2024 Project Report

for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Fenugreek Response to Range of Nitrogen Fertilizer Rates

(Project #20230545)

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Agriculture Demonstration of Practices and Technologies (ADOPT)

Project Final Report

The final project report should be made available electronically (MS Word). Additional data tables and or graphs may be submitted in spreadsheet format. Due to formatting, printing and distribution requirements, final reports will not be accepted as PDF documents. Completed reports must be returned by email to Evaluation.Coordinator@gov.sk.ca.

Project Title:	Fenugreek Response to a Range of Nitrogen Fertilizer Rates
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Project Location(s): *Provide the name or number of the rural municipality, nearest town or legal land location if possible. Provide the name of any cooperating landowner(s).*	Indian Head, Saskatchewan (R.M. #156); Outlook, Saskatchewan (R.M. #284); Redvers, SK (R.M. #61); Swift Current, SK (R.M. #137)
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Sustainable Canadian Agricultural Partnership

Saskatchewan

Canada

Abstract *(maximum 200 words)*

Detail key elements from the project objectives, methodology, results and conclusions to provide a short concise summary of the project. List extension activities such as field days or workshops and include the number of people who visited the project.

Fenugreek trials were initiated at Indian Head, Outlook (irrigated), Redvers, and Swift Current. In addition to demonstrating fenugreek adaption to contrasting environments, the project explored the response to N fertilizer rates ranging from <50-175 kg N/ha, including residual soil N. To varying degrees, the 2024 season started cool and wet but finished hot and dry. Averaging 2500-2600 kg/ha and peaking at 2800-3000 kg/ha, the highest yields were at Indian Head and Outlook. Despite being the wettest location, yields at Redvers were only 1300 kg/ha, presumably because factors other than N were most yield limiting. At Swift Current, the driest and hottest location, yields averaged only 550 kg/ha. Side-banded urea only affected emergence at Swift Current, where high rates slightly reduced plant populations. Delayed crop senescence with high N occurred at 2/3 sites where relative maturity was rated; however, any impacts were not agronomically important in the end. Yield responses to N rate varied widely. At Indian Head, the response was strong with yields increasing to the highest rate and, conservatively, the economically optimal rate being at least 125 kg N/ha (soil plus fertilizer). At Redvers and Swift Current the response was modest with yields peaking at 75-100 kg N/ha while, at Outlook, the response was not significant and trended slightly negative. Additional data is required to make more confident N fertility recommendations for fenugreek.

Project Objectives

Provide a short statement outlining the project objectives. Identify the key concept this project was designed to demonstrate. For example, you might use a statement such as *"This project was intended to demonstrate and compare the benefits of……" or "The objective of this project was to demonstrate the impact of…."*

The overall objective was to demonstrate the response of fenugreek to nitrogen (N) fertility and build upon past work exploring the overall adaption of this crop to a range of Saskatchewan environments.

Project Rationale

Briefly describe why this project is of interest to local producers. Why is it important to have this project? What are the potential beneficial outcomes? What is the perceived need?

Fenugreek (*Trigonella foenum-graecum* L.) is a self-pollinating, annual legume which is adapted to cool, dry environments and, as such, suitable for growth in the semi-arid regions of western Canada (i.e., Acharya et al. 2008; Thomas et al. 2011). In recent years, Agri-ARM sites featured fenugreek alongside several other specialty pulse crop options coordinated by the Saskatchewan Pulse Growers. Fenugreek yields in the 2022 demonstrations were highly variable, below 1000 kg/ha at Redvers, Scott, and Melfort, but ~1000-2000 kg/ha at Yorkton, Swift Current, Outlook, and Prince Albert, and 3500 kg/ha at Indian Head (Wall 2023). In 2023, yields were variable when all eight Agri-ARM locations were considered; however, most locations did not control weeds. For three of the locations involved in the current project, yields in 2023 were 2581 kg/ha at Indian Head, 1428 kg/ha at Redvers, and 410 kg/ha at Swift Current (Wall 2024). The low yields at Swift Current were attributed to extreme drought and it is likely that fenugreek is not particularly well adapted to the dry Brown soil zone; however, this is important information for growers regardless. Although farmers have grown limited acres of fenugreek under contract in Saskatchewan for over a decade, public information on its adaptation and best management practices remains limited. The proposed project was initiated to enhance our understanding of fenugreek adaptation across contrasting Saskatchewan environments, gain experience in its production and management, and improve basic fertility management recommendations. As a pulse crop that is well-adapted to Saskatchewan conditions (particularly in the dark Brown and Black soil zones), has good weed control options, and does not host Aphanomyces root rot, fenugreek has potential to be an attractive option to farmers looking diversify their rotations or find viable alternatives to more traditional pulses.

As a legume, fenugreek can fix atmospheric N if nodulation is sufficient. Although the strain of rhizobium that infects fenugreek is similar to that of alfalfa or clover, commercial fenugreek inoculant options are not available and the products tested to date have not produced sufficient yield responses to justify their use (i.e., https://saskpulse.com/growing-pulses/fenugreek). Research is underway to determine if any current products may be effective or new strains will need to be commercialized (https://www.agwest.sk.ca/insight-plant-health-evaluating-nitrogen-fixing-inoculants-for-fenugreek); however, in the meantime, supplemental fertilizer is the most reliable option to ensure the crop's N demands are met. With that, we anticipate that new growers of this crop to have will have questions on the extent to which supplemental N fertilizer is necessary and how much should be applied. Agronomic research on this subject specific to western Canada has been extremely limited. While examples of fenugreek N response research from other arid regions such as India and North Africa exist, the research is often either poorly executed or not clearly described, making it difficult to extract meaningful recommendations from (i.e., Deshmukh et al. 2020; Gutema et al. 2021; Mohammed et al. 2021). Nonetheless, these examples do appear to show potential for substantial yield responses to additions of N fertilizer for this crop.

