Saskatchewan
Soil Conservation
Association

Soil Facts

Grow Your Own N

As the price of nitrogen continues to edge upwards, many producers are looking for alternatives to control this particular input cost. Nitrogen is most often the limiting nutrient for crop production. Yet nitrogen gas (N_2) constitutes approximately 78% of the earth's atmosphere. The supply of elemental N is inexhaustible because elemental N is in dynamic equilibrium with the various fixed forms. As N is fixed by various processes, there is also a release of elemental N to the atmosphere from fixed forms by microbiological and chemical processes.

Table 1: Nitrogen fixation in inoculated legumes grown under irrigation in southern Alberta. (Adapted from R.J. Rennie, formerly at Agriculture Research Station, Lethbridge, AB) (Based on 2005 fertilizer prices)

Legume	Plant-N derived From atmosphere * (%)	N fixed Symbiotically (lb/ac)	N-fertilizer Equivalent ($/ac)
Alfalfa	80	267	107
Sweetclover	90	223	89
Fababean	90	267	107
Field pea	80	178	71
Lentil	80	134	54
Soybean	50	134	54
Chickpea	70	108	43
Dry bean	50	62	25

* - Determined by 15N isotope techniques

For centuries the use of legumes in crop rotations and the application of animal manures were the principal ways of supplying additional N to non-legume crops. With the manufacture of synthetic nitrogen fertilizers, the use of legumes and manure began to dwindle. Now as the cost of natural gas has risen, so too, has the cost of synthetic nitrogen fertilizers. Producers are reassessing their N options.

Nitrogen Fixation Process

The nitrogen fixation process is a symbiotic relationship between legume plants and certain bacteria called *rhizobia*. Soon after the legume seed germinates, the rhizobia, either present in the soil or added as a seed inoculum, penetrate the root hairs and move into the root. The rhizobia quickly multiply and cause swelling of the root to form nodules.

Nitrogen gas present in the soil air is "fixed" or bound by the bacteria which feed on carbohydrates that are produced by the plant via photosynthesis. From the N_2 in the soil air and the hydrogen from the plant's carbohydrates, the rhizobia produce ammonia (NH_3). The ammonia becomes a source of N for the plant to grow. This symbiotic relationship allows both the plant and the bacteria to flourish.

Although legumes have the ability to fix N from the atmosphere, legumes will preferentially use soil nitrogen if it is available. The amount of nitrogen that is fixed varies with the legume species and the variety. Legumes grown on the prairies can fix between 50 to 90% of their total N requirements (Table 1).

Nitrogen Benefits – pulse legumes

As legumes have a unique ability to fix their own nitrogen, they can significantly reduce our reliance on non-renewable energy to produce nitrogen fertilizer. Research in Manitoba looked at the N benefits of pulse crops in the rotation. The amount of N fixed by pulses is generally limited by their relatively small and shallow root system and short growth period. A major portion of the fixed N accumulates in the seed and is thereby removed from the field with harvest of the grain legume. Some leakage of N from the roots does occur during the growing season and there is a further N credit from the breakdown of the residues from the pulse crop (Table 2).

Research in northeastern Saskatchewan found that fababeans, field peas and lentils improved barley yield by 21% in the first year and wheat yield by 12% in the second year following the pulse crop (Wright, 1990). The study showed that even at rates of 180 lbs/ac of fertilizer N the barley yields on barley stubble were not able to attain the barley yields of those on pulse residues (Figure 1). This study showed that not only do legumes, including pulses,

provide N-credits, but they also provide other rotational benefits including disease suppression.

Table 2: N-credit (lb/ac per 1000 lbs of grain harvested) attributed to different grain legumes in crop rotation with wheat. (Adapted from Przednowek et al., 2004)

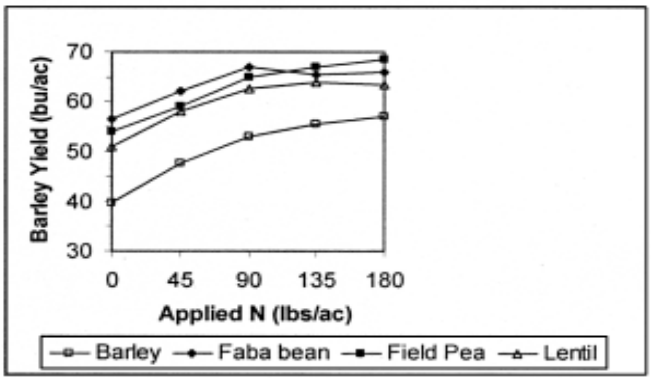
Site and Year	Field Pea	Dry Bean	Chickpea	Soybean
Carman – 1998	11	3	-	0
Carman – 1999	12	7	1	0.8
Carman – 2000*	-0.1	-1	1.6	1.7
Brandon – 2000**	14	5	16	5

