HUMEFERT TRIAL: OXI-APP™ SYSTEM

HOOPENBERG BERRY FARM
SUMMER SEASON, 2021/2022

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Southern Cross Trust

May 2022

INDEX

ADVANTAGES OF THE OXI-APP™ SYSTEM

- Research and practical observations have demonstrated the following advantages of the OXI-APP™ SYSTEM in South Africa:

  - Increased water and salt percolation
  - Decreased soil compaction
  - Increased root depth, volume and health
  - Less sedimentation and algae/bacterial growth in filters and irrigation lines (cleans out the irrigation system)
  - Decreased effect of water biology on emitter blockages
  - Peroxone (dihydrogen trioxide) is formed by the system and acts as a powerful oxidant
  - Magnesium and sodium leaching out of the rhizosphere
  - Increased chelation and uptake of certain plant nutrients
  - Slow release carbon source and nutrient for rhizosphere micro organisms

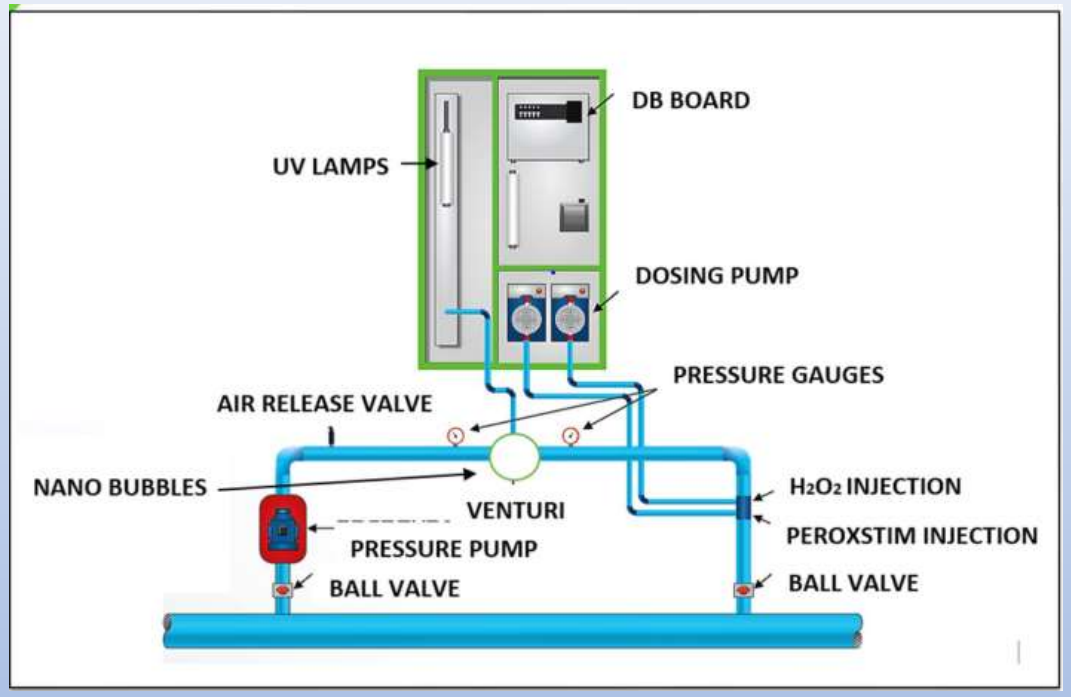
ADVANTAGES OF THE OXI-APP™ SYSTEM IN BLUEBERRY PRODUCTION IN SUBSTRATE

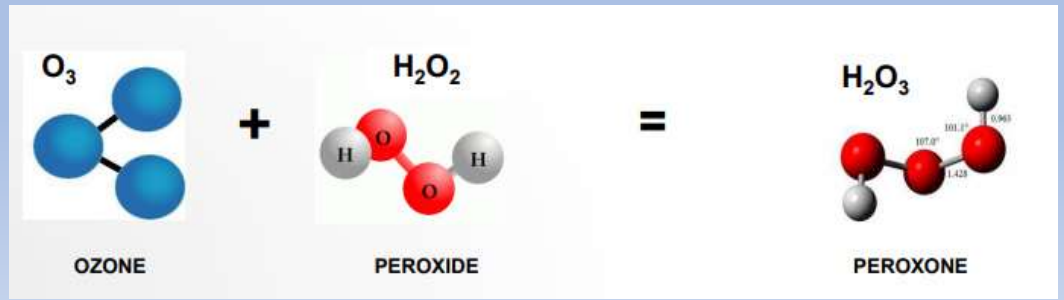
- To demonstrate the advantages of the system, the following data was gathered in the Hoopenberg blueberry production unit in the Western Cape:
  - Filter and dripper blockages
  - Nutrient element measurements
  - Biological testing of irrigation water: plant pathogens
  - Biological testing of irrigation water: human pathogens
  - Vegetative plant development
  - Substrate measurements
  - Substrate colonisation by algae and moss
  - Disease propagules in the top of the substrate
  - Root health monitoring
  - Final yield and quality of the berries in the treated and untreated blocks will be documented by the end of 2022

TREATMENTS

- Two treatments
- **Treatment 1**: OXI-APP^{TM} system from Humefert. Fifteen percent of the irrigation water volume, before the filter system, were treated with the OXI-APP^{TM} system on a continuous basis. The treated water were then injected and mixed into the final irrigation water volume used during irrigation of the blueberry crop. Two powerful oxidants, Ozone (O3) and Hydrogen peroxide (H2O2), were injected into the irrigation water to form amongst others Peroxone (dihydrogen trioxide) or H2O3 which is much more potent than either O3 or H2O2 on there own. A biostimulant and organic chelate is added to chelate cations and help with root development.
- **Treatment 2**: Control treatment. Constant dosing of hydrogen peroxide into the irrigation water at 20 ppm's
- Water treatments started at the beginning of Nomeber 2021 and evaluations were done throughout the season, with the last vegetative, substrate and root evaluations around 25 February 2022

