Optimizing Nitrogen Rates for Pinto and Navy Beans

Dry bean yield matched maximum yield at the lowest rate of N fertilizer applied which was 35 lbs N/ac and equivalent to 60-90 lbs total N/ac as a combination of fertilizer and soil residual-N. However, the economic optimum scenario was not applying N fertilizer at all.

DRY BEANS ARE relatively poor nitrogen (N) fixers, producing less than 45% of their N requirement, on average, through biological N fixation. Currently, commercial inoculants are not easily accessed nor commonly applied. As a result, dry beans are typically fertilized like a non-legume crop. Application of N fertilizer at a rate of 70 lbs N/ac is common practice, though recommendations vary by region.

Nitrogen uptake rates in dry beans range from 3.9-4.7 lbs N required per cwt of seed, meaning a 2,000 lb/ac dry bean crop would require 78-90 lbs N/ac. This nitrogen may be derived from a combination of residual soil N, biological N fixation and N fertilizer. This experiment evaluated N fertilizer rates while a follow-up companion study has been evaluating inoculant options.

Five rates of N fertilizer (0, 35, 70, 105 and 140 lbs N/ac) were compared in Windbreaker pinto beans and T9905 navy beans at Carman and Portage la Prairie from 2017 to 2019. Nitrogen was applied as spring broadcasted urea and incorporated prior to planting dry beans. Non-inoculated dry beans were planted on 15-inch rows into tilled wheat stubble. Residual N levels among site-years ranged from 23-56 lbs N/ac (0-24" depth).

The 2017 to 2019 growing seasons were dry and warm. This lack of soil moisture may have influenced N dynamics throughout this study, reducing mineralization, inhibiting nodule development and promoting root exploration to access deep N (>24").

Nodulation was low overall, which is not surprising since beans were not inoculated, and sites did not have recent dry bean history. At flowering, dry bean nodulation was evaluated on a scale of 0-4, with 4 being >20 nodules per plant and 0 being no nodules present. Pinto beans had slightly greater nodulation than navy beans (0.6 vs. 0.4). Nodule development in this study is a result of native rhizobia populations since beans were not inoculated. As N fertilizer rate increased, dry bean nodulation score decreased.

Yield response to nitrogen rate did not vary with market class. Dry bean yield was only significantly increased over the 0 N control at the greatest rate of 140 lbs N/ac, which boosted yield by 17% (Figure 1). The yields of the other N rates were no different from the control. However, yield was maximized at the lowest rate of N applied (35 lbs N/ac), which was equivalent to 60-90 lbs of total N/ac (as a combination of N applied and soil residual N).

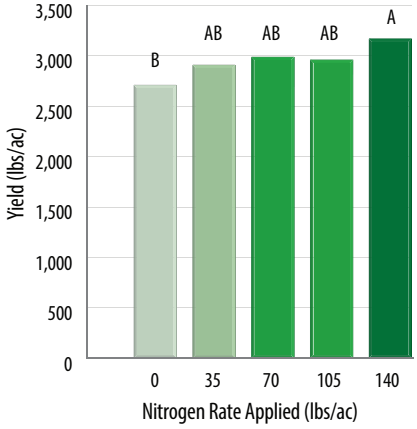
Which N rate was the most economical? Across multiple N cost and bean pricing scenarios, the return on investment was statistically similar for all rates of N application. This indicates that the economic optimum practice in these experiments was not applying N at all.

Yield from the 0 N control was exceptional, averaging 2700 lbs/ac and resulting in 83% of maximum yield. Total N uptake in the 0 N control was estimated to be 64-169 lbs N/ac. Residual soil N would have only provided 23-56 lbs N/ac, resulting in a deficit of 8-131 lbs N/ac. Soil samples were taken post-harvest and found residual N levels in the 0 N control ranging from 20-60 lbs N/ac. This post-harvest surplus indicates N requirements of dry beans were met through a combination of biological N fixation, mineralization and accessing deep nitrogen sources.

Emerging guidelines from this research suggest that full fertilization to meet N requirements may not be necessary in Manitoba and that biological N fixation is contributing to the N requirements of dry bean. In this study, non-fertilized, non-inoculated beans resulted in 83% of maximum yield. Applying the highest rate of N maximized yield but was not economical. Applying N fertilizer at a rate of 35 lbs/ac or to reach 70 lbs/ac of total N (including soil residual N) matched maximum yield without reducing nodulation.

Results from this research are being reviewed in conjunction with inoculant evaluation research and on-farm N fertility trials to revisit N management recommendations for dry beans in Manitoba. Future work will measure biological N fixation in current varieties.

Figure 1. Dry bean yield (lbs/ac) response to nitrogen rate (lbs/ac) at Carman and Portage (2017-2019) averaged across pinto and navy bean market classes.



Bars followed by different letters are statistically different at $p < 0.05$.

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