Literature Cited

Acharya, S. N., Thomas, J. E., and Basu, S. K. 2008. Fenugreek, an Alternative Crop for Semiarid Regions of North America. Crop. Sci. **48:** 841-853.

Deshmukh, A. A., Nagre, P. K., and Wagh, A. P. 2020. Response of Fenugreek (*Trigonella foenum-graecum* L.) to Different Levels of Nitrogen and Phosphorus. International Journal of Chemical Studies. **8:** 1401-1405. doi.org/10.22271/chemi.2020.v8.i4m.9794

Gutema C., Abdullahi, J., and Tana T. 2021. Growth and Yield of Fenugreek (*Trigonella foenum-graecum* L.) Varieties as Influenced by Application of NPS Fertilzer at Ginir, South-eastern Ethiopia. Agriculture, Foresty, and Fisheries. **10:** 66-74. doi: 10.11648/j.aff.20211002.15.

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Thomas, J. E., Bandara, M., Driedger, D., and Lee, E. 2011. Fenugreek in Western Canada. The Americas Journal of Plant Science and Biotechnology. 5: 32-44.

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Methodology

Fully describe how the project was set up and run. You should provide enough information so that any reader can understand what you did, and where and when you did it. From that they can determine if your report has any relevance to their own operation. For example, your description should include all relevant items such as 1) the number and size of any field plots, 2) what was seeded, 3) what treatments were applied to the plots, 4) the schedule or timing of any relevant activities such as seeding, treatment application or harvest, and 5) what was measured to evaluate the success of any treatment. If your project dealt with animals, you should be sure to include 1) the number of animals in each trial group, 2) the treatment or procedure applied to each group, and 3) what was measured to evaluate the success of each treatment.

Field trials with fenugreek were established at four locations; Indian Head (thin Black soil zone), Outlook (Brown soil zone, irrigated), Redvers (Black soil zone), and Swift Current (dry Brown soil zone). The locations were selected to represent a variety of Saskatchewan environments, and the treatments were simply seven nitrogen (N) fertilizer rates, one of which was a control where no N beyond that provided by phosphorus (P) products was applied. All supplemental N was provided as side-banded urea and, in addition to the control, the rates evaluated were 50, 75, 100, 125, 150, and 175 kg N/ha (soil NO_3-N plus fertilizer). These seven N fertility treatments were arranged in a Randomized Complete Block Design with four replicates.

Plot size and seeding equipment varied with location; however, all drills had the capability of side-banding fertilizer. The fenugreek was direct seeded into cereal stubble at all locations except for Outlook, where the previous crop was field pea. All nutrients other than N were intended to be non-limiting and, apart from pre-seed broadcast potassium sulphate (0-0-53-18), all fertilizer was side-banded. As required by protocol, no rhizobia inoculants were used. All locations used the same seed source with CDC Canafen as the variety and a target rate of 220 viable seeds/m^2. Weeds were controlled using pre-emergent and in-crop herbicides at some locations while others relied on hand weeding. Insects and disease were controlled using foliar-applied insecticides and fungicides at the discretion of individual site-mangers. All pertinent and available information on agronomic practices, field operations, and data collection activities are provided in Table 8 of the Appendices.

Various data were collected throughout the growing season and from the harvested grain samples. While fall, whole site composite soil test results were sometimes used to determine the fertilizer rates, composite soil samples for the specific trial areas were collected in the spring and analyzed for basic chemical/physical properties and residual nutrient levels. As a measure of overall establishment success and trial uniformity at each site, and to determine if side-banded urea affected emergence, plant densities were estimated by counting seedlings in at least 2 x 1 m sections of crop row and converting the averaged values to plants/m^2. Nodulation potential for each location was documented by digging up a few plants from the guard plots, where no supplemental N was applied, and assigning an overall, subjective rating on the level of nodulation using a scale of 0-3 (0 – no nodules; 1 – sparsely nodulated, 2 – moderately nodulated, and 3 – well nodulated). The relative maturity of each plot was rated when senescence was first observed using a scale of 1-3 where 1 was advanced maturity, 2 was average maturity, and 3 was delayed maturity. Grain yields for each plot were determined by weighing the harvest sample from each plot, adjusting for dockage, and, where seed moisture content was available, adjusting the weights to a uniform seed moisture content of 13%.

Response data for each location were analyzed using the generalized linear mixed model procedure (GLIMMIX) of SAS Studio with the N rate effects considered fixed and replicate effects treated as random. The control, where no additional N was applied, was compared to the combined fertilized treatments and orthogonal contrasts were used to test whether any responses were linear, quadratic (curvilinear), or not significant. Treatment means were separated using Fisher's protected LSD test. All treatment effects and differences between means were considered significant at $P \leq 0.05$. Due to the relatively small number of locations, variable data quality, and clear differences amongst sites, we did not see sufficient value in combining data across locations for analyses to do so at this time.