THE OXI-APP™ SYSTEM





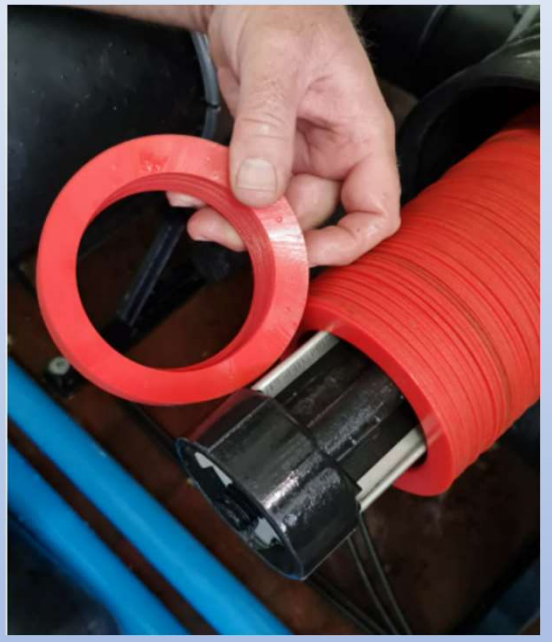
DATA COLLECTION AT HOOPENBERG
FILTER, DRIPPER & IRRIGATION LINE OBSERVATIONS

DATA COLLECTION AT HOOPENBERG

FILTER, DRIPPER & IRRIGATION LINE OBSERVATIONS: OXI-APP SYSTEM

11 November 2021

25 February 2022



Both water treatments were applied from the start of November 2021 on a continual basis before the filter system.
The ring filter system was examined for contamination on 11 November 2021 and 25 February 2022

DATA COLLECTION AT HOOPENBERG

FILTER, DRIPPER & IRRIGATION LINE OBSERVATIONS: CONTROL TREATMENT

11 November 2021

25 February 2022

Both water treatments were applied from the start of November 2021 on a continual basis before the filter system.
In the control treatment, hydrogen peroxide was applied at 20 ppm's.
The ring filters were cleaned on a weekly basis in the control system.
The ring filter system was examined for contamination on 11 November 2021 and 25 February 2022

DATA COLLECTION AT HOOPENBERG

FILTER, DRIPPER & IRRIGATION LINE OBSERVATIONS: ARROW DRIPPER PHOTOS

14 January 2022

Control treatment

14 January 2022

OXI-APP SYSTEM

Twenty arrow drippers were randomly examined for contamination and discolouration on 14 January 2022 in the five greenhouse bays selected for this trial

DATA COLLECTION AT HOOPENBERG

FILTER, DRIPPER & IRRIGATION LINE OBSERVATIONS: ARROW DRIPPER PHOTOS

20 May 2022

Control treatment

20 May 2022

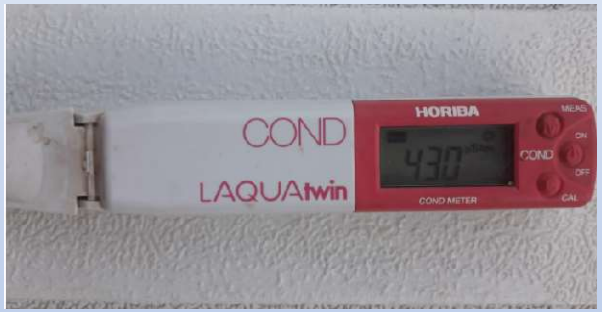
OXI-APP SYSTEM

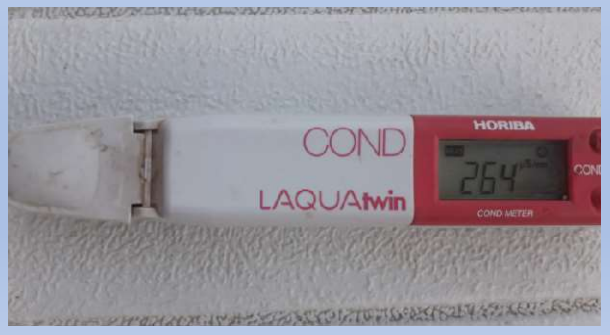
Twenty arrow drippers were randomly examined for contamination and discolouration on 20 May 2022 in the five greenhouse bays selected for this trial

DATA COLLECTION AT HOOPENBERG

FILTER, DRIPPER & IRRIGATION LINE OBSERVATIONS: LINE CONTAMINATION

18 March 2022





Twenty random dripper lines, in the five selected greenhouse bays, were cut open and examined for contamination and discolouration on 18 March 2022. The contamination on the inside of the lines were removed with an earbud and dissolved in 20ml distilled water before the conductivity was measured with a Horiba LaquaTwin instrument

DATA COLLECTION AT HOOPENBERG

FILTER, DRIPPER & IRRIGATION LINE OBSERVATIONS: LINE CONTAMINATION

20 May 2022

Control treatment

OXI-APP SYSTEM

Twenty random dripper lines, in the five selected greenhouse bays, were cut open and examined for contamination and discolouration on 20 May 2022. The contamination on the inside of the lines were removed with an earbud and dissolved in 20ml distilled water before the conductivity was measured with a Horiba LaquaTwin instrument

FILTER, DRIPPER & IRRIGATION LINE OBSERVATIONS:
SUMMARY OF RESULTS

- Photos of the ring filters on both 11 November 2021 and 25 February 2022 clearly indicates the ability of the OXI-APP system to keep the filters clean, both on the outside and inside. At times, a light slimy sedimentation was observed on the outside of the filter rings in both treatments, especially when the water turbidity was at its worst. The inside of the filter rings did however stay clean in the OXI-APP treatment.
- When the contamination on the arrow drippers were compared on 14 January 2022, little differences could be observed visually. Some of the arrow drippers in the OXI-APP treatment were however cleaner towards the top of the dripper. When this exercise was repeated on 20 May 2022, the OXI-APP treated drippers were visually cleaner than the control, with a larger part of the shaft being free of algae and sedimentation.
- The discolouration inside the irrigation lines was mainly due to brown sedimentation. Some fungal, bacterial and algae growth was also observed, but in much smaller quantities. From the photos it is clear that the OXI-APP system was very successful in lowering the discolouration and sedimentation problems inside the dripper lines on both evaluation dates (18 March & 20 May 2022). When the conductivity of the sedimentation in solution was compared on 18 March, the control treatment had a conductivity of 430 us/cm and the OXI-APP system a conductivity of 264 us/cm. This means that the combined salt deposits inside the irrigation lines were approximately 40% lower in the OXI-APP system. This tendency repeated itself on 20 May. On this date the control treatment had a conductivity of 727 us/cm and the OXI-APP system a conductivity of 356 us/cm. The combined salt deposits inside the irrigation lines were therefor 51% lower in the OXI-APP system on 20 May.

