A Greenhouse for Tropical Lowlands (Malaysia)

Training Manual: Guidelines for the Planning and Organisation of Training Activities

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Prepared with the support of

Ministry of Economic Affairs, Agriculture and Innovation

Wageningen UR Greenhouse Horticulture report GTB 1162

May, 2012

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Preface

A greenhouse suitable for lowland tropics has been developed during 2008 - 2012 in a collaborative project named 'Tropical Horticulture in Malaysia' between The Department of Agriculture of Malaysia, Wageningen University and Research Centre, and Asian Perlite Industries. The project was motivated by the need to expand greenhouse horticulture in Malaysia to the tropical lowlands, as space in the Cameroon Highlands, where greenhouse horticulture has been concentrated, is getting scarce. The project was supported by the Netherlands Ministry of Economic Affairs, Agriculture and Innovation, and the Department of Agriculture of Malaysia.

One of the major achievements of the project has been the establishment of a 'Tropical Greenhouse' that is suitable for the climate in the lowland tropics, with its high temperature, radiation and humidity (Elings et al., 2012). This manual partly builds on the experiences gained in these tropical greenhouses, that serve as a nucleus for further knowledge spread.

This Training Manual on tropical lowland greenhouse horticulture has been prepared as a manual for training of trainers staff of the Department of Agriculture of Malaysia, agricultural extension workers of the government, trainers of educational institutes engaged in greenhouse training and for private sector actors working in greenhouses.

The training material introduces concepts and principles related to development, implementation and evaluation of training programmes with emphasis on tropical lowland greenhouse horticulture. The manual contains 20 chapters on specific issues with some background information, a few highlights, some illustrations and sample exercises that can be used in a training programme.

The manual has been developed based on the experience gained during the project and should provide the reader with inspiration to developing and organizing efficient training programmes and sessions. It is very generic and can therefore be used for many greenhouse situations, even for non-greenhouse settings.

The manual is seen as a living document and as such we would welcome any comments or feedback from trainers in the field.

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April - May 2012

Acknowledgements

The project 'Tropical Horticulture in Malaysia' has during the years 2008 – 2012 been enabled by the support and involvement of a large number of people.

We would like to thank the former and present Director Generals of the Malaysian Department of Agriculture: Roseley Khalid, Sulaiman Md. Zain, and Mustafa Kamal Baharuddin; the Deputy Director General of the Department of Agriculture, Sabtu Selamat; the former and present Directors of Horticulture of the Department of Agriculture: A. Rahman Ismail, and Norma Othman; the former and present Deputy Directors of Horticulture of the Department of Agriculture: Cheah Lee Shen, and Nordin Mamat; and the Secretariat Staff: Khazana Ibrahim, Beverlien Christine Daiman, and Khairul Amri.

The tropical greenhouses are located at the facilities of the Department of Agriculture in Serdang, near to Kuala Lumpur. Our gratitude goes towards the Station Director: Ramli Md. Afandi; the Technical Officers: Khairul Izhar Lafasa Rais, Norhidayah Mohd Yusof, and Wan Muhammad Zukarnain; to the Technical Assistants: Alina Abdul Aziz, Muhammad Akmal , Mohd Nasir Ali, and Amat Khri Mardi; and to the Engineering Officer: Hilmi Rabiki.

We highly appreciate the very good care taken of the crops and the greenhouses by farmers Zulfa Zamzam, Noorhartini Derapi, and Shahrizal Jalil.

We thank from Priva, who supplied the computerized fertigation system, Marten Hartong and Lars Stevenson.

The Netherlands Ministry of Economic Affairs, Agriculture and Innovation has been very supportive throughout the years. For this we thank the Agricultural Councellor in Kuala Lumpur Mr. Adrie de Roo, Netherlands Government, the Agricultural Councellor in Jakarta, Mr. Jean Rummenie, and his Assistant, Mr. KC Chong.

We are very thankful having worked with all of you.

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1 Introduction

1.1 Why a guideline for training activities?

The general objectives of this project were to introduce a greenhouse system in Malaysia with a high natural ventilation capacity that is suitable for use in the lowland tropical climate which is characterized by high temperatures, and to enable the trainers engaged in greenhouse production training to develop, organize and implement effective training programmes in relation to the new type of greenhouse. The core component of this project has been the transfer of knowledge, know-how and information in order to upgrade the technical and managerial performance of farmers working in these types of greenhouses.

This paper provides a standard framework for planning, organising and documenting training activities. It is prepared with a view on providing a practical guideline for the trainers and remind the trainers on some key aspects related to training planning and organisation thereby enhancing the general quality and impact of the various training activities.

1.2 How to use this guide

This guide and can be used in a variety of ways. Our main objective was to provide you with a process for developing and conducting an effective training programmes.

The guide contains two main parts. The first part of the manual, chapters 1-9, gives guidelines on how to set up any kind of training programme and centres around 7 questions:

- Who will be the learners?
- What are the aims of the training and the learning objectives?
- What will be the content of the subject?
- What training methods and media will be used?
- How will be sequence the content?
- What resources do we need to organise?
- How are we going to monitor and evaluate the training?

The second part of the manual, chapters 10-20, focuses on giving training programmes in specific areas of greenhouse horticulture in Malaysia. The knowledge we provide is based upon the experiences acquired during the implementation of the project on tropical lowland greenhouse horticulture in Malaysia, and on experiences from horticulture in The Netherlands. The following subjects are dealt with:

- General introduction to greenhouse
- Greenhouse construction and installation
- Computer system used in the greenhouse
- Crop management
- Climate change
- Fertigation
- Hygiene measures
- Scouting
- Integrated pest management
- Cost-benefit analysis

If you are experienced in giving trainings already, you might want to focus on the chapters that you are most interested in. However, if you are new to training, we strongly suggest that you read the entire training manual so that you get an overview on how trainings should be organized. Then you can revisit the chapters as you go along with organizing your training activities.

1.3 What do we mean with training?

In the context of this Twinning Project we will define training as follows: Training is the acquisition of skills, concepts and/or attitudes that result in improved performance in an on-the-job situation.

In practice training can take many forms ranging from more formal classroom based activities such as lectures and workshops to very practical and more informal activities such as study tours, work placements and role plays. Whatever form you opt for in your training, it is important that you use this guideline during the preparation and implementation process.

1.4 Providing a framework for planning

Trainers seem to differ in how they like to approach the planning of their courses and lessons[1]. To a large extent their approach depends on whether they think mainly of their subject matter or of their trainees. Text box 1 below summarises these two sets of approaches. For effective planning, you will hacombine some approaches from both lists!

Text box 1:	Two Sets of Approaches to Training Planning
SUBJECT ORIENTED	LEARNER ORIENTED
Review your knowledge on the subject Discuss it with other experts Analyse similar training programmes Select books around which you will organize the teaching	Think of which competences the learners should attain Study the current work of the learners Analyse the background and motivation of the learners

There are at least **seven major questions** that we must ask ourselves in planning a training course or lesson:

- Who will be the learners?
- What are the aims of the training and the learning objectives?
- What will be the subject content?
- What training methods and media will be used?
- How will we sequence the content?
- What resources do we need to organise?
- How are we going to monitor and evaluate the training?

[1]The comments and suggestions made in this paper are equally relevant whether you are planning a whole course that will occupy the trainee for several days or weeks, or as little as one 'lesson', which is seen as a 'self-contained and coherent chunk of learning'.

Individual questions cannot be addressed without reference to all the questions. When you determine the aims and objectives of your training, you will find it impossible not to consider the group you will be training. Similarly, the choice of training methods and media will be determined to a considerable extent by the type of trainee, the available resources and your training objectives. So, while you are working your way through this sequence of questions, you may have to refer back and forth and make adjustments in what you wrote down previously.

In the coming section the general guideline for the planning and organisation of training activities is outlined on the basis of these seven questions.

2 Who will be the trainees?

The planning process of a training programme starts with **the identification of the trainees.** There are **four types of information** that you might need about your prospective trainees:

- Professional information
  - What is the current (and future) designation of the people you will have to train?
  - How does the training fit in with their (future) roles and tasks?
- Subject background
  - What knowledge, skills and attitudes do they already have regarding the subject of the training?
  - Have they had prior experience with (parts of) the subject of training?
  - Do they have professional experience and/or interests that are relevant for the training?
- Learning needs
- Other factors important for organisational issues
  - How many trainees?
  - What is their age range?
  - Both sexes?

2.1 What are the learning needs of the trainees?

Analysis of organizational and individual learning needs and the characteristics of the potential participants provides the basis for the development of the training programme. We implement such an assessment in order:

- to focus learning on *what is really important* for the job *and* the individuals involved (and not yet known by the participants) and to avoid that we try to solve problems with training that are not solvable by training alone. That is to say: in order to be able to formulate relevant and realistic learning *objectives.*
- to be able to develop an effective training *strategy,* select appropriate training *methods* and to arrive at appropriate *arrangements* for training (timing, duration, food, place, setting, group composition, etcetera) well adapted to the needs and circumstances of the participants.
- to assess the need for *required support and follow-up* after training.

