<u>Project Identification</u>

Project Title: Dry bean response to nitrogen fertilizer rates in dryland, solid-seeded production

Project Number: ADOPT20200511

Producer Group Sponsoring the Project: Northeast Agriculture Research Foundation

Project Location(s): RM of Star City no. 428 SE 31-44-18 W2

Project start and end dates (month & year): April 2021 to February 2022

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Objectives and Rationale:

Project objectives: To demonstrate the response of dryland, solid-seeded black beans to varying nitrogen (N) fertilizer rates, across a range of conditions in Saskatchewan.

Project Rationale:
Dry beans are a high value pulse crop that can be grown to provide diversity in crop rotations. Many areas utilize peas, soybeans, or lentils as the main pulse crop options; however, disease issues, such as Aphanomyces have led producers to seek alternative non-host pulse crops to adopt into their rotations, such as dry beans. CDC Blackstrap is a newly adapted dry bean variety that has been successful under dryland, narrow-row production in Saskatchewan. It is an early maturing variety that is well suited for shorter growing seasons, and has high pod set for ease of harvesting with straight cut headers. Although dry beans are considered a legume crop, they are not able to efficiently fix nitrogen to support their growing needs. In addition, available inoculants for dry beans have proved to be ineffective in previous demonstrations. Due to this, nitrogen fertilizer has been relied on in commercial production to meet the nitrogen demands of dry bean crops. Although nitrogen is often supplied in the form of additional fertilizer, very little is known of the correct rate needed to optimize yield and quality of dry beans. This demonstration intended to evaluate increasing nitrogen fertility when growing dry beans to determine optimal rates for producers to use under dryland, narrow row production.

Methodology and Results

Methodology: This small plot demonstration was apart of the multi-location ADOPT trial organized by IHARF. At Melfort the demonstration was located at SE 31-44-18 W2 in the RM of Star City. The demonstration was set up in a Randomized Complete Block Design with 4 replicates. Treatments varied based on 5 different nitrogen rates with a control for comparison (Table 1). In the original protocol treatment 2 was 45 Kg of N/ha, however this treatment was increased to 55 Kg of N/ha due to high residual nitrogen in the soil (Table 1).

Table 1. Treatments used in Dry bean response to nitrogen fertilizer rate in dryland, solid-seeded production in Melfort, SK 2021.

Treatment #	Kg of N/ha (Soil + Fertilizer)
1	0
2	55
3	75
4	105
5	135
6	155

At Melfort plots were 2-m wide by 7-m long. Prior to seeding, the test site was soil sampled for residual nutrient levels (Table 2). Results of the soil test were used for fertilizer recommendations. On May 19th, 2021 all plots were seeded at a 2-inch depth into wheat stubble and were then rolled that same day. Seeding was completed using a 6-row Fabro plot seeder on 30.5 cm row spacing. Seeding rate was adjusted for 88% germination and a 213.8g TKW, while targeting 40 viable seeds/m^2. Nitrogen was applied based on soil available nitrogen in the top 30cm of soil to meet the targeted treatment rates. Phosphorus and Sulphur were the only other supplemented nutrients and were applied at 34 kg/ha and 8 kg/ha, respectively. All nitrogen was applied as 46-0-0, phosphorus was applied as 11-52-0, and sulphur as 21-0-0-24. All fertility was applied in the side-band at seeding

Table 2: Residual soil nutrient levels found in Dry bean response to nitrogen fertilizer rate in dryland, solid-seeded production in Melfort, SK 2021. Nitrogen and sulphur levels based on 0-30cm depth, while phosphorus and potassium are based on 0-15cm depth.

Residual Soil Levels			
Nitrogen (kg/ha)	*Phosphorus (ppm)*	*Potassium (ppm)*	*Sulphur (kg/ha)*
36	7	474	27

The trial received crop protection products as required. The seed was treated with Apron Maxx at 325mL/100kg of seed and Vibrance 500FS at 10mL/100kg of seed for early protection from seed and soil borne diseases. A pre-emergent herbicide of Glyphosate 540 was applied at 1.34L/ac on May 31st and an in-crop herbicide application of Viper ADV at 0.4L/ac on June 30th was applied for weed control. The plots at the Melfort site were not sprayed with a fungicide in 2021. All plots were desiccated on September 9th with Glyphosate 540 at 0.67L/ac. All plots were harvested on September 21st with a plot combine, in which 5 full crop rows were collected.