DATA COLLECTION AT HOOPENBERG
NUTRIENT ELEMENT MEASUREMENTS

DATA COLLECTION AT HOOPENBERG
NUTRIENT ELEMENT MEASUREMENTS

First 20 seconds

After 20 seconds

After 40 seconds

Water nutrient samples were collected directly from the dripper pipes after 40 seconds of water flow.

Samples were submitted to SGS laboratories in Strand, Western Cape

DATA COLLECTION AT Hoopenberg: SGS NUTRIENT ELEMENT MEASUREMENTS

Analysis	METHOD	AT SOURCE K116: SAMPLE 1		AT SOURCE K118: SAMPLE 2		AT DRIPPER K117: CONTROL		AT DRIPPER K115: OXI-APP SYSTEM	
		mg/l	me/l	mg/l	me/l	mg/l	me/l	mg/l	me/l
Carbonate as $CaCO_3$	CALC	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.00
Bicarbonate as $CaCO_3$	CALC	15.9	0.32	17.2	0.3	19.6	0.4	12.3	0.25
Chloride (Cl^-)	AN-003	16	0.45	15.0	0.4	15.9	0.4	15	0.42
Sulphate ($SO_4^{=}$) analysed as S	AN-005	4	0.08	4.2	0.1	4.1	0.1	10	0.21
Nitrate (NO_3^-)	AN-004	<0.5	0.00	<0.5	0.0	<0.5	0.0	3	0.05
Phosphate ($H_2PO_4^-$) analysed as P	AN-006	<0.37	0.00	<0.37	0.0	<0.37	0.0	1.5	0.02
		Tot	*0.85*	*Tot*	*0.85*	*Tot*	*0.93*	*Tot*	*0.94*
Calcium (Ca^{++})	AN-005	5	0.2	5	0.2	4	0.2	4	0.2
Magnesium (Mg^{++})	AN-005	2	0.1	2	0.1	2	0.1	2	0.1
Potassium (K^+)	AN-005	1	0.0	1	0.0	1	0.0	2	0.1
Sodium (Na^+)	AN-005	9	0.4	9	0.4	10	0.4	9	0.4
Ammonium (NH_4^+)	AN-004	0.2	0.01	<0.05	0.01	<0.05	0.00	2.1	0.12
Copper (Cu^{++})	AN-005	0.012	0.00	<0.007	0.00	<0.007	0.00	0.005	0.00
Zinc ($Zinc^{++}$)	AN-005	0.012	0.00	0.013	0.00	0.017	0.00	0.016	0.00
Manganese (Mn^{++})	AN-005	0.010	0.00	<0.016	0.00	<0.016	0.00	0.076	0.00
Iron (Fe^{++})	AN-005	0.207	0.01	0.192	0.01	0.163	0.01	5.972	0.21
Boron (B^{+++})	AN-005	0.014	0.00	0.015	0.00	0.015	0.00	0.018	0.00
		Tot	*0.81*	*Tot*	*0.81*	*Tot*	*0.82*	*Tot*	*1.10*
Alkalinity as mg/l $CaCO_3$	AN-002	16		17		20		12	
Total Hard as mg/l $CaCO_3$	CALC	19		19		18		16	
Ca Hard as mg/l $CaCO_3$	CALC	12		11		11		9	
Mg Hard as mg/l $CaCO_3$	CALC	8		8		7		7	
Total dissolved solids (mg/l)	CALC	60		58		59		73	
Conductivity mS/m @ 25°C	AN-005	9		9		9		11	
pH @ 25°C	AN-001	7.1		7.1		7.1		5.6	
SAR	CALC	0.87		0.87		0.97		0.99	
USDA C value	CALC	C1		C1		C1		C1	
USDA S value	CALC	C1		C1		C1		C1	
Langelier Index	CALC	-2.4		-2.3		-2.3		-4.1	
Aggressiveness Index	CALC	9.3		9.4		9.4		7.7	
Corrosivity Index	CALC	1.7		1.5		1.4		2.6	
Rayznar Index	CALC	11.9		11.8		11.8		13.8	
Residual Sodium Carbonate (me/l)	CALC	-0.1		0.0		0.0		-0.1	

NUTRIENT ELEMENT MEASUREMENTS: SUMMARY OF RESULTS

- From the SGS nutrient solution analyses, the following differences were identified between the OXI-APP treatment (K115), and the control treatment (K117) at the drippers:

- The bicarbonate (HCO3-) levels were 37.3% less in the OXI-APP system (12.3mg/L vs. 19.6mg/L). Together with an increase in the sulphate levels, this decreased the water pH to 5.6, compared to the control treatment pH of 7.1. As expected from a lower bicarbonate level, the total alkalinity in the OXI-APP system also decreased from 20mg/L CaCO3 to 12mg/L CaCO3. As the CaCO3 levels decreased, the Langelier index changed from -2.3mg/L to -4.1mg/L, and the Corrosivity index increased from 1.4 to 2.5.

- The sulphate levels, analysed as S, increased with 59% in the water (10mg/L vs 4.1mg/L).

- The nitrate levels increased significantly from <0.5mg/L to 3mg/L. This is an increase of 600%. The ammonium levels also increased from <0.05mg/L to 2.1mg/l. This more than 400%.

- Phosphate levels, analysed as P, increased from <0.37mg/L to 1.5mg/L. This is an increase of more than 400%

- There were very little differences in the Ca, Mg, K and Na cation levels between the two treatments

- After the OXI-APP treatment the Mn and Fe levels increased significantly from < 0.016mg/L to 0.076mg/L, and from 0.163mg/L to 5.972mg/L respectively. This is an increase of more than 475% for Mn, and more than 3600% for Fe. The charge of these cation micro nutrients also changed to Mn^{3+} and Fe^{3+}. Copper, zinc and boron levels were very similar when the two treatments were compared.

