National greenhouse waste-water recycling project

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Graeme Smith Consulting

Project Number: VG09073

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FINAL REPORT

PROJECT NUMBER – VG09073

NATIONAL GREENHOUSE WASTE-WATER RECYCLING PROJECT

15TH May 2011

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VG09073 - NATIONAL GREENHOUSE WASTE-WATER RECYCLING PROJECT

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Purpose: The national greenhouse waste-water recirculation project was designed to deliver necessary skills to greenhouse vegetable growers in converting their current free-drainage (open) systems to full recycling (closed).
The project aimed to collect the technical knowledge and information required to enable growers to efficiently convert their greenhouse waste-water systems.
A further aim of this project was to investigate any potential pathology issues related to recycling waste-water including assessing the efficacy of various sterilisation systems.
The knowledge gained have been delivered to key Australian growing areas by a series of theoretical & practical workshops.

Funding Source: Horticulture Australia Limited

Collaborating Institutions:
Graeme Smith Consulting, Goulburn Ovens Institute of TAFE, Growool Horticultural Systems

Date of Report: **15th May 2011**

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Appendices (all attached as PDF Files)

Summary

The national greenhouse waste-water recirculation project was designed to deliver necessary skills to greenhouse vegetable growers in converting their current free-drainage (open) systems to full recycling (closed) as per the following:

- collect the technical knowledge and information required to enable growers to efficiently convert their greenhouse waste-water systems.
- investigate any potential pathology issues related to recycling waste-water including assessing the efficacy of various sterilisation systems.
- knowledge gained was delivered to key Australian growing areas by a series of theoretical & practical workshops.
- A literature review was conducted to assess the current information available about converting systems, waste-water sterilisation options and recycling nutrients. This review ensured global world's best-practice was included in project and knowledge gaps were identified and research commissioned to address issues.
- A training package containing information and course details was developed for delivery to industry.
- It was identified that waste-water products from hydroponic systems are potentially harmful to the environment and should be managed on farm.
- Additionally, greenhouse growers can substantially reduce their cost of production through average savings of 40% water and 60% fertilizer and further reduce their impact on the natural environment. (resulting in an average annual saving for every 4,000m2 greenhouse system of ±$15,000)
- This project identified from the hundreds of workshop attendees that the average drain % was ±40% (to maintain a suitable root-zone condition) and 60% fertiliser savings calculated Pre EC (drain EC x drain % e.g. 3.7 x 40% = 1.5 Pre EC, feed EC = 2.6, 1.5 / 2.6 = ±60% fertiliser savings)
- Municipality's reluctance to issue new (or extend existing) permits for greenhouse production based on perceived environmental impacts is minimised
- Growers gained skills to safely recirculate nutrient rich waste-water, sterilise and neutralise disease pathogens and rebalance nutrient inputs and outputs.

The investment was relatively low with high returns on the cost of production and for the natural environment as this project has the capacity to deliver an annual benefit to industry of $25million and divert around 5,000 mega-litres of nutrient-rich water from impacting on the natural environment

Introduction

The project aimed to address a significant market failure in the Australian protected cropping industry by developing a comprehensive workshop training program for delivery to all greenhouse or hydroponic growers.
Even though we operate in a global economy and therefore compete against imported horticultural produce, we do not enjoy equal access to training opportunities that has the capacity to significantly lift our productivity and quality. Skills' training at all levels was considered necessary to underpin industry development & growth.

The Australian protected cropping industry is composed of approx 1,665 vegetable growers producing in 1,341Ha of greenhouses.
They currently contribute over $1.3billion farm-gate value through the production of major vegetable crops including cucumbers, capsicums, egg plants, tomatoes, lettuce, herbs, Asian greens and strawberries.

Of these numbers, approx 95% would be growing in an artificial substrate (or growing media) to provide a nutrient and water buffer to each plant.
(n.b. most hydroponic lettuce, herb and Asian vegetable systems, etc are water-based systems and do not utilize a growing media).

Industry estimates that prior to this project, around 95% of media-based growers are in 'Open' systems that free-drain their nutrient rich waste-water to the environment.

A recent HAL project (VG05095 – Pathways to Production, a skilling initiative of the protected cropping industry), conducted a needs and gap analysis of the Australian protected cropping industry by facilitating a number of grower workshops in all states to ascertain their training and development needs.
An outcome of these workshops was an identified desire to lower their water and fertilizer use as well as their impact on the natural environment, by converting to 'Closed' systems whereby all waste-water drained from their greenhouses was fully recycled back through the crop following suitable treatment.
This was in part driven by their concern for the environment (especially the parlous state of the national water balance), and by the manyfold increases in water and fertilizer costs.
(from start to finish of project, water had increased from an average of $1/kl to ±$2/kl, and fertilisers from $1.80m^2 to ±$3/m^2)
Additionally today, an increasing number of municipalities are refusing permits to new industry entrants (or expansion of existing enterprises) due to their concern for waste-water impacts on the local environment.
This trend has significant implications for growth and development of our industry and is most apparent in the Sydney basin and Brisbane regions.
This project provided the capacity to overcome these restrictions by informing growers how to reduce their waste-water effluent to negligible levels.

This initiative was identified by the AusVeg & HAL Protected Cropping Working Group as the top industry priority for '09 – '10.

The project delivered to all media-based hydroponic growers the technical skills and knowledge to convert from Open to Closed systems for full waste-water recycling to save on average around 40% of all water and 60% of all fertilizer supplied to their crops and develop their systems to become even more environmentally sound and responsible.
It should be noted that greenhouse growers today are already using around ±80% less water than traditional farming activities, however the waste-water impact on the natural environment can still be considerable. Growers recognise that irrespective of how little water they use or lose as waste-water (compared to traditional farming activities), they can always strive to be even better and save significant monies in the process.

Of the above total industry 1,665 growers in 1,341Ha of protected cropping, approx 400Ha is for fresh tomato growing & 250Ha for lettuce & herbs, both of which are <u>not</u> considered for this project.
Therefore approx 664Ha of protected cropping was targeted for delivery via a series of hands-on skills-based workshops in the main greenhouse growing areas of Australia.
Typical water savings per Ha = 7.5M/L @ $1,000/M/L = $7,500
Typical fertiliser savings per Ha = $1.80m2 = $18,000
Total average savings per Ha = $25,500
$25,500 x 664Ha = $16,932,000 potential savings annually. (n.b. around $25million if tomato and lettuce/herb growers included)
Additionally, around 4,980 mega-litres of nutrient rich water is diverted from the natural environment.

n.b. whilst there are a minimal number of greenhouse growers in soil based systems, the principles involved in converting an ‘open’ to ‘closed’ recycling system are based on hydroponic technologies and systems, therefore soil based growers were not initially considered as a high priority for this project, other than pathology issues and outcomes are still relevant to soil growers as well as the suite or sterilising treatment options, therefore there would be flow-on benefits for soil greenhouse growers as well. Consequently there were some soil greenhouse growers who attended the workshops (mainly Virginia SA) who also benefited from learning detailed hydroponic techniques as well.

Anecdotal industry evidence suggests that current greenhouse ‘soil’ growers are increasingly adopting standard hydroponic irrigation, fertigation and environment management techniques and take up of ‘soilless substrates’ is considered the next logical step.

Some expected benefit/consequences of this work are a significant lift in grower productivity and viability with a concomitant decrease in cost of production through improved production techniques. Improved techniques should translate into enhanced production and quality that satisfies the QA requirements of both domestic & export markets leading to enhanced market opportunities.

Target audience was all growers in the Australian protected cropping industry with no or little formal horticultural training in their field (industry estimates over 90% of current growers).

Project evaluation is ultimately proved by increased lift in production per m^2 (standard measure used worldwide to compare production systems and individual growers), as well as increased uptake of product by consumers.
Qualitative & quantitative data can also be assessed through the main grower distribution markets in all major capital cities. Grower feedback can be sought to assess pre & post production levels per m^2 with an industry database developed to track grower accreditation levels and production improvements.
It is proposed that regular consultation with the National Greenhouse Vegetable Working Group and AusVeg IDO's re outcomes and on-going adoption of project be conducted.

Factors considered necessary for project adoption included ensuring that the grower’s needs were comprehensively surveyed, prioritised and effectively delivered. Significant production advantages were clearly articulated to all growers to overcome some reticence to sharing production data. Failure to reach the majority of industry growers would have impacted on the programmes success, therefore it was imperative to run workshops in all states to ensure reasonable data capture and skills delivery.

Methods & Activities

Literature Review

This process revealed a number of support resources suitable for the project:

- A book called “Plant Nutrition of Greenhouse Crops” (Sonneveld & Voogt, Springer Publications) was released recently that covers all the conventional nutritional recipes and adjustments for traditional & emerging greenhouse crops and growing media. This publication will assist the project by providing sound advice on optimising water and fertiliser uptake.
- A software program from Haifa Chemicals Ltd called “Haifast” has been developed to assist greenhouse growers to develop their nutritional recipes based on analysis of their fresh water supply/s and drain water. These recipes are then automatically adjusted to the normal standard feed recommendations for crop age and physiological stages. This resource will greatly simplify greenhouse growers ability to balance their crop nutrition when converting to a ‘closed’ recycling system. (See appendix i.)

- Investigations were held in relation to water disinfection options when converting to a closed greenhouse system. Conventional treatment options used globally in greenhouses systems included:
  ozone, heat (pasteurisation), UV, slow biological, chlorine dioxide, iodine, copper, hypochlorite, monochloramine, quaternary ammonium, sand & activated-carbon filtration and possibly others?
  These systems will be tested pre & post treatment for pathogen load to gauge effectiveness and annual costs per m/l of water treatment to assist greenhouse growers to make informed technology choices. (see appendix h. & k.)

Practical & Technical Training in The Netherlands

Graeme Smith (main project investigator) and Rick Donnan (project collaborator) travelled to The Netherlands (as part of Project 'VG09068 – European Greenhouse Study Tour October 2009') to assess firsthand the practical methods used by growers to disinfect their recycled water supply (as noted above). This tour provided a first-hand view of various systems, their geometry and their efficacy and this information formed part of the workshop presentations.

Graeme & Rick attended two days intensive technical training in conversion to closed greenhouse systems at the Practical Training Centre Plus in Ede, Holland. This training covered the following aspects:

1. Hydroponic nutrient feed recipes for all identified vegetable crops
2. Recipes to cover the changing physiological stages for each crop
3. Root-zone nutrition targets for each vegetable crop
4. Adaption recipes to balance and control root-zone nutrition
5. Interpretation of laboratory drain analysis results
6. How to convert from Open to Closed Systems by capture of drain water and reuse
7. Plant nutrition and nutrient management
8. Drain water sterilization options and assessment

Included in the training sessions were visits to major technology manufacturers to discuss one-on-one the technical aspects and benefits of various water disinfection options. Companies visited included 'van Dijk Heating' who produce a heat (pasteurisation) system (commonly used in The Netherlands), and 'Lenntech' who produce both UV and Chlorine Dioxide treatment systems (also commonly used in The Netherlands glasshouse industry). Both manufacturers made available software to calculate investment and annual running costs that was made available to growers attending the workshops. (see appendix h.)

Full Workshop Development

Graeme, Rick Donnan and Leigh Taig (GOTafe Production Horticulture Manager) met on a number of occasions to develop the technical content of the workshops that consisted of the following elements:

- Plant Nutrition, Water Quality, EC & pH (see appendix e.)
- Conversion to a Closed System (see appendix f.)
- Water Sample Collection Options
- Water Disinfection Options and Costings (see appendix h.)
- Haifast Nutrition Software Demonstration & Training (see appendix i.)

Also developed was a workshop timeline. (see appendix d.)

Industry Workbook

The units outlined above in Full Workshop Development formed the key components of the Industry Workbook that was made available to all workshop attendees.
The workbook included a loose-leaf binder (for easy unit updates) and an attached CD Rom containing the Haifast nutrition software.
Investigations were undertaken with Steven Carruthers (owner of Casper Publications and publisher of "Practical Hydroponic & Greenhouses' magazine), to assess the development of an 'e-book' following completion of the workshops and pathology trials as an effective method of making available this information to industry in the future.

Workshops Delivered

It was resolved to conduct a pilot workshop with a greenhouse reference group in the Bellarine Peninsula area of Victoria in February 2010, to ensure each subject is well covered and sufficient time is allowed to meet the needs of the growers.
Following this pilot, the balance of the national workshops were delivered from March to October 2010.

Workshops have been delivered at the following locations:

- Victoria (4),
  Geelong, 10 Participants
  Shepparton, 14 Participants
  Cranbourne, 19 Participants
  Werribee, 18 Participants

- New South Wales (1),
  Coffs Harbour, 20 Participants

- Queensland (2),
  Brisbane, 23 Participants
  Bundaberg, 16 Participants

- Western Australia (1),
  Baldivis, 19 Participants

- South Australia (2),
  Virginia, 15 Participants
  Virginia, 15 Participants

- Tasmania (1),
  Campbelltown, 16 Participants

- New South Wales (3)
  Tahmoor, 12 Participants
  Riverstone, 23 Participants
  Kemps Creek, 30 Participants

A total of 230 attendees have experienced the 14 workshops in 6 states.

Formal Agreements with Project Sub-Contractors

Graeme Smith Consulting entered into formal sub-contract agreements with key project partners to ensure the project was delivered on-time, on-budget and to an agreed technical level. Contracts completed included:

- Leigh Taig of GOTafe whose main responsibilities include providing for each workshop location the following: (to suit minimum 30 people)
  1. Suitable workshop location with private presentation room (to agreed cities and dates)
  2. Suitable IT facilities for workshops (data-show projector, screen, 15 x laptops, whiteboard, markers, tables & seats, etc)
  3. Suitable catering needs (morning & afternoon tea, lunch, tea/coffee, etc)
  4. Suitable industry workbook (loose-leaf binder style), and CD ROM
  5. Certificate of Attainment/Attendance per workshop participant

- Rick Donnan of Growool Horticultural Systems P/L provided a sound technical basis to assist *Graeme Smith Consulting* to deliver technical training services for the project
  1. Suitable workshop location with private presentation room (to agreed cities and dates)
  2. Technical basis to include assistance with development of suitable presentation information for the project, and subsequent presentations at national workshops
  3. Project to include all national workshop locations
  4. Presentation information included subjects included in Full Workshop Development above.

- Len Tesoriero of NSW DPI Pathology is conducting the pre & post pathogen trials of various industry disinfection systems.

Pathology Testing Program

The data collected in the grower database revealed a significant diversity of sterilisation systems utilised in the industry Australia wide.
Growers were asked if they would agree to be involved in a free trial whereby water samples would be collected pre & post treatment to assess effectiveness of these diverse systems.
These samples are to be sent to Len Tesoriero (NSW DPI Pathology), for testing of crop specific pathogens (eg. Pythium, phytophthora, fusarium, Bacterial Canker, etc)

A letter was sent to all volunteers of this testing program (see database below & appendix k.) outlining the collection and mailing process of the water samples.
Included is a copy of 'Plant Disease Diagnosis Request' from NSW Industry & Investment Plant Health Diagnostic Service (see appendix l.)
2 one-litre bottles have been mailed to each grower for each test (1 x input and 1 x output) to allow for replicates of each test, therefore some growers have received multiple packages to reflect multiple treatment systems, water sources or crops.

The data collected in the grower database revealed a significant diversity of sterilisation systems utilised in the industry Australia wide and included: UV, Ozone, Hydrogen Peroxide, slow biological, Iodine, reverse osmosis, ultra-filtration, chlorine dioxide and beneficial microbes, etc.
At time of writing, NSW DPI Pathology have not completed their trials, therefore no final report from them, however some trials that have been completed indicate a significant lack of efficacy in some of the treatment systems.
This non-performance could be due to less than ideal management by the grower or point to substantive failings in the technology itself.
Len is requesting follow-up samples from these enterprises to ensure testing and sampling integrity and will provide direct feedback to assist each grower affected.

Workshop Participant Volunteer List

	Workshop Participant Volunteer List				Raw or Recycle		
Code	Company Name	Contact Name	State	sterilisation unit		Crop/s	Pathogens to be Tested
PTP01	ST Tomato Farm	Michael Tran	Vic	vibrex	Raw	tomato eggplant	Cmm, Fusarium, Pythium, Phytophthora
PTP02	Bang Trinh P/L	Bang Trinh	Vic	vibrex	Raw	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP03	J & A Brandsema	Anthony Brandsema	Tas	hydrogen peroxide	Raw	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP04	J & A Brandsema	Anthony Brandsema	Tas	hydrogen peroxide	Recycle	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP05	P'petual Holdings P/L	Andrew Potter	SA	RO	Raw	tomato, cucumber	Cmm, Fusarium, Pythium, Phytophthora
PTP06	Zedfarm	Peter Zulpo	Qld	ozone	Recycle	tomato, herbs	Cmm, Fusarium, Pythium, Phytophthora
PTP07	Zedfarm	Peter Zulpo	Qld	UV	Recycle	tomato, herbs	Cmm, Fusarium, Pythium, Phytophthora
PTP08	Virginia Produce P/L	Thien Dinh Vu	SA	ultrafiltration	Recycle	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP09	Virginia Produce P/L	Thien Dinh Vu	SA	RO	Recycle	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP10	D T Vu Hydropnics	Dinh Thi Vu	SA	ultrafiltration	Raw	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP11	D T Vu Hydropnics	Dinh Thi Vu	SA	ultrafiltration	Recycle	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP12	N C Nguyen	Ngoc Cuong Nguyen	SA	UV	Raw	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP13	N C Nguyen	Ngoc Cuong Nguyen	SA	UV	Recycle	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP14	R&M Standing	Robert Standing	NSW	UV	Raw	tomato, cucumber, eggplant	Cmm, Fusarium, Pythium, Phytophthora
PTP15	Flavourfull Hydroponics	Ross Mathiesen	Vic	RO	Raw	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP16	Havilah Hydroponics	Adrian Stanley	Qld	ozone	Recycle	cucumber, lettuce	Fusarium, Pythium, Phytophthora
PTP17	Havilah Hydroponics	Adrian Stanley	Qld	iodine	Recycle	cucumber, lettuce	Fusarium, Pythium, Phytophthora
PTP18	Bestmann Hydroponics	Malcolm England	Qld	ozone, microbes	Recycle	lettuce, tom, herb, asian greens	Cmm, Fusarium, Pythium, Phytophthora
PTP19	Ironbark Hydroponics	Keith Waddell	Qld	ozone	Raw	lettuce	Fusarium, Pythium, Phytophthora
PTP20	Pure Natives	Cornelia Payne	Qld	UV	Raw	flannel flower	nematodes
PTP21	Hydro-Harvest	Glenn Hinton	Qld	RO	Raw	Asian vegetables	Fusarium, Pythium, Phytophthora
PTP22	Vertical Farm Systems	John Leslie	Qld	UV	Recycle	Rocket Basil---	Fusarium, Pythium, Phytophthora
PTP23	Boxsell Hydroponics	Glenn Boxsell	Qld	RO	Raw	Leaf Vine Crop	Fusarium, Pythium, Phytophthora
PTP24	Boxsell Hydroponics	Glenn Boxsell	Qld	Carbon	Recycle	Leaf Vine Crop	Fusarium, Pythium, Phytophthora
PTP25	Bratasha Farm	Ray Bertinazzi	Qld	ozone	Recycle	Asian vegetables	Fusarium, Pythium, Phytophthora
PTP26	D'Vineripe	Michelle Gladwin	SA	RO	Raw	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP27	D'Vineripe	Michelle Gladwin	SA	UV	Recycle	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP28	KJ & O Webb P/L	Keith Webb	SA	ultrafiltration	Raw	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP29	KJ & O Webb P/L	Keith Webb	SA	ultrafiltration	Recycle	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP30	Eden Farms	Jason Smith	Qld	hydrogen peroxide	raw	cucumber	Fusarium, Pythium, Phytophthora
PTP31	Clean Green Hydro	Brian Ellis	Qld	ozone	Recycle	fancy lettuce, asian veg	Fusarium, Pythium, Phytophthora
PTP32	Clean Green Hydro	Brian Ellis	Qld	iodine	Recycle	fancy lettuce, asian veg	Fusarium, Pythium, Phytophthora
PTP33	J & F Eberhard	Jochen & Friederike Eberhard	Qld	hydrogen peroxide	Raw	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP34	J & F Eberhard	Jochen & Friederike Eberhard	Qld	hydrogen peroxide	Recycle	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP35	Alma Hydroponics	Ian Mortlock	Vic	iodine	Recycle	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP36	Stakehill Hydroponics	Alex Norman	WA	UV	Recycle	tomato	Cmm, Fusarium, Pythium, Phytophthora
PTP37	Westgro Hydroponics	Paul Humble	WA	UV	Recycle	cucumber	Cmm, Fusarium, Pythium, Phytophthora
PTP38	Paulmar Hydroponics	Paul Mifsud	Vic	ozone	Recycle	lettuce	Fusarium, Pythium, Phytophthora
PTP39	Bellarine Hydroponics	Anne Wilson	Vic	Slow Biological	recycle	tomatoes	Cmm, Fusarium, Pythium, Phytophthora
PTP40	Bellarine Hydroponics	Anne Wilson	Vic	Iodine	recycle	tomatoes	Cmm, Fusarium, Pythium, Phytophthora

PCA Tender – Laboratory Analysis of Greenhouse Nutrient Solutions

An outcome of this project is a tender to supply to all PCA members a cost-effective laboratory analysis of their water and nutrient solutions to an industry standard.
The project delivers skills-based training on converting systems from open (free-drainage) to closed (full recycling) resulting in 60% (on average) of fertiliser nutrition being sourced from the drain water that requires laboratory analysis to rebalance input nutrition.
This tender was subsequently awarded to Hortus Technical Services of Bundaberg QLD, who met all the relevant testing and reporting criteria and offered a full nutrient solution analysis for $69, a discount of $20 per sample to PCA members. (see appendix m.)

Grower Database

A grower database has been tabulated from all the workshops that will provide for an important industry resource and included the following information:
a. Industry demographics
b. System sizes
c. Crops grown
d. Growing system types
e. Types of sterilisation systems used

Workshop Comments

It was considered important that the project measured its effectiveness with all attendees asked the following questions:
a. I had sufficient info about content?
b. Responses to enquiry/registration were timely?
c. Content was relevant to my workplace?
d. Method of delivery was appropriate?
e. Information will help my business?
f. Presenters had good knowledge
g. Facilities suitable?
h. Best part of workshop?
i. Worst part of workshop
j. Do you think you have enough information to convert to closed system?