To assess treatment differences, data collection consisted of plant density, disease ratings, maturity, height, seed yield, seed size and an economic analysis. Methodology for this data collection is described below. The single site year of data was analyzed using Randomized Complete Block in Statistix 10.

Results

Environmental Conditions:

The environmental conditions of 2021 were marked by being warmer and dryer than the long-term average for several months of the growing season. The mean temperature was greater than the long-term average from June-September (Table 3). The deviation from the long-term mean temperature was most pronounced in September and July when the temperature was 3.2°C and 2.6°C greater than the mean, respectively. May was the only month that was cooler than average with a monthly mean of 9.6°C relative to the long-term mean of 10.7°C (Table 3). Across the growing season, Melfort received 55% of the long-term average for precipitation. From May-September, all months except August (16.9mm above normal) received below average precipitation. This deficit was most pronounced in July and September which received 76.5mm and 31.2mm of precipitation less than the long-term average.

Table 3: Mean temperatures and precipitation collect from the Environment Canada Weather Station at Melfort SK., from May to September 2021.

	May	June	July	August	September	Average/Total
			--- Mean Temperature (°C) ---			
2021	9.6	18.2	20.1	16.9	14	15.8
Long-Term[x]	10.7	15.9	17.5	16.8	10.8	14.3
			--- Total Precipitation (mm) ---			
2021	31.4	37.6	0.2	69.3	7.5	146
Long-Term[x]	42.9	54.3	76.7	52.4	38.7	265.0

[x] Long-term climate normal from Environment Canada Weather Station located at Melfort SK., from 1981-2010

Plant Density:

Plant density was assessed on July 14th where the seedlings were counted along 2 1-meter crop rows per plot. Plant density was described in Table 4. The analysis of variance (ANOVA) identified that there was no significant difference (p=0.40) between the plant density of the treatments (Table 4). After pairwise comparison of the treatments, they were all identified to be statistically similar to each other. Numerically speaking, treatment 3 (75 kg N/ha) had the greatest plant density of 36.5 plants/m^2 while the control and treatment 5 had the lowest plant densities of 31.0 plants/m^2.

Table 4. Statistical analyses and treatment means for Dry bean response to nitrogen fertilizer rate in dryland, solid-seeded production in Melfort, SK 2021. Means within a column followed by the same letter do not significantly differ (Tukey-Kramer, P ≤ 0.05).

	Plant Density[y] (plants/m^2)	Disease	Height (cm)	Maturity [y]	Yield (kg/ha)[y]	Yield (lbs/ac)[y]	Seed Size [y]
P-value	0.4034	0.045*	0.1415	<0.0001***	0.0011**	0.0011**	<0.0001***
Grand Mean	33.9	1.5	30.8	103.8	1048.9	935.0	194.4
CV	14.79	47.14	5.74	0.6	8.83	8.83	2.18
Treatment							
0 Kg of N/ha	31.0 a	0.5 b	30.3ab	100.0 c	888.7 d	792.2 d	176.9 c
55 Kg of N/ha	35.9 a	1.3 ab	30.9 ab	100.0 c	923.7 cd	823.3 cd	181.5 c
75 Kg of N/ha	36.5 a	1.5 ab	31.1ab	104.3 b	1036.4 bc	923.8 bc	192.3 b
105 Kg of N/ha	36.3 a	1.5 ab	31.4a	105.0 b	1075.7 ab	958.9 ab	197.6 b
135 Kg of N/ha	31.0 a	2.3 a	28.6b	106.8 a	1167.5 ab	1040.7 ab	205.9 a
155 Kg of N/ha	33.0 a	2.0 a	32.3a	106.8 a	1201.6 a	1071.1 a	212.1 a

* significant p<0.05, **significant p<0.01, *** significant p<0.001

[y] signify treatments that are significantly different at p<0.05

Disease Ratings:

Disease was assessed on July 8, 2021 in which every plot was rated for severity of bacterial blight infection. A scale of 0-10 was to be used to rate severity. The ANOVA identified that there were significant differences (p<0.05) between the disease ratings of the treatments (Table 4). After pairwise comparison of the treatments, two groups were identified. The control treatment (0kg N/ha) had the lowest disease severity rating at 0.5 which was significantly different from treatments 5 (Disease severity=2.25) and 6 (Disease severity=2) that received the highest nitrogen levels. Treatments 2, 3, and 4 fell into both groups a and b and were similar in disease level to both the control in the low group and treatments 5 and 6 in the high group. Therefore, disease severity followed a linear pattern becoming more severe with a higher nitrogen rate, potentially because of a denser crop canopy.

