Nitrogen Use Efficiency of Different Dry Bean Market Classes in Ontario

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Introduction

Success of the Green Revolution during the second half of the 20th century was in large part due to investments in irrigation infrastructure and development of regionally-adapted crops that were responsive to N fertilizers. Global use of N fertilizer has increased dramatically in response to rising global demand for food, feed, fiber, and, more recently, fuel. Nitrogen fertilizer use exceeded 90 million Mg for the 2005-2006 crop cycle, up from less than 12 million Mg in the early 1960s (Westhoff, 2009). The increased employment of symbiotic nitrogen fixation (SNF) in agriculture world-wide is “only one aspect of the new green revolution, but a critical one” (Emerich & Krishnan, 2009).

Cropping systems involving N_2 fixing legumes in rotation (or in companion cropping) with non-N_2-fixing species offer opportunities to reduce N-fertilizer application and to improve the overall nitrogen use efficiency of the cropping systems and will likely be an important strategy in meeting cropping system’s nitrogen needs. However, despite this inherent ability of legumes, SNF potential in dry bean is low, compared to other legumes (Isoi & Yoshida, 1991).

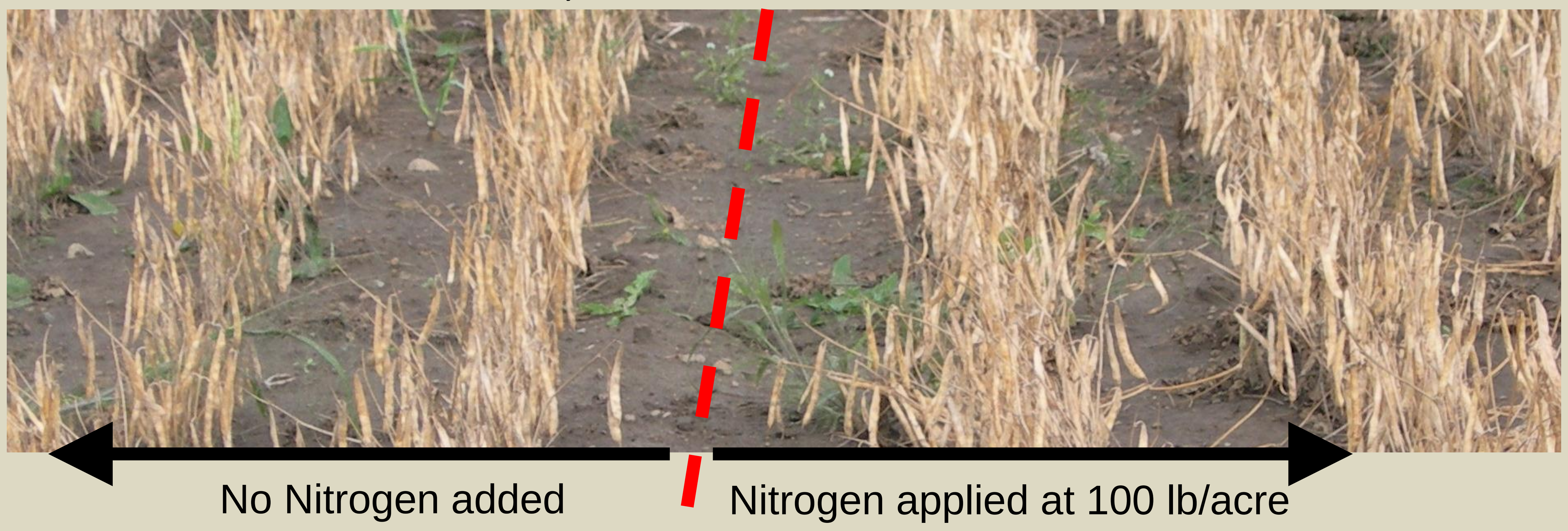
This study looks at the response of a diverse collection of dry bean genotypes of various seed classes under limited nitrogen availability. Nitrogen-responsive high yielding genotypes can be separated from genotypes with stable yield under varied nitrogen regimes, offering opportunities for breeding to reduce the use of this important nutrient.

