

**A COMPARISON OF TWO LIQUID AND ONE POWDER
FORMULATION OF *BRADYRHIZOBIUM JAPONICUM*
INOCULANTS ON THE DEVELOPMENT OF NITROGEN-FIXING
NODULES ON SOYBEAN (*GLYCINE MAX* L. MERILL)**

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Seeds of soybean variety LS 6161 (Roundup Ready®, from Link Seeds(Pty) Ltd, South Africa) were treated with three formulations of *Bradyrhizobium japonicum*, and immediately planted, with an untreated control, in field trials on two farms in the Natal Midlands, South Africa. Two of the three *B. japonicum* seed treatments were liquid formulations, one of an anonymous Northern Hemisphere strain (Treatment A), and the other with the well established South African strain WB74 (Treatment B). The third product was a granular formulation of strain WB74 (Eco-Soy™, from Plant Health Products (Pty) Ltd, South Africa), which was applied at two rates. At maturity, but before drying off, the plots were harvested, and all plants were evaluated for the number of active and inactive nodules, as determined by dissection and colour evaluation, assuming red nodules to be actively fixing nitrogen, and green nodules to be inactive. At Baynesfield Estate, where inoculated soybeans have been farmed for decades, the mean nodule number of the control treatment was low (21) but 100% were red, nitrogen fixing nodules, reflecting a high background level of effective nitrogen fixing rhizobia in the soil. In contrast, at Ukulinga Research Farm, the control plants developed a large number of nodules per plant (55), but 88% were green, non-nitrogen-fixing nodules, reflecting a high level of competitive wild strains of rhizobia. Use of Treatment A did not increase the number of nodules relative to the control (17, and 39 nodules per plant at Baynesfield and Ukulinga, respectively), and 100% and 27% were nitrogen fixing nodules, respectively. This suggests that the Treatment A has a strain of *B. japonicum* that competes poorly in the test soils with wild strains of rhizobia. Although the nodulation count was similar (25 and 43 nodules per plant, at Ukulinga and Baynesfield, respectively), Treatment B was more competitive, with 66% of the nodules being active at Ukulinga. The best performing product was Eco-Soy™ at half rate (69 nodules with 90% active at Ukulinga), with the full rate treatment reducing efficacy (36 nodules with 85% active at Ukulinga). Seeds were also treated with a combination of Eco-T® (*Trichoderma harzianum* from Plant Health Products) and Eco-Soy™ (*B. japonicum*) to determine whether Eco-T® had an effect on nodule formation on roots. However, there was no interaction between the two microbes, and nodulation levels were similar (21 and 36 nodules (Eco-Soy™) versus 21 and 29 nodules (Eco-Soy™ + Eco-T®)), at Ukulinga and Baynesfield, respectively.

A comparison of 2 liquid Rhizobium formulations vs a powdered Rhizobium formulation, on the development of active nodules on roots of soya plants (*Glycine max* L. Merrill)



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Research Outcomes

Trial Comparison :

Novel Powder formulation of Rhizobium vs 2 liquid formulations

1. A novel Powder formulation of Rhizobium WB74 => highest yield

11-18% extra due to Powder Treatment

Powder formulation => most functional Rhizobium root nodules

2. Powder formulation, on seed, viable for 4 days
3. No significant differences statistically in yield (only 3 reps)
5. Value of Rhizobium application

Extra income: Powder vs Control

At a cost of R107 per ha

- Baynesfield R1500 per ha extra income
- On 500, 000 ha in SA $\approx$ R 7 billion !

Need for Functional Rhizobia on Soybean in SA

- South African soils
 - Acid – pH 4.0 – 5.5
 - **Mo** present BUT is bound to clays in acid soils
 - **Low P** : 2 to 10 ppm
 - Low **organic matter** : <2%
 - Low populations of beneficial Rhizobia
 - Dryland production affected by temporary **drought stress** in most seasons
- N as a % of input costs of maize = ???????
 - Nitrogen fertilization has conflicting results (Salvagiotti *et al.*, 2008)
- Current Rhizobium inoculants
 - Competing with parasitic indigenous Rhizobia
 - Liquid Rhizobium inoculants have **short shelf lives + refrigeration**
 - Poor survival on seed
- Strain compatibility – crop x strain

Rhizobium field trials

- Trials x 2 sites:
 - Ukulinga Research Farm (University of KwaZulu-Natal)
 - No prior soybean crops; tilled, irrigated
 - Baynesfield Estate (30km away)
 - Regular soybean crops, inoculated with WB74, no-till, dryland
- 3 x Rhizobium formulations:
 - Liquid formulations
 1. Non-WB74 formulation
 2. WB74 formulation
 - Powder formulation
 - WB74 formulation (WB74 = the only registered, superior strain for soybean under South African conditions)
 - Root growth stimulator and biocontrol agent
 - Eco-T[®] = a strain of *Trichoderma harzianum* isolated in SA