Results *(you must provide the following information)*

Present and discuss any project results, including any data or measurements taken to evaluate the demonstration. Include things that didn't appear to work. These results are just as important to share. List extension activities such as field days or workshops. List the activity, the date it occurred, and the number of people who attended.

Soil Test Results and Growing Season Weather

Again, while the soil test results used to determine fertilizer rates sometimes differed, all the specific trial areas were sampled in the spring and selected results are presented in Table 1. Except for Swift Current where the site-specific samples showed comparatively high residual N, any discrepancies between these results and those used to calculate fertilizer rates were minor and not considered important. Indian Head had the finest soil texture (≥50% clay) and highest organic matter (5.2%), with moderate residual N estimated at 29 kg NO_3-N/ha for the 60 cm soil depth. The Outlook site had relatively coarse textured soil and intermediate organic matter (3.0%), while residual N at this location was

moderate with an estimated 36 kg NO_3-N/ha. Redvers has a more intermediate (loamy) soil texture, organic matter (3.0%) and, at 19 kg NO_3-N/ha, had the lowest residual N levels of all the 2024 sites. Finally, Swift Current, has a medium textured soil and lower organic matter at 2.5%. Attributed to past droughts and subsequently low yields, Swift Current had unusually high residual N levels at 91 kg N/ha; however, the assumption used to calculate N rates was 39 kg N/ha. Consequently, the amount of N applied as urea to reach the 50 kg N/ha target was only 6 kg N/ha, even with potassium sulphate (which does not contain any N) as the S source.

Table 1. Selected soil test analyses results for ADOPT (20230545) fenugreek N response demonstration conducted at Indian Head (IH), Outlook (OL), Redvers (RV), and Swift Current (SW) in 2024. Unless otherwise indicated, all measurements are representative of the 0-15 cm soil profile.

Parameter	IH-24	OL-24	RV-24	SW-24
pH	7.6	7.9	8.2	6.5
Organic Matter (%)	5.2	3.1	3.0	2.5
CEC (meq)	50.0	20.4	32.5	17.3
NO_3-N (kg/ha)[Z]	29	36	19	91[Y]
Olsen-P (ppm)	8	7	3	12
K (ppm)	587	351	265	211
kg S/ha (kg/ha)[Z]	29	111	372	29

[Z] Values for residual NO_3-N and S are for the 0-60 cm soil profile

[Y] The residual NO_3-N level used to calculated fertilizer rates at SW-24 was 39 kg/ha

Mean monthly temperatures and precipitation totals for the four-month (May through August) growing season are presented in Tables 2 and 3, respectively. For all locations, temperatures were slightly below average in May and particularly cool in June, followed by a remarkably hot July and average to slightly above average temperatures in August. The precipitation patterns were such that cumulative rainfall in May and June were above average at all locations but well below average in July. August participation varied with conditions being very dry in the western part of the province (Outlook and Swift Current) but wetter to the east, particularly at Indian Head where frequent thunderstorms resulted in over 70 mm or nearly 140% of average precipitation for the month. Over the four-month period, Indian Head and Outlook had close to average temperatures and precipitation amounts, Redvers was slightly wetter than average with about average temperatures, and Swift Current was slightly hotter and drier than average. For all locations, it was a season of extremes characterized by both cool periods with excess moisture and saturated soils followed by periods of prolonged heat and drought.

Table 2. Mean monthly temperatures along with long-term (LT; 1981-2010) averages for the 2024 growing season at Indian Head (IH), Outlook (OL), Redvers (RV), and Swift Current (SW), Saskatchewan.

Year	May	June	July	August	May-Aug
	---------- Mean Temperature (°C) ----------				
IH-24	10.6	13.6	19.5	17.9	15.4 (-0.2)
IH-LT	10.8	15.8	18.2	17.4	15.6
OL-24	11.2	14.2	20.4	18.1	16.0 (-0.1)
OL-LT	11.5	16.1	18.9	18.0	16.1
RV-24	10.9	14.7	20.0	17.7	15.8 (-0.2)
RV-LT	11.1	16.2	18.7	18.0	16.0
SW-24	10.6	14.3	21.3	19.4	16.4 (+0.6)
SW-LT	11.0	15.7	18.4	17.9	15.8

Table 3. Total monthly precipitation amounts along with long-term (LT; 1981-2010) averages for the 2024 growing season at Indian Head (IH),

Outlook (OL), Redvers (RV), and Swift Current (SW), Saskatchewan.

Year	May	June	July	August	May-Aug
	---------- Total Precipitation (mm) ----------				
IH-24	63.7	74.9	37.4	71.2	248 (102%)
IH-LT	51.7	77.4	63.8	51.2	244
OL-24	65.7	122.0 (75)	19.1 (106)	3.8 (75)	211 (103%)
OL-LT	42.6	63.9	56.1	42.8	205
RV-24	92.0	156.2	13.4	39.0	301 (113%)
RV-LT	60.0	95.2	65.5	46.6	267
SW-24	73.6	52.1	18.6	18.2	163 (87%)
SW-LT	42.1	66.1	44.0	35.4	188

Indian Head (2024)

Results from Indian Head are summarized in Table 4. Establishment was excellent with rapid emergence, uniform plots, and average plant densities of 231 plants/m^2. The seedlings at this location were exposed to a -3.5 °C frost event on May 25, 11 days after seeding and within a few days of emergence, but no tissue damage or injury was observed. The combination of pre-seed and in-crop herbicides along with hand-weeding of herbicide resistant kochia kept the plots free of weeds all season long. The main insect pests observed were grasshoppers during early flowering and blister beetles during mid to late flowering – both of which were controlled with foliar insecticides. Significant leaf disease, presumably Cercospora leaf spot, was observed in early July, but appeared to be suppressed with a single foliar fungicide application followed by an extended dry period.

