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26/09/2023

Integrated Pest Management (IPM) for main season polytunnel strawberry production

AGENDA

2:00 – 3.00pm PM, IPM Strawberries, HC Classroom

Delivered by: **David Davidson** - Koppert

3:00 – 3.30PM – Crop walk and discussion, HC Strawberry tunnel

Delivered by:

Ben Eaton – CAFRE HC Manager (Crop management practices and procurement)

James Crawford – CAFRE Horticulture Adviser (Initial crop and facilities management)

Mark Huey - CAFRE Horticulture Technologist (Technical notes and project delivery)

Lucille Gilpin – CAFRE HE Lecturer (Initial project leader as Horticulture Technologist)

Conor Gallinagh - CAFRE Senior Horticulture Adviser (Project concept and industry communication)

Kostas Xyntaris - CAFRE Senior Horticulture Technologist (Technical notes supervision and project delivery)

3:45 PM – Final Discussions / Conclusions, HC Classroom

4 PM - Close of Event

➢ The main pests and diseases found in strawberry crops are:

- Strawberry powdery mildew (SPM)
- Botrytis
- Crown rot
- Aphids
- Red spider mite
- Thrips

✓ Project set up to demonstrate IPM in polytunnel strawberry production using only biological pesticides and predators.

✓ Tray plants of 'Malling Centenary' planted in coir filled trays in the first week of July 2023 at a density of ~10 plants/metre.

✓ This cultivar is prone to crown rot, but decision was made to rely solely on biological fungicide to control it (Trianum G in substrate) and no Paraat drench was applied.

✓ Environmental data, yield and plant losses recorded.

Relative Humidity and Temperature

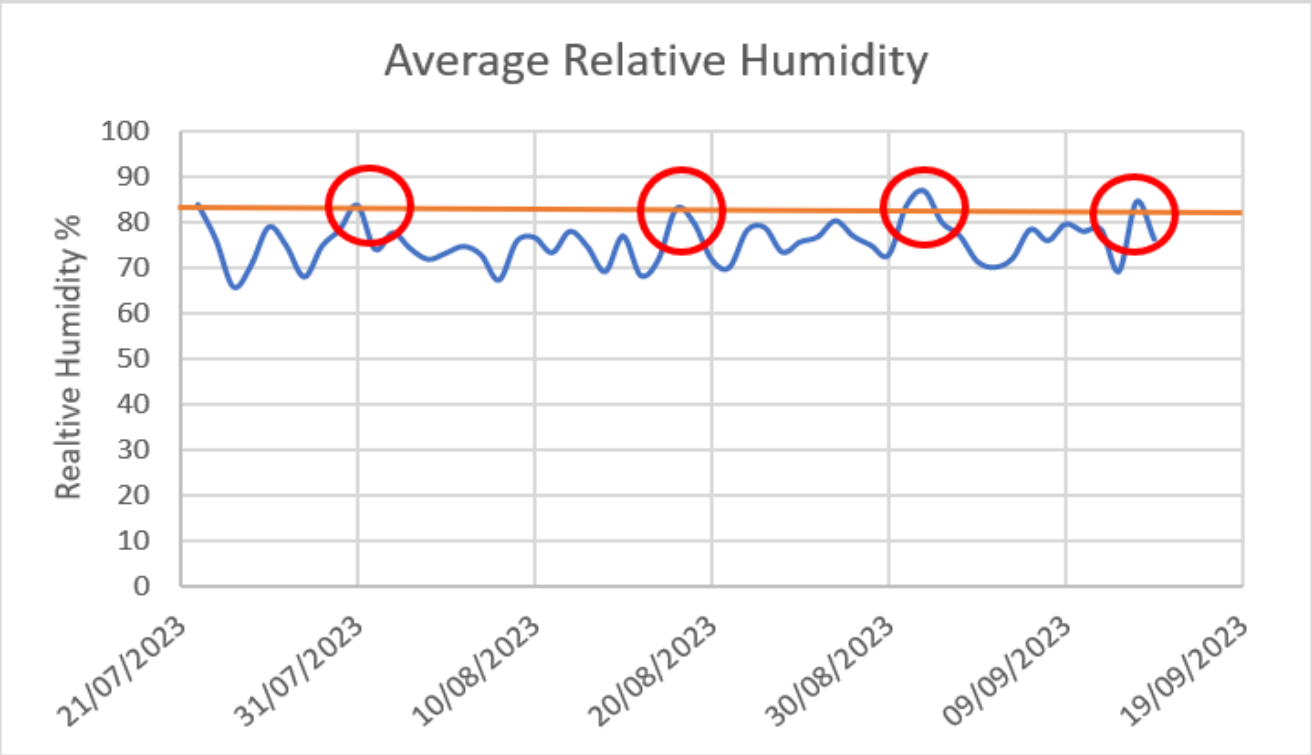
- ✓ AHDB Strawberry Powdery Mildew (SPM) model suggests RH> 82% and temperature >14°C generates high risk of active infection.
- ✓ In the botrytis model RH > 82% and temperature >16°C creates high risk.
- ✓ AHDB guidance with model was during low-risk periods, no treatment.
- ✓ Medium risk – preventative spray with biological fungicide (Amylo X, Serenade etc.)
- ✓ Advice at high-risk periods/active disease found is to use eradicant fungicides – *none used in this demonstration.*
- ✓ 'Moderate' risk for most of growing season
- ✓ 4 high risk periods from end July to mid-September for SPM/botrytis.
- ✓ Just using SB Invigorator still produced a clean crop.

