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PROJECT REPORT

To:
Horticultural Development Council
18 Lavant Street
Petersfield
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PC 83

Tomatoes: Irrigation Systems
for NFT

January 1996

FINAL REPORT

Project Number:	PC83
Project Title:	Tomatoes: Irrigation Systems for NFT
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Authentication

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

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Relevance to Growers and Practical Application

Application

To compare rockwool and NFT growing systems for tomatoes and in particular to consider ways of optimising NFT systems.

This project has shown that NFT systems can produce crops with yields equivalent to a standard rockwool run-to-waste system when grown under similar conditions. The fruit quality from the NFT crops can be higher than the rockwool and is combined with a larger fruit size.

Results obtained in 1995 suggest that large increases in yield could be achieved by modifying the channel length or solution inlets to produce a system where fresh nutrient solution is added more frequently to the channel. This result has now been taken up for evaluation by commerce in 1996.

Summary

A three year trial was set up in 1993 to study crop growth and productivity of tomatoes in Nutrient Film Technique (NFT) with the aim of optimising yields from an NFT grown crop. In all three years the NFT treatments were compared to a standard rockwool run-to-waste system and in years one and two also to a rockwool recirculation system.

In **year one** no significant variation in monetary return was observed when a standard NFT system was compared to either rockwool system. A slight reduction in yield was produced in a NFT drip irrigation system. Fruit quality was higher in the NFT systems than the rockwool at the beginning of the season.

A comparison of flow rates in the NFT channel (5 l/min and 10 l/min) indicated that increasing flow rate has a beneficial effect on fruit yield. However, the increase in yield produced by increasing the flow rate to 10 l/min would be far outweighed by the cost of extra equipment and increased electricity required to produce this extra flow.

If existing rockwool growers changed to NFT, an NFT system using a drip irrigation system to run the NFT flow could reduce the setting-up costs by eliminating the need for the installation of a new system. The drip irrigation system performed well at the beginning of the season when the plants were small and the weather did not generate excessive demands for water by the plants. However, in August and September, the hot weather caused some water stress to the plants at the top of the channel which caused a slight reduction in yield and fruit quality.

Increasing the flow rate in the NFT channel from 5 l/min to 10 l/min maintained an increased solution oxygen content at the end of the channel which may have resulted in the increase in yield in this treatment.

In **Year two** the treatments were designed to concentrate on modifying the NFT solution to improve the root environment with the aim of maximising yields.

An oxygen deficiency in the solution had been highlighted in year one as a possible cause of reduction in yield in an NFT system. Oxygen was added to the NFT solution before it entered the trough to raise the dissolved oxygen content of the solution by 100%.

Magnetisation has been claimed, in a trial on a commercial nursery, to affect NFT grown crops by significantly increasing yield. A 'Polar' magnet was installed in the line of the feed solution with the aim of producing the magnetising effect.

Both of the treated NFT systems were compared against a control, all with a flow of 5 l/min.

The NFT systems all produced slightly lower yields than both rockwool treatments leading to slightly lower monetary values. The total yields produced by the NFT systems were similar. However, while the oxygen treatment maintained comparable yields to the control consistently throughout the season, the magnet treatment produced higher yields at the beginning of the season and lower yields at the end of the season.

Fruit quality was generally higher in the NFT systems than the rockwool, similar to the results observed in year one. But, the NFT magnet produced a high level of Blossom-end rot at the end of the season which increased the percentage waste and reduced percentage Class I.

In **year three** four NFT treatments were assessed, NFT 3l control, NFT 3l with oxygenation, NFT 5l control and NFT 5l with magnet, in comparison with two rockwool treatments, Rockwool run-to-waste control and Rockwool run-to-waste + magnet.

There were no significant differences in yield between the rockwool and NFT treatments. The rockwool treatments produced a higher percentage of Grade D fruit throughout the season.

Three out of the four NFT treatments, 3 l/min control, 5 l/min control and 3 l/min with oxygenation, all produced higher yields than the rockwool. There were slight differences between these with the 3l treatment significantly greater than the other two.

The NFT magnet, at a 5 l/min flow rate, produced a significantly lower yield and monetary return than the 5l/min control. Yield from the magnet treatment was higher than the standard rockwool throughout the period March to June then after July it began to decrease until it was significantly lower in September and October. This was partly due to consistent increases in percentage waste fruit after July.

The rockwool magnet treatment produced a slightly higher yield than the standard rockwool treatment.

The division of the NFT channels into four plots allowed an assessment of yield along the NFT channel to be carried out. In three out of the four NFT treatments, 3 l/min control, 5 l/min control and 5 l/min with magnet, the yield decreased as the distance from the NFT inlet increased. This reduction in yield was recorded as 10% between the first and second plots along the channel (see Figure 1).

Introduction

The solution which runs-off from hydroponically grown crops can be high in levels of nutrients and some pesticides. European legislation covering the amounts of chemicals which can enter watercourses is highly relevant to the type of pollution caused by glasshouse run-off and therefore methods of reducing the pollution risk are being considered. Both Nutrient Film Technique systems and Recirculation in standard rockwool systems aim to reduce run-off to zero by collecting all of the run-off and recirculating it back to the crop.

NFT and recirculation systems are both suitable for growing tomato crops however, crop productivity in NFT has been observed to be lower on a commercial nursery than crops grown in standard rockwool run-to-waste systems. The aim of this project was to study NFT systems in comparison with rockwool run-to-waste and rockwool recirculation systems to determine which factors, if any, may not be optimised in an NFT system and may be depressing yield.

NFT systems are initially costly to install and the increased costs of continuously pumping nutrient solution to the crop, collecting it and returning it to the mixing tank for re-use must also be taken into account. Growers may be unwilling to convert their nurseries to an NFT system if there is potential for lower yields. This trial looked at a modified NFT system where each plant was constantly fed from a conventional dripper as used for rockwool but the plants were placed in an NFT trough without rockwool so the solution could be collected and returned to the mixing tank. Also rockwool recirculation was studied by placing the slabs into a channel to collect the run-off and recycle it.

This trial investigated several systems for optimising the root environment of NFT systems;

- Increased flow rate to maximise the amount of nutrients passing the root system, especially at the end of the trough.
- Oxygenation of the nutrient solution.
- Magnetisation of the nutrient solution.

These NFT systems were compared against a standard rockwool run-to-waste system as the control.

Materials and Methods

Cultural Details 1995

Variety:	Liberto
Sowing Date:	22 November 1994
Planting Date:	30 December 1994
Bags Slit:	6 January 1995
First Harvest, overall:	16 March 1995
Final Recorded Harvest:	30 October 1995
Plant Population:	11,000 plants/acre increasing to 13,800 shoots/acre by taking sideshoots in Week 9, late February.

Irrigation (rockwool system): 150 ml per 100J or every 2 hours

Shelf Life Conditions: 20°C, 12 hours illumination per 24 hours, 65% RH.

Temperature Regime: 18°C day, 16°C night

CO_2 Regime: 1000 ppm upto end of April, followed by maintenance of 350 ppm.

Humidity Control:

Using humidity deficit measurement additional minimum pipe heat followed by minimum ventilation to prevent high humidity conditions.

Temperature and ventilation setpoints were changed according to visual plant growth by the majority of varieties.

In all respects crop management followed best commercial practice.

Treatments 1995

1. NFT 5 l/min/channel *.

2. NFT 5 l/min/channel * treated with a polar magnet +.

3. NFT 3 l/min/channel *.

4. NFT 3 l/min/channel * with oxygen injected into the nutrient solution #.

5. Standard rockwool run-to-waste, 15 cm wide Grodan slabs.

6. Standard rockwool run-to-waste, 15 cm wide Grodan slabs, with a permanent magnet placed in the line of the nutrient solution.

* All NFT systems consisted of polythene lined 25 cm wide galvanised channels, 30 m long, set up with a slope of 1 in 80. Run-off was collected in 50 l below-ground tanks and pumped continuously to large mixing tanks for the addition of acid and nutrients as required before returning to the crop.

\+ A polar magnet was fitted in-line on the nutrient solution line as it left the feed machine and before going to the crop.

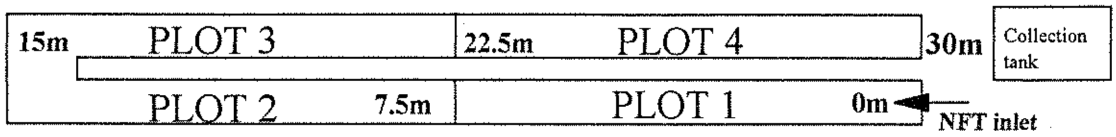
\# Oxygen was injected into the nutrient solution after it left the feed machine, through a sparge valve. Oxygen levels were set at double the non-oxygenated solution, 3 l/min control. This required an injection rate of 210 cc/min O_2 (7 cc/l).

Trial Design

The trial was carried out in half of a 980 m^2 , 4.2m high modern venlo glasshouse at HRI Stockbridge House.

The NFT trial design comprised 4 NFT system treatments applied to complete double rows of plants. Each system was replicated twice giving a total of eight double rows of NFT treated plants. Each double row of NFT plants was subdivided for recording purposes into two single rows and each single row was subdivided into two half-rows so that each NFT trough was divided into four quarters. The four quarters of each NFT trough were recorded separately as individual plots (Figure 1) to monitor the effects of oxygen or nutrient depletion along the length of each NFT trough. The NFT inlet was on the north side of a double row in one replicate half of the experiment and on the south side of a double row in the other replicate half of the experiment so that north-south effects on the NFT gradient were balanced. Possible positional effects were corrected by growing double rows of rockwool plants between each pair of NFT double rows and by adjusting the NFT sub-plot yields by a covariance adjustment on the corresponding sub-plot yields from the rockwool double rows.

Figure 1: Division of an NFT channel to form 4 plots each 7.5 m long.



15m - distance from inlet

Explanation of Statistical Terms

Throughout the report a number of statistical terms are referred to; these are:

SED = The standard error of the difference when comparing two means in that column of data.

A statistical term easier to interpret:

LSD 5% = The least (minimum) difference when comparing any two figures within a given column that is required for those figures to be statistically different.

A number of common notations are also used to indicate the degree to which values are significantly different.

NS = Not significant.

* = P <0.05, ie. the probability of this result occurring by chance is equal to or less than 1 in 20 (0.05 = 5%).

** = P <0.01, ie. the probability of this result occurring by chance is equal to or less than 1 in 100 (0.01 = 1%).

*** = $P < 0.001$, ie. the probability of this result occurring by chance is equal to or less than 1 in 1000 (0.001 = 0.1%).

Records and Assessments

1. Plant height fortnightly, until the first plants reached the wire.

2. Leaf number monthly, to the wire.

3. Stem diameter monthly. Measure at the leaf below the top truss in flower.

4. Overall vigour score monthly.

5. Leaf length and width (3 times). One leaf above the top truss being harvested.

6. Yield in size grades 3 times per week.

7. Fruit quality at each harvest.

8. Shelf-life (3 times).

9. Fruit flavour (2 times).

Root Measurements

1. Root development (twice weekly) until a full mat formed.

2. Score roots monthly thereafter for both amount and colour.

Nutrient Solution Records

1. Monitoring of flow rates to ensure they stay at 3 and 5l/min/trough.

2. Solution oxygen levels and temperature in all NFT systems weekly at the beginning of each plot (Figure 1), and at the end of the channel.

3. Weekly monitoring of solution samples for full nutrient analysis from all of the systems (Appendix I).

RESULTS

Plant Growth and Development

Differences in plant growth and development between treatments were generally small. Only results showing observable differences are reported below. Data tables for plant height, leaf number, vigour, stem diameter, leaf length, leaf width and root growth are presented in Appendix II.

Plant height

Plants in the two rockwool treatments were of similar heights. Rockwool grown plants were approximately 10 cm taller than those in NFT (Figure 2).

Plants in the NFT 51 control treatment were slightly taller (2 cm) than the plants in other NFT treatments.

Leaf Number

Leaf number was slightly higher on plants in the two rockwool treatments than any of the NFT treatments.

Vigour

There was no consistent difference in plant vigour scores between either rockwool or NFT 31 grown plants. The vigour of the NFT oxygen treatment, however, was reduced in May compared to all other treatments.

Stem Diameter

Stem diameter of plants on the rockwool magnet treatment was thinner than plants on the standard rockwool treatment.

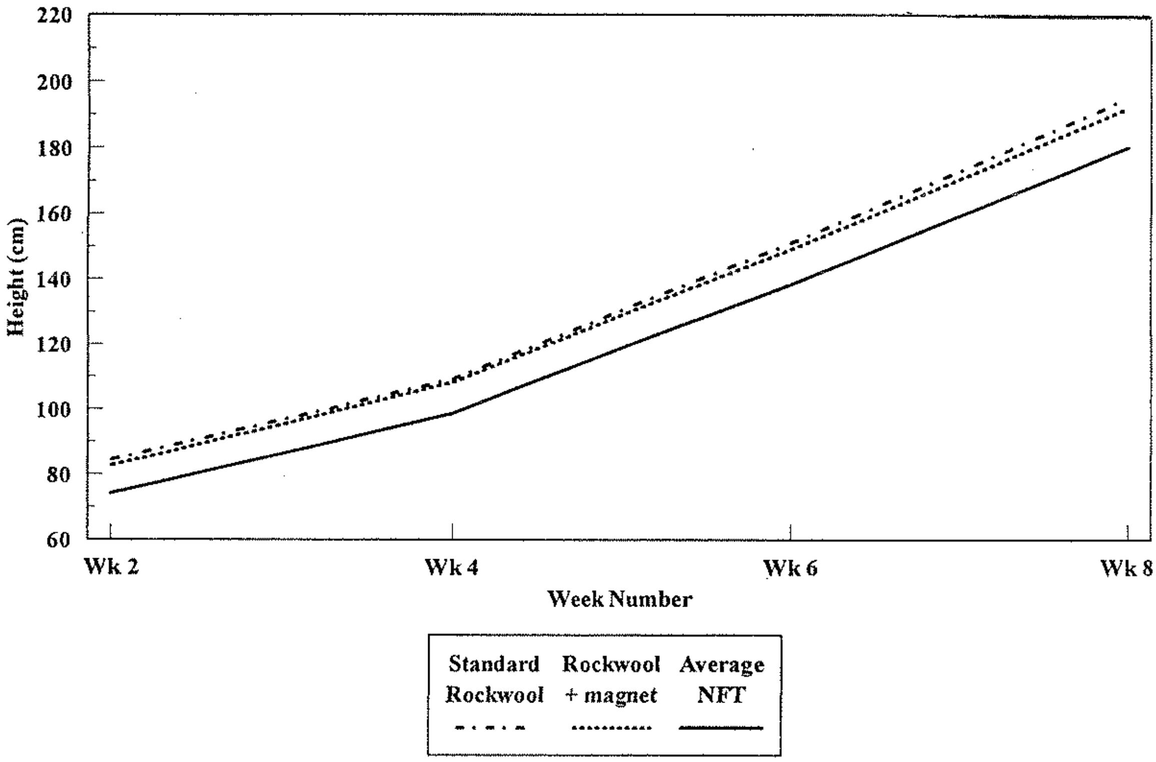
Plants on NFT had similar stem diameters for most of the year. In May, however, a reduction was measured in the stem diameter of the NFT 31 oxygen treatment.

