Direct assessment of the release of fixed nitrogen in the rhizosphere of pea, lentil, chickpea and faba bean

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SPG Contributions	Project Status	Duration/Timeline of Project (Year to Year)	Co-funders	Total Project Cost
$65,785.65	Completed	April 2015 – March 2017	Saskatchewan Ministry of Agriculture – Agriculture Development Fund (ADF); Western Grains Research Foundation	$194,133.65

Project Description

To determine N2 fixation in lentil, pea, chickpea, and faba bean using continuous 15N2 labelling; to determine the release of fixed-N into the rhizosphere of mature lentil, pea, chickpea, and faba bean; to quantify the supply of fixed-N from the pulse crop residues to the N uptake of a subsequent cereal crop (wheat); to assess the N2O emissions from soils containing pulse vs. wheat residues and identify the source of soil-emitted N2O.

Estimates of N2O emissions in Canada are based on current Intergovernmental Panel on Climate Change (IPCC) methodologies which indicate that 24% of all agriculture based emissions are associated with the use of nitrogen (N) fertilizers and that another 17% are associated with the decomposition of crop residues. At present, the IPCC applies the same emission factor to both fertilizer-N and residue-N; i.e., it assumes that 1.0% of all fertilizer/residue N is lost as N2O. However, research specific to the Western Canadian prairies (including Saskatchewan) has shown that the N2O emission factor for N fertilizers in this region averages about 0.4 to 0.6%, which is well below the current IPCC emission factor. As a result, the IPCC Tier II methodology allows for the use of region-specific emission factors when calculating greenhouse gas inventories. Yet, the methodology still assumes that fertilizer and residue N are equivalent, which is supported by recent meta-analyses of data available in the literature. However, very few of these studies involved the use of 15N-labelled residues and were, therefore, not able to separate out residue-derived (i.e., direct effect) emissions from residue-induced (i.e., indirect effect) emissions. Understanding these differences is key to developing appropriate mitigation strategies, and studies using 15N-labelled residues generally show that the emissions of residue-derived N2O are lower than those for equivalent amounts of fertilizer N.

Our research examined biological nitrogen fixation (BNF) by several grain legume (pulse) crops in order to assess the contribution of fixed-N to the N-uptake by a subsequent wheat crop and the production of residue derived N2O emissions when wheat was grown on the pulse residues. Nitrogen-15 labelled pulse residues were produced by growing plants in a rootbox system that included a 15N2-enriched soil atmosphere. This allowed us to obtain a direct measure of BNF in a side-by-side comparison of peas, lentils, chickpeas, and faba beans.

Outcome

In terms of above-ground biomass, BNF (expressed as a percentage of total plant N derived from the atmosphere; i.e., Ndfa) was greatest for faba beans (71%) and chickpeas (65%), intermediate for lentils (58%), and lowest for peas (28%). It was determined that poor nodulation of the pea resulted in the low Ndfa values, hence pea was not included in the wheat phase of the study. Whereas faba beans allocated more of its fixed-N to the above-ground biomass—the seed in particular— chickpeas allocated more fixed-N to the below-ground (root) biomass. As a result, on a whole-plant basis BNF was greatest for chickpeas (68%), intermediate for faba beans (60%) and lentils (54%), and lowest for peas (27%). During the wheat phase of the study, we determined that grain yield was about 30% greater for wheat on pulse residue compared to wheat on wheat residue. In terms of total 15N recovery, the amount of 15N in the wheat was strongly correlated with the total amount of 15N added as residue; but as a percentage of total 15N, we found that there was greater recovery from the lentil residue than from either chickpeas or faba beans. This suggests that N in lentil was more readily available than that in the other pulses presumably reflecting differences in the quality (decomposability) of the pulse residues. Likewise, cumulative N2O emissions (total and 15N-N2O) during the wheat phase tended to increase as the amount of total and 15N in the residues increased, though the emission factor for residue-derived 15N-N2O was greatest for lentils and lowest for chickpeas. These data support for the argument that, in terms of N2O emissions, residue-N is not equivalent to fertilizer-N, and that accurate accounting of both the N-credit and N-penalty associated with the decomposition of pulse crop residues deserves more attention. Demonstrating that pulse crop residues have low N2O emissions also should serve as a marketing tool for the pulse industry as consumers become increasingly aware of "carbon footprints" associated with different products.

Research Objective

OBJECTIVE 1
To determine N2 fixation in lentil, pea, chickpea, and faba bean using continuous 15N2 labelling.

OBJECTIVE 4
To assess the N2O emissions from soils containing pulse vs. wheat residues and identify the source of soil-emitted N2O.

OBJECTIVE 2
To determine the release of fixed-N into the rhizosphere of mature lentil, pea, chickpea, and faba bean.

OBJECTIVE 3
To quantify the supply of fixed-N from the pulse crop residues to the N uptake of a subsequent cereal crop (wheat).