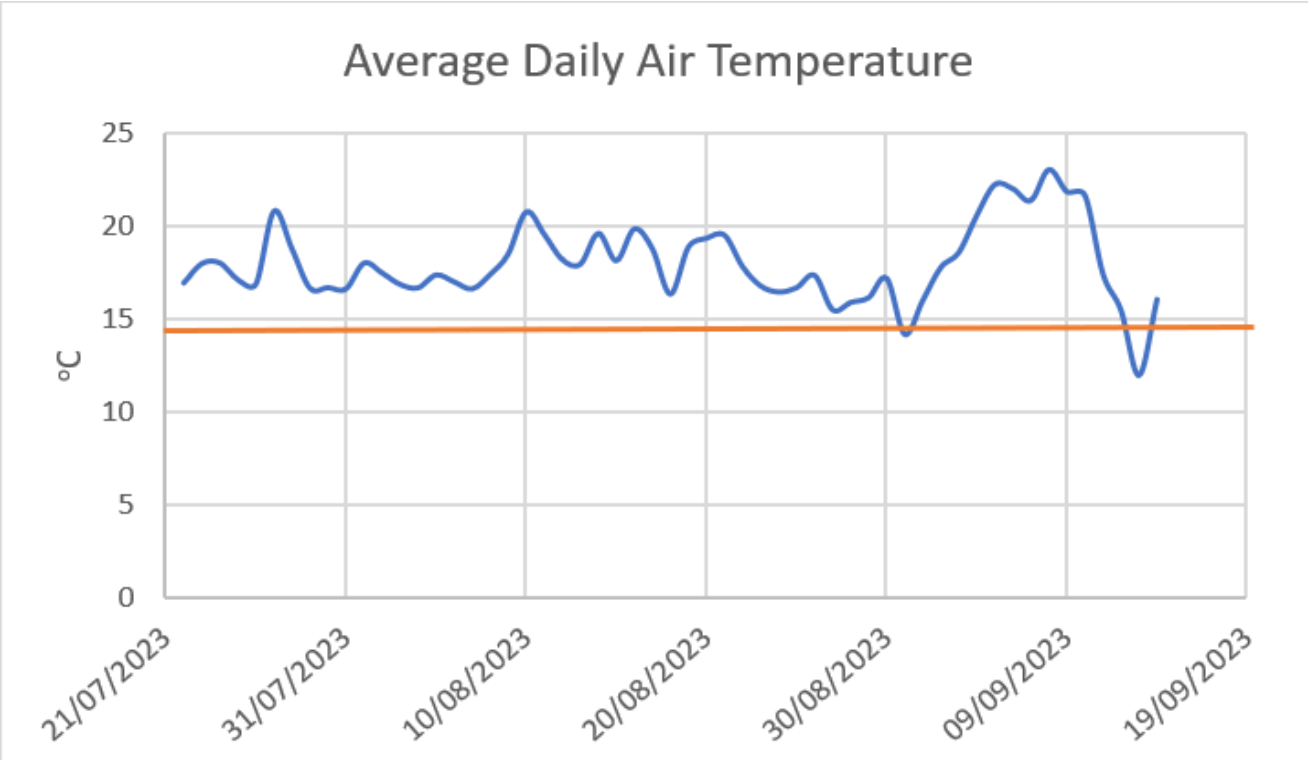
Table classifying low, medium, and high-risk infection periods for SPM and botrytis based on relative humidity and temperature from AHDB report SF 157 '*Improving integrated disease management in strawberry – final report*'.