- As expected from the increased oxidation and dissociation of ionic compounds, the total dissolved solids increased from 59mg/L to 73mg/L in the OXI-APP system. For the same reason the electrical conductivity also increased from 9ms/m to 11ms/m.

DATA COLLECTION AT HOOPENBERG
BIOLOGICAL TESTING OF IRRIGATION WATER

DATA COLLECTION AT HOOPENBERG
BIOLOGICAL TESTING OF IRRIGATION WATER: PLANT PATHOGENS

- Disease Clinic, Stellenbosch University – Testing for water borne pathogens:

Monster

Water

Verwysing

1164/21 A: "At Source"

1164/21 B: "At drip"

Identifikasie

Die water monsters is afsonderlik getoets vir:

1. Die teenwoordigheid van moontlike swampatogene deur die water (500ml) te filtreer. Die filtreer papier is in 9ml steriele water geplaas om te week en "gevortex" (moederoplossing). 'n Verdunningsreeks is opgemaak, deurdat 1 mL van die moederoplossing in 9 mL gesteriliseerde water geplaas is om die eerste verdunning op te maak. Verdere verdunnings is gemaak tot by 10^{-4}. Hierdie verdunning is op ADA ('n algemene groeimedium vir swamme) uitgeplaat. Die verdunningsreeks is drie keer herhaal.

2. Die teenwoordigheid van *Pythium, Phytopythium* en *Phytophthora* (Oömisete), deur gebruik te maak van 'n lokaasmetode en selektiewe media.

Resultate

1. Geen moontlike swampatogene is geïsoleer nie.

2. Geen oömisete is geïsoleer nie.

'At source': Untreated Theewaterskloof & borehole water mix

'At drip': Irrigation water treated with OXI-APP™ system

DATA COLLECTION AT HOOPENBERG
BIOLOGICAL TESTING OF IRRIGATION WATER: HUMAN PATHOGENS

- SGS laboratories, Strand, Western-Cape - Testing for human pathogens:

Lab ident:	**MT21-12795.002**
Sample type:	Water
Sample Ident:	WK118

Analysis	Method	Result	Unit
Total Plate Count (Water)	WI-AN-047 based on SANS 5221:2007	850	cfu/ml
E. coli (Water)	WI-AN-047 based on Colilert Method	12	MPN/100ml
Total Coliforms (Water)	WI-AN-047 based on Colilert Method	770	MPN/100ml

'At source':

Untreated Theewaterskloof & borehole water mix

Lab ident:	**MT21-12795.001**
Sample type:	Water
Sample Ident:	WK117

Analysis	Method	Result	Unit
Total Plate Count (Water)	WI-AN-047 based on SANS 5221:2007	870	cfu/ml
E. coli (Water)	WI-AN-047 based on Colilert Method	2	MPN/100ml
Total Coliforms (Water)	WI-AN-047 based on Colilert Method	14	MPN/100ml

'At drip':

Irrigation water treated with OXI-APP^{TM} system

BIOLOGICAL TESTING OF IRRIGATION WATER: DISCUSSION OF RESULTS

- No water borne plant pathogens were detected in the source or drip water samples
- No conclusion could therefor be made regarding the water sterilisation effect of the OXI-APP™ system

- The following human pathogen indicators were tested in the two water samples:
  - Total plate counts (colony forming units per ml water)
  - *Escherichia coli* (most probable number per 100ml water)
  - Total coliforms (most probable number per 100ml water)
- Total plate count is a method of estimating the total number of microorganisms (mold, yeast, bacteria) in a given sample of water. *E. coli* is a bacterium that can cause severe foodborn disease. Although most *E. coli* strains are harmless, some strains can cause human illness through toxin production. The presence of total coliforms indicate that your water source has been exposed to environmental contamination from soil, plants or animals. Although most species of coliform have no impact on human health, high numbers of certain species can have a human impact.
- The total plate counts were very similar for the two water samples (850 vs 870 cfu/ml). The Oxi-App™ system reduced the *E. coli* counts significantly (2 vs 12 MPN/100ml). The Oxi-App™ system also reduced the total coliforms significantly (14 vs 770 MPN/100ml).

DATA COLLECTION AT HOOPENBERG
VEGETATIVE PLANT DEVELOPMENT

DATA COLLECTION AT HOOPENBERG

VEGETATIVE PLANT DEVELOPMENT: CROP PHOTOS

Control plants

OXI-APP plants

DATA COLLECTION AT HOOPENBERG
VEGETATIVE PLANT DEVELOPMENT: NUMBER OF CANES

Table 1. Number of new bearing canes

Plant number	Number of bearing canes/plant	
	Control	OXI-APP
1	80	84
2	54	90
3	67	75
4	54	65
5	70	86
6	45	73
7	86	87
8	45	59
9	60	55
10	57	65
Average:	**61,8**	**73,9**

Five bays where chosen in the treated blocks, with two Eureka Sunrise plants chosen in the middle row of each greenhouse bay

In each of the bays, the 20th and 40th plants was used for data gathering

The above results are the total number of new canes per plant after the last summer pruning action

DATA COLLECTION AT HOOPENBERG
VEGETATIVE PLANT DEVELOPMENT: CANE LENGTH

Table 2. Bearing cane length in the two treatments

Plant number	Bearing cane length (mm)	
	Control	OXI-APP
1	220, 216, 190, 178, 166, 220	175, 176, 195, 155, 187, 222
2	230. 210, 247, 185, 180, 140	173, 293, 217, 215, 238, 176
3	130, 135, 140, 165, 195, 255	190, 135, 238, 115, 260, 175
4	185, 135, 170, 144, 143, 171	178, 170, 115, 147, 260, 150
5	190, 225, 260, 185, 141, 210	174, 301, 131, 135, 260, 160
6	240, 176, 235, 190, 285, 150	295, 100, 140, 200, 275, 220
7	220, 300, 214, 155, 185, 127	295, 205, 168, 289, 124, 310
8	200, 167, 190, 150, 160, 171	235, 96, 205, 135, 230, 153
9	127, 229, 290, 311, 184, 250	153, 150, 205, 137, 260, 175
10	135, 225, 176, 167, 167, 160	215, 115, 147, 135, 200, 289
Average:	**189 mm**	**194,5 mm**

