



Independent Trial

USA Corn Trials 2013 - 2017

Memphis Tennessee, USA 2013 - 2017

Location Year

Agricenter International Corn

Conducted by Crop

Small plot replicated

Trial Type

Aim

To evaluate the impact on corn 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.

In order to get 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 Dent Corn with differing fertiliser regimes.

This report details the outcomes of trials performed on corn.

Each year, a full biostimulant treatment was applied to a fertiliser application representing GSP, and another representing GSP less 15% Nitrogen. Several additional biostimulant programs were performed over the five years in order to evaluate additional aspects of biostimulant performance.

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	Dent Corn				
Study Design	Randomise Complete Block				
Plot Size	25 x 30ft	10 x 30ft			
Number of treatments	4	6	5		
Plots per treatment	5	4			

Soil Characteristics

Each year new sites were utilised. Soil parameters for each year are provided in the table below:

Table 2: Summary of Soil Parameters

Year	2013	2014	2015	2016	2017
% Sand	27.6%	49.4%	11.3%	13.6%	14.6%
% Silt	33.6%	41.0%	71.0%	61.6%	59.6%
% Clay	38.8%	9.7%	17.7%	24.6%	24.2%
% Organic Matter	1.7%	1.8%	1.7%	2.4%	2.1%
pH	6.4	6.8	6.3	6.3	6.2
CEC	6.2	7.4	4.8	8.7	8.5
Fertility	Good				
Drainage	Good				

Treatments

Each plot had fertiliser applied prior to planting as well as additional nitrogen fertiliser knifed in at the appropriate growth stage (typically at or just prior to V8).

Fertiliser rates were based on standard practice in the Tennessee area.

GSP had solid fertiliser applied at the rate of; 22kg of nitrogen, 39kg of phosphorus and 80kg of potassium per hectare (approximately 200kg per hectare of MAP and 160kg per hectare of MoP); plus the equivalent of 168kg per hectare of nitrogen knifed in as liquid fertiliser (UAN).



Plots where fertiliser applied was GSP less 15% nitrogen (GSP -15%N), had the same amount of solid fertiliser applied, but a reduced amount of liquid fertiliser, being the equivalent of 143kg of nitrogen per hectare.

Per year the following treatments were performed:

Table 3: Treatments Performed per Year

Year	T1	T2	T2a	T3	T3a	T4	T5	T6	T7
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 and T2a represent GSP with a full biostimulants program
- T3 and T3a represent GSP -15%N with a full biostimulants program
- T4 represents GSP with only soil applied *Soil & Seed*
- T5 represents GSP -15%N with only soil applied *Soil & Seed*
- T6 represents GSP -15%N with a full biostimulants program at lower rates than T2 and T2a, and
- T7 represents GSP with a full (yet reduced) biostimulants program applied at planting only.

Of note is that Treatment 2a utilises the same ratio and rate of biostimulants as Treatment 2, the difference in 2a is that the total amount of *Balance & Grow* was applied in a single application. The same is true when comparing Treatment 3a and Treatment 3. For this reason, Treatment 2 and Treatment 2a are considered the same (T2) for the remainder of this report, as are Treatments 3 and 3a (reported as T3).

Background to Treatment Selection

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

Given that GSP in the USA is for fertiliser (including all phosphorus and potassium) to be applied upfront with additional nitrogen fertiliser applied at or prior to V8, Treatment T3 was implemented to identify if BioAg biostimulants could improve nitrogen use efficiency such that equivalent or improved yields could be achieved with less nitrogen being applied.

Treatment T4 and T5 were chosen to evaluate the impact of only applying the soil inoculant *Soil & Seed*; or otherwise stated as the impact of removing the foliar biostimulants from the treatment. T4 and T5 represent GSP and GSP -15%N respectively.



T6 was a full program at lower rates of use over GSP -15%N. This was performed to ascertain if rates of biostimulant could be further fine-tuned and deliver the same yield result as T3. While the 2014 treatment results were equivalent to T3 it was decided not to continue with the evaluation of this treatment, but rather to remain with the rates that had been optimised through field work. T6 is not discussed in the 'Results' section of this report.

