Effect of Nitrogen and *Rhizobium* Inoculation on Yield and Biological Dinitrogen Fixation of Blue Lupins (*Lupinus angustifolius*)

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Advantages of cultivation of lupins

- N_2- fixation ability, phosphate-mobilizing efficiency, deep root system: support the soil fertility, improvement of cereal rotations, esp. at sandy soils
- High seed protein content with much lysine, substitution of food mixtures for monogastrids
- Low labor intensity in spring (time of fertilization and pesticide treatment in German cereal production)

Further advantages of Blue Lupins (*Lupinus angustifolius*)

- Tolerance against Anthracnosis
- More lime tolerant than yellow lupins
- Low amounts of anti nutritive substances (e. g. tannins or lectins)

- Therefore: **More than 90% of German lupin cropping area are blue lupins**

But: Knowledge about dinitrogen fixation and nutrients demand of blue lupins under German conditions (cultivars) is low

Aims of study

is to estimate

Amount and duration of symbiotic dinitrogen fixation

- Influence of *Rhizobium* inoculation and N supply on dinitrogen fixation and yield

Experimental conditions

- pot experiment (Mitscherlich pots)
- *L. angustifolius*, var. “Boruta”
- substrate: quartz sand 5 kg + 1 kg soil

  (0.76 g double lactate soluble K/kg soil,

  0.087 g soluble and exchangeable N/kg soil)
- Inoculation with *Rhizobium lupini* (HiStick, Radicin)

  N supply at sowing (0.6 g N) and flowering (0.4 g N) as $(^{15}NH_4)_2SO_4$ (10 at% $^{15}N_{exe}$.) or without combined N supply

Parameters

- separation of plants in roots, shoots and pods
- dry matter estimation
- total N (C/N analyser Elementar Hanau, Germany)
- ^{15}N abundance (NOI emission spectrometer Fischer Leipzig, Germany)

Application of ^{15}N labelled N fertilizer:

to distinguish between the fertilizer derived plant N and other N origins

Calculation of origin of plant nitrogen 1

Fertilizer borne N = mg $^{15}N_{exc.}$ in plant · 10

(abundance fertilizer N: 10 at-% $^{15}N_{exc.}$)

Calculation of origin of plant nitrogen 2

N deposition up to flowering (6 weeks) = 3.7 mg / pot

N deposition up to ripeness (10 weeks) = 6.2 mg / pot

Seed borne N= 31 mg / pot (analysed)

Soil borne N = 86.8 mg / pot (calculated from soluble soil N, assumption : uptake percentage analogous to the fertilizer N uptake)

Calculation of origin of plant N
3

N_2 fixation =

Total plant N – (fertilizer

derived N seed borne N +

deposition derived N + soil

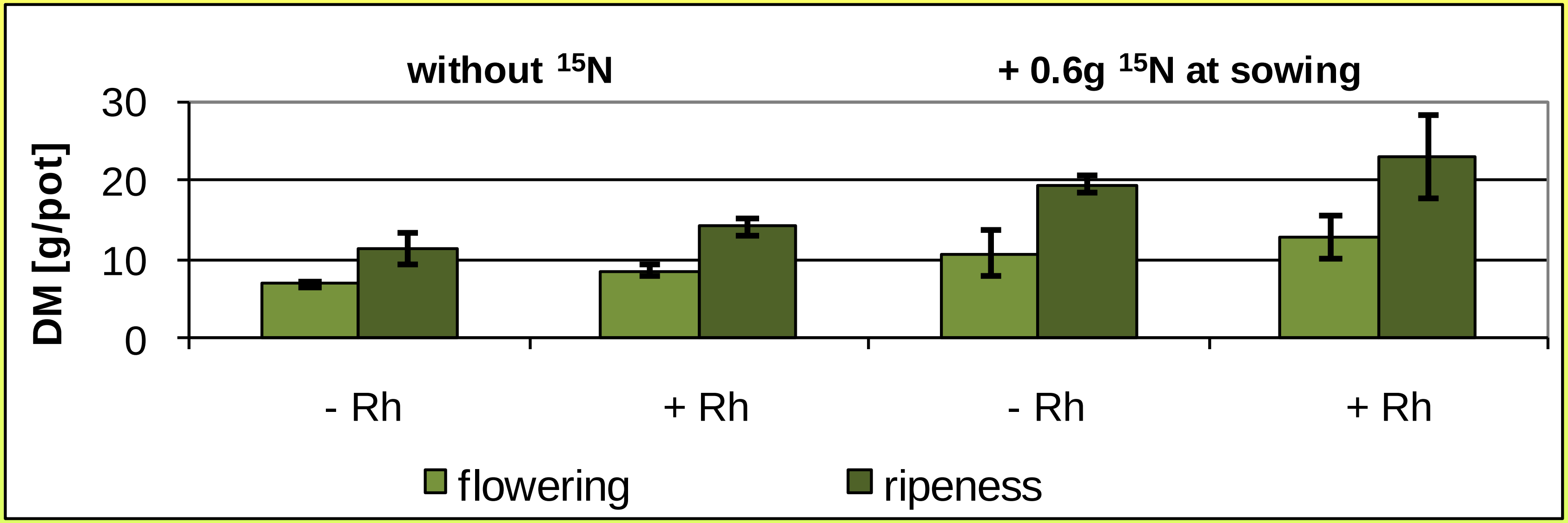
borne N)

Results

1.