Physical measurement of length of new canes after detachment from plant

In each of the five chosen bays, the 20th and 40th plants were used for data gathering

Six newly formed canes were randomly collected from the top growth of the 10 selected plants

The above results are the length of the 60 selected canes, 6 canes per plant

DATA COLLECTION AT HOOPENBERG
VEGETATIVE PLANT DEVELOPMENT: LEAF MEASUREMENTS

Table 3. Leaf chlorophyll concentration and measurements in the control treatment

Plant number	Chlorophyll concentration (ppm)	Leaf width (mm)	Leaf length (mm)
1	57, 47, 51, 49, 50, 48	24, 25, 23, 23, 24, 25	47, 48, 58, 53, 37, 39
2	51, 46, 49, 49, 47, 52	24, 26, 35, 25, 34, 36	58, 57, 55, 58, 51, 39
3	54, 50, 56, 51, 50, 50	25, 24, 29, 27, 25, 33	52, 52, 53, 53, 45, 40
4	42, 56, 47, 50, 55, 46	30, 33, 36, 30, 28, 35	41, 44, 47, 52, 52, 52
5	54, 55, 48, 50, 56, 49	25, 35. 27, 31, 40, 36	64, 57, 45, 76, 64, 52
6	55, 51, 55, 52, 52, 27	25, 26, 23, 28, 33, 37	50, 58, 71, 80, 70, 74
7	45, 55, 53, 52, 51, 42	40, 25, 23, 26, 27, 24	72, 64, 55, 62, 70, 52
8	50, 53, 46, 49, 56, 57	25, 24, 23, 29, 26, 29	78, 80, 80, 60, 66, 54
9	51, 57, 61, 42, 54, 55	24, 25, 20, 27, 24, 24	56, 70, 70, 76, 52, 44
10	46, 56, 47, 54, 59, 48	30, 27, 17, 25, 26, 25	51, 48, 55, 50, 46, 52
Average:	**51.3 ppm**	**27.2 mm**	**56.7 mm**

Measurement of chlorophyl concentration

Six newly formed canes were collected randomly from the top growth of the 10 selected plants

The largest leaf was detached from each of the 60 canes, and the leaf width and length measured

The same leaf was used to determine the chlorophyll concentration

DATA COLLECTION AT HOOPENBERG
VEGETATIVE PLANT DEVELOPMENT: LEAF MEASUREMENTS

Table 4. Leaf chlorophyll concentration and measurements in the OXI-APP treatment

Plant number	Chlorophyll concentration (ppm)	Leaf width (mm)	Leaf length (mm)
1	58, 61, 56, 52, 54, 54	31, 39, 24, 26, 37, 35	69, 64, 53, 34, 40, 54
2	51, 56, 49, 59, 50, 61	29, 27, 27, 31, 40, 28	40, 56, 50, 39, 64, 52
3	55, 42, 53, 57, 48, 59	24, 25, 24, 26, 15, 29	51, 49, 50, 53, 42, 46
4	58, 52, 56, 60, 52, 56	24, 25, 18, 24, 40, 22	48, 56, 49, 46, 73, 46
5	48, 55, 46, 54, 50, 56	43, 20, 26, 33, 26, 27	52, 39, 47, 57, 40, 51
6	54, 52, 52, 56, 54, 59	33, 19, 22, 19, 31, 25	57, 39, 38, 28, 56, 48
7	54, 51, 52, 56, 52, 58	24, 24, 38, 37, 20, 24	43, 54, 56, 50, 35, 40
8	56, 54, 54, 60, 54, 58	25, 36, 25, 25, 25, 19	45, 62, 50, 42, 50, 44
9	62, 60, 55, 57, 50, 56	18, 23, 23, 28, 24, 35	37, 44, 39, 54, 43, 50
10	59, 57, 50, 54, 56, 56	27, 24, 25, 31, 26, 33	53, 87, 53, 56, 46, 60
Average:	**54.6 ppm**	**27.2 mm**	**49.5 mm**

Six newly formed canes were collected randomly from the top growth of the 10 selected plants

The largest leaf was detached from ech of the 60 canes, and the leaf width and length measured

The same leaf was used to determine the chlorophyll concentration

DATA COLLECTION AT HOOPENBERG
VEGETATIVE PLANT DEVELOPMENT: PETIOLE SAP ANALYSES

Table 5. Petiole sap analyses

Treatment	Date	NO3-N (ppm)	K (ppm)	Ca (ppm)	Na (ppm)	EC (ms/cm)	Brix (%)
Control	25/2/2022	1250	1700	3	69	2,78	2,3
	18/3/2022	140	840	4	17	2,28	2,8
OXI-APP	25/2/2022	1200	1800	2	78	3,05	2,2
	18/3/2022	140	810	4	25	2,36	2,5

On each of the collection dates, the petiole sap of 30 newly formed, detached leaves were extracted and measured for the above indicators.

PPM: parts per million.

EC (ms/cm): electrical conductivity in millisimens/centimeter

VEGETATIVE PLANT DEVELOPMENT: SUMMARY OF RESULTS

- The OXI-APP treated plants formed an average of 73.95 new bearing canes per plant after the last summer pruning action, compared to 61.8 new canes in the control treatments. This is a difference of 16.4% between the two groups of plants.
- The OXI-APP treated plants noticeably exhibited softer new cane growth. The OXI-APP treated plants had an average cane length of 194.5mm compared to an average of 189mm in the control plants. This small difference was approximately 3%.
- The average leaf chlorophyll in the sixty selected leaves were 51.3ppm for the control treatment, and 54.6ppm in the OXI-APP treatment. This is a difference of approximately 6% in favour of the OXI-APP system.
- The leaf width was the same in both treatments, but the control treatment had slightly longer leaves. The length of the control treatment leaves were 56.7mm on average, compared to 49.5mm in the OXI-APP treatment. The difference in leaf length was 12.7% in favour of the control treatment.
- Petiole sap analyses indicated very little differences between the two treatments. The higher substrate EC in the OXI-APP treatment resulted in higher petiole sap analyses as expected.

