Project title:	AHDB Horticulture Field Vegetable Centre – Brassicas, Scotland – Swede bio-stimulants screen
Project number:	FV 462
Project leader:	Angela Huckle, ADAS Horticulture
Report:	Annual report, December 2020
Previous report:	None
Key staff:	Angela Huckle, ADAS Horticulture (report editor) Gabrielle Roxby, ADAS Horticulture (report author) Chris Dyer, ADAS Statistician James Rome, East of Scotland Growers Duncan MacLachlan, East of Scotland Growers Euan Alexander, Kettle Produce Alex Aitken, Kettle Produce Duncan Carr, Oxford Agricultural Trials
Location of project:	Balmullo, Scotland
Industry Representative:	James Rome, East of Scotland Growers, Prestonhall Industrial Estate, Cupar, Fife
Date project commenced:	1 April 2020

DISCLAIMER

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

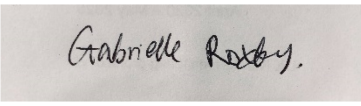
AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Gabrielle Roxby

Senior Research Technician

ADAS Horticulture

Signature ....

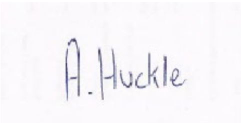
.... Date ......24 December 2020.

Report authorised by:

Angela Huckle

Associate Director – Crop Health

ADAS Horticulture

Signature ....

... Date ......24 December 2020

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GROWER SUMMARY

Headline

- All treatment programmes in the experiment were safe to use over swedes with no adverse effects observed on the crop.
- By the conclusion of the trial - one month after the third and final biostimulant application – there were no significant differences in biomass measurements, but selected treatments indicated a trend for a higher mean biomass of both the swede and crop foliage (shoots) compared to the untreated control.
- In plants treated with either SupaStandPhos followed by Fortifos, Zenith or a coded product, trends for an increase in weight of 25% or more in terms of combined crop biomass (both root and foliage weights) were observed compared to the other treatments and the untreated plots.

Background

The objective of this trial is to compare a number of commercially available biostimulants and evaluate effects on crop growth and biomass of both roots (including the swede) and shoots, as well as any effects on crop health, where possible.

With the continued loss of chemical active ingredients, biostimulants continue to be of great interest to horticultural growers due to the benefits claimed by manufacturers with regards to increasing crop health and resilience against pests and pathogens.

This is an area which is expanding rapidly with an increasing number of products available based on a range of different constituents, such as amino acids, seaweed extracts, growth promoting bacteria, phosphites, humic and fulvic substances for example. These are sometimes now formulated as a combined blend in selected products.

In high value horticulture crops even a small increase in yield or shelf-life, or increased tolerance to disease or drought can mean a larger increase in profit margins than is seen in cereals, and therefore many growers are keen to try these products but unsure of their efficacy as claimed by the manufacturers.

The biostimulants market was reviewed for cereals and oilseeds growers by Dr Kate Storer of ADAS (AHDB funded Research Review No. 89. A review of the function, efficacy and value of biostimulant products available for UK Cereals & Oilseeds was prepared by ADAS as part of a nine-month project (2140032125) which started in November 2015).

On the cereals monitor farms those biostimulants identified with potential are frequently being chosen as a subject to trial, and field vegetable growers are also keen to see independent trials of these products. The review, crucially, also evaluated a wide variety of literature sources to find evidence of benefits associated with the use of biostimulants. Although product diversity made the process of detecting significant benefits challenging, some positive yield results were identified in cereal experiments. It was also noted that limited data was available for UK conditions. For the most common product categories – seaweed extracts, humic substances, phosphite and plant growth promoting bacteria – statistically significant yield responses were observed for 3/7, 3/4, 4/17 and 13/15 cereal experiments, respectively. Dr Kate Storer was quoted "We need to better understand, however, management requirements of these products under UK field conditions to improve consistency of performance, both under experimental and commercial conditions."

A range of biostimulant products were chosen to trial in discussion with East of Scotland Growers and Kettle Produce, and shortlisted to ten programmes.

Summary

Methods

This trial was located at the East Scotland Growers trial ground in Balmullo, Scotland within a crop of the commercially grown variety of swede, Magres, drilled on 29 May. The trial design comprised a fully randomised block design with 11 treatments (Table 1 and 2), including one untreated control and was replicated five times – though only four replicates were assessed for the final destructive assessment due to time constraints. An area of 11 metres wide gave a total trial area of 11 m x 120 m (1320 m^2). Plots were 10m of a 1.8 m-wide bed, comprising five rows of swede. Altogether the trial was seven beds wide including guards either side of the trial. The central row was used for all assessments and excluded the 0.5 m at the end of each plot from the area to be assessed. One half of the plot was used for foliar assessments, while the remaining half was left for destructive assessments.

Table 1. Treatment programmes and timings of applications used in the trial

	Timing 1 – once seedlings established 3-4 leaves 2 July		Timing 2 – approx. 3 weeks after T1 application 6 August		Timing 3 – approx. 3 weeks after T2 application 28 August	
Trt no	**Product**	**Rate (L/ha or kg/ha)**	**Product**	**Rate (L/ha or kg/ha)**	**Product**	**Rate (L/ha or kg/ha)**
1	Untreated control	-	Untreated control	-	Untreated control	-
2	Bridgeway	2.0	Bridgeway	2.0	Bridgeway	2.0
3*	Omex Bio 20	2.0	Omex Bio 20	2.0	Omex Bio 20	2.0
4	TTL plus	1.0	TTL plus	2.5	TTL plus	2.5
5	Zenith	0.15	Zenith	0.15	Zenith	0.15
6	SupaStandPhos	7.0	Fortifos 600	1.5	Fortifos 600	1.5
7	Coded 1	-	Coded 1	-	Coded 1	-
8	AF Turret + AF Nurture	0.05 0.032	AF Phosphorous + AF Nurture	5.0 2.0	AF Phosphorous + AF Nurture	5.0 2.0
9	AF Bioflex + Naturamin	2.0 0.5	AF Bioflex + Naturamin	2.0 0.5	AF Bioflex + Naturamin	2.0 0.5
10	NTS Tri-Kelp	0.4	NTS Tri-Kelp	0.4	NTS Tri-Kelp	0.4
11	NTS Triacontionol	0.032	NTS Triacontionol	0.032	NTS Triacontionol	0.032

* Omex Bio20 was applied 3 times at a lower rate instead of twice as usually recommended – this was agreed with Omex.

Table 2. The biostimulant product details and constituents from available label data. Coded product not included in the list due to confidentiality.

Product	Active ingredient (s)	Company
Bridgeway	Amino acid complex – 18 L-isomer amino acids and peptides, Nitrogen (5%), biological organic carbon (17.5%)	Interagro
Bio 20	Kelp (18.5%) and nutrients – Nitrogen (13.2%), Phosphorous (13.2%), Potassium (13.2%) plus trace elements (Fe, Mn, Cu, Zn, B, Co and Mo)	Omex
TTL Plus	Fulvic and humic acids	Nutrimate
Zenith	Bioeffector – phyto active carbon compounds	Pharm Fertilisers
SupaStandPhos	Plant hormones derived from seaweed plus starter fertiliser – Nitrogen (5%), Phosphorous (18.2%), Potassium (3%) plus trace elements (Fe, Mn, Cu, Zn, Co and Mo)	Pharm Fertilisers

Product	Active ingredient (s)	Company
Fortifos 600	Phosphorous acid (600 g/L) as mono and di potassium phosphonate	Pharm Fertilisers
AF Turret	Starter fertiliser – Nitrogen (8.9%) Phosphorous 13.6%), plus Mg, S, Mn and Zn	Aiva Fertilisers
AF Nurture	Fulvic and humic acids plus Potassium (1.1%), Mg, S, Ca and trace elements (So, Cu, Fe, Mn and Zn)	Aiva Fertilisers
AF Phosphorous	Foliar nutrients inc phosphorous. Nitrogen (7%), Phosphorous (13.8%), and Mg, S and Zn	Aiva Fertilisers
AF Bioflex	Seaweed (*Ascophllum nodosum),* Fulvic and humic acid, Nitrogen (0.95%), Phosphorous (0.14%), Potassium (2.28%), plus Mg, S, So, Cl, Ca and antioxidants	Aiva Fertilisers
Naturamin	Amino acids (80%) and Nitrogen (12.8%)	Novokem
Tri-Kelp	Soluble Organic Seaweed Powder (*Laminaria, Sargassum, Ascophllum nodosum*) – Alginic acid (18%) Nitrogen (0.89%) Potassium (15%) plus trace elements including silicon	Nutri-Tech Solutions
Nutri- Stim Triacontinol	Triacontinol 2.5% - naturally occurring plant growth promoter	Nutri-Tech Solutions

The swedes were netted for insect exclusion, with the net being removed for each application and replaced afterwards. The initial placement of the nets was delayed and the swede seedlings subsequently suffered damage from pigeons, the crop recovered, but the initial biostimulant application was delayed for two weeks to allow enough foliage, and true leaves to be present to absorb the foliar biostimulant sprays.