Condition		SPM risk
Temperature	Humidity	
< 14	Not relevant	Low
≥ 14	< 82%	Moderate
≥ 14	≥ 82%	High
		Botrytis risk
Not relevant	< 82%	Low
< 16	82% - 87%	
< 16	≥ 87%	Moderate
≥ 16	≥ 82%	High

Graphs showing average daily temperature and humidity levels in polytunnel at HC.

Orange lines indicate high risk conditions for SPM (greater than 82% RH, 14°C), red circles are high risk infection periods for SPM and botrytis.





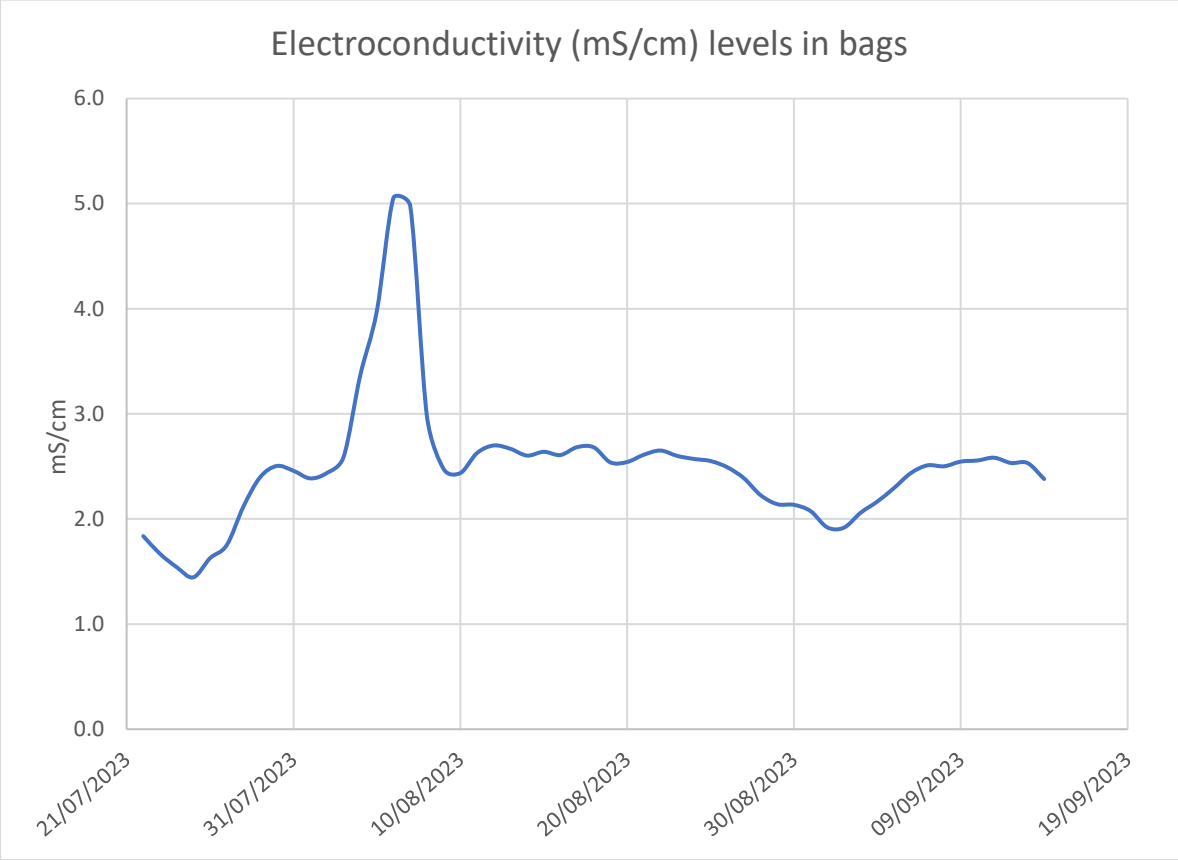
Insect control

- ✓ Industry heavily reliant on biologicals during cropping.
- ✓ Aphids – Aphidscout, Aphidend, Chrysopa
- ✓ Thrips – Thripex
- ✓ Spider mite – Spidex
- ✓ Very low infestation of any pest in crop
- ✓ Note - tunnel is ~ 288m^2, actual cropping area is 175m$^{2.}$

Fertiliser

- Used recipe suggested by fertiliser company, aim for ~2.0mS/cm.
- Spike in early season caused by breakdown in irrigation equipment.

