The effect of biostimulant products applied to vining peas, combining peas and spring beans

2019
Year 2

PGRO

For: PGRO

Date of project: Year 2, 2019

Date of report: October 2019

Objectives:

Yield potential is determined by environment, genetics and phenology versus yield loss and quality which is determined by abiotic and biotic stresses. Can a biostimulant produce a positive response to the effects of stress?

These trials aim to evaluate the effects of biostimulant products in peas and beans. To assess the potential benefits they add to yield and disease tolerance.

To identify trends that show which product(s) and application method(s) are best suited to each crop. To improve decision making when using biostimulants in the field.

Summary:

None of the biostimulant applications had any effects on crop emergence, chlorophyll content or yield in any of the crops.

The application of Phorce, a product containing phosphite, significantly reduced infections levels of downy mildew in spring beans. Pea downy mildew or pea foot rot were affected by any of the treatments.

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Introduction

The European biostimulants industry council (EBIC) defined biostimulants as "derived from natural or biological sources and can i) enhance plant growth and development when applied in small quantities; ii) help improve the efficiency of plant nutrients, as measured by either improved nutrient uptake or reduced nutrient losses to the environment, or both; or act as soil amendments to help improve soil structure, function, or performance and thus enhance plant response" (Biostimulant, 2013).

Soil-borne disease management is a key priority for legume production in the UK and Europe. New biological products may offer an opportunity to improve management of soil-borne diseases and our project aims to test a variety of biostimulants, biocontrol agents and nutritional products in field conditions. *Aphanomyces euteiches* (root rot) and *Peronospora viciae* (downy mildew) are soil-borne diseases that cause major yield losses, uneven maturity and quality reduction in peas and faba beans. They produce long-lasting resting spores which lead to a build-up of soil disease levels when legumes are grown regularly in rotations. Root rot is increasing in areas of the UK previously thought to be free of the disease and there are currently no chemical means of control. Current restrictions to the use of plant protection products may lead to difficulty for control of downy mildew in the future.

Previous work conducted by PGRO has shown some positive results on yield with using a bio stimulant product. Along with the increasing interest and demand for alternatives to pesticides, it was decided to conduct further investigation using the same products in several crops over three consecutive years. Two soil applied, five seed treated, four foliar and one soil + foliar products were selected with the aim to cover a range of application methods and active substances. The treatments will be applied on spring beans (*Vicia faba*), vining peas and combining peas (*Pisum sativum*) over three growing seasons, 2018 – 2020.

Method:

Trial was a randomized complete plot design, untreated plots included within block.

Spray applications were made using a Handheld AZO plot spray, flat fan LD110 nozzles, operating at 2 bar. All applications were applied at 200 l/ha except for treatment 13 which was applied at 300 l/ha.

Treated seed was treated using a Hege seed treating machine.

All trials received a pre-emergence herbicide application.

Treatment list:

Trt No.	Product name	Rate	Application Method	Number of applications	Application Timing		
					T0	T1	T2
1	Untreated (Check)	_	_	_			
2	TFP Pro Soil	1.0 l/ha	Soil	1	pre drilling	_	_
3	Serenade ASO	8.0 l/ha	Soil	1	pre/post drilling	_	_
4	Radiate	2.0 l/tonne	Seed	1	seed	_	_
5	Start-uP	2.0 l/tonne	Seed	1	seed	_	_
6	Take Off ST	1.0 l/tonne	Seed	1	seed	_	_
7	MultiMax GPA	200 ml/tonne	Seed	1	seed	_	_
8	KickOff	4.0 l/tonne	Seed	1	seed	_	_
9	TFP Pro-Tect	1.0l/ha	Foliar	2	_	4-5 leaf pairs	21DALA
10	Zynergy + Na13	1.0 l/ha + 0.1% sp/v	Foliar	2	_	early flower	10-14DALA
11	Foliar Tonic (Agrihit)	0.667 l/ha	Foliar	2	_	early flower	10-14DALA
12	Phorce	1.0 l/ha	Foliar	2	_	2nd node	pre flowering
13	Prestop	250g/in 300 litres H2O	Soil + Foliar	2	pre-emergence	flower bud	

Treatment list and timings apply to all crops

Product	Ingredient(s)
TFP Pro Soil	Plant extracts, enzymes, minerals and metabolites
Serenade ASO	*Bacillius stubtilis*
Radiate	Micronutrient blend
Start-uP	Calcium, sulphur and zinc
Take Off ST	Phosphite, manganese, zinc, biostimulant PGA
MultiMax GPA	Phosphite, manganese, zinc, biostimulant
KickOff	Phosphorous, manganese, potassium, nitrogen, zinc, sulphate, amino acid
TFP Pro-Tect	Plant extracts, enzymes, minerals and metabolites
Zynergy	Copper, zinc, sulphur
Foliar Tonic	Plant Extracts
Phorce	NPK 03:38:15 (P as phosphite)
Prestop	*Gliocladium catenulatum* J1446

Trials diary:

Vining Peas, Holbeach – Downy Mildew

Variety Savannah, target population 100 plants/m^2 at 25cm row spacings.

11th April: Drilled, Trts 2, 3 & 13 applied
30th April: Trt 12 applied, Plant counts
13th May: Trt 9 applied
31st May: Downy mildew assessment
6th June: Trt 9 applied
12th June: Trts 10, 11, 12 & 13 applied
26th June: Trts 10 & 11 applied
8th July: Chlorophyll assessment

Vining Peas, Holbeach – Aphanomyces

Variety Savannah, target population 100 plants/m^2 at 25cm row spacings.

7th May: Drilled, Trts 2, 3 and 13 applied
23rd May: Plants counts
31st May: Trt 12 applied
12th June: Trt 9 applied
26th June: Trts 9, 10, 11, 12 & 13 applied
8th July: Trts 10 & 11 applied
15th July: Foot rot and chlorophyll assessment

Combining Peas, Stubton PGRO Trial Ground 2019

Variety Karioka, target population 70 plants/m^2 at 25cm row spacings.

26th March: Drilled. Trt 2 applied
28th March: Trts 3 & 13 applied
1st May: Plant counts, Trt 12 applied
13th May: Trt 9 applied
4th June: Trt 9 applied
12th June: Trt 10, 11, 12 & 13 applied
27th June: Trt 10 & 11 applied
17th July: Chlorophyll assessment
16th August: Harvested

Spring Beans, Stubton PGRO Trial Ground 2019

Variety Fuego, target population 50 plants/m^2 at 25cm row spacings.

19th March: Drilled, Trts 2 & 3 applied
28th March: Trt 13 applied
12th April: Plant counts
13th May: Trt 9 applied
4th June: Trt 9 applied
12th June: Trts 10, 11, 12 & 13 applied
24th June: Downy mildew assessment
27th June: Trts 10 & 11 applied
11th July: Chlorophyll assessment
20th August: Harvested

Results:

4 trials were conducted in 2019. 2 in vining peas, 1 in combining peas and 1 in spring beans. The trials had a total of 13 treatments with 4 application methods - 2 soil, 5 seed, 4 foliar and 1 soil + foliar. The treatments and application methods were identical for all 4 trials.

Vining peas

Plant counts were made in all plots with soil or seed applied treatments. No significant differences were observed compared to the untreated. The first of the vining pea trials developed significant downy mildew infection but no significant differences between treatments were observed (Graph 1). However, three of the four seed treatments recorded lower levels of infection compared to the untreated. Chlorophyll contents were recorded but none of the treatments had a significant effect (Graph 2). Due to severe bird damage to the pods the trial was not harvested.