* - high background levels of N
** - drier soil conditions

Nitrogen Benefits – forage legumes

Forages legumes can provide a simple solution to the rising cost of nitrogen fertilizer. Research has found the average annual contribution of N by alfalfa is 45 lbs/ac and under ideal growing conditions, it can be as high as 107 lbs/ac (Kelner, 1994). Studies show yield benefits from forage legumes can last up to a decade after termination (Hoyt and Leitch, 1983). Not only do grain crops yield more after forages, but also the rotational benefit from field peas is greater where alfalfa has been included previously in the crop rotation (Table 3).

Figure 1: Average yield response of barley to N fertilizer when grown on barley, fababean, field pea and lentil residues in Northeast Saskatchewan (Adapted from Wright, 1990).



Forage Termination

When tillage is used to terminate a forage stand, a substantial amount of N can be released during the first season. Under warm wet soil conditions, N can be lost as N_2O through denitrification. Nitrous oxide (N_2O) is considered to be a serious greenhouse gas. Tillage can also cause an increase in the nitrate levels below the root zone through leaching, particularly in lighter soils. When herbicides are used to terminate a forage stand, the release of N is considerably slower thereby providing other benefits. Mohr (1996) found the slower release of N is more like a split N application for subsequent crops. The late season N can build higher protein levels in cereal crops grown the following year. It also improves N use efficiency.

Table 3: Wheat yields as influenced by previous crop type (adapted from M. Entz, University of Manitoba).

Note: no nitrogen fertilizer added to any of these rotations over the six-year study period.

W-Wheat; P-Field Pea; B-Barley; A-Alfalfa.

Crop Rotation	Grain Yield of Wheat (bu/ac)	Nitrogen Uptake by Wheat (lbs/ac)
1. W-P-B-W-W-W	15.8	29.2
2. W-P-B-W-P-W	20.2	43.0
3. A-A-W-W-W-W	24.0	43.7
4. A-A-W-W-P-W	37.5	74.8
5. A-A-A-W-W-W	25.1	41.5
6. A-A-A-A-W-W	33.7	51.4
7. A-A-A-A-A-W	46.1	82.5

In 2000, Manitoba revised its guidelines for the N contributions from alfalfa. Research showed no difference in the N contribution between herbicide-terminated alfalfa and that which had been terminated by tillage (Mohr, et al., 2000) (Table 4). The N contribution is based on a full stand of alfalfa with all top growth returned to the soil. For stands which do not have a minimum five plants/m^2, the N contribution or credit should be adjusted lower. Three to four plants equals a 2/3 credit; one to two plants equals a 1/3 credit; while less than one plant/m^2 receives no N credit. It should be noted that

forages may be terminated with glyphosate and subsequently harvested. This also reduces the N credit.

Table 4: N contributions from alfalfa for following crops (adapted from Mohr, et al., 2000)

Termination Time	N Contribution to the following crop (lb N/ac) Tillage = Herbicide
Before July	90
July-August	70
Fall	45
Spring	30

While forage legumes increase the N levels of soils, they can also deplete other nutrients such as P, K, and S, particularly when the forage has been removed rather than grazed. Therefore it is important to soil test after terminating forages to meet the upcoming crop's nutrient requirements. Often crop failures after terminating forages can be linked to nutrient deficiencies and not just moisture depletion.

Some of the Legumes grown in Saskatchewan

Annuals:

- Chickpea
- Faba bean
- Dry bean
- Field pea
- Lentil
- Lupin

Biennials:

- White Blossom Sweetclover
- Yellow Blossom Sweetclover

Perennials:

- Alfalfa
- Alsike Clover
- Red Clover
- Sainfion
- Birdsfoot Trefoil

For More Information

1-800-213-4287 or www.ssca.ca

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