Treatments were applied using a precision knapsack sprayer with a 1.5 metre boom and 02F110 nozzles at medium quality and 200 litres per hectare water volume. All treatments were applied post-planting at the following timings:

- Timing 1: 2 July 2020 –post-emergence, once seedlings are established (3-4 leaves)
- Timing 2: 6 August 2020- 25 cm height foliage – 6-8 leaves
- Timing 3: 28 August 2020 – 35 cm height foliage – roots expanding

The crop growth stage was recorded at each spray application visit.

Hummingbird Technologies used a drone or unmanned aerial vehicle (UAV) to scan the crop to capture data for normalised difference vegetation index (NDVI). The crops were flown and data collected on two occasions; first, once the crop was at around eight leaves and approximately two weeks after the first biostimulant application (20 July), with the second flight at root expansion, and ten days after the second biostimulant application (19 August).

Two destructive assessments took place to measure the weights of the plant roots and shoots or foliage. Samples were taken from the middle row and the top five metres of the plot avoiding the 0.5 m at the plot edges. The top half of the plot was used for destructive assessments and the bottom half was used for visual assessments. Plots were sampled on August 10th, one week after the second biostimulant application and then on September 23rd, four weeks after the final biostimulant application. At the first sampling five samples were taken per plot for measurement, while at the second and final sampling ten plants were measured per plot to gain a more representative mean due to the variation in root size. This gave 25 samples per treatment in the first sampling, and 40 per treatment in the second sampling as only four replicates were included for the latter sampling due to time restraints, The plants were dug up and shaken carefully to remove as much soil as possible and to prevent the fine roots from tearing, and a fresh weight was taken of all five or ten plants in the plot separately. A mean was then taken from these measurements per plot. The roots were then cut off to be weighed and the weight of the top of the plant was then extrapolated from total fresh weight minus the weight of roots.

Discussion and Conclusion

All treatment programmes in the experiment were safe to use over swedes with no adverse effects observed on the crop. By the conclusion of the trial - one month after the third and final biostimulant application – there were no significant differences in biomass measurements, but several treatments showed higher mean biomass of both the swede and crop foliage (shoots) compared to the untreated control. Plots where SupaStandPhos then Fortifos, Zenith or the coded product were applied (Treatments 5, 6 and 7) show trends for an increase in weight of 25% or more in terms of combined crop biomass (both root and foliage weights) compared to the other treatments and the untreated plots (Table 3).

While, the top three treatments which showed the overall highest mean biomass in the first assessment were the coded product (Treatment 7), followed by Omex Bio 20 and AF Bioflex Plus Naturamin. The latter two products contained the highest percentage of nitrogen at c. 13% w/w applied at each spray which could have led to the greater investment in foliar growth at this earlier swede growth stage (BBCH 18).

Table 3. Results of second destructive harvest on 23 September, one month after the final biostimulant application. Table showing total mean swede, root and foliage weights in grams. Figures highlighted in bold are 5% greater in weight than the untreated control (Treatment 1) in its respective category.

Trt no	Treatment name	Full destructive assessment - 23 September			
		Mean whole plant weight (g)	Mean swede/ root weight (g)	Mean foliage weight (g)	Mean root: foliage %
1	Untreated	698.5	224.0	474.4	29.6
2	Bridgeway	702.4	**251.7**	450.6	**34.6**
3	Omex Bio 20	718.9	**236.0**	482.9	29.2
4	TTL plus	**762.2**	**301.4**	460.8	**40.5**
5	Zenith	**857.3**	**325.7**	**531.6**	**35.2**
6	SupaStandPhos then Fortifos	**901.4**	**323.4**	**578.0**	**38.8**
7	Coded 1	**803.4**	**277.3**	**526.1**	29.6
8	AF Turret + AF Nurture then AF Turret + AF Phosphorous	681.9	207.7	474.3	26.0
9	AF Bioflex + Naturamin	610.1	191.0	419.1	29.2
10	NTS Tri- Kelp	**767.8**	221.6	**546.3**	27.6
11	NTS Triacontinol	**754.3**	**270.4**	483.9	**32.2**
	F pr value	0.236	0.113	0.355	0.149
	d.f.	10	10	10	10
	L.S.D	202.5	100.5	125.3	10.58

Additionally, at the first biomass assessment, though NTS Triacontinol (Treatment 11) and TTL Plus (Treatment 4) did not have the greatest total mean biomass, these treatments showed the greatest root to 'shoot' ratio, which could suggest greater investment in root growth as a result of the application of the biostimulant treatment.

There are many biological processes and pathways which are implicated to be triggered by the use of biostimulants, and while some modes of action have been elucidated, they are still not yet fully understood. Fulvic and humic acids - contained in products TTL Plus, AF Nurture and AF Bioflex - show evidence in studies to increase nutrient use efficiency and uptake, while seaweed derived substances can trigger a hormonal response in the plant. But, there did not appear to be a response from the swede plants to a particular type of product. For example, SupaStandPhos contained kelp plus major nutrients (N, P, K) and trace elements similar to NTS Tri-Kelp and Omex Bio20, but those products did not increase biomass to the same degree by the conclusion of the trial as the programme containing SupaStandPhos.

However, as aforementioned it was difficult to confidently identify trends in this experiment due to the variability in the crop, which meant that no significant differences could be determined.

Further work in a crop with less variability may elucidate more consistent trends, and therefore it would be of benefit to repeat this work to see if similar trends can be observed in another trial.

References

Storer, K. *et al* (2016). A review of the function, efficacy and value of biostimulant products available for UK cereals and oilseeds. AHDB Research Review No. 89

Financial Benefits

It is difficult to confidently determine the financial benefits of the use of biostimulants from this trial as there were no significant conclusions.

SCIENCE SECTION

Introduction

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A range of biostimulant products were chosen to trial in discussion with East of Scotland Growers and Kettle Produce, and shortlisted to ten programmes.

Materials and methods

This trial was located at the East Scotland Growers trial ground in Balmullo, Scotland within a crop of the commercially grown variety of swede, Magres, drilled on 29 May. The trial design comprised a fully randomised block design with 11 treatments (Table 4 and 5), including one untreated control and was replicated five times – though only four replicates were assessed for the final destructive assessment due to time constraints. An area of 11 metres wide gave a total trial area of 11 m x 120 m (1320 m^2). Plots were 10 m of a 1.8 m-wide bed, comprising five rows of swede. Altogether the trial was seven beds wide including guards either side of the trial. The central row was used for all assessments and excluded the 0.5 m at the end of each plot from the area to be assessed. One half of the plot was used for foliar assessments, while the remaining half was left for destructive assessments.

Table 4. Treatment programmes and timings of applications used in the trial

	Timing 1 – once seedlings established 3-4 leaves 2 July		**Timing 2 – approx. 3 weeks after T1 application 6 August**		**Timing 3 – approx. 3 weeks after T2 application 28 August**	
Trt no	**Product**	**Rate (L/ha or kg/ha)**	**Product**	**Rate (L/ha or kg/ha)**	**Product**	**Rate (L/ha or kg/ha)**
1	Untreated control	-	Untreated control	-	Untreated control	-
2	Bridgeway	2.0	Bridgeway	2.0	Bridgeway	2.0
3*	Omex Bio 20	2.0	Omex Bio 20	2.0	Omex Bio 20	2.0
4	TTL plus	1.0	TTL plus	2.5	TTL plus	2.5
5	Zenith	0.15	Zenith	0.15	Zenith	0.15
6	SupaStandPhos	7.0	Fortifos 600	1.5	Fortifos 600	1.5
7	Coded 1	-	Coded 1	-	Coded 1	-
8	AF Turret + AF Nurture	0.05 0.032	AF Phosphorous + AF Nurture	5.0 2.0	AF Phosphorous + AF Nurture	5.0 2.0
9	AF Bioflex + Naturamin	2.0 0.5	AF Bioflex + Naturamin	2.0 0.5	AF Bioflex + Naturamin	2.0 0.5
10	NTS Tri-Kelp	0.4	NTS Tri-Kelp	0.4	NTS Tri-Kelp	0.4
11	NTS Triacontionol	0.032	NTS Triacontionol	0.032	NTS Triacontionol	0.032

* Omex Bio20 was applied 3 times at a lower rate instead of twice as usually recommended – this was agreed with Omex.

