Overview of Rhizobial Inoculation: Techniques and On-farm Efficacy Determinants

N2Africa - Putting nitrogen fixation to work for smallholder farmers in Africa

Key facts

- *Legume inoculants contain live bacteria called rhizobia which symbiotically fix nitrogen.*
- *Rhizobial inoculants are much cheaper than mineral N fertilizer.*
- *Legume species need specific rhizobial inoculants.*
- *Phosphatic fertilizers help the rhizobia inoculants work well with the legume.*
- *Applying the optimum rate of inoculant helps ensure prompt and effective nodulation and provides good competition against other soil rhizobia that may be less effective at nitrogen fixation.*
- *Rhizobia are sensitive to a range of stresses (e.g. high temperature and desiccation), which decrease their viability and inoculants should be considered as perishable products.*
- *All inoculants should be used before the expiry date.*

Materials required for inoculation

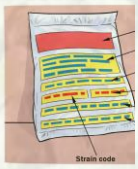
Rhizobia inoculant, plastic bottle (1 liter), water, sugar solution (10% - 10 teaspoon in 900 ml water) sugar or sticking material or lukewarm water if not using sugar solution, teaspoon/ soda bottle a container big enough to mix the inoculant with the seed to be inoculated.

Seed inoculation processes

In general, for every 1 kg of legume seed: use 4 teaspoons or soda bottle-lid (20ml) of the sticker solution and add 2 heaped teaspoons or soda bottle-lid (10 g) inoculant.

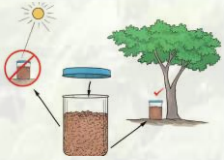
1. Add proportional sticker amount to the weighed amount of seed to be planted on the same day. Mix until all the seeds are evenly coated with the sticker.

2. Shake and open the inoculant sachet under the shade and pour the recommended amount onto the moistened seeds.



3. In case of portion of inoculant in a sachet is remaining, expel air immediately, seal and store it in cool and dry area for the next day use. Trying to use all inoculants of an open sachet is strictly advised.

4. Mix seed and inoculant by slowly shaking until all the seeds are uniformly coated. Be careful not to split the seeds or peel the outer coat by using excessive force.



5. Keep the dressed seed lot spread under shaded for air drying for few minutes.

6. Rhizobial numbers on seed are highest immediately after inoculation. Hence, It is recommended that farmers sow inoculated legume seed immediately inoculation.

NB: If a certain legume grower wants to treat the seed with pesticides, always apply insecticides (i.e. Imidalem) first, followed by fungicides (i.e. Apron star), and finally the inoculant or follow instructions on the packets.

Major determinants for on-farm rhizobial inoculant efficacy

1. Agro-ecological factors

The inherent characteristics of soils and climate often affect the success of rhizobial inoculation.

- **Soil pH:** below 5.5 adversely affects rhizobia survival and nodulation particularly for faba bean.
- **Soil nitrogen**: As carryover nitrogen levels in the soil rises, nodule formation is negatively affected. However, up to 20 kg N ha^{-1} would be required for startup in depleted soils.
- **Bioavailable Phosphorus**: bioavailable P enhances effectiveness of rhizobia by >6% in Ethiopian soils.
- **Native rhizobia**: native rhizobia (≥ 1×10^3 cells g^{-1} air dry soil, compete with the elite rhizobial inoculant for the infection sites and results in poor nodulation.
- **Climate**: Extreme water and temperature stresses survival, migration, and nodule initiation of rhizobia.

2. Inoculant factors

Regardless of formulation, the strain of rhizobium must have the following traits:

- **Infectiveness**: the ability of a rhizobial strain to compete within the soil and induce nodule formation.
- **Effectiveness**: the ability of rhizobial strain to fix high levels of nitrogen within nodules.
- **Quality (number and age)**: ≥1.0 x10^7cells g^{-1} dry carrier, and ≤ 12 months.

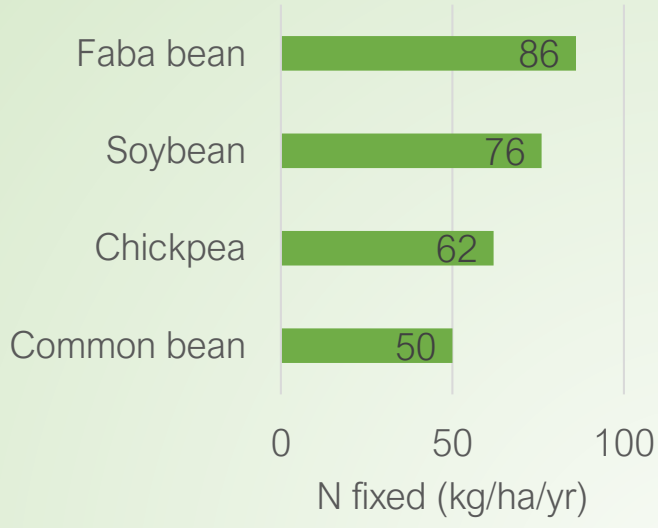
3. Host factors:

- **Plant selection** (host genotype) dictates biological nitrogen fixation. Variations in nitrogen fixation (symbiotic effectiveness) have been confirmed not only among legume species, but also among improved varieties. For instance, keeping remaining factors constant, faba bean > soybean > chickpea > common bean in biological nitrogen fixation (BNF) volume per unit area per year.
- **Stressed genotypes** have poor ability to signal the rhizobia regarding its need for nitrogen, thus delaying nodulation and nitrogen fixation.

4. Agronomic factors

Management practices that increase nitrogen demand by the host plant is a promising avenue to increase nitrogen fixation in grain legumes in a cropping system. The most likely practices to have a positive impact on BNF are:

- Early planting and proper drainage practices
- Improving pest management practices
- Improving soil structure
- Conversion from conventional tillage to zero or minimal tillage
- Improving the overall fertility status of the soil, while maintaining low levels of available soil N.



Useful References

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- **CGIAR. 2012. CGIAR Research Program on Grain Legumes: Leveraging legumes to combat poverty, hunger, malnutrition, and environmental degradation. IITA, ICRISAT, CIAT, ICARDA.**
- **Getahun Mitiku, Abere Mnalku and James W. 2018. Application guideline for rhizobial biofertilizer. EIAR, Addis Ababa.**

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