AGR1406: Direct assessment of the release of fixed N in the rhizosphere of peas, lentils, chickpeas, and faba beans

Estimates of N_2O 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 N_2O. However, research specific to the Western Canadian prairies (including Saskatchewan) has shown that the N_2O 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 ^{15}N-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 ^{15}N-labelled residues generally show that the emissions of residue-derived N_2O 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 N_2O 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 $^{15}N_2$-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. 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 ^{15}N recovery, the amount of ^{15}N in the wheat was strongly correlated with the total amount of ^{15}N added as residue; but as a percentage of total ^{15}N, 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 N_2O emissions (total and ^{15}N-N_2O) during the wheat phase tended to increase as the amount of total and ^{15}N in the residues increased, though the emission factor for residue-derived ^{15}N-N_2O was greatest for lentils and lowest for chickpeas. These data support for the argument that, in terms of N_2O 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 N_2O emissions also should serve as a marketing tool for the pulse industry as consumers become increasingly aware of “carbon footprints” associated with different products.