Table 5. The biostimulant product details and constituents from available label data. Coded product not included in the list due to confidentiality.

Product	Active ingredient (s)	Company
Bridgeway	Amino acid complex – 18 L-isomer amino acids and peptides, Nitrogen (5%), biological organic carbon (17.5%)	Interagro
Bio 20	Kelp (18.5%) and nutrients – Nitrogen (13.2%), Phosphorous (13.2%), Potassium (13.2%) plus trace elements (Fe, Mn, Cu, Zn, B, Co and Mo)	Omex
TTL Plus	Fulvic and humic acids	Nutrimate
Zenith	Bioeffector – phyto active carbon compounds	Pharm Fertilisers
SupaStandPhos	Plant hormones derived from seaweed plus starter fertiliser – Nitrogen (5%), Phosphorous (18.2%), Potassium (3%) plus trace elements (Fe, Mn, Cu, Zn, Co and Mo)	Pharm Fertilisers
Fortifos 600	Phosphorous acid (600 g/L) as mono and di potassium phosphonate	Pharm Fertilisers
AF Turret	Starter fertiliser – Nitrogen (8.9%) Phosphorous 13.6%), plus Mg, S, Mn and Zn	Aiva Fertilisers
AF Nurture	Fulvic and humic acids plus Potassium (1.1%), Mg, S, Ca and trace elements (So, Cu, Fe, Mn and Zn)	Aiva Fertilisers
AF Phosphorous	Foliar nutrients inc phosphorous. Nitrogen (7%), Phosphorous (13.8%), and Mg, S and Zn	Aiva Fertilisers
AF Bioflex	Seaweed (*Ascophllum nodosum),* Fulvic and humic acid, Nitrogen (0.95%), Phosphorous (0.14%), Potassium (2.28%), plus Mg, S, So, Cl, Ca and antioxidants	Aiva Fertilisers
Naturamin	Amino acids (80%) and Nitrogen (12.8%)	Novokem
Tri-Kelp	Soluble Organic Seaweed Powder (*Laminaria, Sargassum, Ascophllum nodosum*) – Alginic acid (18%) Nitrogen (0.89%) Potassium (15%) plus trace elements including silicon	Nutri-Tech Solutions
Nutri- Stim Triacontinol	Triacontinol 2.5% - naturally occurring plant growth promoter	Nutri-Tech Solutions

The swedes were netted for insect exclusion, with the net being removed for each application and replaced afterwards. The initial placement of the nets was delayed and the swede seedlings subsequently suffered damage from pigeons, the crop recovered, but the initial biostimulant application was delayed for two weeks to allow enough foliage, and true leaves to be present to absorb the foliar biostimulant sprays.

Treatments were applied using an Azo precision knapsack sprayer with a 1.5 metre boom and 02F110 nozzles at medium quality and 200 litres per hectare water volume. All treatments were applied post-planting at the following timings:

- Timing 1: 2 July 2020 –post-emergence, once seedlings are established (3-4 leaves)
- Timing 2: 6 August 2020- 25 cm height foliage – 6-8 leaves
- Timing 3: 28 August 2020 – 35 cm height foliage – roots expanding

The crop growth stage was recorded at each spray application visit.

Table 6. Application details

	Application 1	Application 2	Application 3
Application date	02/07/2020	06/08/2020	28/08/2020
Time of day	19:30	08:10	08:00
Crop growth stage (Max, min average BBCH)	3-4 true leaves BBCH 13-14	25 cm BBCH 16-18	35 cm BBCH41
Crop height (cm)	15	25	35
Crop coverage (%)	15	75	90
Application Method	Spray	Spray	Spray
Application Placement	Foliar	Foliar	Foliar
Application equipment	Azo small plot sprayer	Azo small plot sprayer	Azo small plot sprayer
Nozzle pressure	2.0	2.0	2.0
Nozzle type	Flat fan	Flat fan	Flat fan
Nozzle size	DG Teejet F1102	DG Teejet F1102	DG Teejet F1102
Application water volume/ha	200 L	200	200
Temperature of air - shade (°C)	15.3	18.9	11.1
Relative humidity (%)	75	80	82
Wind speed range (kph)	2	8	12
Dew presence (Y/N)	N	Y	Y
Temperature of soil - 2-5 cm (°C)	13.5	12.7	7.6
Wetness of soil - 2-5 cm	Moist	Moist	Wet
Cloud cover (%)	80	50	100

Hummingbird Technologies used a drone or unmanned aerial vehicle (UAV) to scan the crop to capture data for normalised difference vegetation index (NDVI). The crops were flown and data collected on two occasions; first, once the crop was at around eight leaves and approximately two weeks after the first biostimulant application (20 July), with the second flight at root expansion, and ten days after the second biostimulant application (19 August).

Two destructive assessments took place to measure the weights of the plant roots and shoots or foliage. Samples were taken from the middle row and the top five metres of the plot avoiding the 0.5 m at the plot edges. The top half of the plot was used for destructive assessments and the bottom half was used for visual assessments. Plots were sampled on August 10th, one week after the second biostimulant application and then on September 23rd, four weeks after the final biostimulant application. At the first sampling five samples were taken per plot for measurement, while at the second and final sampling ten plants were measured per plot to gain a more representative mean due to the variation in root size. This gave 25 samples per treatment in the first sampling, and 40 per treatment in the second sampling as only four replicates were included for the latter sampling due to time restraints, The plants were dug up and shaken carefully to remove as much soil as possible and to prevent the fine roots from tearing, and a fresh weight was taken of all five or ten plants in the plot separately. A mean was then taken from these measurements per plot. The roots were then cut off to be weighed and the weight of the top of the plant was then extrapolated from total fresh weight minus the weight of roots.

Data were analysed using ANOVA and Duncan's post- hoc by the ADAS statistician Chris Dyer.

Results

No symptoms of phytotoxicity or crop damage was observed in the crop at the destructive assessments.

NDVI images

The digital images from the multispectral scans on 20 July and 19 August are included below (Figure 1 and 2). The swede trial area is shown by the blue box, and it can be seen that there are no clear differences in NDVI between any of the plots. Any variations in colour in Figure 1, are likely due to natural background variations in plant population or soil conditions as they appear as broad variations which run across beds.

Figure 1. NDVI image of the trial area on 20 July with the swede trial area indicated by the blue box. NDVI image supplied by Hummingbird Technologies.