The responses have been tabulated (see appendix n.)

Workbook Updates

The supplied workshop workbooks have been progressively updated following feedback from each workshop to more closely reflect the technology utilised in the Australian greenhouse and hydroponic industry. This is to ensure that only the most recent industry technical information can be presented as an industry resource following completion of the project

Industry Workbook Development

The entire project is planned to be available via an industry workbook. This workbook is to be delivered in the form of an 'e-book' to facilitate the ease of delivery to Australian greenhouse or hydroponic growers.

Delivery can then be facilitated by either:

a) Email
b) Websites (e.g. www.graemesmithconsulting.com , www.protectedcroppingaustralia.com)
c) Or CD Rom (via mail or industry events)

Main subjects of industry workbook (e-book):

a) Introduction
b) Course Outcomes and Accreditation
c) Plant Nutrition, Water Quality, EC & pH
d) Conversion to Closed Greenhouse Systems
a) Maintenance Program for Closed Greenhouse Systems
b) Water Disinfection Options & Costings
c) Haifast Nutrition Software
d) Outcomes of pathology trials
e) Outcomes of sterilisation systems trials
f) Preferred industry supplier of laboratory analysis of nutrient solutions
g) Acknowledgements

An e-book compiler (Active E-Book Compiler), has been purchased to ensure international publishing specifications and norms are maintained for the workbook.

CD Roms will be produced by Casper Publications (editors and publishers of 'Practical Hydroponics and Greenhouse Magazine), who will also provide disk cover printing.

Industry Presentations

The outcomes of this project are planned to be communicated to industry at a wide-range of forums, with a particular focus on the original workshop locations around the nation. This is consistent with advice given to participants during the original workshops to ensure we report back directly to industry.

Presentations Completed

As at time of this report, the following reports to industry have been completed:

1. VIC - Hydroponic Farmers Federation October AGM & grower meeting in Yendon
2. WA – West Australian Greenhouse Growers Association April grower meeting in Perth
3. TAS – Tasmanian Association of Greenhouse Growers May AGM & grower meeting in Campbell Town
4. SA – SARDI Local Growers meeting in March at Virginia Horticulture Centre
5. PCA national 'Soilless Australia' magazine to all association membership

Presentations to come

1. SA - PCA national biennial industry conference in Adelaide in July 2011
2. NSW – at Coffs Harbour & selected Sydney grower meetings with NSW DPI in June 2011
3. QLD – at Bundaberg Fruit & Vegetable Growers Association in June 2010
4. Practical Hydroponics & Greenhouses (national and international trade magazine)
6. AusVeg national magazine – 'Vegetables Australia'
7. PCA & Graeme Smith Consulting Web sites

Summary of Key Project Outcomes

The project key outcomes included the following:

a) National workshops (deliver skills for industry to convert to closed systems)
   A total of 230 attendees have experienced the 14 workshops in 6 states.

b) Capacity to save industry $25million annually in water and fertiliser costs
   (significantly lower each growers cost of production)

c) Divert 5 G/L nutrient rich water from impacting on natural environment

d) Efficacy testing of common industry sterilisation systems
   (test for common crop pathogens, Pythium, phytophthora, fusarium & Cmm)

e) Preferred industry supplier of laboratory analysis of nutrient solutions
   Hortus Technical Services delivery cost-effective analytical services to an industry standard

f) Haifast Nutritional software (full greenhouse crop recipes for differing physiological stages and nutrient re-balancing for closed systems)

g) Free copy of project 'e-book' via various websites (ongoing delivery of skills to all of industry)

ACKNOWLEDGEMENTS

In my role as Project Leader, I wish to thank the participants below for their co-operation and technical input. Their interest in all things greenhouse and hydroponic, and the general spirit of togetherness was most satisfying. I thank them for their friendship and I specially thank them for their contribution to the information included in this report, therefore recognition and appreciation is for their welcome contribution to ensuring a successful project:

Collaborating Institutions:

PCA	Saskia Blanch, Secretary, Protected Cropping Australia
Steven Carruthers	Casper Publications, Practical Hydroponics & Greenhouse Magazine
NSW DPI	Jeremy Badgery-Parker, National Centre for Greenhouse Horticulture, Gosford NSW
SARDI	Kaye Ferguson & Barbara Hall
Nicholas Srour	T&W Greenhouses NSW
GOTafe	Leigh Taig & Ross Wade, Goulburn Ovens TAFE, Shepparton VIC
Rick Donnan	Rick Donnan P/L
Growool	Growool Horticultural Systems
VHC	Peter De Lacy & Mike Redmond, Virginia Horticulture Centre SA
HFF	Carl van Loon, President, Hydroponic Farmers Federation VIC
TAGG	Anthony Brandsema, Tasmanian Association of Greenhouse Growers TAS
WAGGA	Paul Humble, President, West Australian Association of Greenhouse Growers WA
Len Tesoriero	NSW DPI Pathology
BFVGA	Max Horvath, Bundaberg Fruit & Vegetable Growers Association QLD
Ben van Onna	Senior Trainer PTC+ Ede (The Netherlands)
Herman Eijkelboom	Senior Trainer PTC+ Ede (The Netherlands)
Peter van den Brink	Coordinator PTC+ Ede (The Netherlands)
HAL & AusVeg	Protected Cropping Working Group – all group members
Shaul Gilan	Haifa Australia

Graeme Smith
Project Leader

National Greenhouse Waste-Water Recycling Project

(A skills initiative for ALL Australian greenhouse & hydroponic vegetable growers)

You are invited to attend a *FREE* workshop to develop a sound understanding of the skills and technology required to convert from an Open to a Closed System

Typical Annual Savings per Hectare (10,000m2)
Fertiliser - $30,000, Water - $7,500 - Total = $37,500/ha

Workshop Subjects

1. Hydroponic nutrient feed recipes for all identified vegetable crops
2. Recipes to cover the changing physiological stages (maturity) for each crop
3. Root-zone nutrition targets for each vegetable crop
4. Adaption recipes to balance and control root-zone nutrition
5. Interpretation of laboratory drain analysis results
6. How to convert from Open to Closed Systems by capture of drain water and reuse
7. Plant nutrition and nutrient management
8. Drain water sterilization options and assessment (investment and annual running costs)
9. Demonstration of recycling equipment (blend valves and controllers)
10. Workbook and CD ROM containing automatic greenhouse nutrition software program

Workshop Registration

Growers can register for the free workshops by completing the course registration form (attached), or can be downloaded from www.graemesmithconsulting.com or by contacting Ross Wade of GOTafe on (03) 5833 2816, or email Ross on rwade@gotafe.vic.edu.au

Workshop Program *(each day 9.30am – 4.30pm)*

State	City Location	Venue	Date/s
VIC	Shepparton Werribee Cranbourne	GOTAFE Campus Fryers St: 152 Fryers St Werribee RSL: 2 Synnot Street Amstel Golf Club 1000 Frankston -Cranbourne Rd	Wed 17th March Tue 23rd March Wed 24th March
TAS	Campbell Town	Campbell Town Hotel: 118 High Street	Wed 14th April
NSW	Coffs Harbour Luddenham Oakville Tahmoor	Catholic Club, 61a West High Street Golf & Country Club, Twin Creeks Drive Joseph Azzi Farm, Smith Road Said Azzi Farm, Bargo River Road	Wed 12th May Tue 22nd June Wed 23rd June Thu 24th June
WA	Baldivis	Old Barnyard Function Centre: 441 Old Mandurah Rd	Tue 8th June
QLD	Brisbane Bundaberg	Virginia Golf Club, 10 Elliot Road, Banyo Alloway Country Club: Goodwood Road	Tue 20th July Wed 21st July
SA	Murray Bridge Virginia Virginia	Murray Bridge Racing Club: Maurice Road Virginia Horticultural Centre Virginia Horticultural Centre	Tue 10th August Wed 11th August Thu 12th August

(N.B. lunch, morning & afternoon teas included in free workshop)

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Workshop Registration Form

I ____ (name) will be attending the workshop at

____ (city) on ______________________ (date)

My farm is ______________________________________ (business name) and I currently grow

greenhouse or hydroponic vegetables ____ (crop/s)

My address is ____

____

My contact phone number is ____ (inc area code)

Or mobile number is ____

Email contact is ____

I will bring my own Laptop computer (IBM compatible) to load software program _________ (yes/no)

I will bring a recent fresh water and drain water laboratory analysis to load in program _____yes/no)

Please either fax or email this registration form at least 1 week before the workshop date. (to allow for venue and catering)

Fax to Ross Wade at GOTafe on (03) 5833 2881, or
Email to rwade@gotafe.vic.edu.au
Any workshop questions, please phone Ross Wade (03) 5833 2816, or

(Alternate Contact: Graeme Smith on 0427 339 009 or graeme@graemesmithconsulting.com)

Workshop Facilitators: Graeme Smith (Graeme Smith Consulting)
Rick Donnan (Growool Horticultural Systems)
Leigh Taig / Ross Wade (Horticulture Centre – Goulburn Ovens TAFE)

appendix b.

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PROJECT WORKBOOK

Facilitated by

GRAEME SMITH CONSULTING

www.graemesmithconsulting.com

Project Collaborators

Rick Donnan – Growool Horticultural Systems P/L

Leigh Taig & Ross Wade – GOTafe Shepparton

National Greenhouse Waste-Water Recycling Project

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National Greenhouse Waste-Water Recycling Project

Project Collaborators

Rick Donnan – Growool Horticultural Systems P/L

Leigh Taig & Ross Wade – GOTafe Shepparton

National Greenhouse Waste-Water Recycling Project

•High proportion of media-based greenhouse vegetable growers are 'free drainage' (± 90%)

•Converting from 'open' to 'closed' can save industry ± $25million annually (water & fertiliser)

•Also save ± 5 giga-litres nutrient rich water impacting on the natural environment

•Workshops in 'Pathways to Production' locations

• Plan to tender out national water analysis to labs for industry members

•Pre & Post sterilisation treatment pathology trials

•Project rolled-out March – January 2011

• Project funding support from HAL and AusVeg

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Recycling Outcomes (typical systems)

- Save up to 40%+ water
  e.g. 4,000m2 x 600,000J x 3ml x 40% / 1,000 =
  3,000,000lt (3ML) x $1.00/kl = $3,000
- Save up to 60%+ fertiliser
  e.g. 4,000m2 x $5.00/m2 x 60% = $12,000
- Total Annual Saving (water & fertiliser)
  = $15,000 (per 4000m2)

National Greenhouse Waste-Water Recycling Project

Recycling Outcomes (typical systems)

- Save up to 40%+ water
- Save up to 60%+ fertiliser
- Save $$$
- Be better informed on crop nutrition and uptake rates
- Be environmentally sound & responsible

National Greenhouse Waste-Water Recycling Project

- All information and references on websites on project completion (GSC, AHGA, AusVeg, etc)
- Information presented to suit all levels of expertice

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National Greenhouse Waste-Water Recycling Project (VG09073)

Workshop Timetable

Time	Subject	Presenter/s
09.30 - 10.00	Arrival Coffee/Tea	
10.00 - 10.15	Welcome & Introductions	Graeme Smith
10.15 - 10.30	Course Outcomes and Accreditation	Graeme Smith & Leigh Taig
10.30 - 12.00	Plant Nutrition, Water Quality, EC & pH	Rick Donnan
12.00 -12.30	Lunch	
12.30 - 1.30	Conversion to Closed Systems & Maintenance Program for Closed Systems	Graeme Smith
1.30 - 2.15	Water Disinfection Options & Costings	Rick Donnan
2.15 - 3.00	Haifast Nutrition Software Demonstration	Graeme Smith
3.00 - 3.15	Afternoon Tea	
3.15 - 4.00	Haifast Nutrition Software Training	Graeme Smith
4.00 - 4.30	Workshop Wrap-Up & Close	

 Page 1 of 1 Workshop Timetable

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Waste-Water Recycling Project

Plant nutrition, water quality, EC and pH

by Rick Donnan

Growool Horticultural Systems Pty Ltd

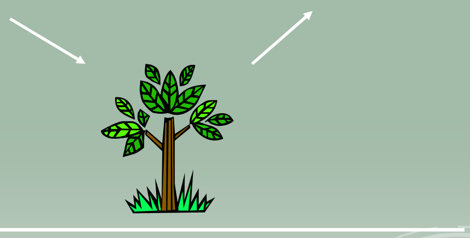
Definitions

- Electrical conductivity (EC) measures solution strength.
  - Unit = milli Siemens per centimetre = mS/cm.
  - Doesn't indicate individual nutrient strengths.
- Ions – all inorganic fertilisers dissolve to give positively and negatively charged ions.
- pH measures acidity. pH 7 is neutral.
  - Below 7 is acid. - Above 7 is alkaline.
- Radiation.
  - Visible light = PAR
  - Heat radiation = infra red (IR)
  - Ultra violet radiation (UV)

Influences on plant growth

radiation
CO2
relative humidity
temperature
leaf area
wind

water
oxygen

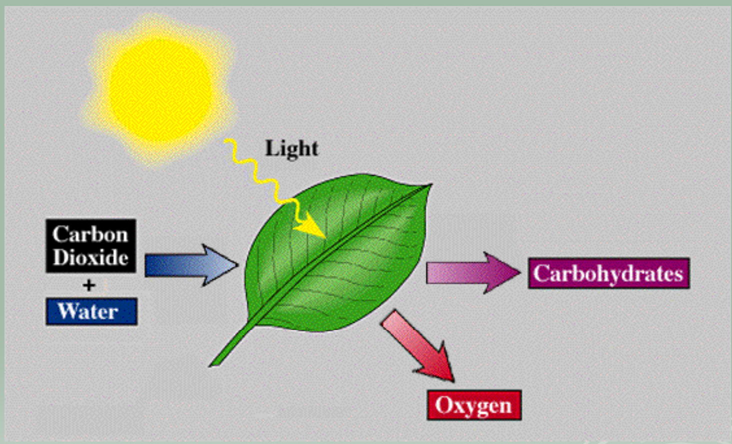


The aerial part of the plant

The major processes are:

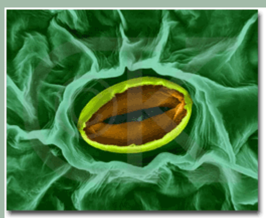
- Photosynthesis
- Transpiration
- Transport
- Respiration

Photosynthesis



Transpiration

- Evaporation of water from leaves keeps the leaves cool.
- The main driver of transpiration is radiation.
- Transpiration is through stomata in the underside of the leaves. They also allow CO_2 in, and oxygen out.



- An infra-red thermometer can measure leaf temperature, which should be no higher than air temperature.

Factors influencing water demand

Water demand increases with:

- higher radiation intensity
- greater effective leaf area
- higher air temperature
- lower relative humidity
- higher wind speed

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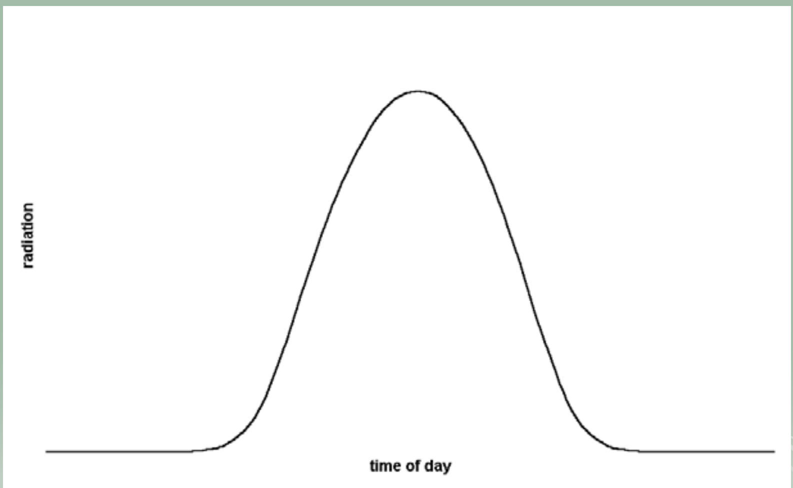
Radiation pattern



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Root uptake mechanisms

Water

- The mechanism is osmosis.
- This is the transfer of water through a membrane.
- The driving force is concentration difference.

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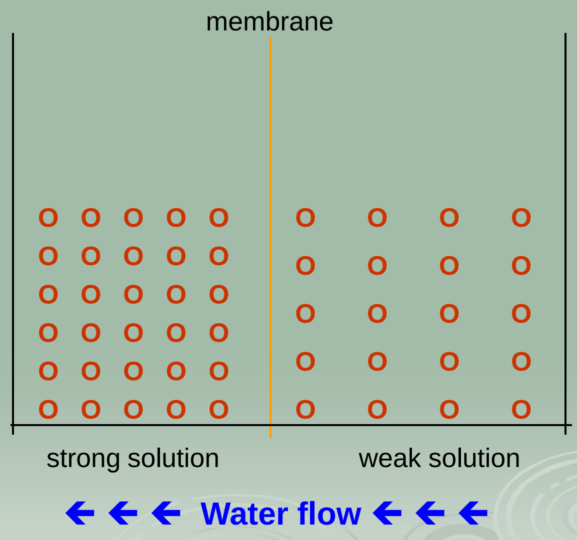
Osmosis – initial conditions



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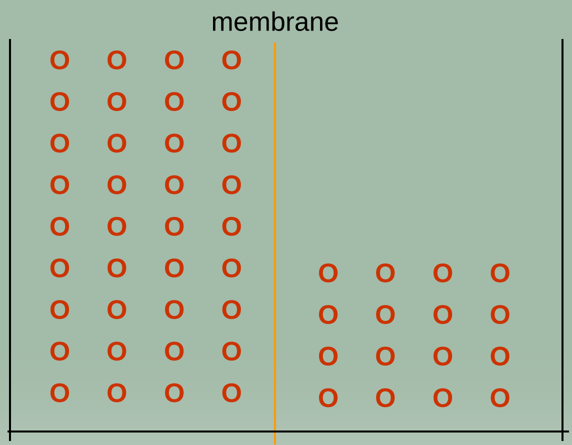
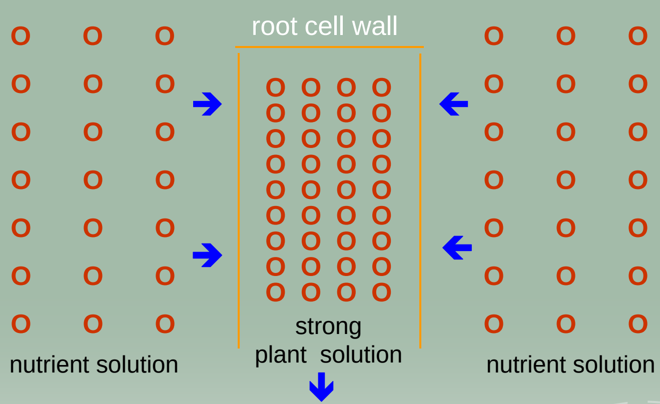
Osmosis – final conditions



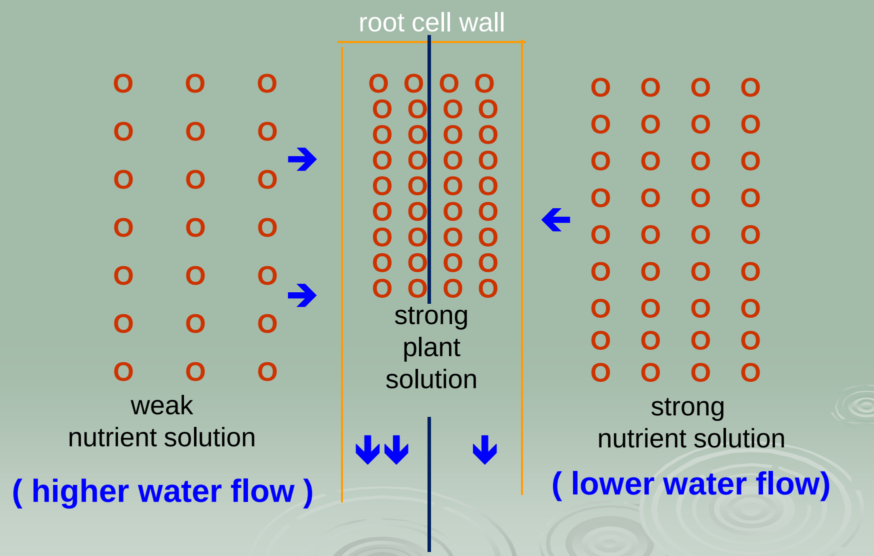
Strengths equalise both sides

Osmosis in the root zone



Water flows from the nutrient solution into the stronger plant root solution

Influence of nutrient solution strength



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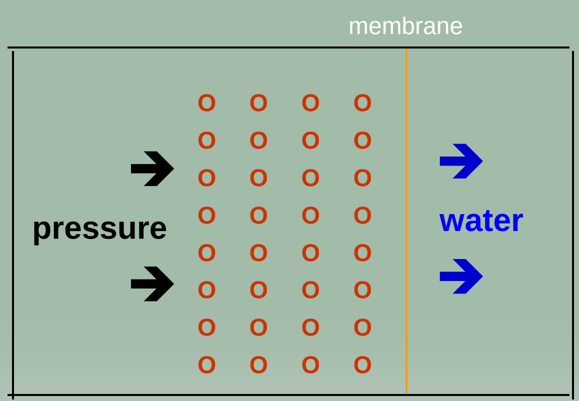
Reverse osmosis

an industrial process



Pressure is applied to reverse the natural flow

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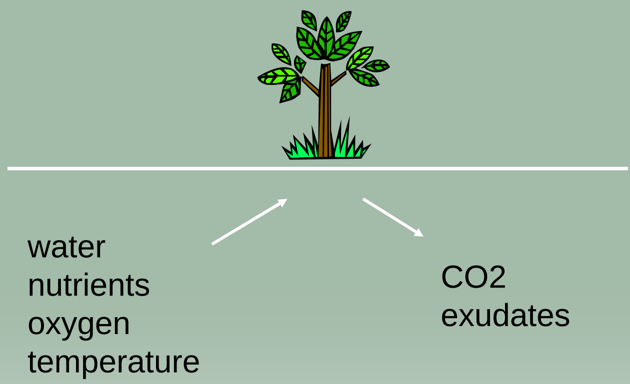
Other root influences



Root temperature is important

- Roots perform well over the range 20 to 25 C.
- Lower root temperatures slow plant growth. Below 15 C plant growth virtually stops.
- Root temperatures sustained at 30 C can result in root damage and disease attack.
- Root temperatures sustained at 35 C usually result in plant death.

