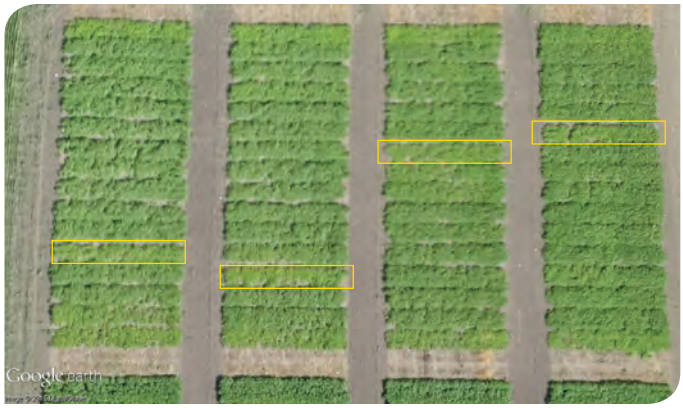
SOYBEAN INOCULANT STRATEGIES

Choosing an inoculant for your soybeans can be overwhelming, considering the product, formulation, rate and combination options. In complement to the On-Farm Network Inoculant Trial (see *The Bean Report*, page 34 for trial results), Manitoba Pulse & Soybean Growers (MPSG) also invested in small-plot research trials to evaluate many inoculant strategies simultaneously in Manitoba.

The complete list of inoculant strategies tested, listed in Table 1, were selected to address four specific objectives: is there any additional yield benefit to 1) using in-furrow granular (instead of seed-applied liquid) inoculant 2) double inoculating (seed-applied liquid + granular in-furrow), 3) increasing the rate of inoculant (from 1x to 2x) or 4) using "enhanced" inoculant products?



Melita, 2015. Untreated control plots yellowed mid-season.

WHAT ARE 'ENHANCED' INOCULANTS?

All inoculant products used in this trial contain *Bradyrhizobium japonicum* – the soybean-specific bacteria which causes nodule development on roots and biologically fixes nitrogen (N) within the nodules. In this trial, treatments termed 'enhanced' are those formulated with additional molecules or living organisms which claim to improve nodulation, early crop development or plant nutrition.

Both the Jumpstart (+ liquid Cell Tech) and the granular TagTeam treatments contained a phosphate-solubilizing rhizopheric fungus, *Penicillium bilaii* in addition to the *B. japonicum* bacteria. *P. bilaii* lives in the rhizosphere (soil immediately surrounding the root) and may increase soil phosphorus (P) solubility and hence, plant uptake, by secreting organic acids that acidify the soil or chelate P molecules, protecting P from precipitation or adsorption to soil.

Nodulator N/T is formulated with *Bacillus subtilis*: a plant growth promoting rhizobacteria which may increase soybean growth and nodule formation resulting from co-inoculation with *B. japonicum*.

Optimize is formulated with the lipo-chitooligosaccharide (LCO) molecule. Nodulation requires both the plant root and *B. japonicum* bacteria to send and receive signals for the process to initiate. The bacteria migrate towards roots, attracted by root exudate (root to bacteria signals); these exudates cause the bacteria to produce proteins called Nod factors (LCOs). The LCO molecules (bacteria to plant signals) in Optimize may hasten the process of nodule development.

PRELIMINARY TRIAL RESULTS

Field sites selected for this trial at Melita (2014 and 2015), Roblin (2015), Carberry (2015), had no history of soybeans, while the field site at Carman (2015) last had soybeans planted in 2007. Inoculant treatments were applied to NSC Reston seed (without seed treatment) and seeded at 210,000 seeds/ac on narrow row spacing (7.5–12 inches) into cereal or flax stubble. Liquid inoculants were seed-applied and granular inoculants were applied in-furrow.

Due to the limited history of soybeans in rotation at selected field sites, we expected to see a yield response to inoculants at all site-years; therefore, data from all five site-years was combined for statistical analysis. Unsurprisingly, inoculant treatments increased soybean yield by 10.5 bu/ac, on average, compared to the non-inoculated soybeans (Table 2).

There was, however, no statistical difference in seed yield between individual inoculant strategies (Table 2). For example, there was no difference in seed yield between in-furrow granular inoculant compared to seed-applied liquid inoculant, nor was there a difference between single versus double inoculation treatments (Table 2). Similarly, there was no yield difference between 1x and 2x rates of liquid or granular inoculant (Table 2). In addition, 'enhanced' inoculant treatments did not result in higher yields compared to the standard *B. rhizobium* inoculant of equivalent formulation (Table 2).

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Table 1. Soybean yield (bu/ac) of each inoculant strategy, averaged across all five site-years.