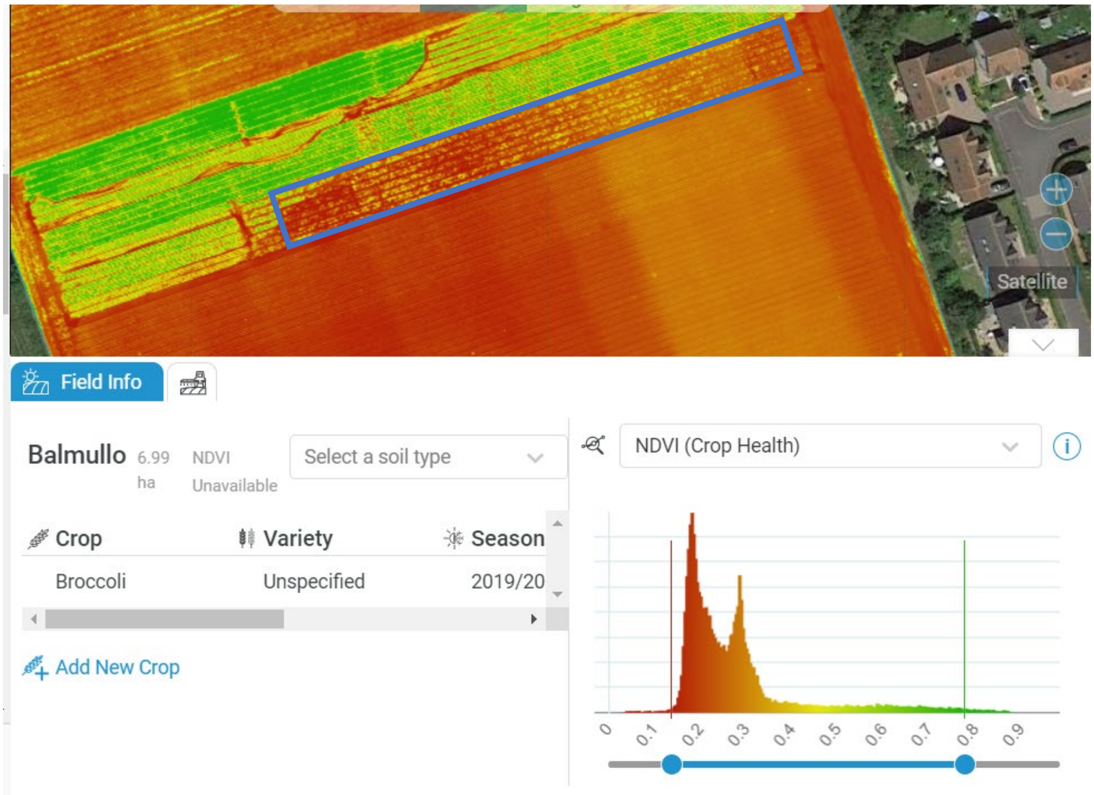
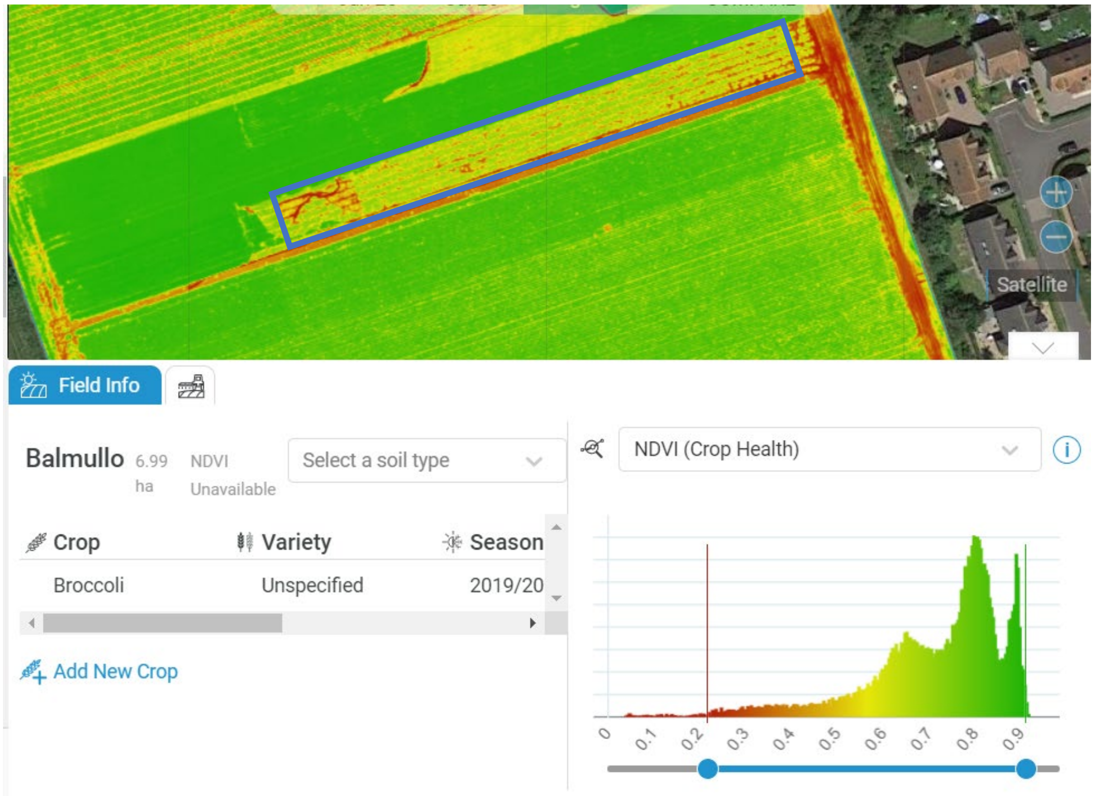


Figure 2. NDVI image of the trial area on 19 August with the swede trial area indicated by the blue box. NDVI image supplied by Hummingbird Technologies



Biomass assessments

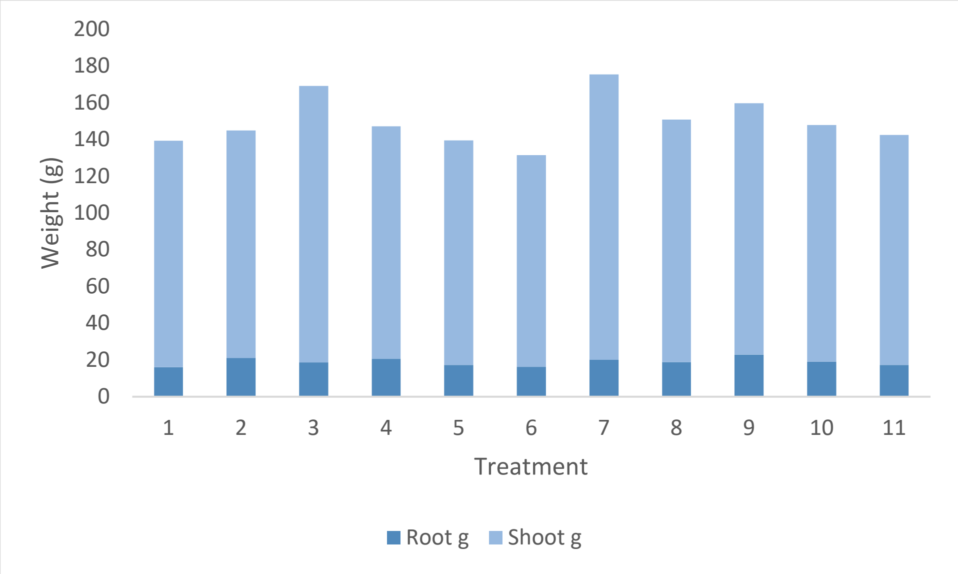
First destructive harvest

There was a high degree of variability in values for the mean root and foliage (shoot) weights between both the different treatments, and also the five blocks within each treatment (Appendix, Table A and B). Due to this variability no statistically significant differences could be determined between the treated plots compared to the untreated control. The treatments with a biomass at least 5% larger than the untreated plots are shown in bold in Table 7 to demonstrate the plots which indicated a trend for greater biomass, but it should be reminded that this is not significant and cannot be confidently attributed to consistent treatment effect rather than natural background trends in variability. The top three treatments which showed the overall highest mean biomass in the first assessment were the coded product (Treatment 7), followed by Omex Bio 20 and AF Bioflex Plus Naturamin (Figure 3). The latter two products contained the highest percentage of nitrogen at c. 13% w/w applied at each spray which could have led to the greater investment in foliar growth at this swede growth stage (BBCH 18).

Table 7. Results of first destructive harvest on 10 August, one week after the second biostimulant application. Table showing total mean root and 'shoot' (foliage) weight in grams. Figures highlighted in bold are 5% greater in weight than the untreated control (Treatment 1) in its respective category.