Root exudates

- Roots exude a huge range of natural chemicals, plus some charged ions.
- These are mainly organic (carbon based) chemicals.
- These organic chemicals are not charged, and hence do not register on an EC meter.
- If not reduced, they can continue to build up with time.

Root aeration is vital

- The roots take in oxygen.
- The plant uses energy by ‘burning’ sugars, and exudes carbon dioxide (CO2) This is Respiration, which continues over the whole 24 hours.
- The growing medium must allow access of oxygen, and allow removal of CO2.
- Poor aeration results in root death.

Void space

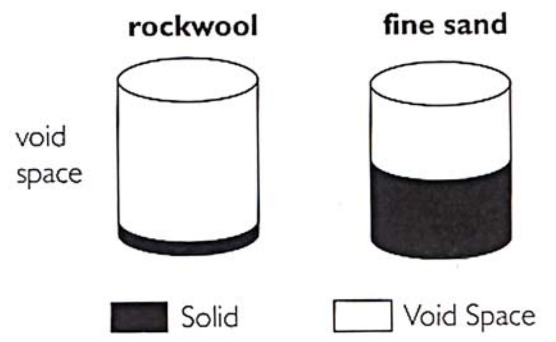


Fig 1. *Void space rockwool v. fine sand*

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Air / water characteristics

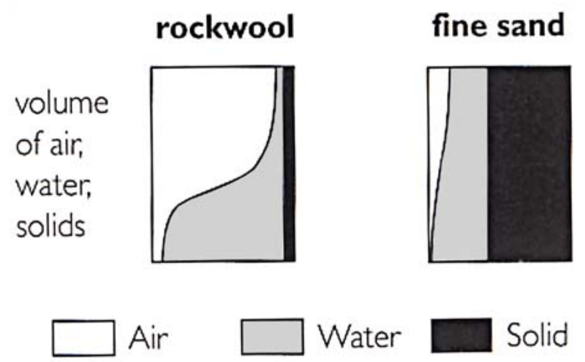

Fig 2. *Air/Water profile with height - rockwool v. fine sand*

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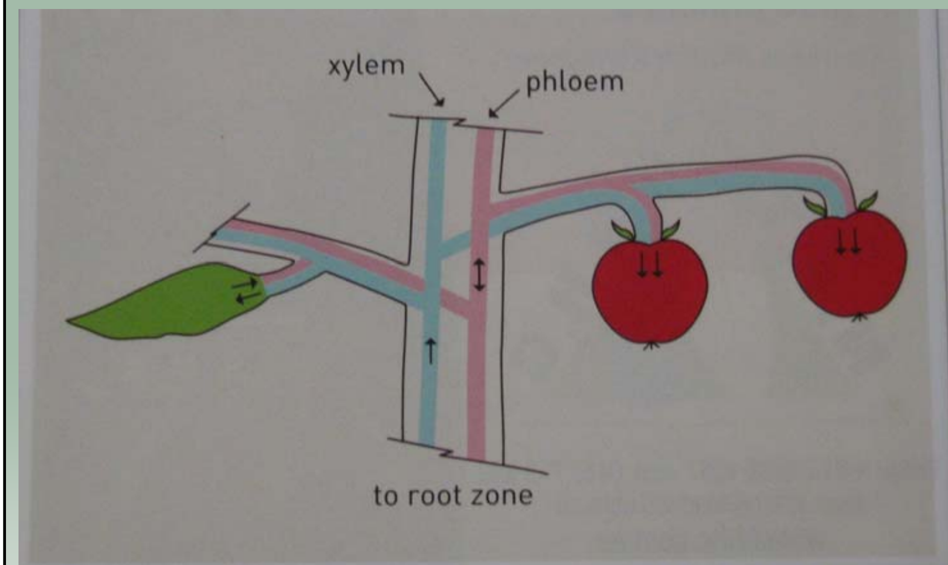
Solution flows within a plant

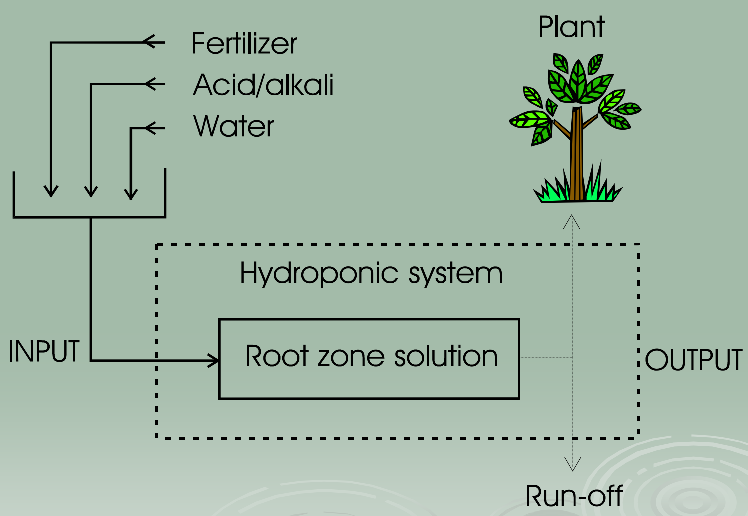


System requirements

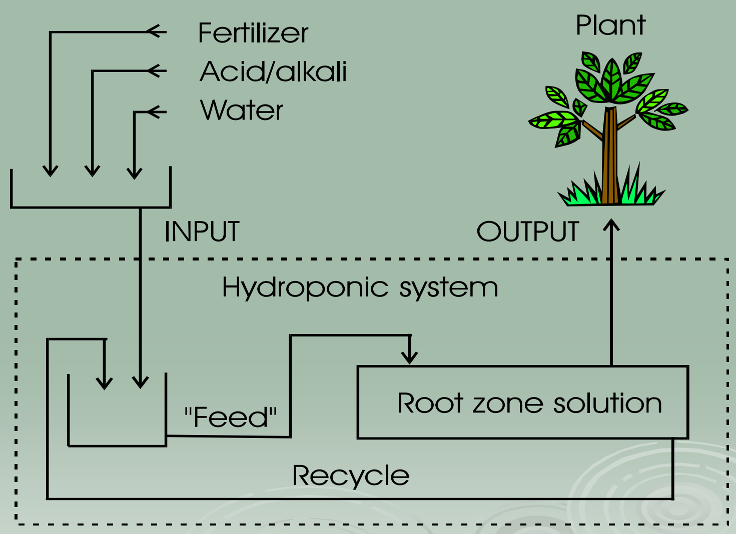
The system must provide the plant roots with:

- Adequate water.
- Adequate oxygen.
- Adequate balanced nutrients.
- Sufficient void space for the mature plant roots.

Flow diagram – “open” (free drainage) system



Flow diagram – “closed” (recycling) system



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Closed and open systems

- Closed systems give easier control of :-

  - watering,
  - pH (acidity) of root zone solution
  - EC (electrical conductivity) of root zone solution

- Closed systems are vulnerable to spread of disease
  - may need to disinfect the recycle stream

- Open systems give easier control of:-
  - nutrient balance of root zone solution
  - less vulnerable to the spread of disease

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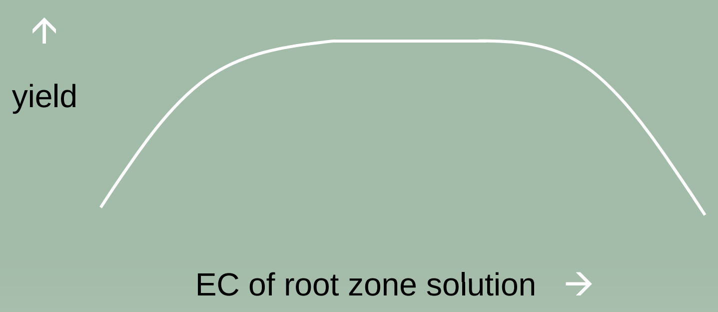
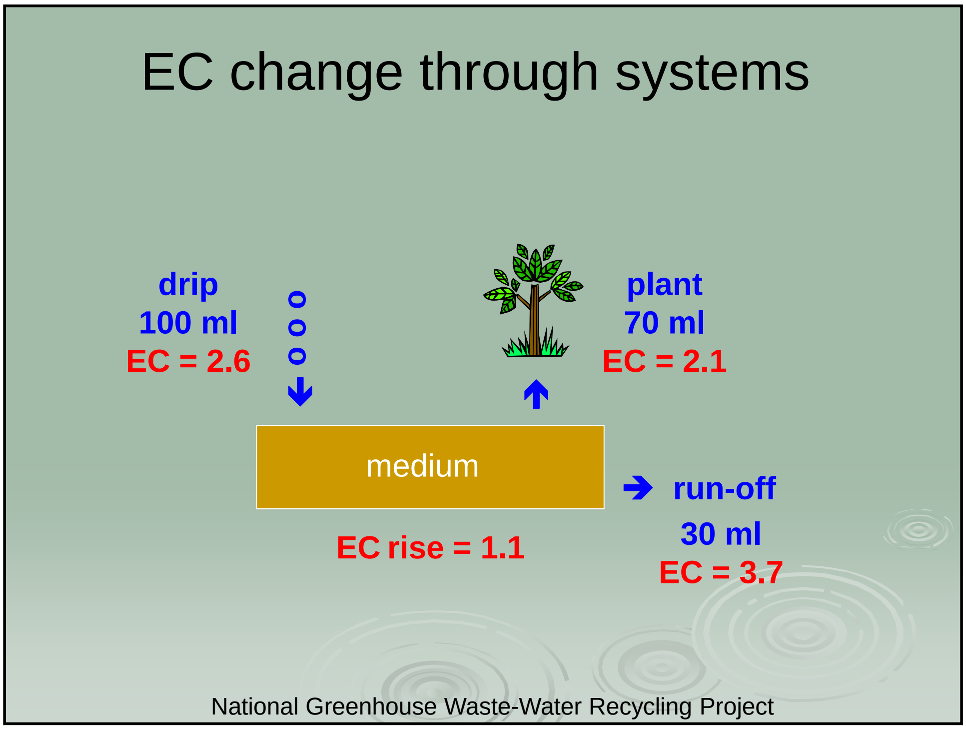
Raw water

- Adequate and reliable quantity.
- Freedom from pathogens.
  - Sterilization.
- Dissolved solids.
  - Reverse osmosis

Effect of EC upon yield




EC change through systems
drip
100 ml
EC = 2.6
plant
70 ml
EC = 2.1
medium
run-off
30 ml
EC = 3.7
EC rise = 1.1
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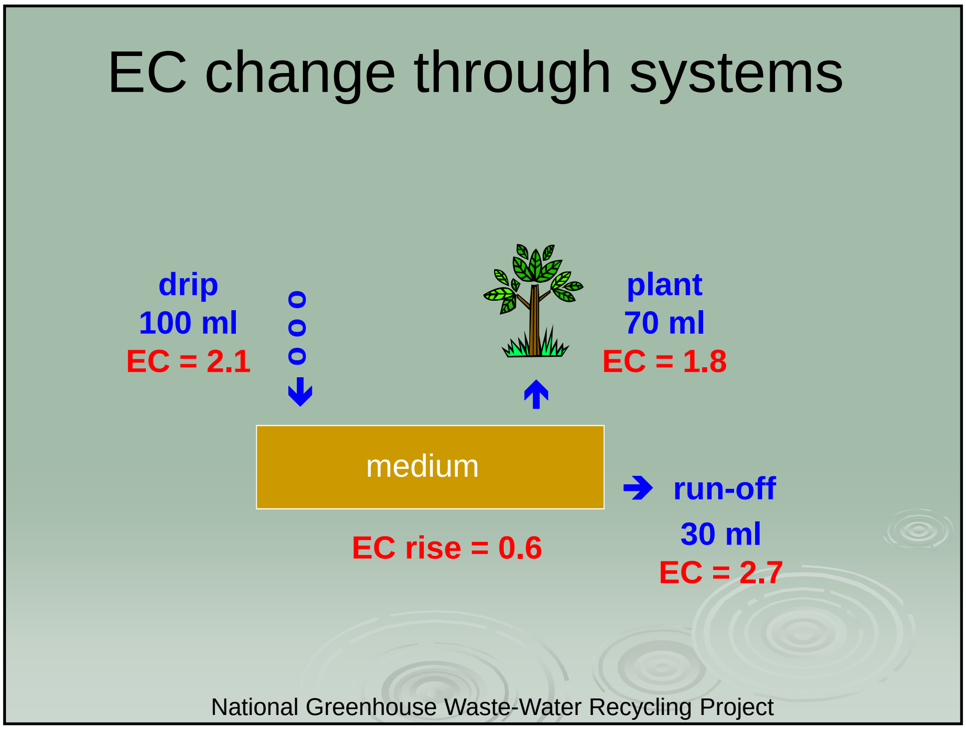
EC change through systems
drip
100 ml
EC = 2.1
plant
70 ml
EC = 1.8
medium
run-off
30 ml
EC = 2.7
EC rise = 0.6
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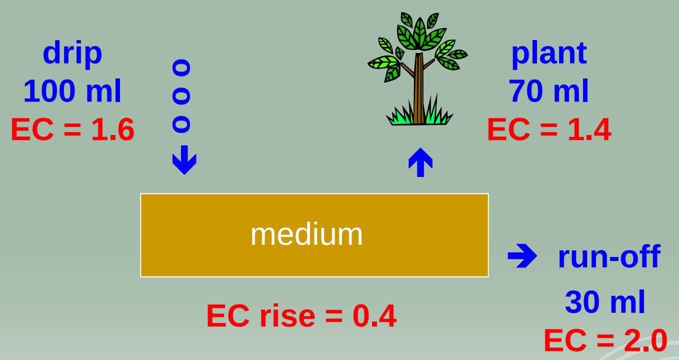
EC change through systems



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EC change through systems

	feed	run-off	EC rise	plant
volume	100 ml	30 ml		70 ml
I	2.6	3.7	1.1	2.1
II	2.1	2.7	0.6	1.8
III	1.6	2.0	0.4	1.4

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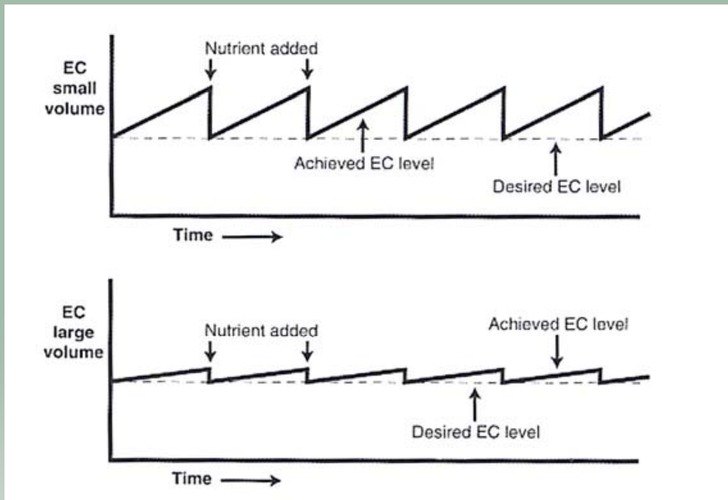
Effect of volume per plant



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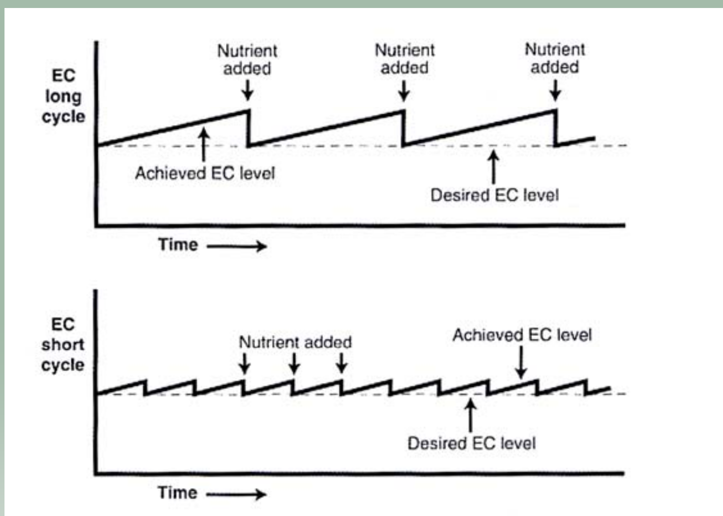
Effect of irrigation frequency



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Water management of media

- Done by irrigation management.
- Water content measurement.
- Irrigation initiation, frequency.
- Overnight it is best to have less water, more air. This is managed by irrigation stop and start times.

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Irrigation management

- Water uptake by roots responds to plant demand.
- Water uptake is mostly due to transpiration, the main driver of which is radiation.
- The plant uptake must be replaced.
- The irrigation system must be able to meet peak demand.

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Plant nutrition

continued

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Nutrition definitions

- Ions. Fertilisers dissolve in water to give a positive charged ion and a negative charged ion.
- Input. Nutrients added into a system from A & B fertilisers, plus acid/alkali, plus dissolved solids in the raw water.
- Root zone solution. The solution around the plant roots. The best estimate of this is usually the run-off solution.
- ppm. Parts per million. Measures the concentration of individual nutrients. Equivalent to milligram/litre mg/l.

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Macronutrients (major nutrients)

nutrient	ion	range - ppm
nitrogen	NO3- & NH4+	70 - 300
potassium	K+	150 - 500
magnesium	Mg++	15 - 80
phosphorus	H2PO4-	15 - 80
calcium	Ca++	70 - 250
sulphur	SO4--	20 - 250

Micronutrients (trace elements)

nutrient	ion	range - ppm
iron	Fe++ (chelate)	0.8 - 6
zinc	Zn++	0.1 – 0.6
manganese	Mn++	0.5 – 2.0
boron	B4O7--	0.1 – 0.6
copper	Cu++	0.05 – 1.0
molybdenum	MoO4--	0.05 – 0.15

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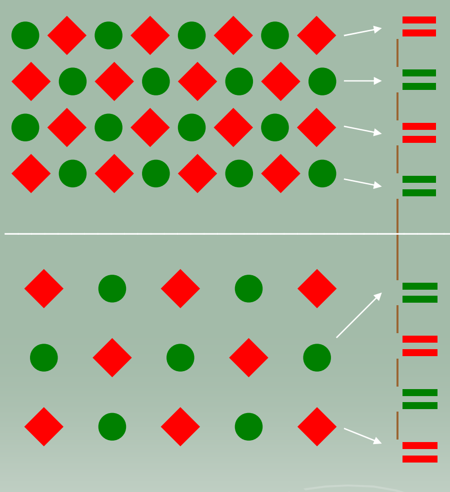
Root uptake mechanisms
Nutrients

- The mechanism is mostly active.
- Specific nutrient ions move through ‘channels’ in root cell walls.
- Uptake responds to plant demand.
- The stronger the nutrient solution - the higher the nutrient uptake.
- The ratio of individual ions is more important than their actual concentration.

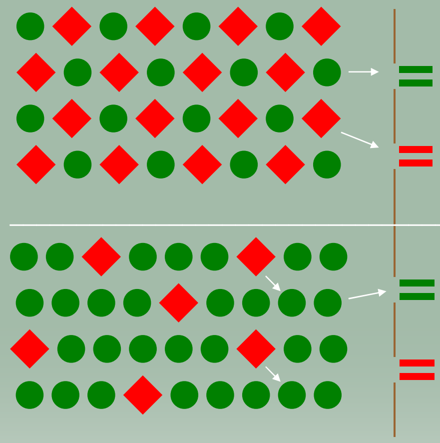
Nutrient uptake - concentration



Higher concentration
=
higher nutrient uptake

Lower concentration
=
lower nutrient uptake

Nutrient uptake - balance



Nutrient solution
in balance
= balanced
nutrient uptake

Nutrient solution
out of balance
= low uptake of ◆
= deficiency of ◆

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Movement of nutrients
through the plant

- The strongest demand is at the growing point.
- If a ‘mobile’ nutrient is deficient it can move to the top, so the older leaves show the deficiency symptoms.
- If a ‘fixed’ nutrient is deficient it can’t move to the top, so the youngest leaves show the deficiency symptoms.

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Mobile & fixed nutrients

mobile	fixed	variable
nitrogen	calcium	sulphur
phosphorus	manganese	copper
potassium	boron	zinc
magnesium	iron	molybdenum
chloride		

Movement of calcium
through the plant

- Calcium is a ‘fixed’ nutrient, so the youngest leaves and fruit show the deficiency symptoms.
- Calcium only moves with the water, so if this slows or stops (low transpiration), the developing leaves and fruit can’t get enough calcium.
- In capsicum, the result is blossom end rot.
- In lettuce, the result is tip-burn.
- These symptoms take about 2 weeks to show up.

Nutrient deficiency symptoms
mobile nutrient (older leaves)

Phosphorus deficiency in cucumber.

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Nutrient deficiency symptoms
fixed nutrient (young leaves)

Iron deficiency in capsicum.

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Nutrient deficiency symptoms
fixed nutrient

Blossom end rot in capsicum.

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Nutrient deficiency symptoms
fixed nutrient

Tip-burn in lettuce

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Management strategy

- Manage the root zone solution.
- Analyse the run-off daily for pH and EC.
- Measure the volume per cent of the run-off daily.
- Get regular nutrient analysis of the run-off.
- Record all results. Keep a diary .
- Look for trends and adjust 'softly, softly'.