2.1.1 How to define a training need?

A training need is well defined when we can describe clearly:

- what (type of) *persons*
- have what kind of *problems*
- in performing which *tasks*
- implemented to achieve which *aims;*
- whether those problems are *amenable to training,* that is to say (at least partly) solvable by inducing certain changes in Knowledge, Awareness, Skills, Aspiration

2.1.2 What and how to assess?

- Job analysis
  - what are the tasks to be performed in this job
  - determine which tasks are most important for good job performance

Result: critical tasks to be performed

- Task analysis (esp. critical tasks)
  - what steps/components are involved in each of the tasks
  - what are the most important ones?
  - what are the facts, skills and attitudes related to each task
  - define minimum standards

Result: required KAS (knowledge, attitude, skills) for good job performance

- Performance / gap analysis
  - assess the actual performance of potential participants
  - define gaps in KAS of the potential participants

Result: "objective" training needs

- Need analysis
  - asses the training needs as perceived by the potential participants

Result: "felt" needs

- Analysis of trainability
  - which performance problems are amenable for training?
  - in which aspects is the training likely to have good impact under the conditions given?

Result: priority areas for training

Some assessment techniques:

- meetings with senior officers
- analysis of policy and programme documents
- field visits
- structured observation of job performers who are seen as exemplary "role-model"
- brainstorming with individuals who are "in the best position to know best"
- analysis of critical incidents
- appraisal reports
- group meetings to discuss job-related problems
- analysis of critical incidents (gathered from reports/records and/or from persons)
- client group interviews
- appraisal by supervisor
- observation of potential trainees / tests
- written self-assessment
- individual and group discussion with potential participants
- diagnosis of the causes of the performance problems with the "role set"; problem trees
- review of impacts of earlier training experiences in this field.

Learning needs can be defined properly, if

- the type of persons by whom the job has to be done is clearly indicated
- the type of problems the training refers to is described,
- the performance elements of the particular job can be distinguished, *and*
- the aims the job is meant for can be identified.

2.2 What will be the aim and learning objectives?

It is useful to start thinking about the aims and objectives at the same time as when you define the participants of your training programme or lesson. The difference between aims and objectives is as follows:

- **Aims** – a general statement of what you hope to training will achieve; the aim usually provides information on the rationale behind the training programme.
- **Objectives** – a statement of what learners should be able to do or do better as a result of having partaken during the training programme (or lesson).

Generally, we can distinguish between three major areas of learning, called domains:

- the **cognitive** domain: knowledge, understanding, analysis; facts and images about situations and the capacity to analyse these situations;
- the **affective** domain: awareness, attitudes, aspirations, orientations, feelings, emotions; meaning attached to certain situations;
- the **psycho-motoric** domain: behaviour, performance, acting; the observable (re-)actions to (in) certain situations.

Development of a certain "ability" normally includes all three domains.

2.2.1 Why objectives?

The formulation of objectives:

- facilitates the planning of the training activity, by making it easier to select relevant learning experiences and contents systematically;
- makes the training more effective and efficient by orienting the implementation: the trainer concentrates more on what is really needed and is prevented to stray off, and participant learning is stimulated by clarifying for each part of the training what they are going to learn and how they can assess progress made (what they should be able to do if they attained the objective);
- provides a sound basis for evaluation of the training;
- improve the impact of the training by concentrating attention on the resulting change in behaviour and action in the field rather than increase in knowledge and skills as such.

2.2.2 Writing performance objectives

Trainers are tempted to formulate objectives in terms of what they themselves are going to do in the training e.g. "teaching the trainees how to define objectives". You might call this "teaching objectives". This type of objectives do not tell much about what the *participant* will be able to do at the end of the training. Hence, it will be better when the objective describes the desired performance of the *participant.*

Objectives should describe *observable* behaviour. Trainers are often using words like "understand" or "know" "be aware" when defining objectives. Such words may indicate perfectly what we expect the student to learn but we cannot observe what happens inside the head. To assess whether the student “understands” or “knows”, we need verbs that describe some *observable activity.* The description “the trainee knows how the content of a cube must be calculated” is less clear than “the trainee will be able to calculate the contents of a cube”.

How to formulate a performance objective?
- use active verbs
- specify what has to be performed
- indicate a standard
- specify conditions

Apart from characterizing learning methods according to the domains of Knowledge, Skills or Attitude, these methods may be scored against the potential of information transfer, interest raising value, information transformation or stimulation to active participant involvement.

It is customary to start an objective with a phrase like “at the end of the training, the participant should be able to…..”, or “have improved their ability to ……….” The second part of an objective is the verb.

The *standard form* of a performance objective consists of three components or characteristics:
- the performance: what the trainee is expected to do upon completion of the training. The performance consists of a verb that denotes the behavior to be demonstrated (e.g. “type”) and the result of that action that will be assessed (e.g. “a document of x words”);
- the conditions: under what conditions the participant is expected to demonstrate the performance (e.g. “given an electric typewriter);
- the standards: describes how well the participant is expected to perform: how often, how fast, how many (e.g. “within y minutes and with no more than z mistakes”). The complete example reads now: “Given an electric typewriter, the participant should be able to type a document of x words within y minutes with less than z mistakes”.

Text box 2	Verbs to be used for formulating performance objectives	
Knowledge Acquisition	**Skill Building**	**Attitude Change and Utilization**
To identify	To demonstrate	To challenge
To list	To produce	To defend
To compare and contrast	To calculate	To judge
To describe	To adjust	To question
To state	To install	To accept
To differentiate	To assemble	To adopt
To prepare	To operate	To advocate
To recall	To detect	To bargain
To classify	To locate	To cooperate
To categorize	To isolate	To endorse
To chart	To arrange	To justify
To rank	To build	To persuade
To distinguish	To conduct	To resolve
To explain	To detect	To select
To outline	To execute	To dispute
To analyze	To fix	
To evaluate	To lay out	
To formulate	To perform	
To investigate	To sort	
To modify		
To report		

Verbs to avoid:

- to know
- to understand
- to be aware of

The remaining part of a well-formulated objective provides a qualification and/or a quantification of the skill, attitude or knowledge that you intend to pass on. In this way you make the objective measurable and verifiable.

By formulating clear and verifiable objectives you make your intentions with training explicit for yourself, your colleagues and ultimately the trainees. Furthermore, thinking out clear objectives can help you to distinguish between possible and essential content and helps in measuring the impact and success of the training.

For examples of aims and objectives, please refer to chapters 9-20.

3 What is learning?

Learning is the accumulation of knowledge/skills and the ability to constantly improve the effectiveness of action by individuals, teams, organizations and society at large Learning involves applying lessons learned into future actions, which provides the basis for another cycle of learning.

3.1 How do adults learn?

1. Adults are voluntary learners. Adults rarely learn if they do not find the topic relevant to their lives.
2. Relevance: Adults learn best when the context of the training is close to their own tasks or jobs.
3. Experience: Adults have experience and can help each other to learn.
4. Peers: Adults learn most from their peers. Exchange of experience results in effective learning.
5. Active involvement and participation – best for learning
6. Their short-term memory becomes weaker. Reinforcement by repetition can help.
7. Own pace. Too much hurrying may impede their learning capabilities.
8. Dignity. If Adults are not treated with respect and made to feel humiliated or laughed at before others, they may refuse any further learning in that context.

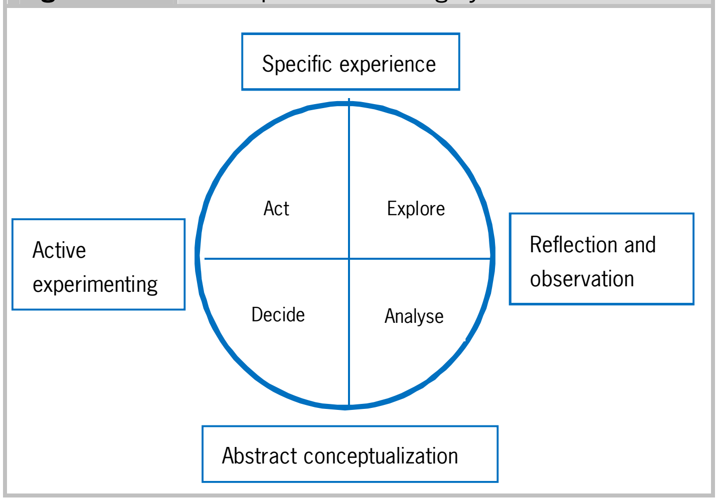
3.2 Experiential learning cycle

One of the main concepts around learning was developed by the American researcher David Kolb: the theory of learning by experience, The theory explains to a great extent the essence of the processes of interaction taking place during interactive training.

According to David Kolb, the learning cycle consists of four successive and interconnected stages:

1. Specific experience
2. Reflection and observation
3. Abstract conceptualization and
4. Active experimenting.

Figure 1 The experiential learning cycle



During the first stage of the cycle, the participants use either some specific personal experience that they already have or, as happens much more often, immediately obtain this experience with the help of a specially organized interaction during the learning activity.

During the stage of reflection and observation, conditions are created for the critical observation of, and reflection on what has been experienced and discussions are held among observing participants who are in some way related to the experience.

