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Lentil-wheat rotation enhances fertilizer N use efficiency by 46%

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Introduction

In semiarid Canadian prairie, wheat is traditionally grown continuously or with summerfallow in a rotation. Continuous wheat production requires high input of inorganic fertilizer, whereas summerfallowing has negative environmental consequences. Annual pulses, such as dry pea (*Pisum sativum* L.) and lentil (*Lens culinaris* Medik.), have been used to diversify the conventional cereal-based monoculture in the region. However, little is known about the long-term effect of pulse-cereal rotation systems on soil N status as compared with cereal monoculture in the semiarid prairie conditions.

Fig. 1. Yantai Gan examining a lentil field that was directly seeded in standing wheat stubble, Swift Current, Saskatchewan

Materials & Methods

A field study, started in 1979 at the AAFC Swift Current Research and Development Centre, in Saskatchewan, compares a lentil-wheat rotation (LentW) with continuous wheat monoculture (ContW), in replicated experiments for a period of 25 years (1979-2005). Each plot was 10 X 20 m in size. Each year, soil NO_3-N (0–0.6m depth) and soil P (0–0.15m depth) were measured in each plot in fall and fertilizer rate was determined based on the soil test and the estimated yield potential. All other crop inputs were recorded each year for each treatment.

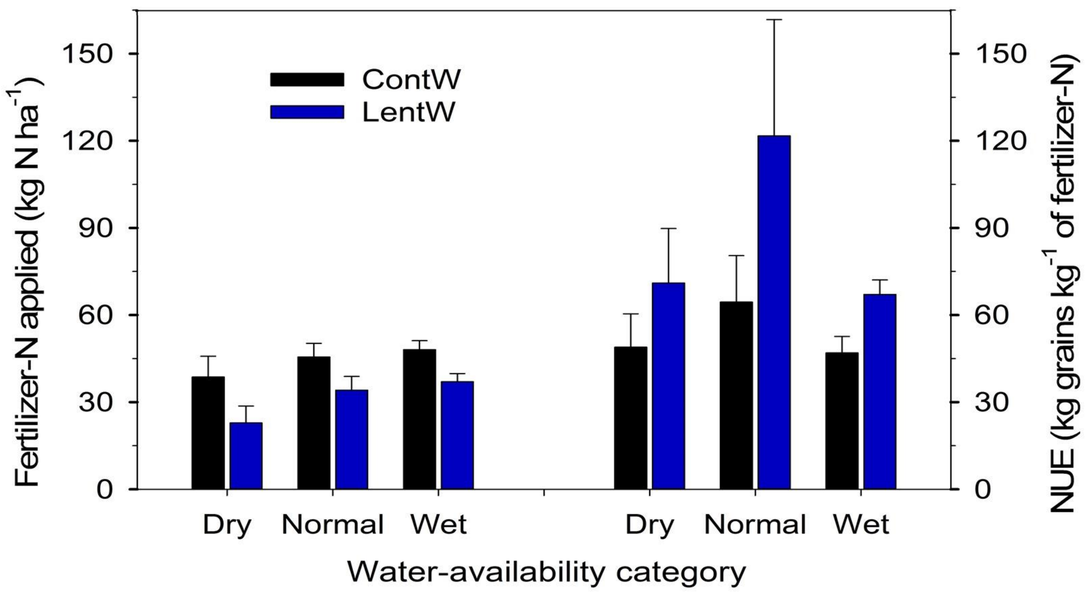

Fig. 2 Amounts of fertilizer-N and NUE of wheat in the continuous wheat (ContW) and lentil-wheat (LentW) systems

Results & Discussion

- Averaged over 25 years, wheat in the lentil-wheat (LentW) rotation produced a similar quantity of grain as in the continuous wheat (ContW), averaging 1860 ± 150 kg ha^{-1} yr^{-1}, but the LentW did so with 29% less N fertilizer per year (**Table 1**).
- Consequently, fertilizer N use efficiency for the wheat in LentW averaged 46% greater than in ContW (**Fig. 2**).

Table 1 Wheat grain yield in relation to N fertilizer in continuous wheat (ContW) compared with lentil-wheat rotation (LentW) under different water availabilities

Water availability	Cropping system	Grain yield (kg ha^{-1})			N fertilizer (kg ha^{-1})
		Mean	Min	Max	Mean
Dry	ContW	1,086	201	1,712	38.7
	LentW	1,021	218	2,063	22.9
Normal	ContW	2,054	982	3,130	45.5
	LentW	2,180	1,040	3,484	34.1
Wet	ContW	2,248	1,566	2,917	48.1
	LentW	2,389	2,104	2,594	37.0
Mean	*ContW*	*1,822*	*201*	*3,130*	*44.1*
	LentW	*1,897*	*218*	*3,484*	*31.5*

- The enhanced NUE of wheat in the LentW system was partly due to soil residual N that was contributed by the previous lentil in the rotation that fixes atmospheric N_2 through effective nodulation (**Fig. 3**).
- The long-term effects of the inclusion of lentil in rotation include reduced use of inorganic N fertilizer, increased soil organic carbon (SOC), and lowered carbon footprints (**Fig. 3**).

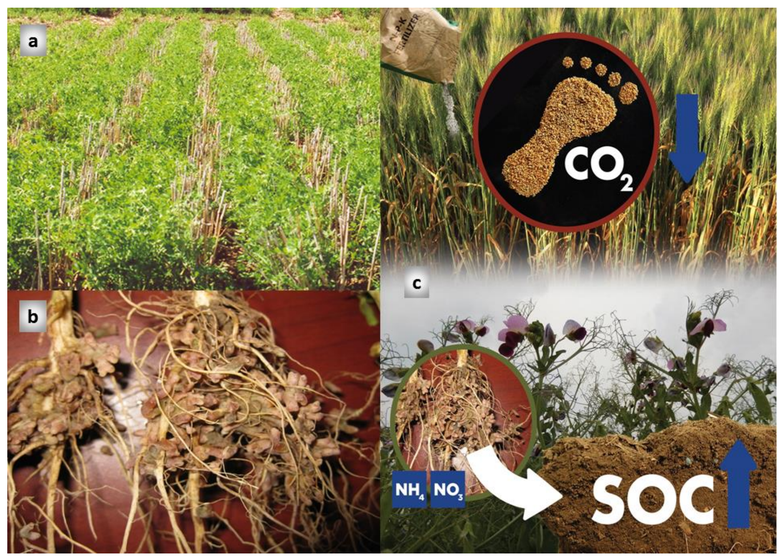

Fig. 3 On the Canadian prairie (a) the direct-seeded lentil crop normally forms (b) effective nodules on the roots, helping (c) reduce inorganic N fertilizer, increase SOC, and lowering footprints

Conclusions

A pulse-cereal rotation can serve as an effective alternative to the traditional cereal-summerfallow system in semiarid areas. The key impacts of the pulse-based system are the high N use efficiency, and the improved soil fertility and environmental sustainability for the long term.

Key references

Gan, Y. et al. Improving farming practices reduce the carbon footprint of spring wheat production. Nat. Commun. 5:5012 doi: 10.1038/ncomms6012 (2014).

Gan, Y., Hamel, C., Kutcher, H.R., Poppy, L., 2016. Lentil enhances agroecosystem productivity with increased residual soil water and nitrogen. Renew. Agric. Food Syst., 1-12.