Measurements

❖ Nodules analysed at flowering

- ❖ Total number of nodules
- ❖ Total number of functional nodules

❖ Crop Yield







Figure 1. Yield in tons per hectare at Ukulinga Research Farm

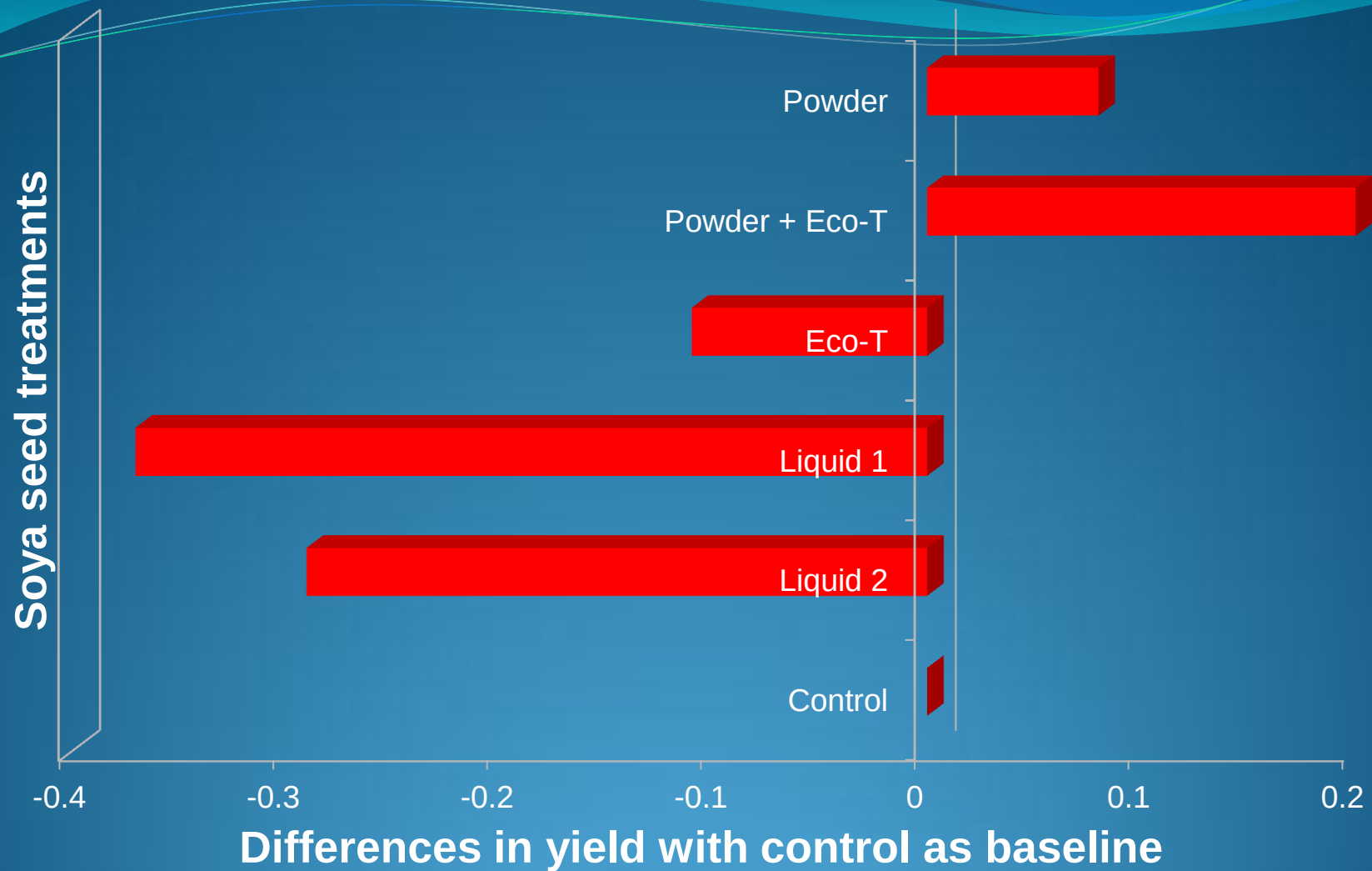


Figure 2. Yield in tons per hectare at Baynesfield Estate