Height:

Height was assessed on July 29th, 2021 in which 4 plants per plot were measured in height to the nearest centimeter. The ANOVA identified that there was no significant difference (p=0.14) between the canopy height of the treatments (Table 4). Pairwise comparison identified two groups of treatments with treatments 4 and 5 having the largest plant height at 31.4cm and 32.3cm respectively. Both of these treatments were significantly taller than treatment 5 that had a mean plant height of 28.6 cm, while all remaining treatments were statistically similar. No apparent trend was observed between plant height and nitrogen rate as the shortest and tallest means were the three treatments with the greatest nitrogen rates.

Maturity:

Maturity was assessed on August 31st, 2021 where the Julian date was recorded when each plot reached the 60% buckskin stage. The ANOVA identified that there was a highly significant difference (p<0.001) between the maturity dates of the various treatments (Table 4). Nitrogen rate and crop maturity appeared to be positively related with the low nitrogen treatments having the earliest maturity and the high nitrogen treatments having the latest maturity. After pairwise comparison, three groups of treatments were identified based on maturity date of which there was no overlap between the groups. The control and treatment 2 made up group C with the earliest maturity at 100 days. This was statistically different from treatments 3 (104.25 days) and 4 (105 days) that made up group B. Group A was made up of treatments 5 and 6 (106.75 days to maturity). The maturity of treatments 5 and 6 was significantly greater than the four other treatments.

Seed Yield:

Seed yield was assessed by cleaning and weighing every harvested plot sample. Plot weights were converted in kg/ha and lbs/ac equivalents while correcting to 16% seed moisture. The ANOVA identified that there was a significant difference (p<0.01) in the seed yield between the treatments (Table 4). Seed yield and nitrogen rate were positively related with the control having the lowest yield and the high nitrogen treatments having the greatest seed yield. The control had a statistically similar yield to treatment 2 but was significantly different from the remaining four treatments. Treatment 2 had a statistically similar yield to the control and treatment 3. The yield of treatment 3 was also statistically similar to treatments 4 and 5. Treatments 4, 5, and 6 formed the highest yielding group that were all statistically similar to each other. These groupings were the same when considering yield from a kg/ha basis and a lbs/ac perspective.

Seed size:

Seed size was assessed by counting and weighing 200 seeds per plot to calculate the average seed weight expressed in grams/1000 seeds. The ANOVA identified highly significant differences (p<0.001) between the seed size of the treatments (Table 4). There was a positive relationship between nitrogen rate and seed size. Pairwise comparison identified three groups of treatments that did not overlap. The control and treatment 2 were statistically similar with the lowest seed size. Treatments 3 and 4 formed the middle group which was significantly greater than the control and treatment 2 but significantly less than treatments 5 and 6. Treatments 5 and 6 had similar seed sizes that were significantly greater than the four other treatments.

Economic Analysis:

Economic analysis was completed using the 2021 Crop Planning Guide from the Saskatchewan Ministry of Agriculture. It is worth noting that a column was only available for the Dark Brown soil zone and this study was conducted in the black soil zone.

Total non-urea costs included all items from the “Variable Expenses” (Excluding Nitrogen fertilizer) and “Other Expenses” sections of the Crop Planning Guide. It is important to note that an approximate sulphur fertilizer cost was not included in the Crop Planning guide and therefore total non-urea costs may actually be slightly higher than described in Table 5. However, this is not important in differentiating treatments as all treatments received the same rate of 21-0-0-24. The rate of urea applied is based on the target total nitrogen minus the nitrogen supplied by the soil, the monoammonium phosphate, and the ammonium sulfate. Total urea cost is based on a unitary cost of $409.91/tonne which according to indexmundi.com was the cost of urea in Western Canada in Canadian Dollars in April of 2021. Gross revenue is the product of the treatment yield described in Table 4 and the price for black beans in January 2022 from the Viterra bean plant in Bow Island, AB which was $1.21/kg. Based on April 2021 urea prices, all treatments posted a net profit that was positively related to the nitrogen rate (Table 4). The control had the lowest profit at $273.00/ha while treatment 6 (155 kg N/ha) had the highest net profit at $558.01/ha. While profitability of the high nitrogen treatments would be different if considering urea prices in early 2022 (~ $1,130.00 CAD/tonne according to indexmundi.com), all treatments would still likely be profitable due to strong commodity prices in the winter of 2022.