The productivity of such discussions will be greatest if the 'triangular rule is observed by each of the participants. According to this rule three components are equally important — the topic, the group, and the person themselves. Unless all three components are present during the discussions, the emphasis will shift to one of these aspects which will negatively affect the effectiveness of the discussions.

In the third stage of the cycle, "Abstract Conceptualization", a unique knowledge can appear as a result of the joint reflections by the participants. The value of this unique knowledge is not in the information gained, but in its creative character. The value of this knowledge is strengthened by the participants' interaction, i.e. their joint movement in some singular direction with the goal of realizing their individual needs. The results of interaction in this stage are expressed in the form of conclusions and deductions from the participants themselves, as a result of this joint reflection.

In addition, as one of the ways to explain the experience obtained, the participants of a workshop can be offered theories that explain the aspects discussed in some particular way. This in no way means the substitution of personal conclusions by the concepts established, rather the theories offered help the participants to fully formulate and realize their own deductions.

During the final stage of the cycle, the possibility to review the formulated conclusions is especially important. Most often, this review takes place during the practice, and finally leads to gaining new specific experiences, which in turn become the beginning of a new learning cycle.

It is essential, during the development of the training programme, to take into account the different quadrants of the experiential learning cycle, and to plan facilitation methods that will cater to needs of the audience. Not all people favor all four learning quadrants. Farmers will not be happy with listening to power point presentations or lectures for most part of the day. They would likely to prefer discussions where they can share their experiences, ask questions, see greenhouse technology and production, and can reflect on how they could improve their own operations.

3.3 Knowledge transfer and innovation

Everett M. Rogers was professor at Stanford University, and he is famously known for his book "Diffusion of Innovations" which describes how, why, and at what rate new ideas and technology spread across communities. Innovation could better be understood as a new emerging technology, concept or idea, while diffusion is characterized as spread of innovation through certain channels over time among the members of a social system.

Rogers proposes that adopters of any new innovation or idea can be categorized as innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%) and laggards (16%), based on the mathematically based Bell curve. These categories, based on standard deviations from the mean of the normal curve, provide a common language for innovation researchers. Each adopter's willingness and ability to adopt an innovation depends on their awareness, interest, evaluation, trial, and adoption. People can fall into different categories for different innovations.

Rogers classifies adopters of innovations into five distinct categories:

- Innovators (Risk takers, eager to try new ideas, can be assumed as gatekeepers of diffusion dynamics)
- Early Adopters (Opinion leaders, more socially forward, experiment with new ideas in a careful way)
- Early Majority (Intellectual people, careful but adopt the trends more quickly than the average)
- Late Majority (Sceptic people, follow the trend after the majority of society has adopted)
- Laggards (Conservative people with belief in conventional ways, tend to be advanced in age)

The implications of this on knowledge transfer (training) are

1. It is quite normal to meet trainees who are not yet enthusiastic about a certain type of innovation; it takes time to transfer innovation.
2. Therefore, selection of trainees is a crucial part of the training development and implementation process. In case of a new greenhouse technology transfer, it is worthwhile to focus in the early stages of knowledge transfer on the more progressive farmers: innovators and early adopters.

4 What will be the subject content?

What are the main topics, concepts, principles, etc. to be covered in your training? Many thoughts about the content will arise already in the process of thinking about the participants and the objectives. Some of the ideas on how to plan the content of your training (such as the checking of existing reference books, discussing it with other experts, etc.) have been listed already in text box 1 above.

Two other ideas that may help you to sort out the content of your training are:

- **Analyse the main concepts** that are important in relation to the subject matter. You can do this analysis, for example by undertaking one or more of these activities:
  - Isolating the main facts, principles, examples, etc. of the subject matter
  - Defining the main concepts in a dictionary-type manner
  - Listing of some clear examples
  - Drawing up of a model
- **Prepare a diagram** in which the relationship between the main factors are drawn, for example by:
  - Showing the causes and effects relationships in the case of a 'problem-solving' exercise
  - Drawing a matrix in order to get a systematic overview of how different sets of aspects influence each other
  - Outlining an algorithm in which the connections between different steps or phases are to be covered (e.g. a decision-making process or a step-by-step approach to diagnosing plant material).

Text box 3	Examples of methods and means of training

- Orientation visit to the tropical greenhouse to see structure of the greenhouse
- Orientation visit to a traditional type of greenhouse to see its structure of greenhouse and compare it with that of a tropical greenhouse
- Guided group discussion centres around the following themes: (a) hygiene measures, (b) scouting, (c) IPM
- Lecture on greenhouse construction
- Hand-out summarising the costs and benefits of the tropical greenhouse
- Case studies of farmers growing in the tropical greenhouse
- Sub-group exercise:
- Lists possible hygiene measures used in the tropical greenhouse
- Presentation of the outcome of the sub-group exercises followed by a discussion

However you decide on the possible content of your training, keep these two pieces of advice in mind:

- Do not overload the programme, but stick to what is essential in relation to the objectives and manageable for the participants
- Try to leave an opening for adding the trainees' own content; this requires maybe some improvisation, but enables you to tailor the training to the needs and interests of the group!

5 What training methods and media are to be used?

Now that the participants, objectives and subjects of the training are defined you can start to think more about the methods and media that you may want to use. It is beyond the scope of this paper to outline all possible methods and media imaginable. Below you will find some general recommendations and points for consideration.

Different people have different learning styles as it was explained in chapter 3. Therefore try always to incorporate different methods in your programme to cater for as many different styles as possible. Some people are more analytical and benefit from very informative and logically sequenced training sessions such as lectures. Others learn better by finding out for themselves and need hands-on or more experimental training activities. In the figure below you find a general categorisation of the various categories of 'learners' and their key characteristics. Which learning style fits you best?

Concrete

Dynamic learner:
- Intuitive
- Unstructured
- Experimental
- Changeable

Innovative learner:
- Social
- Innovative
- Feeling
- Listener

Doing ⟷ **Watching**

Common sense learner:
- Practical
- Hands-on
- Reality-oriented
- Problem solving

Analytic learner:
- Expert oriented
- Data collector
- Sequential
- Intellectual

Abstract

The general aims, objectives and the subject matter also determine the appropriateness of various methods and media. For example, if the aim and subject is skill acquisition, then the most appropriate methods include demonstrations, practical exercises, instructional videos, immediate feedback and correction. However, if the training is centred on cognitive change – knowing and understanding – you may want to go for lectures, group discussions, case studies, readers, etc. Sometimes training is also used to alter attitudes and outlooks. In this case question-answer sessions, group discussions, case studies, role plays and coaching may be more appropriate methods.

The availability of facilities, time and budgets are another important category of determinants. It may be a wonderful idea to use an instructional video if you wish to introduce a new technique or skill. However, unless it will be used by a large number of trainees for a considerable time, you will find that the advantages normally do not outweigh the costs and time involved in producing the video. Instead a chart or sequential diagram will be more cost-effective. A practical whereby all participants can apply and test their new skills may be a desirable component of the training programme, but is also time consuming and requires the availability of the appropriate facilities. If either time or facilities are lacking, you will have to organise something else, for example a method demonstration.

Lastly, it is important to opt for a training method that suits your own skills, experience and preference. For example, if you do not feel very confident to stand in front of a group, then try to minimise the number of presentations and lectures. You may be much better in organising and coordinating study tours, practical assignments, group discussions or other more informal methods.

6 How are we going to organise and manage the training?

Once you have got some notion of the content and the training methods, you need to start thinking about the sequencing. How might the various ideas and subjects best be ordered within your programme? Here are some of the types of sequencing that you may need within your training programme:

- **Chronological sequence**, for example when dealing with scientific discoveries, development of institutions or programmes, etc.
- **Causal sequence**, which is closely related to the chronological order, but which emphasises the cause-effect relationship
- **Topic-by-topic**, when a number of related topics and themes which could be studied in any order
- **Backward chaining**, when the training is aimed at learning of a sequence of activities (e.g. introduction of Good Laboratory Practices) or decision-making (e.g. determining whether an organism is harmful or not), it may be useful to teach the final step first; you might then continue with the previous steps.
- **Problem-centred sequence,** by starting with analysing problem and then engaging the participants in developing solutions, you may provide them with a realistic context in which they can easily see the relevance of the new skills and knowledge.

Other important organisational issues that need to be defined beforehand, particularly when more than one trainers are involved are:

- A list of the main resources and facilities that are required that will serve as guide for planning and checking the availability
- The division of the main responsibilities for developing and implementing the training activities
- The timing of the preparatory activities and dates of implementation.

7 How are we going to monitor and evaluate the training?

It is essential to monitor the trainings we organize and implement to be able to:

- to guide and stimulate the learning process (continuous in-course evaluation)
- to obtain feedback for improving the training programme for planning adequate support and follow-up actions
- accountability to policy makers, who will have to make decisions about the continuation of the programme (relevancy, affectivity, and cost efficiency of the training)
- to (future) clients, who have the right to know how effective the training (was) is and to receive follow-up

7.1 What do we evaluate?

The following "evaluation levels" can be distinguished:

- **A: Process:** Participants' and trainers' observations and feelings about the learning process: learning climate, content, training methods, organization, participation, intermediate learning results. This entails continuous evaluation during the course.
- **B: Learning outcomes:** What the participant learned during the course: new skills, attitudes, facts, principles. This entails "testing" participants' competence to perform at the end of the training according to the set objectives.
- **C: Behavioural change:** The effect of the training on the individual performance on the job. This entails examining changes in individual behaviour attributable to training.
- **D: Impacts:** The effects of the improved performance (attributable to training) on farmer's level: e.g. increased farmer organization, enhanced level of knowledge and skills, improvements in technology used, and ultimately: higher production level, more sustainability, less risks, etcetera.