Leaf Length and Width

The NFT 51 control and NFT 51 magnet treatments produced plants with the largest leaf size.

The NFT 31 control and NFT 31 oxygen treatments generally produced plants with the smallest leaf size.

Figure 2: Plant height (cm).



Root Development in NFT

The total amount of root was greater but individual root length was shorter from plants in the NFT oxygen treatment, particularly early in the season.

After May the root colour in the oxygen treatment deteriorated rapidly. By the end of the season root colour was equal in all treatments.

Fruit development

The initial harvest of fruit from both rockwool treatments was slightly earlier than the NFT treatments (Figure 3a).

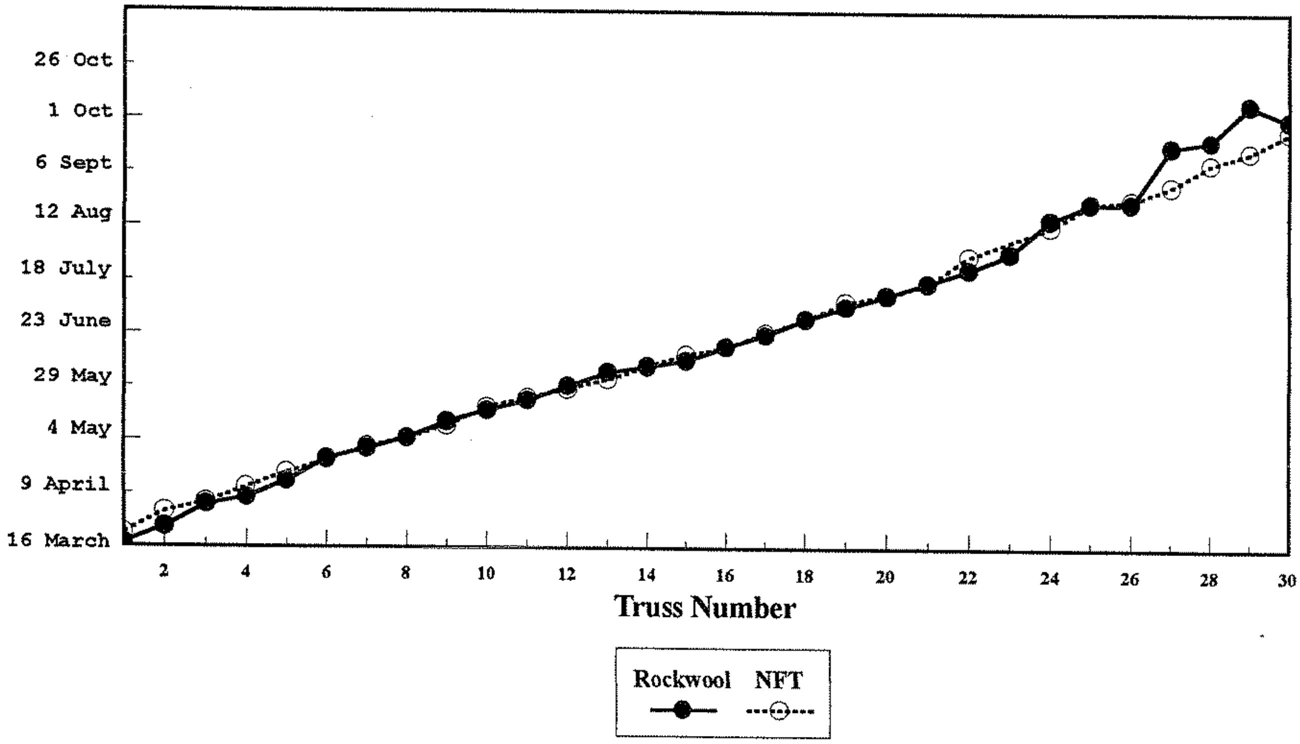
After April trusses were harvested slightly earlier from the rockwool magnet treatment than the standard rockwool (Figure 3b). The rockwool magnet treatment produced less trusses in total than the standard rockwool.

Trusses in the NFT 51 magnet treatment were harvested slightly later than in the NFT 51 control treatment. Again the magnet treatment produced fewer trusses (Figure 3c).

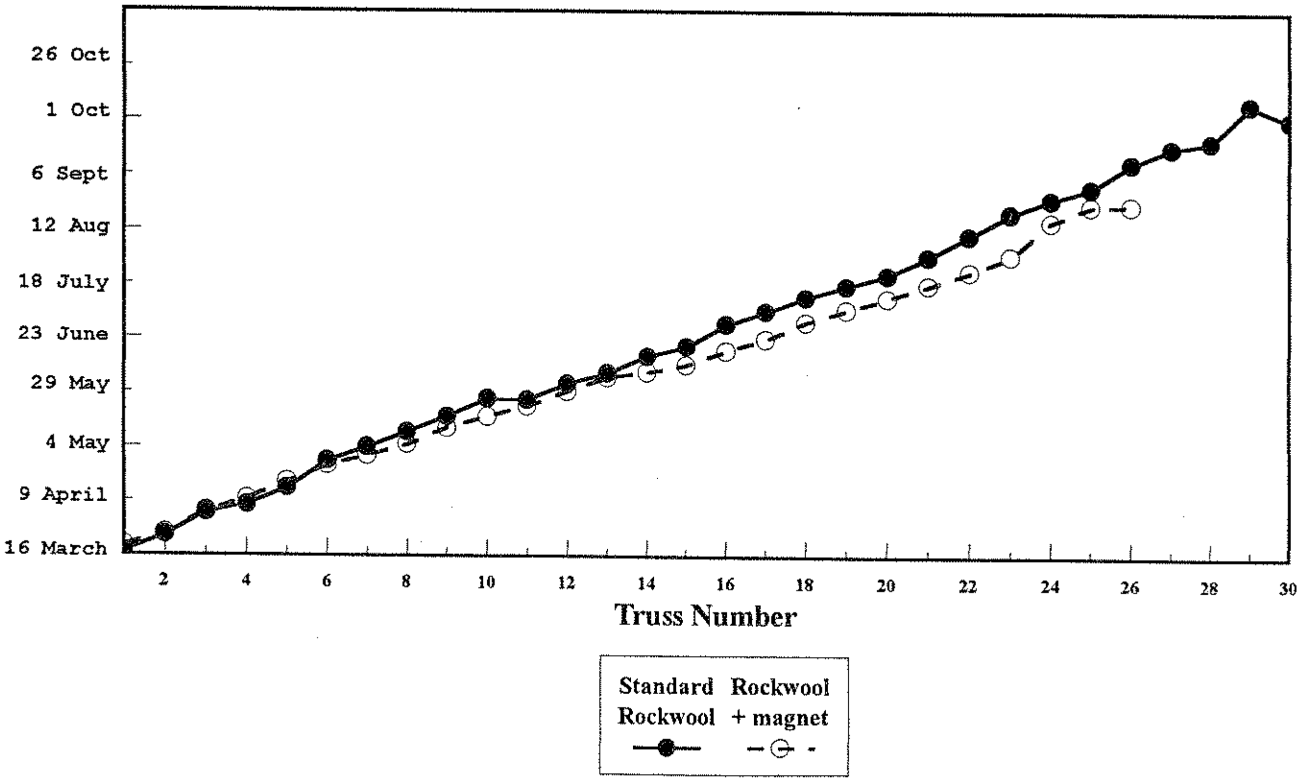
The NFT 31 oxygen treatment produced less trusses in total than the NFT 31 control and NFT 51 control (Figure 3d).

Figures 3a & b: Date of First Harvest of Successive Trusses

a: Average Rockwool and Average NFT

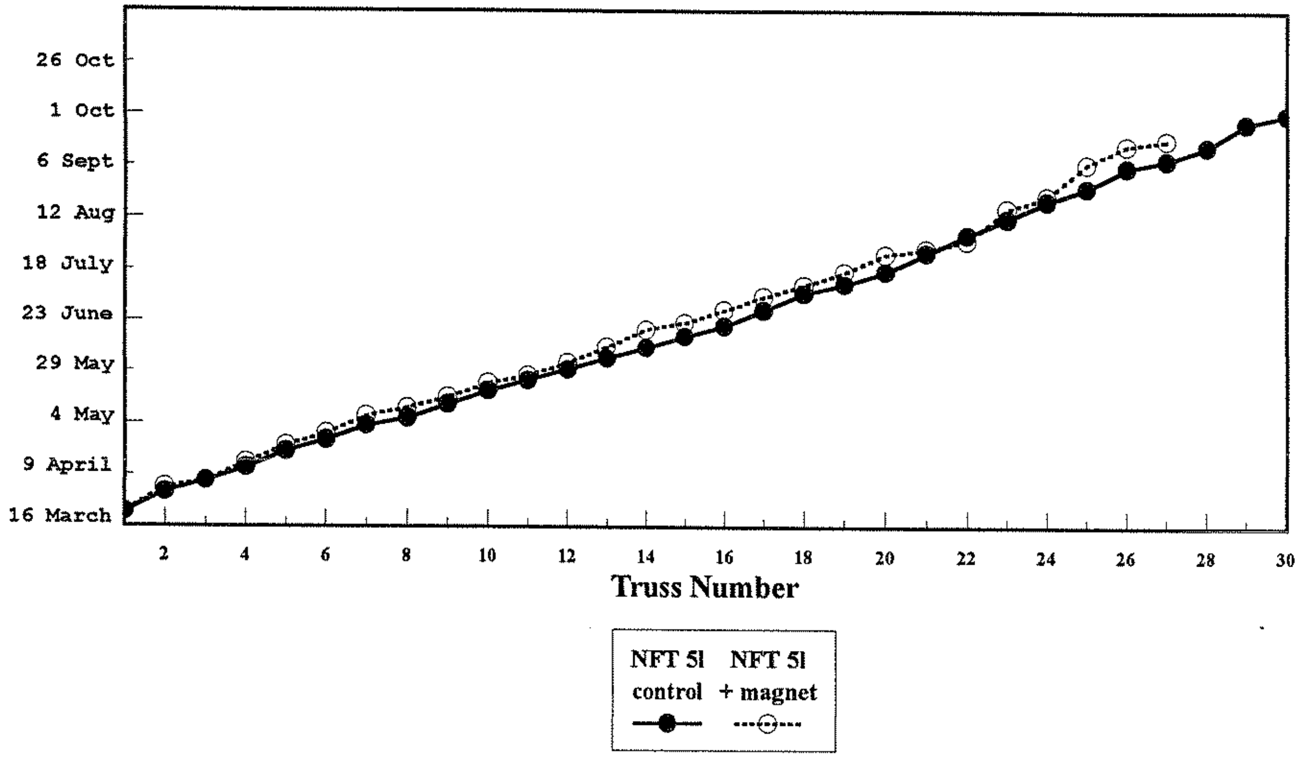


b: Rockwool and Rockwool + magnet

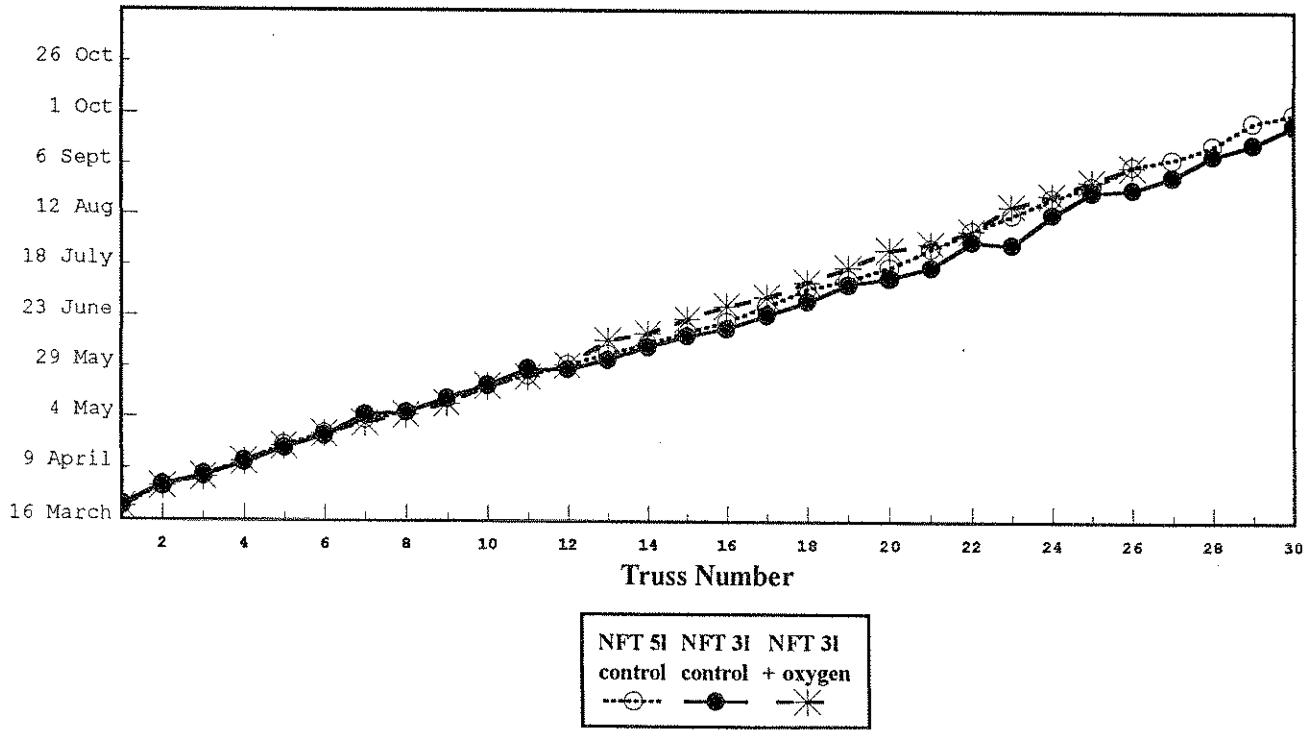


Figures 3c & d: Date of First Harvest of Successive Trusses

c: NFT 5l control and NFT 5l magnet



d: NFT 3l control, NFT 5l control and NFT 3l + oxygen



RESULTS (Treatment effects)

Monetary Value (£/m^2) (Table 1)

The monetary value to the end of May shows that there were no significant differences between the rockwool and NFT treatments but the NFT 31 control and NFT 51 control were slightly higher than both rockwool treatments.

