Project title	Dwarf green beans: evaluation of Rhizobium inoculant for nitrogen fixation
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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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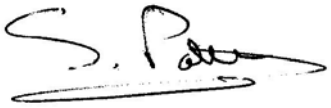

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Grower Summary

Headline

- Granular *Rhizobium* inoculant can be applied to the soil at drilling. Inoculant applied at 10kg/ha provides equivalent yield to current N recommendations and a saving of 50 or more kg of N.

Background and expected deliverables

Green beans do not produce active nitrogen fixing nodules from a naturally occurring source of *Rhizobium* spp. There is therefore a high requirement for nitrogen fertiliser for the crop which is drilled from mid-May and harvested from mid-August. Beans are not efficient in using this nitrogen and there is a risk of nitrate leaching during the short growing season. Substituting some of this nitrogen with the use of an added soil applied granular inoculant specific for green beans, can result in cost savings being made**.**

Summary of the project and main conclusions

A granular inoculant (Nodulator) containing species specific strains of *Rhizobium* spp was applied to the seedbed using a granular distributor at sowing time. The inoculant resulted in a significantly high level of nodulation where no nitrogen fertiliser had been applied either with or without inoculant. The yields indicated that 10kg /ha of Nodulator was comparable with the yields obtained from 150kg of Nitrogen.

Financial benefits

Current recommendations for nitrogen fertiliser in green beans is 100 – 150 kg/ha of N. Use of an inoculant at 10kg/ha costing around £34/ha, can result in the reduction in the amount of nitrogen by up to 100kg/ha and result in a saving of around £80/ha.

Action points for growers

- Limited data suggest that a granular inoculant (Nodulator) applied to the seed bed at a rate of 10kg/ha allows natural nitrogen fixation through increased nodulation by the green beans to produce an equivalent yield increase to that obtained from 150kg/ha of nitrogen fertiliser.
- Use a granular distributor to apply an accurate amount of granules at sowing time.

Science Section

Introduction

Around 2000ha of green beans (*Phaseolus vulgaris*) are grown in the UK for the fresh market or for freezing. Production is highly mechanized and seed is imported from either Europe or the USA and is usually treated in the exporting country with a mixture of an insecticide and a fungicide. This gives protection against bean seed fly larvae (*Delia platura*) and damping off diseases caused by *Pythium* or *Rhizoctonia* spp. Crops planted from mid May until early July to provide a harvest from August to September. Seed is drilled by precision planters usually in 2m wide beds, pre-cultivated and with a fertiliser application of around 120 -180 kg nitrogen per hectare. In some cases the dose is split between predrilling and post emergence on the lighter free draining soil types particularly where irrigation is used or there has been excessive rainfall. Harvest is usually by machine.

Although a member of the Leguminosae, because green beans are not native to the UK, there is no effective population of *Rhizobium phaseoli* present in soils to allow natural nodulation and nitrogen fixation to occur, hence the requirement of nitrogen fertiliser. The potential benefits of using an inoculum to promote nitrogen fixation in Phaseolus have been demonstrated and there have been attempts to provide an effective inoculant of Rhizobium for green beans in the UK, the formulations were based on a milled peat which is mixed with the seed at drilling time. In commercial production, it was difficult to add the inoculant to the seed drill during the planting operation and some variability of performance may have been due to poor mixing, poor seed adhesion and toxicity from the pesticide seed treatment. In the most effective cases however, nitrogen could be reduced by around 50kg/ha with the inoculant. But despite this, practice of seed inoculation has not been carried out in the UK for many years.

The recent increase in the cost of nitrogen however has highlighted areas where savings could be made and the recent development of a clay granular formulation of Rhizobium inoculant (Nodulator®) for *Phaseolus vulgaris* has meant a re-evaluation of inoculation in green beans for UK production. This product is stable and can be stored for some time before use. In a small plot trial carried out in Norfolk by PGRO in 2008, the inoculant produced active nodules on Laguna and Scuba green beans. There was a background population of natural Rhizobium but this appeared to be generally inactive and suppressed by the 100 kg/ha standard treatment of nitrogen. The higher rate of inoculant plus 50 kg/ha of nitrogen both improved the nodulation score and the harvested pods yielded similar to the standard treatments. This proposal is to further evaluate the value of a Rhizobium inoculant that can be applied by standard granule applicator to the seed bed during drilling.

Materials and methods

Two replicated field trials were sown in two commercial crops in Norfolk and Littleport, Cambridgeshire on an organic loam soil with a high proportion of silt. The green bean variety Venice, previously treated with a commercial insecticide/fungicide product was drilled using a Stanhay precision drill at 4 rows in a 1.8m bed. Each plot was be 10m x 1.8m. The inoculant granules Nodulator, were obtained from Becker Underwood plc and applied through a drill mounted Horstine Farmery applicator with fish tail distributors set within the seeding band.