Ideally we should set objectives of training at all four levels. The formulation of performance objectives enables evaluation at level **B** (end of course evaluation) as well as level **C** (impact evaluation). At level **C** and more so at level **D** it becomes very difficult to determine which effects can be attributed to the training programme and what is due to other sources of change.

7.2 When do we evaluate?

Before the training

- to match the course (objectives, methods, organization) with the training needs of organization and individuals
- to pre-test educational material

During the training

On-going evaluation is an essential *precondition* for applying participatory approaches in group learning events. it does not suffice to have an evaluation at the end of the course during which the participants express their opinion and appraisal of the event by means of a questionnaire or a discussion. Ongoing evaluation by the participants is an essential element of the participatory learning process:

- to stimulate the participation of the participants in the steering of the course and
- to make them *share responsibility* for the course;
- to optimally *adapt contents and learning methods* to participants' needs and interests;
- to *develop a good team spirit and learning climate;*
- to stimulate learning.

End of the training

- to get feedback from participants on the organization and implementation of the training course
- to assess the learning outcomes

After the training

- to evaluate impacts on performance on the job and at farmer's level
- to determine cost-effectiveness
- to give individual follow-up
- to determine the requirements for additional follow-up and institutional support

7.3 Who will evaluate?

Before training: Training organizer
During training: Participants and trainers
End of training: Participants and trainers (partially: training organizer)
After training: Training organizer, supervisors, trainees, clients (and sometimes outsiders)

7.4 How do we evaluate?

Before training: see needs assessment and pre-testing

During training: see in-course evaluation

End of training:

- performance tests
- self-assessment
- group discussion
- questionnaire
- interviews

Impact evaluation:

- Interviews
- individual participants
- clients of participants
- role-set

- analysis of cases/critical incidents
- job performance analysis (before/after observation)
- evaluation seminar with group of ex-participants and job-related other persons
- action learning network: ex-participants exchange experiences amongst themselves and with the training institute.

7.5 Evaluation techniques

Some of the evaluation techniques you might use during implementation of a group learning event are:

- **keyword collection** on cards to answer in an early stage of the workshop the question *"what should happen, what should not happen in this workshop"* and *regular review* during the workshop of the degree in which *rules* established are maintained;
- **establishment of an evaluation committee,** which presents every morning first hour their evaluation of the previous day followed by a short discussion amongst participants;
- **daily mood barometer,** each participant places at the end of each day a dot on a chart representing his/her evaluation of mood and atmosphere of that day. The "weighed" average of the dots for each day can be connected; the resulting lines represents the changes in group atmosphere over time;
- **group growth barometer,** all participants give scores to a limited number of questions with respect to both task- and maintenance dimension of group learning. On a chart or blackboard the individual scores are numbered. In a short discussion very low or high scores (indicating different views on what is happening) can be discussed and group scores can be compared with the results on previous days;
- **making a drawing, poem or song** in a small group representing their feelings about the learning event, might function well to express more subjective feelings and discuss group development and interrelations between participants;
- **reflection on slides, drawings or charts** representing the main topics of the programme might be helpful to discuss the main learning results; **case-studies** dealing with key-problems might be used to assess the level of learners' achievement;
- **simple but well-chosen questions** are an effective tool for evaluation of small group work or plenary sessions. (e.g. "what has been helpful/not helpful so far?" "What suggestions do you have to make group learning more effective?" etc.;
- **informal oral interviews:** talk with participants during drinks, dinner, etc. to get some valuable feedback of the participants;
- **structured interviews/written questionnaires** might provide you with additional information about individual achievements and participants' views on the learning event;
- **observation**: continuous and sensitive observation of verbal and non-verbal behavior of individual participants and of group interactions brings you in touch with participants' feelings (and this may lead you to the right questions or other interventions).

The above-mentioned techniques refer mainly to the evaluation of the group learning process. What about the individual learning progress? What about tests and exams?

In conventional teaching tests and techniques play an important role: it provides the main selection mechanism. In participatory training we are not interested in "grading" the participants. What matters is that participants get feedback on their attempts to improve their knowledge and skills and discover how to further improve, and that the trainer learns where training was effective and for whom or on what points extra efforts are needed. In (adult) education we want everybody to do well.

Also in participatory adult education the group will apply tests but with other aims and of another nature than in conventional learning approaches. Tests will focus on thinking and understanding, rather than on memory and repeating facts. Tests will have focus on performing what has been learned (on behavioral skills: e.g. solving a problem or implementing certain tasks, rather than filling in questionnaires (theory book knowledge). Tests will be the start of new learning, rather than just measuring the result of earlier sessions. In participatory education participants will help each other to find the appropriate solutions and are encouraged to use all the materials available, instead of the complete isolation that is common practice in conventional approach testing.

8 Guidelines and tips for training of trainers

Training is more effective if visuals are used to communicate and if participants actively participate in the workshop proceedings – or in the words of Confusius1: '*I hear and I forget; I see and I remember; I do and I understand.*'

Below you can find a series of pointers and considerations that can be used in any training of trainers exercise.

Planning/preparation checklist for facilitators

- Think of the best trainer/facilitator you ever had; list qualities that made them great; then identify your weak points as facilitator and try to improve
- Arrange for an acceptable venue (light, electricity, nice table setting where people can see each other - with break-out rooms, refreshments, visual equipment)
- Make sure you have all the (visual) materials needed - paper, pens, flipcharts, tape, markers, etc.;
- Ensure you understand and have internalized all tools before being a facilitator otherwise you can't talk with confidence
- Prepare well and rehearse

Good Techniques/Practices for Training

- Relax and energize participants. Facilitate name-learning
- Familiarize participants with each other and with organizations represented
- Ensure all participants understand the aims and objectives of the workshop;
- Always properly introduce the key aims of the training, and use an ice-breaker through which everybody is introduced, especially if you do not know participants well. Icebreakers are very important to keep a group interested and working together effectively. They are useful for training workshops, and for the actual monitoring process that involves group discussions and exercises
- Ensure all the activities planned for the workshop are acceptable to the participants
- Agree upon a timetable
- List expectations, and get a sense of the level of knowledge present among participants at the start of the training
- Adapt the programme to address the felt needs and make and modifications to content or
- structure as requested by the group
- Agree to 'rules' of the workshop (e.g. mutual respect, one speaker at a time, no mobile phones, etc.);
- Emphasize 'learning by doing' as the approach that will be taken during training;
- Start every day with a recapitulation of the previous day. Then introduce the agenda for the day and seek inputs. For every training block explain what they will do, then do it, then summarize what was done including a list of key points (if possible summarized by participants)
- Use a variety of communication methods: show a wide range of visual aids (simple, easy to read in color and size, key words not long stories), involve children, encourage plenary discussion, group work, individual work, role-playing, etc.
- Role-play a bad facilitator versus a good facilitator for contrast and clarity
- Also remember to incorporate activities that: invigorate participants and refresh participants (who have been working hard) in between training activities;
- Stick to time-frames where possible
- Have a strong closing session where you review aims and expectations, summarize what was learnt, commit to action, and close with appreciation and congratulations

- Always build in an evaluation of the training as improvements can always be made. Any simple evaluation is suggested to focus on the following questions:
  - What did you like about the training?
  - What suggestions do you have to improve future training sessions?
  - What will you do as follow up to the training?

Attitude/behaviour as facilitator

- Stay relaxed and calm
- Be open and honest
- Be a good listener; observe, record, observe, record…
- Do not panic when the group in silent; wait patiently for them to think about what they want to say;
- Do not interrupt people
- Do not make judgments of people's responses (for example, saying that 'this is good, and that is bad') or humiliate anyone
- Do not let arguments dominate the discussion; encourage participants to re-focus on the main topic
- Have eye contact, stand up and move around, speak slowly, use your voice (intonation)
- Make it as interactive as possible - involve and engage participants. Ask questions and invite participants to tell their stories;
- Use humor if natural for you, and smile
- Choose words, stories, numbers, and cases that capture interest (use real examples to illustrate your points)
- Address concerns, questions, issues as raised by participants, while sticking to the main
- messages you want to get across

Reference

For further reading, please be referred to ILO TICW-project's publication on Participatory Project Monitoring – in particular the Annex on Training of Trainers.