Soil ▇ Seed ▇ Foliar ▇ Soil + Foliar ▇
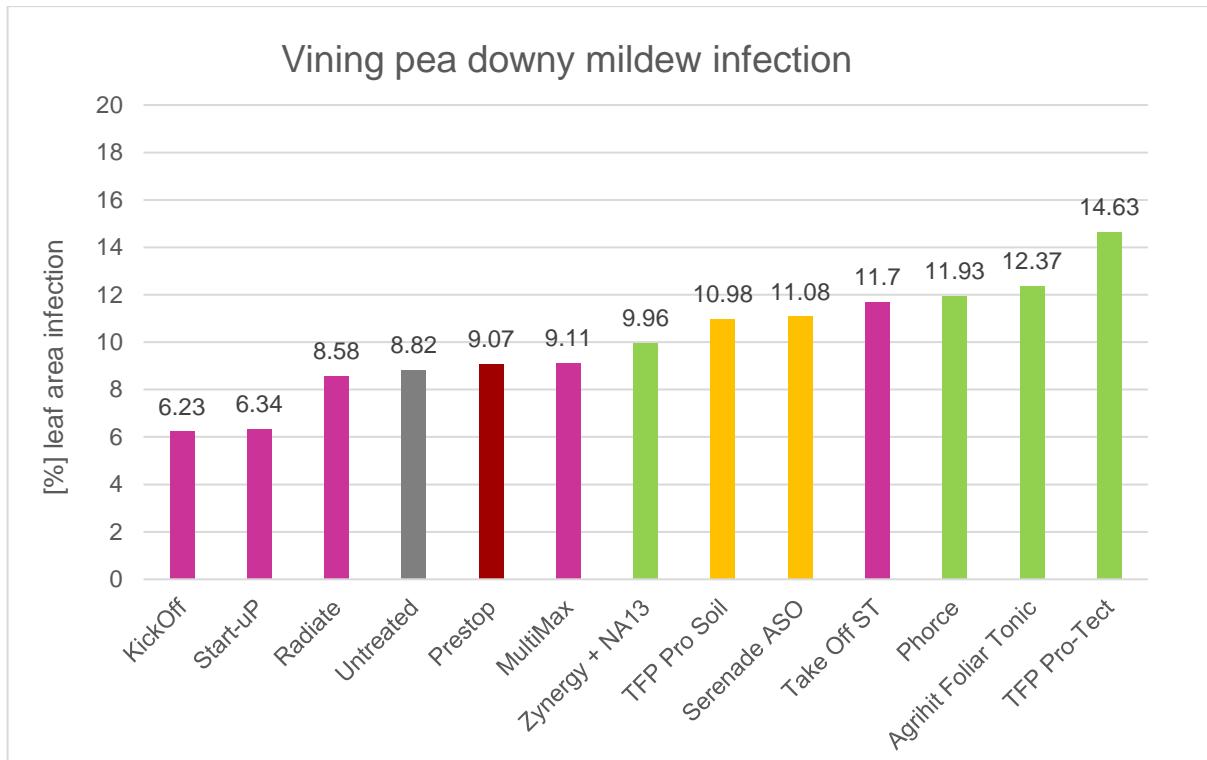
Graph 1
31st May – Downy mildew infection, mean % infection per plant, across 4 reps, 25 plts/plot. Standard error 2.88. No significant differences.
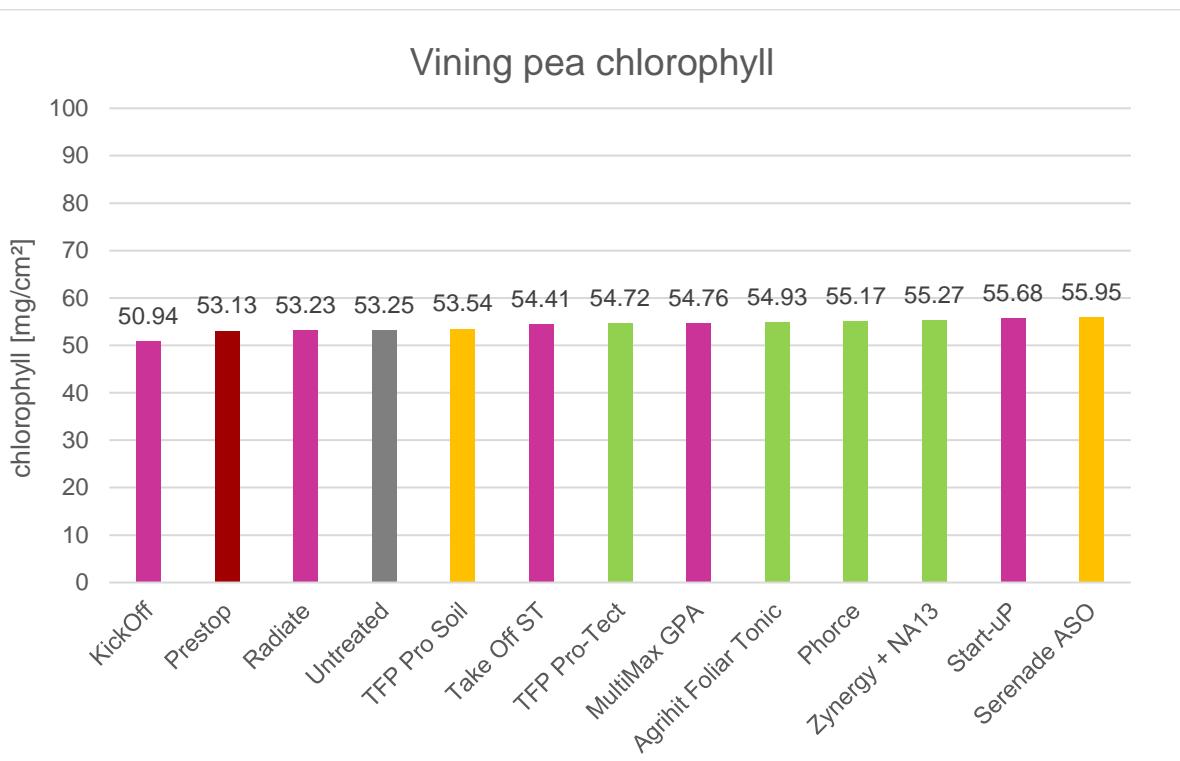
Graph 2
8th July – Chlorophyll, mean mg/cm² per plant, across 4 reps, 10 plts/plot. Standard error: 1.51. No significant differences.

In the second vining pea trial, plant counts were conducted following emergence and prior to foot rot infection, in plots with soil and seed applied treatments with no significant differences. Chlorophyll contents were recorded but none of the treatments had a significant effect (Graph 3). Plants developed severe infection with pea foot rot, in this field mainly caused by *Fusarium solani*, one of the major three pea foot rot pathogens. Plants with scores lower than 2 are only mildly infected with foot rot and influence on yield is low. Scores of 3 and 4 show medium infection with foot rot and plants suffer from decreased ability to take up water and nutrients. Plants that score over 4 are so heavily infected with foot rot that plant death is possible and large reductions in yield can be expected. Under high foot rot pressure, observing differences by treatment is difficult and, in this trial, none of the treatments had any significant effect on disease severity (Graph 4). The trial was abandoned prior to harvest due to the high incidence of foot rot.
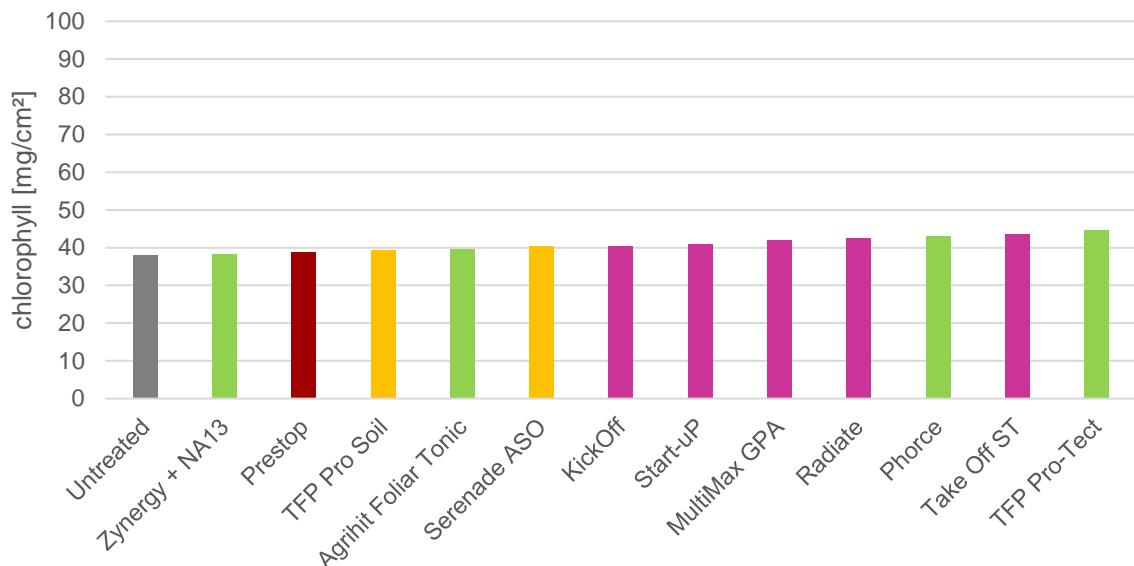
Graph 3
15th July – Chlorophyll, mean mg/cm² per plant, across 4 reps, 10 plts/plot. Standard error: 3.26. All treatments recorded higher levels of chlorophyll, however there were no significant differences.
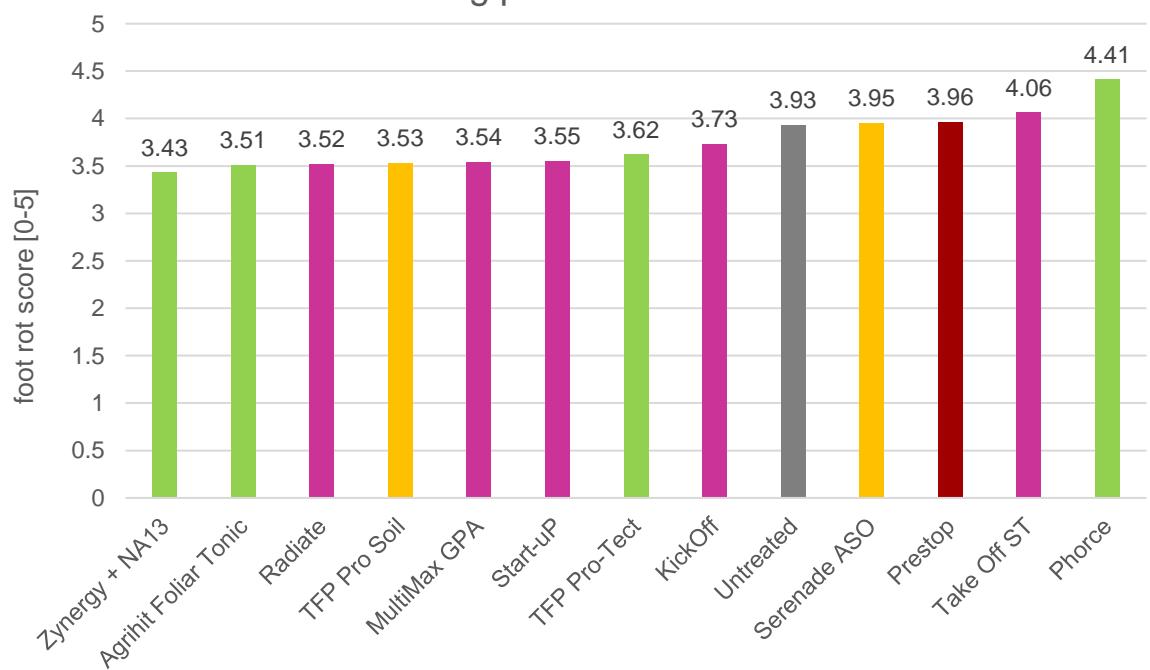
Graph 4
15th July – Mean foot rot score across 4 reps, 25 plts/plot. Score 0-5 where 0 = no disease present, 5 = dead root. Standard error: 0.3082. No significant differences.