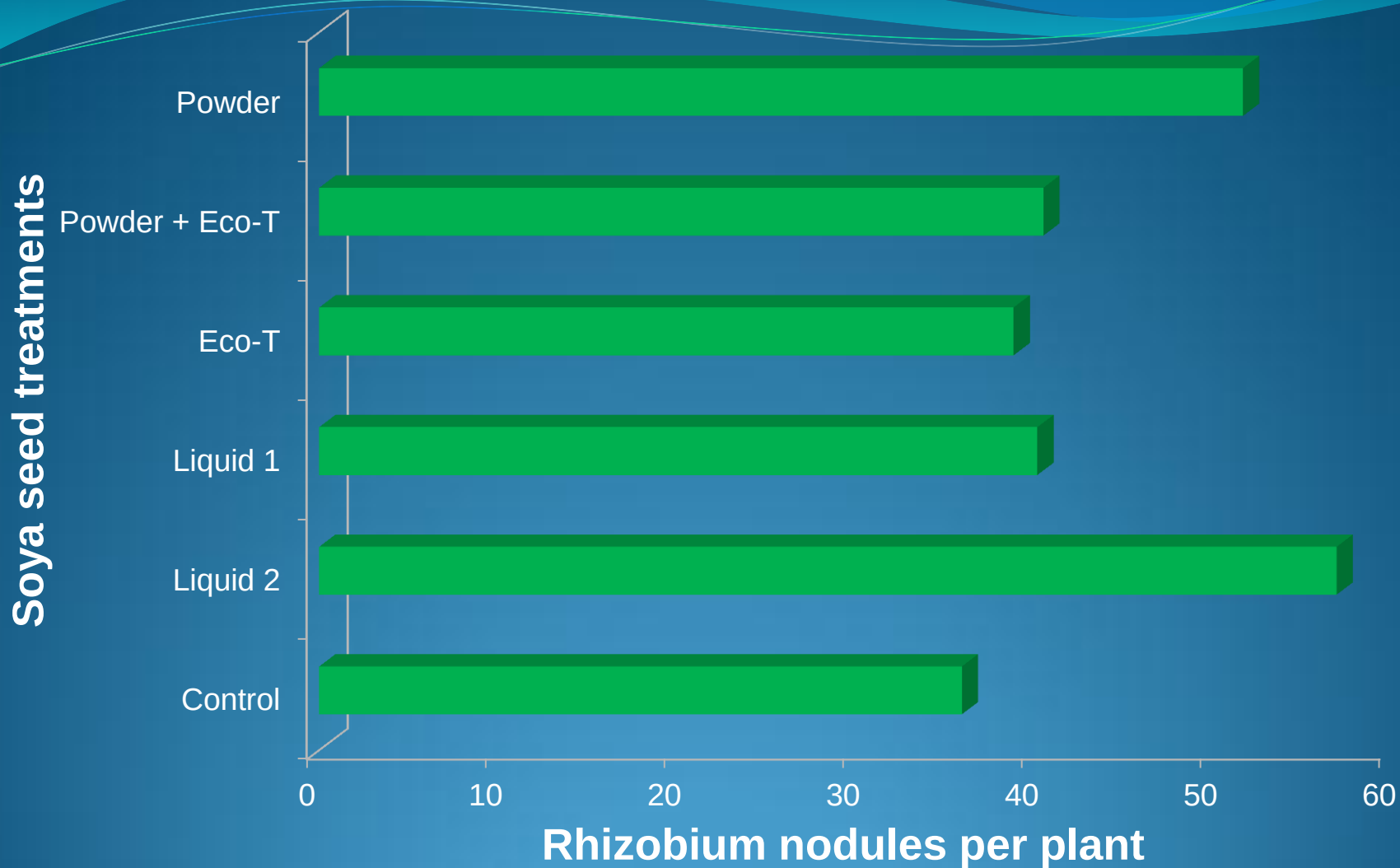


Figure 3. Number of Rhizobium nodules per plant at Ukulinga Research Farm

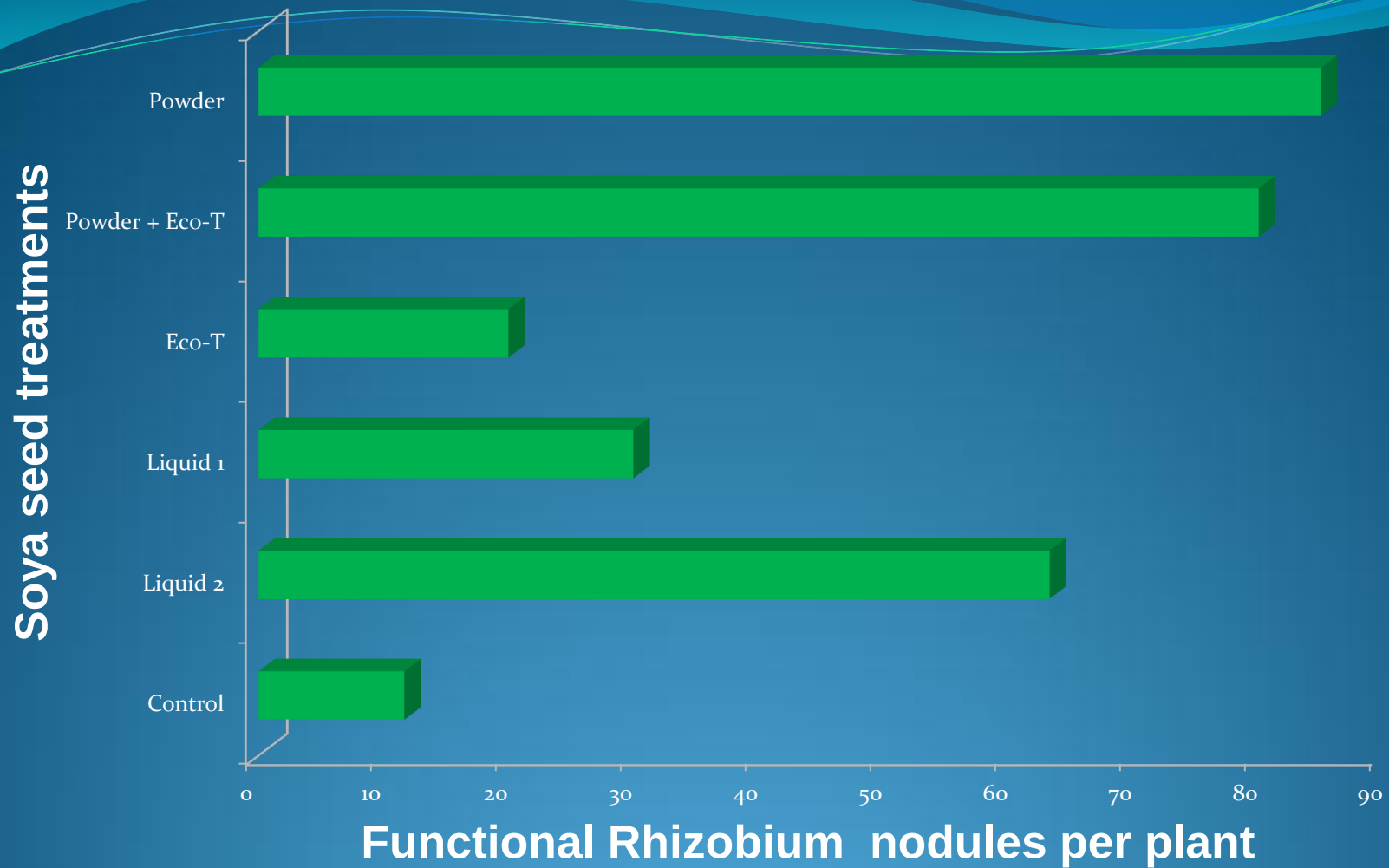


Figure 4. Number of functional Rhizobium root nodules per soya plant at Ukulinga Research Farm