9 Summarising the training plan

To conclude this guideline the main elements of the training plan are listed briefly once more:

- Provide a brief description of **the training participants** that includes information on their designation and responsibilities, their background, motivation, etc. as well the number of participants
- **Clearly formulated aims and objectives** through which you make your intentions explicit for yourself, your colleagues and ultimately the trainees
- A summary overview of **the subject matter of the training** in line with the objectives and needs and interests of the participants
- The **training methods and media** that you intend to apply and which taken into account the needs of different learning styles, the nature of the aims, objectives and subjects, the available facilities, budgets and time and your own preferences and talents
- A **summary of the main organisational issues** such as the sequencing of the activities, the required resources and facilities, the division of responsibilities and the timing in preparation and implementation.

In chapters 10-20 of this training manual, you will find examples for planning of training and training sessions.

10 Sample training programme outline

Training Title: Melon production in tropical lowland greenhouses

Participants: The participants (10) of the course will consist of senior trainers from NATC (7) and extension officers (3)

All participants have substantial knowledge and expertise related to the greenhouse production, and 5 of the participants have extensive experience in melon production. Although most of them have a theoretical grasp of IPM, none of them have any practical experience with IPM, neither with crop production in tropical lowland greenhouses. Both target groups will become responsible for training current and future farmers in tropical lowland greenhouse production.

Aims and Learning Objectives:

The overall aim of this course is to provide the participants with a clear perspective on how to operate a tropical lowland greenhouse together with the corresponding computerized system for fertigation.

At the end of the course the participants should be able:

- Explain set up of greenhouse, hardware and software of the computer system and their impact on production
- Describe climate management in the greenhouse and explain its impact on production
- Explain and demonstrate how fertigation is used in the greenhouse
- Explain and demonstrate use of hygiene measure in and around the greenhouse
- Scouting: Explain what scouting is; Demonstrate how to carry out scouting in any greenhouse with help of greenhouse map; Based on observations make a decision on whether control measures are necessary, and if yes, what kind
- Describe crop management principles for lemon in the greenhouse
- Carry out cost-benefit analysis for different scenarios (e.g. 1,5, 10 greenhouses; different produce)

Key subjects:

- Introduction to tropical lowland greenhouse production
- Construction and installation of the greenhouse
- Climate management
- Fertigation
- Hygiene measures in and around the greenhouse
- Scouting and monitoring
- Integrated pest management (IPM)
- Crop management
- Economics; cost-benefit analysis

Training methods

- Orientation visit to the tropical lowland greenhouse
- Orientation visit to other type of greenhouses; comparison between the different types
- Guided group discussion centred around the key subjects above
- Lectures on construction of greenhouse, hardware and software of computer system, cost-benefit analysis and on integrated pest management

– Hand-out summarising the above mentioned lectures
– Group exercise:
  - Scouting
  - Cost-benefit analysis
– Presentation of the outcome of the group exercises followed by a discussion

Organisational issues

– Tentative programme:
  - 9 times half a day programme in a 12-week period (during the life-cycle of melon)
– Resources:
  - Lecture/meeting room for the given days
  - Hand outs on based on programme
  - Slides matching given lectures
  - External resource people: farmers having already experience with tropical lowland greenhouse production
– Responsibilities:
  - Department of Agriculture staff: overall coordination, contacting external resource people, preparation and implementation for all days
– Timing:
  - Programme discussed and finalised 3 weeks before it commences
  - External resource people contacted 3 weeks prior training programme
  - Notes for presentation and hand outs ready 1 week before training programme commences
  - Expected dates of course: as agreed on

Recommended programme

	Training topics	**Key learning points**
Prior to production	General introduction to greenhouse; Construction and installation	Describe impact of the tropical greenhouse in lowland tropical horticulture Identify differences between traditional greenhouse and a xx greenhouse
	System check greenhouse:	Demonstrate how to prepare greenhouse for next production cycle: repair greenhouse construction, cover, ground plastic, doors, etc. (development of a check-list: e.g. At least once every 3 seasons (rock melon), refresh polybags and cocopeat, remove all weeds inside and around the greenhouse, destroy old shoes, buy new ones, empty waste bin, clean greenhouse, etc.)
	System check fertigation system	Control whether system works
	System check computer system	Describe computer system in the tropical greenhouse Describe how computer makes decision Evaluate whether the computer has made the right decisions based on the records Exercises 1 and 4

Week 1	Crop management 1	Describe the important steps during a season. Develop strategic choices related to production Translate strategic choices into operational decisions.
Week 2	Fertigation	Describe fertigation; how it can be implemented Develop fertigation strategy Perform necessary checks
	Hygiene measures	Explain why hygiene measures in the greenhouse are essential Define list of hygiene measures for tropical lowland greenhouse Demonstrate how to implement hygiene measures in lowland greenhouse Check whether hygiene measure are properly implemented in greenhouse
	Scouting and monitoring 1.	Explain what scouting is Demonstrate how to carry out scouting in any greenhouse with help of greenhouse map Based on observations make a decision on whether control measures are necessary, and if yes, what kind
Week 3	IPM	Explain why hygiene measures in the greenhouse are essential Define list of hygiene measures for tropical lowland greenhouse Demonstrate how to implement hygiene measures in lowland greenhouse Check whether hygiene measure are properly implemented in greenhouse
	Scouting and monitoring 2.	Repeat exercises from Scouting 1.
Week 4	Crop production 2.	Continue with previous crop management session
	Climate management	List and explain key factors in relation to climate management in the tropical greenhouse Explain how the tropical greenhouse can contribute to optimal climate management Evaluate collected climate data in relation to settings and decisions made by the computer system.
	Scouting and monitoring 3.	Repeat exercises from Scouting 1.
Week 5	No training	
Week 6	Economics (cost / benefit analysis)	Compute in a simple manner the costs of a greenhouse Compute in a simple manner the benefits of a greenhouse Compute in a simple manner the net profit of a greenhouse Compare the net profits of different greenhouse types
	Scouting and monitoring	Repeat exercises from Scouting 1.

Week 7	No training	
Week 8	Fertigation 2.	Evaluate fertigation system operations on cloudy / sunny days
	Computer system	Implement exercises 2 and 3 to check computer systems
	Scouting and monitoring	Repeat exercises from Scouting 1.
Week 9	No training	
Week 10	Scouting and monitoring	Repeat exercises from Scouting 1.
Week 11	No training	
Week 12	Scouting and monitoring	Repeat exercises from Scouting 1.
	Sanitation	Evaluate and implement what needs to be done at end of production cycle and in between production.

11 Training session on general introduction to greenhouse for tropical lowlands

Learning objectives

By the end of the training session, participants will be able to:

- Describe impact of the tropical greenhouse in lowland tropical horticulture
- Identify differences between traditional greenhouse and a xx greenhouse

Structure for training session

1. Introduction to the tropical greenhouse in a classroom (30 minutes).
2. Participant define differences between a traditional greenhouse and a tropical greenhouse (40 minutes).
3. Reflection on exercise in classroom (30 minutes).

Background information

There is a growing demand for high-quality vegetables in Malaysia and surrounding countries. Greenhouse production in lowland tropics is possible if a well-designed greenhouse is used that keeps the temperature relatively low, enables integrated pest management and is equipped with a computerized fertigation system.

Demand for quality. An increasing group of consumers wants high-quality vegetables, and farmers want to combine high quality and high production. This is possible in a greenhouse that is specifically designed for the conditions in the lowland tropics.

Greenhouse design and climate management. The main climate characteristic of the lowland tropics are high temperatures and high humidity levels. High natural ventilation rates (mechanical ventilation costs too much energy) keep the temperature and humidity similar to the outside ones. This is achieved through open sides and a chimney construction in the top.

Integrated pest management. The greenhouse itself is an important pest protection device, provided it is equipped with screens in all openings, and a double-door system. Stringent sanitation measures limit the unwanted spread of pests and diseases. These and other elements of integrated pest management lead to a minimum use of chemicals and lower the residue levels of the fruits.

Water and nutrients. It is very important to maintain crop transpiration as this cools the crop canopy. Transpiration rates are high in the lowland tropics, especially around noon. Wind speeds are often low at that moment, which increases the need for good ventilation. Irrigation frequencies of several times per hour are needed, which can only be realized by a computer-guided irrigation system. A computer system can also balance the concentration of nutrient, avoiding over-use of expensive fertilizers.

Crop management. In comparison with cultivation outdoor and in traditional greenhouses, the crop will be more productive. In the case of rock melon, for instance, more fruits per square meter can be grown.

Therefore, the number of fruits per stem, the number of stems per plant, and the number of plants per square meter must be carefully balanced. Some experimenting by the farmer is required here.

Business case. A greenhouse of this type has a pay-back time of approximately 2.5 – 6.2 years, depending on the computer system used and interest rate assumed (see also the chapter with exercises on Economics). Because of the high-quality products, integration in a demand-driven value chain offers much prospect.

Exercise on general introduction to greenhouse

Objective of exercise: to identify and explain differences between a traditional and a tropical greenhouse.

Preparation for exercise by facilitator: list of key differences between a traditional greenhouse and a tropical greenhouse. They are requested to do this in terms of climate (temperature, light), crop management, crop performance, harvested product, water and nutrient application, skills of the grower, and other aspects.