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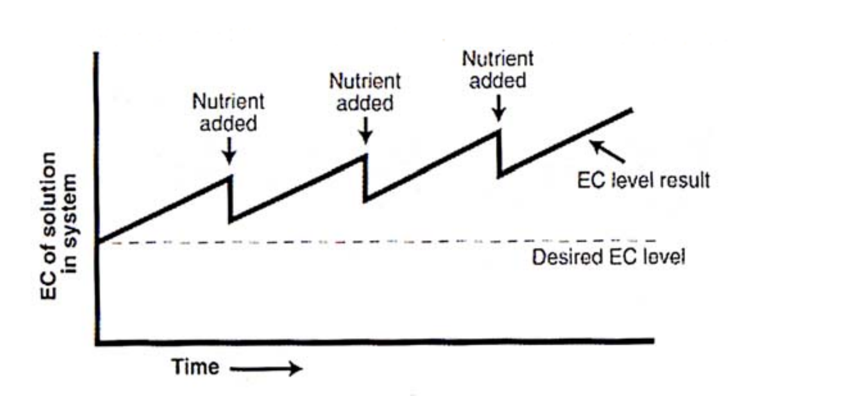
Possible result of not checking the root zone solution



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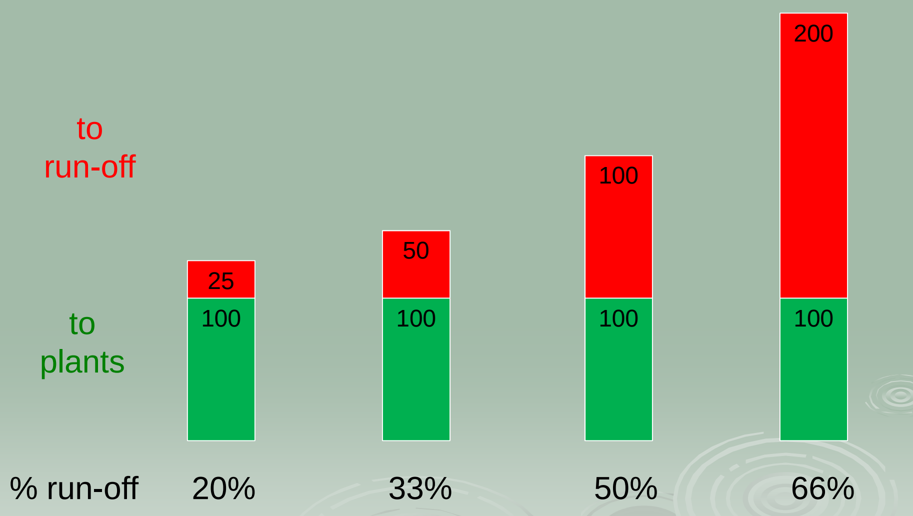
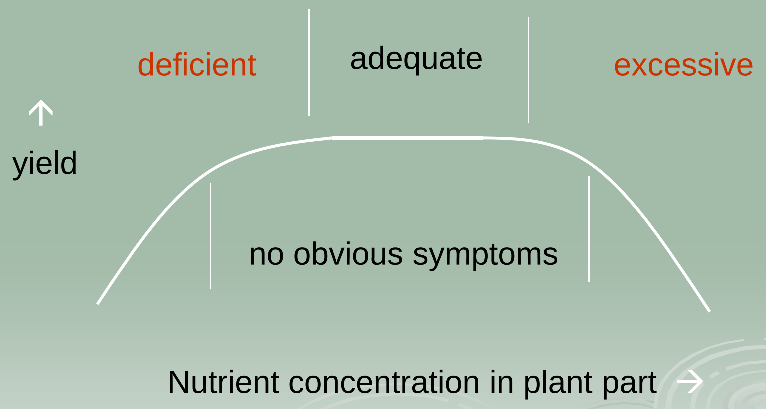
How much run-off ?



Basic nutrient management

- Control the root zone solution (keep constant). The best guide is the run-off solution.
- In balancing nutrients, it is their ratios which is important, rather than just absolute values.
- The nutrient balance of the run-off solution will always be different to the fertiliser (input) solution.
- Adjust the A and B fertilisers (input) gently to correct trends and allow for expected future changes.

Nutrient concentrations in plants



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Relative ease of nutrient uptake

Rate of uptake	Nutrient
Extremely fast	ammonium (NH_4^-)
Very fast	phosphorus ($H_2PO_4^-$)
Fast	potassium (K^+)
Moderate	nitrate (NO_3^-)
Slow	calcium (Ca^{++}), magnesium (Mg^{++}), sulphur (SO_4^{--})

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Difference between fertiliser and root zone solutions

- The optimum root zone balance is set to assist nutrient uptake into the plant.
- This stays constant throughout the life of the crop.
- To keep in balance, the A and B fertiliser (input) balance must be equal to the plant uptake.
- This can change through the stages of growth of the crop.

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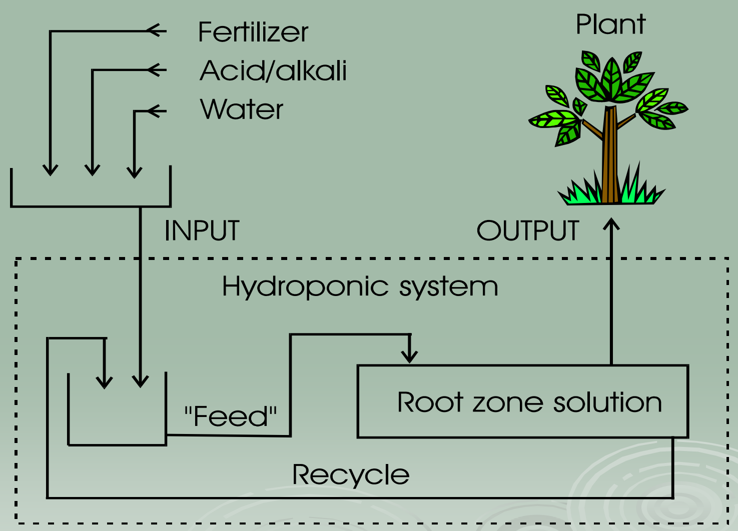
Flow diagram – "closed" (recycling) system



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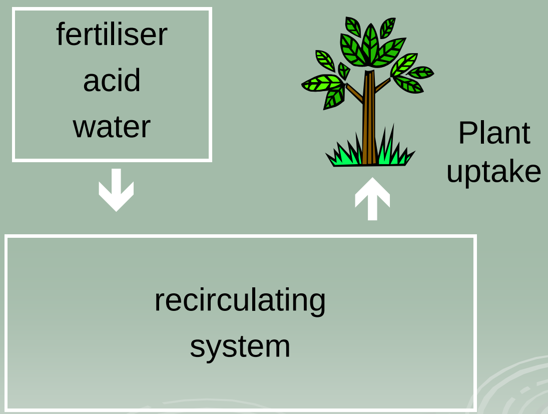
Input must equal plant uptake (to keep recycling solution steady)



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Difference between input and root zone solutions - example

- Compare the input and root zone solutions for closed (recycle) systems.
- As an example use the Dutch nutrient solution guidelines for cucumbers in rockwool.
- All units in ppm.

Adapted from Sonneveld & Straver, “Nutrient solutions for vegetables & flowers grown in water or substrates”, Praktijkonderzoek Plant & Omgerving, Naaldwijk, the Netherlands.

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Comparing solution analyses

nutrient	symbol	input	root zone
calcium	Ca	110	261
magnesium	Mg	24	73
sulphur	SO4 as S	32	112
nitrate	NO3 as N	165	252
potassium	K	254	313
phosphorus	H2PO4 as P	39	28
ammonium	NH4 as N	14	< 7

EC **1.8** **3.0**

Need to be at the same strength for comparison

Comparing solution analyses

nutrient	symbol	input	converted input
calcium	Ca	110	181
magnesium	Mg	24	42
sulphur	SO4 as S	32	53
nitrate	NO3 as N	165	271
potassium	K	254	417
phosphorus	H2PO4 as P	39	64
ammonium	NH4 as N	14	23

To compare - multiply individual inputs by 3.0 / 1.8

National Greenhouse Waste-Water Recycling Project

Comparing solution analyses

nutrient	symbol	converted input	root zone
calcium	Ca	181	261
magnesium	Mg	42	73
sulphur	SO4 as S	53	112
nitrate	NO3 as N	270	252
potassium	K	417	313
phosphorus	H2PO4 as P	64	28
ammonium	NH4 as N	23	< 7

Comparison is OK, because they are at the same strength

Influences on nutrient balance

- Raw water quality:
  - Hard water
  - Iron
  - Sodium chloride (salt)
- Acid / alkali addition for pH control
- Ammonium for pH control

Sensitivity to sodium chloride

Very sensitive	Sensitive	Tolerant
bean	cucumber	tomato
anthurium	capsicum	spinach
cymbidium	egg plant	endive
	lettuce	carnation
	gerbera	chrysanthemum
	alstroemeria	gypsophila
	rose	freesia

Adapted from Sonnevels, de Kreij, van der Wees, “Normen voor waterkwaliteit in de glastuinbouw”, Praktijkonderzoek Plant & Omgerving, Naaldwijk, the Netherlands.

Ammonium for pH control

↗ ↘

NO_3^- OH^-

pH drift – pH rises

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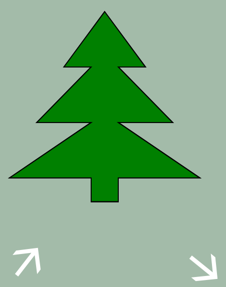
Ammonium for pH control

Add
ammonium
ion to feed



NH_4^+ H$^+$

pH reverses drift – pH falls

Basis for corrective action

- Only adjust ammonium to control pH
- Take care with phosphate.
- Modify your make-up solution depending upon how far from standard is the root zone solution analysis.
- For severe cases you may need to check with tissue analysis.

Making up fertilisers

- Use the percentages on the fertiliser label when doing calculations.
- It is rare that calculations come out exactly.
Check that your compromise is sensible and not merely the last item calculated.
- If using concentrates, they must be separated as at least two parts , “A” and “B”.
- Take care handling all fertilisers, but especially acids and alkalis.

Start-up solutions

- Use this when first filling a hydroponic system.
- The start up solution is simply the root zone solution recommended for that crop.
- Thereafter use a suitable make-up solution.
- Published make-up solutions are only a base to start working from, and should be adjusted to match the plant uptake.

Nutrient management background

- Keep nutrition in perspective.
- Control the root zone solution.
- Allow for your raw water quality.
- Take care with pH control.

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Practical Management

- Manage the root zone solution.
- Analyse the run-off daily for pH and EC.
- Measure the volume per cent of the run-off daily.
- Get regular nutrient analysis of the run-off.
- Record all results. Keep a diary.
- Look for trends and adjust ‘softly, softly’.

National Greenhouse Waste-Water Recycling Project

Conversion to Closed Hydroponic Greenhouse Systems

Facilitated by

GRAEME SMITH CONSULTING

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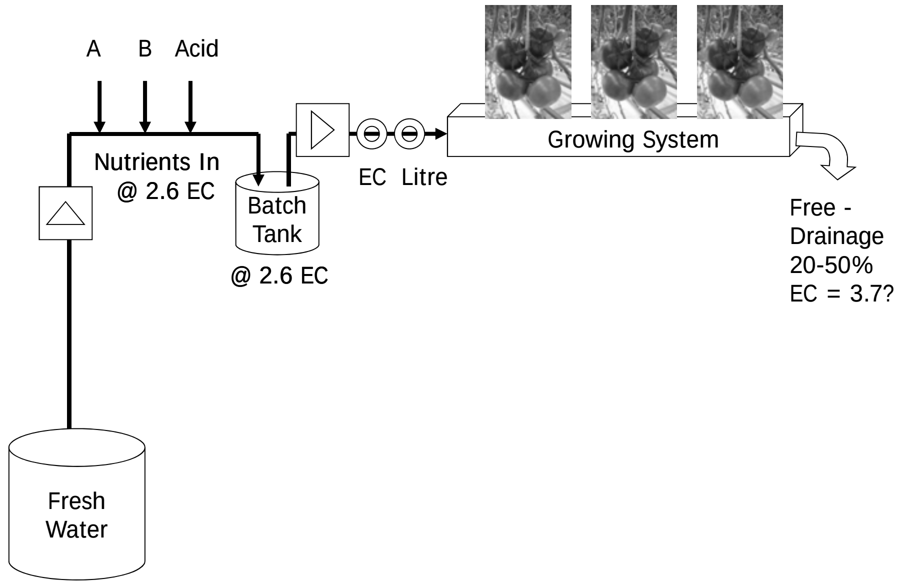
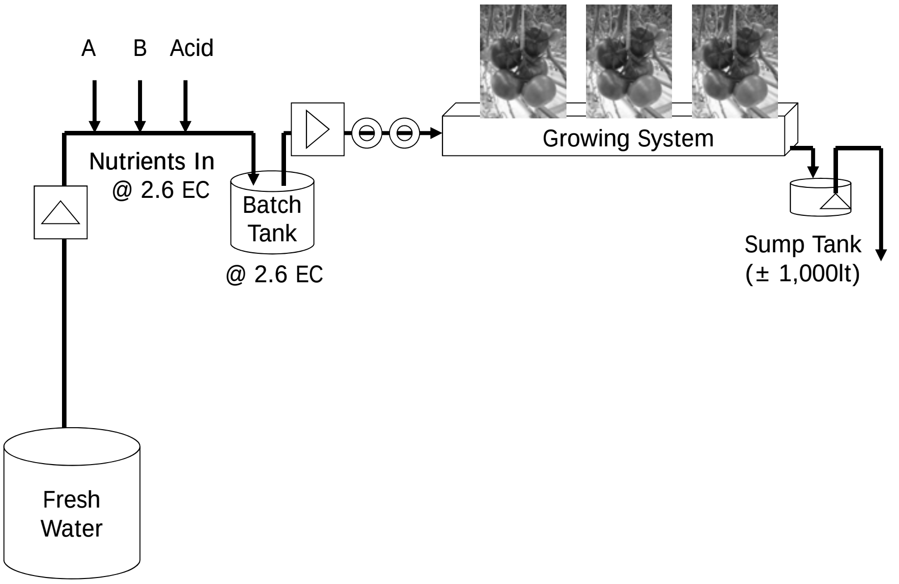
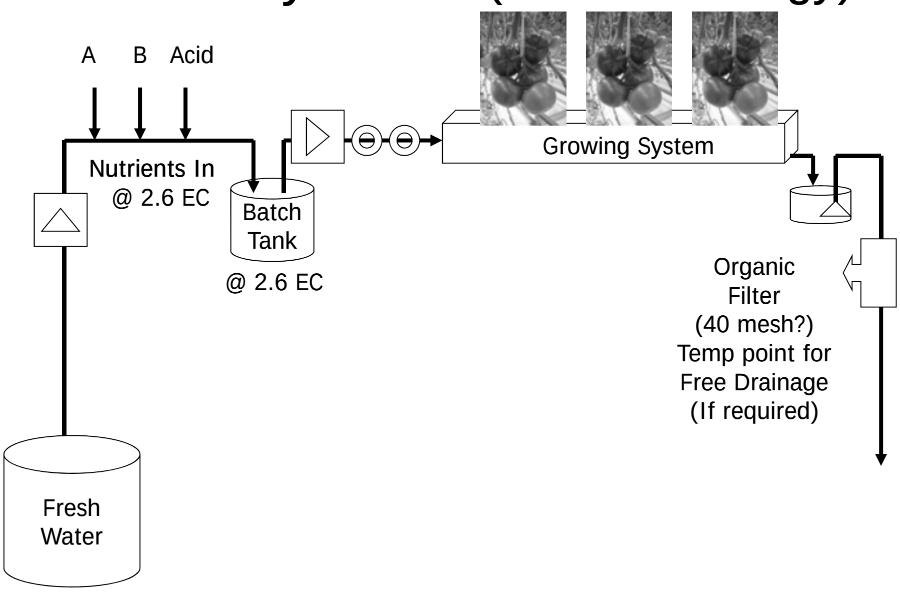
OPEN System – (old technology)



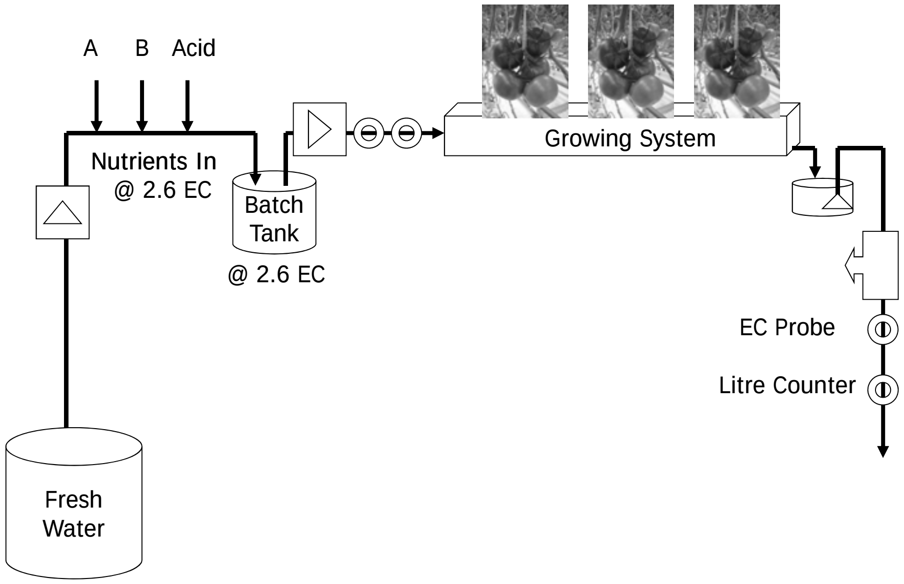
CLOSED System – (new technology)



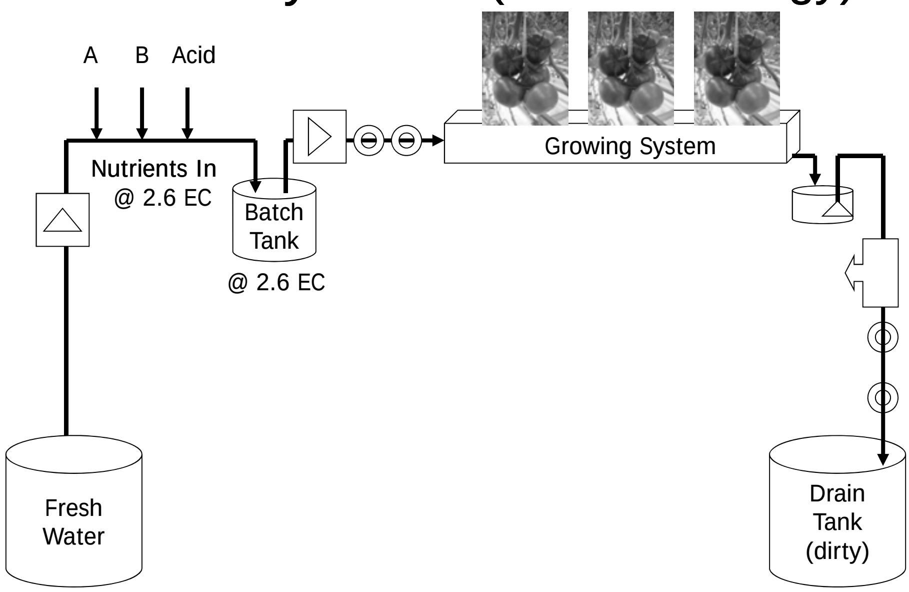
CLOSED System – (new technology)



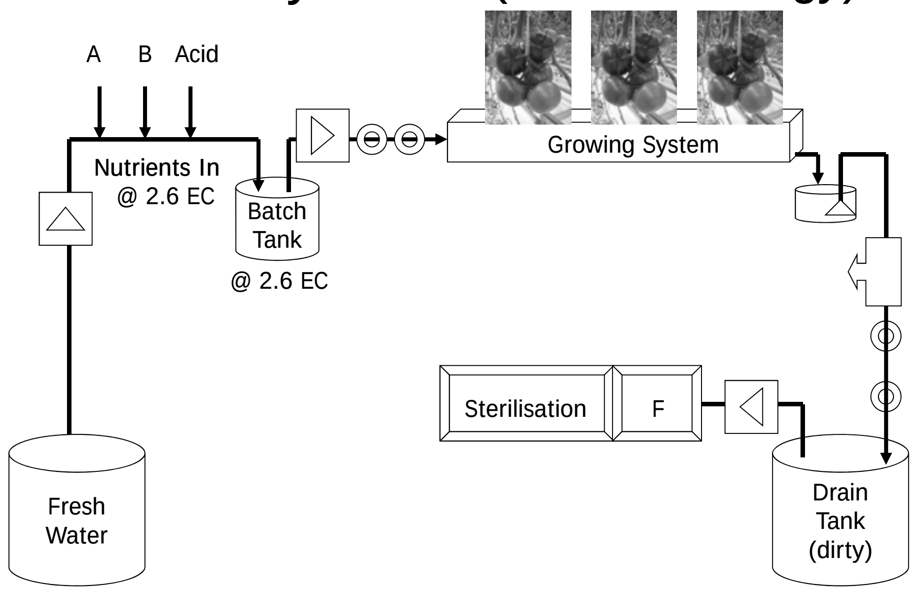
CLOSED System – (new technology)



CLOSED System – (new technology)



CLOSED System – (new technology)