Recorded electroconductivity (EC) levels in bags in mS/cm (Milli-Siemens/cm)



Foliar and substrate analysis

Greenmount strawberry crop substrate parameters along with normal ranges and notes.				
Parameter	**Greenmount crop analysis[1]**	**Recommended range[2]**	**units**	**Notes[2]**
Electrical conductivity (EC)	499	660 - 1100	µS	Indicated range refers to substrate EC when reported by laboratory analysis, not the EC of the feed solution within the substrate as measured by portable probes such as the WET sensor. The latter will give a higher reading equivalent to the run-off solution. High conductivities reduce water uptake and increase fruit firmness and flavour but can reduce yields and in extreme cases cause marginal scorch to the foliage. Excessive ECs can be reduced by flushing with calcium nitrate solution (for excess NaCl) or plain water.
Nitrate (NO_3) N	102.7	31-92	Mg/L	Deficiency causes small, yellow, or reddish leaves and poor growth. High levels can cause excessive growth
Ammonia-N	1.8	<3.3	Mg/L	Excess levels limit calcium uptake, and affects fruit firmness and colour
Total soluble N	104.4		Mg/L	
Phosphorus	31.5	7 - 20	Mg/L	Deficiency causes small pale leaves, small fruit, and lower yields
Potassium	187.1	65 - 129	Mg/L	Deficiency causes poorer flavoured fruit and brown leaf margins. Excess levels limit calcium uptake and affects fruit firmness and colour
Magnesium	37.9	13 - 26	Mg/L	Deficiency causes interveinal reddening of older leaves. Excessive magnesium is not normally a problem but could reduce potassium uptake
Calcium	135.4	53 - 110	Mg/L	Deficiency causes tip burn on the young leaves and soft fruit particularly when associated with high potassium or magnesium levels
Sodium	101.7	<51	Mg/L	To reduce excess salts flush through with calcium nitrate solution
Chloride	90.1	<77	Mg/L	To reduce excess salts flush through with calcium nitrate solution
Boron	0.21	0.12 – 0.19	Mg/L	Deficiency causes yellowed leaves and small deformed fruit
Copper	<0.01	0.02 – 0.04	Mg/L	Deficiency causes yellowed leaves, shoot die back and small fruit
Manganese	0.04	0.24 – 0.48	Mg/L	Deficiency causes interveinal leaf yellowing, more diffuse than with iron deficiency
Zinc	0.16	0.72 – 1.07	Mg/L	Deficiencies causes pale green leaves with narrow concave blades, plus reports of poorer flavoured fruit. Excess causes leaf scorch and reduces iron deficiency
Iron	0.27	0.62 – 1.	Mg/L	Deficiency causes interveinal yellow leaves, in extreme cases completely bleached, but symptoms more often caused by poor uptake than low levels in substrate.

Sources: [1]NRM, https://cawood.co.uk/nrm/ ,
[2] https://projectbluearchive.blob.core.windows.net/media/Default/Horticulture/Publications/Strawberry%20analysis%20A1%20chart%20V3.pdf

- Higher than recommend levels of sodium/chloride – incomplete flushing of coir at start?
- NPK's all at high end of range (reflection of high EC used).
- Some low levels of micronutrients, not always reflected in leaf analysis.

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Leaf tissue analysis and NRM guidelines.