Nitrogen fertiliser (as ammonium nitrate) was applied as a broadcast treatment immediately prior to drilling.

The treatments were as follows:-

treatment no.	Inoculant (kg/ha)	Nitrogen (kg/ha)
1	Nil	Nil
2	Nil	150
3	5	Nil
4	10	Nil
5	5	50
6	10	50
7	5	100
8	10	100

Each treatment was replicated four times. The trials were managed as part of the commercial crop and herbicide programmes applied as necessary.
Due to a period of drought at the Norfolk site, plant emergence was severely delayed and the plots became poorly established. It was decided not to proceed with this trial. At Littleport, however growth was normal and at the freezing stage for the green pods, plants were dug from five randomly selected areas of each plot and the roots examined for the presence of nodules. Nodulation was scored visually on the individual plants dug from each sampling point using a score of nodulation as follows:-

0 = no nodules
1 = 1-5 nodules
2 = 6-10 nodules
3 = <10 nodules

The beans were then harvested and the pods from 20 randomly selected plants from each plot were weighed.
Data were analysed by analysis of variance (Genstat5)

Results

The trial in Norfolk was abandoned after very poor emergence of bean plants within the trial area following a prolonged period of drought. At the Littleport site, the beans emerged well and evenly across the trial area. There was no evidence of disease and at harvest, the root nodulation scores were calculated the results are shown in table 1.

Table 1. Nodulation of green beans

Treatment number	treatment	Nodule score/plant
1	Nil	0.43
2	150kgN	0.20
3	Nodulator 5 kg	1.14
4	Nodulator 10 kg	1.08
5	Nodulator 5kg + 50kg N	0.79
6	Nodulator 10kg + 50kg N	1.25
7	Nodulator 5kg + 100kg N	0.63
8	Nodulator 10kg + 100kg N	0.33
LSD @p=0.05		0.66 (sig)
cv%		61.7

There was a low background level of natural Rhizobium in the soil which produced some nodulation on the nil treatment plots. However it appeared that this was suppressed where nitrogen had been applied at the high rate. The Nodulator at both 5kg and 10kg in the

absence of any nitrogen fertiliser resulted in an increase of nodulation. The addition of 50 kg of nitrogen to the 5kg of Nodulator appeared to slightly suppress nodulation and this was more evident where 100 kg of nitrogen had been used. However at 10kg of Nodulator, the 50 kg of nitrogen did not appear to affect the amount of nodulation. Where 100kg of nitrogen had been applied, nodulation was obviously suppressed.
The weight of pods from 20 plants in each plot was recorded and the analysed results of the mean weights are shown in table 2.

Table 2. Pod weights

Treatment number	treatment	Weight of pods	% increase over nil treatment
1	Nil	2.12	100
2	150kgN	2.48	117
3	Nodulator 5 kg	2.22	105
4	Nodulator 10 kg	2.38	112
5	Nodulator 5kg + 50kg N	2.11	99
6	Nodulator 10kg + 50kg N	2.03	96
7	Nodulator 5kg + 100kg N	2.23	105
8	Nodulator 10kg + 100kg N	2.28	108
LSD @p=0.05		0.77 (nsd)	
cv%		23.6	

Although the differences in the weight of the harvested pods was not statistically significant, there was an indication that the use of Nodulator at 5 kg or 10kg/ha produced yields that were higher than the untreated beans and that at 10kg of Nodulator, the yield was only just below that from the 150 kg/ha of nitrogen. That was comparable with the high yield obtained from the 150 kg/ha of nitrogen.

Discussion

Unfortunately the trial at Norfolk was unsuccessfully established and so the results obtained in this project were limited. However, earlier work had shown the potential for Nodulator to replace some or all of the nitrogen fertiliser (Biddle and Thompson 2009) and this year's project has also suggested that this is achievable. Yields were not statistically different but the trend for increased yield reflected the use o the Nodulator and the increase in nodulation. This compared very well with the 150 kg Nitrogen used as a standard commercial treatment and the work clearly indicates the value of an inoculant that can perform in a relatively dry season.

Conclusions

Nodulator granules applied to the seedbed at sowing produced effective levels of nodulation of the roots of the green beans and yields appeared to be comparable with those achieved by the use of nitrogen. The results of this limited work however should give growers some confidence in the use of the granular Nodulator inoculant

Glossary

References

Biddle AJ and Thompson S (2009). Response og green beans to Rhizobium inoculation of the seed bed. Seed production in a changing environment. Symposium Proceedings No 83. BCPC, UK . 134 -137