DATA COLLECTION AT HOOPENBERG
SUBSTRATE MEASUREMENTS

DATA COLLECTION AT HOOPENBERG

SUBSTRATE MEASUREMENTS: CONDUCTIVITY & MOISTURE

Tabel 6. Substrate measurements in the control treatment

18 March 2022

20 May 2022

Plant number	Substrate measurements EC (ms/cm) Top on bag	EC (ms/cm) Bottom of bag	Moisture % Top of bag	Moisture % Bottom of bag	Root zone brix
1	1,3	1,6	44	56	0,1
2	1,4	1,44	44	52	0,1
3	1,37	1,61	43	67	0,5
4	1,31	1,81	54	57	0,1
5	1,49	1,61	41	59	0,1
6	1,7	1,56	46	67	0,1
7	1,71	1,3	53	67	0,1
8	1,32	1,63	48	58	0,2
9	1,4	1,6	40	55	0,3
10	1,47	1,65	44	50	0,2
Average:	**1,447 ms/cm**	**1,581 ms/cm**	**45,7%**	**58,8%**	**0,18 %**

Five bays where chosen in the treated block, with two Eureka Sunrise plants chosen in the middle row of each greenhouse bay

In each of the bays, the 20th and 40th plants were used for data gathering

The above results are from the substrate of the ten selected plants

Electrical conductivity (EC) and moisture percentage were measured with a BlueLab Pulse meter

DATA COLLECTION AT HOOPENBERG

SUBSTRATE MEASUREMENTS: CONDUCTIVITY & MOISTURE

Tabel 7. Substrate measurements in the OXI-APP treatment

18 March 2022

Plant number	Substrate measurements EC (ms/cm) Top on bag	EC (ms/cm) Bottom of bag	Moisture % Top of bag	Moisture % Bottom of bag	20 May 2022 Root zone brix (%)
1	1,8	1,9	43	48	0,6
2	1,6	2	53	55	0,2
3	1,6	2,2	44	48	0,3
4	1,3	1,9	44	46	0,1
5	1,8	2,2	53	67	0,4
6	1,88	1,7	57	51	0,1
7	1,49	1,94	61	58	0,2
8	1,2	2	39	58	0,1
9	1,4	1,6	42	53	0,3
10	2,1	1,35	44	44	0,2
Average:	**1,617 ms/cm**	**1,879 ms/cm**	**48 %**	**52,8 %**	**0,24 %**

Five bays where chosen in the treated block, with two Eureka Sunrise plants chosen in the middle row of each greenhouse bay

In each of the bays, the 20th and 40th plants were used for data gathering

The above results are from the substrate of the ten selected plants

Electrical conductivity (EC) and moisture percentage were measured with a BlueLab Pulse meter

DATA COLLECTION AT HOOPENBERG
SUBSTRATE MEASUREMENTS: SURFACE GROWTH

Table 8. Substrate surface covered by moss and algae

Row	Percentage substrate surface area covered by moss & algae	
	Control	OXI-APP
1	15%	12%
2	10%	10%
3	10%	7%
4	1,50%	3%
5	20%	2%
6	20%	5%
7	10%	11%
8	5%	12%
9	20%	3%
10	5%	2%
Average:	**12%**	**7%**

The percentage substrate surface area covered by algae and moss growth was scored on the same 10 plants used in the other evaluations

DATA COLLECTION AT HOOPENBERG

SUBSTRATE MEASUREMENTS: DISEASE PROPAGULES IN THE TOP OF THE SUBSTRATE

Disease Clinic (Stellenbosch University) results:

Results

No *Botrytis* sp. was isolated from the samples.

Various saprophytic fungi (including *Aspergillus*, *Penicillium*, *Cladosporium* and *Rhizopus*/*Mucor*) were noted on the plates of both samples. The total colony forming units (CFU) of the saprophytic fungi per gram of substrate was:

Sample A: 5 x 10^4 spores per gram of substrate

Sample B: 3 x 10^4 spores per gram of substrate

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Departement Plantpatologie • Department of Plant Pathology

Two samples, labelled A (block where irrigation water was treated with 20ppm hydrogen peroxide) and B (block where irrigation water was treated with the OXI-APP™ system), were submitted. A combined sample comprised of 30 randomly taken sub-samples in the top 3cm of substrate. The samples were air dried before isolation. A dilution plating technique was done by placing 10gram of the air-dried substrate in 100 ml sterilised water and mixing vigorously for 30 seconds. One millilitre of stock solution was pipetted into 9 ml of sterilized water in order to make the first dilution. Futher dilutions were made in a similar fashion up to 10^{-3}. These solutions were plated out on *Botrytis* selective growth medium. The dilution series were repeated 3 times for each sample. The results are given as Colony Forming Units per gram of substrate.

SUBSTRATE MEASUREMENTS: SUMMARY OF RESULTS

- The average EC measurements in the top of the substrate was approximately 10% higher in the OXI-APP system (1.62 ms/cm vs. 1.44 ms/cm).
- In the same bags, the substrate in the OXI-APP system also had a 16% higher EC in the bottom on the bags (lower third of the substrate). The EC in the OXI-APP treatment was 1.88 ms/cm, compared to 1.58 ms/cm in the control treatment.
- Since there was a difference in the chlorophyll concentration in the new cane leaves between the two treatments, we decided to measure the brix of the root exudate. The brix percentage was measured in the top of the bags amongst the bulk of the feeder roots, close to the main stem. The OXI-APP treatment system delived a root zone brix of 0.24%, compared to 0.18% in the control treatment. This is an increase of 25%.

- When the substrate was examined physically, the control treatment was noticeably wetter in the bottom of the bags. Less roots were also observed in this zone. The moisture percentage in the bottom third of the substrate was 52.8% for the OXI-APP treatment, compared to 58.8% in the control treatment.
- The moisture percentage in the top of the bags was however slightly dryer in the control treatment (45.7%), compared to the 48% of the OXI-APP treatment.