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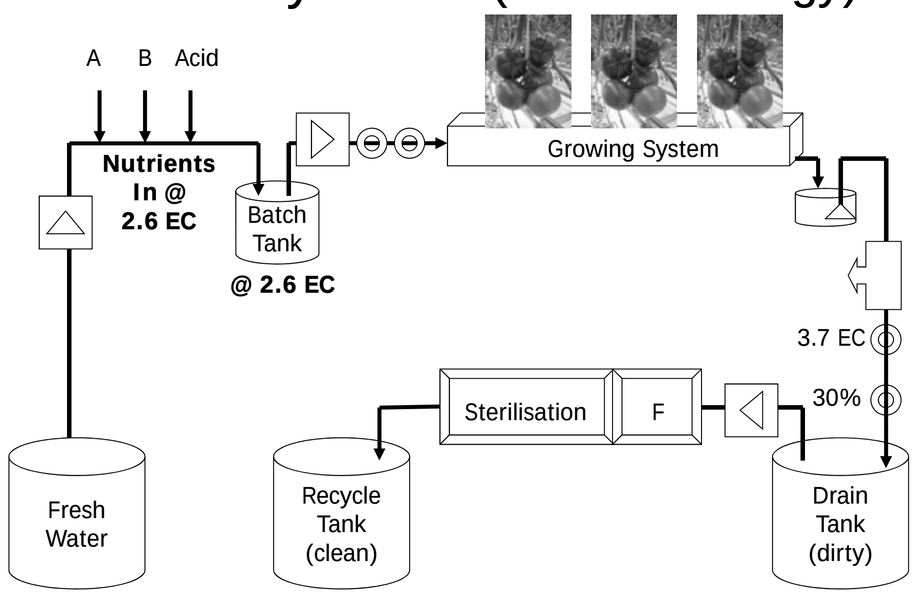
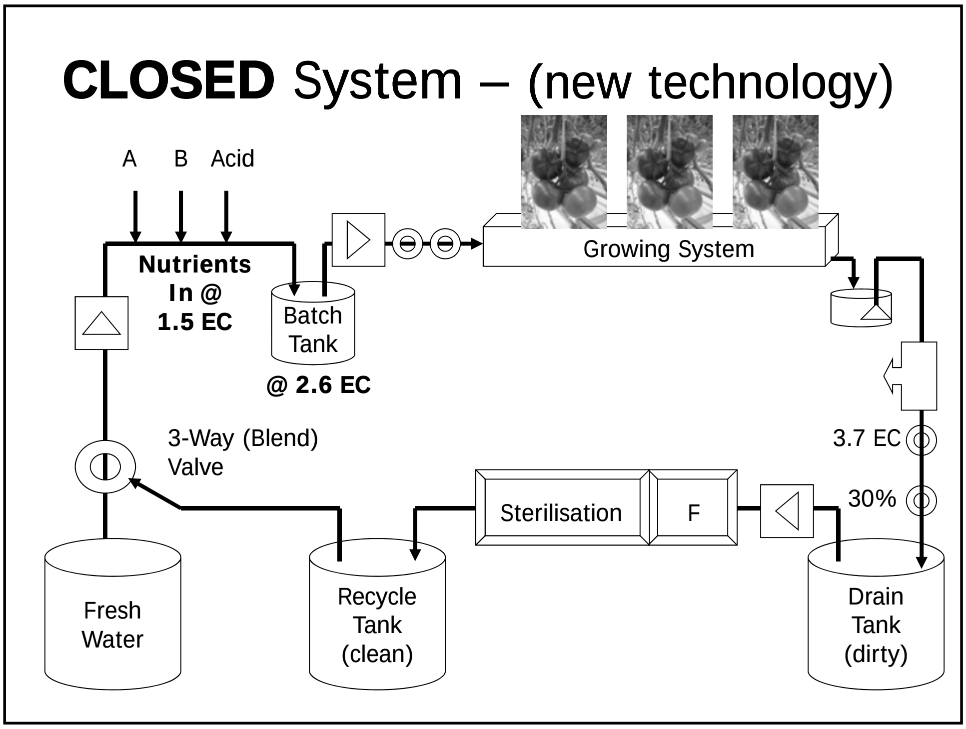
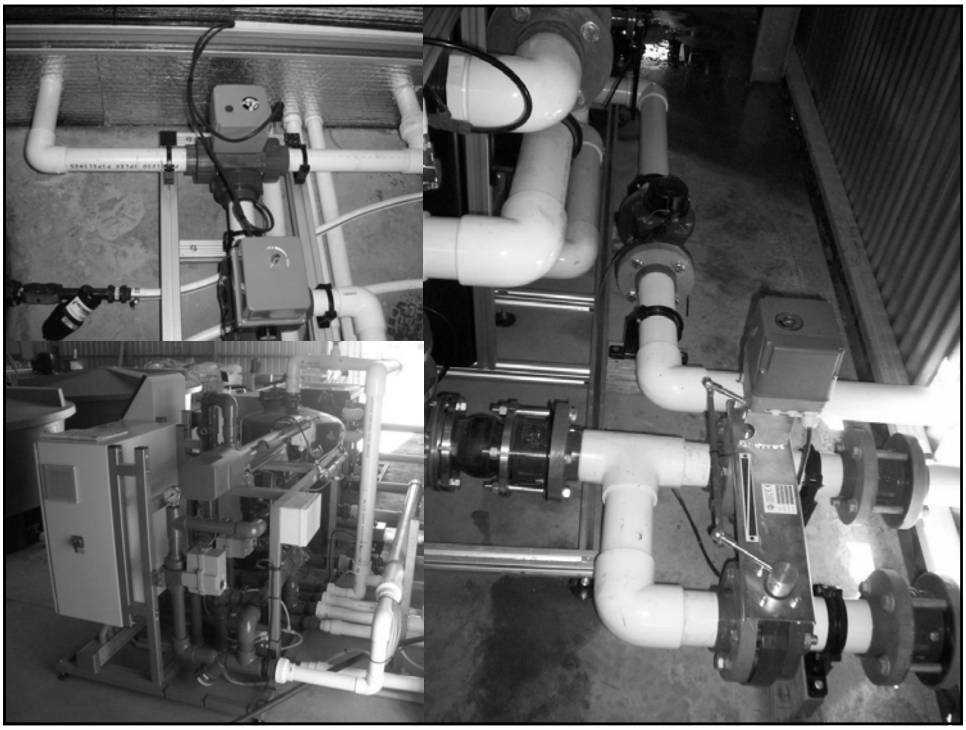
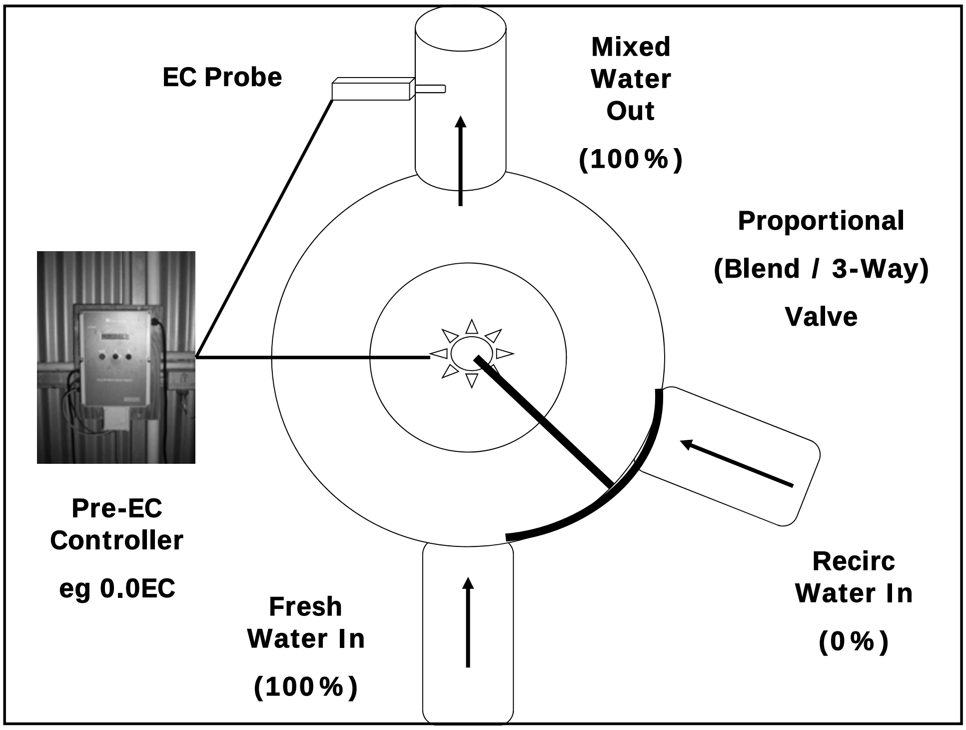
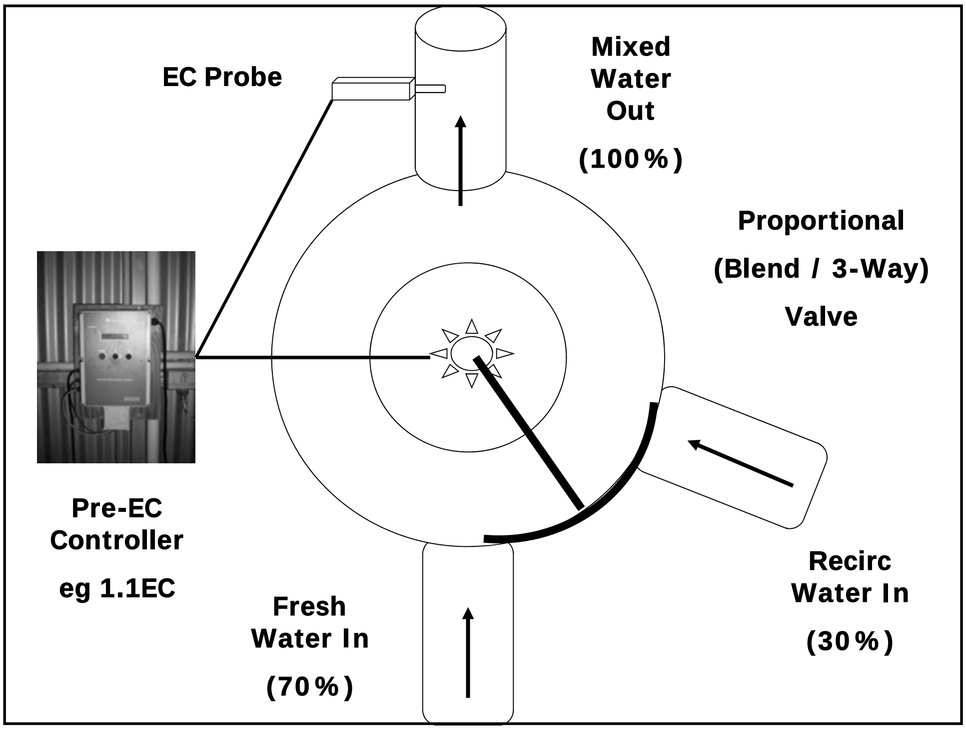



CLOSED System – (new technology)
A
B
Acid
Nutrients In @ 1.5 EC
Batch Tank
@ 2.6 EC
Growing System
3-Way (Blend) Valve
3.7 EC
30%
Sterilisation
F
Fresh Water
Recycle Tank (clean)
Drain Tank (dirty)

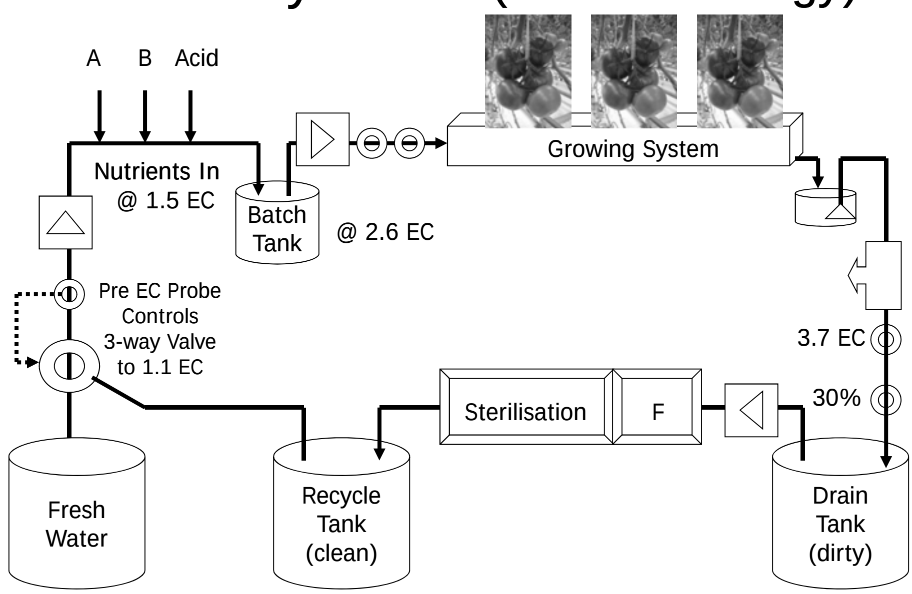



NutriDose II
EC pH Blend
1.52 14.00 00%
Autogrow Systems
MADE IN NEW ZEALAND
Run-Off Recirculation System
MODE
Powerplants
MINIGROW
www.powerplants.com.au
POWERPLANTS
BACK
ADJUST


EC Probe
Mixed
Water
Out
(100%)
Proportional
(Blend / 3-Way)
Valve
Pre-EC
Controller
eg 0.0EC
Fresh
Water In
(100%)
Recirc
Water In
(0%)



CLOSED System – (new technology)



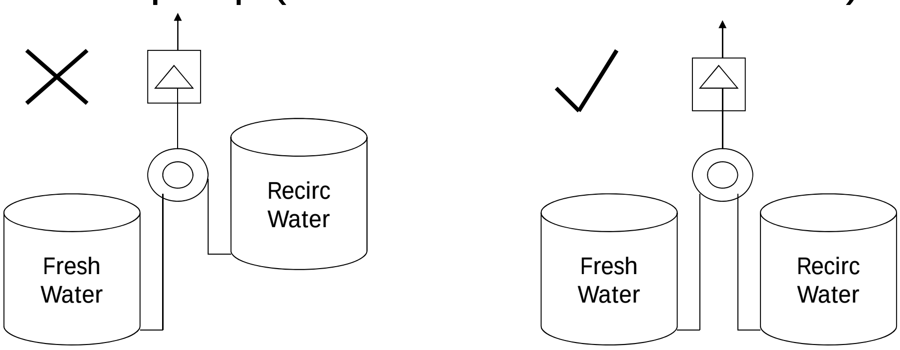
Basic Design Principles for Closed Systems

- Drain & Recirc Tanks to hold ± 2 days recirc water
- Tank Calculation Example:
  greenhouse m2 x light sum in Joules (brightest day) x 3 / 1,000
  (e.g. 4,000 x 3,200 x 3 / 1,000 = 38,400lt)

  (n.b allows for 50% drain over 2 days)

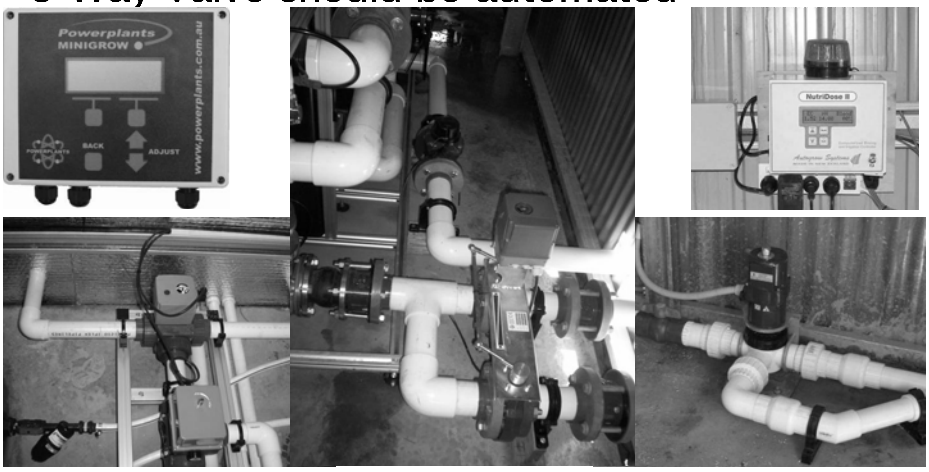
Basic Design Principles for Closed Systems

- Recirc & Fresh-Water Tanks same ground & water level to present same water pressure & flow to pump (or fit non-return/check valves)



Basic Design Principles for Closed Systems

- 3-Way Valve should be automated



Basic Management Principles for Closed Systems

- Different Pre-EC set-points for different crops

Typical Reference Figures:

Crop	Pre EC		Dose EC		Drip EC	Drain EC
Tomatoes	1.0	+	1.6	=	2.6	3.7
Capsicums	0.5	+	1.6	=	2.1	2.7
Cucumbers	0.5	+	1.7	=	2.2	2.7
Eggplant	0.4	+	1.7	=	2.1	2.7
Strawberry	1.0	+	0.7	=	1.7	2.0

- Calculated Pre-EC level:
  = drain EC x 24hr runoff %
  (eg. 3.7 x 30% = 1.1EC)

Basic Management Principles for Closed Systems

- Feed recipes vary from Free-Drainage systems

e.g. Open	N	P	K	Ca	Mg	S
(ppm)	224	47	371	217	58	141

Closed	N	P	K	Ca	Mg	S
(ppm)	151	39	254	110	24	48

- However root-zone targets remain the same

e.g.	N	P	K	Ca	Mg	S
(ppm)	322	31	313	401	109	218

Basic Management Principles for Closed Systems

- Drain analysis frequency, 1 month after planting, then every 2 - 3 weeks in summer and every 3 – 4 in winter
(to keep system stable and balanced)

- Minimum Water Quality for Closed Systems:

EC	=	< 0.5 (may be higher based on elemental load)
Na	=	< 35ppm
CL	=	< 35ppm
HCO_3	=	20 – 80ppm (bicarbonates)

Basic Management Principles for Closed Systems (cont……)

- Same principles apply if nutrient batching or direct injection
- Run disinfection system at night when system is stable
- Allow bypass at organic filter for temporary free-drainage (and first week or two to discharge any waste material)
- Fit one-way (check) valves to stop any backflow or syphoning
- All fittings to be PVC, Poly or Stainless Steel (inc pump impellors) to avoid corrosion or contamination of water
- Minimum pre-filtration for all sterilising systems ±40µm

Basic Management Principles for Closed Systems (cont……)

- Drain analysis always from the drain tank (however allow for recycle tank losses following sterilisation treatment)
- Nutrient/water mixing always on low-pressure (suction) side of pump.
- Ideally all drain water captured in pipe systems and kept isolated from the ground (to avoid cross-contamination)
- Perform dripper audit to ensure system/numbers are correct
- Adaption recipes for a maximum of two weeks to avoid over-correction

Rain Water Harvesting

- Greenhouse roofs capture rainwater that can be stored for irrigation/fogging use
- 1mm rain per m2 = 1 litre
  e.g. 700mm x 4,000m2 = 2,800,000 litres
- 7.2M/L irrigation water / 4,000m2
  2.8 / 7.2 = 39% water saving (Free Drain)
  2.8 / 3.6 = 78% water saving (50% recirc)
- Assumes annual rainfall, all water captured and stored, no leakage or evaporation

Thank You.

Questions?

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National Greenhouse Waste-Water Recycling Project

Maintenance Program for Closed Hydroponics Systems

General notes:

- Sensors checked regularly for calibration and proper location
- Irrigation & fertigation systems checked to ensure even & reliable delivery of nutrients and water
- Nutrient samples periodically analysed to protect crop nutrition
- Regular monitoring of drip & drain EC, pH & water volume
- Routine maintenance (drippers, filters, meters, gauges, etc)

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Maintenance Program for Closed Hydroponics Systems

Portable EC & pH meters

- 2 most fundamental items in greenhouse systems
- Keeps grower informed of both crop and equipment performance
- Spots early any developing problems or drift in conditions
- Daily checks prove irrigation strategy
- Regularly calibrate with standard solutions
- Store well to maintain good condition

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Maintenance Program for Closed Hydroponics Systems

DRIP

•Setup monitoring vessel (jar, bottle, etc) to capture 1 spare dripper per irrigation valve

•Important to ensure dripper spike is at the same level as all the other spikes in the row

•Measure and record EC, pH and volume at same time **daily** (look for variations in results between drippers indicating irrigation control problems, etc)

•Empty vessels after recording and restore to normal ready for the next 24hours.

•Compare readings with computer set-points or crop targets to ensure readings are as expected.

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Maintenance Program for Closed Hydroponics Systems

DRAIN

•Setup test stations (minimum 1 per 1,000m2) to capture (or measure) all run-off over 24 hours

•Best to capture entire greenhouse drain for most reliable results, however 1 complete row will also provide good averages (smaller number of plants will assist, but are less reliable)

•If unable to capture entire 24hr volume, target from 11am – 3.30pm only! (period of highest radiation levels)

•Do not select outside rows or under gutters, etc. (Select representative sample row only)

National Greenhouse Waste-Water Recycling Project

Maintenance Program for Closed Hydroponics Systems

DRAIN

•Measure and record EC, pH and volume at same time daily

•Use drip & drain volume figures to calculate % run-off

•Monitor first drain times (target around 10 – 11.00am daily). If early or late, adjust irrigation start times &/or volume in 1st period to compensate.

•Compare readings with crop targets to ensure readings are as expected.

•If EC is high, flush out excess salts the following day only during middle period

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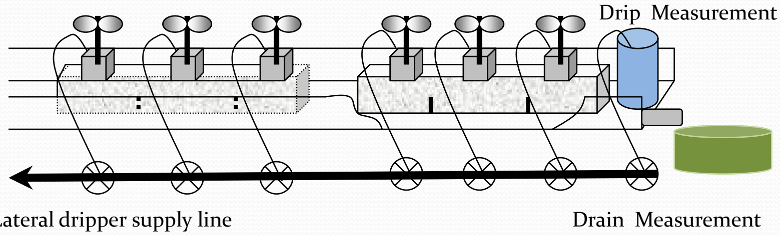
Maintenance Program for Closed Hydroponics Systems

Floor Channel or Hanging Gutter System



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Maintenance Program for Closed Hydroponics Systems

Date	EC Drip	Volume Drip	EC Drain	Volume Drain	% Runoff	pH Drip	pH Drain	'A' Tank Depth	'B' Tank Depth
12th Mar	2.55	100	3.85	33	33%	5.5	6.1	600	600
13th	2.60	99	3.95	30	30%	5.5	6.1	585 (15)	586 (14)
14th	2.60	100	4.00	28	28%	5.6	6.0	559 (26)	562 (24) – adjust
15th	2.58	101	3.85	39	39%	5.7	5.9	539 (20)	542 (20)
16th	2.58	100	3.80	33	33%	5.6	6.0	515 (24)	518 (24)

Sample measurement testing schedule

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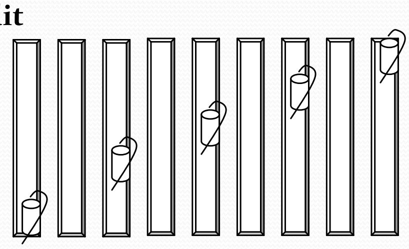
Maintenance Program for Closed Hydroponics Systems

Dripper Audit



- Select drippers diagonally across an irrigation zone
- Place drippers in small cup and initiate 2 x irrigations (for better average)
- Ensure all cups are within 5% or each other

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Maintenance Program for Closed Hydroponics Systems

Dripper Pressure

- Pressure compensated drippers avoid uneven output and siphoning
- Ensure pump is sized to irrigation load per valve
- Ensure correct sizing in mains and lateral irrigation lines
- Rule of thumb! (minimum pressures)

Irrigation pump supply pressure –	3 Bar (300kpa)
Irrigation zone valve pressure -	2 Bar (200kpa)
Most distant dripper in zone -	1 Bar (100kpa)
(Micro-tube	0.5 Bar (50kpa)

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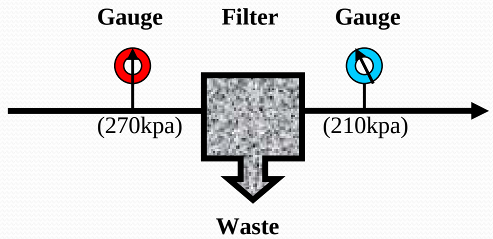
Maintenance Program for Closed Hydroponics Systems

Filter Maintenance



- Correct filtration ensure system has minimal maintenance and prevents blockages
- Pre & Post pressure gauges keeps flushing to a minimum and saves water
- Clean when difference of 0.5 Bar (50kpa) between gauges

Important to use suitable tools to ensure optimum root-zone conditions at all times (monitor & record Drip & Drain EC, pH, Volume, Water Content and Runoff % DAILY!)