Reported: 15/09/23

SAMPLE NAME: STRAWBERRY **CROP: STRAWBERRY**

ANALYSIS	RESULT	INTERPRETATION (Deficient / Low / Normal / High / Excessive)	COMMENTS
Nitrogen (N) [N:S Ratio]	2.85 %	2.50 | 2.80 | 3.50 | 5.00	Nutrient status satisfactory.
Sulphur (S) [21.2 : 1]	0.134 %	0.03 | 0.09 | 0.20 | 0.50	Nutrient status satisfactory.
Phosphorus (P)	0.463 %	0.25 | 0.28 | 0.35 | 1.00	P is high. Possible causes: high soil P or excessive P fertiliser.
Potassium (K)	3.01 %	1.00 | 1.50 | 2.50 | 4.00	K is high. Possible causes: high soil K or excessive K fertiliser.
Calcium (Ca)	2.59 %	0.08 | 0.20 | 1.50 | 3.00	Ca is high. Possible causes: diseased or dead tissue sampled old plant tissue sampled.
Magnesium (Mg)	0.571 %	0.10 | 0.14 | 0.24 | 0.80	Mg is high. Possible causes: diseased or dead tissue sampled old plant tissue sampled.
Manganese (Mn)	160 mg/kg	4.00 | 25 | 100 | 150	Mn is high. Possible causes: high N/P applications on low pH or low OM soils, low soil pH, soil or fungicide contamination .
Iron (Fe)	134 mg/kg	50 | 70 | 250 | 350	Nutrient status satisfactory.
Copper (Cu)	2.47 mg/kg	2.00 | 3.00 | 12 | 20	Cu is low. Possible causes: low soil availability high soil pH, high soil organic matter high soil Fe/Mn, leaching.
Zinc (Zn)	21.3 mg/kg	6.00 | 15 | 60 | 100	Nutrient status satisfactory.
Boron (B)	52.2 mg/kg	18 | 22 | 80 | 140	Nutrient status satisfactory.

The points summarised above are only meant as a guide to the likely cause of a nutrient problem. It is beyond the scope of this report to consider trace element interactions, lock up etc.

- Leaf analysis showed running higher NPK's than required – use lower EC next year.
- Copper low – was low in substrate analysis as well.
- Iron, zinc, and boron fine.

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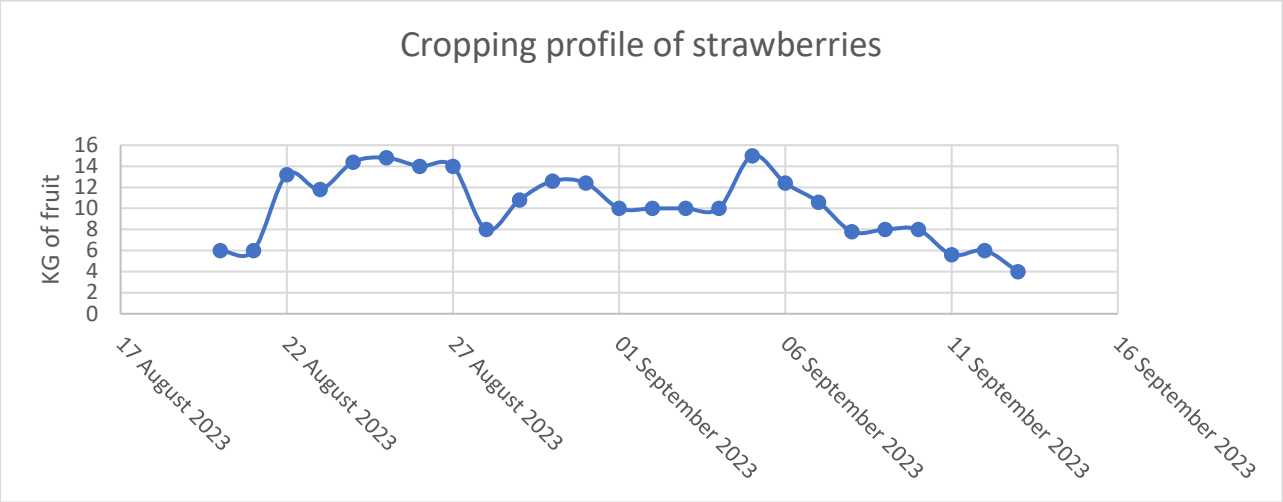
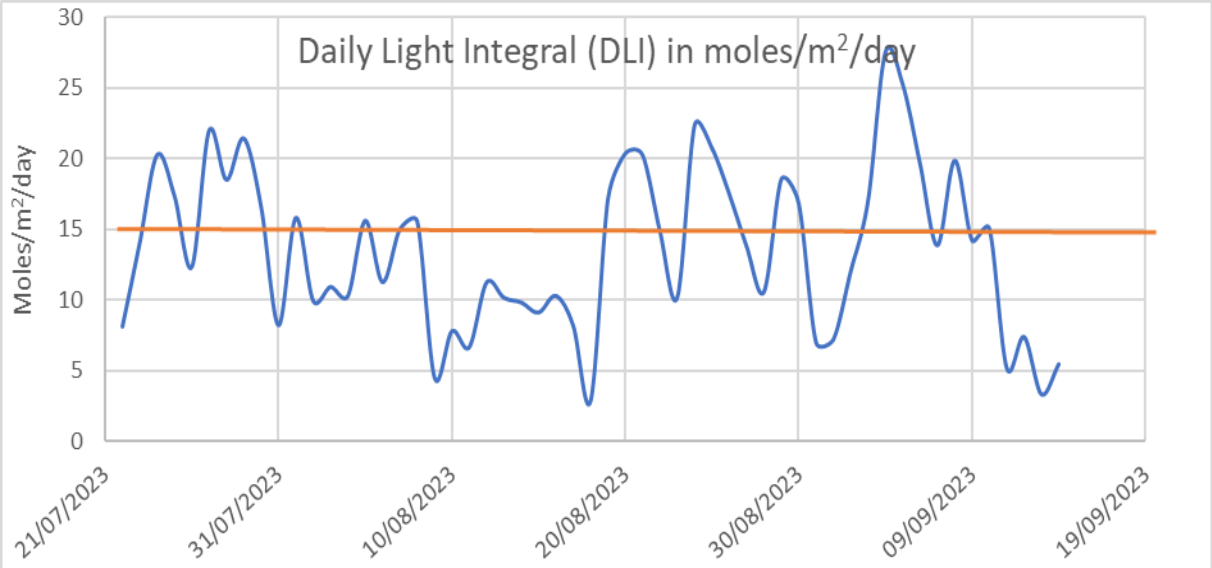
Yield