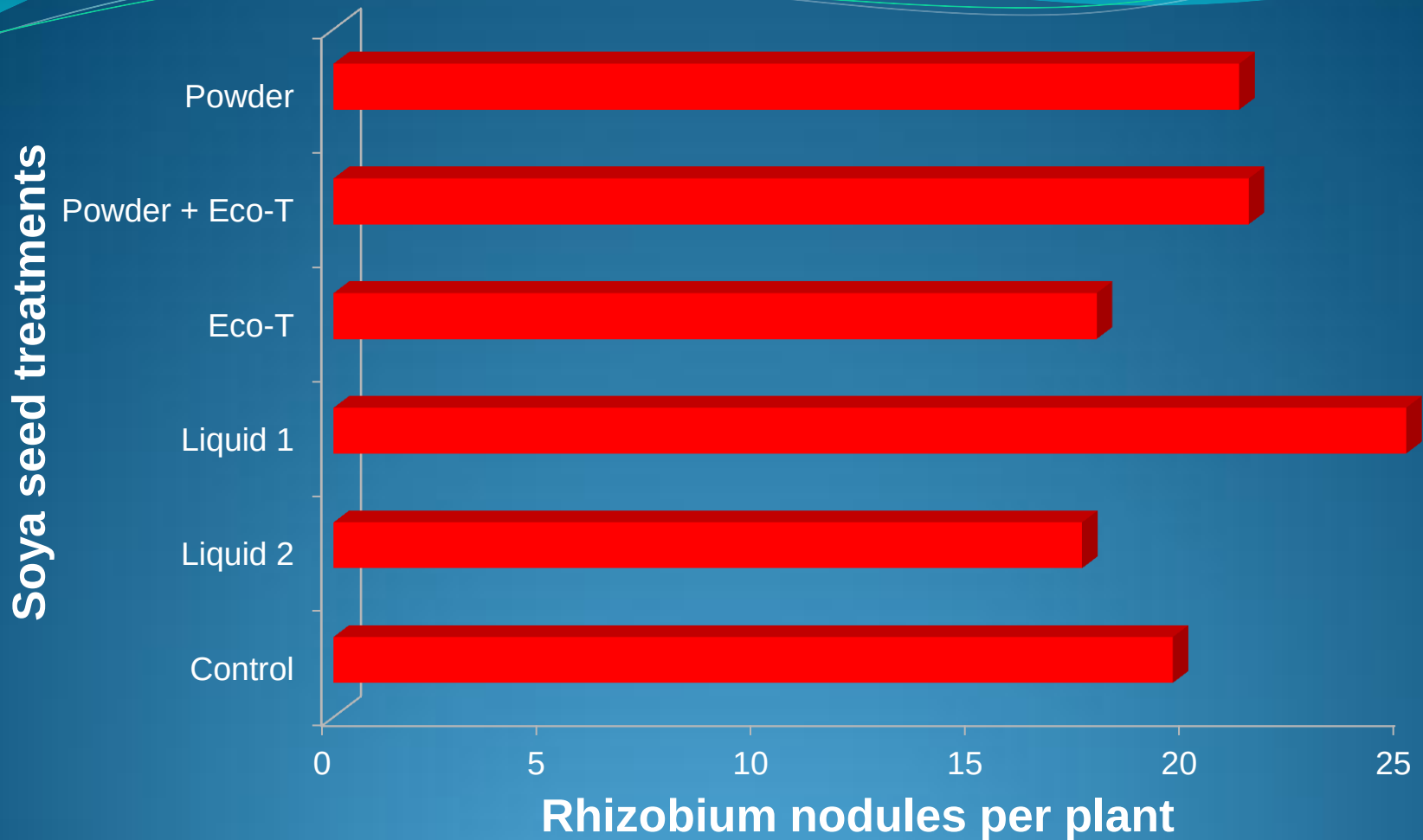


Figure 5. Number of Rhizobium nodules per plant at Baynesfield Estate

