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Spray inoculating grain legumes

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Legumes, such as lupins, soybeans, fieldpeas, chickpeas, mungbeans, cowpeas and fababeans, get most of their nitrogen from root nodules, making the use of nitrogenous fertilizers with them unnecessary. These nodules are formed by particular bacteria called *Rhizobium*. If the proper *Rhizobium* is not already present in the soil it must be provided. The usual way has been to inoculate the seed with a slurry of peat in which *Rhizobium* has been grown.

The slurry is usually mixed with pasture seed in a concrete mixer or a tub. When the inoculated seed is dry it is sown in the normal way. This method also works very well for cropping small areas with grain legumes. But when large areas are being sown, this method of seed inoculation is a lot more work and becomes a serious bottleneck.

For instance, using a seeding rate for lupins of 80 kilograms per hectare, it is easy to see that inoculating enough seed for one day's sowing is going to be a huge task.

Seed for	Pasture (e.g. subclover)	Grain legume (e.g. lupins)
40 ha	160 kg (= 4 kg/ha)	3200 kg (= 80 kg/ha)

Some farmers have even hired concrete mixing trucks to do the job; others have resorted to sprinkling the inoculant on to the seed in the seedbox. This practice is not recommended because so much inoculant is lost as the seed passes through the planter that nodulation may be unsatisfactory and crop yield reduced.

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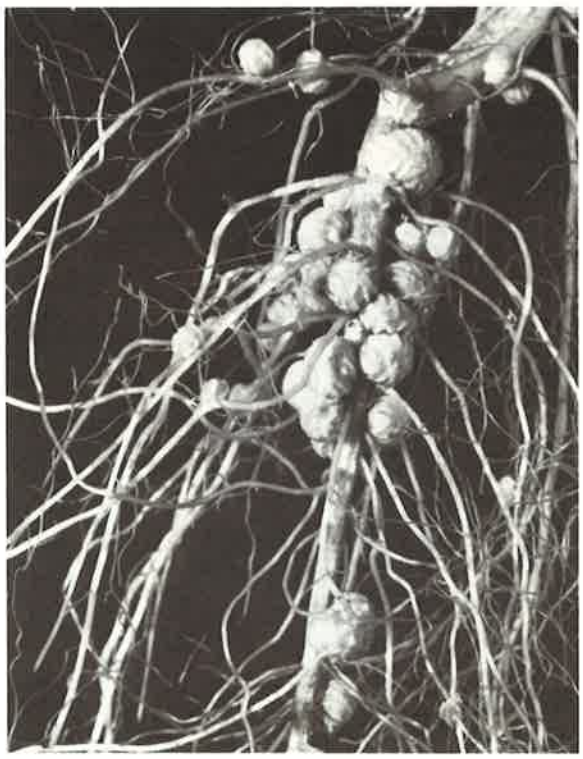
Researchers in CSIRO and the Department of Agriculture have been looking for alternative methods of inoculation. The best for broadacre sowings of crop legumes seems to be spray inoculation. This means that *Rhizobium* peat culture is mixed with water to make a liquid inoculant which can be sprayed directly into the seedbed at the time of sowing. When the seed germinates, its roots pass through a band of inoculated soil, leading to formation of nodules. Because the seed and rhizobia are physically separated, seed may be treated with agro-chemicals which would be toxic to rhizobia when in direct contact. Spray inoculation has consistently given excellent

Effective nodules on soybean roots *(Photo: C. Totterdell, CSIRO)*



nodulation and high yielding crops in many trials and on those properties where it has been used.

A spray inoculation system which can be readily mounted on a seed drill is illustrated in the accompanying diagram. There is nothing complicated about spray inoculation for it uses basic spraying equipment. This can be set aside especially for the purpose, or it can be the equipment used for other spraying jobs provided it has been thoroughly cleaned. Some details of the components, which are readily available either on the farm or commercially, are given below.

