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Biological N_2 fixation, nodulation and N accumulation in pulse crops on the semiarid Canadian prairie

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Introduction

Grain legumes are a group of crops grown worldwide primarily for their protein-rich seeds that are used as human food, animal feeds, or in industrial products. They also lay a significant role in nitrogen cycling by fixing atmospheric N_2 through biological nitrogen fixation (BNF). BNF efficiency is reported to vary among pulse species and cultivars but information is scarce in the Canadian prairie growth environment.

Materials & methods

A 3-year field study was conducted at the Agriculture and Agri-Food Canada (AAFC) Research farm, Swift Current, Saskatchewan (50°25´N, 107°44´W) in 2008, 2009 and 2010 to quantify the BNF ability and related traits, and the effect of BNF on crop yield in chickpea (*Cicer arietinum* L.), dry bean (*Phaseolus vulgaris* L.), faba bean (*Vicia faba* L.), field pea (*Pisum sativum* L.) and lentil (*Lens culinaris* Medik.). In each plot, the number of nodules per plant was counted at the early- and later-flowering stages.

Fig. 1 Digging roots for nodule measurements from different pulse crops

Results & discussion

- BNF varied according to growing season, and pulses had a higher BNF in the wetter 2010 than the drier 2009 (Table 1).
- In 2010, faba bean and chickpea had the highest BNF at 106 kg N ha^{-1}, followed by lentil, field pea, and dry bean at 87, 69, and 12 kg N ha^{-1}, respectively (Table 1).
- Across years, field pea had the most stable BNF ability and seed yield. There are large differences in BNF and yield among cultivars within a species and the magnitude of the difference varied with years (Fig. 2).
- Most pulse crops had a higher number of nodules at the early flowering stage, but the nodule weight was higher at late flowering stage (Table 1).
- At the late flowering stage, chickpea had the highest number of nodules in 2008 (36.7 $plant^{-1}$) (Table 1).

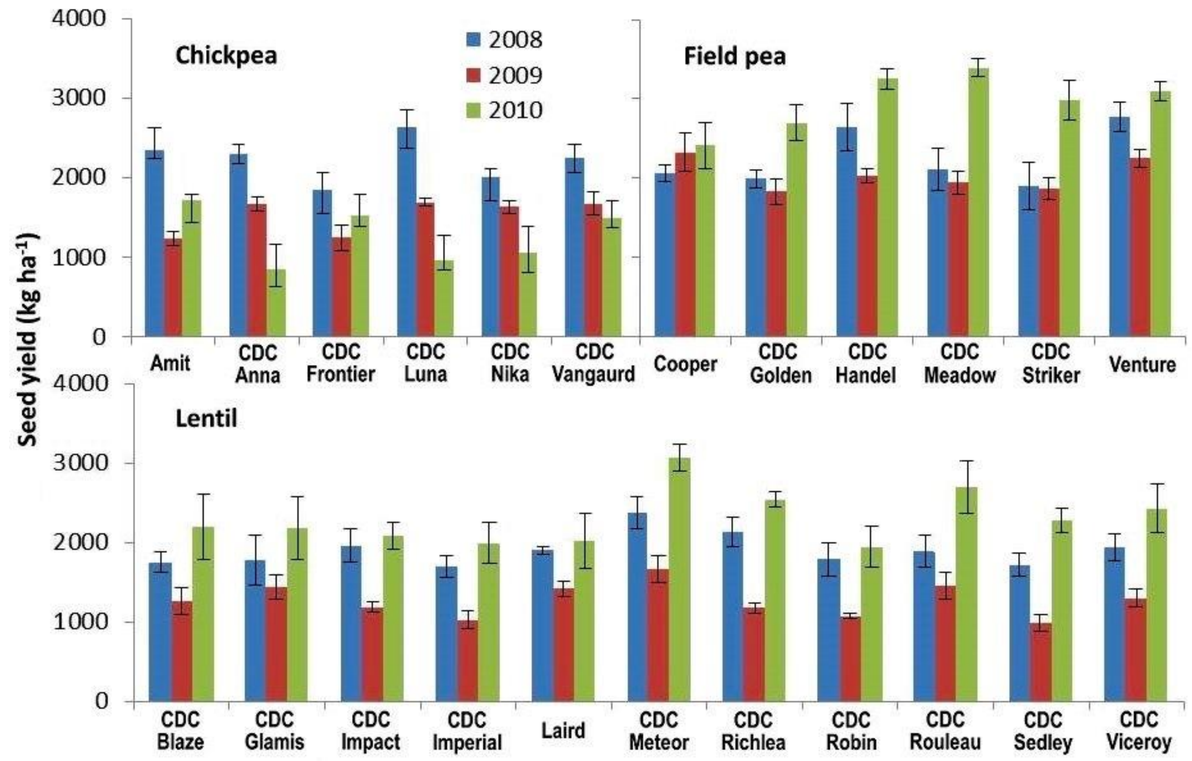

Fig. 2 Seed yield of different pulse crops

- Both seed and straw N accumulation varied significantly over growing seasons and were higher in 2010 (data now shown).
- Seed N content was highest in field pea and faba bean, while straw N content was highest in faba bean (data not shown).

Table 1 Nodulation and N_2 fixation in different pulse species

Year	Chickpea	Dry bean	Faba bean	Field pea	Lentil
Early flower nodule number ($plant^{-1}$)					
2008	25.9^{a}	0.1^{b}	35.2^{a}	28.2^{a}	21.7^{a}
2009	18.8	8.3	8.4	14.8	12.0
2010	37.9^{b}	4.3^{d}	50.3^{a}	40.7^{b}	24.0^{c}
Early flower nodule weight (mg $plant^{-1}$)					
2008	118.0^{a}	1.0^{b}	80.0^{a}	100.0^{a}	14.0^{b}
2009	59.0	18.0	29.0	54.0	42.0
2010	122.0^{a}	3.0^{c}	44.0^{bc}	63.0^{b}	12.0^{c}
Late flower nodule number ($plant^{-1}$)					
2008	36.7^{a}	0.9^{b}	22.0^{a}	28.1^{a}	21.3^{ab}
2009	15.4	7.3	7.0	13.5	10.6
Late flower nodule weight (mg $plant^{-1}$)					
2008	203.0^{a}	16.0^{c}	90.0^{bc}	157.0^{ab}	18.0^{c}
2009	80.0	20.0	29.0	64.0	51.0
N fixed (kg ha^{-1})					
2008	30.6^{c}	0.8^{d}	49.5^{ab}	58.3^{a}	38.2^{bc}
2009	21.0^{bc}	15.4^{c}	45.4^{a}	36.6^{ab}	23.0^{bc}
2010	103.6^{a}	11.9^{c}	107.7^{a}	68.5^{b}	86.8^{ab}

Conclusions

Large genetic variability in BNF, N accumulation and yield suggest the possibility that pulse cultivars with a higher N_2-fixing ability and seed yield can be developed through selection of the N_2-fixing traits.

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