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Maintenance Program for Closed Hydroponics Systems

Nutrient Drain Reference Standard Analysis

•Vital to adjust lab sample EC to a reference standard

•e.g. Lab drain sample EC = 2.3 mS/cm
reference standard EC = 3.0 mS/cm
divide reference standard / lab sample (3.0 / 2.3 = 1.3)

•Multiply all elements (ions) by conversion factor (1.3)

•e.g. N = 255 x 1.3 = 332ppm, P = 50 x 1.3 = 65, etc for all elements

•Now a direct comparison can be made to a guideline to see if the feed solution needs adjusting

•Important to be realistic and not try for too much precision

•Concentrate on trends rather than absolute values

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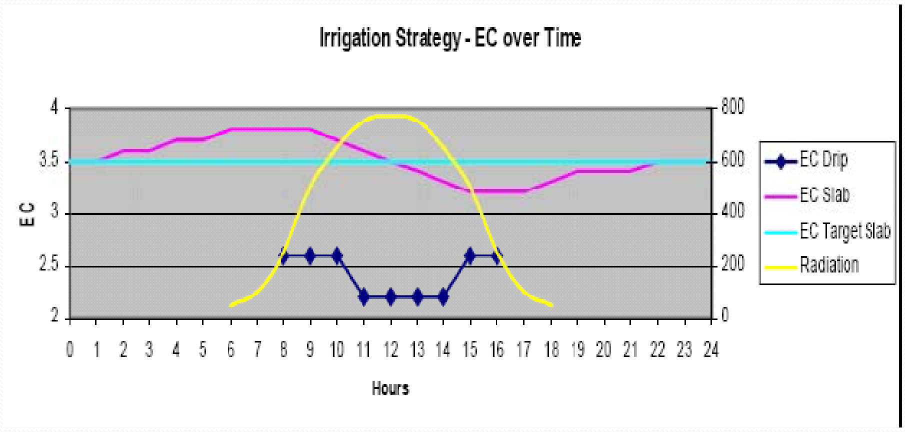
Maintenance Program for Closed Hydroponics Systems



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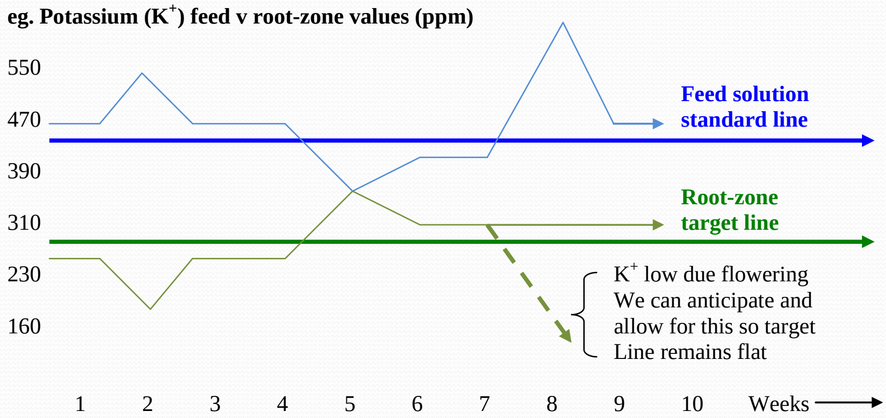
Maintenance Program for Closed Hydroponics Systems

eg. Potassium (K^+) feed v root-zone values (ppm)



National Greenhouse Waste-Water Recycling Project

Grower	Date	Source	N	NH4	P	K	Ca	Mg	S	Fe	Mn	Zn	B	Cu	Mo	HCO3	Na
Graphics	16-Dec-08	G/H 2 Drain	315	0	45	435	337	134	309	1.49	0.12	1.49	1.00	0.10	0.03		317

© Graeme Smith Consulting **NUTRIENT DRAIN REFERENCE STANDARD ANALYSIS (TOMATOES)**

ION	N	NH4N	Total N	P	K	Ca	Mg	S	EC	pH
Lab Result	315	0	315	45	435	337	134	309	4.81	6.2
Root-Zone Target	328	< 7	328	61	482	374	122	283	3.70	5.2 - 7.2
Corrected	242		242	35	335	259	103	238		
Range Low	238		238	22	254	321	66	128		
Range High	392		392	62	391	481	158	289		

	Fe	Mn	B	Cu	Zn	Mo	Na	Cl	HCO3
Lab Result	1.49	0.12	1.00	0.10	1.49	0.03	317	164	0
Root-Zone Target	1.28	0.12	0.98	0.13	1.11	sign			20 - 80
Corrected	1.15	0.09	0.77	0.08	1.15	0.02	244	126	0
Range Low	1.01	0.16	0.38	0.03	0.33	sign			
Range High	1.96	0.55	0.70	0.10	0.65	sign			

Nutrient Source: G/H 2 Drain
Test Date: 16/12/08

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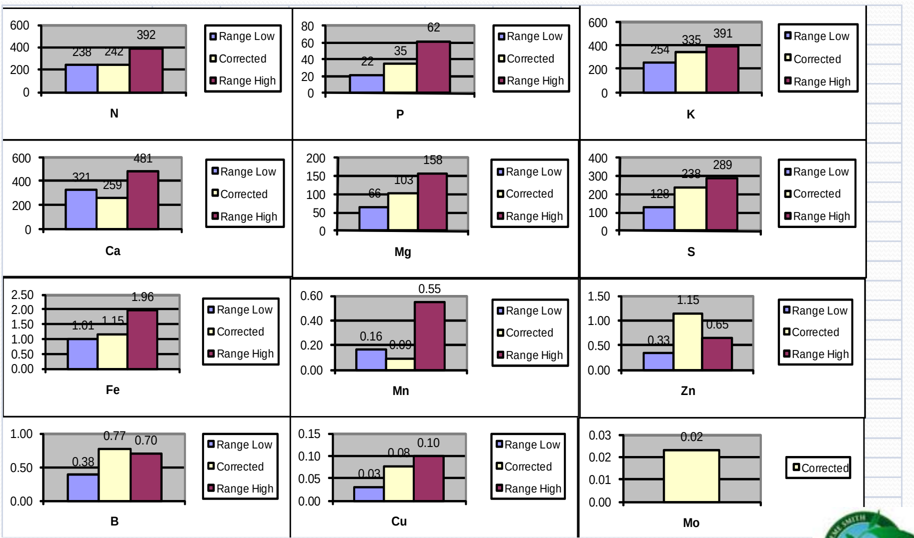


National Greenhouse Waste-Water Recycling Project

Maintenance Program for Closed Hydroponics Systems

Laboratory Drain Analysis Sampling

- Growing medium sampling difficult due to distribution patterns
- Can use syringe but minimum 40 samples required
- Commonly some difference between growing medium and drain water, but close enough for guidelines
- Most importantly it will be consistent!
- Collect samples late morning following first drainage

National Greenhouse Waste-Water Recycling Project

Maintenance Program for Closed Hydroponics Systems

Laboratory Drain Analysis Sampling

- Minimum sample size 150ml (preferably dark containers)
- Mark containers (name, time, date, location, type, etc)
- Send samples via express post to laboratory
- If you keep a 2nd sample, it can be used to check your meters
- Expect sample results in maximum 3 days (via fax or email, etc)
- Begin sampling 1 month after planting, then every 2-3 weeks in summer & 3 – 4 weeks winter, finish after topping crop.

National Greenhouse Waste-Water Recycling Project

Maintenance Program for Closed Hydroponics Systems

Soil & Plant Analysis Laboratory

CSBP

72510
Lexmez Pty Ltd

ANALYSIS REPORT

	Lab No	100077	100078
	Name	HSE 1 DRAIN	HSE 4 DRAIN
	Code	24/01/10	24/01/10
	Customer	LEXMEZ	LEXMEZ
Ammonium Nitrogen	mg/L	0.74	0.95
Nitrate Nitrogen	mg/L	292.04	262.28
Boron	mg/L	0.54	0.57
Calcium	mg/L	378.00	363.60
Chloride	mg/L	170.00	158.10
Copper	mg/L	0.10	0.09
Iron	mg/L	2.00	1.79
Magnesium	mg/L	136.40	92.00
Manganese	mg/L	0.29	0.19
Phosphorous	mg/L	58.00	57.80
Potassium	mg/L	382.60	331.80
Sodium	mg/L	129.30	139.60
Sulphur	mg/L	200.60	204.20
Zinc	mg/L	0.49	0.51
Conductivity	dS/m	4.000	4.160
pH		5.61	5.83

appendix h.

Waste water recycling

Water sterilisation
- options and costings

by Rick Donnan

Growool Horticultural Systems Pty Ltd

Converting to recirculation

Savings estimates

The values of savings quoted here are based on general figures.

Individual farm savings depend upon the crop being grown, current usage, total percentage run-off, and solution strength, etc, and may differ from the quoted figures.

Annual water savings

Basis of calculated annual savings:

- Total water usage = 1,800 litre / m2.
- Save 40% = 750 litre / m2.
- Water cost = $1.00 / ‘000 litre
- Total saving = $0.75 / m2,
- or = $750 / ‘000 m2,

Annual fertiliser savings

Basis of calculated annual savings:

- Total fertiliser cost = $5.00 /m2.
- Save 60% = $3.00 /m2.
- Total saving = $3,000 /’000m2.

Converting to recirculation

Total annual savings

Total combined annual savings:

- per m2 = \$0.75 + \$3.00 = \$3.75 / m2.
- per '000 m2 = \$750 + \$3,000 = \$3,750 / '000m2.
- per hectare = \$7,500 + \$30,000 = \$37,500 / hectare.

Savings comparisons

typical greenhouse areas

Greenhouse areas used for comparisons

- 2,500 m2.
- 5,000 m2.
- 10,000 m2 = 1 hectare
- 50,000 m2 = 5 hectare

Annual savings comparisons

for typical greenhouse areas

Total savings (rounded) for typical greenhouse areas:

- 2,500 m2 = $9,500.
- 5,000 m2 = $19,000.
- 10,000 m2 = $37,500
- 50,000 m2 = $190,000

Converting to recirculation

Recycle volumes

Basis of calculated recycle flow rates:

- Maximum usage = 10 litre / m2 / day.
- Use 40% recycle = 4 litre / m2 / day.
- Sterilise this volume over 18 hours.

Recycle flow rates

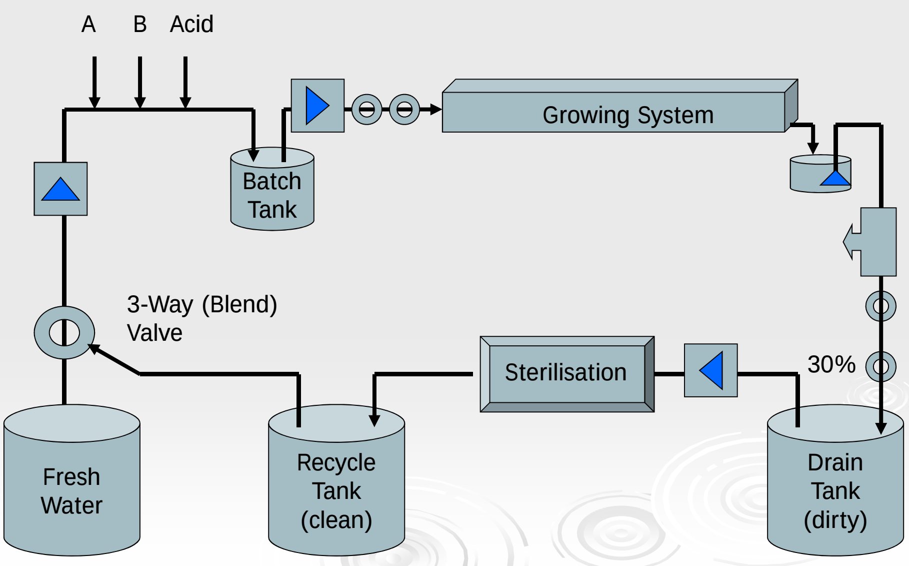
for typical greenhouse areas

Maximum flow averaged over 18 hours.

- 2,500 m2 = 550 litre/hour.
- 5,000 m2 = 1,100 litre/hour.
- 10,000 m2 = 2,200 litre/hour.
- 50,000 m2 = 11,000 litre/hour.

Waste Recovery - sterilisation

CLOSED System – (new technology)



Sterilisation (disinfection) choices

- Dutch “total kill”.
- Do you need to sterilise ? Beneficials.
- What is the risk if you don’t sterilise ?
- What is the risk if you install sterilisation equipment that only gives partial kill ?
- What is the cost if your crop fails ?
- What is the cost if you are fined by the EPA ?

Major costed sterilisation options

- Ultra violet (UV)
- Heat treatment.
- Chemical treatment – oxidising agents –
  - Ozone.
- Slow biological filtration.

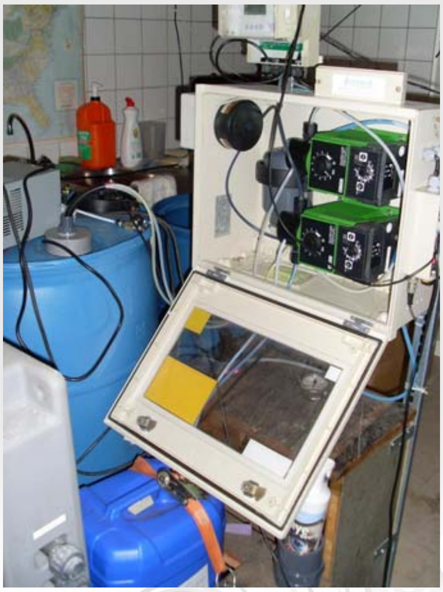
Other sterilisation options

- Chlorine dioxide
- Calcium hypochlorite
- Hydrogen peroxide
- Iodine

Sterilisation – chemicals (oxidising agents)

- Equipment costs are relatively low.
- They don't kill nematodes.
- Strengths high enough to guarantee to kill all pathogens, will also kill the plants.
- They damage roots as well as pathogens.
- Must be deactivated before feeding the plants.
- Low dosage may help prevent the spread of minor infection, but not heavier infection.
- Calcium hypochlorite is the cheapest, but is the most risky to manage.
- The other chemicals are relatively expensive to use.
- All these chemical are dangerous to people.

Chlorine dioxide equipment



Sterilisation equipment costing

- All costs do not include GST.
- All sterilisation equipment cost estimates are for capital cost only, and do not include installation or depreciation.
- Capital costs vary between manufacturers, suppliers and locations and can change significantly with time.
- Operating costs, especially electricity and gas, can also vary greatly.
- Therefore the capital and operating costs given should be taken as rough estimates only.
- If considering any equipment, you need to do your own detailed costing and not rely on these figures alone.

Sterilisation option costing

All systems include the following:

- A coarse organic filter (and bypass valve)
- 'Dirty' and 'clean' holding tanks.
- A good sand (zeolite) filter before the sterilising unit.
- A 3-way 'blend' valve and controller.
- Additional pumps and piping.
- All are treated at the 'strong' option.

UV equipment

UV equipment

Waste Recovery - sterilisation

Ultra violet (UV)

Pros (benefits)

- Intensity adjustable to suit what needs killing.
- Now proven and in common use in Holland.
- Can give complete kill.

Cons (disadvantages)

- Relatively high capital cost for effective units.
- Destroys iron Fe in treated solution.
- Good pre-filtration (clear solution) essential.
- Must clean the cell and check transmission.
- Low power machines don't kill everything.

Waste Recovery - sterilisation

Low power UV

- There is cheap UV equipment used to treat water
- These give a good kill in clean water using low intensity UV (typically under 40 mJ/cm2).
- The water they treat must have:
- 90 % transmission, low iron, low dissolved solids (TDS).
- Recycled run-off is far worse than this, with transmission typically 20 to 40%.
- To kill all plant pathogens, and especially viruses, needs intensities up to 250 mJ/vm2, not water sterilisers.
- To be effective, all UV equipment must have transmission from the lamp checked, to ensure it is performing properly.

Costs of UV treatment - 1

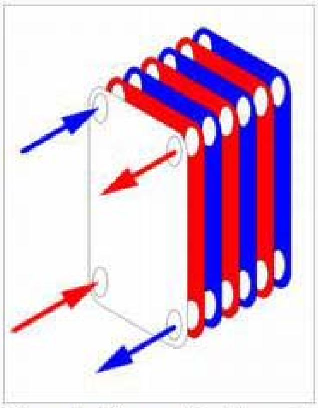
Greenhouse area	2,500 m2	5,000 m2
Installed unit	$30,000 est	$30,000 est
Tanks, etc	$11,000	$17,000
Maintenance pa	$1,000	$1,500
Electricity pa	$1,000	$1,500
Chemicals pa	?	?
Total running cost pa	$2,000	$3,000
Savings pa	$9,500	$19,000

Costs of UV treatment - 2

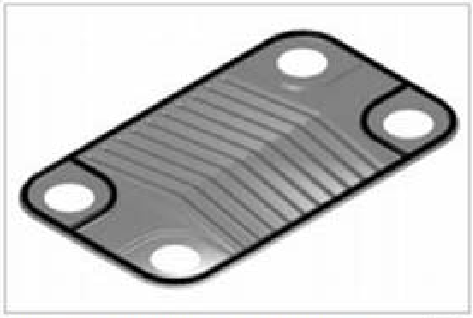
Greenhouse area	10,000 m2	50,000 m2
Installed unit	$60,000	$90,000
Tanks, etc	$30,000	$70,000
Maintenance pa	$3,000	$7,000
Electricity pa	$2,000	$5,000
Chemicals	?	?
Total running cost pa	$5,000	$12,000
Savings pa	$37,500	$190,000

Heat treatment equipment

counter-current heat exchanger



Conceptual diagram of a plate and frame heat exchanger.



A single plate heat exchanger

Heat treatment - basics

From
'dirty' tank
20 C

Counter-
current
heat
exchanger

92 C

97 C

Small
heater

25 C

To treated
tank

Needs either 30 seconds at 95 C, or 3 minutes at 83 C.

Heat treatment equipment

Heat treatment (pasteurisation)

Pros

- Now proven and in common use in Holland.
- Can give complete kill.
- Can use electricity, direct gas, or from boiler.

Cons

- Relatively high capital cost for effective units.
- Good pre-filtration (clear solution) essential.
- Difficult to get treated temperature low in summer.
- Better with pH 4 to prevent fouling.

Costs of heat treatment - 1

Greenhouse area	2,500 m2	5,000 m2
Installed unit	$40,000	$40,000
Tanks, etc	$11,000	$17,000
Maintenance pa	$600	$600
Electricity pa	$400	$700
Gas pa	$1,500	$3,000
Total running cost pa	$2,500	$4,300
Savings pa	$9,500	$19,000

Costs of heat treatment - 2

Greenhouse area	10,000 m2	50,000 m2
Installed unit	$50,000	$85,000
Tanks, etc	$30,000	$70,000
Maintenance pa	$1, 000	$2,000
Electricity pa	$1,200	$4,000
Gas pa	$5,000	$20,000
Total running cost pa	$7,200	$26,000
Savings pa	$37,500	$190,000

Ozone equipment

Ozone

Pros

- Only adds oxygen, no other elements added.
- Relatively low running cost.

Cons

- Doesn't kill nematodes.
- Works best at pH over 7, gives –
- Possible problems with iron, phosphorus, calcium.
- Must be deactivated before use.
- Overdosing causes plant death.
- Equipment must be handled safely.

Costs of ozone - 1

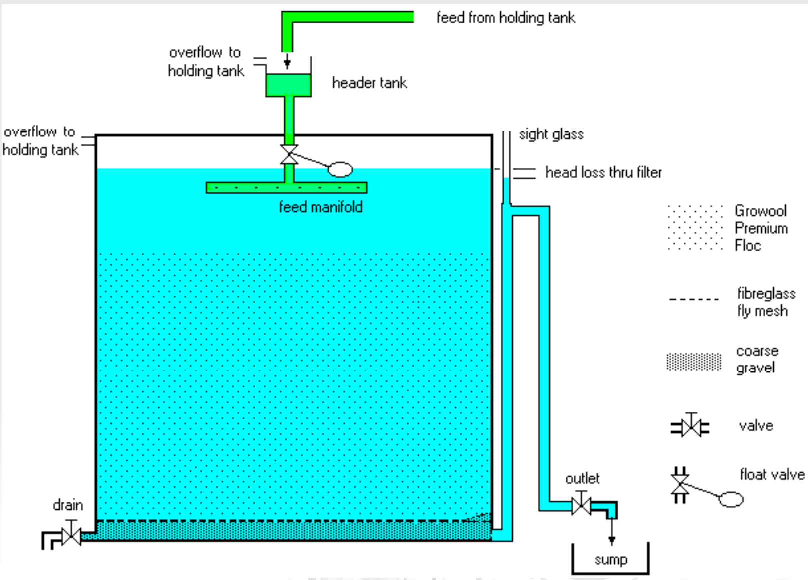
Greenhouse area	2,500 m2	5,000 m2
Installed unit	$10,000	$12,000
Tanks, etc	$11,000	$17,000
Maintenance pa	$300	$400
Electricity pa	$1,000	$1,500
Chemicals pa	?	?
Total running cost pa	$1,300	$1,900
Savings pa	$9,500	$19,000

Costs of ozone - 2

Greenhouse area	10,000 m2	50,000 m2
Installed unit	$16,000	$50,000
Tanks, etc	$30,000	$70,000
Maintenance pa	$500	$2,000
Electricity pa	$2,200	$9,000
Chemicals pa	?	?
Total running cost pa	$2,700	$11,000

Savings pa	$37,500	$190,000

Slow bio-filter



Slow bio-filter

Pros

- Flexible & simple to install and maintain.
- No chemicals involved.

Cons

- Won't kill nematodes or viruses.
- Takes up space.
- Top layer of medium needs replacing when choked.
- Must not use too high a flow rate.