Plant densities were not affected by N rate (P = 0.232) with a range of 216-254 plants/m^2 and neither the linear nor quadratic orthogonal contrasts being significant (P = 0.100-272). The contrast comparing the control to all fertilized treatments was not significant either (P = 0.508). This indicated that the separation between the seed and side-banded N was sufficient, even at the high rates. The exceptionally high plant densities were largely attributed to warm soils, good but not excessive moisture at seeding, and several timely rainfall events after seeding.

The relative maturity of the fenugreek was affected by N rate, with delays first detected at 75 kg N/ha and progressing right to the highest rate. Again, these ratings were relative, and all treatments were physiologically mature by the beginning of September. Furthermore, it was noted that the relative differences appeared to diminish as the plots approached maturity and, by the time the crop was ready to terminate, any maturity effects were not considered agronomically important from a practical perspective. Photos of select plots and their corresponding maturity ratings are provided in Figs. 2-4 of the Appendices.

The overall yield potential was quite high at Indian Head in 2024 with average yields of nearly 2500 kg/ha and 3000 kg/ha in the highest yielding treatment. Notably, there was an exceptionally strong response to N with yields increasing from 1845 kg N/ha where no supplemental urea was applied to 2963 kg/ha when the total (soil NO_3-N plus fertilizer) N level was 175 kg N/ha. Although the highest yields were observed at the highest N rate of 175 kg N/ha (soil plus fertilizer), the quadratic (P < 0.001) response suggested that the incremental gains with additional N were diminishing at the highest rates. The similar yields for the 125-150 kg N/ha may have been due to random variability and the facts that we were approaching maximum yields and comparing relatively small incremental increases in N rate. Root assessments in mid-July found that nodules were present but relatively sparse, with an overall rating of 1.5 on a scale of 0-3 (i.e., Fig. 1 of the Appendices). Some plants appeared to be quite well nodulated while, for others, no nodules whatsoever were observed. Sampling the roots without damaging them proved challenging in the heavy clay soils at Indian Head and it is probable that some of the nodules were stripped during this process.

Table 4. Treatment means and results of the multiple comparisons tests, overall F-tests, and orthogonal contracts for selected response variables in the fenugreek nitrogen (N) response demonstration conducted at Indian Head in 2024 (ADOPT #20230545). For each response variable, values within a column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

	Indian Head 2024		
Nitrogen Rate	**Plant Density**	**Relative Maturity**	**Seed Yield**
	plants/m^2	(1-3)	kg/ha
Control	224 a	1.0 f	1845 f
50 kg N/ha	216 a	1.1 ef	2082 e
75 kg N/ha	221 a	1.3 e	2405 d
100 kg N/ha	232 a	1.6 d	2547 c
125 kg N/ha	254 a	2.1 c	2723 b
150 kg N/ha	241 a	2.6 b	2710 b
175 kg N/ha	228 a	3.0 a	2963 a
S.E.M.	12.1	0.11	114.5
		Pr > F (p-value)	
Overall F-test	0.232	<0.001	<0.001
Check vs Rest	0.508	<0.001	<0.001
N Rate – linear	0.100	<0.001	<0.001
N Rate - quadratic	0.272	<0.001	<0.001

Outlook (2024)

Results from Outlook are presented in Table 5. Establishment was relatively poor at this location with an overall average plant density of 100 plants/m^2 and, as such, an estimated seedling mortality of 55%. With no significant overall F-test (P = 0.984) or contrasts (P = 0.869-0.956), there was no evidence that N rate affected plant populations. This indicates that the separation between seed and side-banded fertilizer was likely sufficient, and the high mortality was not attributable to fertilizer injury. According to SaskPulse, the optimal plant density for fenugreek is 135 plants/square meter; therefore, the observed stands were less than ideal but not necessarily expected to result in major yield loss.

Relative maturity ratings were not completed at Outlook in 2024.

Despite reasonably low residual N levels (30 kg N/ha) and high yield potential (overall average of ~2600 kg/ha), no significant yield response to N fertilization was detected at Outlook. Numerically, the highest yielding treatments were those that received ≤50 kg N/ha (soil plus fertility) and the linear orthogonal contrast suggested a marginally significant (P = 0.076) decline in yield as N fertilizer was increased. With relatively high overall variability and lack of a significant overall F-test (P = 0.546) or 'Check versus rest' contrast (P = 0.169), we cannot be confident that the observed trend for higher yields at the lowest N levels was a genuine response. The root assessments at Outlook suggested that individual plants had 0-3 nodules with an overall average of 1.2 nodules per plant. The overall nodulation rating assigned to this location was 1.5 on a scale of 0-3 (0 is no nodules whatsoever). Importantly, these ratings were subjective and only completed in guard plots where no supplemental urea was applied. While we cannot determine the cause with any certainty, the lack of an N response at Outlook may have been due to biological N fixation, the field pea residues releasing substantial quantities of N throughout the growing season, or a combination of both factors.