How did *Rhizobium* inoculation and N supply influence dry matter yield of blue lupins?

1. Influence of *Rhizobium* inoculation and N supply on dry matter yield of blue lupins at flowering and ripeness

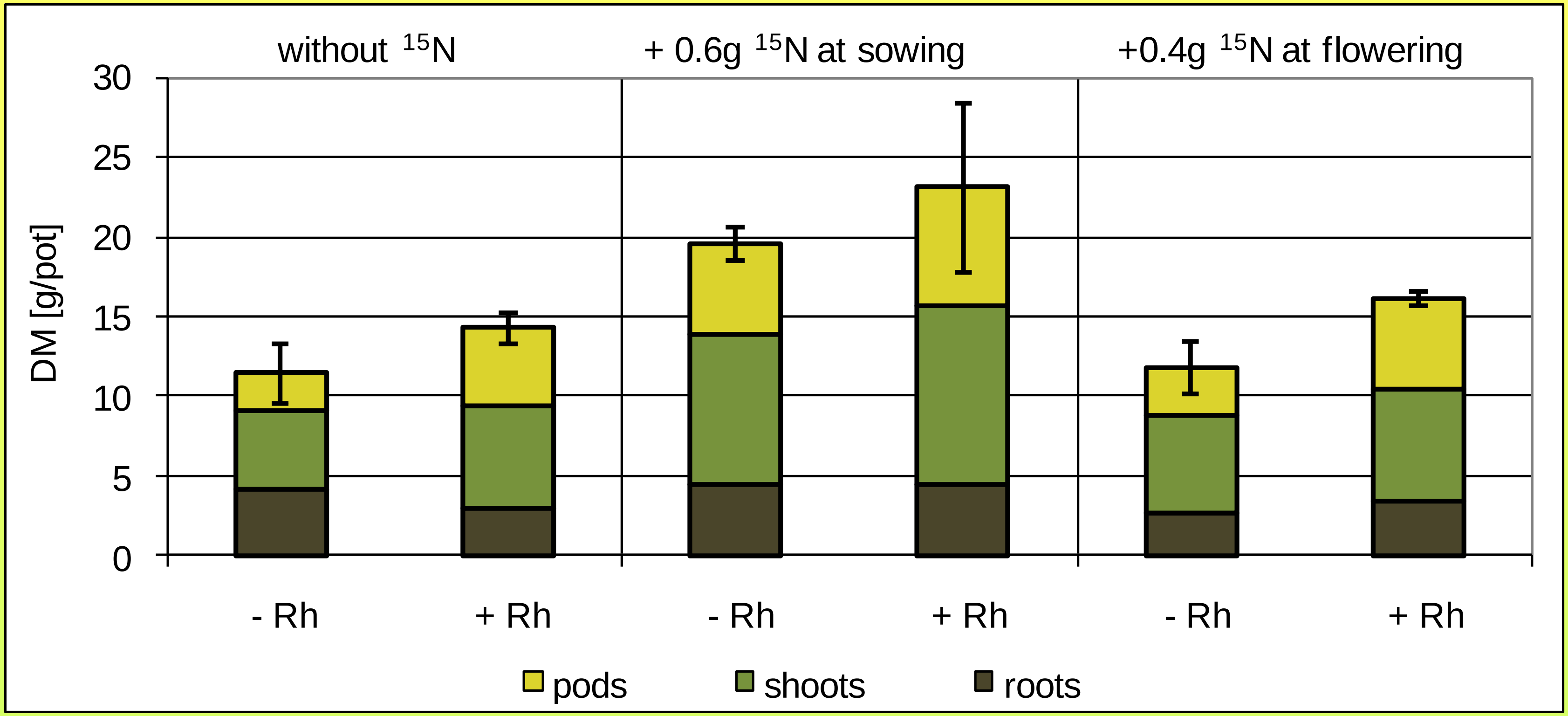


- *Rhizobium* inoculation increased dry matter yield at flowering as well as ripeness independent of N supply
- N supply at sowing increased dry matter yield of inoculated and not inoculated plants, esp. in plants harvested at ripeness

2.