The NFT 31 control had the highest monetary value, with NFT 51 control slightly lower. These were significantly greater than the NFT 31 oxygen and 51 magnet treatments.

At the end of the season the monetary values showed a similar pattern. The average NFT return was significantly higher than the Rockwool return. All of the NFT treatments with the exception of the magnet performed better than the rockwool.

The standard rockwool and rockwool magnet treatments recorded similar end of season total monetary values.

The NFT 31 control produced the highest overall value, slightly greater than NFT 51 control.

The NFT 51 Magnet produced a monetary value significantly lower than all other treatments.

Total Marketable Yield (kg/m^2)(Table 2)

Total marketable yield was excellent from all systems and no differences were observed between the average total yields of the rockwool and NFT treatments.

The rockwool magnet treatment produced slightly higher total yields than the standard rockwool. This was brought about by slightly higher yields in middle of the season.

The NFT 51 magnet treatment produced significantly lower total yields than the NFT 51 control. Early yields were similar in these treatments, the decrease in yield occurring after July.

The NFT 31 control treatment produced slightly higher total yields than the NFT 51 control and NFT 31 oxygen. The NFT 31 oxygen treatment produced similar yields to the NFT 51 control in the early part of the season. Yields in the NFT 31 oxygen were reduced in May, June and July following a feed machine breakdown in April. By August they were equivalent to or better than the other NFT treatments. This produced a final yield lower than the NFT 31 control treatment but similar to the NFT 51 control.

Table 1 **Monetary Value (£/m2)**

Treatment	Total To End May	Total To End Oct
NFT 5L	13.32	29.73
NFT + Magnet	12.22	26.91
NFT 3L	13.83	30.29
NFT + O2	12.67	28.41
Rockwool	12.99	27.63
Rockwool Magnet	12.92	28.41

STATS		
to compare average NFT and rockwool		
SED (4df)	0.134	0.332
LSD (p=0.05)	0.37	0.92
significance	NS	*
to compare between NFT systems		
SED (4df)	0.198	0.49
LSD (p=0.05)	0.55	1.36
significance	**	**

Table 2 Total Marketable Yield (kg/m2)

Treatment	March	April	May	June	July	August	Sept	Oct	Total	Total (Inc Green Fruit)
NFT 5L	1.4	6.7	9.9	8.9	9.2	8.4	6.4	4.0	54.9	55.3
NFT + Magnet	1.4	6.2	9.6	9.0	8.8	7.6	4.4	2.3	49.3	49.5
NFT 3L	1.1	7.0	10.8	8.9	10.0	8.8	6.6	4.4	57.5	58.0
NFT + O2	1.3	6.7	8.4	8.8	9.1	8.9	6.2	4.3	53.8	54.3
Rockwool	1.8	6.5	9.0	8.3	8.2	8.4	6.7	3.8	52.6	53.1
Rockwool Magnet	1.7	6.3	9.2	8.6	8.3	8.6	6.4	4.3	53.4	53.8
STATS										
to compare average NFT and rockwool										
SED (4df)	0.04	0.2	0.2	0.1	0.1	0.3	0.2	0.1	0.5	0.5
LSD (p=0.05)	0.11	-	-	0.38	0.32	-	0.44	0.44	-	-
significance	***	NS	NS	*	***	NS	*	*	NS	NS
to compare between NFT systems										
SED (4df)	0.1	0.2	0.4	0.2	0.2	0.4	0.2	0.2	0.7	0.7
LSD (p=0.05)	0.16	-	0.99	-	0.47	-	0.53	0.53	2.03	2.03
significance	*	NS	*	NS	**	NS	**	***	**	***

Fruit Quality (Tables 3 - 5)

Fruit quality was low (40 - 50 %) in all treatments during the hot weather in the middle of summer (July, August, September) due to downgrading for poor fruit shape.

Few significant differences in fruit quality existed throughout the season and no significant differences were observed in overall fruit quality at the end of the season. In March fruit quality from the rockwool was better than the NFT, while during the summer months the standard rockwool had a higher waste than all the other treatments.

Percentage Class I from the NFT 51 magnet treatment was low at the end of the season (31.3% in October), at the same time corresponding to a high percentage waste in September and October.

The NFT 51 control produced the smallest amount of waste consistently through the trial.

Fruit Size (Tables 6 - 8)

Fruit size was generally larger from the NFT than on the rockwool treatments. Plants on both rockwool treatments produced a higher percentage of fruit in the optimum size grade (D), particularly in April.

NFT 31 control, 51 control and 51 magnet generally produced significantly larger fruit than the NFT 31 oxygen from March to June.

Overall both rockwool treatments and the NFT 31 oxygen treatments produced the highest percentage of Grade D, which were significantly higher than the other NFT treatments.

Fruit size in the NFT 51 magnet treatment began to fall in August. In October a very high proportion (64%) of Grade E was recorded. During this period virtually no Grade C fruit was recorded.

Table 3 Percentage Class I of Total Yield

Treatment	March	April	May	June	July	August	Sept	Oct	Mean	Mean (Inc Green Fruit)
NFT 5L	74.0	83.1	82.3	53.6	43.3	48.8	55.0	46.0	60.0	60.0
NFT + Magnet	77.4	83.4	82.6	55.6	48.4	46.0	53.0	31.3	60.1	60.7
NFT 3L	76.8	86.9	82.9	52.2	45.9	38.9	45.5	41.9	58.1	58.0
NFT + O2	76.6	84.8	82.0	48.2	41.1	44.9	48.7	44.3	56.8	56.8
Rockwool	89.5	84.6	82.2	58.1	42.0	40.9	45.5	37.0	58.2	58.0
Rockwool Magnet	93.0	85.5	82.4	58.0	44.4	44.6	48.8	39.6	59.7	59.6
STATS										
to compare average NFT and rockwool										
SED (4df)	1.4	1.4	1.4	3.2	3.1	2.3	2.7	3.1	0.9	1.0
LSD (p=0.05)	3.89	-	-	-	-	-	-	-	-	-
significance	***	NS	NS	NS	NS	NS	NS	NS	NS	NS
to compare between NFT systems										
SED (4df)	2.0	2.1	2.1	4.7	4.6	3.4	4.0	4.5	1.4	1.4
LSD (p=0.05)	-	-	-	-	-	-	-	-	-	-
significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4 Percentage Class II of Total Yield

Treatment	March	April	May	June	July	August	Sept	Oct	Mean	Mean (Inc Green Fruit)
NFT 5L	25.6	16.4	16.0	44.4	51.5	43.5	36.4	48.8	35.8	35.9
NFT + Magnet	21.7	15.7	16.5	41.7	46.4	40.1	28.7	32.7	32.3	32.2
NFT 3L	22.7	12.6	16.1	46.6	47.9	44.9	41.4	51.4	36.0	36.1
NFT + O2	23.2	14.3	15.9	49.8	53.7	44.4	40.3	49.2	38.0	38.0
Rockwool	10.2	14.7	15.4	38.1	43.4	40.9	45.5	58.2	34.1	34.3
Rockwool Magnet	6.7	13.6	15.8	40.4	45.8	40.0	43.2	54.9	34.2	34.3
STATS										
to compare average NFT and rockwool										
SED (4df)	1.4	1.3	1.0	3.0	3.4	2.1	2.8	2.9	0.5	0.5
LSD (p=0.05)	3.84	-	-	-	-	-	-	8.16	-	-
significance	***	NS	NS	NS	NS	NS	NS	*	NS	NS
to compare between NFT systems										
SED (4df)	2.0	1.9	1.4	4.4	5.0	3.1	4.2	4.3	0.7	0.8
LSD (p=0.05)	-	-	-	-	-	-	-	12.05	2.10	2.10
significance	NS	NS	NS	NS	NS	NS	NS	*	**	**

Table 5 Percentage Waste of Total Yield

Treatment	March	April	May	June	July	August	Sept	Oct	Mean	Mean (Inc Green Fruit)
NFT 5L	0.4	0.5	1.7	2.0	5.2	7.7	8.6	5.2	4.1	4.1
NFT + Magnet	0.9	0.9	0.9	2.7	5.2	13.9	18.4	35.9	7.0	7.1
NFT 3L	0.4	0.5	1.0	1.2	6.2	16.2	13.1	6.7	5.9	5.9
NFT + O2	0.2	0.8	2.1	2.0	5.2	10.7	11.0	6.6	5.2	5.1
Rockwool	0.4	0.8	2.4	3.8	14.5	18.3	9.1	4.9	7.8	7.7
Rockwool Magnet	0.3	0.9	1.8	1.7	9.8	15.5	8.1	5.5	6.1	6.1
STATS										
to compare average NFT and rockwool										
SED (4df)	0.2	0.3	0.6	1.0	1.7	1.4	0.4	1.1	0.5	0.5
LSD (p=0.05)	-	-	-	-	4.63	3.99	1.05	1.39	1.35	1.35
significance	NS	NS	NS	NS	*	*	***	**	*	*
to compare between NFT systems										
SED (4df)	0.3	0.4	0.9	1.5	2.5	2.1	0.6	1.6	0.7	0.7
LSD (p=0.05)	-	-	-	-	-	-	1.67	4.41	-	-
significance	NS	NS	NS	NS	NS	NS	***	***	NS	NS

Table 6 Percentage Grade C of Class I (57-67 mm)

Treatment	March	April	May	June	July	August	Sept	Oct	Mean	Mean (Inc Green Fruit)
NFT 5L	17.6	18.9	11.3	3.0	2.1	0.4	0.7	0.9	7.7	7.7
NFT + Magnet	13.3	15.9	10.5	3.7	1.9	0.3	0.1	0.0	7.1	7.1
NFT 3L	12.4	22.2	17.0	4.9	2.2	1.0	1.0	0.8	10.4	10.3
NFT + O2	8.2	15.0	7.6	1.9	3.1	1.5	1.3	0.4	6.0	5.9
Rockwool	6.0	10.2	6.0	1.6	0.3	1.0	2.0	3.0	4.4	4.4
Rockwool Magnet	5.5	9.7	7.0	1.8	0.4	1.4	3.2	1.5	4.5	4.5
STATS										
to compare average NFT and rockwool										
SED (4df)	1.4	1.0	1.6	0.6	0.1	0.5	0.9	1.0	0.5	0.6
LSD (p=0.05)	3.89	2.83	4.57	1.61	0.41	-	-	-	1.53	1.53
significance	**	**	*	*	***	NS	NS	NS	**	**
to compare between NFT systems										
SED (4df)	2.0	1.5	2.4	0.9	0.2	0.8	1.3	1.5	0.8	0.8
LSD (p=0.05)	5.63	4.19	-	-	0.60	-	-	-	2.26	2.26
significance	*	*	NS	NS	*	NS	NS	NS	*	*

Table 7 Percentage Grade D of Class I (47-57 mm)

Treatment	March	April	May	June	July	August	Sept	Oct	Mean	Mean (Inc Green Fruit)
NFT 5L	78.1	74.4	76.1	74.1	83.0	83.1	75.0	76.3	77.2	77.2
NFT + Magnet	82.7	78.9	77.9	76.4	82.4	62.3	39.8	34.6	73.0	72.8
NFT 3L	84.3	74.0	75.1	75.8	82.5	75.5	79.2	80.0	76.9	77.0
NFT + O2	87.8	78.4	76.1	78.2	82.4	86.9	83.4	86.0	80.7	80.7
Rockwool	88.4	83.6	78.9	70.6	76.2	86.3	89.6	87.7	81.0	81.0
Rockwool Magnet	88.4	83.8	80.9	76.7	80.9	88.3	85.9	90.0	82.9	82.9
STATS										
to compare average NFT and rockwool										
SED (4df)	1.1	1.0	1.7	4.0	3.6	2.3	2.1	4.4	0.8	0.8
LSD (p=0.05)	2.91	2.72	-	-	-	6.43	5.74	7.77	2.27	2.27
significance	**	**	NS	NS	NS	*	***	*	**	**
to compare between NFT systems										
SED (4df)	1.5	1.5	2.6	5.9	5.4	3.4	3.1	6.5	1.2	1.2
LSD (p=0.05)	4.29	4.03	-	-	-	9.51	8.61	8.61	3.36	3.36
significance	*	*	NS	NS	NS	**	***	**	*	*

Table 8 Percentage Grade E of Class I (40-47 mm)

Treatment	March	April	May	June	July	August	Sept	Oct	Mean	Mean (Inc Green Fruit)
NFT 5L	4.2	6.2	12.2	22.1	14.5	16.4	24.2	22.4	14.7	14.7
NFT + Magnet	3.8	4.7	11.4	19.4	15.1	36.5	56.9	63.1	19.2	19.3
NFT 3L	3.2	3.4	7.5	16.2	14.3	22.9	19.7	17.0	11.7	11.8
NFT + O2	3.9	6.2	15.7	18.5	14.0	11.5	15.2	13.5	12.8	12.9
Rockwool	5.4	5.9	14.8	26.1	21.3	12.3	8.3	9.2	13.9	13.9
Rockwool Magnet	5.9	6.2	11.8	20.5	17.8	10.2	10.8	8.4	12.1	12.1
STATS										
to compare average NFT and rockwool										
SED (4df)	0.7	0.4	1.7	3.9	2.6	2.9	2.1	3.4	0.9	0.9
LSD (p=0.05)	-	-	-	-	-	8.03	5.82	7.77	-	-
significance	NS	NS	NS	NS	NS	*	***	**	NS	NS
to compare between NFT systems										
SED (4df)	1.0	0.6	2.5	5.7	3.8	4.3	3.1	5.0	1.3	1.3
LSD (p=0.05)	-	1.62	-	-	-	11.86	8.61	13.97	3.58	3.58
significance	NS	*	NS	NS	NS	*	***	**	*	*

Fruit Physical Characteristics (Appendix III)

Fruit was assessed 3 times during the season (April, June and August) for physical characteristics.

All of the fruit disorders assessed were at very low levels and were similar for most of the treatments.