Combining peas

Plant counts were in all plots with soil and seed applied treatments with no significant differences. Although not statistically significant, chlorophyll contents in combining peas were slightly higher in most treatments compared to the untreated (Graph 5). The same was true for yield, but here also, differences were not significant (Graph 6).

Combining pea chlorophyll
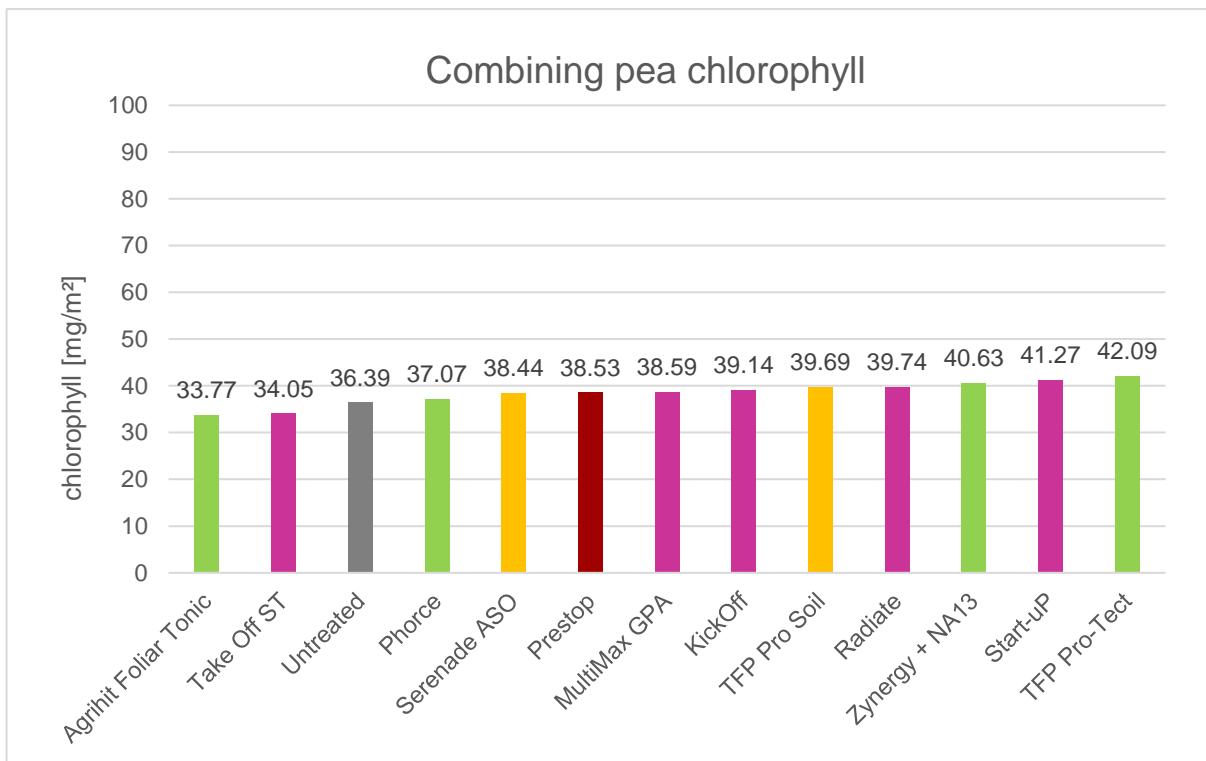
Graph 5
17th July – Chlorophyll, mean mg/cm² per plant, across 4 reps, 10 plts/plot. Standard error: 2.81. No significant differences.

Combining pea yield
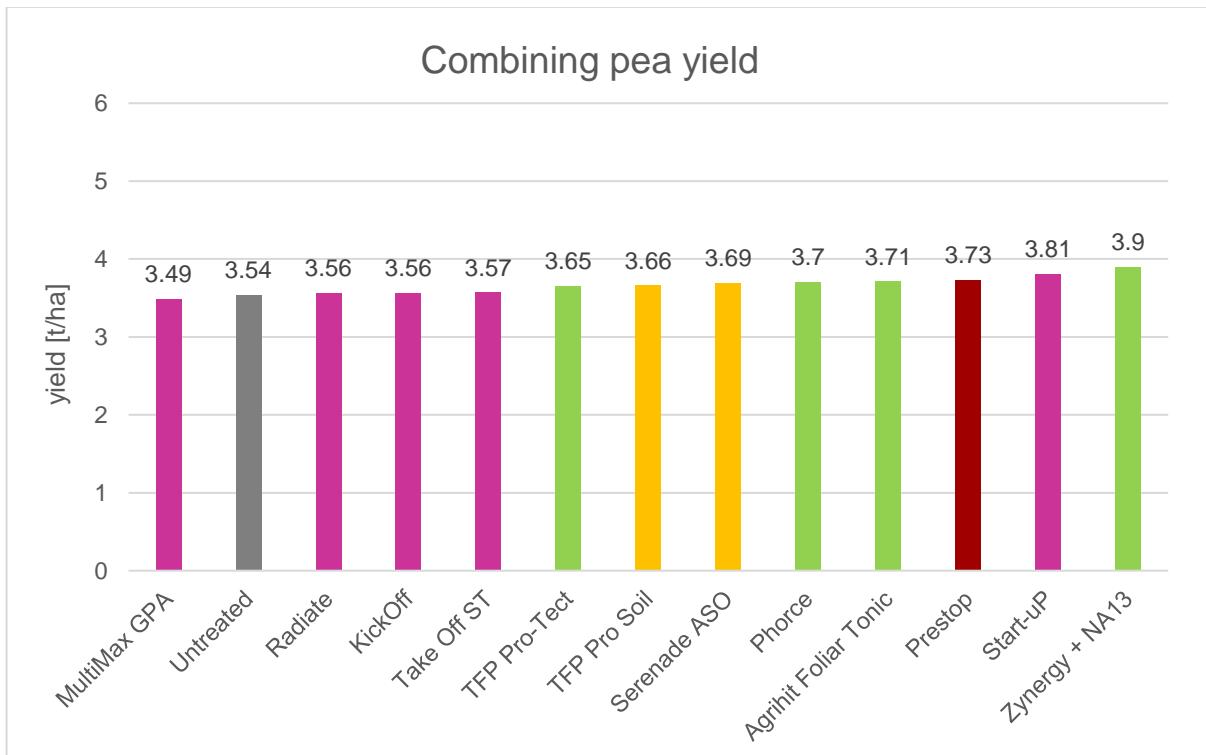
Graph 6
16th August - Mean harvest yield t/ha, across 4 reps, 2 x 10m. Standard error: 0.246. No significant differences.

