



Independent Trial

USA Soybean Trials 2013 - 2017

Memphis Tennessee, USA

2013 - 2017

Location

Year

Agricenter International

Soybean

Conducted by

Crop

Small plot replicated

Trial Type

Aim

To evaluate the impact on soybean yields when applying BioAg liquid biostimulants to fertiliser regimes representing Grower Standard Practice (GSP) and GSP less 15% nitrogen.



Introduction

In-field use and demonstrations in Australia’s cropping regions had identified positive yield responses when applying BioAg’s fermented liquid cultures on a range of crops.

BioAg had been able to optimise the foliar component of its biostimulant program in domestic demonstrations and field work. Evaluations were still required to optimise rates for the soil applied biostimulant (*Soil & Seed*) in soybeans. A component of these trials was to assess varying rates of use of *Soil & Seed*.

In order to achieve more reliable, replicable, year on year results we needed to run independent, small plot replicated trials.

Agricenter International was engaged to perform a range of trials on behalf of BioAg to evaluate the impacts of applying BioAg’s liquid biostimulants over a range of crop and fertiliser regimes.

This report details the outcomes of trials performed on soybean.

Each year, a full biostimulant treatment was applied to a fertiliser application representing GSP. A number of biostimulant programs were performed over the five years. In year 5 biostimulant treatments were applied over treatments where less nitrogen fertiliser was applied.

Method

Trial Design

The analysis was done using small plot replicated trials. The first treatment was always GSP with additional treatments incorporating BioAg biostimulants at and post planting.

The table below summarises the basic trial information. A known sized strip within the plot was harvested and yields measured.

Table 1: Summary of Trial Parameters

Year	2013	2014	2015	2016	2017
Crop	Soybean				
Study Design	Randomise Complete Block				
Plot Size	8 x 200ft	10 x 30ft	8 x 200ft	10 x 25ft	
Number of treatments	4				
Plots per treatment	4				

Soil Characteristics

Each year new sites were utilised. Soil parameters for each year are provided in Table 2 on the following page.

Table 2: Summary of Soil Parameters

Year	2013	2014	2015	2016	2017
% Sand	13.6%	27.6%	11.3%	27.6%	13.6%
% Silt	61.6%	33.6%	79.0%	33.6%	61.6%
% Clay	24.6%	38.8%	9.7%	38.8%	24.6%
% Organic Matter	1.4%	1.7%	1.2%	1.7%	1.4%
pH	6.5	6.4	6.9	6.4	6.5
CEC	6.5	6.2	6.1	6.2	9.5
Fertility	Good		Excellent	Good	
Drainage	Good				

Treatments

Each plot had fertiliser applied prior to planting.

Fertiliser rates were based on GSP in the Tennessee area.

GSP had solid fertiliser applied at the rate of; 22kg of nitrogen, 39kg of phosphorus and 74kg of potassium per hectare.

In year 5 treatments T7 and T8 were performed with 15% less nitrogen applied than GSP.

Per year the following treatments were performed:

Table 3: Treatments Performed per Year

Year	T1	T2	T3	T4	T5	T6	T7	T8
2013	✓	✓			✓	✓		
2014	✓	✓	✓	✓				
2015	✓	✓	✓	✓				
2016	✓	✓	✓	✓				
2017	✓	✓					✓	✓

The treatments are detailed in Table 7 in the appendix, including rates of fertiliser and biostimulants, as well as application timing in days post planting and growth stage.

The treatments can be grouped as follows:

- T1 was performed each year and represents GSP.
- T2 is GSP with a biostimulants program using a low rate of soil applied biostimulant with a full application of foliar applied biostimulants.
- T3 is GSP with a biostimulants program using a high rate of soil applied biostimulant with a full application of foliar applied biostimulants.
- T4 is GSP with only soil applied biostimulant at a high rate.
- T5 is GSP with a biostimulants program comprising a very low rate of soil applied biostimulant with a full application of foliar applied biostimulants.