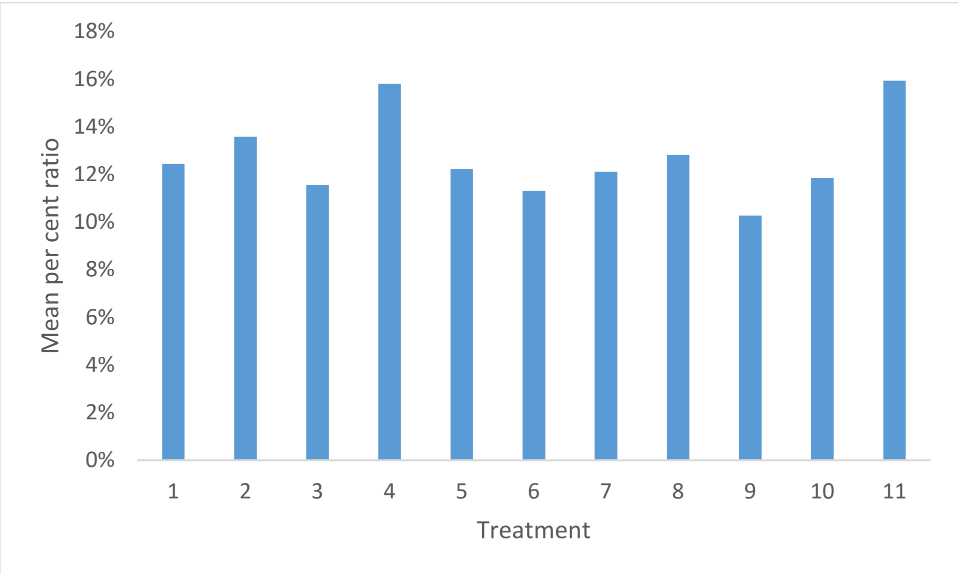
Trt no	Treatment name	First destructive harvest - 10 August		
		Mean root weight (g)	Mean foliage weight (g)	Root: foliage %
1	Untreated	16.2	123.2	12.44
2	Bridgeway	**21.1**	123.8	13.59
3	Omex Bio 20	**18.7**	**150.4**	11.55
4	TTL plus	**20.6**	126.5	15.81
5	Zenith	**17.2**	122.2	12.23
6	SupaStandPhos then Fortifos	16.3	115.2	11.31
7	Coded 1	**20.0**	**155.3**	12.12
8	AF Turret + AF Nurture then AF Turret + AF Phosphorous	**18.9**	**131.9**	12.82
9	AF Bioflex + Naturamin	**22.8**	**136.8**	10.27
10	NTS Tri- Kelp	**19.1**	128.8	11.86
11	NTS Triacontinol	**17.3**	125.0	15.94
	F pr value	0.951	0.974	N/A
	d.f.	10	10	N/A
	L.S.D	9.79	62.95	N/A

Figure 3. Results of first destructive harvest on 10 August, one week after the second biostimulant application showing total mean root and 'shoot' (foliage) weight by treatment number with root weight in dark blue and shoot weight in light blue. Balmullo, Scotland.



Though NTS Triacontinol (Treatment 11) and TTL Plus (Treatment 4) do not have the greatest total mean biomass (Figure 1) these treatments show the greatest root to 'shoot' ratio (Figure 4), which could suggest greater investment in root growth as a result of the application of the biostimulant treatment.

Figure 4. Mean percent root: shoot biomass ratio by treatment. Results of first destructive harvest on 10 August, one week after the second bio stimulant application. Balmullo, Scotland.



Second destructive harvest

Similarly variable results in biomass to the first destructive harvest can be observed in the final destructive swede harvest, undertaken at four weeks after the final biostimulant application. Therefore, due to the high variability there were no significant differences in biomass between plots treated with the biostimulants, compared to the untreated control plots (Table 8). High variation in plant weight and foliar weight (P = 0.236 and 0.355 respectively) was also detected within replicates of the same treatment. As in the first biomass assessment, the treatments with a biomass at least 5% larger than the untreated plots are shown in bold in Table 5 to demonstrate the plots which indicated a trend for greater biomass, but it should be reminded that this is not significant and cannot be confidently attributed to consistent treatment effect rather than natural background trends in variability

Plots treated with SupaStandPhos then Fortifos (Treatment 6) were among the treatments which had the highest root, foliage and plant biomass but did not perform significantly better than the control. Again due to the high variation between plant weights of Treatment 6, despite total mean biomass reaching over one kg in two of the replications (Appendix, Table D).

Focussing on the percent ratio of root matter to foliage (Table 8 and Figure 5), there is a trend for selected treatments to increase percent root to foliage ratio at least 5% greater than that of the untreated control. Plots treated with SupaStandPhos then Fortifos, Zenith or TTLPlus show the greatest investment in the mass of swede and roots increasing weight by a mean of at least 75g compared to the untreated control. However, it should be noted that the untreated control has a low mean ratio, and this result was pulled down by one very low sample in the fourth replicate. If this anomaly were to be ignored, the overall mean root to foliage ratio would be 33% rather than 29.6%, thus showing an even more highly homogenous data set and less distinction between treatments.

Table 8. Results of second destructive harvest on 23 September, one month after the final biostimulant application. Table showing total mean swede, root and foliage weights in grams. Figures highlighted in bold are 5% greater in weight than the untreated control (Treatment 1) in its respective category.

Trt no	Treatment name	Full destructive assessment - 23 September			
		Mean whole plant weight (g)	Mean swede/ root weight (g)	Mean foliage weight (g)	Mean root: foliage %
1	Untreated	698.5	224.0	474.4	29.6
2	Bridgeway	702.4	**251.7**	450.6	**34.6**
3	Omex Bio 20	718.9	**236.0**	482.9	29.2
4	TTL plus	**762.2**	**301.4**	460.8	**40.5**
5	Zenith	**857.3**	**325.7**	**531.6**	**35.2**
6	SupaStandPhos then Fortifos	**901.4**	**323.4**	**578.0**	**38.8**
7	Coded 1	**803.4**	**277.3**	**526.1**	29.6
8	AF Turret + AF Nurture then AF Turret + AF Phosphorous	681.9	207.7	474.3	26.0
9	AF Bioflex + Naturamin	610.1	191.0	419.1	29.2
10	NTS Tri- Kelp	**767.8**	221.6	**546.3**	27.6
11	NTS Triacontinol	**754.3**	**270.4**	483.9	**32.2**
	F pr value	0.236	0.113	0.355	0.149
	d.f.	10	10	10	10
	L.S.D	202.5	100.5	125.3	10.58

Figure 5. Mean percent root: foliage biomass ratio from the results derived from the destructive assessment on 23rd September, Balmullo. Scotland.

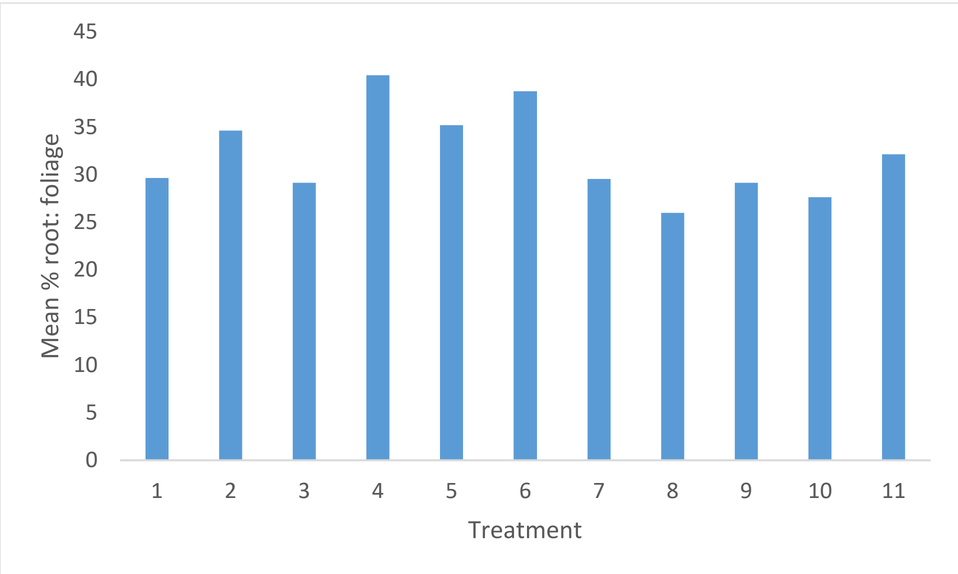
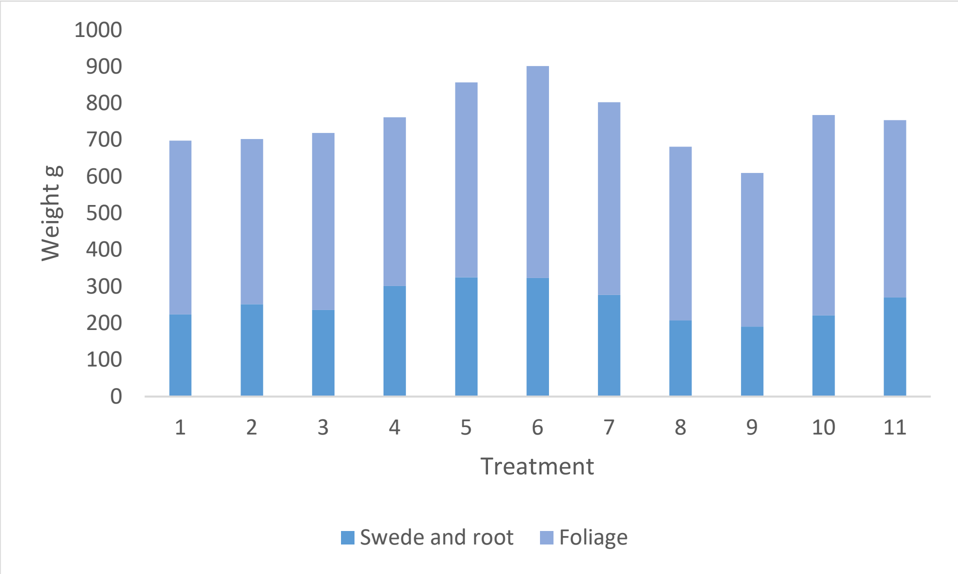


