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Legumes and soil health

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Rotational grains like pea or perennial forages like alfalfa are examples of legumes that play an important role by adding diversity, lowering nitrogen (N) costs and improving overall soil health in our agricultural systems. Legumes are an important part of native plant community diversity, improving livestock forage nutrition and contributing to the valuable organic N pool accumulated over centuries of prairie soil development.

In N limiting soils, legumes form a symbiotic relationship with rhizobia bacteria. Plant roots release a flavinoid molecule that triggers soil bacteria to release what's called 'nodulation factor', stimulating root nodule formation.¹ Rhizobia then inhabit the nodule, fed by plant carbohydrates while helping to transform atmospheric-N into plant available ammonium N. Research has shown the very high potential for nitrogen fixation by legumes (Table 1) - a major cost savings at today's fertilizer prices, taking advantage of the fact that about 80% of Earth's atmosphere is N-gas.

Table 1. Nitrogen Fixation in Legumes Grown Under Irrigation in Southern Alberta.²

Crop	N Fixed Symbiotically (lb N/ac)
Alfalfa	267
Fababean	267
Field Pea	178
Lentil	134
Soybean	134
Chickpea	108
Dry bean	62

While there are other examples where free living soil organisms can fix atmospheric N into plant available forms, most of these occur in soils from other regions and are thought to be insignificant for prairie

¹ "The Legume-Root Nodule Symbiosis." *Boundless Microbiology*. Boundless, 21 Jul. 2015. Retrieved 09 Oct. 2015 from <https://www.boundless.com/microbiology/textbooks/boundless-microbiology-textbook/microbial-ecology-16/microbial-symbioses-196/the-legume-root-nodule-symbiosis-993-7114/>

² R.J. Rennie as cited in "Soil improvement with legumes in rotations." <http://www.agriculture.gov.sk.ca/Default.aspx?DN=4b50acd7-fb26-49a9-a31c-829f38598d7e>

agriculture.³ Lightning strikes are another but relatively insignificant source of atmospheric N fixation for prairie soils.

Including perennial legumes like alfalfa or clover in hay and pasture stands improves forage quality and reduces some of the N fertilizer requirements compared to a straight grass stand. Legumes do shed some biologically fixed N directly to grass species through the decomposition of roots or root exudates in fields managed for hay but for pastured systems, considerably more fixed N is cycled back into soil through livestock waste products in support of non-legume species. Research has shown the significant annual crop yield benefits from including a legume based perennial crop sequence in rotation.⁴

Figure 1. Nodules on an alfalfa plant⁵



Legume grain crops do supply some N to following crops – often referred to as an “N-credit”. However, the observed rotational benefits are often greater than can be accounted for by N alone. Some of those potential benefits include enhanced soil microbial diversity, cultural disease control and other soil related factors like improved structure and moisture carryover.

In summary, legumes are important crops that add rotational and forage stand diversity, helping to transform atmospheric N into biologically available soil organic N. Over the centuries of soil development they have contributed to the buildup of the prairie soil organic N pool and continue to play an important role for soil health.

³ Soil Health. Nitrogen-Fixing Associations. Chapter 3.3. <http://www.soilhealth.com/soils-are-alive/how-do-soil-organisms-affect-plants/p-03.htm>

⁴ The benefits of including forages in rotation. Manitoba Agriculture. <https://www.gov.mb.ca/agriculture/crops/production/forages/benefits-of-including-forages-in-your-crop-rotation.html>

⁵ 22th North American Conference on Symbiotic Nitrogen Fixation, University of Minnesota. 2013. <http://www.bti.umn.edu/nasnfc/program.php>