- It was very difficult to score the percentage substrate surface area covered by algae and moss growth on the selected plants because of the dence plant growth. Visually, the OXI-APP treatment had less algae and moss surface growth. The data collected indicated approximately 42% less algae and moss surface growth in the OXI-APP system.
- When the disease propagules in the top of the substrate were compared, the OXI-APP treated substrate had 40% less saprophytic fungi in the dilution plates. Some of these fungi included *Aspergillus, Penicillium, Cladosporium*, and *Rhizopus*. No *Botrytis* was isolated from the samples.

DATA COLLECTION AT HOOPENBERG
ROOT CHARACTERISTICS

DATA COLLECTION AT HOOPENBERG
ROOT CHARACTERISTICS: PHOTOS IN GROWTH BAGS

Control treatment

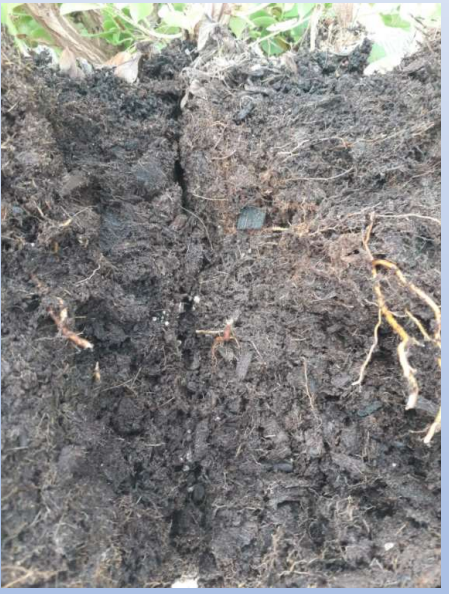
Plant 1 | Plant 2 | Plant 3 | Plant 4 | Plant 5

The plastic growth bags were removed from the substrate on the ten selected plants and evaluated for internal root characteristics after carefully opening up the substrate to the core over the length of the pots

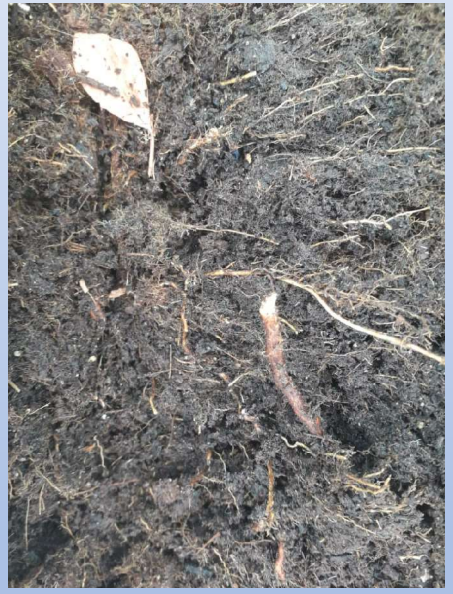
DATA COLLECTION AT HOOPENBERG
ROOT CHARACTERISTICS: PHOTOS IN GROWTH BAGS

Control treatment

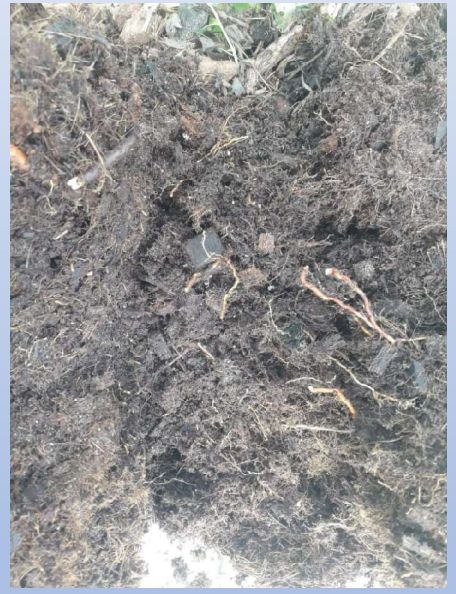
Plant 6



Plant 7



Plant 8



Plant 9

Plant 10

The plastic growth bags were removed from the substrate on the ten selected plants and evaluated for internal root characteristics after carefully opening up the substrate to the core over the length of the pots

DATA COLLECTION AT HOOPENBERG
ROOT CHARACTERISTICS: PHOTOS IN GROWTH BAGS

OXI-APP™ system

Plant 1

Plant 2

Plant 3

Plant 4

Plant 5

The plastic growth bags were removed from the substrate on the ten selected plants and evaluated for internal root characteristics after carefully opening up the substrate to the core over the length of the pots

DATA COLLECTION AT HOOPENBERG
ROOT CHARACTERISTICS: PHOTOS IN GROWTH BAGS

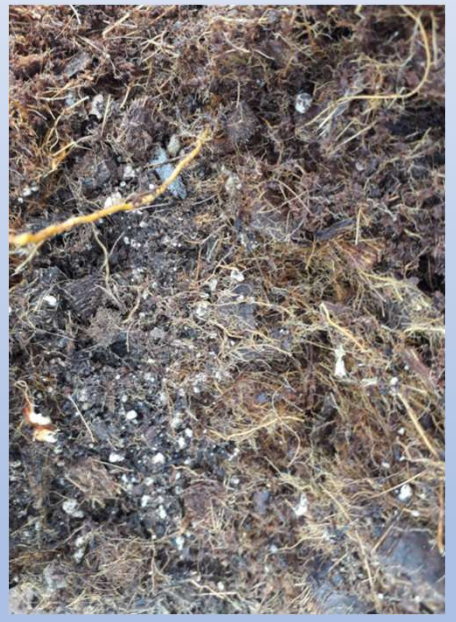
OXI-APP™ system

Plant 6

Plant 7

Plant 8

Plant 9



Plant 10

The plastic growth bags were removed from the substrate on the ten selected plants and evaluated for internal root characteristics after carefully opening up the substrate to the core over the length of the pots

DATA COLLECTION AT HOOPENBERG
ROOT CHARACTERISTICS: FRESH ROOT WEIGHT

Control treatment

Oxi App treatment

Eighty grams of substrate was removed from the core of the 10 selected bags and soaked in water over night before separation of roots and substrate. A total of 800 grams of substrate was therefor collected per treatment. After removal of the roots, they were dried externally with a cloth and left for another 10 minutes to dry before their fresh weight was determined