Plant counts were in all plots with soil and seed applied treatments with no significant differences. This year, fairly high levels of downy mildew occurred in the spring bean trial. The application of Phorce led to a significant decrease in levels of downy mildew compared to all other treatments (Graph 7). Chlorophyll contents did not differ by treatments and only KickOff recorded a higher level of chlorophyll compared to the untreated (Graph 8). No significant differences in bean yield were observed (Graph 9). Only two treatments recorded higher yields than the untreated.
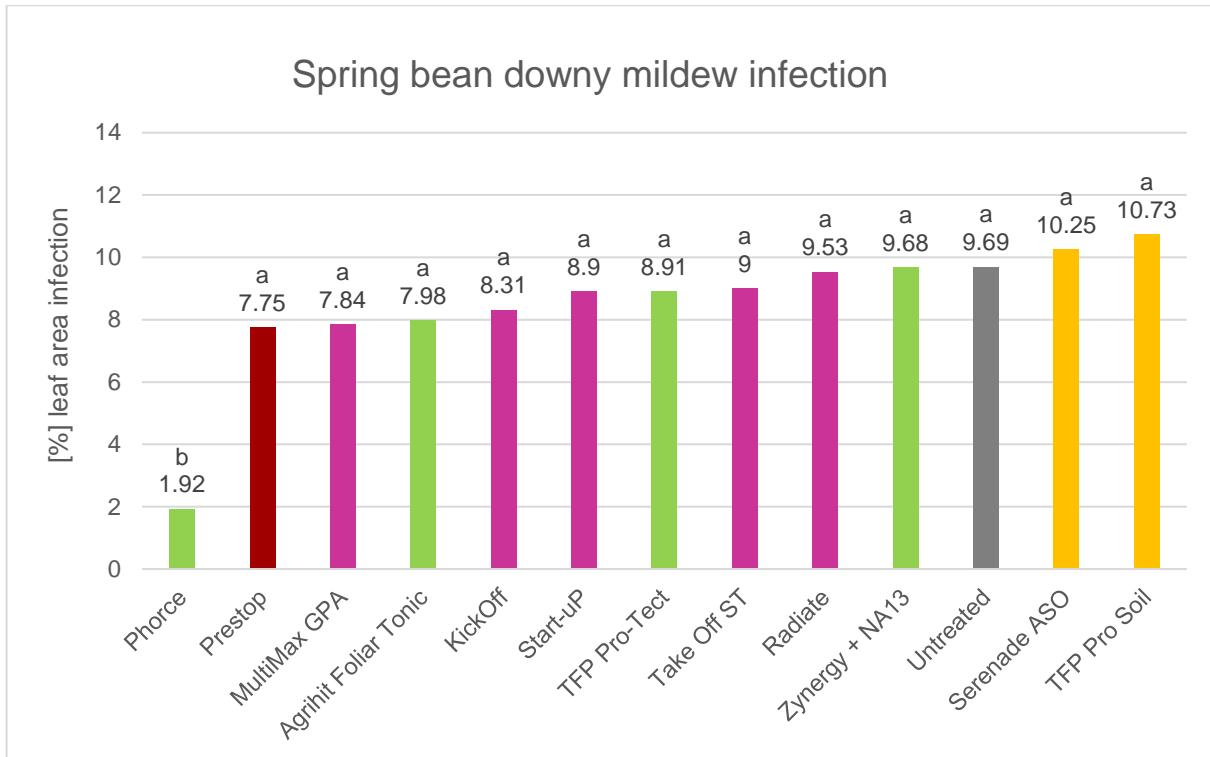
Graph 7
24th June – Downy mildew infection, mean % infection per plant, across 4 reps, 25 plts/plot. Standard error: 1.63. Treatment Phorce gave a significant reduction of infection compared to all other treatments.
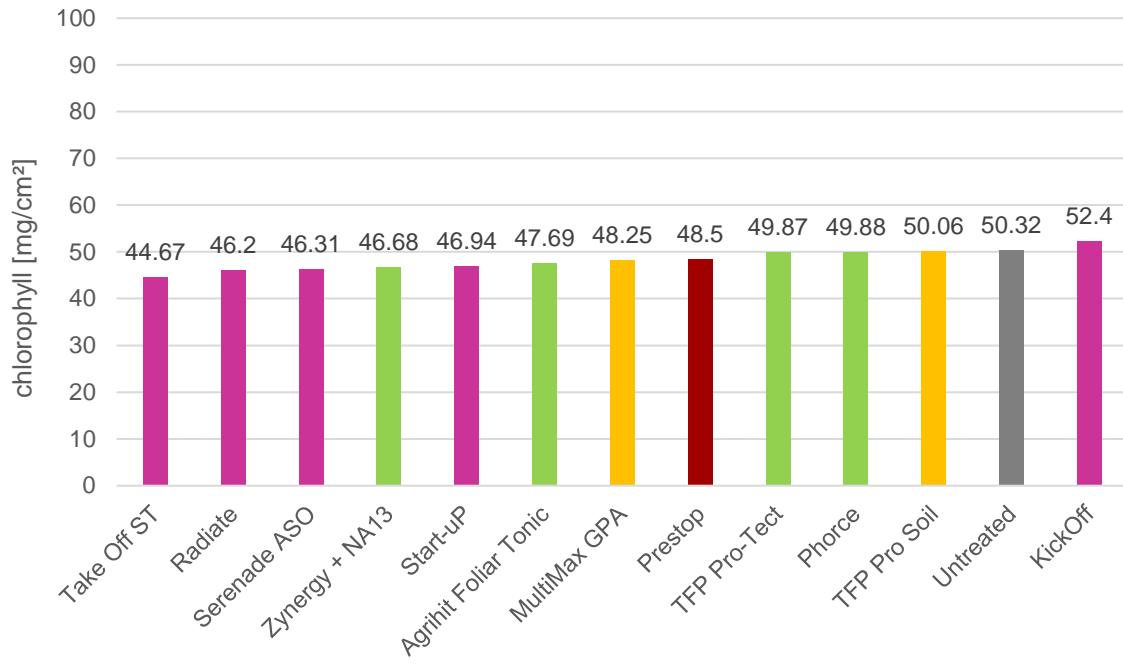
Graph 8
11th July – Chlorophyll, mean mg/cm² per plant, across 4 reps, 10 plts/plot. Standard error: 2.71. No significant differences.
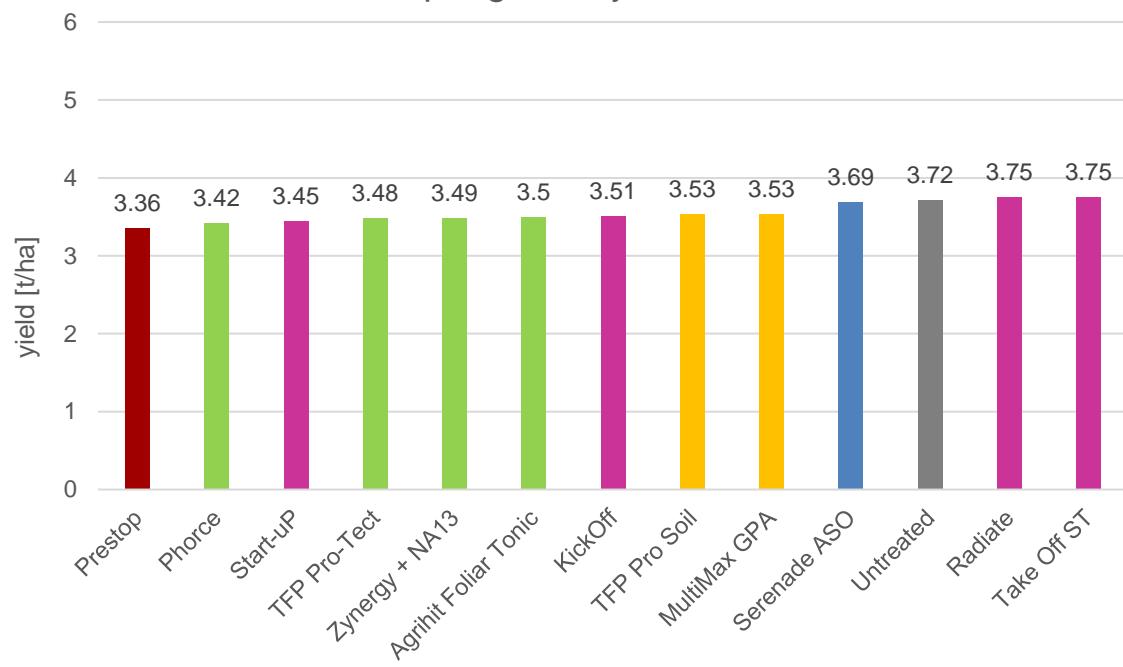
Graph 9
20th August - Mean harvest yield t/ha, across 4 reps, 2 x 10m. Standard error: 0.3208. No significant differences.