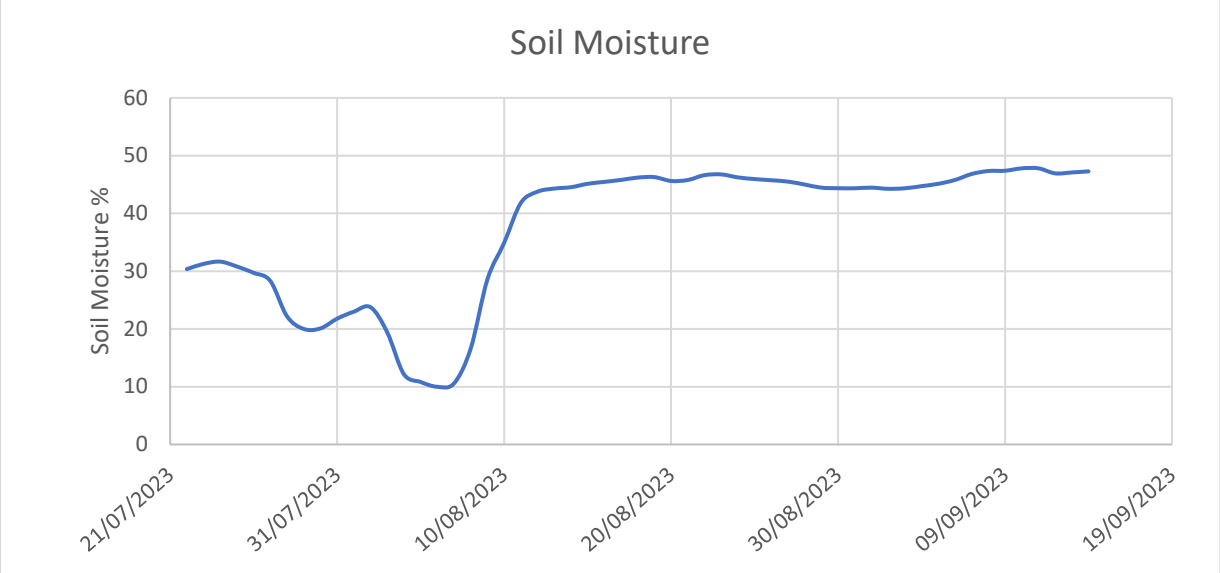
- Based on all 960 in tunnel producing strawberries = 293g/plant.
- Crown rot resulted in high losses.
- Lost trusses and plants calculated at 24% = 730 plants are producing strawberries.
- Adjusted for these losses = 385g/plant.
- Impact was to reduce potential total yield over cropping area by 88.5kg (5t/ha, 2t/acre)
- Claimed yield for cultivar (400g/plant).

➢ Daily Light Integral (DLI) at canopy level in tunnel

Orange line indicates minimum light energy (15/moles/m2) needed to maximise strawberry production.