Spray inoculation equipment mounted on a tractor *(Photo: R. Gault, CSIRO)*

COMPONENTS

The tank

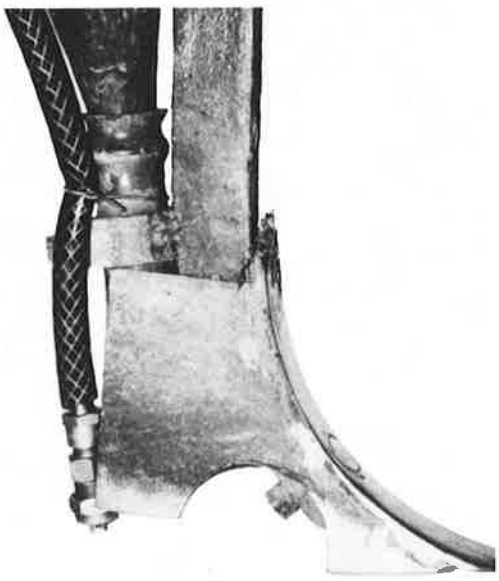
The inoculant tank can be made of steel but plastic or fibreglass is preferred for ease of maintenance. It should be painted white to reflect heat and is best mounted on the front of the tractor. The size of the tank should be such that the rate of delivery of its contents is synchronized with seed and fertilizer delivery.

Delivery outlets

The delivery outlets should be capable of delivering liquid inoculant in large droplets into the seed furrow in a band 5 to 8 cm wide across the root zone at a low volume (about 112 L/ha) and medium pressure (140 kPa). Capillary tubes are preferred. The volume of liquid inoculant delivered is determined by the choice of diameter and length of capillary tubing, and by regulation of pumping pressure. Vinyl tubing is best, but other plastic forms or copper tubing also work well.

The capillary tubes must all be the same length to ensure that the delivery rate from each is identical. Fit the capillary outlet with a small deflector plate so the liquid inoculant is delivered into the furrow as a fan-shaped spray instead of a jet. The capillary tubing should be mounted behind the seed boot so the delivery outlet is situated 2.5 to 5 cm above the bottom of the furrow. This arrangement minimizes the risk of splash or drift onto the boot which could lead to a build-up of soil and blockage of seed flow.