Discussion:

All applications were made at the correct timings. Both vining pea trials were abandoned prior to harvest, the downy mildew trial suffered heavy bird damage to the pods and the *Aphanomyces* trial suffered from very heavy foot rot.

There was no significant effect on yield by any of the products.

There was no significant effect on chlorophyll.

There was no significant effect on crop emergence.

High levels of downy mildew occurred in the spring bean trial. Phosphite, an active ingredient in Phorce, has been reported by growers to reduce levels of downy mildew infection. In the spring bean trial in 2019 Phorce significantly decreased downy mildew. Levels of infection exceeded 10% in 2019 which were higher than in 2018. The reduction in infection achieved by Phorce in 2019 might have been due to higher disease pressure.

This year has not clearly identified any products that provided a statistically significant benefit to either yield or crop health except treatment Phorce which led to reduction in downy mildew in spring beans. However, this did not lead to an increase in yield.

This is a three-year study looking at the same treatments within the same crops and further results on product performance will continue into the final year. After two years of trials there has not been any treatment that has consistently shown a significant benefit to any of the crops. In 2018, there were prolonged periods of drought and high temperatures that reduced disease development and could have also masked any potential benefits on yield. Although there were higher levels of disease in 2019 product applications had no significant impact on yield.

Rob Glover
Technical Officer
October 2019

Appendix

Weather

Holbeach -

Moulton ISPALDIN12

DATE	Temperature			Humidity			Precip. Accum.
	High	Avg	Low	High	Avg	Low	Sum
04/01/2019	13.8 C	7.1 C	2.2 C	86 %	71 %	48 %	0.00 mm
04/02/2019	8.9 C	4.7 C	1.2 C	91 %	85 %	69 %	5.59 mm
04/03/2019	10.2 C	5.2 C	0.7 C	93 %	79 %	57 %	0.25 mm
04/04/2019	10.9 C	5.2 C	-0.4 C	92 %	76 %	52 %	0.00 mm
04/05/2019	14.3 C	9.5 C	4.2 C	83 %	60 %	37 %	0.00 mm
04/06/2019	11.1 C	7.2 C	3.2 C	92 %	81 %	67 %	0.00 mm
04/07/2019	11.1 C	8.6 C	7.3 C	94 %	91 %	85 %	0.76 mm
04/08/2019	15.2 C	10.1 C	6.0 C	95 %	85 %	66 %	0.00 mm
04/09/2019	10.6 C	8.0 C	5.3 C	92 %	77 %	64 %	0.00 mm
04/10/2019	10.4 C	6.7 C	3.7 C	78 %	66 %	54 %	0.00 mm
04/11/2019	10.1 C	5.7 C	2.3 C	78 %	64 %	49 %	0.00 mm
04/12/2019	10.9 C	5.1 C	0.1 C	86 %	69 %	47 %	0.00 mm
4/13/2019	9.5 C	4.7 C	-0.2 C	84 %	67 %	45 %	0.00 mm
4/14/2019	8.7 C	5.1 C	0.3 C	81 %	67 %	51 %	0.00 mm
4/15/2019	13.7 C	7.9 C	2.4 C	90 %	72 %	49 %	0.00 mm
4/16/2019	14.5 C	9.3 C	4.9 C	91 %	79 %	61 %	0.00 mm
4/17/2019	17.0 C	10.7 C	4.5 C	93 %	79 %	64 %	0.00 mm
4/18/2019	18.3 C	11.5 C	5.5 C	95 %	79 %	57 %	0.00 mm
4/19/2019	18.9 C	12.2 C	5.9 C	91 %	73 %	47 %	0.00 mm
4/20/2019	21.1 C	11.1 C	4.1 C	94 %	77 %	46 %	0.00 mm
4/21/2019	24.1 C	13.1 C	3.6 C	94 %	66 %	28 %	0.25 mm
4/22/2019	24.9 C	14.5 C	3.5 C	86 %	59 %	24 %	0.00 mm
4/23/2019	17.7 C	12.5 C	8.5 C	87 %	74 %	57 %	0.00 mm
4/24/2019	21.4 C	12.9 C	6.4 C	92 %	73 %	49 %	0.00 mm
4/25/2019	17.5 C	12.2 C	7.5 C	87 %	69 %	44 %	0.00 mm
4/26/2019	17.7 C	11.5 C	3.9 C	90 %	68 %	42 %	0.00 mm
4/27/2019	9.9 C	8.4 C	6.8 C	86 %	75 %	64 %	0.76 mm
4/28/2019	12.8 C	8.8 C	5.7 C	87 %	79 %	60 %	0.51 mm
4/29/2019	14.2 C	8.8 C	4.6 C	94 %	83 %	62 %	0.25 mm
4/30/2019	15.6 C	9.6 C	3.5 C	92 %	77 %	52 %	0.00 mm
	Temperature			Humidity			Precip. Accum.
DATE	High	Avg	Low	High	Avg	Low	Sum
05/01/2019	19.1 C	11.7 C	3.6 C	92 %	75 %	46 %	5.08 mm
05/02/2019	16.1 C	11.3 C	8.0 C	91 %	79 %	57 %	12.95 mm
05/03/2019	9.0 C	7.5 C	5.4 C	91 %	85 %	76 %	0.25 mm
05/04/2019	10.1 C	6.4 C	2.1 C	85 %	75 %	62 %	1.27 mm
05/05/2019	12.3 C	7.7 C	3.6 C	86 %	67 %	44 %	0.00 mm
05/06/2019	11.6 C	8.2 C	4.2 C	84 %	70 %	49 %	0.25 mm
05/07/2019	15.3 C	9.1 C	5.6 C	89 %	74 %	40 %	0.51 mm

DATE	High	Avg	Low	High	Avg	Low	Sum
05/08/2019	11.6 C	9.4 C	7.5 C	92 %	87 %	82 %	13.72 mm
05/09/2019	10.4 C	8.6 C	7.3 C	90 %	87 %	80 %	0.25 mm
05/10/2019	12.8 C	8.6 C	6.0 C	91 %	85 %	67 %	3.56 mm
05/11/2019	14.8 C	10.4 C	7.1 C	92 %	77 %	54 %	0.51 mm
05/12/2019	17.0 C	10.8 C	3.3 C	91 %	67 %	35 %	0.00 mm
5/13/2019	19.1 C	10.5 C	2.7 C	89 %	68 %	41 %	0.00 mm
5/14/2019	20.5 C	12.4 C	4.4 C	86 %	63 %	42 %	0.00 mm
5/15/2019	17.9 C	11.6 C	5.1 C	85 %	66 %	41 %	0.00 mm
5/16/2019	18.6 C	11.5 C	5.8 C	88 %	70 %	33 %	0.00 mm
5/17/2019	15.8 C	11.8 C	9.7 C	88 %	79 %	62 %	0.51 mm
5/18/2019	15.5 C	12.0 C	9.9 C	92 %	88 %	75 %	4.32 mm
5/19/2019	19.7 C	12.7 C	7.4 C	96 %	81 %	52 %	0.25 mm
5/20/2019	20.2 C	14.0 C	10.1 C	89 %	75 %	48 %	0.00 mm
5/21/2019	20.3 C	13.6 C	7.6 C	89 %	69 %	38 %	0.00 mm
5/22/2019	19.9 C	13.9 C	7.8 C	79 %	59 %	36 %	0.00 mm
5/23/2019	21.9 C	15.2 C	8.4 C	84 %	60 %	33 %	0.00 mm
5/24/2019	22.5 C	16.0 C	9.2 C	83 %	61 %	37 %	0.00 mm
5/25/2019	21.3 C	16.2 C	10.9 C	85 %	63 %	40 %	0.00 mm
5/26/2019	19.1 C	16.1 C	10.6 C	81 %	71 %	49 %	0.51 mm
5/27/2019	16.8 C	12.4 C	8.7 C	83 %	71 %	53 %	2.29 mm
5/28/2019	16.4 C	11.6 C	9.0 C	89 %	80 %	58 %	5.84 mm
5/29/2019	16.3 C	11.3 C	6.0 C	95 %	83 %	57 %	1.52 mm
5/30/2019	22.3 C	17.6 C	13.6 C	94 %	76 %	59 %	0.51 mm
5/31/2019	21.1 C	16.5 C	11.7 C	85 %	72 %	56 %	0.00 mm