Figure 6. Mean total plant weight by treatment, with foliage and root weight specified in dark blue and light blue, respectively. Results of final destructive harvest on 23rd September, one month after the final bio stimulant application.



Discussion and conclusions

All treatment programmes in the experiment were safe to use over swedes with no adverse effects observed on the crop. By the conclusion of the trial - one month after the third and final biostimulant application – there were no significant differences in biomass measurements, but several treatments showed higher mean biomass of both the swede and crop foliage (shoots) compared to the untreated control. Plots where SupaStandPhos then Fortifos, Zenith or the coded product were applied (Treatments 5, 6 and 7) show trends for an increase in weight of 25% or more in terms of combined crop biomass (both root and foliage weights) compared to the other treatments and the untreated plots.

While, the top three treatments which showed the overall highest mean biomass in the first assessment were the coded product (Treatment 7), followed by Omex Bio 20 and AF Bioflex Plus Naturamin. The latter two products contained the highest percentage of nitrogen at c. 13% w/w applied at each spray which could have led to the greater investment in foliar growth at this earlier swede growth stage (BBCH 18).

Additionally, at the first biomass assessment, though NTS Triacontinol (Treatment 11) and TTL Plus (Treatment 4) did not have the greatest total mean biomass, these treatments showed the greatest root to 'shoot' ratio, which could suggest greater investment in root growth as a result of the application of the biostimulant treatment.

There are many biological processes and pathways which are implicated to be triggered by the use of biostimulants, and while some modes of action have been elucidated, they are still not yet fully understood. Fulvic and humic acids - contained in products TTL Plus, AF Nurture and AF Bioflex - show evidence in studies to increase nutrient use efficiency and uptake, while seaweed derived substances can trigger a hormonal response in the plant. But, there did not appear to be a response from the swede plants to a particular type of product. For example, SupaStandPhos contained kelp plus major nutrients (N, P, K) and trace elements similar to NTS Tri-Kelp and Omex Bio20, but those products did not increase biomass to the same degree by the conclusion of the trial as the programme containing SupaStandPhos.

However, as aforementioned it was difficult to confidently identify trends in this experiment due to the variability in the crop, which meant that no significant differences could be determined.

Further work in a crop with less variability may elucidate more consistent trends, and therefore it would be of benefit to repeat this work to see if similar trends can be observed in another trial.

References

Storer, K. *et al* (2016). A review of the function, efficacy and value of biostimulant products available for UK cereals and oilseeds. AHDB Research Review No. 89

Knowledge and Technology Transfer

East of Scotland Grower Group day – spoke to small groups of growers in organised slots who came to view the trials – 23 and 24 September 2020

Video of overview of trials at Scottish Strategic Centre for Brassicas – https://www.youtube.com/watch?v=7kj8vNOogg8

Presentation to the Brassica Grower Association – 14 October 2020

Acknowledgements

AHDB for funding the work, and also the biostimulant companies for their financial contributions as well as providing samples for the trials. Thanks should also be given to East of Scotland Growers (ESG) for hosting the trial and Kettle Produce for their input. Particular thanks should be given to James Rome and Duncan MacLachlan of ESG for their technical input and in-kind support with trial management and assessments.

Appendices

Table A. Mean total **root biomass in g** per plot from five plants sampled per plot in first destructive harvest on 10/09/2020 by treatment and replicate to show variation.

Treatment	Block					Total mean
	1	2	3	4	5	
1	13.8	22.4	31.2	8.6	17	18.6
2	21.2	12.2	17.8	14.2	36.2	20.32
3	29.8	23.6	20	19.2	9.2	20.36
4	24	25.6	15.2	20.2	11	19.2
5	13	24.2	17.2	20.6	6	16.2
6	19.2	19.4	37.6	11.4	12.2	19.96
7	17.2	23.8	7.8	6.4	12.2	13.48
8	21.4	22.8	21.8	15	31.4	22.48
9	16.8	21.8	13.4	9.8	19.8	16.32
10	30.8	15	24.2	3.2	22.2	19.08
11	14.6	24.4	31.8	16.8	22.4	22

Table B. Mean total **shoot biomass in g** per plot from five plants sampled per plot in first destructive harvest on 10/09/2020 by treatment and replicate to show variation.

Treatment	Block					Total mean
	1	2	3	4	5	
1	85.4	183	130.6	74.6	147.6	124.24
2	155.4	92.4	91.2	94	209.4	128.48
3	183	157.4	146.2	157.6	88	146.44
4	138.2	185.2	79.8	161.8	51.4	123.28
5	77.4	196.6	92	166.4	47.6	116
6	175.2	185	162.8	114	112	149.8
7	114.4	176.6	63.2	65.4	105.4	105
8	133.2	199.4	89.6	128	264.6	162.96
9	136.6	177.8	84.4	83.8	161.6	128.84
10	219.2	131.4	122.8	37.2	169.4	136
11	77.6	160	149.2	114.6	89.6	118.2

Table C. Mean of **root: shoot ratio %** per plot from five plants sampled per plot in first destructive harvest on 10/09/2020 by treatment and replicate to show variation.

Treatment	Block					Total mean
	1	2		1	2	
1	12.60%	10.13%	19.00%	10.24%	10.22%	12.44%
2	11.80%	12.91%	16.14%	12.84%	14.25%	13.59%
3	14.34%	12.65%	11.70%	10.29%	8.77%	11.55%
4	16.31%	11.95%	15.88%	11.55%	23.34%	15.81%
5	14.37%	10.63%	14.78%	10.58%	10.77%	12.23%
6	9.83%	9.35%	18.56%	8.99%	9.83%	11.31%
7	19.70%	11.36%	11.23%	8.28%	10.00%	12.12%

Treatment	Block					Total mean
	1	2		1	2	
8	13.34%	10.50%	19.01%	10.61%	10.66%	12.82%
9	9.91%	10.56%	11.37%	9.07%	10.45%	10.27%
10	12.49%	10.81%	16.48%	8.28%	11.22%	11.86%
11	17.47%	12.49%	17.44%	12.38%	19.94%	15.94%

Table D. Mean total **plant weight** in g per plot from ten plants sampled per plot from final destructive harvest on 23/09/2020 by treatment and replicate to show variation.

Treatment	Block				Total mean
	1	2	3	4	
1	774.15	833.8	583.15	602.7	698.45
2	755.4	662.6	620.35	771.1	702.3625
3	796.9	814.55	623.2	640.9	718.8875
4	678.95	787.35	955.55	626.85	762.175
5	966.25	790.35	935.8	736.8	857.3
6	628.35	1049.55	1049.75	877.9	901.3875
7	849.45	702.95	583.05	1078.15	803.4
8	770.6	707.45	470	779.65	681.925
9	750.35	509.35	732.6	448.25	610.1375
10	782.95	853.75	641.65	792.95	767.825
11	740.9	742.95	783.2	750.2	754.3125

Table E. Mean total **root weight** in g per plot from ten plants sampled per plot from final destructive harvest on 23/09/2020 by treatment and replicate to show variation.