Fruit picked in April was of excellent quality. Levels of Ribbing, Fine net cracking and Radial cracking increased slightly as the season progressed.

In general both rockwool treatments had the highest levels of both radial cracking and fine net cracking, particularly in August, while the NFT 51 control and NFT 51 magnet treatments had the least.

Fruit from the rockwool magnet treatment was less boxy than fruit from the standard rockwool.

The NFT 51 magnet treatment produced fruit with less Goldspot but slightly more Flecking than the NFT 51 control.

The NFT 31 control and NFT 31 oxygen had more Fine net cracking, Radial cracking and Flecking than the 51 control. The NFT 31 control showed less Goldspot in April than the other NFT treatments.

Fruit Composition (Appendix IV)

Fruit pH, sugar content and percentage dry matter were measured 3 times during the season (April, June and August).

Fruit composition varied little between the treatments. The standard rockwool had slightly higher sugar levels than the other treatments and the NFT 31 control lower sugar levels.

Shelf Life (Appendix IV)

Percentage weight loss and firmness after 6 days in shelf life conditions were measured 3 times during the season (April, June and August).

After 6 days in shelf life conditions percentage weight loss was greatest in the rockwool magnet treatment in April and in the standard rockwool in August. Fruit from both NFT 51 treatments generally lost less fresh weight during shelf life than fruit from any of the other treatments.

In August the two rockwool treatments produced the softest fruit and the two NFT 51 treatments the firmest.

Taste Testing (Appendix V)

Flavour assessments were carried out in June with a panel of assessors tasting pairs of fruit and scoring for sweetness, sharpness, firmness of flesh and overall flavour.

Flavour assessments carried out in June indicated that the rockwool magnet had the best overall flavour, with the standard rockwool treatment second best. All of the flavour scores correlated with the sweetness scores as fruit with a high sweetness also scored a high overall flavour.

Dissolved Oxygen Content and Temperature of NFT Solution

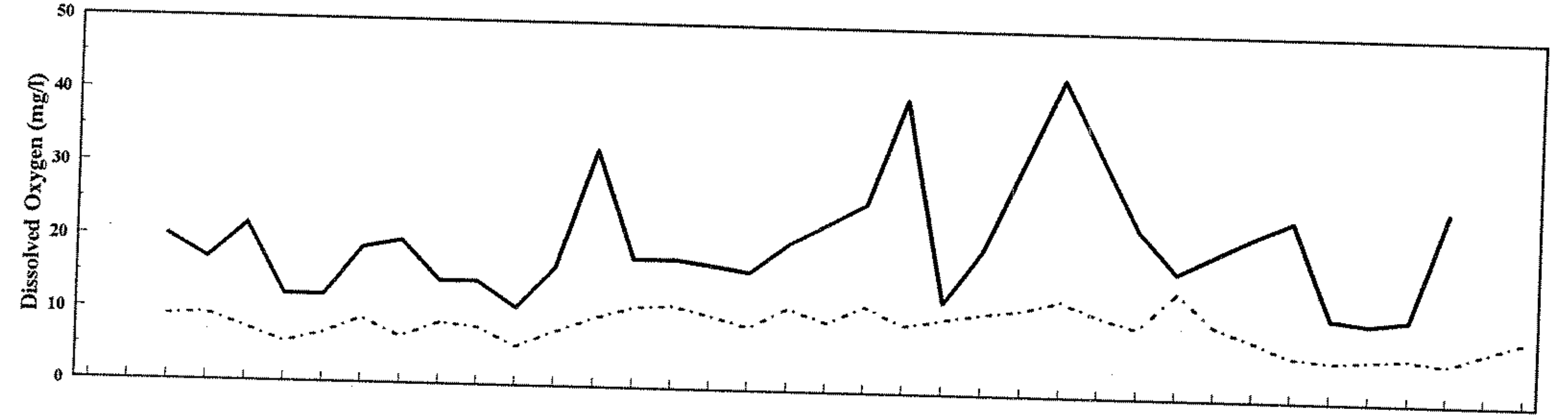
The dissolved oxygen content at the start of the NFT 31 oxygen treatment was maintained at approximately double that measured in the unoxygenated treatments (Figure 4a). Figure 4b shows that the oxygen content was also maintained at a higher concentration at the end of the channel. The rate of decrease in dissolved oxygen concentration along the channel in the NFT 31 oxygen treatment was greater then in the unoxygenated treatments (Figure 4c).

The temperature of all four nutrient solutions remained similar along the length of the trough regardless of treatment, Figure 5 shows the measured temperatures at the beginning of the channels.

The NFT 31 control maintained a slightly higher dissolved oxygen level down the channel than the NFT 51 control, although both systems started at the inlet end with similar dissolved oxygen levels.

Figures 4a & b: Dissolved Oxygen Content of NFT Solution

a: Channel Inlet



b: Channel Outlet

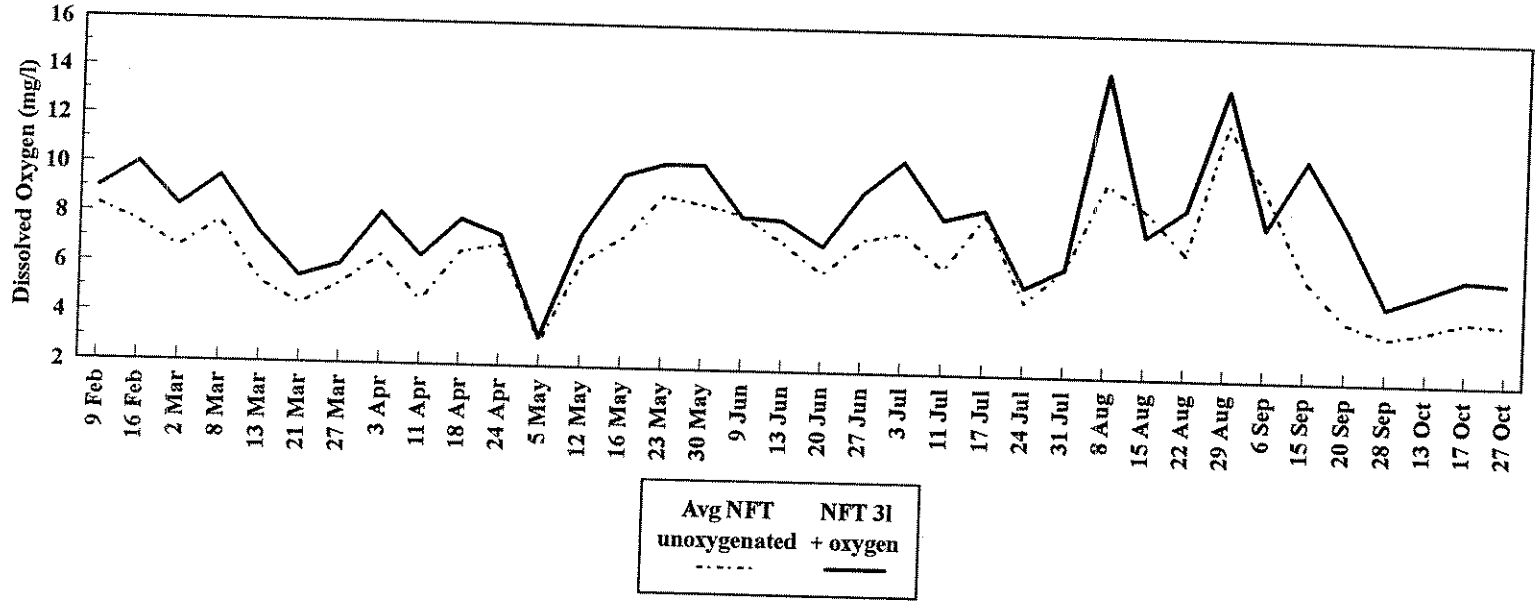


Figure 4c: Reduction in dissolved oxygen concentration along a 30m NFT channel

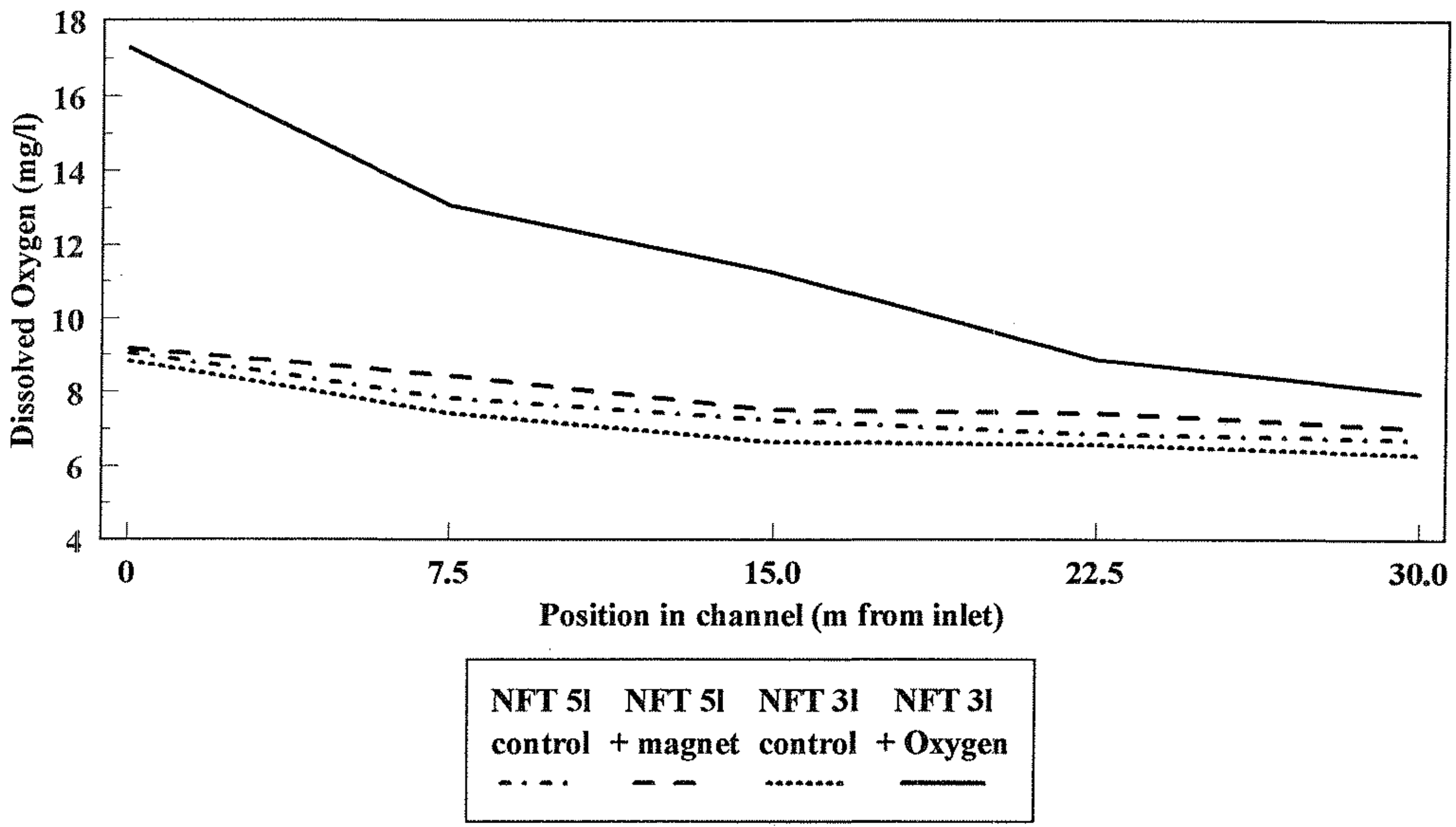
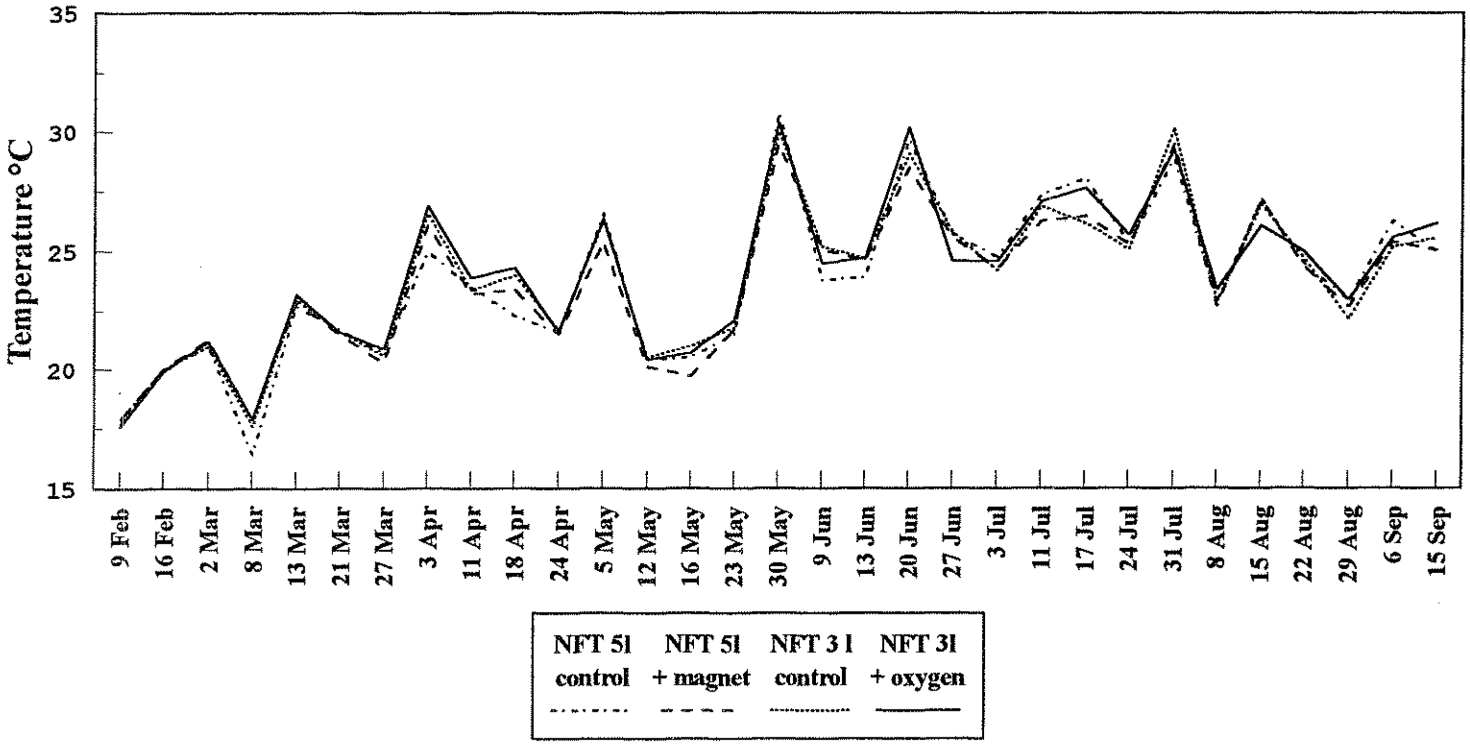


Figure 5: Temperature of NFT Solution

Channel Inlet



Gradient effects along the NFT Channel

Figure 1 shows the arrangement of plots within the NFT trough. By recording the yield from each of these plots separately this data was used to determine the effect of position in the trough on yield (Appendix VI).