Table 5. Treatment means and results of the multiple comparisons tests, overall F-tests, and orthogonal contracts for selected response variables in the fenugreek nitrogen (N) response demonstration conducted at Outlook in 2024 (ADOPT #20230545). For each response variable, values within a column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

	Outlook 2024		
Nitrogen Rate	**Plant Density**	**Relative Maturity [z]**	**Seed Yield**
	plants/m^2	(1-3)	kg/ha
Control	102 a	—	2858 a
50 kg N/ha	96 a	—	2856 a
75 kg N/ha	103 a	—	2519 a
100 kg N/ha	99 a	—	2489 a
125 kg N/ha	97 a	—	2439 a
150 kg N/ha	106 a	—	2530 a
175 kg N/ha	99 a	—	2417 a
S.E.M.	10.1	—	204.2
	Pr > F (p-value)		
Overall F-test	0.984	—	0.546
Check vs Rest	0.869	—	0.169
N Rate – linear	0.869	—	0.076
N Rate - quadratic	0.956	—	0.364

[z] Data not collected at Outlook 2024

Redvers (2024)

Results for Redvers are provided in Table 6. With an overall observed plant density of 143 plants/m^2, the estimated seeding mortality was 35%, not as high as Indian Head but better than Outlook. With this level of establishment, we did not expect stands to have a negative impact on the crop's ability to compete with weeds, maturity, or seed yield. Neither the overall F-test (P = 0.198), 'Check versus Rest' comparison (P = 0.846), nor orthogonal contrasts (P = 0.133-0.306) were significant for plant densities at Redvers, indicating that the separation between the seed and side-banded fertilizer was sufficient and N rate did not affect establishment.

Unlike Indian Head and Swift Current where these ratings were completed earlier, the relative maturity assessments were completed relatively late at Redvers, just prior to desiccation with diquat. At this time, the only observed treatment effect was that the plants were slightly delayed in the control (2.8) relative to all the treatments that received supplemental urea (2.0). It is likely that the trends earlier in the season, when the plants first started to show signs of maturing, would have differed; however, this later set of ratings is useful to confirm that the higher rates of N did not, in the end, have any meaningful negative impact on maturity. We speculated that this was also largely the case at Indian Head, even though the ratings from earlier in the season described visual differences across N levels in when crop senescence was initiated. While we did not necessarily get the expected N rate effect on maturity at Redvers, it is not especially uncommon for severe nutrient deficiencies to hinder plant development.

The overall yield potential at Redvers was substantially less than Indian Head or Outlook with an overall mean yield of ~1300 kg/ha. Although the test of fixed effects was not significant for yield at Redvers (P = 0.177), the 'Check versus Rest' comparison indicated a significant (P= 0.015) overall response to N and the linear orthogonal contrast was also significant (P = 0.050). Yields appeared to be optimized at relatively low N rates with 75 kg N/ha (soil plus fertilizer) being the highest yielding treatment. That said, without a significant overall F-test, we cannot say that even the highest yielding treatment significantly differed from the control when individual means were compared. When the roots were assessed, nodulation was rated at 2.0, on a scale of 0-3 (where 3 is well nodulated); therefore, it is possible that the weak response was partly attributable to biological mineralization. This was the highest nodulation rating of any locations; however, the subjective nature of these ratings makes it difficult to confidently compare mineralization potential across environments. With relatively low yields despite being the wettest location, it is also possible that other

factors such as crop pests (weeds, disease, or insects), were generally more limiting to yield than N fertility at Redvers.

Table 6. Treatment means and results of the multiple comparisons tests, overall F-tests, and orthogonal contracts for selected response variables in the fenugreek nitrogen (N) response demonstration conducted at Redvers in 2024 (ADOPT #20230545). For each response variable, values within a column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

	Redvers 2024		
Nitrogen Rate	**Plant Density**	**Relative Maturity**	**Seed Yield**
	plants/m^2	(1-3)	kg/ha
Control	142 a	2.8 a	1025 a
50 kg N/ha	148 a	2.0 b	1270 a
75 kg N/ha	152 a	2.0 b	1519 a
100 kg N/ha	138 a	2.0 b	1326 a
125 kg N/ha	146 a	2.0 b	1347 a
150 kg N/ha	154 a	2.0 b	1488 a
175 kg N/ha	124 a	2.0 b	1384 a
S.E.M.	9.2	0.09	129.4
		Pr > F (p-value)	
Overall F-test	0.198	<0.001	0.177
Check vs Rest	0.846	<0.001	0.015
N Rate – linear	0.306	<0.001	0.050
N Rate - quadratic	0.133	<0.001	0.121

Swift Current (2024)

Results for Swift Current are provided in Table 7. Establishment was quite poor at this location with an overall average of 73 plants/m^2, or 67% seedling mortality. These low populations were likely limiting to yield and had potential to impede the crop's ability to compete with weeds. Notably, we did see an N rate effect on emergence whereby the overall F-test was significant ($P = 0.024$), the fertilized treatments, on average, had worse plant stands than the control (70 versus 86 plants/m^2; $P = 0.022$), and plant densities decreased linearly ($P < 0.001$) with increasing N rate. This result indicated that, under the conditions encountered, separation between the seed and side-banded N was not sufficient to eliminate the risk of seedling injury.