- T6 is GSP with a biostimulants program comprising a mid-rate of soil applied biostimulant with a full application of foliar applied biostimulants.
- T7 is GSP -15%N with a biostimulants program equivalent to T3; and
- T8 is GSP -15%N with a biostimulants program equivalent to T4.

Background to Treatment Selection

Treatment T2 is based upon in field results achieved in Australia and replicates a typical program recommended by BioAg for soybean.

Treatments T5 and T6 were performed to evaluate any difference in higher and lower rates of soil applied biostimulant (*Soil & Seed*).

After the 2013 trial year there was evidence that higher rates of *Soil & Seed* led to higher yields. As such it was decided to run trials comparing a typical rate of *Soil & Seed* (7.4L/Ha) and a higher rate of *Soil & Seed* (9.4L/Ha) as part of a full program. The higher rates of *Soil & Seed* are represented by treatment T4.

Treatments T7 and T8 were run in the last year of soybean trials, 2017. These were introduced as a result of the very good outcomes we were achieving in cotton trials, which were indicating improved yields when incorporating biostimulants in programs with less nitrogen fertiliser. Treatment T7 included a full program of biostimulants, while treatment T8 included *Soil & Seed* only.

Results

Yield results for treatments are provided below in tonnes per hectare:

Table 4: Yield Results per Treatment per Year

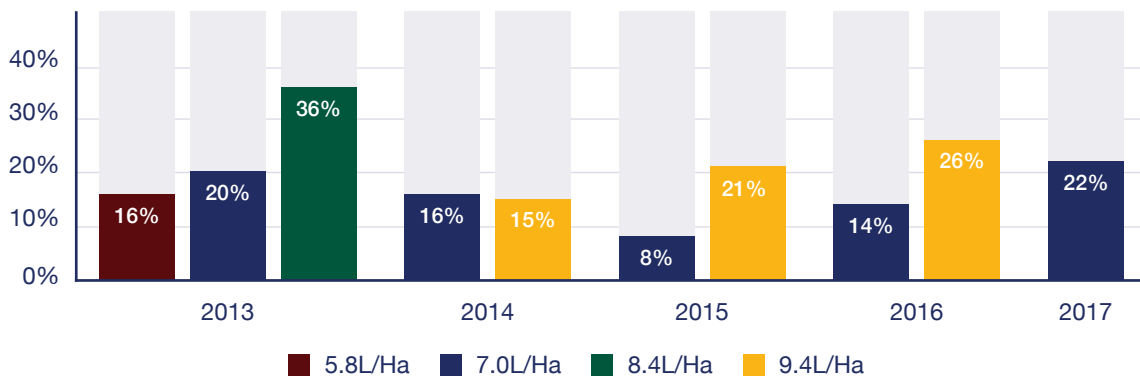
Year	T1	T2	T3	T4	T5	T6	T7	T8	LSD (P=.05)	Std Dev
2013	2.23	2.68			2.59	3.04			0.17	0.11
2014	2.87	3.34	3.29	3.11					0.18	0.11
2015	3.23	3.48	3.91	3.21					0.44	0.28
2016	3.68	4.18	4.63	3.83					0.21	0.13
2017	3.95	4.81					4.90	3.96	0.33	0.21

GSP (T1) v GSP with a Full Biostimulant Program (T2, T3, T5 & T6)

While a 'Full Biostimulant' program was used for each of these treatments, programs with differing amounts of soil applied biostimulant (*Soil & Seed*) were evaluated.

In year one *Soil & Seed* was used in three treatments at 5.8, 7.0 and 8.4L/Ha respectively.

**Yield Improvement Over GSP
Full Foliar with Varying Soil Biostimulant Rates**



As can be seen in the year one results above, the higher rates of *Soil & Seed* delivered higher yields. Based on this in 2014, 2015 and 2016 we consolidated to two treatments comprising 7.0 and 9.4L/Ha of *Soil & Seed*.