Objective

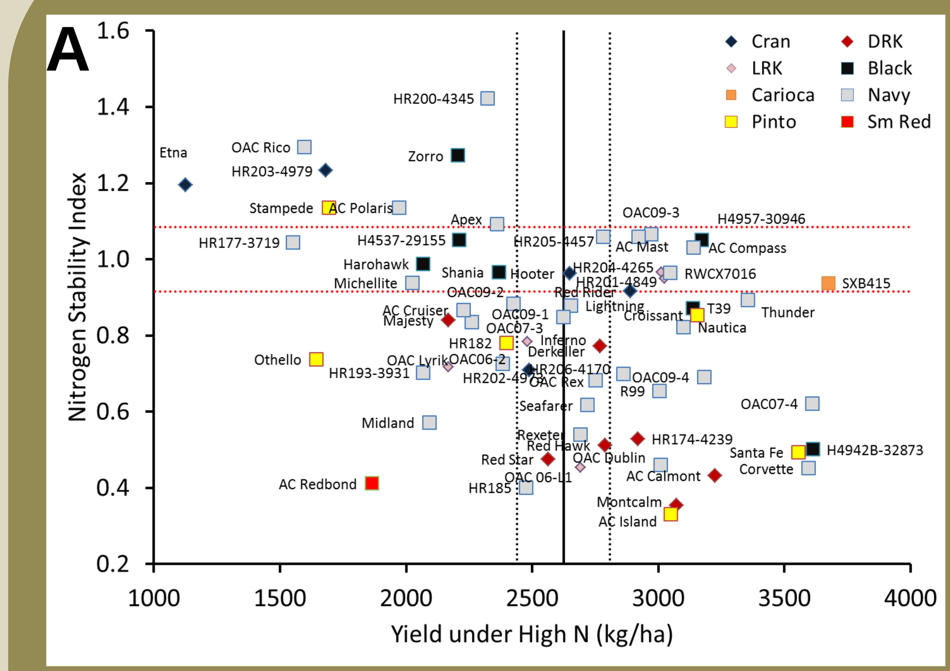
To examine the response of a diverse collection of dry bean genotypes of various seed classes under limited Nitrogen availability.

Materials and Methods

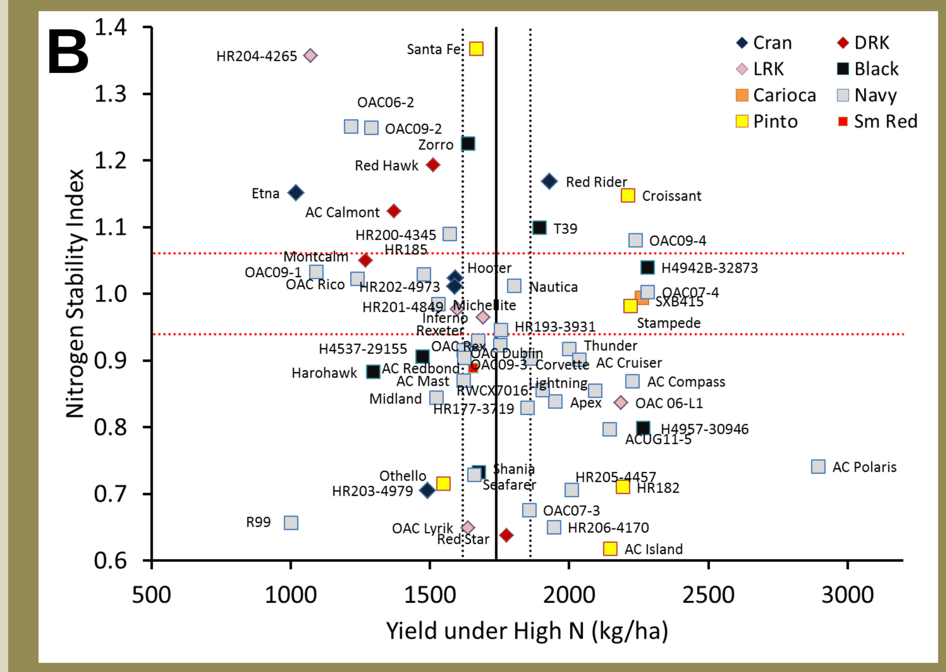
Treatments included 64 genotypes across different market classes, with two nitrogen levels applied at planting using a lattice design. Fields for the experiment were nitrogen poor, without any nitrogen amendment and planted with cereals harvested as forage for the previous two crop years. In the high nitrogen treatment 100 lb/acre actual N was applied as ammonium nitrate; P and K were applied according to soil test recommendations. Plots were direct harvested at maturity.



Results & Discussion



2010:
As expected, the majority of the high-yielding genotypes are nitrogen responsive (i.e. Nitrogen Stability Index (NSI) < 1). However, representatives from the navy, cranberry, and black seed classes, as well the sole carioca line are found to be high yielding stably across high and low nitrogen treatments (i.e. NSI ≅ 1).



2011:
The majority of high yielding lines were again nitrogen responsive. Representatives from various seed classes were again found to be stably high yielding, but only SXB415 appears in this area in both years. Notably, a few lines are found to be high yielding with an NSI > 1.