At Swift Current in 2024, the relative maturity ratings were completed twice, first on July 22 and again on August 13. This provided a good opportunity to assess the relative differences in maturity during both the early stages of crop senescence and again closer to harvest. At both times, the trends were the same with significant overall F-tests ($P <$ 0.001-0.016), 'Check versus Rest' comparisons ($P <$ 0.001-0.017), and linear orthogonal contrasts ($P < 0.001$); however, the spread in visible maturity differences was slightly greater at the earlier stage. In any case, with the hot and dry finish to the season, delayed maturity was not a concern, and the plots were ready to combine by late-August without desiccation.

Although fenugreek can tolerate high temperatures quite well, late-season drought has potential to greatly reduce seed yields, and this was particularly evident at Swift Current in 2024. The overall average yield was 550 kg/ha, compared to 1300 kg/ha at Redvers and 2500 kg/ha or more at Outlook and Indian Head. Somewhat unexpectedly given the low yield potential and high residual N levels, there was a yield response to N fertilization at Swift Current with significant overall F-tests ($P = 0.024$), 'Check versus Rest' comparisons ($P = 0.028$), and linear/quadratic orthogonal contrasts ($P =$ 0.005-0.033). Although the response was small in absolute terms, the maximum yield achieved at 100 kg N/ha (soil plus fertilizer) was 53% higher than that observed in the control. No further yield increases were observed with subsequent additions N and yields tended to decline slightly at the highest rates, possibly due to the reductions in plant density.

Table 7. Treatment means and results of the multiple comparisons tests, overall F-tests, and orthogonal contracts for selected response variables in the fenugreek nitrogen (N) response demonstration conducted at Swift Current in 2024 (ADOPT #20230545). For each response variable, values within a column followed by the same letter do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

	Swift Current 2024			
Nitrogen Rate	**Plant Density**	**Rel. Maturity-1**	**Rel. Maturity-2**	**Seed Yield**
	---- plants/m^2 -----	-------- (1-3) --------	-------- (1-3) --------	------- kg/ha -------
Control	86 a	1.0 c	1.5 b	475 c
50 kg N/ha	85 a	1.5 bc	1.5 b	490 c
75 kg N/ha	75 ab	1.5 bc	2.0 ab	497 bc
100 kg N/ha	73 ab	2.0 ab	2.0 ab	622 a
125 kg N/ha	66 b	2.0 ab	2.3 a	588 ab
150 kg N/ha	63 b	2.5 a	2.5 a	587 ab
175 kg N/ha	58 b	2.5 a	2.5 a	567 ab
S.E.M.	6.0	0.22	0.28	68.7
	---------- Pr > F (p-value) ----------			
Overall F-test	0.024	<0.001	0.016	0.024
Check vs Rest	0.022	<0.001	0.017	0.028
N Rate – linear	<0.001	<0.001	<0.001	0.005
N Rate - quadratic	0.628	0.478	0.426	0.033

Extension Activities

This demonstration was a scheduled stop during the Indian Head Crop Management Field Day hosted by IHARF and AAFC on July 16, 2024. The event was attended by roughly 145 participants and Chris Holzapfel (IHARF), with help from Meagan Reed (SaskPulse) led a discussion on fenugreek adaptation, agronomy, market uses, and potential for expansion of acreage. The plots at Indian Head were also briefly shown during a tour coordinated with the National Circle of Indigenous Agriculture and attended by 40 participants. Chris Holzapfel presented key findings from the project during the IHARF Winter Seminar/AGM on February 5, 2025, in Melville. At Swift Current, the plots were visited during a small site visit/tour with members of the Agriculture Research Branch of the Saskatchewan Ministry of Agriculture on July 3, 2024. This final technical report and PowerPoint slides from the IHARF AGM will available online.

Conclusions and Recommendations

Describe what was learned from the demonstration. Highlight any significant conclusions and provide recommendations for the application and adoption of the project results. Be sure that you have presented the relevant data to support your conclusions. Identify any further research, development and communication needs, if applicable.

Overall, this project showed that fenugreek has potential to be quite well-adapted to Saskatchewan growing conditions; however, more data and experience is required to improve the potential for success on individual farms and better understand where this crop should specifically be grown. Yields at Indian Head and under irrigation at Outlook were quite high while, at Redvers, yields were lower than expected given the specific weather and environmental conditions encountered. With a weak N response, it is not clear what the most yield limiting factor was at Redvers. In contrast, yields were extremely low at Swift Current and, while 2024 was a challenging season for this location, it is likely that the risk of late season drought may be too high in the dry Brown soil zone for this crop. Producers and agronomists would benefit from more research and extension regarding weed control options in fenugreek production and more data is required to better understand the potential disease and insect pests that might affect it, along with how best to manage these pests. While beyond the scope of this project, work to develop end uses/processing capacity and marketing opportunities are critical for fenugreek acreage to be able to grow to the extent where is would be a viable crop option for a meaningful percentage of Saskatchewan farmers.