Costs of slow bio-filter - 1

Greenhouse area	2,500 m2	5,000 m2
Installed unit	$5,000	$7,000
Tanks, etc	$11,000	$17,000
Maintenance pa	$100	$100
Electricity pa	$600	$800
Medium pa	$300	$500
Total running cost pa	$1, 000	$1,400

Savings pa	$9,500	$19,000

Costs of slow bio-filter - 2

Greenhouse area	10,000 m2	50,000 m2
Installed unit	$12,000	$53,000
Tanks, etc	$30,000	$70,000
Maintenance pa	$200	$300
Electricity pa	$1,200	$1,700
Medium pa	$1,200	$5,000
Total running cost pa	$2,600	$7,000

Savings pa	$37,500	$190,000

Comparisons for 2,500 m2

type	total capital	annual running cost	annual savings
UV	$41,000 est	2,000	$9,500
heat	$51,000	2,500	$9,500
ozone	$21,000	1,300	$9,500
Slow filter	$16,000	1,000	$9,500

Comparisons for 5,000 m2

type	total capital	annual running cost	annual savings
UV	$47,000	$3,000	$19,000
heat	$57,000	$4,300	$19,000
ozone	$29,000	$1,900	$19,000
slow filter	$24,000	$1,400	$19,000

Comparisons for 10,000 m2

type	total capital	annual running cost	annual savings
UV	$90,000	$5,000	$37,500
heat	$80,000	$7,200	$37,500
ozone	$46,000	$2,700	$37,500
Slow filter	$32,000	$2,600	$37,500

Comparisons for 5 hectare

type	total capital	annual running cost	annual savings
UV	$160,000	$12,000	$190,000
heat	$155,000	$26,000	$190,000
ozone	$120,000	$11,000	$190,000
Slow filter	$123,000	$7,000	$190,000

National Greenhouse Waste-Water Recycling Project

Haifast Nutrition Software (www.haifachem.com/)

Haifast.exe

Software Installation Steps:

1. Download 2 x Haifa files from above website (or copy both files from CD to desktop)
   (1st file: http://www.multifeedbigbag.nl/haifast/setuphf-3.0.0.exe)
   (2nd file: http://www.multifeedbigbag.nl/haifast/updatehf-3.0.0.exe)
2. Save both files to 'Desktop'
3. Run 1st setup file from 'Desktop' (double click)
4. Run 2nd update file from 'Desktop' (double click)
5. Run Haifast program on 'Desktop'

   Haifast.exe
6. Select Haifast logo (top left of screen)
7. Select 'English' and 'PPM', then 'Close'
8. Exit program
9. Again run Haifast program from 'Desktop'

   Haifast.exe
10. Select 'Miscellaneous' (top right of screen)
11. Select ' To Select Fertilisers', then 'Select All'
12. Select 'Update database'
13. Haifast Software is now ready to use! (navigation keys bottom right of screen!)
14. Print out entire 'Help' file to assist understanding of software (found in Miscellaneous)

n.b. Some anomalies currently exist in the program as follows:

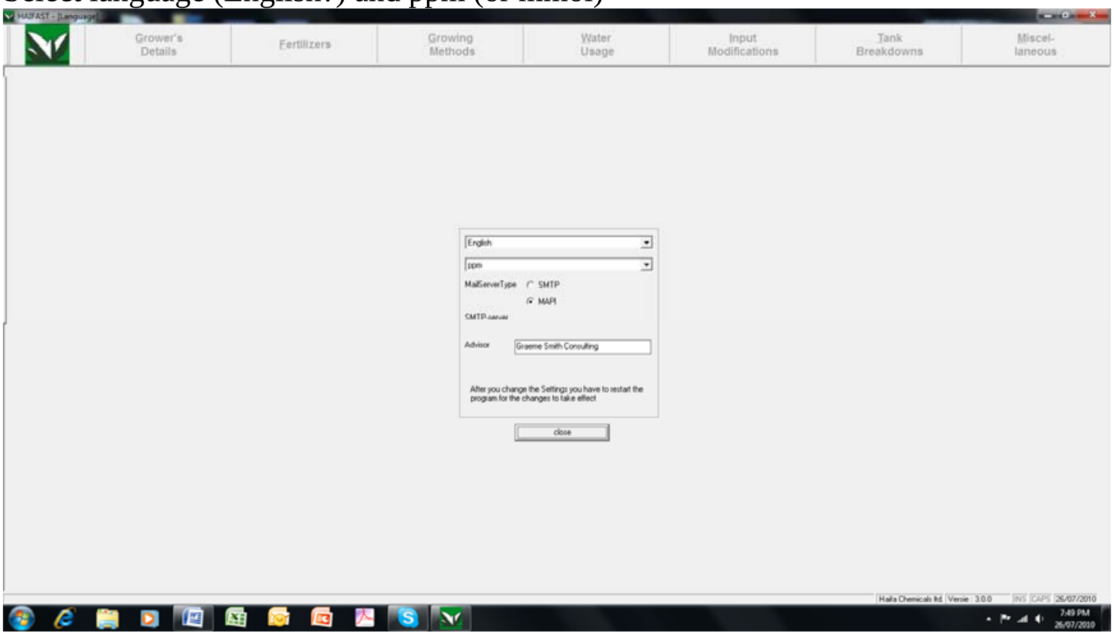
- Software calculates Nitrogen as NO3 and not pure N, therefore a conversion factor of 4.43 needs to be applied to convert. (multiply N x 4.43 to convert to N03)
- Same for Phosphorus, H2PO4 instead of P (multiply P x 3.13 to convert to H2PO4)
- Same for Sulphur, SO4 instead of S (multiply S x 3.0 to convert to SO4)
- Trace elements are shown as PPB in tables, not PPM (multiply x 1,000 to convert)
- There is no AU (Australia) choice in software
- A number of common Australian trace element fertilizers are missing
- Some text is in Dutch

We have requested these and other anomalies be rectified by the software developers at Haifa. (future updates on Haifast website as available)

Screenshot Examples of using Haifast Nutrition Software

(e.g. Recipe for ‘Lettuce in Recirculating Water’, to be inputted by growers)

Select language (English?) and ppm (or mmol)



Input recipe into ‘Additional Crops’ under ‘Miscellaneous’
n.b. positive & negative ions (cations and anions) must balance exactly before saving

	Number	Name
Crop	1	Lettuce (in recirculating water)

Standard nutrient solution

NH4	K	Ca	Mg	NO3	Cl	SO4	H2PO4	Si	Fe	Mn	Zn	B	Cu	Mo	EC
21.60	430.10	180.45	24.30	1,178.00	0.00	105.71	194.00	0.00	2,240.00	270.00	260.00	320.00	50.00	50.00	2.32

Kationen 23.20 Anionen 23.20

Former New Delete Next

Input grower contact details

Grower

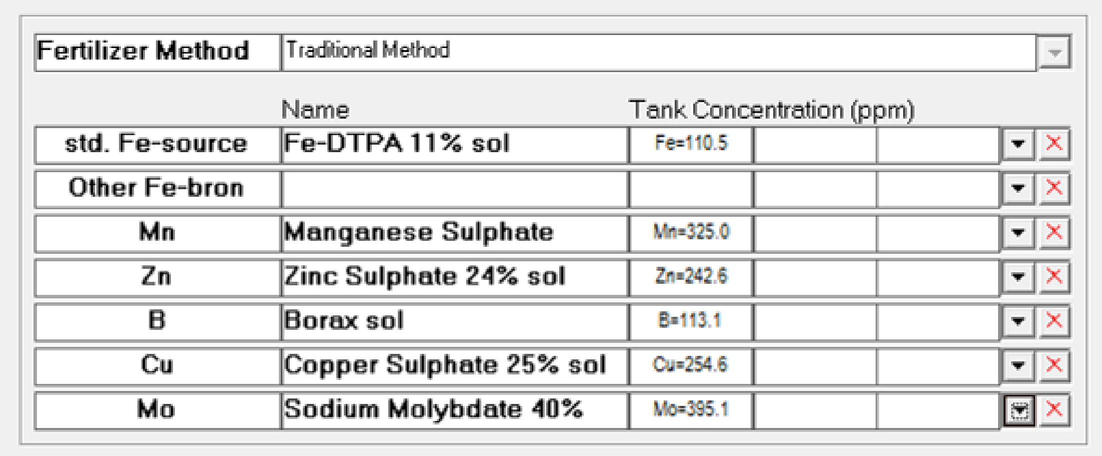
Reference No.	001	Country	GB
Name	Graeme Smith Consulting	Telephone No.	+613 5427 2143
Address	PO Box 789	Mobile	+61 (0)427 339 009
Postcode	3442	E-Mail	graeme@graemesmithconsulting.com
City	Woodend Victoria	Fax Number	+613 5427 3843

Select your fertilizers (macro elements)

Fertilizer Method Traditional Method

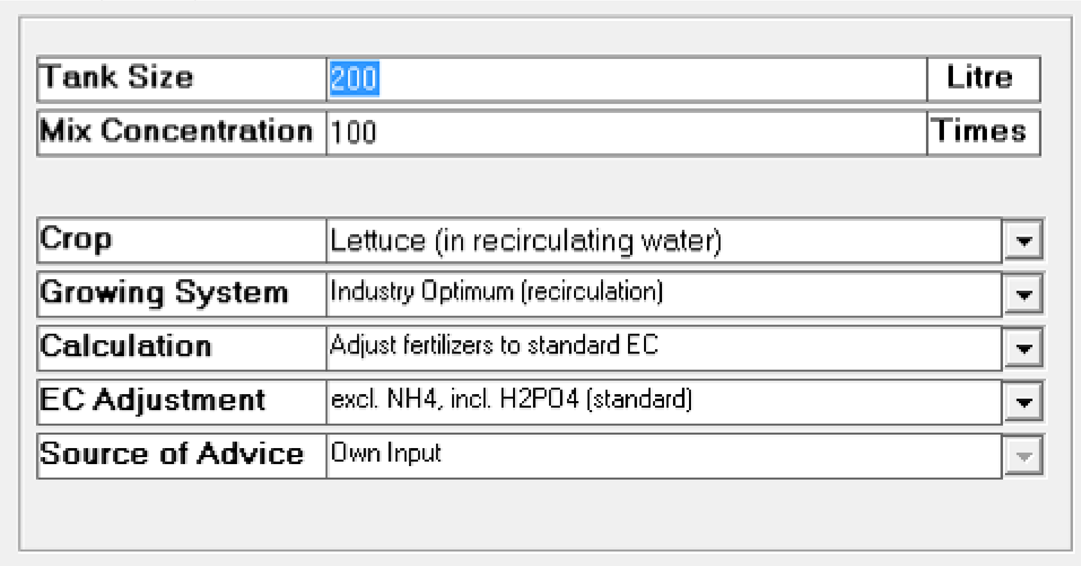
	Name	Tank Concentration (ppm)		
NH4	**Ammonium Nitrate liq**	NH4=115.6	NO3=398.0	
K	**Potassium Nitrate sol**	K=387.1	NO3=613.8	
Ca	**Calcium Nitrate sol**	Ca=185.7	NH4=16.7	NO3=631.8
Mg	**Magnesium. Sulphate sol**	SO4=389.2	Mg=98.4	
NO3				
Cl	**Potassium Chloride sol**	Cl=473.2	K=521.2	
SO4	**Potassium sulphate sol**	SO4=550.7	K=448.1	
H2PO4	**Multi-MKP sol**	H2PO4=698.4	K=281.5	
Other P-bron				
Acid	**Nitric Acid 75% liq**	H=11.9	NO3=737.8	
Si	**Potasium Metasilicate**	Si=91.3	K=254.2	H=-6.5

Select your fertilizers (trace elements)



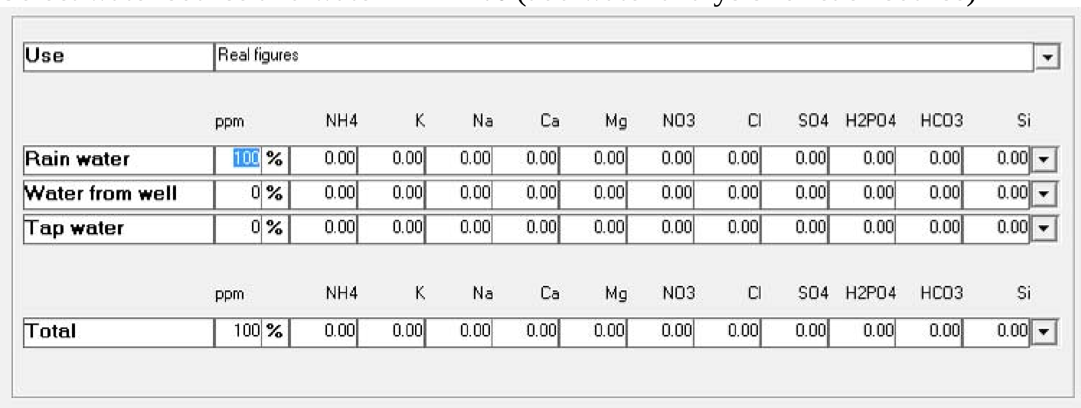
Fertilizer Method	Traditional Method	
	Name	**Tank Concentration (ppm)**
std. Fe-source	Fe-DTPA 11% sol	Fe=110.5
Other Fe-bron		
Mn	Manganese Sulphate	Mn=325.0
Zn	Zinc Sulphate 24% sol	Zn=242.6
B	Borax sol	B=113.1
Cu	Copper Sulphate 25% sol	Cu=254.6
Mo	Sodium Molybdate 40%	Mo=395.1

Select system type and crop



Tank Size	200	Litre
Mix Concentration	100	Times
Crop	Lettuce (in recirculating water)	
Growing System	Industry Optimum (recirculation)	
Calculation	Adjust fertilizers to standard EC	
EC Adjustment	excl. NH4, incl. H2PO4 (standard)	
Source of Advice	Own Input	

Select water source and water mix in % (add water analysis for each source)



Use: Real figures

	ppm		NH4	K	Na	Ca	Mg	NO3	Cl	SO4	H2PO4	HCO3	Si
Rain water	100	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water from well	0	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tap water	0	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	ppm		NH4	K	Na	Ca	Mg	NO3	Cl	SO4	H2PO4	HCO3	Si
Total	100	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

System will report elemental formula recommendations after each stage after selecting your Feed (added) EC level. (n.b. software advises normal industry standard feed EC for each crop)

	Standard nutrition solution	Compensation during crop	After correction	Elements added via water	Elements added via fertilizers	
NH4	21.60	0.00	21.60	0.00	21.60	ppm
K	430.10	0.00	430.10	0.00	430.10	ppm
Na	0.00	0.00	0.00	0.00	0.00	ppm
Ca	180.45	0.00	180.45	0.00	180.45	ppm
Mg	24.30	0.00	24.30	0.00	24.30	ppm
NO3	1,178.00	0.00	1,178.00	0.00	1,178.00	ppm
Cl	0.00	0.00	0.00	0.00	0.00	ppm
SO4	105.71	0.00	105.71	0.00	105.71	ppm
H2PO4	194.00	0.00	194.00	0.00	194.00	ppm
H	0.00	0.00	0.00	0.00	0.00	ppm
Si	0.00	0.00	0.00	0.00	0.00	ppm
Fe	2,240.00	0.00	2,240.00	0.00	2,240.00	ppm
Mn	270.00	0.00	270.00	0.00	270.00	ppm
Zn	260.00	0.00	260.00	0.00	260.00	ppm
B	320.00	0.00	320.00	0.00	320.00	ppm
Cu	50.00	0.00	50.00	0.00	50.00	ppm
Mo	50.00	0.00	50.00	0.00	50.00	ppm

Standard EC 2.32 mS/cm

Added EC 2.32 mS/cm

Previous adaptation

System will advise 'ingredient' formula based on previous screens

NH4	K	Na	Ca	Mg	NO3	Cl	SO4	H2PO4	H	Si	Fe	Mn	Zn	B	Cu	Mo
21.60	430.10	0.00	180.45	24.30	178.00	0.00	105.71	194.00	0.00	0.00	240.00	270.00	260.00	320.00	50.00	50.00

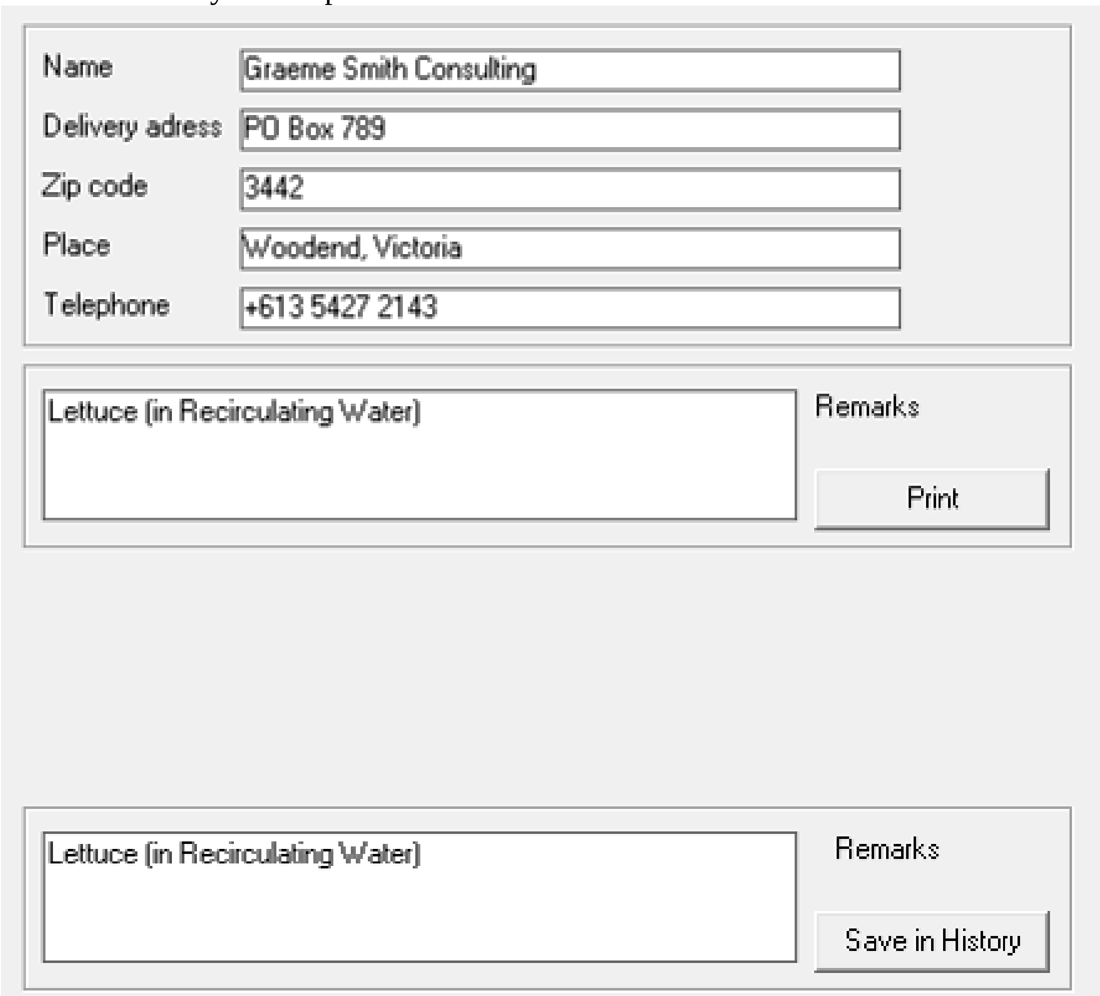
A-tank (100x)

Calcium Nitrate sol	19.4	kg
Ammonium Nitrate liq	0.7	liter
Potassium Nitrate sol	4.1	kg
Fe-DTPA 11% sol	405	gram

B-tank (100x)

Magnesium. Sulphate sol	4.9	kg
Multi-MKP sol	5.6	kg
Potassium Nitrate sol	13.6	kg
Manganese Sulphate 32.5% sol	17	gram
Zinc Sulphate 24% sol	21	gram
Borax sol	57	gram
Copper Sulphate 25% sol	4	gram
Sodium Molybdate 40% sol	3	gram

Print &/or Save your recipe



Example printout

Overview nutrient solutions   Monday, 26 Jul 2010

Graeme Smith Consulting
PO Box 789
3442 Woodend, Victoria

General information

Crop	Lettuce (in recirculating water)
Growth Stage	Standard
Rain water	100 %
Water from well	0 %
Tap water	0 %
Tank Size	200 liter
Standard EC	2.32 mS/cm
Added EC	2.32 mS/cm
Mix Concentration	100 x
Remarks	

A-tank		
Calcium Nitrate sol	19.4	kg
Ammonium Nitrate liq	0.7	liter
Potassium Nitrate sol	4.1	kg
Fe-DTPA 11% sol	405	gram

B-tank		
Magnesium. Sulphate sol	4.9	kg
Multi-MKP sol	5.6	kg
Potassium Nitrate sol	13.6	kg
Manganese Sulphate 32.5% sol	17	gram
Zinc Sulphate 24% sol	21	gram
Borax sol	57	gram
Copper Sulphate 25% sol	4	gram
Sodium Molybdate 40% sol	3	gram

	NH4	K	Ca	Mg	NO3	Cl	SO4	H2PO4	H	Si	Fe	Mn	Zn	B	Cu	Mo
nutrition solution	21.60	430.10	180.45	24.30	1,178.	0.00	105.71	194.00	0.00	0.00	2,240.	270.00	260.00	320.00	50.00	50.00
crop compensation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
after correction	21.60	430.10	180.45	24.30	1,178.	0.00	105.71	194.00	0.00	0.00	2,240.	270.00	260.00	320.00	50.00	50.00
water input	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
drain input	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
fertiliser input	21.60	430.10	180.45	24.30	1,178.	0.00	105.71	194.00	0.00	0.00	2,240.	270.00	260.00	320.00	50.00	50.00

Warning:

Versie 3.0.0   99:92:000:01

Haifa

appendix j.