Needed tools:

- Paper
- Pens

Explanation of the exercise

1. Participants form groups of 4.
2. Participants will brainstorm in groups on the expected differences between a traditional greenhouse and a tropical greenhouse. They are requested to do this in terms of climate, crop management, crop performance, harvested product, water and nutrient application, skills of the grower, and other aspects.
3. Participants will present their findings in plenary session.
4. Facilitator merges findings, add his / her own thoughts to present a complete overview of the differences.

Reflection on the exercise:

To enhance discussions, the following issues could be touched upon:

- Situation in the Cameroon Highlands
- Situation in the tropical lowlands – climate
- Specifications of the greenhouse system
  - Climate (temperature, light transmission)
  - pest and disease management, sanitation
  - fertigation
- Results on climate
- Results on pests and diseases
- Results on fertigation
- Results on production
- Business case
- Prospects, value chain

12 Training session on greenhouse construction and installation

Greenhouses protect the crop from rain and insects in tropical regions. Greenhouses also reduce radiation levels which is beneficial for the crop during periods of high radiation. Given the climate at the low land of Malaysia cooling a greenhouse is most economically done by natural ventilation. The greenhouse is therefore designed for maximum natural ventilation. The final design was a three span greenhouse with tilted side walls fitted with insect nets to reduce air resistance and top vents allowing hot air to leave the greenhouse specially in no wind conditions.

Materials. The construction is made of aluminium, which is light and strong, and can be obtained locally. The construction can be manufactured locally. Since the primary goal of a greenhouse in Malaysia is to protect the crop from rain and insects, the covering is made of plastic and the side walls are made of insect nets allowing ventilation (mesh 32). These holes may not be small enough for all pests (e.g., trips is very small), but ventilation becomes too low if a net with smaller holes is used. The cover diffuses the solar light which thereby is distributed more evenly over the crop. A covering with a high light diffusing property (haze more than 70%) can increase production by more than 8%.

Installation. It is important to use a good-quality installation. If pumps, valves, computers, etcetera break down, then this easily results in strong yield reduction. And if the installation does break down, it must be repaired without delay.

Water discharge. The discharge of rainwater should be so that is does not harm the crop. Gutters must be well-connected. Optimally this water is gathered and stored to be used as irrigation water since the quality of rainwater is high.

Maintenance. The barrier for rain and insects should be maintained properly in order to reach good quality production. The greenhouse cover must be cleaned periodically, as otherwise the light is blocked. How to clean the roof should be considered. It is important to have budget available for immediate repairs.

Surroundings. The surroundings of the greenhouse determine the production as well. Free ventilation may be blocked by surrounding buildings, vegetation or hills increasing the greenhouse temperature. Also surrounding vegetation or other farms increase the chance of insects and pests.

<u>Exercises</u>

1. Participants form small groups, and move to the greenhouse
2. Participants move around the greenhouse (and inside, if there is no crop), and register and discuss specific design issues.
3. The issues are discussed plenary.

13 Training session on the computer system

Learning objectives

By the end of the training session, participants will be able to:

- Describe computer system in the tropical greenhouse
- Describe how computer makes decision
- Evaluate whether the computer has made the right decisions based on the records

Structure for training session

1. Introduction to the computer system of in the tropical greenhouse, in terms of hardware and software settings (30 minutes).
2. Participants define checks for computer and devices followed by discussion (30 minutes)
3. Participants perform checks and discuss whether the computer made the right decisions; discussion follows (45 minutes).
4. Participants define desired computer system on their farm; discussion follows (30 minutes).

Background information

The computer system consists of sensors that obtain environmental information, a computer that receives the information and takes operational management decisions, and devices such as pumps and valves with which the decisions are implemented. The computer takes decisions on the basis of settings that are provided by the grower. Therefore, it is the grower who is ultimately in command and responsible!

Sensors. Any good decision in greenhouse horticulture can only be taken on the basis of objective information. Sensors that obtain information on the greenhouse environment provide that. Most relevant is information on solar radiation, soil moisture content, outdoor and indoor temperature, and indoor relative air humidity. The sensors must be checked (cleaned and calibrated by the supplying company, for instance) as they will otherwise not provide correct information and wrong decisions are taken.

The computer. The computer itself is the hardware, that must be of high quality as it should not break down; equally or more important is the software. The software processes the environmental information, combines it with the settings, and takes in name of the grower an operational decision. For instance, with regards to the irrigation frequency and the electrical conductivity (EC).

The computer is a delicate device. It must be well-protected against lightening with a pole, power surges, and unwanted software (viruses, malware, and others). Use for other purposes than greenhouse management should be forbidden.

Devices. The devices receive instructions from the computer to realize, for example, a certain irrigation frequency and EC. A/B solutions are mixed with water and sent to the plants at given moments, for a given duration. Devices should be checked in advance of the season and a number of times during the season.

Settings. The computer software needs settings to make decisions. For instance, the grower should indicate at what soil moisture content a new irrigation must take place. The computer will then execute this instruction coming from the grower.

Text box 4	Settings of the computer system

The computer in the tropical greenhouse is supplied by the Priva company, and is of the 'Maximizer' type. It is a fairly advanced system (but not the top model) that is able to manage the application of water and nutrients. It can do this separately for a maximum of ten greenhouse.

In the projects, the some of the settings used were:

- The EC of the irrigation water gradually increases from 1 to 3 during the season. The EC is a measure for the nutrient concentration. These values are for rock melon; a different crop needs different values. Please consult an expert.
- At sunny days more water is applied than at dull days. At sunny days therefore, the EC is lowered, as otherwise too much nutrients would be applied over the course of the day. Please consult the manual and/or an expert for details.
- The amount of water to be applied is based upon the reading by the soil moisture sensor, which is placed in one of the polybags. If the reading falls below the set point (for example, 475 – see below), then water is applied.
- At the beginning of the season, the readings of this sensor must be calibrated. A polybag filled with cocopeat is brought to the right moisture content, the soil moisture sensor is placed, and the value provided by the soil moisture sensor is stored in the computer system for reference during the rest of the season. It takes 30-60 minutes before the reading stabilizes. This value is probably somewhere in the range of 470-480 (the value itself is meaningless).

Data. The computer records all information on the settings, environment and decisions. These data must be evaluated on a daily basis in order to determine whether the cultivation strategy is correctly implemented given the environmental conditions.

More / less advanced computer systems. A good computer system is able to determine the amounts of water and nutrients that are needed by the crop, and is able to mix these independently from each other. If much water is needed because it is a bright day, only the amount of water will be increased. The amount of nutrients does not change, and therefore, the nutrient concentration is reduced (although EC requirements by the crop may put limits to this). More simple systems will not be able to manage water and nutrients separately, which results in a sub-optimal fertigation regime.

Exercises on computer system

Objective of exercises: to explain how the computer system operates in the greenhouse

Preparation for exercise by facilitator: check whether computer system works properly. The facilitator should understand the working of settings and computer decisions.

Needed tools

- Paper
- Pens
- Access to computer system of the greenhouse

Explanation of the exercises

Exercise 1

1. Participants will form groups of maximum 4
2. Facilitator asks participants to brainstorm how the sensors, the computer and the devices could be checked before the growing season.
3. Groups present their findings in plenary session.
4. Facilitator draws up final check list together with participants

Exercise 2
Exercise 2 is a follow-up on exercise 1.

- Participants read Appendix 10 on the Systems check of the computer and irrigation system.
- Participants operate in groups.
- The facilitator removes the wet sock from the measuring box and puts it onto the wrong probe in the box. Participants try to observe the difference on the computer screen.
- Increase the level in pressure between different greenhouses and let the students try to achieve the same levels in the different greenhouses.

Exercise 3

1. Participants perform checks in the same groups
2. Participants are requested to study the sensor information, the settings, and the decisions taken by the computer on a particular date. Have the right decisions been taken? Why (not)?
3. Discussion in plenary session

Exercise 4

1. Participants are requested to describe individually the desired computer system for their farm. What components are needed?
2. Plenary discussion about the desired systems

Reflection on the exercise

To enhance discussions, the following issues should be discussed:
- Use high-quality components for sensors, computer and devices. Protect the system against damage and unwanted software.
- The grower is responsible for the settings and the fertigation strategy. The computer just takes operational decisions in name of the grower.
- relevance
- maintenance
- settings
- periodic checks
- virus control
- authorization
- data storage
- data interpretation
- what happens when there is a power failure.

14 Training session on crop management

1. - Introduction

Learning objectives

By the end of the training session, participants will be able to:

- Describe the important steps during a season.
- Be able to motivate strategic choices.
- Be able to translate strategic choices into operational decisions.

Structure for training session

1. Introduction to crop management for melon (30 minutes)
2. Participants study the relation between a cultivation strategy and operational decisions that are made during the growing season (30 minutes)
3. Participants perform a check on the quality of the greenhouse (30 minutes)

Background information

The potential production in a tropical greenhouse is higher than in case of cultivation outdoors or in a traditional greenhouse. The management of the crop must make this possible, and should be aimed at a strong plant that reaches maximum production in combination with high quality. A cultivation plant that is made in advance is the sound basis for good crop management from sowing to harvest.