Yields decreased with position down the channel from the inlet end (Figure 6a). The reduction in yield between position 0 m to 7.5 m was between 9 and 14% at the end of the season, depending on the treatment. Throughout the season this reduction varied with very high percentage reductions observed in March (19 - 35%) and lower percentage reductions in June (2 - 6%). Higher prices early in the season would have therefore accentuated the differences in yield observed between the positions along the channel (table 9).

The yield recorded in the NFT + oxygen treatment did not decrease along the channel (Figure 6b).

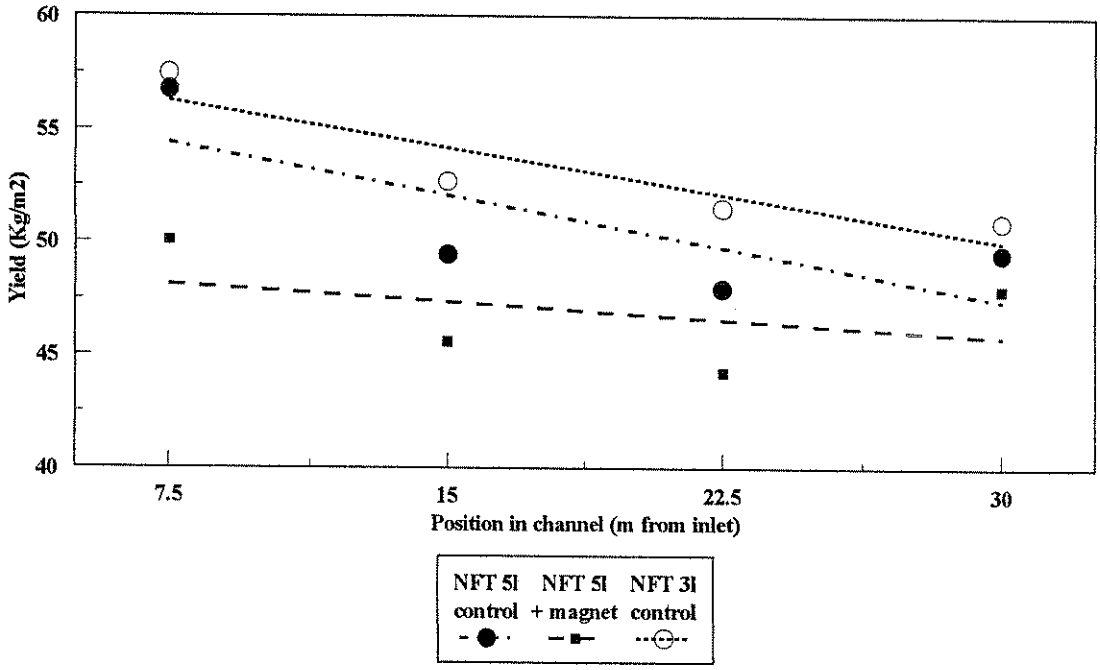
Table 9: Monetary Value (£/m^2) recorded along the NFT channel

To the End of the Trial

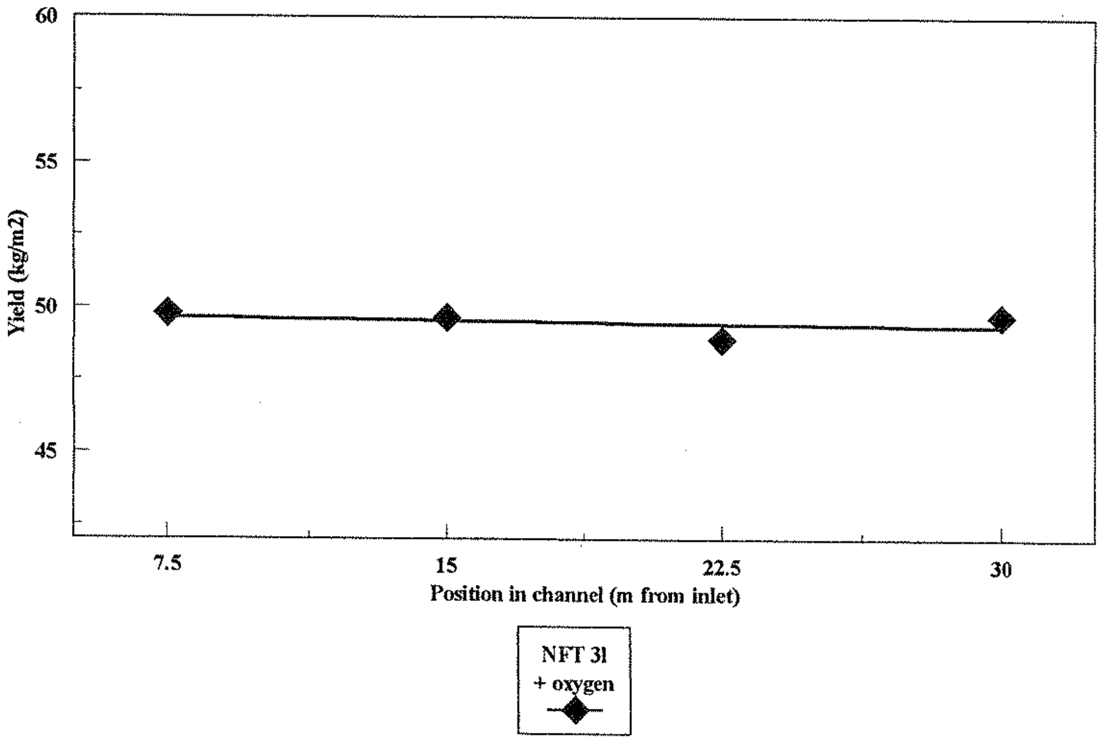
Treatment	Distance of start of plot from inlet				% Decrease between Plots 1 and 2
	0 m	7.5 m	15 m	22.5 m	
NFT 51	33.90	28.92	28.08	28.55	15.0
NFT + magnet	29.13	26.38	25.12	27.23	9.4
NFT 31	33.21	30.32	29.17	29.03	8.7
NFT + oxygen	29.40	28.70	27.78	28.44	2.4

Figures 6a & b: Yield Measured Along an NFT Channel

a: 3l NFT control, 5l NFT control and NFT 5l + magnet



b: NFT 3l + oxygen



Discussion (1995 Results)

Plant growth and development were similar for all treatments. Plants growing in both rockwool treatments were taller than the NFT plants and had a greater number of leaves. NFT plants were not put immediately on full flow but watered intermittently for the first few weeks which may have led to a longer establishment period allowing the rockwool grown plants to gain an initial growth benefit.

Reduced growth in the oxygen treatment after May, in terms of reduced vigour, narrower stem diameter and poor root colour, was related to the breakdown of the feed machine not to a treatment effect.

Both magnet treatments and the NFT 31 oxygen treatment had less trusses overall than the other treatments, however, differences in yield were not commensurate with a reduction in fruit number suggesting that each truss must have contained more fruit as fruit size was not altered.

In terms of total marketable yield and monetary value the NFT treatments performed equally as well as or better than the rockwool. The highest yielding treatment was the NFT 31 control producing 58 kg/m^2 (235 tonnes/ acre) which gave a monetary return of £30.29 /m^2. In the very early season, March, the rockwool yield was higher than the NFT yield, which was probably due to the better plant establishment achieved on the rockwool plots. The rockwool plants were also, on average, harvested earlier than the NFT plants. During the months April to August the NFT produced higher yields than the rockwool which increased the overall NFT yield.

At the end of the season (September and October) the rockwool magnet produced a significantly lower marketable yield due to a reduction in Class I fruit and a large increase in waste fruit. This decrease in quality significantly reduced the monetary value of the magnet treatment.

After a reduction in marketable yield in May, the yield from the NFT 31 oxygen treatment increased to remain similar to, or higher than the other treatments suggesting that, had there not been a feed machine fault this treatment would have had yields as good as, or better than, the other treatments. Even with this decrease in yield in May the NFT 31 oxygen treatment had a higher monetary value than the standard rockwool treatment.

Yield and monetary return on the rockwool magnet treatment were slightly higher than on the standard rockwool but this was not significantly different.

Fruit size was higher on the NFT plots than on the rockwool, with a greater percentage Grade C. However the rockwool plots had a higher percentage Grade D with similar amounts of Grade E

The observation of decreases in yield occurring as the distance from the inlet of the NFT channel increased suggests that large increases in yield could be achieved if all of the plants were grown in sections of channel approximately 7.5 m long, close to the inlet.

Discussion (1993 - 1995)

This trial aimed to compare rockwool and NFT growing systems for tomatoes and in particular to consider ways of optimising NFT systems.

ROCKWOOL 'V' NFT

Plant growth

In all three years of the trial early plant growth was controlled easily on the NFT systems using intermittent flow of the solution and high conductivity. This led to slower plant establishment in the NFT systems than in the rockwool systems. Early plant growth was reduced in the NFT systems, which, in 1995, was visible as a 10 cm reduction in plant height and lower leaf numbers and stem diameters. In all three years this also led to a delayed initial harvest of fruit. In 1993 when fruit set was recorded this was not affected by the delay in establishment.

Yield and Monetary Returns

In the first two years of the trial fruit yield and overall monetary return was lower from the NFT systems than from the standard rockwool treatment. However, in both 1993 and 1994 the NFT systems performed as well as the rockwool with recirculation in terms of total fruit production.

In 1995 the NFT treatments performed as well as, or better than, the rockwool. The highest yielding treatment, NFT 31 control (58 kg/m^2, £32.09/m^2) produced significantly better yields than the standard rockwool (53.1 kg/m^2, £27.63/m^2).

Fruit Quality

Fruit quality in the NFT treatments was generally better than in the rockwool in the first two years of the trial. In the final year quality was reduced as a whole due to downgrading for poor shape in the very hot weather. This led to similarly low levels of percentage Class I fruit in all the NFT treatments.

Fruit Size

Fruit size was larger from the NFT treatments than the rockwool, with a significantly higher percentage in the optimum size Grade D from the rockwool. The exception to this was in 1995 when more Grade D fruit was recorded from the NFT 31 oxygen treatment than the other NFT treatments.

ROCKWOOL 'V' RECIRCULATION IN ROCKWOOL

The use of conventional rockwool slabs in a recirculating system produced slightly lower yields than the standard rockwool 'run-to-waste' in this trial. Fruit quality and fruit size were unchanged.

RECIRCULATION IN ROCKWOOL 'V' NFT

Yields in the NFT treatments were generally similar to those in the rockwool recirculation, suggesting that the reduction in yield is due to the recirculation of the nutrient solution and not to the NFT system specifically. Fruit quality was better in the NFT than the rockwool recirculation with a higher percentage Class I and less waste. Fruit size between the treatments varied but there was generally less Grade D in the NFT than the rockwool recirculation treatment.

NFT SYSTEMS

In 1993 the use of a drip irrigation system to provide the nutrient solution for the NFT system was successful in the early part of the season when the plants were small and were not using large amounts of water for transpiration. However, when the plants grew larger, in the summer, the quantity of water available to the plants at the top of the channel was not sufficient. These plants therefore suffered and total yield was reduced compared to the other NFT systems.

Use of a higher flow rate in 1993 (10 l/min compared to 5 l/min) increased the crop yield slightly, however, the increase in costs required to produce the extra flow and in additional collection equipment would not have been covered by the increase in monetary return produced (£0.61 /m^2). Measurements of dissolved oxygen concentration in the solution recorded an increased level in the solution flowing out of the higher rate channels which may have produced more optimal conditions in the root environment. In 1994 the addition of oxygen to a 'standard' flow rate NFT system (5 l/min) was assessed alongside a 'standard' 5 l/min control. In this case yields were not increased compared to the control. To determine the effect of additional oxygen supply to a slower flowing NFT solution in 1995, a 3 l/min NFT treatment with 100% increased oxygen levels was assessed in comparison with a 3l /min control and a 5 l/min control. The highest yield was produced in the 3 l/min control with no extra yield increase produced by the addition of oxygen to the nutrient solution. A feed machine failure in the NFT 3l oxygen treatment meant interpretation of this result would be unreliable. Addition of a permanent magnet to the NFT system in both 1994 and 1995 did not result in significant yield increases. In 1994 the total yield was slightly increased at the end of the season, early yields were greater than the other NFT systems however after July larger amounts of waste were produced due to an increased incidence of blossom end rot. This increase in BER was also observed in 1995 where yields were significantly reduced at the end of the season. Plant analysis carried out in 1994 did not indicate that fruit from the magnet treatment contained higher levels of nutrients than the other systems.

Generally fruit quality, fruit size, fruit characteristics and keeping quality were similar in all of the NFT treatments. In 1995 the oxygen treatment produced slightly more fruit in the optimum size, Grade D.

This project has shown that NFT systems can produce crops which yield as highly as standard rockwool run-to-waste systems when grown under similar conditions. The fruit quality from the NFT crops can be higher than the rockwool and is combined with a larger fruit size.

Optimisation of the NFT environment may be able to increase yields further with the correct addition of oxygen to the solution and a greater understanding of the effect of the flow on the crops. Preliminary results obtained in 1995 suggest that large increases in yield could be achieved by modifying the channel length or solution inlets to produce a system where fresh nutrient solution is added more frequently to the channel.

Conclusions

1) Collection and recirculation of nutrient solution in either rockwool or NFT can produce crops comparable to rockwool run-to-waste.

2) NFT grown crops are capable of producing yields equivalent to, or higher than, rockwool grown crops.

3) Initial results suggest that the addition of oxygen to the nutrient solution may not produce increased yields.

4) Initial results suggest that the addition of a permanent magnet to the nutrient solution of either an NFT system or a rockwool run-to-waste may not produce increased yields.