DATA COLLECTION AT HOOPENBERG
ROOT CHARACTERISTICS: ROOT PHOTOS

Control treatment





DATA COLLECTION AT HOOPENBERG
ROOT CHARACTERISTICS: ROOT PHOTOS

Oxi App treatment

DATA COLLECTION AT HOOPENBERG
ROOT CHARACTERISTICS: ROOT SCORING

Control

Oxi App treatment

One hundred individual roots were removed after fresh root weighing, and scored according to root colour and root thickness

DATA COLLECTION AT HOOPENBERG
ROOT CHARACTERISTICS: ROOT SCORING

Table 9. Root scoring according to colour and thickness

Treatment:	Root colour			Root thickness		
	Light brown	Medium brown	Charcoal/black	Thick (structural)	Medium (water roots)	Fine (feeder roots)
Control	4%	81%	15%	4%	36%	60%
OXI-APP	7%	90%	3%	5%	28%	67%

DATA COLLECTION AT HOOPENBERG

ROOT CHARACTERISTICS: FRESH ROOTS BEFORE & AFTER DRYING

OXI-APP Control

Fresh roots before drying in oven

OXI-APP Control

Picture of roots after oven drying

DATA COLLECTION AT HOOPENBERG
ROOT CHARACTERISTICS: DRY ROOT WEIGHT

Control treatment

OXI-APP treatment

The root dry-weight was determined after drying the fresh root samples in an oven at 180°C for 30 minutes

ROOT CHARACTERISTICS: SUMMARY OF RESULTS

- In both treatments, the lower substrate area were fairly wet (more than 50% moisture measured). The lower substrate portion in the control treatment was wetter than the OXI-App treatment and the roots mainly grew in the top 70-80% of the bag. The Oxi-APP treatment resulted in healthier, lighter-coloured and deeper roots, as can be seen on the photos taken from the core of the root systems. More structural and medium sized roots were visible in the control treatment and many of the finer roots were much darker and had damping-off symptoms.
- The OXI-APP treatment resulted a more finer roots and a greater root volume. When the weight of the fresh roots, that were removed from the 800 grams of substrate, were compared, the control treatment had 37 grams of roots compared to 43 grams in the OXI-APP treatment. This is a difference of 14%.
- The root scoring results in Table 9 indicated a high percentage charcoal or black coloured roots in the control treatment. According to the results, the OXI-APP treatment had almost 80% less charcoal and black coloured roots, and 12% more light and medium-brown coloured roots. From a root thickness perspective the percentage thick structural roots were almost identical. Although the control treatment had more roots in the medium thickness category, it had approximately 10.5% less finer roots.
- Although there was a difference in the fresh root weight in favour of the OXI-APP treatment, the dried roots had exactly the same weight after the oven dehydration process (9 grams each).

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY (A)

- The OXI-APP system was successful in keeping the filter rings clean and the discolouration and sedimentation inside the irrigation pipes to a minimum. This resulted in a significant decrease of salt deposits inside the irrigation pipes. Although the contamination in the dripper lines were not analysed, some of the following biotic and abiotic causes could be the reason for the green and brown sedimentation observed: insoluble Fe and Ca forms, green and red algae, iron bacteria, common bacteria, bacterial slimes, and sulfate reducing bacteria. Once the algae or bacteria forms a matrix inside the dripper lines, they trap oxidised Fe and insoluble Ca complexes. This is often referred to as a scale or rust build up. Based on the above observations, the OXI-APP system should result in less dripper blockages, better water distribution and minimal crop damage.
- The healthier, finer and deeper root system observed in the OXI-APP system resulted in less water saturation in the bottom of the bags. This more balanced air to water ratio resulted in a higher substrate and leaf petiole EC. This in turn stimulated the plants to form a significantly higher number of new bearing canes after pruning. Although the number of bearing canes were 16.4% higher in the OXI-APP system, they still managed to be of a greater length. The new cane leaves in the OXI-APP system also had a 6% higher chlorophyll concentration. The good substrate ‘air filled porosity’ and higher carbohydrate levels obtained from the increased crop biomass, should in turn favour the ‘cycle of energy production and demand’. This was demonstrated by the 25% higher root exudate brix in the OXI-APP system. In the larger sceme of things, the root system will always benefit more in the short term, hopefully resulting in higher fruit yields and enhanced quality later in the season.

EXECUTIVE SUMMARY (B)

- The water oxidation observed with the OXI-APP system accelerated the conversion of ionic compounds to single ions. For this reason, higher electrical conductivity and higher total dissolved soilids were measured at the drippers in the OXI-APP system. This is usually an indication of more plant available mineral ions in the fertigation water. The OXI-APP system increased the plant available sulphate, nitrate, ammonium, phosphate, manganese and iron levels significantly. The decrease in water pH, bicarbonate levels and total alkalinity will further enhance nutrient availability. This accelerated oxidation also resulted in an increased change of charge of manganese and iron to Mn^{3+} and Fe^{3+}. These oxidised forms (Mn^{3+} and Fe^{3+}) are less toxic to plants, and cannot be utilised by manganese and iron oxidizing bacteria as a food and energy source. Because these bacteria live in symbioses with micro-algae, a significant reduction in bacterial counts will result in less micro-algae clumps or cell-masses that causes dripper line blockages. The data supported this and showed a 40% reduction in the amount of algae and moss growth, as well as in the saprophytic fungi in the top of the substrate. In the long run this should increase aeration into the substrate, and lower the fungal inoculum concentration in the top of the substrate.
- Although no plant patogens were detected in the water samples, there were high human pathogen counts in the untreated water (especially *E. coli* and total coliforms). The South African limits for human pathogens are < 1000 cfu/ml heterotrophic plant count, no *E. coli*, and < 10 cfu/100ml total coliforms. In both water samples the heterotrophic plate counts were less than 1000 cfu/ml. The Oxi-App™ system reduced the *E. coli* and total coliform counts significantly. This system can therefor be used to effectively lower the human pathogen counts in irrigation water and improve food safety for the export market.