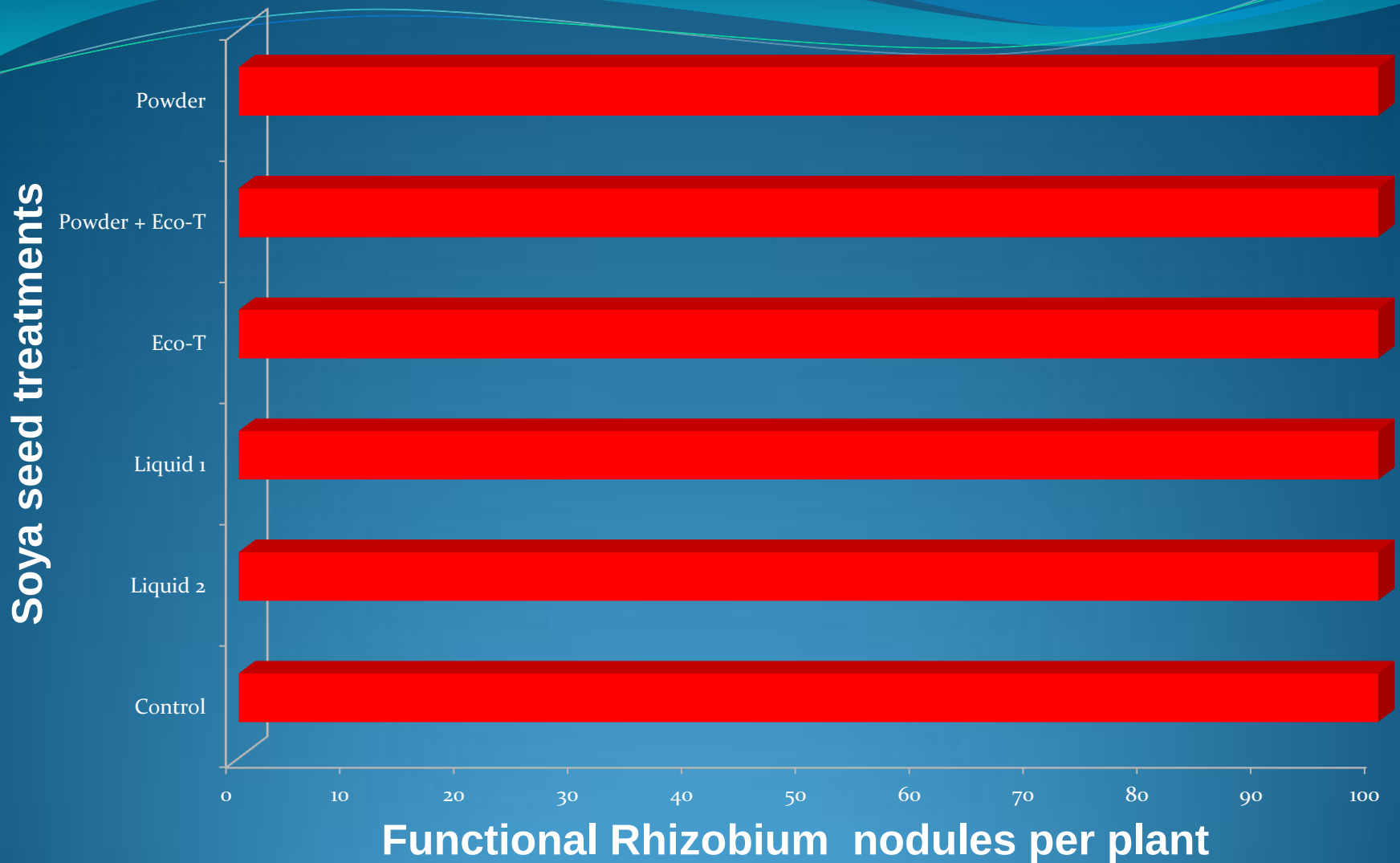


Figure 6. Number of functional Rhizobium root nodules per soya plant at Baynesfield Estate