Treatment	Yield (bu/ac)
Untreated	31.7
Liquid Cell Tech	43.2
2x Liquid Cell Tech	45.4
Liquid + Granular Cell Tech	41.3
Granular Cell Tech	42.7
2x Granular Cell Tech	42.1
Liquid Cell Tech + Jumpstart	38.0
Liquid Optimize	43.1
Granular TagTeam	39.9
Granular Nodulator	42.2
2x Granular Nodulator	43.6
Liquid Nodulator N/T	42.4
2x Liquid Nodulator N/T	41.3
Liquid + Granular Nodulator	43.7
Mean	41.6
CV %	20.6
F value	2.46
P>F	0.0124

Table 2. Difference in soybean yield (bu/ac) between various inoculant treatments, averaged across all five site-years.

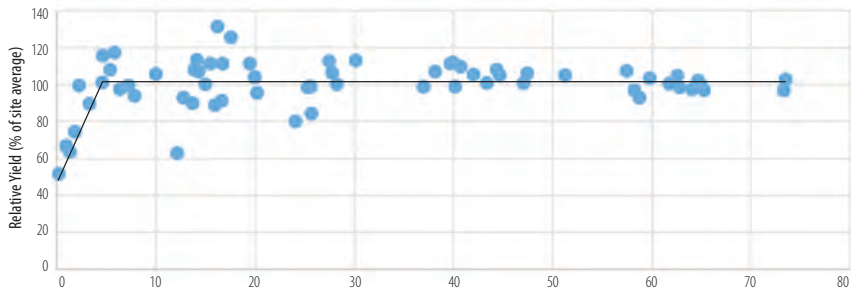
Treatment 1	Treatment 2	Difference between Treatment 1 – Treatment 2	
All Inoculant Treatments	Untreated	10.5	*
Liquid Cell Tech	2x Liquid Cell Tech	-2.2	NS
Liquid Cell Tech	Granular Cell Tech	0.5	NS
Liquid Cell Tech	Liquid + Granular Cell Tech	1.9	NS
Granular Cell Tech	2x Granular Cell Tech	0.5	NS
2x Granular Cell Tech	Liquid + Granular Cell Tech	0.8	NS
Liquid Cell Tech	Optimize	0.1	NS
Liquid Cell Tech	Liquid Cell Tech + Jumpstart	5.2	NS
Granular Cell Tech	Granular TagTeam	2.8	NS
Liquid Cell Tech	Liquid Nodulator N/T	0.8	NS
Liquid Nodulator N/T	2x Liquid Nodulator N/T	1.2	NS
Liquid Nodulator N/T	Liquid + Granular Nodulator	-1.3	NS
Granular Nodulator	2x Granular Nodulator	-1.3	NS

* Difference between treatment means is statistically significant at P<0.0001
NS Difference between treatment means is not statistically significant

Although there was no benefit to double inoculation in this trial (in-furrow granular inoculant in addition to a seed-applied liquid inoculant), MPSG still recommends double inoculating soybeans when grown on fields with two or less soybean crops grown previously (for more information regarding inoculant recommendations, see *The Bean Report*, page 36). There are several possible explanations for the lack of response to double inoculation in this trial which cannot always be guaranteed under field conditions:

1. **Soybeans were seeded into ideal soil conditions.** These trials were all seeded in late May/early June, when soil conditions were relatively favourable for crop emergence and inoculum survival. Unfavourable soil conditions, i.e. cooler and wetter soil, often encountered with earlier seeding dates may reduce the viability of your inoculant; therefore, using a granular inoculant in addition to the seed applied inoculant may ensure adequate rhizobium populations are present.
2. **Inoculants were properly stored, handled and applied.** Inoculants should always been kept in a cool, dry environment, should not be frozen, used before the expiration date and opened only just before using. Ideally, seed treated with liquid inoculant should be planted within the same day as inoculant application (although planting windows for seed-applied inoculants vary – read individual product labels).
3. **No compatibility issue with seed treatment.** Fungicide and/or insecticide seed treatments may affect the effectiveness of seed-applied liquid inoculant (check product compatibility for various product combinations); however, in this experiment seed treatment was not applied in an effort to standardized inoculant application and avoid potential differences in treatment compatibility.

Figure 1. Relationship Between Number of Nodules per Plant and Soybean Yield



HOW MANY NODULES SHOULD A SOYBEAN HAVE?

Regardless of your chosen inoculant strategy, you should assess the success of your inoculant on every field every year to not only evaluate inoculant effectiveness but also ensure your crop will have adequate N during critical growth stages to maximize yield. Count the number of nodules per plant on at least 10 plants from representative areas in the field when soybeans are at the R-1 to R-4 stage. At R-4 to R-5, N fixation and N requirements for soybean have reached a maximum. Results from all sites in this inoculant trial showed that at least five nodules per plant were required to reach the average yield at each site (average yield ranged from 35 to 49 bu/ac) (Figure 1).

This trial will be repeated in 2016.

MPSG thanks collaborators from WADO (Melita), CMCDC (Carberry), PCDF (Roblin) and the U of M (Carman). ■

MPSG is now contributing to SPG's Variety Release program. Breeder pea seed is now available to Manitoba Select Growers.