	Temperature			Humidity			Precip. Accum.
DATE	High	Avg	Low	High	Avg	Low	Sum
06/01/2019	25.0 C	18.8 C	11.6 C	90 %	67 %	44 %	0.00 mm
06/02/2019	25.3 C	18.9 C	12.5 C	85 %	68 %	38 %	0.00 mm
06/03/2019	19.5 C	14.7 C	9.2 C	87 %	64 %	42 %	0.00 mm
06/04/2019	17.9 C	13.1 C	7.7 C	92 %	79 %	53 %	3.56 mm
06/05/2019	17.6 C	13.6 C	8.8 C	95 %	74 %	51 %	0.25 mm
06/06/2019	19.6 C	14.7 C	8.9 C	83 %	60 %	37 %	0.00 mm
06/07/2019	17.9 C	12.8 C	6.7 C	89 %	78 %	56 %	4.32 mm
06/08/2019	13.0 C	11.6 C	8.9 C	93 %	85 %	71 %	3.30 mm
06/09/2019	19.2 C	13.2 C	6.7 C	90 %	71 %	43 %	0.51 mm
06/10/2019	12.2 C	10.9 C	9.8 C	91 %	88 %	78 %	25.91 mm
06/11/2019	11.1 C	10.4 C	9.7 C	96 %	95 %	92 %	53.09 mm
06/12/2019	14.8 C	11.8 C	9.9 C	98 %	94 %	84 %	16.76 mm
6/13/2019	13.2 C	11.5 C	10.3 C	96 %	94 %	92 %	23.62 mm
6/14/2019	18.2 C	13.6 C	10.6 C	96 %	85 %	62 %	2.03 mm
6/15/2019	19.1 C	13.3 C	8.2 C	92 %	80 %	59 %	2.79 mm
6/16/2019	20.2 C	14.3 C	8.7 C	92 %	80 %	59 %	4.32 mm
6/17/2019	20.4 C	16.2 C	12.1 C	86 %	70 %	54 %	0.00 mm
6/18/2019	19.8 C	15.3 C	10.1 C	90 %	79 %	60 %	4.83 mm
6/19/2019	18.8 C	15.9 C	13.3 C	93 %	85 %	71 %	1.52 mm
6/20/2019	18.5 C	15.2 C	11.9 C	83 %	69 %	53 %	0.00 mm
6/21/2019	20.1 C	14.6 C	8.0 C	83 %	64 %	44 %	0.00 mm
6/22/2019	23.1 C	15.8 C	9.8 C	89 %	71 %	42 %	0.00 mm
6/23/2019	20.9 C	15.1 C	10.1 C	89 %	82 %	69 %	0.00 mm
6/24/2019	24.4 C	19.5 C	14.2 C	92 %	83 %	70 %	0.00 mm

Date	High	Avg	Low	High	Avg	Low	Sum
6/25/2019	19.2 C	15.7 C	14.4 C	92 %	91 %	87 %	4.06 mm
6/26/2019	16.1 C	14.2 C	12.2 C	91 %	83 %	76 %	0.00 mm
6/27/2019	17.9 C	14.1 C	10.8 C	86 %	77 %	67 %	0.00 mm
6/28/2019	20.2 C	16.2 C	12.6 C	85 %	76 %	67 %	0.00 mm
6/29/2019	30.4 C	21.4 C	10.9 C	92 %	70 %	43 %	0.00 mm
6/30/2019	23.3 C	19.1 C	14.1 C	82 %	64 %	46 %	0.00 mm

Stubton -

Claypole ICLAYPOL2

Date	Temperature			Humidity			Precip. Accum.
	High	Avg	Low	High	Avg	Low	Sum
03-01-19	10.5 C	8.6 C	7.1 C	53 %	53 %	52 %	0.25 mm
03-02-19	14.5 C	10.7 C	7.2 C	53 %	53 %	52 %	0.25 mm
03-03-19	12.6 C	9.7 C	6.2 C	53 %	53 %	52 %	3.30 mm
03-04-19	11.2 C	6.8 C	4.0 C	99 %	55 %	1 %	0.00 mm
03-05-19	12.5 C	7.3 C	3.0 C	99 %	54 %	1 %	1.78 mm
03-06-19	14.8 C	11.0 C	7.9 C	53 %	53 %	52 %	6.35 mm
03-07-19	8.5 C	7.0 C	5.1 C	53 %	52 %	52 %	0.25 mm
03-08-19	9.8 C	6.4 C	2.6 C	53 %	52 %	52 %	0.25 mm
03-09-19	11.5 C	8.2 C	5.9 C	99 %	60 %	1 %	0.00 mm
03-10-19	8.7 C	4.8 C	1.9 C	99 %	53 %	1 %	12.95 mm
03-11-19	10.7 C	6.8 C	2.7 C	99 %	59 %	1 %	0.00 mm
03-12-19	11.0 C	7.1 C	3.7 C	53 %	52 %	52 %	8.64 mm
3/13/2019	9.0 C	7.1 C	6.3 C	53 %	52 %	52 %	0.00 mm
3/14/2019	11.8 C	9.7 C	8.8 C	99 %	50 %	1 %	0.25 mm
3/15/2019	13.8 C	11.0 C	7.3 C	99 %	61 %	1 %	0.00 mm
3/16/2019	13.0 C	10.2 C	6.0 C	53 %	53 %	52 %	4.83 mm
3/17/2019	10.6 C	6.3 C	3.3 C	99 %	55 %	1 %	0.00 mm
3/18/2019	11.9 C	8.1 C	3.9 C	53 %	53 %	43 %	0.00 mm
3/19/2019	13.7 C	10.8 C	6.5 C	53 %	53 %	52 %	0.00 mm
3/20/2019	17.7 C	12.0 C	8.1 C	54 %	53 %	53 %	0.00 mm
3/21/2019	16.6 C	12.0 C	7.5 C	54 %	53 %	52 %	0.00 mm
3/22/2019	14.4 C	12.2 C	10.9 C	53 %	53 %	53 %	0.00 mm
3/23/2019	12.3 C	9.7 C	7.3 C	99 %	58 %	1 %	0.00 mm
3/24/2019	12.6 C	8.4 C	2.8 C	99 %	61 %	1 %	0.25 mm
3/25/2019	12.9 C	8.3 C	3.9 C	99 %	56 %	1 %	0.00 mm
3/26/2019	14.3 C	7.7 C	1.3 C	99 %	54 %	1 %	0.00 mm
3/27/2019	13.4 C	10.1 C	5.2 C	99 %	50 %	1 %	0.00 mm
3/28/2019	17.1 C	9.6 C	3.7 C	99 %	58 %	1 %	0.00 mm
3/29/2019	18.2 C	10.5 C	3.8 C	99 %	55 %	1 %	0.00 mm
3/31/2019	11.7 C	8.3 C	3.7 C	99 %	63 %	1 %	0.00 mm
3/31/2019	7.9 C	7.7 C	7.3 C	53 %	53 %	52 %	0.00 mm
3/31/2019	7.9 C	7.7 C	7.3 C	53 %	53 %	52 %	0.00 mm