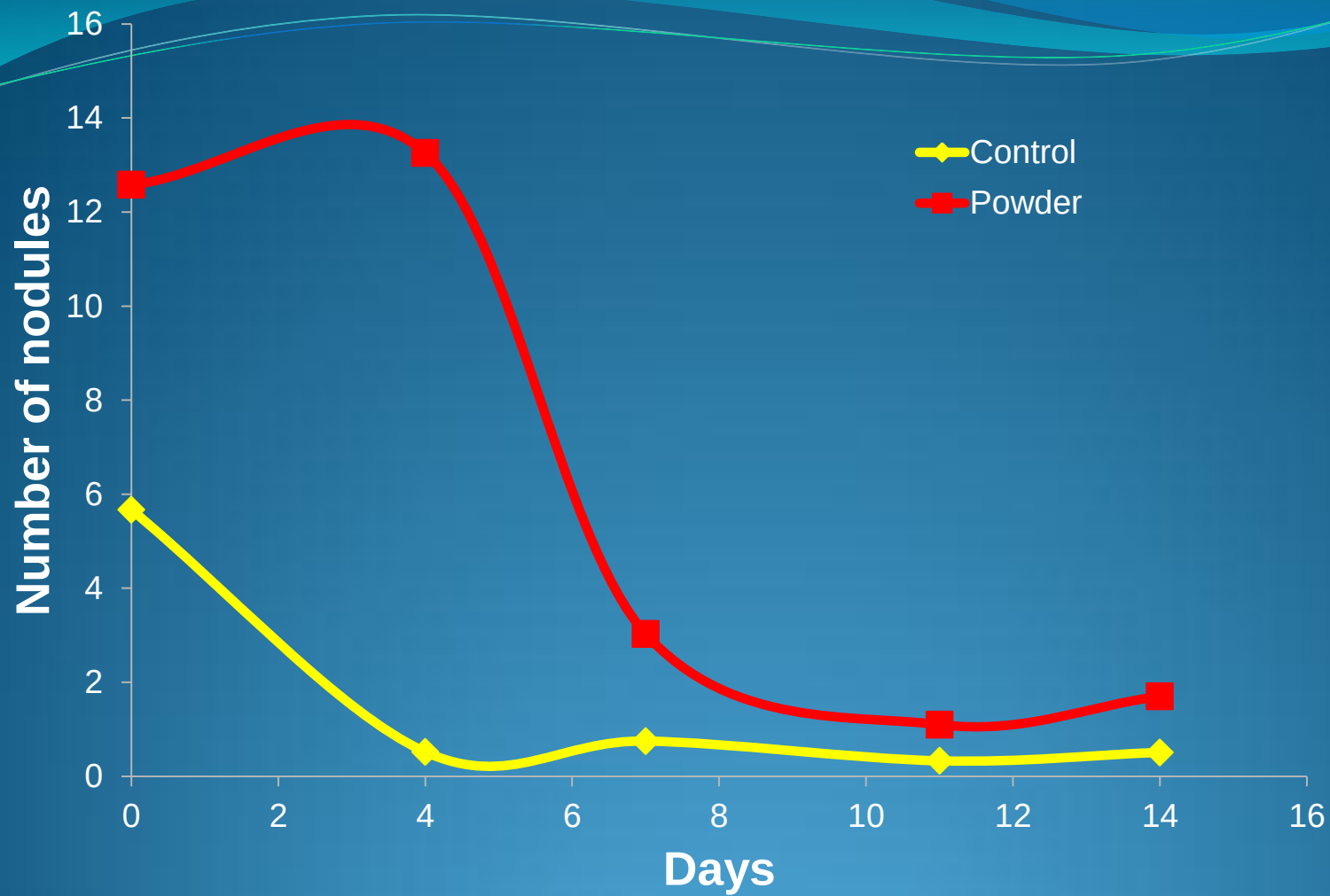


Figure 7. Longevity of inoculum on seed

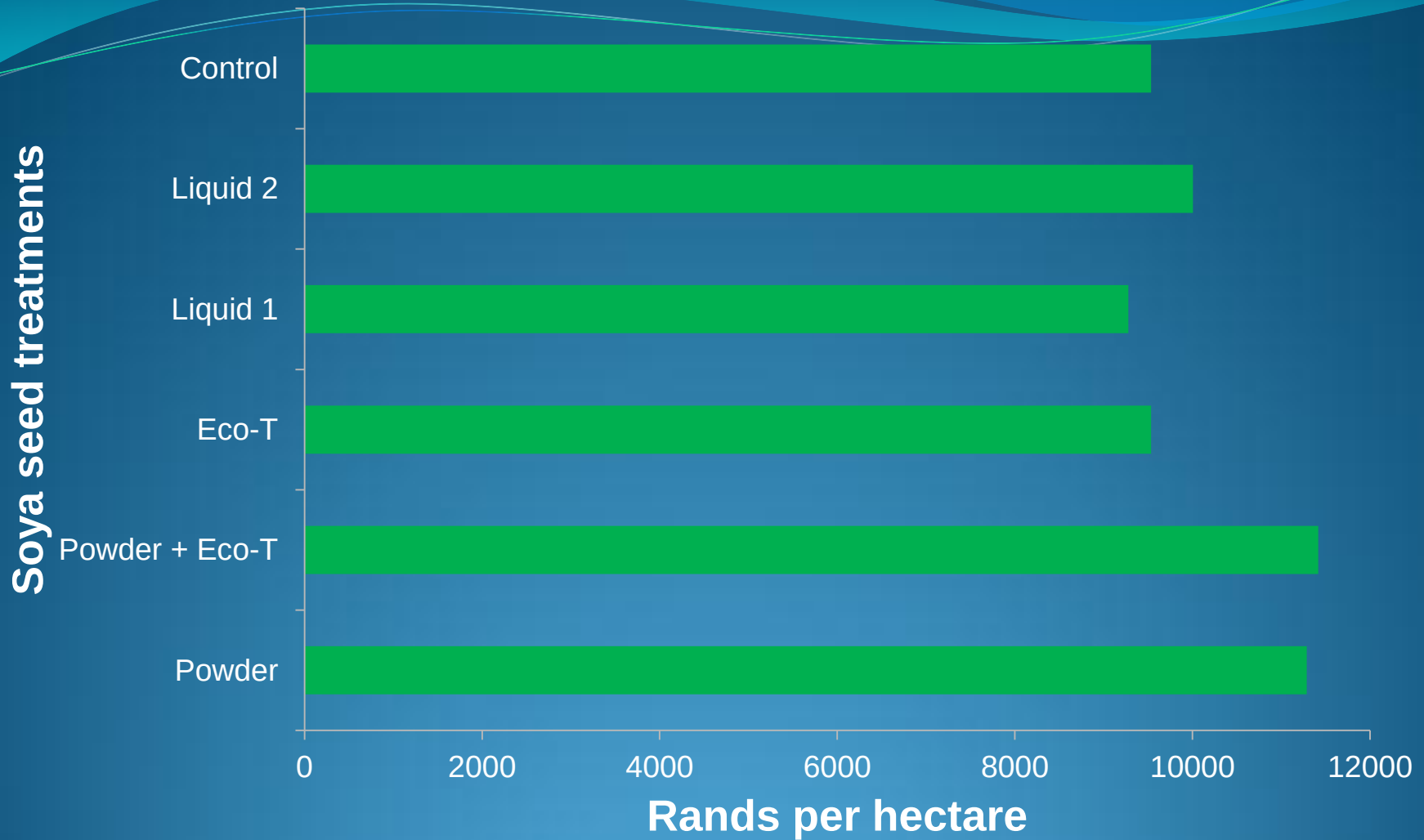


Figure 8. Rands per hectare for Ukulinga Research Farm

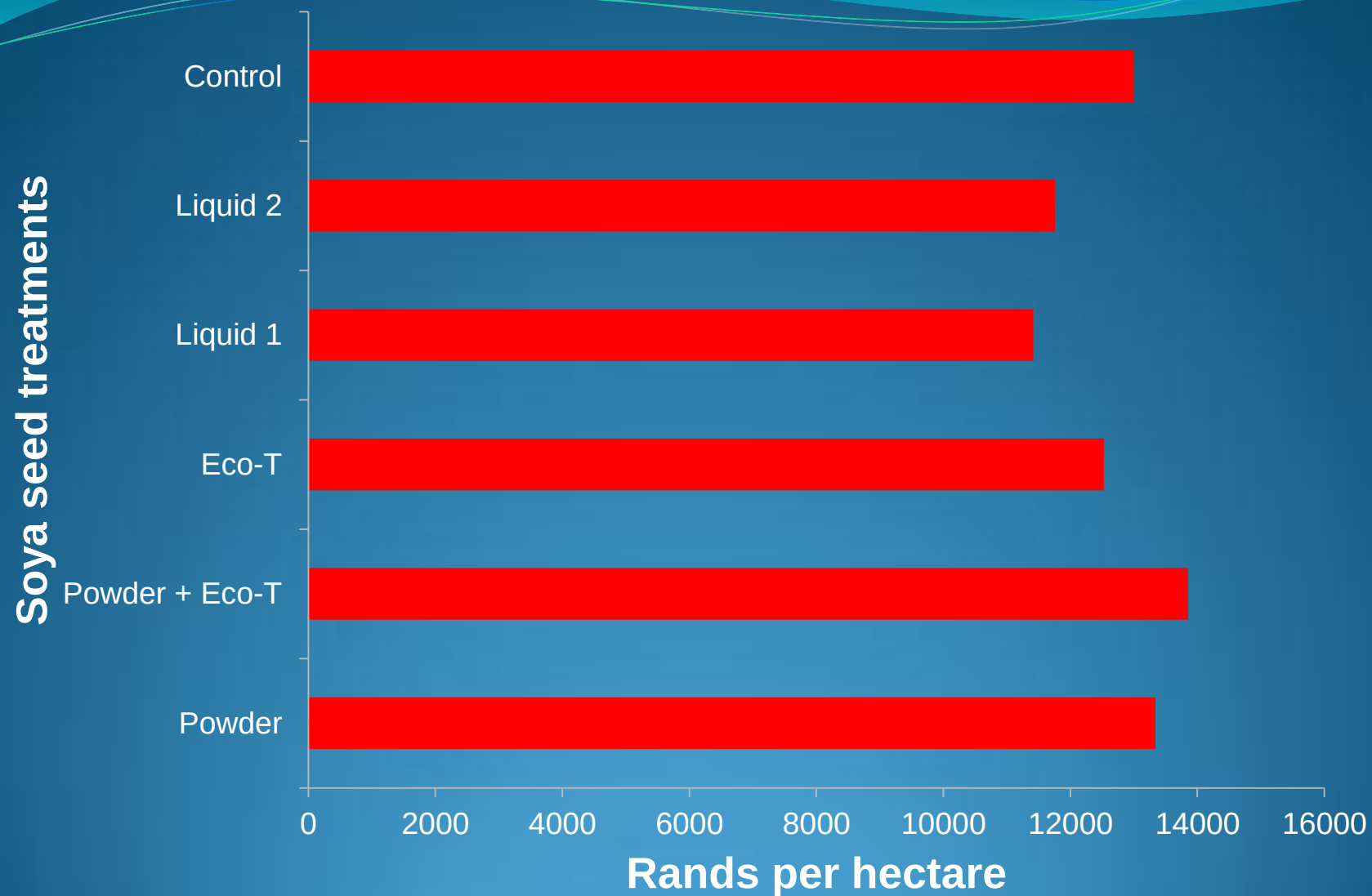


Figure 9. Rands per hectare for Baynesfield Estate

Financials of applying rhizobia

- Virgin Soils
 - Yield increase = 6.5
 - Value of X $\approx$ R900
- Repeat Soybean soil
 - Yield increase = 19.7
 - Value of X $\approx$ R1900
- Mean of both = \$D / ha gross
- Cost of product per ha = R107

Net value of applying Rhizobium $\approx$ R1500 / ha
 $\approx$ USD 170 / ha

Take Away Message

1. A novel powder formulation developed
 - a. Highest level of nodulation in the field
 - b. Good shelflife at room temperature
 - c. Stable on seed for up to 4 days post-treatment
 - d. Yield increases of 11-18%
 - e. Approx value of R1500 t ha⁻¹ increase with WB74 inoculation
2. Repeat application of Rhizobium WB74 => high background inoculum
3. High levels of wild parasitic Rhizobia in virgin soils
4. Non-indigenous rhizobium in Liquid 1 is not very competitive in SA soils

Thank you:

- **FARMS**

- Baynesfield Estate
- Ukulinga Research Farm

- **FUNDING**

- NRF THRIP
- Plant Health Products (Pty) Ltd
- Link Seeds (provision of the soya seeds)
- Madumbi Biologicals

- **CONFERENCE SPONSORS**

- World Institute for Soy for Human Health (WiSHH)