5) The simple conversion of a drip fed system to NFT is not successful.

6) Further increases in yield from an NFT system may still be possible by the optimisation of the system, such as channel length and inlet position.

Appendix I Weekly Nutrient Analysis Results (mg/l).

NFT 5L

	11th Jan	18th Jan	26th Jan	2nd Feb	8th Feb	15th Feb	22nd Feb	1st March	8th March	15th March	22nd March	29 March	5 April	11 Apr	18 Apr	25 Apr	2 May
pH	5.8	5.8	5.8	5.8	6.2	6.2	6.5	6.3	6.3	6.3	6.3	6.2	6.3	6.3	6	6.1	6.2
EC	5330	2770	5400	5520	5850	5470	5960	4860	4570	4560	4940	4010	4670	4950	4350	5040	4100
NO3-N	600	557	523	454	479	454	433	340	378	309	357	376	387	380	378	410	370
NH4-N	12	3.8	4.6	4.6	0.3	0.2	0.2	1.9	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2
K	952	1095	934	1122	1041	848	822	581	478	419	461	440	464	441	390	502	637
Ca	411	450	470	438	526	564	589	466	434	454	544	427	445	460	410	465	368
Mg	142	160	137	160	153	147	150	140	140	157	197	158	194	216	196	239	141
P	46	65	49	58	36	30	20	2	18	27	32	24	40	39	32	45	66
Fe	4.38	5.53	2.09	3.62	4.53	4.29	4.77	3.79	3.82	4.12	5.4	3.25	3.7	3.95	3.08	2.37	2.9
Zn	0.88	2.94	1.62	1.25	1.06	2.26	2.44	2.75	2.6	2.68	2.61	1.38	1.72	1.89	1.54	1.27	1.25
Mn	0.81	1.11	0.49	0.59	0.25	0.37	0.15	1.37	0.75	0.22	0.45	0.12	1	0.34	0.31	0.6	0.35
Cu	0.5	0.73	0.59	0.35	0.31	0.4	0.43	0.35	0.52	0.38	0.54	0.37	0.42	0.81	0.47	0.41	0.52
B	0.91	1.68	0.83	1.28	1.23	1.14	1.14	0.98	1.12	1.1	1.37	1	1.34	1.05	1.18	1.28	0.91
Na	18	20	13	25	19	23	37	38	50	49	46	44	52	52	50	60	49
Cl	57	55	58	377	427	411	461	418	414	318	265	231	195	181	146	129	89
S	255	334	284	318	296	294	292	234	156	283	321	176	275	334	290	336	231
HCO3	31	24	24	31	43	37	37	31	31	37	37	37	49	49	24	43	61
Mo		0.16	0.1	0.12	0.13	0.14	0.13	0.11	0.16	0.15	0.24	0.31	0.13	0.34	0.26	0.2	0.12

	9 May	16 May	23 May	30 May	6 Jun	13 Jun	27 Jun	4 Jul	11 Jul	18 Jul	25 Jul	1 Aug	8 Aug	15 Aug	22 Aug	29 Aug	12 Sept
pH	6.2	6.8	6.4	6.4	6.4	6.4	5.8	6.2	6.3	6.2	6.3	6.3	6.3	6.4	6.4	6.4	6.4
EC	3570	3190	3520	3610	3585	3976	4068	3884	3967	4095	4031	4104	3958	4030	4168	4018	3796
NO3-N	360	326	416	373	392	448	435	420	431	448	451	437	411	427	440	426	459
NH4-N	0.2	9	0.1	0.1	0.2	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.1	0.4	0.3	0.3	0.2
K	429	555	564	494	585	627	680	322	310	668	636	632	600	624	602	570	743
Ca	312	259	313	263	273	323	331	313	381	321	300	320	288	326	343	277	257
Mg	139	76	118	128	104	125	106	113	146	117	136	140	134	136	56	123	87
P	57	42	34	40	47	61	65	51	46	43	35	38	31	32	29	29	46
Fe	2.8	4.1	3.24	2.13	2.56	4.16	5.41	1.82	4.65	3.55	2.87	3.91	2.29	4.14	3.06	2.52	3.81
Zn	0.78	0.33	0.45	0.54	0.49	0.54	0.91	1.24	1.72	1.38	0.95	0.82	0.67	0.74	0.62	0.48	0.28
Mn	0.15	0.57	0.17	0.6	0.15	0.38	0.75	0.58	1.51	0.4	0.2	0.87	0.23	0.33	0.15	0.34	0.61
Cu	0.29	0.31	0.31	0.68	0.24	0.28	0.21	0.34	0.44	0.48	0.3	0.33	0.3	0.34	0.39	0.34	0.27
B	0.57	0.74	0.94	0.93	0.73	0.38	0.38	0.56	0.76	0.53	0.41	0.42	0.29	0.31	0.32	0.26	0.29
Na	61	23	40	33	36	36	42	23	26	46	42	44	44	50	54	43	19
Cl	119	45	43	55	41	33	62	75	95	68	63	74	78	71	96	93	35
S	188	100	152	143	82	57	56	62	76	17	56	67	59	36	28	55	47
HCO3	49	104	43	55		0.11	0.09	0.16	0.19	0.13	0.13	0.12	0.08	0.11	0.09	0.08	0.06
Mo	0.13	0.21	0.32	0.27		94	24	44	39	32	34	22	32	24	30	28	42

Appendix I cont...

NFT 5L + Magnet

	11th Jan	18th Jan	26th Jan	2nd Feb	8th Feb	15th Feb	22nd Feb	1st March	8th March	15th March	22nd March	29 March	5 April	11 Apr	18 Apr	25 Apr	2 May
pH	5.9	5.9	5.8	5.8	5.8	5.9	5.9	5.6	5.8	5.8	6.3	5.8	5.8	5.7	5.8	5.8	5.7
EC	5320	5680	5400	5580	5600	5410	5960	4930	4730	5240	4100	4290	5410	5130	4490	5540	4320
NO3-N	572	536	486	549	552	528	508	415	434	338	354	396	370	346	359	391	390
NH4-N	10.4	0.5	0.5	0.2	0.2	0.2	0.2	1.8	0.3	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2
K	977	1100	894	1060	1013	805	827	625	404	274	373	197	148	139	277	295	623
Ca	403	390	460	396	499	561	576	510	478	530	448	528	584	561	454	607	393
Mg	150	170	161	161	163	168	172	183	186	214	160	203	268	264	219	311	148
P	50	56	27	46	30	19	6	10	12	12	28	16	24	34	33	38	75
Fe	3.5	3.35	0.83	2.52	4.2	3.64	3.83	4.43	4.14	4.46	4.32	3.64	4.37	5.06	3.3	3.17	3.71
Zn	1.51	2.81	1.27	1.52	1.37	3.21	3.76	4.28	4	4.9	2.14	2.9	4.1	4.36	3.02	3.51	1.49
Mn	0.83	0.83	0.2	0.4	0.36	0.53	0.16	1.6	1.18	0.55	0.36	0.13	1.08	0.42	1.11	0.49	0.28
Cu	0.53	0.68	0.47	0.35	0.36	0.4	0.44	0.38	0.32	0.42	0.46	0.41	0.74	0.92	0.52	0.6	1.08
B	1.03	1.57	0.54	1.17	1.24	1.09	1.2	1.22	1.32	1.33	1.15	1.21	1.67	2.02	1.28	1.61	1.18
Na	19	22	16	23	20	26	40	49	48	65	37	71	79	80	62	88	46
Cl	57	55	64	100	153	186	260	261	296	309	265	318	310	324	206	215	84
S	200	314	335	288	296	294	340	332	234	414	221	173	403	350	332	417	258
HCO3	37	37	24	31	24	31	18	18	24	18	37	31	31	37	31	31	37
Mo		0.21	0.11	0.12	0.16	0.13	0.14	0.12	0.17	0.13	0.29	0.33	0.12	0.46	0.17	0.25	0.34

	9 May	16 May	23 May	30 May	6 Jun	13 Jun	27 Jun	4 Jul	11 Jul	18 Jul	25 Jul	1 Aug	8 Aug	15 Aug	22 Aug	29 Aug	12 Sept
pH	5.7	5.9	5.8	6	5.9	5.8	5.7	5.8	5.6	5.6	5.7	5.8	5.7	6.3	5.9	5.9	5.8
EC	4330	4830	3720	3750	3837	3939	4443	4049	4352	3985	4196	4260	4022	3937	4326	4165	3743
NO3-N	357	526	440	397	429	456	458	418	442	441	437	432	398	421	475	454	473
NH4-N	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.2	0.3	11.5	0.3	0.2	1
K	346	805	520	362	380	363	664	234	210	712	295	288	256	744	684	588	583
Ca	424	374	334	317	372	414	381	413	474	310	392	446	403	260	290	290	354
Mg	203	147	137	143	136	177	164	161	195	105	210	214	201	91	31	99	70
P	77	53	41	32	39	54	81	79	63	67	19	17	11	58	40	30	16
Fe	2.95	7.9	4.47	3.58	3.37	3.46	3.47	2.13	2.97	4.01	1.15	2.94	1.99	4.04	2.61	1.89	4.68
Zn	1.5	0.7	0.86	1.18	1.34	1.72	1.1	1.62	2.24	1.27	2	1.9	1.73	0.48	0.45	0.61	0.66
Mn	0.44	0.58	0.13	0.78	0.14	0.38	0.86	0.23	1.27	0.79	0.09	0.96	0.27	0.88	0.48	0.38	0.24
Cu	0.5	0.43	0.44	0.9	0.53	0.53	0.39	0.5	0.57	0.4	0.46	0.47	0.45	0.16	0.32	0.41	0.42
B	0.72	0.9	1.15	1.03	0.8	0.46	0.47	0.5	0.65	0.47	0.53	0.51	0.4	0.28	0.24	0.2	0.15
Na	67	33	40	49	66	72	58	38	47	32	106	106	98	20	37	38	34
Cl	114	50	49	74	64	58	68	98	118	52	135	154	146	45	66	79	58
S	262	213	173	160	98	76	49	82	112	24	56	104	84	46	10	45	34
HCO3	37	31	24	31		0.15	0.13	0.14	0.17	0.12	0.15	0.16	0.1	0.07	0.04	0.04	0.01
Mo	0.21	0.25	0.37	0.24		65	29	23	27	13	10	12	15	49	22	53	13

Appendix I cont...

NFT 3L

	11th Jan	18th Jan	26th Jan	2nd Feb	8th Feb	15th Feb	22nd Feb	1st March	8th March	15th March	22nd March	29 March	5 April	11 Apr	18 Apr	25 Apr	2 May
pH	5.9	5.6	5.7	5.5	5.8	5.8	6.1	5.6	5.9	5.8	6.1	5.9	5.8	5.7	5.9	5.9	5.8
EC	5020	5360	5040	5.19	5320	5710	5850	4730	4690	4880	4580	4110	4470	4270	4050	4470	4680
NO3-N	542	505	478	464	492	531	512	420	436	347	400	436	472	510	518	495	286
NH4-N	10.6	1.3	1.4	0.6	0.5	0.4	0.2	2.6	0.4	0.2	0.3	1	0.6	0.4	0.7	0.3	0.2
K	769	947	890	1050	896	865	744	514	590	630	681	657	629	574	439	666	955
Ca	441	370	410	400	469	563	632	548	474	344	404	373	421	529	519	449	174
Mg	126	148	147	168	164	181	156	140	106	160	164	125	139	102	51	131	224
P	46	56	40	38	19	7	6	5	32	86	82	46	67	34	4	55	143
Fe	3.59	4.12	1.66	2.47	1.79	2.04	3.2	3.24	5	3.79	4.44	3.34	4.23	6.07	5.98	3.84	0.96
Zn	1.14	3.9	2.53	3.67	2.88	7.8	8.15	7.62	1.35	1.63	1.26	0.72	0.94	1.02	0.46	0.65	0.89
Mn	0.81	1.24	0.47	0.54	0.24	0.44	0.23	0.79	0.42	0.51	0.46	0.22	1.16	0.28	0.02	1.22	1.49
Cu	0.47	0.64	0.66	0.43	0.36	0.39	0.33	0.21	0.36	0.37	0.44	0.36	0.42	0.88	0.32	0.31	0.57
B	0.92	1.65	0.81	1.25	1.3	1.18	1.1	0.86	0.8	1.18	1.22	0.81	1.15	1.18	0.3	0.65	1.49
Na	17	19	10	28	19	31	45	48	68	35	35	34	38	36	32	34	39
Cl	54	55	64	183	239	239	372	361	375	165	124	124	140	87	51	53	65
S	198	293	294	344	320	292	274	219	162	352	296	155	250	146	55	192	399
HCO3	37	18	18	18	18	24	24	18	24	31	49	37	31	24	43	31	55
Mo		0.13	0.09	0.12	0.14	0.11	0.12	0.08	0.1	0.14	0.24	0.31	0.12	0.32	0.09	0.14	0.15

	9 May	16 May	23 May	30 May	6 Jun	13 Jun	27 Jun	4 Jul	11 Jul	18 Jul	25 Jul	1 Aug	8 Aug	15 Aug	22 Aug	29 Aug	12 Sept
pH	5.9	6.2	6.1	6.2	6.1	6.1	6.1	6.1	6.1	6	6.1	6	6	6.3	6.2	6.2	6.1
EC	4370	3240	3710	3740	3828	4178	4269	4095	4278	4535	4269	4471	4233	4391	4483	3880	4154
NO3-N	243	351	439	417	446	492	475	457	490	506	501	495	472	494	506	496	472
NH4-N	0.2	1.5	0.2	0.1	0.3	0.2	0.3	4	0.3	0.3	0.3	0.2	0.1	0.5	0.3	0.2	0.6
K	743	545	533	565	652	685	748	390	366	760	776	732	680	740	668	668	757
Ca	137	267	304	281	301	332	369	298	414	340	320	336	329	376	387	339	299
Mg	266	78	98	109	96	98	109	87	128	92	118	100	109	121	59	99	100
P	146	40	34	45	56	61	58	54	49	40	50	42	35	37	37	36	44
Fe	1.92	4.1	4.63	3.84	4.45	5.71	4.51	2.4	3.67	3.55	4.48	3.13	2.88	5.39	4.49	3.67	3.83
Zn	1.12	0.44	0.53	0.55	0.55	0.6	0.69	1.87	2.2	1.37	0.71	0.63	0.63	0.68	0.57	0.48	0.4
Mn	0.39	0.42	0.26	0.26	0.56	0.34	1.11	1.86	1.55	0.63	0.64	0.39	0.3	0.45	0.26	0.47	0.52
Cu	0.44	0.32	0.36	0.68	0.25	0.23	0.26	0.38	0.47	0.4	0.26	0.26	0.26	0.28	0.29	0.29	0.28
B	1.27	0.68	0.76	0.88	0.62	0.32	0.35	0.65	0.84	0.47	0.32	0.34	0.26	0.28	0.3	0.25	0.29
Na	44	21	42	29	33	29	36	15	19	38	24	34	36	40	41	34	28
Cl	96	45	46	55	41	30	56	76	68	57	46	71	63	63	76	57	45
S	398	103	162	145	69	47	52	55	65	9	48	56	49	32	50	23	44
HCO3	49	37	37	43		0.07	0.09	0.18	0.2	0.11	0.11	0.1	0.07	0.1	0.07	0.08	0.06
Mo	0.25	0.14	0.31	0.32		52	39	37	26	30	30	27	22	27	29	22	28

Appendix I cont...