Spray nozzle mounted behind seed boot *(Photo: R. Gault, CSIRO)*



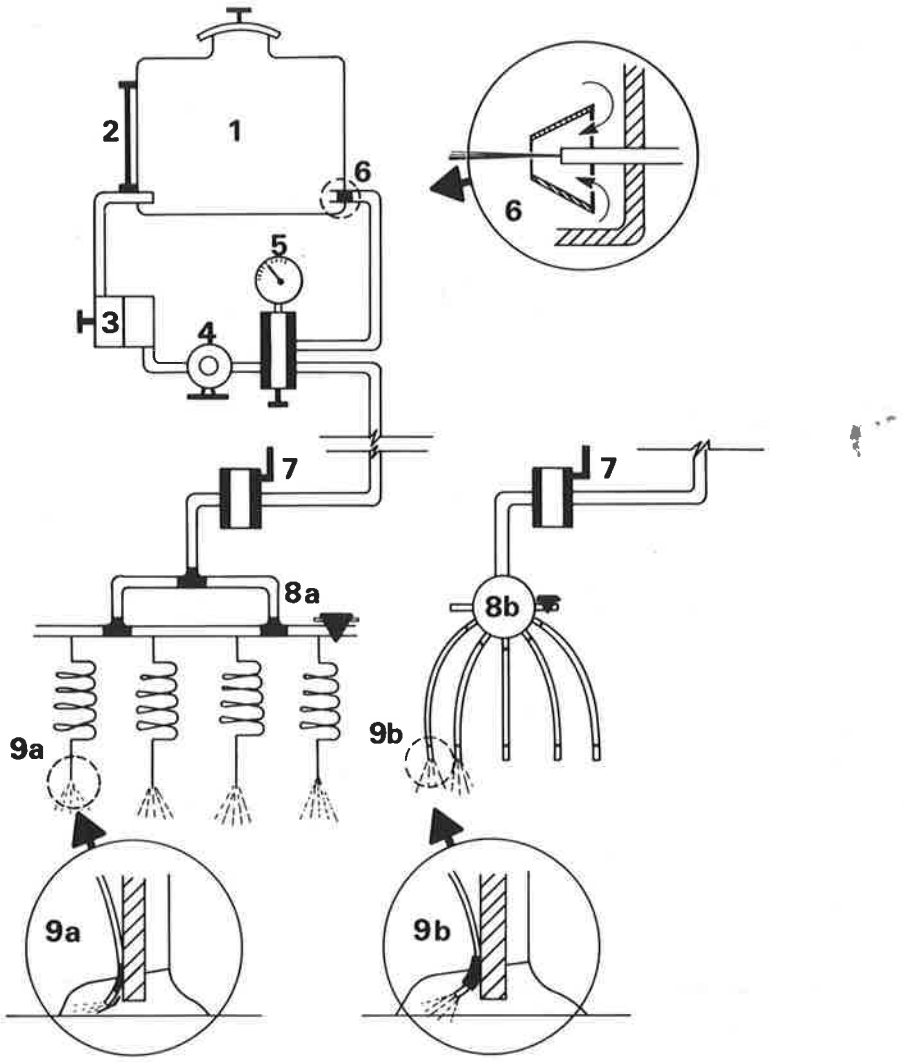
Outlet type	Orifice size (mm)	Length (cm)	Delivery rate at 140 kPa (mL per min)
Capillary tube (copper)	2.50	300	480
Capillary tube	2.50	175	720
Jet nozzle	1.40	—	440

Jet nozzles are a possible alternative to capillary tubes; however, they are more subject to blockages. The nozzle orifice should be larger than the aperture of the filter. Many suitable nozzle types are available. Fan or cone jet nozzles, with an internal whirl plate to aid self-cleaning, are useful. Some nozzles are fitted with filters; these should be removed because they increase the frequency of blockages.

Suitable hoses can be cut from any material; rubber, flexible plastic and rigid polythene hoses have all worked satisfactorily.

The pump

Any gear, piston, centrifugal, roller or diaphragm type pump is satisfactory but diaphragm or roller pumps seem best. Gear pumps and piston pumps have a short life because peat inoculant contains a small amount of abrasive grit. The pump can be driven off the tractor PTO. Pump capacity should be about three times the application rate to the soil so that the rest can be bypassed for agitating the liquid inoculant in the tank.



1. INOCULANT TANK
2. LIQUID LEVEL INDICATOR
3. PANCAKE-TYPE FILTER: side mounted
4. PUMP: driven by tractor power-take-off
5. PRESSURE RELIEF VALVE: with pressure gauge and bypass port
6. BYPASS OUTLET: with venturi attachment to provide agitation
7. GATE VALVE
8. ALTERNATIVE MANIFOLDS:
   a Header
   b Radial with stopcock
9. ALTERNATIVE DELIVERY ORIFICES: attached behind seed tube of seed drill -
   a Capillary tubes: with deflector plate
   b Cone-jet nozzles

The agitator

It is essential that the inoculant in the tank be agitated continuously, otherwise the peat would quickly settle to the bottom. Of various types available, a jet agitator is the simplest. It should be mounted on the bypass outlet near the bottom of the tank. The choice of number and size of jets will depend upon the capacity of the tank, the volume of the bypass and the amount of pressure generated by the returning inoculant.

The filter

Peat inoculant for spray inoculation has to be doubly filtered.

Most substances applied through a pressure sprayer are in solution and although filtration is desirable, it is not critical. Peat inoculant is different. It consists of particles and some short fibres which help to protect the rhizobia.

