Head) Dry Bean Yield & Agronomic Observations, RCBD Analyses, 2020.

Trt	Description	Yield kg/ha	Yield lbs/ac	Seed Weight (gm/1000)	Maturity (days)	White Mold (0 – 5)	Height (cm)	Plant Stand (plants/m2)
1	Uninoculated – 0 N/ac	212	189	215	110	0	21	20
2	N Charge peat – 0 N/ac	94	84	217	110	0	21	23
3	N Charge peat + molasses – 0 N/ac	163	145	221	110	0	21	24
4	N Charge polymer – 0 N/ac	166	148	236	110	0	23	19
5	PRIMO GX2 granular – 0 N/ac	194	173	213	110	0	23	22
6	N Charge + PRIMO GX2 – 0 N/ac	213	190	222	110	0	20	28
7	Uninoculated – 80 N/ac	756	674	242	111	0	30	18
8	N Charge peat – 80 N/ac	1146	1023	210	113	0	30	29
9	N Charge peat + molasses – 80 N/ac	903	806	200	113	0	31	22
10	N Charge polymer – 80 N/ac	885	790	219	113	0	30	18
11	PRIMO GX2 granular – 80 N/ac	1089	971	216	113	0	31	20
12	N Charge + PRIMO GX2 – 80 N/ac	1211	1080	257	113	0	30	26
	LSD (0.05)	171	153	NS	0.6		2.3	6.4
	CV (%)	20.3	20.3	12.9	0.4		6.3	19.9

NS = not significant

Abstract

14. Abstract/Summary

A study was initiated to evaluate the efficacy of a peat and granular dry bean inoculant, manufactured and retailed in the USA, with and without fertilizer nitrogen (N) additions. An additional aspect of the study was to evaluate the potential of CDC Blackstrap as a suitable variety for dry land, solid seeded production. The trial was conducted under natural rainfed conditions at Scott, Redvers, Yorkton and Indian Head. An additional trial was conducted under irrigation at Outlook to serve as a production reference. Peat formulation inoculant was seed applied at 3.1 gm/kg of seed either by itself, with a dilute molasses as a sticking agent or with a commercially applied polymer coating. The granular inoculant was applied at either 4.8 kg/ha or 4.0 kg/ha depending upon the row spacing used. All trials were seeded to establish a plant population of 35 plants/m^2 in a solid seeded system using 25cm (10") or 30cm (12") row spacing. Nitrogen fertilizer treatments were applied at rates so that total available N (soil N plus fertilizer N) equaled 80 lb N/ac. Inoculation failed to provide a yield advantage over un-inoculated dry bean at 4 of 5 locations. At the 5^{th} location yields were very low and variable, with inoculant treatment inconsistences. No inoculant response was obtained when data were combined across locations. However, all trial locations obtained significantly higher yields when fertilizer N was applied. The un-inoculated treatment at the irrigated site was high yielding compared to dry land sites, this is partly attributed to high levels of indigenous *rhizobia* populations from numerous preceding dry bean productions. In general, the observed dry land production of CDC Blackstrap was encouraging. Fertilized treatments resulted in an average of 690 kg/ha (614 lb/ac) greater seed yield than unfertilized treatments under dry land conditions. This study was viewed during field events at all five trial locations, has or will appear in videos created by ECRF & ICDC, and been presented at extension events. Total exposure to producer and agronomists is estimated to be > than 600 in number.