Treatment	Block				Total mean
	1	2	3	4	
1	303.15	273.05	191.5	128.45	224.0375
2	261.95	222.6	178.9	343.5	251.7375
3	271.75	284.65	175.45	212.05	235.975
4	316.7	339.75	364.3	184.9	301.4125
5	344.6	294	405.85	258.5	325.7375
6	189.4	433.75	364.4	305.9	323.3625
7	313.65	246.1	180.6	368.85	277.3
8	200.75	232.55	134.35	262.95	207.65
9	246	147.3	239.25	131.5	191.0125
10	200.4	277.15	214.5	194.2	221.5625
11	310.9	237.95	293.05	239.75	270.4125

Table F. Mean total **foliage weight** in kg per plot from ten plants sampled per plot from final destructive harvest on 23/09/2020 by treatment and replicate to show variation.

Treatment	Block				Total
	1	2	3	4	
1	471	560.75	391.65	474.25	474.4125
2	493.45	440	441.45	427.6	450.625
3	525.15	529.9	447.75	428.85	482.9125
4	362.25	447.6	591.25	441.95	460.7625
5	621.65	496.35	529.95	478.3	531.5625
6	438.95	615.8	685.35	572	578.025
7	535.8	456.85	402.45	709.3	526.1
8	569.85	474.9	335.65	516.7	474.275
9	504.35	362.05	493.35	316.75	419.125
10	582.55	576.6	427.15	598.75	546.2625
11	430	505	490.15	510.45	483.9

Table G. Mean total % **root: foliage ratio** per plot from ten plants sampled per plot from final destructive harvest on 23/09/2020 by treatment and replicate to show variation.

Treatment	Block				Total
	1	2	3	4	
1	36.43	32.05	30.56	19.53	29.64
2	29.82	33.93	26.95	47.78	34.62
3	33.36	28.40	25.64	29.27	29.17
4	41.06	56.21	36.09	28.47	40.46
5	31.75	35.82	39.76	33.53	35.22
6	25.01	38.58	31.95	59.50	38.76
7	29.91	29.64	26.10	32.61	29.56
8	24.40	28.28	25.67	25.63	26.00
9	28.67	27.73	27.37	32.88	29.16
10	23.86	31.66	33.01	21.98	27.63
11	33.24	29.42	32.31	33.66	32.16

Weather data – provided by East of Scotland Growers

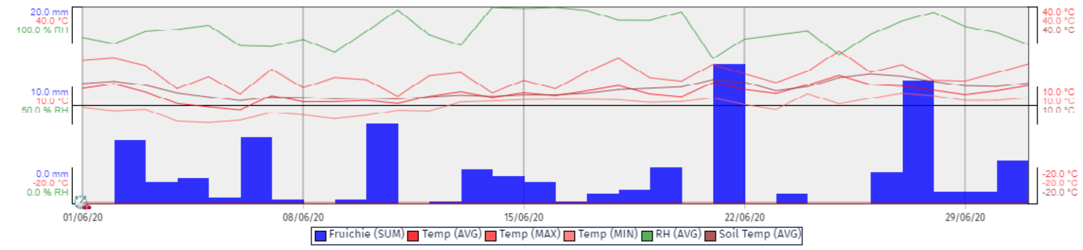
June

2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Y

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SUM (mm)	6.4	2.2	2.6	0.6	6.8	0.4	0.0	0.4	8.2	0.0	0.2	3.4	2.8	2.2	0.2
AVG (°C)	14.1	10.6	9.6	8.7	13.0	11.1	11.1	11.6	10.6	12.8	14.2	12.5	13.9	13.1	14.5
MIN (°C)	8.9	5.3	4.9	5.6	7.9	7.1	6.0	7.0	8.6	8.4	11.1	11.4	11.8	11.9	11.9
MAX (°C)	22.2	15.2	18.8	13.5	21.1	15.4	18.6	17.9	12.8	19.1	20.1	13.9	17.7	15.1	20.3
AVG (% RH)	87.7	89.0	90.9	80.5	80.2	83.8	77.3	87.7	98.8	86.0	80.8	100.0	99.4	100.0	98.5
MIN (% RH)	58.5	74.2	67.2	62.2	62.8	74.1	60.7	69.6	94.8	69.0	65.8	100.0	96.4	100.0	89.0
MAX (% RH)	100.0	100.0	99.6	99.5	99.0	94.8	88.8	98.8	100.0	100.0	99.9	100.0	100.0	100.0	100.0
AVG (°C)	16.2	13.9	12.7	11.5	12.6	12.4	12.0	12.2	11.9	12.7	13.2	12.8	13.3	13.3	13.8

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	June
SUM (mm)	1.0	1.4	3.6	0.0	14.2	0.0	1.0	0.0	0.0	3.2	12.6	1.2	1.2	4.4	80.2
AVG (°C)	16.1	13.6	12.7	17.0	14.9	13.7	16.3	19.2	16.4	15.9	14.7	13.4	14.5	16.1	13.8
MIN (°C)	11.7	11.0	11.2	12.3	10.3	8.9	13.6	10.5	12.2	13.8	13.0	11.5	11.5	12.3	4.9
MAX (°C)	24.4	18.5	17.5	22.5	19.7	17.0	20.4	26.7	20.2	22.5	17.8	17.5	20.0	22.7	26.7
AVG (% RH)	93.5	93.4	97.8	74.0	83.9	85.9	87.9	76.0	86.2	93.2	97.6	90.4	87.2	81.2	88.3
MIN (% RH)	72.5	75.0	82.9	46.3	65.2	73.2	74.0	53.0	72.5	68.5	87.0	78.3	66.0	53.7	46.3
MAX (% RH)	100.0	100.0	100.0	100.0	99.8	98.9	97.7	100.0	99.8	100.0	100.0	96.6	97.0	99.2	100.0
AVG (°C)	14.9	15.2	15.7	17.9	17.1	14.5	15.7	18.5	19.6	18.9	17.3	16.0	15.8	16.9	14.9



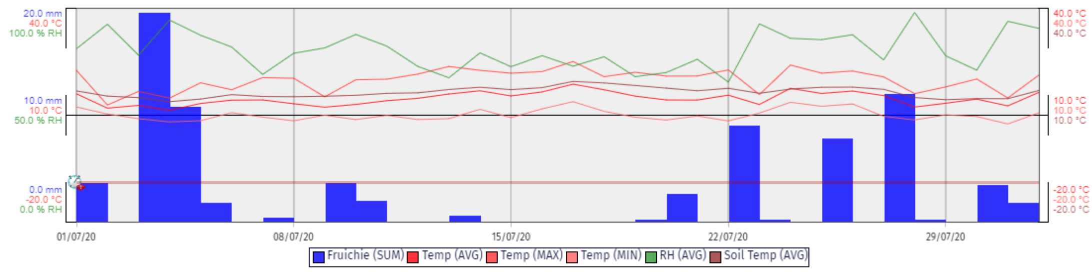
July

2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Y

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SUM (mm)	0.0	19.6	10.8	1.8	0.0	0.4	0.0	3.6	2.0	0.0	0.0	0.6	0.0	0.0	0.0
AVG (°C)	12.8	11.4	13.3	14.3	14.3	13.2	12.3	13.1	14.1	14.8	16.0	16.9	15.4	16.6	18.8
MIN (°C)	9.0	8.1	8.5	10.7	9.5	8.4	10.0	8.8	10.0	8.8	9.0	11.7	9.3	11.8	13.8
MAX (°C)	16.7	14.8	19.2	17.2	20.6	20.4	15.2	20.0	20.2	21.6	23.8	22.7	21.9	22.3	25.1
AVG (% RH)	78.2	94.7	87.6	82.1	69.2	79.1	81.6	88.0	82.5	72.9	67.6	79.3	72.8	78.0	73.1
MIN (% RH)	63.5	69.8	69.2	65.2	47.8	50.5	62.4	53.5	56.2	50.1	44.2	53.9	50.7	55.3	56.0
MAX (% RH)	96.3	100.0	100.0	100.0	89.9	93.6	96.1	100.0	100.0	95.8	88.5	96.4	95.9	97.0	87.7
AVG (°C)	15.0	13.8	14.6	15.8	15.3	15.2	15.4	15.6	16.2	16.3	17.3	17.9	17.2	17.8	19.5