Focussing on N requirements, the responses were extremely variable across locations; therefore, it is difficult to make confident recommendations. At Indian Head, with reasonably low residual N, good pest control, and high yield potential, we achieved the highest yields with 175 kg N/ha (soil plus fertilizer) and, conservatively, can say that at least 125 kg N/ha (soil plus fertilizer) was required to optimize yields and profits. In contrast, there was essentially no benefit to N fertilizer at Outlook, where yields were also high and residual N was reasonably low. Why the response at these sites differed to such an extent, despite these similarities, is unclear; however, one key difference was that the fenugreek at Outlook was seeded into field pea stubble which may released more N over the course of the season. Fenugreek and field peas form symbiotic relationships with different strains of rhizobium; therefore, we do not necessarily expect that this sequence increased biological N fixation compared to seeding into cereal stubble like the other locations. At Redvers, the N response was weak compared to Indian Head, but there did appear to be some benefit to fertilizer application and, strictly looking at the means, yields were optimized with a modest rate of 75 kg N/ha (soil plus fertilizer). Again, factors other than N appeared to be limiting yields at this location and the response may have differed if this were not the case and the yield potential was higher. At Swift Current, yields were maximized at 100 kg N/ha but, again, it is unlikely that this crop would have been profitable at this location regardless of the response or N rate applied. Overall, despite the lack of response at Outlook, it would appear to be reasonable to make a broader recommendation of ensuring 75-125 kg N/ha, including residual soil N for fenugreek. Higher rates may be justifiable for growers who are confident in their ability to grow this crop and have seen substantial benefits to N fertilization in the past. Eventually, we need to better understand why responses occur in some environments but not others and it would be ideal to identify inoculant options to improve biological N_2 fixation, potentially reducing the need for supplemental urea to a large extent. It would be highly beneficial to repeat this project or conduct similar field trials, ideally focussing on the wetter regions with sufficiently long growing seasons where this crop is most likely to succeed.

Sustainable Canadian Agricultural Partnership (Sustainable CAP) Performance Indicators

a) List of performance indicators

Sustainable CAP Indicator	Total Number
Scientific publications from this project (List the publications under section b)	
• Published	None
• Accepted for publication	None

Highly Qualified Personnel (HQPs) trained during this project	
• Master's students	None
• PhD students	None
• Post docs	None
Knowledge transfer products developed based on this project (presentations, brochures, factsheets, flyers, guides, extension articles, podcasts, videos)[1]. List the knowledge transfer products under section (c)	6+

[1] Please only include the number of unique knowledge transfer products.

b) List of scientific journal articles published/accepted for publication from this project. Please ensure that each line includes the following: **Title, Author(s), Journal, Date Published or Accepted for Publication and Link to Article (if available).** *Add additional lines as needed*.

1. Not Applicable – no scientific articles associated with this project have been submitted for peer-review or publication.

c) List of knowledge transfer products/activities developed from this project.

Knowledge Transfer Product or Activity	Event/Location Where Knowledge Transfer Was Conducted	Estimated Number of Producers Participated in Knowledge Transfer	Link (if available)
C. Holzapfel (IHARF) Plot Tour	Crop Management Field Day, Indian Head, SK (Jul-16-2024)	145	https://iharf.ca/indian-head-crop-management-field-day/
D. Petty (IHARF) Plot Tour	NCIAF – IHARF Plot Tour, Indian Head, SK (Aug-7-2024)	40	https://nciaf.ca/
C. Holzapfel (IHARF) Oral Presentation	IHARF Soil and Crop Mgt Seminar & AGM, Melville, SK (Feb-5-2025)	100	https://iharf.ca/iharf-soil-and-crop-management-seminar-agm/
Bryan Nybo and Amber Wall (WCA) Plot Tour	Saskatchewan Ministry of Agriculture Agriculture Research Branch Tour, Swift Current, SK (Jul-3-2024)	9	Not applicable.
Lana Shaw (SERF) Plot Tour	SERF Field Day, Redvers, SK (Jul-24-2024)	30	Not applicable
Final Project Report – Online	IHARF Website	unknown	https://iharf.ca/full-reports/

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Appendices

Identify any changes expected to industry contributions, in-kind support, collaborations or other resources.

Table 8. Selected agronomic information and dates of operations for the 2024 fenugreek nitrogen (N) response demonstration (ADOPT #20230545) conducted at Indian Head (IH), Outlook (OL), Redvers (RV), and Swift Current (SW), Saskatchewan.

Activity	IH-24	OL-24	RV-24	SW-23
Previous Crop	Wheat	Field Pea	Annual Cereal Mix	Wheat
Pre-Emergent Herbicide	May-12-2024 (glyphosate)	None Applied	None Applied	May-16-2024 (glyphosate)
Seeding Date	May-14-2024	May-22-2024	Jun-3-2024	May-27-2024
Row Spacing	30 cm	21 cm	30 cm	21 cm
kg N-P_2O_5-K_2O-S/ha [Z]	7-35-93-32[Y]	4-19-0-0	6-28-0-0	5-22-35-11
Emergence Counts	Jun-7-2024	Jun-17-2024	Jun-21-2024	Jun-13-2024
In-crop Herbicide	Jun-9-2024 (Odyssey + Casiva Ultra Q)	Jun-24-2024 (Centurion)	None Applied	Jun-19-2024 (Assure II)
Nodule Assessment Date	Jul-11-2024 (Rating of 1.5)	Jul-23-2024 (Rating of 1.5)	Aug-8-2024 (Rating of 2)	Jul-23-2024 (Rating of 1.0)
Foliar Insecticide	Jul-11-2024 (Coragen Max) Jul-22-2024 (Cygon 480)	Jul-24-2024 Aug-8-2024 (Matador)	None Applied	Jul-24-2024 (Voliam Xpress)
Foliar Fungicide	Jul-8-2024 (Dyax)	Jul-5-2024 (Dyax)	None Applied	None Applied
Maturity Rating Date	Aug-6-2024	Not Completed	Sep-4-2024	Jul-22-2024 Aug-13-2024
Pre-harvest Herbicide / Desiccant	Sep-5-2024 (glyphosate)	Sep-16-2024 (glyphosate)	Sep-5-2024 (diquat)	None Applied
Harvest Date	Sep-16-2024	Sep-27-2024	Sep-16-2024	Aug-27-2024