NFT 3L + Oxygen

	11th Jan	18th Jan	26th Jan	2nd Feb	8th Feb	15th Feb	22nd Feb	1st March	8th March	15th March	22nd March	29 March	5 April	11 Apr	18 Apr	25 Apr	2 May
pH	5.6	5.6	5.5	5.5	5.6	5.7	5.9	5.7	6.7	5.7	5.8	5.8	5.9	5.7	6.7	6.3	6.4
EC	5600	5960	5790	5880	6460	5320	5150	4360	5190	4360	4570	3930	4280	4310	3700	5150	4450
NO3-N	606	577	554	600	561	465	435	364	403	344	391	427	424	420	351	455	408
NH4-N	15.3	9.5	7.5	0.3	0.9	1.4	0.2	2.3	0.3	0.2	0.2	0.2	0.2	0.2	0.9	0.7	0.2
K	967	1120	1000	1235	1171	860	770	635	691	486	534	486	569	534	546	840	773
Ca	449	400	500	483	608	566	564	461	512	427	528	363	420	407	286	428	403
Mg	146	166	159	172	165	128	121	122	150	122	153	126	152	140	110	185	144
P	49	71	47	52	44	34	24	12	32	39	44	32	52	54	55	92	76
Fe	4.08	4.76	2.56	4.06	5.68	5.71	5.98	4.97	4.58	5.2	6.56	3.7	4.15	4.23	2.04	3.66	3.72
Zn	1.87	2.78	0.9	1.62	0.75	1.68	1.67	1.25	1.3	1.31	1.34	0.76	0.98	1.17	0.86	1.31	1.4
Mn	0.79	1.12	0.47	0.67	0.38	0.42	0.15	0.77	0.52	0.27	0.4	0.16	1.15	0.48	1.01	0.96	0.51
Cu	0.53	0.57	0.49	0.36	0.25	0.24	0.24	0.21	0.48	0.36	0.47	0.33	0.35	0.75	0.31	0.34	0.68
B	0.95	1.6	0.72	1.31	1.27	0.96	0.98	0.84	1	0.98	1.13	0.82	1.15	1.54	0.74	1.23	1.1
Na	17	19	10	25	18	19	28	28	36	36	34	33	38	41	24	36	56
Cl	57	53	58	214	415	388	428	388	372	221	173	152	134	103	54	60	103
S	209	301	334	332	298	240	224	288	232	215	258	146	214	233	171	331	269
HCO3	24	24	24	18	24	31	24	18	24	18	24	31	31	24	85	61	73
Mo		0.19	0.1	0.12	0.16	0.1	0.12	0.08	0.16	0.13	0.24	0.31	0.09	0.36	0.22	0.27	0.16

	9 May	16 May	23 May	30 May	6 Jun	13 Jun	27 Jun	4 Jul	11 Jul	18 Jul	25 Jul	1 Aug	8 Aug	15 Aug	22 Aug	29 Aug	12 Sept
pH	6.7	5.8	5.7	5.9	5.8	5.8	6.3	5.7	5.9	5.7	5.9	6.1	5.7	6	5.9	5.9	5.8
EC	4450	3600	3460	3540	3558	3802	4123	3674	3793	4040	3912	4297	3967	3992	4020	3687	3671
NO3-N	407	365	395	367	380	437	434	409	423	442	437	470	422	418	383	369	444
NH4-N	0.2	0.3	0.1	0.1	0.2	0.3	0.2	2.6	0.6	0.4	2	0.2	0.1	0.4	0.3	0.3	0.5
K	577	630	567	494	583	654	700	340	332	716	736	724	604	652	758	700	641
Ca	374	269	286	263	257	304	318	274	326	307	236	309	283	295	223	149	287
Mg	150	106	119	118	102	100	106	88	121	107	107	128	134	132	75	120	73
P	58	64	51	53	56	69	62	54	49	62	54	53	35	41	91	63	26
Fe	2.89	3.42	3.49	2.92	3.26	4.95	3.54	2.58	3.35	3.76	3.39	3.06	2.07	4.11	2.15	1.35	5.19
Zn	0.8	0.52	0.94	1.14	0.93	0.91	0.55	1.88	1.8	1.26	0.6	0.59	0.64	0.74	0.63	0.43	0.36
Mn	0.21	1.2	0.3	0.21	0.54	0.16	0.56	1.77	1.35	0.76	0.89	0.49	0.19	0.47	0.82	0.77	0.29
Cu	0.17	0.46	0.25	0.61	0.17	0.17	0.3	0.33	0.36	0.42	0.2	0.19	0.19	0.21	0.31	0.24	0.24
B	0.64	1.07	0.94	0.9	0.61	0.31	0.36	0.62	0.67	0.48	0.31	0.41	0.28	0.31	0.51	0.36	0.2
Na	72	25	36	36	31	25	42	15	18	32	20	36	42	46	30	25	28
Cl	129	50	57	63	51	33	59	55	63	54	37	70	78	73	58	60	46
S	216	142	132	146	72	50	58	50	62	24	47	66	58	61	72	34	35
HCO3	73	31	24	31		0.07	0.1	0.15	0.15	0.12	0.09	0.12	0.07	0.09	0.11	0.09	0.03
Mo	0.23	0.2	0.25	0.23		40	54	21	21	17	27	29	17	17	28	17	16

Appendix I cont...

Standard Rockwool (slab)

	11th Jan	18th Jan	26th Jan	2nd Feb	8th Feb	15th Feb	22nd Feb	1st March	8th March	15th March	22nd March	29 March	5 April	11 Apr	25 Apr	9 May	23 May
pH	5.7	5.4	5	5.2	5	6.1	5	4.9	4.9	5.6	5.6	5.8	5.2	5.8	5.9	5.2	6
EC	5530	5600	6180	7280	5720	6620	5890	5650	5620	5330	4870	4590	4850	4750	7720	7810	9440
NO3-N	615	585	582	793	609	718	606	530	574	465	475	534	500	505	768	812	955
NH4-N	15.8	12.1	11.3	1.1	1	1.1	0.2	1.6	0.3	0.4	0.2	0.2	1.5	0.2	2	0.3	0.2
K	910	1045	1080	1307	1036	1025	913	860	748	625	469	620	715	688	1150	1150	1370
Ca	480	390	540	505	509	632	584	515	537	467	492	437	420	446	750	750	740
Mg	155	176	177	192	166	206	168	168	204	164	167	156	161	175	263	234	305
P	48	43	58	46	38	36	34	40	42	40	28	26	40	31	62	92	52
Fe	7.61	5.21	2.43	8.74	7.16	8.55	8.06	6.31	5.16	5.9	5.96	4.27	5.06	5.81	9.23	9.2	13.08
Zn	1.23	1.04	0.37	1.16	0.67	1.43	0.9	0.91	1.23	1.15	0.94	0.68	1.01	1.38	1.26	0.93	0.93
Mn	0.95	0.72	0.28	0.97	0.86	0.77	0.65	0.65	0.63	0.63	0.61	0.49	0.76	0.81	0.96	0.96	0.63
Cu	0.51	0.61	0.45	0.22	0.18	0.18	0.18	0.21	0.31	0.36	0.38	0.34	0.48	0.79	0.32	0.38	0.39
B	1.1	1.23	0.44	1.28	1.21	1.23	1.22	1.2	1.21	1.13	1.06	0.92	1.2	1.66	1.91	0.38	1.51
Na	27	22	12	27	19	26	27	26	34	43	33	38	34	51	60	62	66
Cl	51	53	55	54	55	70	56	42	62	60	61	65	47	70	58	155	69
S	228	243	352	342	270	330	296	326	288	331	307	201	265	226	493	288	394
HCO3	24	18	18	18	12	43	18	12	12	18	18	24	18	24	37	12	61
Mo		0.23	0.1	0.14	0.15	0.11	0.1	0.13	0.18	0.14	0.24	0.28	0.11	0.42	0.32	0.16	0.51

	6 Jun	4 Jul	18 Jul	1 Aug	15 Aug	29 Aug	12 Sept
pH	6.1	6	6.2	6.2	6.2	5.9	5.7
EC	5941	6789	3665	5213	4391	3540	3573
NO3-N	788	757	410	608	496	393	414
NH4-N	0.2	0.4	0.3	0.3	0.7	1.1	0.2
K	1050	666	596	944	796	712	641
Ca	556	604	223	414	309	221	276
Mg	180	158	77	127	99	73	79
P	46	76	33	61	50	45	53
Fe	9.68	10.35	3.13	6.58	4.88	3.45	4.28
Zn	0.67	1.18	0.28	0.49	0.39	0.29	0.32
Mn	0.3	1.08	0.21	0.39	0.45	0.71	0.63
Cu	0.23	0.26	0.07	0.21	0.12	0.12	0.17
B	0.74	0.5	0.18	0.38	0.25	0.22	0.19
Na	47	28	34	44	32	23	25
Cl	54	83	50	65	49	47	39
S	118	96	13	72	22	19	42
HCO3		0.18	0.06	0.11	0.1	0.06	0.03
Mo		44	35	48	37	31	17

Appendix I cont...

Rockwool Magnet (slab)

	2nd Feb	8th Feb	15th Feb	22nd Feb	1st March	8th March	15th March	22nd March	29 March	5 April	11 Apr	25 Apr	9 May	23 May	4 Jul	18 Jul	1 Aug
pH	6	5.7	5.3	5.3	6.5	5.9	6.1	5.8	6	5.6	5.6	5.4	6.3	6.1	5.6	6.2	6.2
EC	8620	6200	6470	6860	8960	7830	7380	4940	4660	4920	4960	6090	7670	8930	7797	3857	5396
NO3-N	1020	656	691	715	807	807	707	495	526	552	412	636	749	938	867	433	607
NH4-N	0.3	0.4	1.9	19.5	0.4	0.3	0.3	0.2	0.5	0.2	0.3	3.9	0.2	0.2	0.5	0.3	0.6
K	1590	1063	979	1088	1261	936	1035	556	689	751	650	1000	1170	1310	738	680	1096
Ca	620	541	620	649	870	678	780	520	415	399	410	470	720	744	685	261	454
Mg	215	177	181	191	280	256	277	164	173	177	155	184	215	280	179	86	164
P	35	32	40	34	42	56	41	36	32	34	36	63	43	54	96	42	63
Fe	10.52	7.79	8.3	8.97	10.54	8.5	9.4	6.24	4	5.55	6.43	7.63	8.08	12.85	11.05	3.39	8.56
Zn	1.49	0.65	1.33	1.41	1.52	2.02	1.94	0.98	0.65	1.64	1.19	0.74	0.81	0.86	1.53	0.34	0.58
Mn	1.07	0.77	0.71	0.65	0.58	0.6	0.57	0.7	0.54	0.68	0.9	1.09	0.9	0.73	1.68	0.24	0.45
Cu	0.25	0.17	0.19	0.19	0.29	0.4	0.43	0.47	0.38	0.37	0.77	0.22	0.37	0.37	0.31	0.11	0.27
B	1.27	1.14	1.22	1.3	1.48	1.93	1.57	1.15	0.94	1.41	1.46	1.54	0.81	1.48	0.56	0.19	0.41
Na	37	19	22	33	38	44	64	34	39	45	43	40	69	67	31	40	42
Cl	63	52	62	59	60	65	71	58	48	50	73	47	129	77	76	65	69
S	256	248	340	324	514	336	505	309	204	235	270	317	400	360	109	16	81
HCO3	61	24	24	24	73	43	43	24	31	24	24	24	49	55	0.13	0.05	0.13
Mo	0.12	0.17	0.08	0.1	0.16	0.28	0.14	0.25	0.16	0.15	0.39	0.33	0.2	0.51	37	40	48

	15 Aug	29 Aug	12 Sept
pH	6	5.6	5.6
EC	4446	4322	3403
NO3-N	491	465	389
NH4-N	0.5	0.5	0.4
K	792	690	602
Ca	310	312	263
Mg	106	119	83
P	53	58	51
Fe	5.23	5.06	4.28
Zn	0.55	0.4	0.34
Mn	0.51	0.7	0.54
Cu	0.15	0.16	0.14
B	0.24	0.23	0.2
Na	36	27	28
Cl	61	38	43
S	48	50	41
HCO3	0.07	0.07	0.07
Mo	24	30	11

Appendix II - Plant Growth and Development Results

Plant Heights (cm)	NFT 5l	NFT 5L + magnet	NFT 3l	NFT 3l + oxygen	Standard Rockwool	Rockwool + magnet
12/1	76	73	74	73	84	83
23/1	100	98	98	98	109	108
7/2	141	138	137	137	151	149
22/2	182	180	179	180	195	192
9/3	215	212	208	215	224	225
21/3	243	243	232	243	259	256
5/4	297	299	287	301	307	315

Leaf Number

12/1	11	11	11	11	12	12
7/2	21	20	20	20	21	22
9/3	29	29	29	29	30	30
5/4	40	40	41	40	41	41

Stem Diameter (mm)

12/1	9.4	9.7	9.4	9.4	10.4	9.8
7/2	13.7	13.4	14.1	13.7	14.3	13.3
9/3	15.1	14.6	14.7	15	14.3	13.3
5/4	13.9	13.5	13.9	14	13.5	12.7
2/5	9.5	9.7	9.9	9.3	8.9	9.2
7/6	10.2	9.8	9.8	9.7	8.8	9.5
4/7	8.8	9.3	9.8	8.8	8.3	8.6
8/8	7.9	7.7	9.3	8.2	8.8	8

Vigour Score (1 - 5 where 5 is most vigorous)