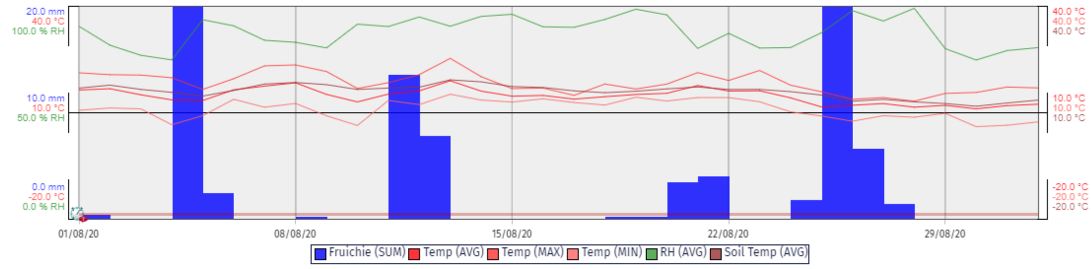
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	July
SUM (mm)	0.0	0.0	0.2	2.6	0.0	9.0	0.2	0.0	7.8	0.0	12.0	0.2	0.0	3.4	1.8	79.6
AVG (°C)	17.2	15.4	14.3	14.3	15.7	13.0	17.6	16.1	16.8	15.5	12.3	13.4	14.6	12.6	16.	14.7
MIN (°C)	11.1	9.4	8.6	9.8	8.4	10.6	13.7	12.5	13.2	9.7	8.7	10.1	9.6	7.5	10.	7.5
MAX (°C)	20.9	22.1	21.0	21.1	22.8	15.8	24.2	21.9	22.5	20.8	16.1	18.0	20.2	14.9	21.	25.1
AVG (% RH)	77.5	68.1	70.1	76.3	65.6	92.9	86.2	85.5	87.8	76.0	98.3	77.9	71.2	94.1	90.	80.6
MIN (% RH)	57.1	44.6	48.0	51.1	42.9	75.9	57.4	63.2	67.7	47.9	93.2	61.3	49.6	79.3	75	42.9
MAX (% RH)	93.8	97.6	90.1	94.5	92.7	100.0	100.0	99.7	100.0	99.1	100.0	98.5	90.4	100.0	100	100.0
AVG (°C)	19.1	18.4	17.7	16.9	17.6	16.2	17.4	17.9	17.9	17.3	15.0	14.4	14.7	14.7	17.	16.5



August

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Y

	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	August
SUM (mm)	0.0	26.4	2.4	0.0	0.0	0.2	0.0	0.0	13.6	7.8	0.0	0.0	0.0	0.0	0.0	0.2	0.2	3.4	4.0	0.0	0.0	1.8	31.6	6.6	1.4	0.0	0.0	0.0	0.0	100.0
AVG (°C)	13.7	13.5	16.5	17.6	18.5	15.2	13.1	15.3	16.2	19.1	16.1	14.7	14.9	13.9	14.6	15.2	15.5	17.7	16.2	16.2	14.2	11.7	12.1	12.6	11.6	12.1	11.1	12.0	12.4	14.7
MIN (°C)	6.6	9.2	13.8	11.6	12.6	9.2	6.4	13.5	12.3	15.3	13.6	13.0	14.0	12.9	12.2	14.4	13.3	14.3	14.3	13.1	10.3	9.1	7.6	9.2	8.7	9.8	6.1	6.5	7.4	6.1
MAX (°C)	19.9	16.6	19.7	23.3	23.5	21.7	16.9	18.5	20.8	25.4	20.2	16.9	17.0	14.9	18.1	16.7	18.1	21.4	19.2	22.0	17.8	16.0	13.8	14.3	13.3	15.5	15.8	17.3	17.1	25.4
AVG (% RH)	75.0	93.9	91.0	84.2	83.3	80.6	91.8	90.7	95.2	90.8	95.5	96.5	90.6	90.3	94.1	98.9	96.2	80.4	87.5	80.5	80.8	87.8	98.2	93.3	99.3	80.3	74.9	79.4	80.7	87.8
MIN (% RH)	51.4	79.6	78.6	63.4	65.9	54.2	79.7	78.1	82.5	73.9	85.2	90.4	81.1	84.7	81.4	92.6	86.1	61.8	76.8	58.8	60.3	71.1	92.0	81.4	94.5	56.0	56.9	53.7	57.0	50.5
MAX (% RH)	98.8	100.0	99.4	99.4	98.1	99.5	100.0	98.9	100.0	100.0	100.0	100.0	98.3	95.9	100.0	100.0	100.0	100.0	98.3	94.6	98.5	100.0	100.0	100.0	100.0	100.0	94.1	94.9	98.8	100.0
AVG (°C)	15.8	14.7	16.3	18.1	18.6	18.0	16.6	17.0	17.3	19.3	18.8	17.4	17.2	16.2	15.7	16.1	16.8	17.3	16.6	16.6	16.0	15.0	13.3	13.8	13.1	12.6	11.8	12.8	13.6	16.0



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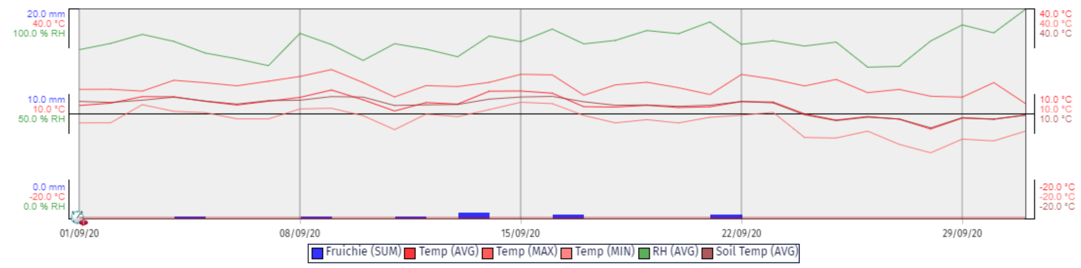
September – note the rain gauge may have been stuck in this month

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	September
SUM (mm)	.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.6	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
AVG (°C)	.1	15.0	14.9	13.6	12.6	13.7	14.7	16.9	14.1	10.8	13.3	12.8	16.5	16.6	15.9	12.1	12.0	12.5	11.8	12.1	13.6	13.4	10.0	8.2	9.2	8.5	5.7	8.8	8.5	9.7	12.3
MIN (°C)	.5	12.7	10.8	10.4	8.6	8.6	11.4	11.6	9.5	5.5	9.9	9.2	11.2	13.3	13.0	9.6	7.4	8.4	7.4	9.0	9.6	10.5	3.2	3.1	5.1	1.3	-1.2	2.8	2.3	5.0	-1.2
MAX (°C)	.1	16.5	19.7	19.0	18.1	19.4	20.7	22.7	19.0	14.9	18.1	17.9	19.1	21.4	21.2	15.4	18.3	19.1	17.5	15.6	21.3	20.0	18.0	19.9	16.1	17.0	15.1	14.8	19.0	13.0	22.7
AVG (% RH)	.7	88.1	84.7	79.1	76.4	73.1	88.5	83.2	75.6	83.6	81.0	77.3	87.3	84.6	90.6	83.5	85.2	89.9	88.4	94.0	83.3	85.0	82.5	84.4	72.4	72.8	84.9	92.6	88.8	100.0	84.1
MIN (% RH)	.3	78.9	65.6	58.2	51.7	41.9	75.6	61.5	57.0	68.7	62.0	54.9	77.1	64.0	67.6	72.7	66.5	61.7	51.3	80.3	54.1	58.2	59.0	55.6	48.0	45.0	46.7	78.5	47.6	100.0	41.9
MAX (% RH)	.6	97.9	98.7	95.9	91.4	97.5	97.2	97.5	96.4	99.5	91.1	97.2	98.6	97.9	100.0	95.3	98.5	100.0	100.0	100.0	100.0	97.4	100.0	100.0	97.7	97.8	100.0	100.0	100.0	100.0	100.0
AVG (°C)	.3	13.9	14.8	13.7	12.8	13.8	13.9	15.0	14.8	12.4	12.6	12.7	14.2	14.9	15.0	13.5	12.5	12.6	12.2	12.5	13.6	13.2	9.8	8.1	9.1	8.6	6.0	8.9	8.5	9.7	12.2



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