T7 was performed to evaluate the impact of timing of application. The soil inoculant and foliar treatments were applied at planting as soil inoculants. The yield response was within the range of Treatments T4 and statistically below the results achieved with Treatment T2. As a result, this treatment was not continued beyond 2014. T7 is not discussed in the 'Results' section of this report.

Results

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

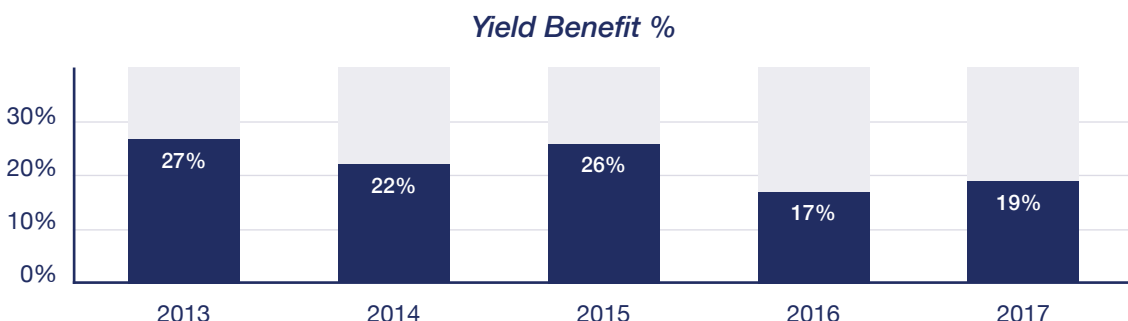
Table 4: Yield Results per Treatment per Year

Year	T1	T2	T3	T4	T5	T6	T7	LSD (P=.05)	Std Dev
2013	10.4	13.2	11.8			12.0		0.3	0.2
2014	10.0	12.2	11.4	10.8	11.1		11.4	0.6	0.4
2015	8.7	11.0	10.1	8.9	8.7			0.8	0.5
2016	9.5	11.1	10.8	10.3	10.3			0.6	0.4
2017	11.7	13.9	12.7	11.4	10.4			1.4	0.9

GSP (T1) v GSP with a Full Biostimulant Program (T2)

The addition of a full program of biostimulants, *Soil & Seed* as a soil inoculant, and *Balance & Grow* and *Fruit & Balance* as foliar treatments to GSP, provided higher yields than GSP alone in each year of the trials.

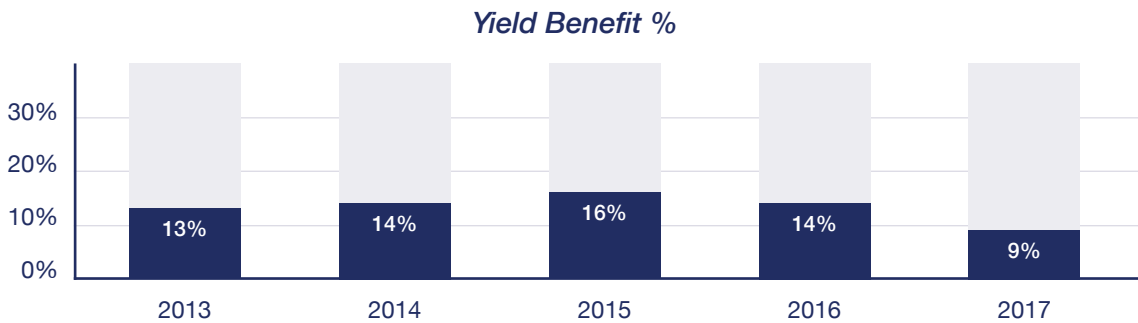
In every year of the trials this treatment provided the highest yield of any and all treatments.



GSP (T1) v GSP-15%N with a Full Biostimulant Program (T3)

While applying less nitrogen the use of a full biostimulant program was still able to enhance yields above GSP in each year. However in 2017 (a high yielding year for GSP due to better seasonal conditions) the yield response was not statistically different.

In comparison to T2, where a full nitrogen application was used, it would appear that each year yields for this treatment were constrained due to a lack of nitrogen.