In all years and for all rates of *Soil & Seed*, treated plots had higher yields to GSP. In all treatments except for the 2015 7.0L/Ha rate of *Soil & Seed*, the yield response was greater than the Least Significant Difference (LSD).

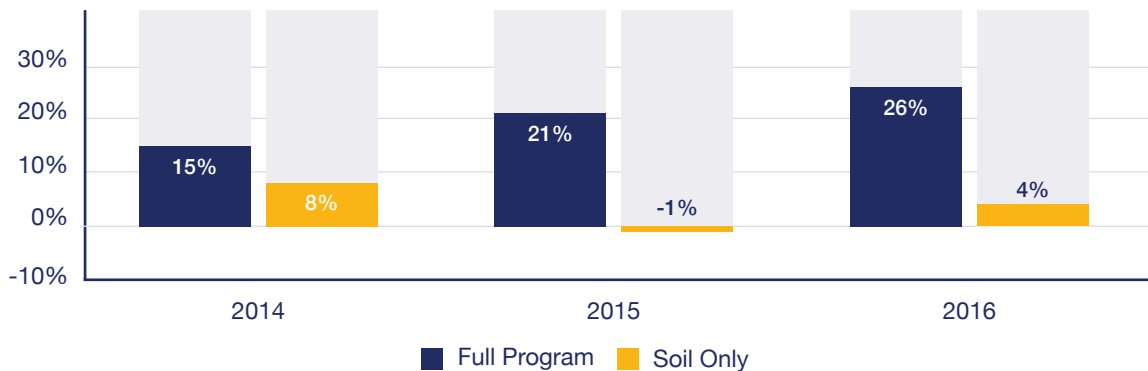
In three of the four years where various rates of *Soil & Seed* as part of a full program were evaluated; higher rates of *Soil & Seed* delivered higher yields.

GSP (T1) v GSP + Full Program (T3) v GSP + Program of Soil Only Biostimulant (T4)

The treatments in these comparisons all used the same rate of soil applied biostimulant (*Soil & Seed*). This was the only biostimulant applied in the ‘Soil Only’ program, while the treatment with the ‘Full Program’ also received the full rate of foliar biostimulants.

While the 2014 results indicated there was incremental benefit in use of the soil and foliar biostimulants. The 2015 and 2016 results did not show this. Indicating that the yields result were only achieved when utilising a full range of biostimulants. As a result the evaluation of these treatments was not continued.

**Yield Improvement over GSP
Full Program v Soil Only Program**



No evaluations were performed with only the foliar treatments.

GSP (T1) v GSP-15% N + Program of Soil Only Biostimulant (T8)

This was evaluated only in the final year of the soybean trials (2017), due to the very good results we were achieving in cotton trials, which were indicating improved yields when incorporating biostimulants in programs with less nitrogen fertiliser.

The treatments delivered the same yield (3.95 and 3.96T/Ha respectively), indicating that *Soil & Seed* was able to offset the yield loss typically associated with reduced nitrogen applications.

GSP + Full Program of Biostimulants (T4) v GSP-15% N + Full Program of Biostimulants (T7)

This was evaluated only in the final year of the soybean trials (2017), due to the very good results we were achieving in cotton trials, which were indicating improved yields when incorporating biostimulants in programs with less nitrogen fertiliser.

The treatments delivered almost the same yield (4.81 and 4.90T/Ha respectively), indicating that the biostimulant program was able to offset the yield loss typically associated with reduced nitrogen applications.

The higher yield outcome with less nitrogen fertiliser indicates improved nutrient use efficiency. Further work should be performed to evaluate rates and the impacts of BioAg biostimulants on nutrient, and in particular nitrogen, use efficiency. These were not continued as part of this trial.

Economics

The following is evaluated in the context of the Australian market. Table 5 evaluates Treatment T2 against GSP.