Table 5. Economic analysis for Dry bean response to nitrogen fertilizer rate in dryland, solid-seeded production in Melfort, SK 2021

Treatment (Total kg N/ha)	Total Non-Urea Costs ($/ha)	Urea Applied (kg/ha)	Total Urea Costs ($/ha)	Gross Revenue ($/ha)	Net Profit ($/ha)
0	$802.33	0	$0	$1,075.33	$273.00
55	$802.33	11	$4.48	$1,117.68	$310.86
75	$802.33	54	$22.31	$1,254.04	$429.41
105	$802.33	120	$49.04	$1,301.60	$450.23
135	$802.33	185	$75.77	$1,412.68	$534.57
155	$802.33	228	$93.60	$1,453.94	$558.01

Conclusions and Recommendations

The objective of this research was to identify the optimum rate of total soil available nitrogen for the production of dry beans on dryland, narrow row production in Saskatchewan. Based on data from the Melfort site, the rate of soil and applied nitrogen was positively related to the disease severity, days to maturity, seed yield, seed size, and net profit. Optimum rates of nitrogen for dry bean production on dryland narrow row production would range from 135-155 kg/ha of total nitrogen to optimize yield and seed size. In 2022, because of the simultaneous rise in both commodity and fertilizer prices, the net profitability of growing drybeans under high nitrogen fertility may vary, however under the prices and conditions of the 2021 season, it was most profitable to grow dry beans under a high nitrogen rate of 155 kg/ha.

Extension Activities

The first-year results of this project in the 2020 growing season at Melfort (ADOPT20190468) were shared at the Saskatchewan Institute of Agrologists Northeast Branch Annual Ag Update on February 1st, 2021. The project was also highlighted at the Northeast Agriculture Research Foundation's Annual Field Day on July 28, 2021 via Youtube. The final report for this project will also be made available at neag.ca

Supporting Information

Acknowledgements

The Northeast Agriculture Research Foundation would like to express our gratitude to the Saskatchewan Ministry of Agriculture's ADOPT program for funding this demonstration and for providing signage. We would like to thank Chris Holzapfel of IHARF for coordinating the project protocol and David MacTaggart and Brianne McInnes of NARF for the data analysis and report writing for this project. Finally, NARF would like to thank Gayelene Dagenais, Caitlyn Hartman, and Carter Fettes for their hard work and dedication in completing this project.

Abstract

Abstract/Summary

Dry beans are an alternative pulse crop option, that may be grown to diversify cropping rotations. Primary pulse crops in the province include field peas, soybeans, and lentils. However, disease issues have led producers to identify alternative crop options to adopt into rotations, such as dry beans. CDC Blackstrap is one of the first commercially available dry bean varieties that is suitable for dryland, narrow row production. It is early maturing and is suited to shorter growing seasons in cooler areas of the province, and offers high pod set for ease of harvesting. Although dry beans are a pulse crop, they are relatively poor at nitrogen fixation, and available inoculants have proven to be relatively ineffective in previous research. Therefore, nitrogen fertilization is currently the best option to provide adequate nitrogen supply in dry bean crops, however very little is known of the best rate to use to optimize dry bean production. To demonstrate the effects of increasing nitrogen rates on a dry bean crop a small plot demonstration was set-up at Melfort to evaluate the effects of a control, 55, 75, 105, 135 and 155 kg/ha of nitrogen on plant density, disease, plant height, maturity, seed yield, seed weight, and economics. Plant density and height were not affected by high rates of nitrogen. The incidence of plant disease, or more specifically bacterial blight was significantly increased as nitrogen increased, however only the greatest nitrogen rates of 135 and 155 kg/ha of N were considered significantly greater than the control. Maturity was also significantly prolonged from the control as nitrogen rate increased. Maturity was greatest at 106.8 days for 135 and 155 kg/ha of N as compared to 100 days for the control. For seed yield and seed size, there was a linear increase as nitrogen rate increased up to 155 kg/ha of N. The increase in yield was likely due in part to the continued increase in seed size as nitrogen rate increased. Lastly, the economic analysis resulted in the greatest net profits at the highest nitrogen rate of 155 kg/ha of N.

Finances

Budget Report

See attached excel spreadsheet