A plan. Crop management starts with taking strategic decisions that are taken at the beginning of the season (only if the situation changes strongly, then the strategy is changed). For example, it is decided to aim for 8 fruits per m^2, and to reach this through 2 fruits per stem, 2 stems per plant, and 2 plants per m^2. The strategy is translated in operational actions during the season. For example, fruits are pruned if more than 2 fruits per stem develop. Cultivar choice is a strategic decision; removal of virus-infected plants is an operational decision.

Record keeping. All activities are recorded in a log book. Whenever a question emerges (for example, when was the last spraying, what repairs were necessary this season?) the log book is used. A lot of other information is also recorded in different ways: climate and fertigation are recorded by the computer and should be studied daily, scouting data, removed plants, production, product quality, costs of inputs and prices of the products sold, etcetera, are all essential information to be recorded systematically. The log book and records are an important element when the season is evaluated – which is important step to improve farming.

Greenhouse. The quality of the greenhouse and its installation determines the production. It is the growing environment of the crop. A complete greenhouse system check is therefore carried out before the growing season. The construction and installation are inspected and repaired, weeds are removed, the growing medium is prepared (in Malaysia usually cocopeat), the greenhouse and the greenhouse cover is cleaned, etcetera. During the growing season, periodic checks and continued maintenance are required.

Seedlings. A healthy and productive crop starts with healthy and strong seedlings. Seeds of an established company are used, as this should guarantee genetic purity and the absence of seed-borne diseases. Seedlings are raised in small pots that are placed inside the greenhouse (or in another place where insects are not present) to avoid early infection. Seedlings are weak, and are best raised under a shade net with adequate quantities of water. Transplanting to the large pots takes place after a few weeks (depends on the crop).

The growing plant. The main objective regarding the growing plant is to create a healthy canopy that intercepts most of the incoming light and will sustain high growth of the fruits. The trick is to leave just the right number of fruits. Too many fruits will lead to small fruits, and too few fruits will lead to large fruits and/or few kilo's. Over the seasons, experience will increase. Binding of the plants (so they grow upward with a nice architecture), putting on additional stem, pruning of side shoots and fruits, and many other activities all are aimed at this capacity of the plant to enable good fruit growth. Greenhouse temperature is low enough to enable pollination with bees, which leads to better fruit set than manual pollination. Crop protection and fertigation (the application of water and nutrients) require continuous attention: observe the situation, decide upon actions to take, and reflect upon the effect of the action (for example, did a different EC indeed lead to a greener crop?)

Harvest. The ripe fruits are harvested, graded (in the case of rock melon in grades A, B and C) at the end of the season and sold on the market.

Exercises on crop management

Objective of exercises: to explain the most important phases of a cultivation cycle, and to understand the making of strategic and operational decisions.

Preparation for exercise by facilitator: ensure access to a greenhouse in advance, and perform own check on the status of the greenhouse. For the harvest, the facilitator is acquainted with fruit grading and knows the market prices.

Needed tools

- Paper
- Pens
- Access to a greenhouse prior to transplanting.
- A camera to take pictures of the greenhouse and crop (and many other items).

Explanation of the exercises

Exercise 1

1. Participants will form groups of maximum 4.
2. Participants select a crop with which they are all acquainted, and list the important phases.
3. Participants list and motivate a number of strategic choices for their crop.
4. Groups present their findings in a plenary session, followed by a discussion.

Exercise 2

1. Same groups as in exercise 1.
2. The strategic decisions of exercise 1 are translated into operational crop management actions.
3. Groups present their findings in a plenary session, followed by a discussion.

Exercise 3

1. Participants will form groups of maximum 4.
2. Participants select a crop with which they are all acquainted, and brainstorm on a number of things that can go wrong.
3. Participants define the causes of the (imaginary) poor crop performance, and provide solutions. Groups present their findings in a plenary session, followed by a discussion.

Exercise 4

1. Before the crop is transplanted, the group visits the greenhouse.
2. Participants form groups of maximum 4.
3. Participants check whether the greenhouse is ready to be used.
4. Groups present their findings in a plenary session, where the facilitator leads a discussion.

Exercise 5

1. The participants engage in harvesting the crop.
2. Participants form groups of maximum 4, and prepare the record keeping.
3. Participants harvest part of the crop (distinguishing grade A, B and C in case of rock melon), and keep good records.
4. Participants compute the production per m^2 and for the entire greenhouse. They also compute the financial returns.

Text box 5	Entrance to the greenhouse

Hygiene measures are very important to protect the crop against pests and diseases (see chapters on crop protection). It depends on the situation whether the participants are allowed into the greenhouse. Here, we have exercises that permit participants into the greenhouse prior to the cultivation season, and at the end of the season when the crop is harvested, and when possible infections can not cause any damage.

Best is to have a greenhouse available for training purposes, and to which participants have access during the entire crop season. It is accepted that production may suffer if training exercises are performed. Then, many more exercises during the season can be developed by the facilitator.

Reflection on the exercise

To enhance discussions the following issues could be touch upon:

- Keep a log book of activities and record all observations. Reflect on this information.
  - Harvest
  - Crop management
  - Learning – evaluation report
- Maintain the greenhouse and its installation, as it is the living environment of the crop.
- Use healthy seed, and raise strong seedlings.
- Focus on the establishment of a healthy canopy, and put on the right number of fruits, which will maximize yield and product quality.
- Greenhouse preparation
- System check prior to transplanting

- Growing medium preparation (cocopeat in Malaysia)
- Transplanting
- Binding
- Additional stems
- Pruning of side shoots
- Pruning of fruits
- Pollination
- Harvesting
- Post-harvest
- Crop protection (see training session 17, 18 and 19)
- Fertigation (see training session 16)

15 Training session on crop management

2. - Climate management

Learning objectives

By the end of the training session, participants will be able to:

- List and explain key factors in relation to climate management in the tropical greenhouse
- Explain how the tropical greenhouse can contribute to optimal climate management
- Evaluate collected climate data in relation to settings and decisions made by the computer system.

Structure for training session

1. Introduction to climate management in the tropical greenhouse (30 minutes)
2. Participant define list differences between a traditional and a tropical greenhouse (40 minutes)
3. Reflection on exercise in classroom (30 minutes)

Background information

A good climate is needed for good crop growth and high production. Especially the temperature is critical in a lowland tropical climate, as high temperatures cause abortion. High temperatures in combination with high radiation and low wind speeds result in insufficient transpiration to cool the crop. In the absence of mechanical cooling (too costly in terms of energy), cooling mainly has to rely on natural ventilation and the use of diffuse foil.

To a crop, a nice climate means: high levels of CO_2, moderate temperatures, moderate to high radiation levels, and moderate humidity levels.

CO_2: High levels of CO_2 stimulate the photosynthesis rate and crop growth. However, the application of CO_2 is not an option in naturally ventilated greenhouses. Not only because the availability is problematic, but also because of the open greenhouse structure any applied CO_2 would escape to the outside. Management of the CO_2 levels is passive, and consists of swift replenishment of CO_2 that is used by the plant through the good ventilation.

Radiation: Radiation is good for photosynthesis. However, high levels of radiation lead to high transpiration rates, as the crop wants to cool itself in this manner. Even when sufficient water is available, then transpiration may be insufficient. Leaves will hang in a ‘droopy’ manner (some crops are more susceptible to this than other crops). This must be avoided, as it is harmful to the growth of the crop. The first measure is the greenhouse design that realizes a high ventilation and a reduced temperature. Measure two is the use of diffuse foil which transforms direct radiation in diffuse radiation. This not only leads to increased production, but also to a lower transpiration.

Temperature: A relatively low temperature is important because high temperatures lead to fruit abortion, and stimulate transpiration. Measures also here consist of the greenhouse design itself and the use of diffuse foil. Additionally, the crop itself has a strong cooling capacity through transpiration. The transpired water contains a certain amount of energy, which leaves the greenhouse through the ventilation openings.

Humidity. The main danger of high humidity is its effect on the spread of some diseases, such as botrytis. High humidity in itself is not really disadvantageous to the crop, although, there is a moderate negative effect on the transpiration.

Exercise on climate management

Objective of exercise: to explain how climate can be managed in the greenhouse

Preparation for exercise by facilitator: extract climate data from records, or makes screen dumps.

Needed tools:

- Paper
- Pens
- Climate data, if possible for a whole season. Or screen dumps of graphics.

Explanation of the exercise

4. Participants will form group of maximum 3
5. Facilitator asks participants to extract from records the climate data of the previous season, and compare the details of a sunny and a cloudy day. What differences are striking? (Remark: it is probably useful if season-long data are provided)
6. After differences are drawn up, participants present their findings by group in plenary session, followed by discussions.

Reflection on the exercise

To enhance discussions, the following issues could be touched upon:

- Ensure a good ventilation rate to manage the temperature, the CO_2 level, and the humidity.
- Ensure a good crop transpiration to further keep the temperature down.
- Use diffuse foil to modify direct radiation in diffuse radiation
- Mechanical cooling: another technology level
- Cleaning of the covering and how the effect can be seen on the climate computer since the radiation will be higher afterwards

16 Training session on crop management

3. - Fertigation

Learning objectives

By the end of the training session, participants will be able to:

- Describe fertigation; how it can be implemented
- Develop fertigation strategy
- Perform necessary checks

Structure for training session

1. Introduction to fertigation (30 minutes)
2. Participants develop fertigation strategy followed by discussion (45 minutes)
3. Participants find the records for a very cloudy and a very sunny day in the computer system, and compare the details of water and nutrient application. They describe the differences, and explain reasons for the differences.
4. Participants perform system check prior to growing season
5. Participants collect the drain water during a cloudy and a sunny day and to compare the quantities and EC. Identify the differences and explain reasons for differences.