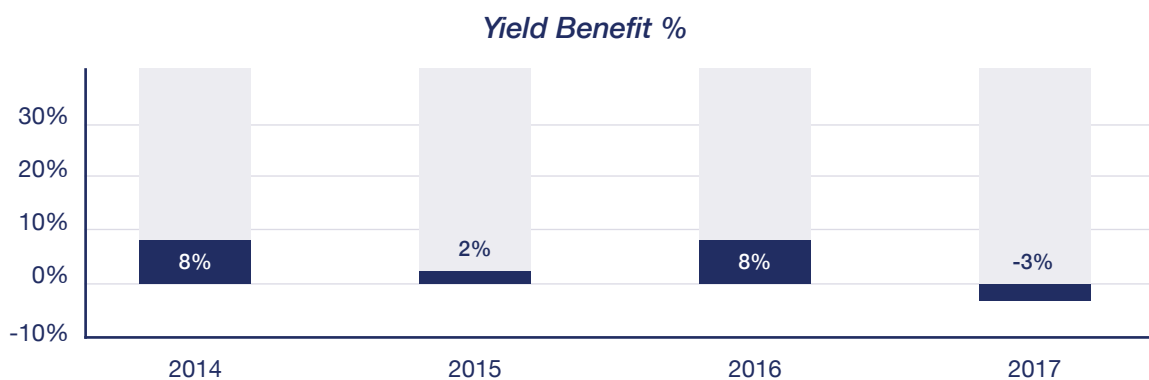


GSP (T1) v GSP with a soil inoculant (T4)

Applying only the soil inoculant *Soil & Seed* produced beneficial results in 2 of the 4 years, 2014 and 2016. In 2015 and 2017 the results were within the range of results for GSP.

Both 2015 and 2017 were the extremes of growing conditions very poor and very good respectively.

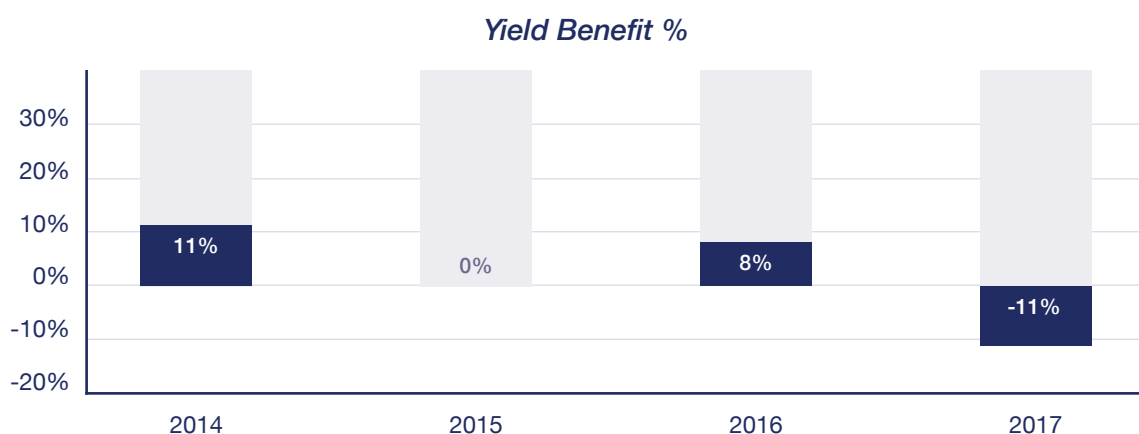
This may indicate that the prolonged stress of a poor growing season offset any early benefits provided by *Soil & Seed*, while the benefits of a good growing season on plant physiology offset any early benefit delivered through *Soil & Seed*. Additional trials would be required to ascertain this.



GSP (T1) v GSP -15%N with a soil inoculant (T5)

The results for this treatment were statistically the same as Treatment T4 above.

In terms of absolute yield, the 2017 results likely reflect the reduced application of nitrogen fertiliser, similar to the possible reason for the results achieved for Treatment T3 in 2017.