➢ Soil moisture levels (%v/v) in substrate.



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➢ Spray Program

Week No.	Product and MAPP	Control of	EAMU	Active	FRAC	Remaining Sprays Available	Protectant or Eradicant
28	SB PLANT INVIGORATOR	General insect control and powdery mildew	Physical mode	Surfactants	N/A	-	P
28	Vidi Parva Biostimulant	Nutrition - Longer roots with more branches and root hairs.	NA	Tryptophan and other free amino acids in herbal extract	NA	NA	NA
28	Vidi Terrum Biostimulant	Nutrition - supports the plant's metabolism leading to better fruit set and size	NA	Free amino acids in herbal extract	NA	NA	NA
29	SB PLANT INVIGORATOR	General insect control and powdery mildew	Physical mode	Surfactants	N/A	-	P
29	Vidi Parva Biostimulant	Nutrition - Longer roots with more branches and root hairs.	NA	Tryptophan and other free amino acids in herbal extract	NA	NA	NA
29	Vidi Terrum Biostimulant	Nutrition - supports the plant's metabolism leading to better fruit set and size	NA	Free amino acids in herbal extract	NA	NA	NA
30	SB PLANT INVIGORATOR	General insect control and powdery mildew	Physical mode	Surfactants	N/A	-	P
30	Trianum P MAPP 16741	*Pythium, Rhizoctonia, Fusarium*	1297 of 2020	*Trichoderma harzianum* strain T22	N/A	12 a year	E
31	SB PLANT INVIGORATOR	General insect control and powdery mildew	Physical mode	Surfactants	N/A	-	P
32	SB PLANT INVIGORATOR	General insect control and powdery mildew	Physical mode	Surfactants	N/A	-	P
33	SB PLANT INVIGORATOR	General insect control and powdery mildew	Physical mode	Surfactants	N/A	-	P
34	SB PLANT INVIGORATOR	General insect control and powdery mildew	Physical mode	Surfactants	N/A	-	P

- ✓ SB Invigorator applied weekly to control insects and SPM.
- ✓ If active infection seen Karma (potassium hydrogen carbonate) was 1st alternative (none was applied).
- ✓ Amylo X and Serenade identified as additional control measures if SPM had developed into an ongoing problem

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➢ Biological treatments

Week No.	Product	Species	Packet size	Recommended coverage
26	Aphiscout	*Aphidius colemani, Aphidius ervi, Aphelinus abdominalis, Praon volucre, Ephedrus cerasicola (parasitic wasps)*	90ml bottle	0.75-1.5 parasitic wasps per m2, 250 to 350m^2
	Spidex	*Phytoseiulus persimilis (mite)*	100ml bottle	2000 mite, 2-50 per m2/release, 400 to 1000m^2
28	Aphiscout	*Aphidius colemani, Aphidius ervi, Aphelinus abdominalis, Praon volucre, Ephedrus cerasicola (parasitic wasps)*	90ml bottle	.75-1.5 parasitic wasps per m2, 250 to 350m^2
	Spidex	*Phytoseiulus persimilis (mite)*	100ml bottle	2000 mite, 2-50 per m2/release, 400 to 1000m^2
30	Aphiscout	*Aphidius colemani, Aphidius ervi, Aphelinus abdominalis, Praon volucre, Ephedrus cerasicola (parasitic wasps)*	90ml bottle	0.75-1.5 parasitic wasps per m2, 250 to 350m^2
	Aphiend	*Aphidoletes aphidimyza* (gall midge)	100ml bottle	1000, 1-10 per m2/release, 100 to 1000m^2
	Thripex	*Neoseiulus cucumeris* (mite)	500ml bottle	50,000, 50-100 per m2/release, 500 to 1000m^2
32	Aphiend	*Aphidoletes aphidimyza* (gall midge)	100ml bottle	1000, 1-10 per m2/release, 100 to 1000m2
	Spidex	*Phytoseiulus persimilis (mite)*	100ml bottle	1000, 1-10 per m2/release, 100 to 1000m^2
34	Aphiscout	*Aphidius colemani, Aphidius ervi, Aphelinus abdominalis, Praon volucre, Ephedrus cerasicola (parasitic wasps)*	90ml bottle	0.75-1.5 parasitic wasps per m2, 250 to 350m^2
	Thripex	*Neoseiulus cucumeris* (mite)	500ml bottle	50,000, 50-100 per m2/release, 500 to 1000m^2
38	Aphiscout	*Aphidius colemani, Aphidius ervi, Aphelinus abdominalis, Praon volucre, Ephedrus cerasicola (parasitic wasps)*	90ml bottle	0.75-1.5 parasitic wasps per m2, 250 to 350m^2
	Spidex	*Phytoseiulus persimilis (mite)*	100ml bottle	1000, 1-10 per m2/release, 100 to 1000m^2
40	Chrysopa	*Chrysoperla carnea*	500ml bottle	1000, 2-20 per m2/release, 50 to 500m^2
42	Chrysopa	*Chrysoperla carnea*	500ml bottle	1000, 2-20 per m2/release, 50 to 500m^2
44	Chrysopa	*Chrysoperla carnea*	500ml bottle	1000, 2-20 per m2/release, 50 to 500m^2