As can be seen even in a year with low yield response their was a positive financial outcome.

Treatment T2

Table 5: Economic Benefit of a Full Biostimulant Program on GSP

Year	2013	2014	2015	2016	2017	Average
Cost of Biostimulants#	\$97					
Yield Benefit T/Ha	0.45	0.46	0.26	0.50	0.86	0.51
Yield Benefit \$/Ha %	\$221	\$227	\$125	\$247	\$422	\$248
Net Return \$/Ha	\$123	\$130	\$28	\$150	\$324	\$151

#Based on a delivered cost of \$7 per litre; %based on ex farm price of \$490 per tonne.

Treatment T4

Each year the full program with higher rates of *Soil & Seed* delivered financial benefit with significant benefit in 2015 and 2016. This result indicates the potential value in utilising higher rates of *Soil & Seed* in any biostimulant program.

Table 6: Financial Returns Over GSP for Treatment T4.

Year	2014	2015	2016	Average
Cost of Biostimulants#	\$97			
Yield Benefit T/Ha	0.42	0.68	0.95	0.68
Yield Benefit \$/Ha %	\$205	\$334	\$466	\$335
Net Return \$/Ha	\$108	\$237	\$369	\$238

#Based on a delivered cost of \$7 per litre; %based on ex farm price of \$490 per tonne.

Conclusion

The overlay of a complete BioAg biostimulant program on GSP for the production of Soybeans delivered the best yield results for all treatments trialled. It provided higher yields than GSP every year.

Benefits were achieved across seasons with high and low yields for GSP and delivered financial benefit in each year.

Higher rates of soil applied biostimulant (*Soil & Seed*) as part of a full biostimulants program delivered higher yields.

It is evident from the trials that consistent results are achieved when utilising both soil applied and foliar biostimulants.

In the one year trialled, the use of biostimulants when using lower rates of nitrogen fertiliser delivered the same yield results as using a full fertiliser program. Additional trials are required but this is an indication that the biostimulants are delivering improved nitrogen use efficiency.

Additional Background – About BioAg

BioAg is an Australian manufacturer of liquid biostimulants and natural phosphate fertilisers. BioAg's liquid biostimulant are a range of proprietary microbial cultures, specifically formulated to support different plant growth stages by improving plant and soil performance.

Each culture / product contains a:

- Balanced food supply of carbohydrates, amino acids, enzymes, vitamins, essential nutrients and growth promoters, that feed both plants and beneficial micro-organisms
- Large and diverse population of beneficial micro-organisms, including fungi, bacteria, yeast and protozoa.

Each product has been developed to:

- Stimulate soil biology and plant processes
- Feed soil biology to ensure it is active and able to interact with the plant
- Improve the balance of beneficial microorganisms in soils, and
- Provides microbial food and microorganisms into soils that are low in microbial activity or diversity due to factors such as, stress (cold, heat or



water logging), lack of plant activity (fallow) and/or due to a lack of plant diversity (monoculture).

Applying the appropriate product at the requisite growth stage will support and enhance:

- Structured vegetative growth and enhance root development
- Nutrient cycling and improved plant availability of nutrients
 - Chelation of nutrients, via amino bonds
 - Conversion of in-organic nutrients into a microbial form (becomes part of the biomass)
 - Helps to unlock nutrients previously bound in soil complexes
 - Improves the flow of nutrients through the plant
- Water retention and uptake, and
- Plant vigour and tolerance to abiotic stresses.

The benefits of biostimulants can be depleted with time. In addition, as plants develop reach their next growth stage the nutritional needs of the plant also change. Applying the appropriate biostimulant, soil inoculant or foliar application, at the right time is a key attribute of any program.