Figure 1. Yield of dry bean lines in high nitrogen conditions versus stability index of yield in A) 2010 and B)2011. The Nitrogen Stability Index is calculated as 1 – ((High N yield – Low N yield)/High N yield) i.e. a line yielding equally in low and high N environments will have a stability index of 1. Also shown: in black are mean yield in High N conditions and 99% confidence limits; in red, 99% confidence limits around a stability index of 1.

	Days to Flowering	Days to Maturity	100 Seed wt. (g)	Height (cm)	Yield (kg/ha)
2010					
High N	43.79	108.98	36.85	54.95	2623.79
Low N	41.90	104.38	35.29	55.68	2071.02
Reduction (%)	4.30	4.20	4.20	1.30	21.00*
2011					
High N	40.16	102.10	n.d.	48.83	1738.51
Low N	38.20	95.68	n.d.	43.45	1607.28
Reduction (%)	4.86	6.29		11.03	7.55

Response of days to flowering and maturity to nitrogen treatment was as expected in both years with added nitrogen increasing the length of the growth stages.

Yield was increased with added nitrogen in both years, but only significantly across all genotypes in 2010. Overall yields were decreased in 2011 possibly due to extended drought during July.

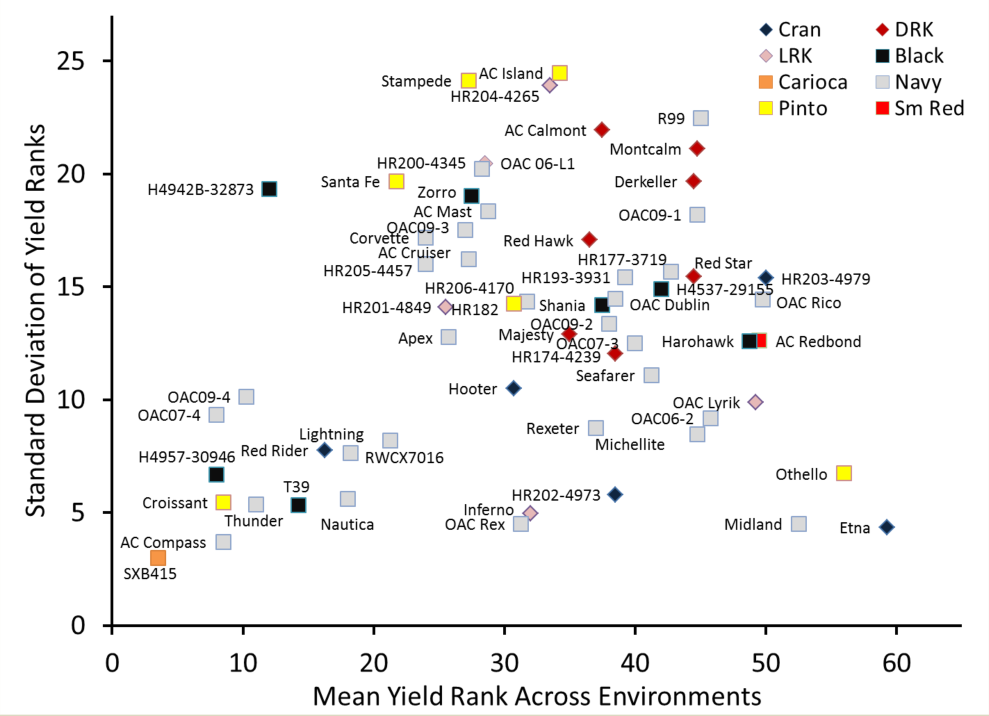


Figure 2. Stability of dry bean lines across all four environments. The mean of the yield rank in each N treatment x Year environment is plotted vs. the standard deviation around that mean. A low value on the x-axis indicates overall high yield and a low standard deviation indicates high overall stability across N treatments and years.

Although data could not be directly combined across the two growing seasons due to large differences in yield, by assigning yield ranks in each environment, breeding opportunities can be found.

Genotypes found in the bottom left quadrant of Fig 2 are overall high and stable yielders. Although most of these lines are from the Meso-American gene pool, genotypes from both gene pools are found in this area. These genotypes are good candidates for breeding new lines that perform well in various nitrogen regimes.

References:

Emerich & Krishnan, 2009; Nitrogen Fixation in Crop Production, Agron. Monograph 52, ASA-CSSA-SSSA.
Isoi & Yoshida, 1991; Soil Sci Plant Nutrit. 37:559.
Westhoff, 2009; pp.309-328 In Nitrogen Fixation in Crop Production, Agron. Monograph 52, ASA-CSSA-SSSA.

Acknowledgements:

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Ontario White Bean Producers
Coloured Bean Growers