In many peat samples, unfortunately, there is also a small proportion of larger fibres which must be removed to avoid the risk of blockages. Efficient filtration, therefore, is essential.

It has been found that best results are obtained with double filtration. Firstly, the peat inoculant slurry should be filtered through two

or three thicknesses of fine muslin or cheese cloth immediately before it is added to the tank. Secondly, a filter should be fitted into the line between the tank outlet and the pump (see 3. Filter in the diagram).

The filter should be about 0.4 mm aperture (40 mesh) and have a large filter surface to reduce the risk of blockage. The pancake type of filter is preferred. If it is mounted on its side, it can be cleaned easily by releasing the clamp which holds it together and flushing it free of peat particles.

The pressure regulator

The pressure regulator bypass to use is the same as that used for boomspraying. It should be set to control pressure to about 140 kPa and to deliver one-third of the total flow of liquid inoculant to the spray nozzles and return the rest to the tank to be agitated. Pressures greater than 175 kPa may be harmful to rhizobia.

The manifold

The manifold which distributes the liquid inoculant to the spray nozzles should be made of copper or some other non-corrosive material. A draincock(s) should be incorporated in the design so that the manifold can be quickly flushed free of sediment. This operation should be carried out each time the filter is flushed.

SELECTION OF INOCULANT

Different crop species require different inoculants. If the wrong inoculant is used the crop will not nodulate. Inoculants are grouped according to legume species which have the same *Rhizobium* requirements.

GROUP E Peas, vetches, tares, broad beans, fababeans, tick beans, lentils
GROUP F French beans, climbing beans, navy beans
GROUP G Lupins
GROUP H Soybeans
GROUP I Cowpeas, peanuts, velvet beans
GROUP J Lablab
MUNG Mung beans
CHICKPEA Chickpeas

Five brands of inoculant are available for inoculating grain legumes *(Photo: J. Gasparotto, Department of Agriculture)*

MIXING THE INOCULANT

Mix an amount of appropriate peat inoculant, corresponding with the normal rate of seed inoculation, into a paste with water. Dilute it to a slurry and filter it through fine muslin, cheese cloth or nylon stocking before adding it to the water-filled tank. Use clean, drinkable water that is cool (less than 27°C). A low volume application of 112 L/ha is enough for spray inoculation. A higher rate is undesirable because of the increased water load, more frequent refilling stops required and because it can lead to premature germination. Check capillary outlets or nozzles for flow before starting each run.

Seeding rate (for lupins, soybeans, chickpeas) (kg per ha)	Inoculant requirement (grams per ha)
40	112
60	168
90	252

250 ha

CLEANING

Equipment must be thoroughly flushed at the end of each day's operation and when sowing is complete. Otherwise, particles of peat will settle and set in the tank, regulator, capillary outlets, etc. and will result in blockages when the equipment is used again.

Where pumps and filters used to spray herbicides or insecticides are used for spray inoculation, the following detoxification procedures will reduce the danger of damage to the inoculant:

- For esters of 2,4-D or MCPA or 2,4,5-T: flush with clean water. Rinse with kerosene. Flush with water again. Fill tank and system with a mixture of one litre of household ammonia to 100 L of water. Leave stand for a day or two and then run it through the system. Rinse thoroughly with water.
- For soluble salts of 2,4-D or MCPA: flush firstly with clean water and then with a detergent solution. This should be followed with the household ammonia treatment outlined above and a water rinse.

OTHER PRECAUTIONS

Remember that rhizobia are living organisms which are very delicate and easily killed by heat, chemicals and excessive pressure. Therefore, packets of inoculant must be kept cool, equipment cleansed of toxic pesticides and pumping pressures kept below 175 kPa.

To maintain a constant flow of spray inoculant, clean filter frequently and check the nozzle flow whenever the seed drill is out of the ground. Provided these precautions are observed, spray inoculation should give excellent nodulation of the crop.

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