- How did *Rhizobium* inoculation and N supply influence the dry matter of different plant parts ?

2. Effect of *Rhizobium* inoculation and N supply on dry matter of different plant parts of blue lupins (harvest at ripeness)

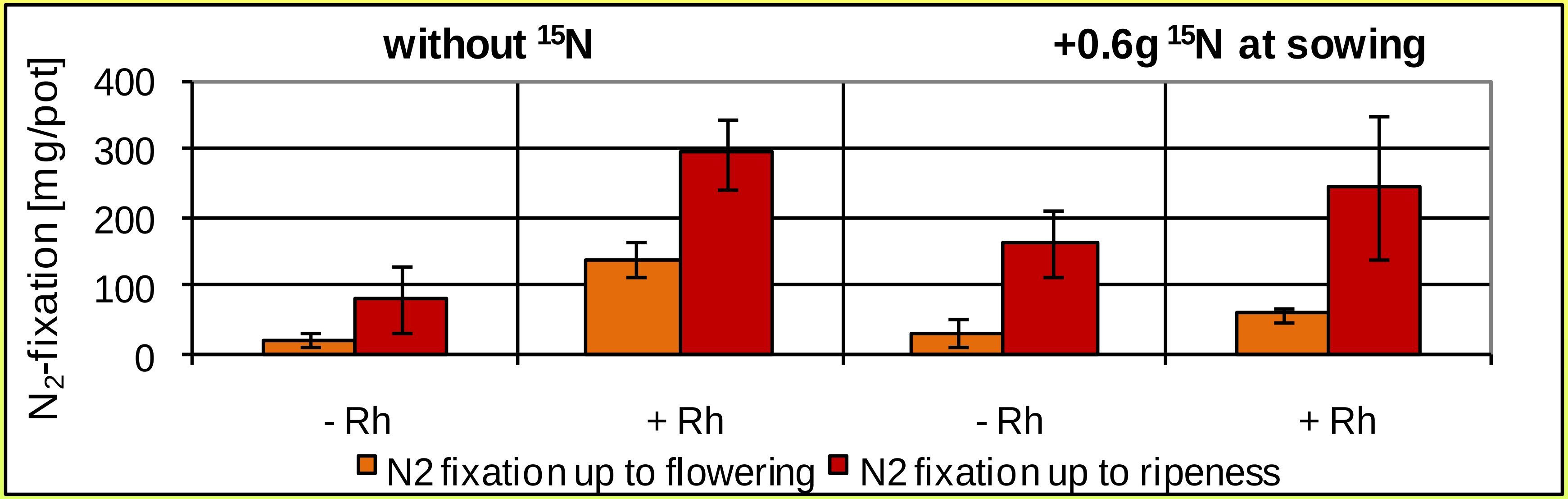


- Inoculation increased dry matter of pods only independent of N supply
- ^{15} N supply at sowing, but not at flowering increases dry matter of pods and shoots of inoculated and not inoculated plants

3.

- Which influence had *Rhizobium* inoculation or N suppy on dinitrogen fixation up to flowering rsp. ripeness?