12/1	2.9	2.8	2.8	2.8	3.4	3.5
7/2	3	2.6	2.6	2.9	3.5	3.4
9/3	3.8	3.5	3.5	4	3.5	3
5/4	3.3	3.6	3.5	3.4	3	3.1
2/5	3.7	3.9	3.7	2.4	2.8	3.2
7/6	2.9	2.4	2.7	2.6	2.3	2.3
4/7	3.7	3.3	2.9	3.7	3.2	3.6
8/8	2.6	2.7	2.9	2.9	2.6	2.7

Leaf Length (cm)

2/6	39.6	37.9	38.7	33.4	38	38.5
6/7	41.2	42.3	40	36.6	38.9	40.4
16/8	38.3	39.4	37.8	38.6	37.1	38

Leaf width (cm)

2/6	38.8	37.6	38.5	34.6	36.3	38.3
6/7	44.6	45.3	37.8	41.5	42	41.7
16/8	35.9	35.5	33.5	35.9	35.5	35.4

Appendix II cont... - NFT Root Growth and Development Results

Root Development (score 1 - 5 where 5 = most)

Amount

	NFT 5l	NFT 5L + magnet	NFT 3l	NFT 3l + oxygen
12/1	1.0	1.2	1.1	1.3
19/1	3.0	3.0	3.0	3.0
23/1	2.9	2.7	2.4	3.4
27/1	3.5	3.6	3.6	3.8
30/1	4.8	4.8	4.8	4.8
13/3	5.0	4.9	5.0	4.8
10/4	4.9	4.4	4.4	4.0
10/5	4.5	4.5	5.0	4.5
13/6	4.8	4.9	5.0	4.8
10/7	4.9	4.9	5.0	5.0
14/8	4.9	5.0	5.0	4.9

Length

	NFT 5l	NFT 5L + magnet	NFT 3l	NFT 3l + oxygen
12/1	1.7	2.0	1.7	1.6
19/1	3.0	3.0	3.0	3.0
23/1	4.1	3.7	3.8	4.1
27/1	4.7	4.2	5.0	4.7
30/1	5.0	5.0	5.0	4.9
13/3	5.0	4.9	5.0	4.9
10/4	4.9	5.0	4.9	4.5
10/5	4.5	4.5	5.0	4.5
13/6	5.0	4.9	5.0	4.9
10/7	5.0	5.0	4.9	5.0
14/8	4.9	5.0	5.0	5.0

Colour

	NFT 5l	NFT 5L + magnet	NFT 3l	NFT 3l + oxygen
12/1	1.0	1.0	1.0	1.0
19/1	1.0	1.0	1.0	1.0
23/1	1.0	1.0	1.0	1.0
27/1	1.0	1.0	1.0	1.0
30/1	1.0	1.0	1.0	1.0
13/3	1.0	1.0	1.1	1.2
10/4	1.2	1.3	1.1	1.0
10/5	2.5	2.5	2.0	3.0
13/6	2.9	2.7	3.2	2.8
10/7	2.3	2.4	2.2	3.0
14/8	2.9	2.4	2.1	2.5
11/10	3.6	4.6	3.4	3.9

Appendix III - Fruit Physical Characteristics

Treatment and assessment date	Fruit Length	Ribbing	Boxy	Nippling	Fine Net Cracking	Radial Cracking	Uneven Ripening	Gold Spot	Flecking
26.4.95									
NFT 5l control	2.0	0.1	0.1	0.0	0.0	0.0	0.1	0.5	0.0
NFT 5l Magnet	1.9	0.1	0.1	0.0	0.0	0.0	0.1	0.3	0.0
NFT 3l control	2.0	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.0
NFT 3l Oxygen	2.0	0.2	0.2	0.0	0.0	0.0	0.1	0.3	0.0
Standard RW	2.0	0.1	0.2	0.0	0.0	0.0	0.1	0.0	0.0
RW Magnet	2.0	0.2	0.2	0.0	0.0	0.0	0.1	0.0	0.0
6.6.95									
NFT 5 L	2.7	0.6	1.3	0.0	0.0	0.0	0.1	0.6	0.2
NFT 5L Magnet	2.3	0.3	1.0	0.0	0.0	0.0	0.1	0.4	0.4
NFT 3L	2.8	0.5	0.9	0.0	0.1	0.0	0.2	0.8	0.5
NFT 3L Oxygen	2.7	0.3	1.1	0.0	0.1	0.1	0.1	0.6	0.5
Standard RW	2.7	0.4	1.1	0.0	0.0	0.1	0.1	0.3	0.5
RW Magnet	2.0	0.3	0.8	0.0	0.0	0.0	0.4	0.3	0.3
8.8.95									
NFT 5 L	2.8	0.5	1.8	0.0	0.5	0.1	0.1	0.7	0.2
NFT 5L Magnet	3.0	0.6	1.8	0.1	0.4	0.1	0.1	0.6	0.3
NFT 3L	2.9	0.7	1.3	0.1	0.8	0.4	0.1	0.6	0.3
NFT 3L Oxygen	2.9	0.4	1.8	0.0	0.9	0.3	0.1	0.6	0.6
Standard RW	2.9	0.3	1.8	0.1	1.5	0.8	0.1	0.2	0.5
RW Magnet	2.9	0.5	1.7	0.0	1.0	0.7	0.2	0.4	0.4

\- DATA NOT AVAILABLE

Appendix IV - Fruit Composition and Shelf Life Results

Treatment and assessment date	Fruit Composition			Weight Loss after Shelf Life Simulation	(Day 6) Firmness
	pH	Sugar	% Dry Matter	% Weight Loss	
26.4.95					
NFT 5 L	7.0	4.1	5.1	3.9	3.0
NFT 5L Magnet	7.2	4.1	5.3	3.9	3.0
NFT 3L	6.5	3.6	5.3	4.4	3.0
NFT 3L Oxygen	6.7	4.0	5.4	3.8	3.0
Standard RW	7.1	4.3	5.4	3.9	2.9
RW Magnet	6.9	4.1	5.4	4.6	3.1
6.6.95					
NFT 5 L	6.7	4.5	5.1	2.6	-
NFT 5L Magnet	5.8	4.8	5.1	2.8	-
NFT 3L	6.4	4.7	5.1	2.6	-
NFT 3L Oxygen	6.6	4.9	5.3	3.1	-
Standard RW	6.5	5.1	5.2	2.2	-
RW Magnet	7.9	4.5	5.1	2.6	-
8.8.95					
NFT 5 L	-	5.5	5.7	3.5	3.6
NFT 5L Magnet	-	4.3	6.1	3.4	3.7
NFT 3L	-	5.5	6.0	4.0	3.8
NFT 3L Oxygen	-	5.1	5.9	3.9	3.8
Standard RW	-	5.4	5.8	5.3	3.9
RW Magnet	-	5.7	5.7	4.2	3.9

\- DATA NOT AVAILABLE

Appendix V - Results of Taste Test Assessments carried out in June

SWEETNESS	SCORE	RANK
NFT 51	0.8	2
NFT + magnet	-0.6	4
NFT 31	-1.4	6
NFT + oxygen	-1.0	5
Standard Rockwool	0.8	2
Rockwool magnet	1.4	1

SHARPNESS	SCORE	RANK
NFT 51	-0.4	4
NFT + magnet	1.6	1
NFT 31	-0.2	3
NFT + oxygen	-0.4	4
Standard Rockwool	-0.6	6
Rockwool magnet	0.0	2

FIRMNESS	SCORE	RANK
NFT 51	-0.2	4
NFT + magnet	0.4	1
NFT 31	-0.2	4
NFT + oxygen	0.4	1
Standard Rockwool	0.2	2
Rockwool magnet	-0.6	6

OVERALL FLAVOUR	SCORE	RANK
NFT 51	0.2	3
NFT + magnet	0.0	4
NFT 31	-1.6	6
NFT + oxygen	-0.4	5
Standard Rockwool	0.4	2
Rockwool magnet	1.4	1

Total Marketable Yield (Kg/m2)

March

distance of start of plot from inlet

	0m	7.5m	15m	22.5m
NFT 5l control	1.75	1.40	1.34	1.32
NFT 5l + magnet	1.69	1.37	1.09	1.31
NFT 3l control	1.35	0.88	0.99	1.24
NFT 3l + oxygen	1.40	1.34	1.15	1.24

April

	0m	7.5m	15m	22.5m
NFT 5l control	7.95	7.02	6.22	5.47
NFT 5l + magnet	7.19	6.58	5.61	5.47
NFT 3l control	7.82	7.11	6.52	6.38
NFT 3l + oxygen	7.44	6.97	6.47	6.00

May

	0m	7.5m	15m	22.5m
NFT 5l control	11.37	9.68	9.10	9.38
NFT 5l + magnet	10.72	9.44	8.62	9.62
NFT 3l control	12.06	10.59	10.31	10.10
NFT 3l + oxygen	8.24	8.43	8.34	8.68

June

	0m	7.5m	15m	22.5m
NFT 5l control	9.12	8.95	8.79	8.91
NFT 5l + magnet	9.25	8.71	8.93	9.04
NFT 3l control	9.01	8.74	8.63	9.38
NFT 3l + oxygen	8.52	8.97	9.12	8.76

Appendix VI cont...

July

	0m	7.5m	15m	22.5m
NFT 5l control	10.01	8.61	8.54	9.53
NFT 5l + magnet	8.92	8.46	8.66	9.16
NFT 3l control	10.80	9.95	9.56	9.60
NFT 3l + oxygen	8.82	8.91	9.00	9.84

August

	0m	7.5m	15m	22.5m
NFT 5l control	9.53	7.92	7.83	8.31
NFT 5l + magnet	7.50	7.05	7.34	8.67
NFT 3l control	9.46	9.02	8.59	8.12
NFT 3l + oxygen	8.72	9.02	8.80	8.95

September

	0m	7.5m	15m	22.5m
NFT 5l control	7.04	5.87	6.13	6.60
NFT 5l + magnet	4.81	3.99	3.97	4.82
NFT 3l control	6.99	6.40	6.93	6.15
NFT 3l + oxygen	6.65	6.01	6.04	6.24

October

	0m	7.5m	15m	22.5m
NFT 5l control	4.48	4.06	3.69	3.76
NFT 5l + magnet	2.49	1.79	2.00	3.10
NFT 3l control	4.64	4.22	4.21	4.36
NFT 3l + oxygen	4.17	4.50	4.26	4.17

Total

	0m	7.5m	15m	22.5m
NFT 5l	61.25	53.51	51.63	53.28
NFT + magnet	52.57	47.37	46.22	51.03
NFT 3l	62.12	56.91	55.72	55.30
NFT + oxygen	53.96	54.15	53.17	53.89

Contract between HRI (hereinafter called the "Contractor") and the Horticultural Development Council (hereinafter called the "Council") for research/development project.

1. **TITLE OF PROJECT** **Contract No: PC/83**

TOMATOES: IRRIGATION SYSTEMS FOR NFT

2. **BACKGROUND AND COMMERCIAL OBJECTIVE**

There is increasing pressure on rockwool tomato growers to minimise the runoff from rockwool systems as the nutrients and pesticides therein are potential pollutants of water supplies. This reduction could be achieved by collection and recirculation of the solution. This method has been used by NFT growers for many years.

Currently crop productivity from NFT systems is lower than that from rockwool systems and it is suggested that inadequate oxygenation of the root zone could contribute to this difference.

This project aims to improve the irrigation of an NFT crop by increasing oxygenation of the root zone. NFT techniques will be compared with a rockwool recirculation system which will help all tomato growers to identify the best system to deal with environmental pressures.

3. **POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY**

Apart from environmental benefits recirculation gives an estimated potential saving in fertilizer and water usage of approximately 20% of current costs for standard rockwool systems.

An increase in yield of approximately 5% could be achieved if productivity from NFT systems could be increased to that of well managed run to waste rockwool systems. This could increase income by up to £14,000/ha (1991 MAFF figures).

4. **SCIENTIFIC/TECHNICAL TARGET OF THE WORK**

The aims of the project are:

1. To determine the effect of method of irrigation on yield and fruit quality of NFT tomatoes.

2. To measure the effects of irrigation systems on oxygenation of the root zone and relate this to crop performance.

3. To compare NFT with recirculation of runoff from a rockwool crop.

5. **CLOSELY RELATED WORK - COMPLETED OR IN PROGRESS**

Initial development work on NFT was carried out at HRI Littlehampton and their basis techniques will be incorporated into this project.

Experimental work on oxygenation of nutrient solution is ongoing in several European countries and it is the intention to develop links with the relevant scientists.

6. DESCRIPTION OF THE WORK

Year 1

The project will be carried out in a 0.1 ha modern high Venlo block at HRI Stockbridge House with full control of the aerial environment, irrigation regimes and nutrient levels.

Experimental details as follows:

Irrigation Treatments

1. Standard NFT, one inlet per trough, flow rate 5 l/minute/trough.

2. Standard NFT, one inlet per trough, flow rate 10 l/minute/trough.

3. Drip feed NFT. Irrigation supplied in equal volumes to each plant on ~~an intermittent~~ a continuous basis using a drip irrigation system. P.E.G.

4. Standard rockwool system with collection and recirculation of runoff.
   Irrigation 150 ml/100 J or 2 hours.
   Target 30% runoff.

5. As 4., but without recirculation.

Cultural Details

Row length - 30 plants.

Varieties - 3 varieties with different growth habits.

Environmental regime - According to the best commercial practice.

Records will include:

Total yield in size grades
Percentage Class I, II and unmarketable fruit
Monitoring of solution oxygen levels
Assessments of root and shoot vigour
Shelf Life Internal Composition
Nutrient solution analysis
Monitoring of glasshouse aerial environment

Years 2 and 3

The treatments and experimental details for years 2 and 3 will be discussed and agreed during the review meeting which will take place at the end of each season.

Availability of results

Interim results will be available to the HDC and visiting groups throughout the trial. A full report will be available at the end of each season.

7. COMMENCEMENT DATE AND DURATION

Start date 01.11.92; duration 3 years.

8. STAFF RESPONSIBILITIES

Project leader: M Hardgrave, HRI Stockbridge House

9. LOCATION

HRI Stockbridge House

Contract No: PC/83

TERMS AND CONDITIONS

The Council's standard terms and conditions of contract shall apply.

Signed for the Contractor(s)	Signature......[signature]......
	Position......Commercial and Marketing Manager HRI......
	Date......1/8/92......
Signed for the Contractor(s)	Signature............
	Position............
	Date............
Signed for the Council	Signature......[signature]......
	Position......CHIEF EXECUTIVE......
	Date......10.11.92......