Date	Temperature			Humidity			Precip. Accum.
	High	Avg	Low	High	Avg	Low	Sum
04-01-19	14.4 C	7.0 C	0.5 C	99 %	58 %	1 %	0.00 mm
04-02-19	10.0 C	5.8 C	2.2 C	53 %	52 %	38 %	5.08 mm
04-03-19	11.5 C	5.7 C	1.6 C	99 %	47 %	1 %	0.25 mm
04-04-19	10.5 C	5.9 C	0.7 C	99 %	51 %	1 %	0.25 mm
04-05-19	14.3 C	9.4 C	4.8 C	99 %	55 %	1 %	0.00 mm
04-06-19	11.6 C	7.9 C	3.2 C	53 %	53 %	52 %	0.00 mm
04-07-19	13.2 C	9.4 C	7.9 C	53 %	53 %	53 %	0.00 mm
04-08-19	16.2 C	10.6 C	8.0 C	53 %	53 %	53 %	0.00 mm
04-09-19	11.2 C	8.1 C	3.2 C	53 %	51 %	16 %	0.00 mm
04-10-19	11.4 C	5.4 C	0.6 C	99 %	49 %	1 %	0.00 mm
04-11-19	11.8 C	7.2 C	2.3 C	99 %	57 %	1 %	0.00 mm
04-12-19	9.8 C	5.6 C	-0.9 C	99 %	60 %	1 %	0.00 mm
4/13/2019	10.4 C	4.3 C	-0.3 C	99 %	52 %	1 %	0.00 mm
4/14/2019	8.8 C	4.6 C	-1.2 C	99 %	58 %	1 %	0.00 mm
4/15/2019	13.8 C	8.1 C	2.2 C	99 %	51 %	1 %	0.00 mm
4/16/2019	13.7 C	9.5 C	4.9 C	53 %	53 %	52 %	0.00 mm
4/17/2019	19.0 C	11.8 C	7.2 C	54 %	53 %	40 %	0.00 mm
4/18/2019	20.0 C	12.0 C	4.1 C	99 %	58 %	1 %	0.00 mm
4/19/2019	23.2 C	12.9 C	5.0 C	99 %	59 %	1 %	0.00 mm
4/20/2019	23.7 C	13.5 C	2.3 C	99 %	51 %	1 %	0.00 mm
4/21/2019	25.2 C	16.4 C	4.2 C	99 %	61 %	1 %	0.00 mm
4/22/2019	23.8 C	14.8 C	4.5 C	99 %	56 %	1 %	0.00 mm
4/23/2019	19.8 C	12.7 C	7.4 C	99 %	59 %	1 %	0.00 mm
4/24/2019	21.0 C	12.3 C	5.9 C	54 %	53 %	52 %	2.29 mm
4/25/2019	16.5 C	11.8 C	7.5 C	54 %	53 %	15 %	3.30 mm
4/26/2019	16.3 C	10.4 C	5.6 C	99 %	51 %	3 %	3.05 mm
4/27/2019	10.1 C	8.6 C	7.2 C	53 %	53 %	52 %	0.51 mm
4/28/2019	13.3 C	9.7 C	6.1 C	53 %	53 %	52 %	0.25 mm
4/29/2019	15.2 C	10.5 C	6.5 C	53 %	53 %	52 %	0.00 mm
4/30/2019	18.5 C	11.3 C	3.3 C	99 %	56 %	1 %	0.00 mm

Date	Temperature			Humidity			Precip. Accum.
	High	Avg	Low	High	Avg	Low	Sum
05-01-19	20.0 C	13.3 C	7.2 C	99 %	55 %	1 %	0.00 mm
05-02-19	15.5 C	11.9 C	9.4 C	53 %	53 %	53 %	8.13 mm
05-03-19	9.6 C	8.1 C	6.2 C	53 %	53 %	52 %	1.52 mm
05-04-19	11.3 C	6.7 C	2.9 C	53 %	51 %	1 %	0.51 mm
05-05-19	13.0 C	8.4 C	3.7 C	99 %	65 %	1 %	0.00 mm
05-06-19	13.4 C	8.9 C	5.0 C	99 %	63 %	1 %	0.00 mm
05-07-19	16.1 C	9.8 C	5.6 C	99 %	54 %	1 %	0.00 mm
05-08-19	11.4 C	9.6 C	8.4 C	53 %	53 %	53 %	10.16 mm
05-09-19	10.1 C	8.5 C	7.3 C	53 %	53 %	52 %	2.03 mm
05-10-19	13.5 C	8.6 C	6.2 C	53 %	53 %	52 %	6.35 mm
05-11-19	15.0 C	10.1 C	6.2 C	53 %	52 %	8 %	0.00 mm
05-12-19	18.7 C	11.0 C	3.3 C	99 %	57 %	1 %	0.00 mm

Date							
5/13/2019	20.4 C	13.3 C	5.5 C	99 %	56 %	1 %	0.00 mm
5/14/2019	20.2 C	14.3 C	5.9 C	99 %	65 %	1 %	0.00 mm
5/15/2019	19.5 C	13.0 C	5.9 C	99 %	51 %	1 %	0.00 mm
5/16/2019	17.6 C	11.5 C	4.2 C	99 %	55 %	1 %	0.00 mm
5/17/2019	17.5 C	12.4 C	8.2 C	54 %	53 %	53 %	0.51 mm
5/18/2019	16.1 C	12.9 C	10.2 C	54 %	53 %	53 %	0.25 mm
5/19/2019	19.8 C	13.9 C	5.9 C	54 %	53 %	52 %	0.00 mm
5/20/2019	20.7 C	15.1 C	9.3 C	99 %	50 %	1 %	0.00 mm
5/21/2019	21.2 C	14.2 C	5.5 C	99 %	58 %	1 %	0.00 mm
5/22/2019	20.8 C	13.5 C	6.5 C	99 %	54 %	1 %	0.00 mm
5/23/2019	22.9 C	16.1 C	8.8 C	99 %	62 %	1 %	0.00 mm
5/24/2019	22.2 C	15.9 C	8.5 C	99 %	65 %	1 %	0.00 mm
5/25/2019	22.4 C	16.5 C	10.3 C	99 %	57 %	1 %	0.00 mm
5/26/2019	19.8 C	16.4 C	11.5 C	54 %	51 %	20 %	1.27 mm
5/27/2019	17.7 C	13.0 C	9.6 C	54 %	53 %	25 %	0.25 mm
5/28/2019	18.5 C	11.9 C	8.9 C	54 %	53 %	22 %	3.56 mm
5/29/2019	16.1 C	12.1 C	4.9 C	53 %	52 %	24 %	1.02 mm
5/30/2019	23.7 C	18.6 C	14.3 C	54 %	54 %	53 %	0.00 mm
5/31/2019	21.4 C	17.2 C	12.2 C	54 %	54 %	53 %	0.00 mm

	Temperature			Humidity			Precip. Accum.
Date	High	Avg	Low	High	Avg	Low	Sum
06-01-19	26.2 C	19.4 C	12.2 C	99 %	48 %	1 %	0.00 mm
06-02-19	23.3 C	18.8 C	12.3 C	54 %	54 %	53 %	3.56 mm
06-03-19	19.7 C	15.2 C	11.1 C	99 %	58 %	1 %	0.00 mm
06-04-19	19.1 C	14.0 C	9.4 C	54 %	52 %	1 %	1.52 mm
06-05-19	18.3 C	14.6 C	10.6 C	54 %	53 %	43 %	0.00 mm
06-06-19	20.1 C	15.2 C	9.9 C	99 %	61 %	1 %	0.00 mm
06-07-19	18.4 C	13.2 C	8.1 C	54 %	53 %	53 %	2.03 mm
06-08-19	14.1 C	12.1 C	9.6 C	53 %	53 %	53 %	3.56 mm
06-09-19	20.2 C	14.0 C	8.4 C	99 %	58 %	1 %	0.25 mm
06-10-19	13.5 C	11.6 C	10.1 C	53 %	53 %	53 %	17.78 mm
06-11-19	10.8 C	10.0 C	9.0 C	53 %	53 %	53 %	74.17 mm
06-12-19	15.9 C	12.7 C	9.7 C	53 %	53 %	53 %	23.11 mm
6/13/2019	15.4 C	12.3 C	10.7 C	53 %	53 %	53 %	8.13 mm
6/14/2019	18.8 C	14.2 C	10.2 C	54 %	53 %	53 %	5.59 mm
6/15/2019	19.1 C	14.5 C	9.9 C	54 %	53 %	53 %	4.57 mm
6/16/2019	20.6 C	15.3 C	9.6 C	54 %	53 %	53 %	0.51 mm
6/17/2019	22.1 C	17.7 C	14.1 C	54 %	54 %	53 %	0.00 mm
6/18/2019	21.2 C	16.8 C	12.6 C	54 %	54 %	53 %	2.03 mm
6/19/2019	20.4 C	17.1 C	14.8 C	54 %	54 %	53 %	0.25 mm
6/20/2019	19.4 C	15.4 C	11.3 C	54 %	53 %	53 %	0.25 mm
6/21/2019	20.3 C	15.0 C	7.6 C	54 %	51 %	14 %	0.00 mm
6/22/2019	24.5 C	17.6 C	9.5 C	99 %	65 %	1 %	0.00 mm
6/23/2019	22.5 C	16.4 C	10.5 C	54 %	53 %	53 %	0.51 mm
6/24/2019	22.3 C	18.1 C	14.7 C	54 %	54 %	53 %	1.78 mm
6/25/2019	18.9 C	15.9 C	14.3 C	54 %	53 %	53 %	13.72 mm
6/26/2019	15.8 C	14.1 C	12.2 C	53 %	53 %	53 %	0.00 mm