BioAg's three core biostimulant products are:

1. *Soil & Seed* is a broad-spectrum microbial inoculant that assists; nutrient accessibility, nutrient solubilisation, nutrient cycling, enhanced seed germination, root development, disease and drought resistance and residue breakdown.
2. *Balance & Grow* is a broad-spectrum source of foods and stimulants for balanced plant functions, plant health, and vegetative growth including; calcium and phosphate, vitamins, minerals, proteins, enzymes, amino acids and carbohydrates.
3. *Fruit & Balance* is formulated to increase flowering, fruit set and soil microbial activity. It delivers a rich source of plant-available phosphate when the plant is under peak load, stimulating strong fruiting and enhancing yield potential. Fruit & Balance contains a rich source of vitamins, minerals, proteins, enzymes, amino acids, carbohydrates, and growth promoters.

Each product is also available as an organic variant.

Appendices

Table 7: Summary of Applications performed for each treatment

	Day Applied from Planting	Growth Stage# BBCH Index	Product †	T1	T2	T2a	T3	T3a	T4	T5	T6
Fertiliser	0	00		GSP*	GSP	GSP	GSP	GSP	GSP	GSP -15%N	GSP -15%N
Application 1	0	00	S&S	7.0	9.4	9.4	9.4	5.8	8.4	9.4	9.4
Application 2	7 to 23	11 to 13	B&G	0.7	0.7	0.7		0.7	0.7	0.7	
Application 3	20 to 44	13 to 22	B&G	2.2	2.2	2.2		2.2	2.2	2.2	
Application 4	44 to 58	60 to 69	F&B	2.0	2.0	2.0		2.0	2.0	2.0	
Application 5	58 to 72	65 to 72	F&B	2.0	2.0	2.0		2.0	2.0	2.0	

Notes:

† S&S is Soil & Seed, B&G is Balance & Grow, and F&B is Fruit & Balance all given as litres per hectare.

* GSP had solid fertiliser applied at the rate of; 22kg of nitrogen, 39kg of phosphorus and 74kg of potassium per hectare. Plots with -15%N (nitrogen) had 19kg of N applied per hectare, P and K rates did not change from GSP.

Growth stage is defined by BBCH – scale for cereals (Reference: [https://en.wikipedia.org/wiki/BBCH-scale_\(bean\)](https://en.wikipedia.org/wiki/BBCH-scale_(bean))). Growth stages are outlined in Table 8 on the following page.

Table 8: Growth Stages

Growth Stage	BBCH	Description
0: Germination	00	Dry seed
	01	Beginning of seed imbibition
1: Leaf development	10	Cotyledons completely unfolded
	12	2 full leaves (first leaf pair unfolded)
	13	3rd true leaf (first trifoliate leaf) unfolded
	1 ..	Stages continuous till . . .
	19	9 or more leaves (2 full leaves, 7 or more trifoliate) unfolded
2: Formation of side shoots	21	First side shoot visible
	22	2nd side shoot visible
	60	First flowers open (sporadically within the population)
	61	Beginning of flowering: 10% of flowers open 1 Beginning of flowering 2
	62	20% of flowers open 1
	63	30% of flowers open 1
	64	40% of flowers open 1
	65	Full flowering: 50% of flowers open 1 Main flowering period 2
	67	Flowering finishing: majority of petals fallen or dry 1
	69	End of flowering: first pods visible 1
7: Development of fruit	71	10% of pods have reached typical length 1 Beginning of pot development 2
	72	20% of pods have reached typical length 1

1 For varieties with limited flowering period

2 For varieties in which the flowering period is not limited

Conversions factors:

1 Bushel = 25.40kg

1 Hectare = 2.47105 Acres

1 Pint = 0.47317 Litres

1 Fluid Oz = 0.02957 Litres

1 unit P2O5 = 0.436 units of P

1 unit K2O = 0.893 units of K

1 lb/A = 1.21kg/ha

Raw Data

The trial data is available from the website www.bioag.com.au. For any questions or enquiries please contact your local BioAg Sales Representative.