

Inoculation of soybean seed

Inoculation for an efficient nitrogen supply

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The soybean, like all legume crops, hosts the nitrogen-fixing nodule bacteria. In soy, this is *Bradyrhizobium japonicum* that does not naturally occur in European soils. Careful seed or soil inoculation is required so that the developing plant root is colonised by this bacterium.

Outcome

If properly inoculated, biological nitrogen fixation (BNF) in soy can fully cover the nitrogen fertiliser needs of the crop. Inoculation typically increases the grain yield and the protein concentration by 40 – 60%. This treatment costs in Central Europe are about 20-30 EUR/ha. The costs per hectare is dependent on product, application rate, country and provider. The return on this investment is therefore very high.

Attention to detail is essential

Seed inoculation: The inoculant is purchased as living strains of rhizobia, either in moist solid or liquid forms. The overall aim is to apply the bacteria to the seed or soil so that it remains viable and can infect all the emerging roots. The easiest way is to buy pre-inoculated seed. Relying on this is not recommended because the viability of the inoculant by the time the seed is sown is very variable. The most common approach is the use of contact inoculation of the seed as soon as possible before sowing. Peat-based preparations (e.g., HiStick, LegumeFix) can be mixed by hand directly in the seed tank or using a cement mixer. Precision mixers are usually mounted to a tractor and are used where a peat-based inoculant has an added polymer adhesive (e.g., Force 48). The adhesive must have enough time to dry on the seed so that the seed does not clump in the seeder.

The seed should be treated gently. Pouring seed between big-bags is a good way of gently mixing the inoculum through the seed.

Inoculation by spraying a stream of seed is very efficient, but this can only be used with liquid preparations (e.g., LiquiFix, Rizoliq, Turbosoy).

Applicability

Theme: Crop nutrition

For: All soybean growers

Where: On all farms where soy is grown

Timing: Shortly before sowing

Equipment: Mixing equipment or spray gun

Follow-up: No follow-up action required

Impact: Optimum yield without fertiliser N.

Soil inoculation: Inoculation of the soil is practiced in France, usually in combination with contact inoculation of seed. Inoculant granules are applied using a granule applicator on the seeder. Very good results are achieved but care must be taken to ensure the granules flow constantly through the seed drill. A combination of contact and soil inoculation is very effective.



Soybean roots build a symbiosis with rhizobium bacteria and form nodules. Inoculated soybeans can source from the air about 60-80% of the total nitrogen that is taken up by the crop. The nodulation should be checked about 6 weeks after sowing by digging up the young plants carefully. Photo by J. Recknagel.

Products and inoculant strains

There are marked differences between products that use the same or similar strains of rhizobium. Peat-based products (e.g., HiStick, LegumeFix) are regarded as standard inoculant products. They have the added advantage of colouring the treated seed. The use of polymer adhesives is particularly relevant for pneumatic seeding because pneumatic seeders tend to remove the inoculant from the seed.



Application of inoculants using a cement mixer is common. The germination rate can be reduced due to physical damage. Larger quantities of seeds are usually inoculated with spraying pistols or mixers mounted on tractors. Photo by Taifun-Tofu GmbH

Liquid inoculants (e.g., LiquiFix, Rizoliq, Turbosoy) come with a range of additives and use polymers for protection and adhesion. In contrast to peat-based products, liquid inoculants don't colour the seed meaning that inoculated seed must be carefully labelled or noted. There are differences between inoculation products in terms of rhizobium strains. While the French G49 strain has been standard, various new strains from Embrapa in Brazil, the USDA, and from Canadian and South African institutes are currently being used. Several manufacturers combine several strains in one product. Even in China, where *Bradyrhizobium japonicum* is plentiful in the soil, the use of inoculants is on the rise because the modern commercial strains promise higher performance.

The density of rhizobia in the product is a key quality feature. How many bacteria per gram are present ex-works, how many survive until

delivery, and what number is actually found on the bean when it comes in contact with the soil? The manufacturer's data are usually between one and three billion per gram of vaccine (1×10^9 or 3×10^9). The higher the initial number, the better the chance that sufficient bacteria will survive even under adverse conditions until germination of the seeds. Nevertheless, a lower density product may be superior if the quality of rhizobia and formulation are better. There are noticeable differences in the quality of rhizobia.

It is crucial that as many as possible survive after sowing until the germination starts. For example, the Rizoliq and Turbosoy promote rhizobium stabilization processes and offer pre-treatment for up to 15 days.

Rhizobium bacteria are sensitive soil pH outside the range 6.5 – 7.5. Biofil/Terragro (Hungary) offer strains which have been selected for acidic or alkaline soils.



A successful inoculation is essential for soybean production. Soybean without nodules (left) suffer from nitrogen deficiencies. Successful inoculation can supply all the additional nitrogen needs from the soil air (right). Photo by J. Wasner

Key practice points

- An effective inoculant must be used as instructed.
- Seeds should be inoculated with a double dose if soybean was never grown on the intended fields. It is advisable to combine in this case two different inoculant products.
- Ideally, inoculation and sowing should take place on the same day so that only freshly inoculated seed is sown. Rizoliq or Turbosoy offer the opportunity of treating seed up to 15 days before sowing.
- Inoculants must be stored in a cool dark place, and never above 25°C.
- UV light kills the bacteria. All exposure of inoculant and inoculated seed to sunlight should be avoided. All work should be done in the shade.
- Seed treated with a polymer adhesive should be stirred about 20 minutes after treatment to prevent clumping.
- The seed drill should be clean of the residue of previous pesticide seed treatments.
- All seed contact with chlorinated water, including chlorinated municipal drinking water, should be prevented.
- About six weeks after sowing, it is possible to check the nodules at soya roots. For this purpose, about five plants from different locations in the field should be dug out with a spade, the soil carefully removed from the roots and the number of nodules counted. An average of 10 to 30 nodules at the roots can be considered as a good or very good nodulation. Pea-sized nodules perform usually better than smaller nodules.

Further information

The online archive for organic farming (Organic Eprints) provides access to a guide on examining nodule activity:

Pommeresche and Hansen (2017): Examining root nodule activity on legumes. FertilCrop Technical Note. (<http://orgprints.org/31344/>)

There is a relatively large number of inoculant producers present on the European market. Following companies are only some examples:

- Agrel, www.agrel.de
- Agritema, www.agritema.com/en
- BASF, www.agricentre.basf.co.uk/en
- Legume Technology, www.legumetechnology.co.uk
- Stoller Europe, www.stollereurope.com/en
- Rizobacter, www.rizobacter.com/en
- Terragro, www.terragro.hu

The website of the German Soybean Association, www.sojafoerderring.de provides comprehensive materials about soybean cultivation including also seeding and inoculation. The website also provides access to the video on inoculating soybean seeds (original title: „Impfung von Sojasaatgut“).

Sources

Large parts of the information presented here is the result of investigations and studies done by the Deutsche Sojaförderring (German Soybean Ass.) together with Taifun-Tofu GmbH, Germany.

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