Date	20.7 C	15.1 C	10.9 C	54 %	53 %	53 %	0.00 mm
6/27/2019	20.7 C	15.1 C	10.9 C	54 %	53 %	53 %	0.00 mm
6/28/2019	21.7 C	16.4 C	12.6 C	54 %	53 %	53 %	0.00 mm
6/29/2019	33.1 C	22.4 C	11.1 C	55 %	54 %	53 %	0.00 mm
6/30/2019	23.7 C	19.5 C	14.3 C	54 %	54 %	53 %	0.00 mm

	Temperature			Humidity			Precip. Accum.
Date	High	Avg	Low	High	Avg	Low	Sum
07-02-19	21.7 C	16.1 C	9.7 C	99 %	48 %	1 %	0.00 mm
07-03-19	21.5 C	16.4 C	10.4 C	54 %	54 %	53 %	0.00 mm
07-05-19	25.8 C	19.8 C	14.3 C	55 %	54 %	43 %	0.00 mm
07-06-19	21.6 C	16.6 C	13.9 C	54 %	54 %	53 %	3.56 mm
07-08-19	19.6 C	14.4 C	11.3 C	54 %	53 %	53 %	0.00 mm
07-12-19	23.6 C	18.9 C	14.6 C	54 %	54 %	53 %	4.57 mm
7/13/2019	23.0 C	17.9 C	14.6 C	54 %	54 %	53 %	21.34 mm
7/14/2019	20.3 C	16.5 C	12.4 C	54 %	54 %	53 %	3.56 mm
7/15/2019	25.1 C	17.7 C	10.5 C	54 %	54 %	53 %	0.00 mm
7/16/2019	26.5 C	20.0 C	12.6 C	55 %	54 %	53 %	0.00 mm
7/17/2019	24.3 C	20.2 C	14.7 C	54 %	54 %	53 %	1.27 mm
7/18/2019	22.1 C	18.5 C	14.7 C	54 %	54 %	53 %	0.00 mm
7/19/2019	19.6 C	16.4 C	12.1 C	54 %	54 %	53 %	5.33 mm
7/20/2019	22.2 C	18.7 C	14.1 C	54 %	54 %	53 %	6.35 mm
7/21/2019	22.8 C	18.2 C	12.0 C	54 %	54 %	53 %	0.00 mm
7/22/2019	28.4 C	22.8 C	18.1 C	55 %	54 %	54 %	0.00 mm
7/23/2019	32.6 C	22.5 C	15.0 C	55 %	54 %	53 %	0.00 mm
7/24/2019	29.6 C	26.3 C	21.4 C	55 %	55 %	54 %	5.33 mm
7/25/2019	38.1 C	28.2 C	17.7 C	99 %	59 %	1 %	0.00 mm
7/26/2019	26.0 C	22.8 C	19.7 C	55 %	54 %	54 %	3.30 mm
7/27/2019	19.7 C	17.8 C	15.9 C	54 %	54 %	53 %	15.24 mm
7/28/2019	18.6 C	16.4 C	14.8 C	54 %	53 %	53 %	17.02 mm
7/29/2019	26.7 C	19.6 C	14.5 C	55 %	49 %	1 %	1.02 mm
7/30/2019	23.9 C	19.7 C	17.1 C	54 %	54 %	54 %	6.10 mm
7/31/2019	19.1 C	17.2 C	15.8 C	54 %	54 %	53 %	3.30 mm

	Temperature			Humidity			Precip. Accum.
Date	High	Avg	Low	High	Avg	Low	Sum
08-01-19	23.5 C	20.5 C	16.3 C	54 %	54 %	53 %	0.00 mm
08-02-19	22.8 C	18.9 C	15.6 C	54 %	54 %	53 %	0.51 mm
08-03-19	25.5 C	20.9 C	12.8 C	55 %	54 %	53 %	0.00 mm
08-04-19	26.8 C	21.4 C	16.7 C	55 %	54 %	53 %	1.52 mm
08-05-19	23.3 C	19.1 C	15.5 C	54 %	54 %	53 %	0.25 mm
08-06-19	23.0 C	18.1 C	14.4 C	54 %	54 %	53 %	0.51 mm
08-07-19	22.5 C	18.3 C	14.6 C	54 %	54 %	53 %	0.00 mm
08-08-19	26.0 C	19.1 C	12.9 C	55 %	54 %	53 %	0.00 mm
08-09-19	25.5 C	20.2 C	16.8 C	55 %	54 %	53 %	25.15 mm
08-10-19	22.1 C	18.6 C	16.8 C	54 %	54 %	53 %	0.25 mm

08-11-19	**21.2** C	**17.4** C	**14.8** C	**54** %	**54** %	**53** %	**0.25** mm
08-12-19	**18.9** C	**14.2** C	**10.9** C	**54** %	**53** %	**53** %	**0.00** mm
8/13/2019	**20.2** C	**14.7** C	**11.1** C	**54** %	**53** %	**53** %	**1.27** mm
8/14/2019	**17.3** C	**14.0** C	**10.7** C	**54** %	**53** %	**53** %	**23.37** mm
8/15/2019	**19.6** C	**16.2** C	**11.7** C	**54** %	**53** %	**53** %	**0.25** mm
8/16/2019	**17.6** C	**14.5** C	**12.1** C	**54** %	**53** %	**53** %	**12.95** mm
8/17/2019	**21.4** C	**16.9** C	**13.3** C	**54** %	**53** %	**53** %	**0.00** mm
8/18/2019	**21.1** C	**17.0** C	**13.2** C	**54** %	**54** %	**53** %	**0.00** mm
8/19/2019	**20.2** C	**16.1** C	**12.1** C	**54** %	**54** %	**53** %	**0.51** mm
8/20/2019	**19.8** C	**17.5** C	**14.1** C	**54** %	**54** %	**53** %	**0.00** mm
8/21/2019	**21.8** C	**17.1** C	**11.9** C	**54** %	**54** %	**53** %	**0.25** mm
8/22/2019	**22.3** C	**18.3** C	**14.3** C	**54** %	**54** %	**53** %	**0.00** mm
8/23/2019	**26.7** C	**20.3** C	**14.9** C	**55** %	**54** %	**53** %	**0.00** mm
8/24/2019	**30.0** C	**22.2** C	**14.1** C	**99** %	**64** %	**1** %	**0.00** mm
8/25/2019	**33.0** C	**22.6** C	**13.4** C	**99** %	**59** %	**1** %	**0.00** mm
8/26/2019	**32.9** C	**24.0** C	**15.9** C	**99** %	**59** %	**1** %	**0.00** mm
8/27/2019	**31.7** C	**22.6** C	**15.8** C	**55** %	**54** %	**53** %	**1.52** mm
8/28/2019	**21.7** C	**18.0** C	**13.5** C	**54** %	**54** %	**53** %	**5.08** mm
8/29/2019	**20.9** C	**15.9** C	**11.1** C	**54** %	**54** %	**53** %	**0.00** mm
8/30/2019	**22.6** C	**18.7** C	**15.4** C	**54** %	**54** %	**53** %	**0.00** mm
8/31/2019	**20.5** C	**16.2** C	**11.1** C	**54** %	**53** %	**53** %	**1.02** mm

References

Biostimulant Coalition, 2013. What are biostimulants? http://www.biostimulantcoalition.org/about/