Nutrient Drain Reference Standard Analysis **Crop =** **Tomatoes**

Grower?	Date	Source	N	NH4	P	K	Ca	Mg	S	Fe	Mn	Zn	B	Cu	Mo	HCO3	Na	Cl	EC	pH
Lab Analysis	12-Apr-10	G/H 2 Drain	140	0.70	0.9	401	498	172	87	2.73	0.7	1.25	1.07	0.09	0.003	0	11	9	4.92	6.1
			(convert NO3 to N, divide NO3 by 4.43, e.g. 1065/4.43 = 240ppm N)																	
Past Analysis	22-May-10	G/H 1 Drain	233	0.40	56	333	243	59	141	0.69	0.6	0.22	0.59	0.05	0.002	39	81	133	3.500	5.6
Past Analysis	12-Apr-10	G/H 2 Drain	240	0.70	65	289	276	64	121	0.77	0.6	0.26	0.60	0.05	0.003	44	76	148	3.06	5.4
Past Analysis																				
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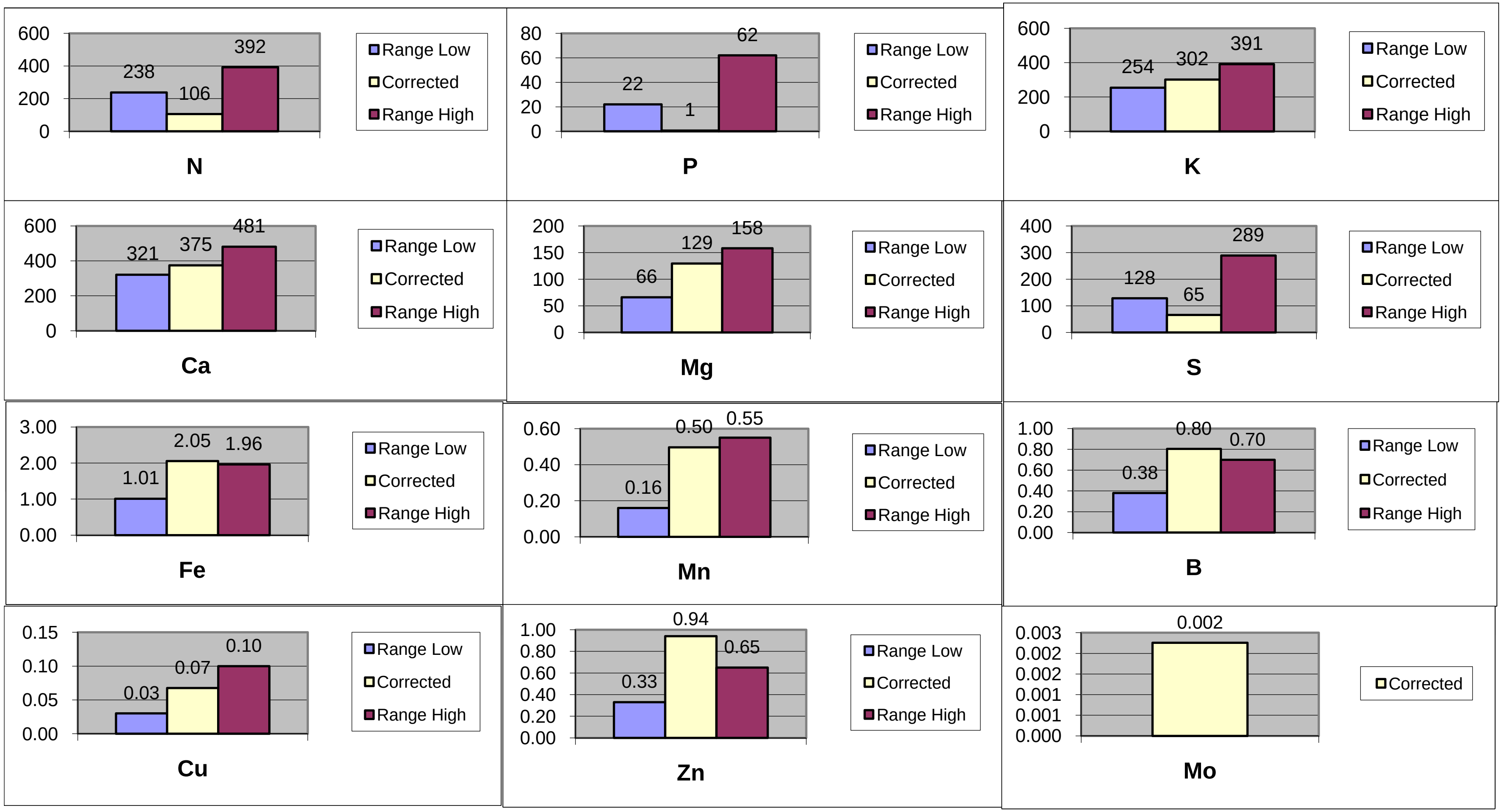
n.b. Enter each laboratory drain analysis in yellow cells, then select 'analysis' tab to see automatic conversion to research guidelines
Select 'Graphics' tab to view graphical representation of adjustment to research guideline for selected greenhouse crop.
Each Ion value should be between the 'corrected' high and low ranges (if outside, may need to adjust 'feed' solution for two weeks?)
Copy each analysis data to spare 'Past Analysis' line for historical reference (nb. only 'copy & paste' data, do not 'cut & paste')

NUTRIENT DRAIN REFERENCE STANDARD ANALYSIS						Crop =	Tomatoes		
© *Graeme Smith Consulting*									
Ions	**N**	**NH4N**	**P**	**K**	**Ca**	**Mg**	**S**	**EC**	**pH**
Lab Result	140	0.7	0.9	401	498	172	87	4.92	6.1
Root-Zone Target	328	< 7	61	482	374	122	283	3.70	5.2 - 7.2
Corrected	106	0.53	1	302	375	129	65		
Range Low	238		22	254	321	66	128		
Range High	392		62	391	481	158	289		
Ions	**Fe**	**Mn**	**B**	**Cu**	**Zn**	**Mo**	**Na**	**Cl**	**HCO3**
Lab Result	2.73	0.66	1.07	0.09	1.25	0.003	11	9	0
Root-Zone Target	1.28	0.12	0.98	0.13	1.11	sign			20 - 80
Corrected	2.05	0.50	0.80	0.07	0.94	0.002	8	7	0
Range Low	1.01	0.16	0.38	0.03	0.33	sign			20
Range High	1.96	0.55	0.70	0.10	0.65	sign			80
Nutrient Source:			G/H 2 Drain						
Test Date:			12/04/10						

appendix J.

Nutrient Drain Reference Standard_Analysis



© Graeme Smith Consulting Crop = **Tomatoes**

Date	Source	N	NH4	P	K	Ca	Mg	S	Fe	Mn	B
12-Apr-10	G/H 2 Drain	106	0.53	1	302	375	129	65	2.05	0.50	0.80

Cu	Zn	Mo	HCO3	Na	Cl	EC	pH	
0.07	0.94	0.002	0	8	7	3.70	6.1	**n.b. all figures corrected to reference EC = 3.70**

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Pathology Testing Program

National Greenhouse Waste-Water Recycling Project

Dear Greenhouse Grower (as addressed)

You have received this package following the national series of workshops, whereby you volunteered to participate in the pathology testing program.
This free program is designed to test the effectiveness of a wide range of sterilisation systems in common use in the Australian protected cropping industry, and will test for the presence of common pathogens including:

- Pythium
- Phytophthora
- Fusarium
- Cmm (Clavibacter – bacterial canker)

Each package includes the following components:

1. Introductory Letter
2. 2 x litre bottles
3. Pre-addressed & pre-paid post bag
4. Plant Disease Diagnosis Request form
5. Water sample collection instructions

The results from all of the tests will be collated and reported to industry in the final project report to HAL in early 2011, however your individual tests will be communicated to you on completion. (n.b. no personal data will be shared)

The pathogens tested for may depend on the type of crops grown or sterilisation system and will be indicated on each package delivered.

We therefore ask that you perform these water tests and post them to the laboratory as soon as possible.

In conclusion, let me thank you in advance for participating in this important industry initiative.

Graeme Smith (CPAg)
Graeme Smith Consulting

Pathology Testing Program

Water Sample Collection Instructions

1. Each package received is to test only <u>one</u> water source and <u>one</u> crop and this information will be identified on the supplied labels

2. You may receive additional packages for alternate crops or water sources.

3. 2 x 1lt bottles have been included for each test:
   1 bottle for immediately <u>before</u> your sterilisation system
   1 bottle for immediately <u>after</u> your sterilisation system

4. The samples will need to be taken when your sterilisation system is active and has been running for a while (for systems that only work in specified periods)

5. It is important that basic hygiene protocols are in place so that the water samples are not contaminated:
   a. keep sample bottles clean
   b. wash hands before sampling
   c. allow water to fill containers a number of times before sealing
   d. ensure caps are screwed on firm so they do not leak in transit (but do not over-tighten)
   e. keep samples away from heat and light
   f. *<u>post samples same day</u>*

6. It is crucial that you take pre & post water samples as close to the treatment system to ensure no contamination or influence from any other systems (however we do not expect you to dismantle your technology, simply test as close as you can)

7. If using hydroponic NFT or Flood & Drain type systems, it may be best to take feed samples at gulley emitters, and drain samples in return water as it cascades back into the tank (assuming you are using Ozone or other chemical type treatment systems directly in recycling tank?)

8. The sample bottles will be printed with your unique code and whether pre (before) or post (after) treatment system.

9. Please ensure you enter date that each sample is taken on each container as well as any special comments you may wish to add. (please include type of sterilisation treatment system, ozone, UV, slow biological, etc)

10. Place samples inside provided pre-paid bag with completed ‘Plant Disease Diagnosis Request’ form. (important to keep samples away from heat and light)

11. Post samples same day (if possible) – postage pre-paid and addressed, simply hand in to Post Office

12. Email or phone me with any questions regarding this collection process.

NSW GOVERNMENT | Industry & Investment

Plant Health Diagnostic Service

Lab no __________
Date / /
(Office use only)

NATA WORLD RECOGNISED ACCREDITATION
NATA accredited facility No 14495

Plant disease diagnosis request

✓PLEASE PRINT CLEARLY ✗ *Running writing leads to errors and delays*

Step 1 Payment authorisation and reporting details

Please note: Diagnostic testing **will NOT** commence until **YOUR complete** billing details and authorisation are received

Submitter declaration: (Submitter receives invoice and report) I understand that there is a minimum fee for sample submission and that fees may be greater, depending on the testing required. I agree to accept all charges for this service.

Name ______________________ Signature ______________________ Date / /

Company ______________________ (*If NSW DII staff member*: Location______________ WBS _____-___)

Address ______________________ Town/suburb ______________________P/code _______

Tel: ______________ Fax: ______________ Mobile ______________

E-mail: ______________________ **Send report by**: ☐ E-mail ☐ Fax ☐ Post

Grower/owner Name ______________ Company ______________ ☐ Requires copy of report
(If different from submitter)

Address ______________________ Town/suburb ______________________P/code _______

Tel: ______________ Fax: ______________ Mobile ______________

Step 2 What testing do you require?

Please note: Testing time varies from **days** to **weeks**, depending on the complexity of the problem and the nature of the tests

A. ☐ Proceed with testing for a complete diagnosis **OR** ☐ Contact submitter to discuss testing requirements or costs
(If no box ticked, then testing for a complete diagnosis is assumed)

B. ☐ Include tests for ______________________ **OR** ☐ Test ONLY for ______________________
(Suspected disease or pathogen) (***Please note***: if this box is ticked **no** other testing will be conducted)

Step 3 Supporting information

Please note: If this submission includes multiple samples, attach additional information identifying each sample clearly

Date collected: / / **Sample locality**: ______________________ **Sample site** ______________________
(If different from grower/owner) (e.g. block, greenhouse, paddock etc.)

GPS coordinates: System ☐ WGS84 ☐ GDA94 ☐ other ______ SOUTH _____° ________' EAST_____° ________'

Sample name ______________ **Variety** ______________ **Genus** ______________**Species**______________
(eg. soil, water or common name)

Symptoms? ____
(e.g. leaf spot, dieback, wilt … of *plant part*? Attach additional information as necessary)

____

______________________ **OR** ☐ Notes attached Symptoms distribution: ☐ Scattered plants ☐ Patches ☐ Uniform over large area

% crop affected ____ When problem started?______________________ Other factors? ______________________
(e.g. weather events, waterlogging, row spacing, sloping ground …

______________________ Other laboratories or other NSW DII staff consulted for this problem? ☐ No ☐ Yes
... fertilisers, herbicides, fungicides, previous crop) (If yes, please attach information on who was consulted and what was concluded?)

Step 4 Packing and sending samples

✓Pack samples in sealed containers ✗Do not place this submission sheet in contact with the sample
✗DO NOT place leaves in contact with plastic wrapping or bags ✗Avoid sending samples over weekends or public holidays
✓Call for packing information OR check our website: **www.dpi.nsw.gov.au/aboutus/services/das/plant-pests-diseases**
✗Post DOES NOT deliver to this address; if post is your only option NEVER address samples to individual staff members
✓We cover freight for samples from NSW if you use ***our*** couriers; call for details
✓Courier (preferred) to: **PHDS, EMAI, Industry and Investment NSW, Woodbridge Road, Menangle NSW 2568**

FOR FURTHER INFORMATION OR TO CHECK CURRENT PRICES PLEASE CALL 1800 675 821

Test results and findings may be provided to authorised staff and used for statistical, surveillance, extension, certification and regulatory purposes in accordance with Departmental policies. The information assists disease and residue control programs and underpins market access for agricultural products. The source of the information will remain confidential unless otherwise required by law or regulatory policies.

appendix m.

15th August 2010

PCA TENDER

'PREFERRED SUPPLIER OF LABORATORY ANALYSIS OF WATER AND HYDROPONIC NUTRIENT SOLUTIONS FOR THE PROTECTED CROPPING INDUSTRY'

To Whom It May Concern

Protected Cropping Australia (PCA), formerly the 'Australian Hydroponic & Greenhouse Association', is the peak industry body representing floriculture, vegetables, herbs & lettuce and allied trade in hydroponics and greenhouse production systems.
The Australian protected cropping industry is valued at $1.3billion (farm-gate) and consists of over 1,600 growers in 1,300ha.

The industry is currently providing skills workshops around the country to media-based hydroponic growers to enable them to convert from 'open' (free-drainage) systems to fully 'closed' (recycling) via the National Greenhouse Waste-Water Recycling project.
This conversion will encourage more growers to adopt regular monitoring and analysis of their hydroponic nutrient solutions as well as their fresh water supplies.

PCA formally invites all analytical laboratories to tender for 'preferred industry supplier' status of analysis of water and hydroponic nutrient solutions for the protected cropping industry.

Benefits of 'Preferred Industry Supplier'

- Free editorial space in industry quarterly magazine ('Soilless Australia') for two editions
- Opportunity for half-price, 1/3 page advertisements in Soilless Australia (8 editions over two years)
- Opportunity to present at PCA biennial industry conference in 2011
- Marketing of your services to the wider protected cropping industry
- Tenure for 'preferred industry supplier' status is for a period of two years

Obligations of 'Preferred Industry Supplier'

- Preferred supplier to conduct laboratory analysis in a timely and professional manner
- Analysis results to be documented as per attached sample
- Results to be communicated to grower via email &/or facsimile
- Results to grower a maximum of 3 days following laboratory receipt
- Analysis actioned on receipt of sample
- Laboratory to hold samples a minimum of seven days after analysis (in case of dispute or re-testing)
- Laboratory to be NATA certified
- Results to be provided in both PPM (mg/l) <u>and</u> mmol (µmol)
- All elements to be analysed as per attached sample
- Recommendations <u>not</u> required (but may be offered if based on hydroponic and not soil principles)
- Report to include sample 'received' date
- Report to include sample 'analysed' date
- Preferred $ rate only offered to current financial members of PCA
- Supply to PCA a rate (in $) per analysis sample for financial PCA members.
- Offered rate to be maintained for entire two year tenure (except with express written permission from PCA)

- Tender to be received by PCA by COB on Monday 1st November 2010

Obligations of PCA

- To offer and maintain benefits to preferred industry supplier as above
- To deliver to preferred supplier a quarterly PCA financial membership update (membership numbers only, no personal details!)
- To encourage uptake of services of preferred supplier to wider protected cropping industry (n.b. PCA provides this opportunity in good faith but offers no guarantees as to uptake of laboratory analysis services over period of tenure of preferred industry supplier)
- Successful tender will be announced at the PCA AGM in Sydney on Thursday 11th November 2010.

PCA invites your participation in this tender to provide these important services to the Australian protected cropping industry.

Further information from:

Graeme Smith

Graeme Smith
President - Protected Cropping Australia
president@ahga.org.au
+61427 339 009

PCA TENDER

'PREFERRED SUPPLIER OF LABORATORY ANALYSIS OF WATER AND HYDROPONIC NUTRIENT SOLUTIONS FOR THE PROTECTED CROPPING INDUSTRY'

Report Specifications Example

Client Details:

Name:	John Smith
Business Name:	ABC Hydroponics
Water Type:	Hydroponic
Sample Type:	Drain Water
Sample Location:	Greenhouse # 2
Crop:	Cucumbers
Crop Stage:	Heavy Fruiting
Sample Date:	14/08/2010
PCA Membership No:	12345
Email (or Fax:)	john@abchydroponics.com.au
Phone:	(03) 5555 1234

Laboratory Details:

Client ID:	HSA1234
Sample ID:	1234567
Sample Rec'd Date:	15/08/2010
Sample Tested Date:	16/08/2010

Item	Symbol	Min Decimal Places	eg.	Unit	eg.	Unit	notes:
Nitrogen	N	1	285.6	ppm		mmol/l	
Nitrate	NO_3	1	1265.2	ppm	20.4	mmol/l	
Ammonium	NH_4	1	1.5	ppm	1.2	mmol/l	
Phosphorus	P	1	28.6	ppm		mmol/l	
Phosphate	H_2PO_4	1	89.5	ppm	1.5	mmol/l	
Potassium	K	1	407.3	ppm	10.4	mmol/l	
Calcium	Ca	1	268.1	ppm	5.6	mmol/l	
Magnesium	Mg	1	93.8	ppm	1.9	mmol/l	
Sulphur	S	1	196.4	ppm	.	mmol/l	
Sulphate	SO_4	1	589.2	ppm	3.9	mmol/l	
Sodium	Na	1	56.3	ppm	2.6	mmol/l	
Chloride	Cl	1	52.8	ppm	1.6	mmol/l	
Silicon	Si	1	14.5	ppm	1.2	mmol/l	Si could be optional?
Iron	Fe	2	1.11	ppm	0.02	mmol/l	
Manganese	Mn	2	0.13	ppm	0.01	µmol/l	
Zinc	Zn	2	0.39	ppm	0.01	µmol/l	
Copper	Cu	2	0.05	ppm	0.01	µmol/l	
Boron	B	2	0.42	ppm	0.04	µmol/l	
Molybdenum	Mo	2	0.05	ppm	0.01	µmol/l	
Bicarbonates	HCO_3	1	67.3	ppm			
Electrical Conductivity	EC	2	3.37	mS/cm			
Acid/Alkalinity	pH	2	6.30	pH			

Protected Cropping Australia

PO Box 538 NARRABEEN NSW 2101 Phone/Fax +61 (02) 9907 6633 Mobile 0414 333 996
www.ahga.org.au administrator@ahga.org.au

appendix n.

Workshop feedback

	Geelong pilot	Shepparton	Werribee	Cranbourne	Campbell Town	Coffs Harbour	Baldivis	Sydney (all 3 workshops)	Virginia 1	Virginia 2	Brisbane	Bundaberg	TOTALS
Total no of Participants	6	10	14	15	12	16							73
Number of respondents to feedback form		10	11	12	11		15	26	11	11	19	12	138
I had sufficient info about content	Agree 5	3	4	6	5		8	14	8	5	7	6	66
	4	6	5	5	5	1	4	7	2	5	11	3	54
	3	1	2		1		3	4	1	1	1	3	17
	2			1				1					2
	Disagree 1												0
Responses to enquiry/registration were timely		5	6	7	7		9	12	7	3	14	8	78
		5	5	3	4	1	3	11	3	6	3	4	48
				2			2	3	1		2		10
									1				1
										1			1
Content was relevant to my workplace		7	6	5	5		11	12	10	6	12	7	81
		3	2	2	5	1	4	10		4	4	4	39
			2	4	1			4		1	4	1	17
			1	1									2
									1				1
Method of delivery was appropriate		6	7	4	6		11	12	7	6	10	8	77
		4	3	4	5	1	4	12	3	4	6	4	50
			1	4				2	1	1	3		12
													0
													0
Information will help my business		7	4	5	9		11	12	5	8	8	8	77
		3	2	5	2	1	4	6	5	1	9	4	42
			4	2				5		2	2		15
													0
									1				1
Presenters had good knowledge		8	8	7	10		12	20	9	8	15	10	107
		2	3	5	1	1	3	8	1	2	3	2	31
								1	1		1		3
													0
													0
Facilities suitable		9	5	5	8		8	11	10	8	7	5	76
		1	5	3	1		4	7	1	3	8	4	37
				4	2	1	2	3			5	3	20
								5					5
													0
Best part of workshop	notes/cd	3	4	2	1	1	4	1	1	2	3	5	27
	ppt						1	2					3
	plant physiol										2		2
	nutrients		3	1							1	3	8
	fert recipes/calcs								1		2		3
	sterilisation										1		1
	presenters	3	1	2				2			1	1	10
	all content		1	4	4		3	6	1	4	3	2	28
	good refresher										1		1
	networking			1			1	1			1		4
	computer session			2	3		2		1	1	1		10
	broad view						3						3
	local context								1				1
	new trends									1			1
	practical advice/application			1				2		2			5
	discussion							1					
	more knowledge							2					
	recycling							1					
	first half										1		1

	no cost to enrol								1				1
	conversion	2	1					2	2	1	2		10
Worst part	costings		2								1		3
	basic at start										1		1
	basic but good		2								1		3
	late start			1				1					2
	too much info!			2	1								3
	chairs			2				1					3
	room temp						1						1
	laptops	2											3
	overlap			1									1
	rushed				1		3	1					5
	no flower info										1		1
	nutrients			1			1	1					3
	figures										1		1
	small writing				1						1		2
	update of software											1	1
	day after hols						1						1
	travel/traffic						1				1		2
	short breaks/sitting						2		1	1			4
	long intro									1			1
	no networking										1		1
	breakfast?						1						1
	sterilisation											2	2
	too long							3					
	chat							1					
	light							1					
	presenter not sticking to manual							1					
	venue							3					
	slides not in order							1					
	coffee		1						1				2
Improvements	provide tables		3	1									2
	more pictures/videos/props			3			1		1				5
	risk management			1									1
	more on nutrient balance			2		1						1	4
	more on recycle systems				1	1			1			1	4
	start earlier				1								1
	grower data/feedback		1		1								2
	more time						3						3
	working eg/site visit						1					1	2
	change slide colours									1	1		2
	align slides with ppt							1		3	2		6
	further reference material									1			1
	more topics								1		1		2
	more local context								1				1
	group work										1		1
	change venue							1					
	follow up, see in action							1					
	more in Perth						1						1
	improve manual							1					
	less lecturing, more class part.							1					
	more update							1					
	practical workshop, farm demo.							1					
	slow down							1					
	more breaks/stretches							1					
	drinking water							1					
	a lot									1			1
	nothing		1		2		4	2	1	1	3	1	15
Do you think you have enough info to convert	yes		6	8	9	1	14	15	7	8	15	10	93
	no		1					2	2		1		6