[Z] Fertility information only includes nutrients provided by phosphorus, potassium, and/or sulfur products applied (i.e., does not include soil residual nutrients or N provided by supplemental urea applied to achieve the target N levels)

[Y] The high rates of potassium sulphate were due to a Valmar calibration error which has since been corrected

Figure 1. Fenugreek roots from plots that did not receive any supplemental N at Indian Head on July 11, 2024. Node the sparse nodulation whereby the plants received an overall nodulation rating of 1.5 on a scale of 0-5 where 0 is no nodules and 3 is well nodulated.

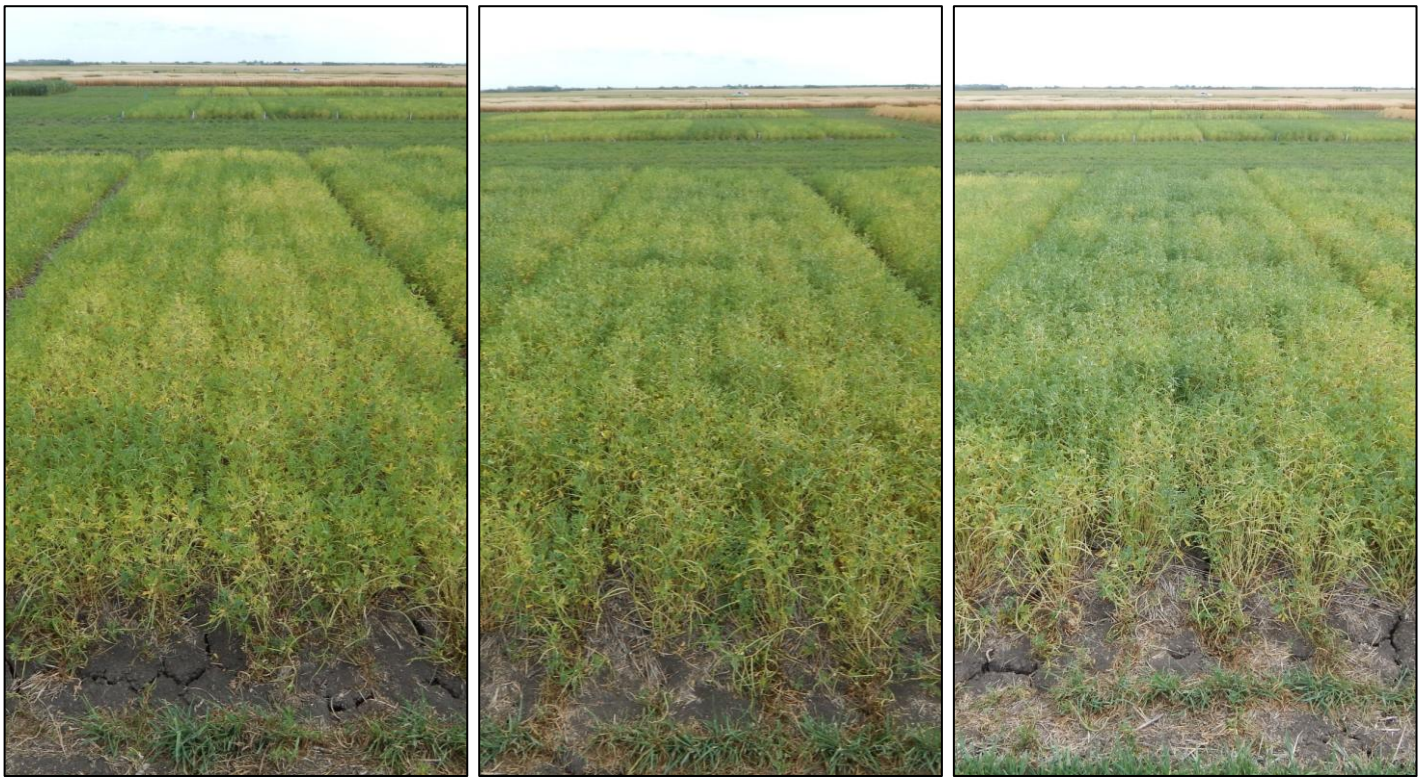

Figure 2. Fenugreek growing at Indian Head, Saskatchewan in 2024 (August 6). From left to right, these plots were fertilized with 50, 125, and 175 kg N/ha (residual soil NO3-N plus fertilizer) and, using a subjective scale of 1-3 (where 3 is delayed), these individual plots received relative maturity ratings of 1.0, 2.0, and 3.0.

Sustainable Canadian Agricultural Partnership
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Expenditure Statement

You must provide an expenditure statement showing how ADOPT funds were used. Expenditures must be reported using the budget categories shown in Appendix B of your contract. We recommend that you report your expenditures using the Excel spreadsheet we have developed for this purpose (ADOPT Expenditure Statement.xls). That spreadsheet is available from the research branch project manager or the evaluation coordinator. *Note that the ADOPT contract requires you to retain all receipts and financial records relating to the project for at least six years after the project is completed.*

Provided in a separate Excel workbook and available upon request.