Of all the treatments evaluated T2, the full fertiliser and full biostimulant program, consistently delivered higher yields than GSP and all other treatments.

Economics

The following is evaluated in the context of the Australian market. The following tables evaluate Treatment T2 and T3 only.

Treatment T2

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

Year	2013	2014	2015	2016	2017	Average
Cost of Biostimulants#	\$123					\$123
Yield Benefit T/Ha	2.8	2.2	2.3	1.6	2.2	2.2
Yield Benefit \$/Ha %	\$560	\$440	\$460	\$320	\$440	\$440
Net Return \$/Ha	\$437	\$317	\$337	\$207	\$317	\$317

#Based on a delivered cost of \$7 per litre; %based on ex farm price of \$200 per tonne.

Treatment T3

Table 6: Economic Benefit of a Full Biostimulant Program on GSP – 15%N

Year	2013	2014	2015	2016	2017	Average
Cost of Biostimulants#	\$123					\$123
Saving in Fertilisers*	\$25					\$25
Net Cost to Grower	\$98					\$98
Yield Benefit T/Ha	1.4	1.4	1.4	1.3	1.0	1.3
Yield Benefit \$/Ha %	\$280	\$280	\$280	\$260	\$200	\$260
Net Return \$/Ha	\$182	\$182	\$182	\$162	\$102	\$162

#Based on a delivered cost of \$7 per litre; * Based on Urea at \$460 per tonne on farm; %based on ex farm price of \$200 per tonne.



Conclusion

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

Benefits were achieved across all seasons; irrespective of achieving high or low yields for GSP and delivered financial benefit in each year.

While other treatments delivered yield benefits in most years, a number of the results were not statistically significant.

It is evident from the trials that consistent increases in yield were achieved when utilising a full biostimulants program, including soil applied and foliar biostimulants.

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

Year	Day Applied from Planting	Growth Stage# BBCH Index	Product †	T1	T2	T2a	T3	T3a	T4	T5	T6	T7
Fertiliser	0	00		GSP*	GSP	GSP	GSP -15%N	GSP -15%N	GSP	GSP -15%N	GSP -15%N	GSP
Application 1	0 (5 in 2014)	00	S&S		9.4	9.4	9.4	9.4	9.4	9.4	8.2	
Application 1a	0	00	S&S/B&G/F&B									9.4/ 4.7/ 4.7
Application 2	14 to 21	11-12 (15 in 2015)	B&G		1.0	4.0	1.0	4.0			1.0	
Application 3	24 to 29	13-14	B&G		1.0		1.0				1.0	
Application 4	29 to 38	15-16	B&G		2.0		2.0				1.5	
Application 5	37 to 48	18-19	F&B		4.0	4.0	4.0	4.0			3.5	

Notes:

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

As can be seen Treatment 2a utilises the same rate of biostimulants as Treatment 2, the difference is that in 2a the total amount of *Balance & Grow* was applied in a single application. The same is true when comparing Treatment 3a and Treatment 3.

* GSP had solid fertiliser applied at the rate of; 22kg of nitrogen, 39kg of phosphorus and 80kg of potassium per hectare (approximately 200kg per hectare of MAP and 160kg per hectare of MoP); plus the equivalent of 168kg per hectare of nitrogen knifed in as liquid fertiliser (UAN).

Plots where fertiliser applied was GSP less 15% nitrogen (GSP -15%N), had the same amount of solid fertiliser applied, but a reduced amount of liquid fertiliser, being the equivalent of 143kg of nitrogen per hectare.



Growth stage is defined by BBCH – scale for cereals (Reference: [https://en.wikipedia.org/wiki/Cereal_growth_staging_scales#BBCH-scale_\(cereals\)](https://en.wikipedia.org/wiki/Cereal_growth_staging_scales#BBCH-scale_(cereals))), Growth stages are outlined in Table 8 below.

Table 8: Growth Stages

Growth Stage	BBCH Index	Description
Germination	00	Dry seed (caryopsis)
1: Leaf development	11	First leaf unfolded
	12	2 leaves unfolded
	13	3 leaves unfolded, continuing as
	1X	Where X leaves are unfolded

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.