3. Influence of Rhizobium inoculation and N supply at sowing on dinitrogen fixation up to flowering and up to ripeness

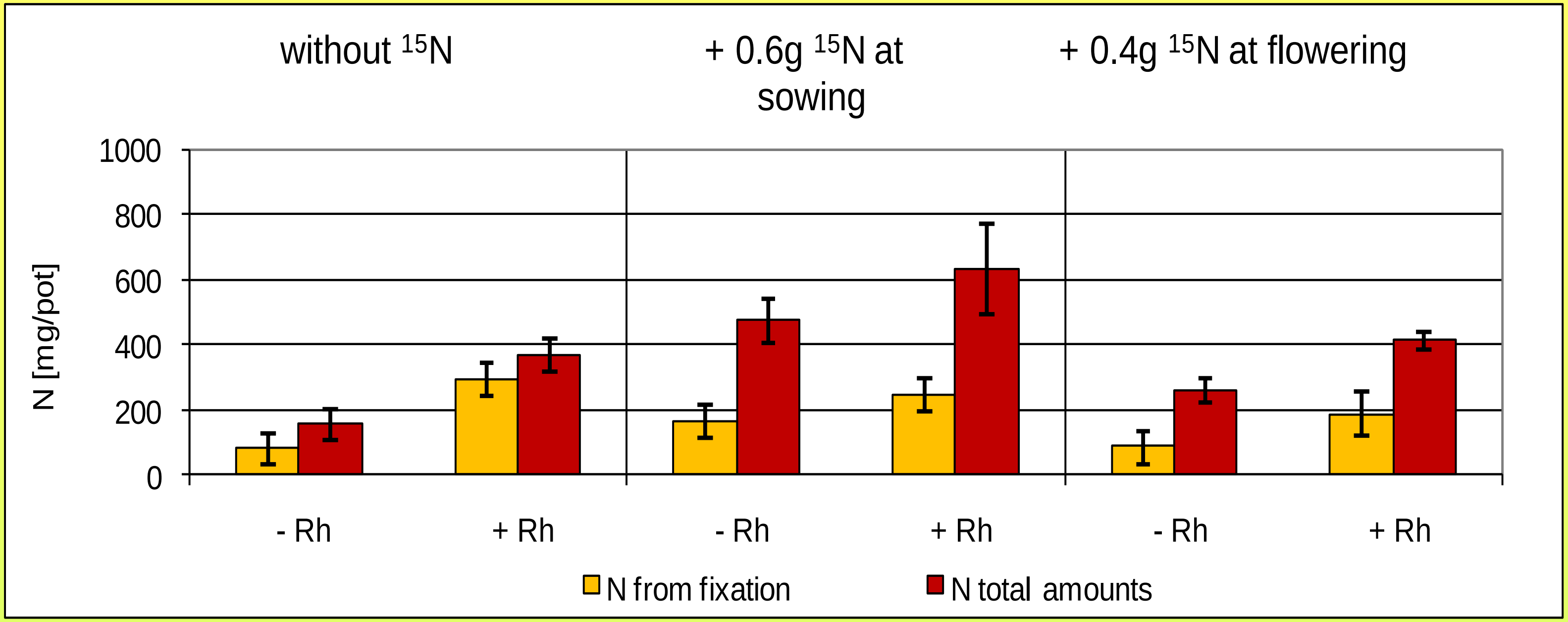


- Not inoculated lupins fixed dinitrogen (perhaps infection with wild strains from soil?)
- N_2-fixation took place in generative stage (after flowering up ripeness)
- *Rhizobium* inoculation increased N_2-fixation esp. after flowering at not N fertilized plants
- N supply at sowing inhibited as a rule N_2-fixation of inoculated blue lupins

4.

- Which effects had *Rhizobium* inoculation and N supply (at flowering or sowing) on total N and fixed N amounts of blue lupins (harvest at ripeness)?

4. Effect of *Rhizobium* inoculation and N supply on total N and fixed N amounts of blue lupins (harvest at ripeness)



- ***Rhizobium* inoculation increased generally N_2-fixation and yield of total N (also in the case of N fertilization). Not inoculated variants fixed N_2 too.**
- **The accumulated total N amount in variants with Rh inoculation was increased with N supply at sowing, but the proportion of N_2 fixation amounts in the variant without N supply 91% und with N supply at sowing only 37% (partial inhibition of dinitrogen fixation of inoculated plants by combined N)**
- **N supply at flowering decreased N_2 fixation in comparison to control without N fertilization (inhibition of N_2 fixation of Rh inoculated lupins after flowering). No substitution of inhibited fixation by mineral N uptake, total N amount was the same (inoculated variant)**

Abstract

The effects of N supply on dinitrogen fixation and yield of blue lupins were investigated in pot experiments with soil as substrate and ^{15}N labeled fertilizer.

The following results were obtained:

1. ***Rhizobia* inoculation increased the symbiotic dinitrogen fixation of lupins with and without the presence of combined nitrogen. *L. angustifolius* fixed considerable amounts of dinitrogen after the flowering also.**
   Therefore, a *Rhizobia* inoculation is necessary for high yields of blue lupins.

2. Mineral-N supply at sowing increased dry matter production, but decreased partly the dinitrogen fixation of blue lupins. The total N- amounts were increased by N supply at sowing esp. in not inoculated plants. Therefore a nitrogen fertilization of blue lupins at vegetation start can be useful (at low effective Rh strains).

3. Mineral-N supply at flowering did not influence the d.m. production of *L. angustifolius* and reduced the dinitrogen fixation after flowering in inoculated plants. A late N supply is not recommendable at blue lupins.

4. The N dynamics of blue lupins, that means the relationships between symbiotic dinitrogen fixation, supply of combined N and protein yields was more similar to yellow lupins than white lupins. The dinitrogen fixation of *L. angustifolius* appear relatively tolerant to mineral- N supply.

Conclusions

Further investigations are necessary:

1. Quantification of N_2 fixation proportion of soil borne *Rhizobia* (wild strains)

2. Influence of K fertilization on N_2 fixation of plants without N fertilization

3. Influence of ***Rhizobium*** inoculation, N supply and K fertilization on seed and crude protein yields of blue lupins

4. More accurate estimation of proportion of soil borne and atmospheric N for the N nutrition of blue lupins