- **Costs**

Predators				
Treatment	**Packet size**	**Cost**	**Cost per m^2 ($175m^2$)**	**Cost treating cropping area of $1000m^2$**
Aphiscout	**90ml @ £17.00**	**£17 x 5 applications = £85**	**£0.45**	**£0.25 ($350m^2$/pack)**
Chrysopha	**Sachets from bucket of 100 (£133.99)**	**£13.39 x 3 (sachets) = £40.17**	**£0.22**	**£0.08 ($500m^2$/pack)**
Aphidend	**100ml bottle @£20.64**	**£20.64 x 2 applications = £41.28**	**£0.23**	**£0.04 ($1000m^2$/pack)**
Spidex	**100ml @£11.28**	**£11.28 x 4 applications = £45.12**	**£0.25**	**£0.04 ($1000m^2$/pack)**
Thripex	**500ml @£13.38**	**£13.38 x 4 applications = £53.52**	**£0.30**	**£0.05 ($1000m^2$/pack)**
		Sub-total predators per m^2	**£1.42**	**£0.87**
		HC Tunnel/$1000m^2$	**£248.50**	**£870**
Fungicides				
Treatment	**Amount used**	**Rate**	**Cost**	
Trianum G	**15g**	**750g/m^3**	**£0.30**	
Sprays				
Treatment	**Amount used**	**Rate**	**Cost per m^2**	
SB Invigorator	**70ml = £2.03**	**10ml with 7 applications @1ml/litre**	**£0.01**	
		HC Tunnel/1000m2	**£2.03**	
		Total cost per tunnel ($288m^2$) of sprays and biologicals	**£305.28**	
Cost per plant (4 rows, 25metres, 960 plants)			**£0.32**	
***Cost per plant treating $1000m^2$, ~8220**			**£0.10**	
Cost of predators per plant			**£0.08**	

***Assuming 6 rows of plants across tunnel**

- ✓ Hard to allocate exact fixed costs – site/crop specific (tunnels size, density, disease/pest

➢ Concluding notes

Possibly slow foliage growth at start crop establishment reduced fruiting capacity.

Lack of irrigation resulting in water stress (see associated graph) and consequently high EC levels may have set back crop and reduced yield potential (number of trusses per plant and number of flowers per truss).

Crop was running at relatively high EC value (~2.2mS) which can reduce average berry size.

Burst of very warm weather from ~4th to 10th September, second half of harvesting period may have reduced average berry size and hence weight.

Large number of single/double crown plants in delivery.

Overcast weather this season reduced light energy (or daily light integral – DLI). University of Arizonan's article 'Considerations for Greenhouse Strawberry Production' stated light energy optimum levels for strawberry production between 15 – 25 moles/m^2/day. At HC, levels were at or below 15 moles/m^2/day for 3 weeks in a row (end July to 20th August) before cropping started (see associated graph) which very likely reduced yield potential. In addition, light energy levels dipped below 15 moles/m2/day for several periods after that.

Commercially acceptable harvested yield was at 385g./plant (excluding plant losses) but when considered 24% plant and truss losses the adjusted yield was 293g./plant. Plant/truss losses with direct impact on yield losses were high and mainly due to crown rot. It is a fungal disease and originates from plant supplier/propagator. There is not much crop protection can do about it.

Other crop pests and diseases were successfully dealt with biological control at economically viable levels. With active ingredients of crop pest and diseases application products continuously being banned, IPM and biological treatment seems to be the only viable and promising way going forwards.


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