Background information

Fertigation is the combination of fertilization and irrigation. The word reflects the fact that in greenhouses, water and nutrients are supplied simultaneously. Both water and nutrient supply should meet the demand of the crop. It is only because of 'system imperfections' that more water and nutrients are applied. If insufficient amounts of water and nutrients are applied, the crop will have sub-optimal growth, be more susceptible to diseases and produce less – or even die. Fertigation is best managed with a computer-based system. This not only saves water and nutrients, but also fuel and electricity.

Plan. A fertigation strategy must be made in advance of the growing season. Especially decisions with regards to the amount of nutrients needed by the crop, and the preferred EC are required. The crop needs usually vary over time (a young plant, an adult vegetative plant, an adult generative plant). The plan translates in computer settings.

Water. An adequate supply of water is essential for the crop. Insufficient water leads to transpiration problems, high leaf temperatures, hanging leaves, wilting or even premature death of the crop. Excess amounts of water cause drainage of valuable nutrients and a root environment that is too wet. The water that is used in greenhouses must be clean, especially free from any pathogens.

Nutrients. Macro- en micronutrients are essential for a variety of physiological processes of the crop. A shortage of nutrients results in sub-optimal growth and production, and greater susceptibility to diseases. Excess supply of nutrients results in a high EC in the root environment, which can be adverse for crop growth, and loss of valuable (also money-wise!) nutrients.

Fertigation – the combination. Fertigation water is prepared by mixing water with nutrients. A and B tanks contain different mixtures of nutrients. The A and B solutions are mixed to a final solution with the proper concentrations of nutrients. The trick is to add water and A/B solutions independently, such that water and nutrients reach the plants in the right amounts, and as little as possible is wasted. Only because of 'system imperfections' more water and nutrients are applied. For example, extra solution is applied to flush out excess of nutrients that build up gradually in the substrate. But this is not a purpose in itself. Also, a crop usually prefers a certain EC, and if this is combined with a high water gift, nutrients may be drained.

Computer-based system. It is extremely difficult to apply the correct amounts of water and nutrients during the day, each day again and again. Not only because of the mixing described above, but also because during hot days (which are standard in Malaysia!) water must be applied very frequently, up to a few times per hour. The water holding capacity of a polybag with cocopeat is low. A computer-based system can manage this nicely. This does not mean that the grower is not in control – on the contrary. The grower can specify the amounts of water and nutrient required, and the computer will ensure that they are applied in the right amounts and at the right moments. Along with the greenhouse construction, pest and disease management, and crop management, a computer-based fertigation system is one of the key elements in the good performance of the tropical greenhouse.

See also box 4.

Record keeping. The computer automatically keeps records, which can be extracted and studied at any moment. It is good habit to do this on a daily basis. The grower remains responsible and should always check an automated system. Also, by daily study of the records, the grower will enhance own skills and understanding.

System maintenance. Of course, the system should work properly. A full system check is required in advance of each season, just as periodic checks are required during the season. A full advance system check includes pipe flushing, checking the drains and drippers, testing whether computer settings result in the desired fertigation water at the drippers. See appendix 10 for details.

A more simple system. It is also possible to use a more simple system. For instance a system that only uses a soil moisture sensor and applies water if the substrate is too dry. This is slightly cheaper in terms of investment, but probably also gives a lower production (some greenhouse tests are needed). There are no other sensors, so no correction for radiation (high radiation –> more water –> lower EC) can be made.

Exercises on fertigation

Objective of exercises: to explain how fertigation is managed in the greenhouse.

Preparation for exercise by facilitator: extract climate data from records.

Needed tools

- Paper
- Pens
- Climate data, if possible, for a whole season
- Access to the computer system of a tropical greenhouse
- Tools to collect water, measure water, EC

Explanation of the exercises

Exercise 1

1. Participants form groups of 5
2. Facilitator request them to develop a fertigation strategy for a rock melon crop, or any other crop.
3. Groups present the developed strategies
4. Plenary discussion follow

Exercise 2

5. Participants stay in the same group formations
6. Facilitator asks participants to find in the computer system a very cloudy and a very sunny day, and compare the details of water and nutrient application. What are the differences, and what has caused these? As an alternative, the facilitator may in advance print a number of screen-dumps from the computer, and distribute these to the participants for analysis.

Exercise 3

7. At the beginning of the season, participants perform a system check (can be done in teams).
   - This requires a training session in advance of transplanting .

Exercise 4

8. Participants are requested to collect the drain water during a cloudy and a sunny day and to compare the quantities and EC. What causes the differences?

Reflection on the exercise

To enhance discussions, the following issues could be touched upon:

- How to make a fertigation strategy. See appendix 3, V –Fertigation for details.
- Do a systems check in advance of the season, and maintain the system during the season.
  - system
  - drain
  - drippers (quantity)
- Study daily study the fertigation regime generated by the computer system.
- Use clean water and high-quality nutrients.
- solution preparation
- computer settings
- pipe flushing
- record keeping
- how to save fuel & electricity
- flushing (advantages and disadvantages)

17 Training session on crop protection

1. - Hygiene measures

Learning objectives

By the end of the training session, participants will be able to:

- Explain why hygiene measures in the greenhouse are essential
- Define list of hygiene measures for tropical lowland greenhouse
- Demonstrate how to implement hygiene measures in lowland greenhouse
- Check whether hygiene measure are properly implemented in greenhouse

Structure for training session

1. Introduction to hygiene measures in classroom (30 minutes)
2. Participant define list of hygiene measures (40 minutes)
3. Visit greenhouse, identify hygiene measure used in greenhouse; compare with own list prepared (45 minutes)
4. Reflection on exercise in classroom (30 minutes)

Background information

Hygiene protocol is the combination of all hygiene measures, and should be treated as a guideline to be applied at the nursery level. In the prevention of diseases and pests, a combination of protective measures should be used. Every single measure below contributes to prevention of disease and pest, and if the total package of hygiene measures is applied in the right manner, there is a good chance of succeeding in the prevention of infection and eradication of these diseases and pests.

Hygiene measures in crop succession

- Remove all plants, tools and other material from the greenhouse.
- Prevent wind-spread of the plant material
- Dispose of all plant material in a well-covered or closed refuse container from the premises within 24 hours
- Prevent contamination of surface water
- Remove leaves, fruits, other plant material and weeds from the soil
- Remove weeds around the greenhouse
- Clean the greenhouse and the remaining parts starting furthest from the entrance with large quantities of clean water
- Take plenty of time for crop succession
- Always work in the same direction
- Place sticky tape in the entrance

Hygiene measure in water systems

- Clean the water drainage by high pressure cleaning with hot water to remove roots
- Fill drip irrigation with nitric acid (pH 1) and leave for 24 h
- Rinse the drip-irrigation with clean water after the nitric acid treatment
- Replace drip pegs with new ones

Hygiene measure in nursery

- Sterilization of sowing equipment
- Take care that the seeds are free of diseases or if you do not trust it a seed treatment is advisable (10% Na_3PO_4) for maximum 2 hours.

Hygiene measures during start of the new crop and control during the growing season

- Use new plastic sheets for paths
- Do not allow people to walk on the soil, then on clean plastic
- Use well-cleaned trays for the plants from the nursery to the greenhouse
- Prevent contact between trays and floor plastic or substrate
- Cordon-off plants that appear to be infected and have tested for the presence of pathogens
- Keep the doors closed
- Only use new or clean clothes and shoes
- Casual staff should not work on more than one nursery on a single day
- Visitors should wear overalls (coats), company footwear and gloves
- Wash hand after arrival and before departure from the nursery.
- Always work in the same direction

Exercise on hygiene measures

Objective of exercise: to define what kind of hygiene measure to take to avoid and prevent pests and diseases in the greenhouse

Preparation for exercise by facilitator: none

Needed tools

- Paper
- Pens

Explanation of the exercise

1. Participants will form group of maximum 3
2. Facilitator asks participants to define classroom a list of hygiene measure to be used in and around the greenhouse: pre-production, during production and after production (see Annex 5 for tomato hygiene protocol for examples)
3. After list has been prepared, participants go into the greenhouse in groups and identify hygiene measures used in and around the greenhouse.
4. Participants go back to classroom and
   - Check for differences in groups between the list of hygiene measures defined before going into greenhouse and after visiting the greenhouse premises.
   - Participants present the differences by groups in plenary session and discuss reasons for the differences.
   - At the end of session, complete list of hygiene measures is drawn up by participants in plenary session.

Reflection on the exercise

The difficulty of this exercise is that not everything can be seen. It is easy to see dirty shoes, or full waste bin, but you cannot see whether something has been cleaned with hot water.

18 Training session on crop protection

2. - Scouting

Learning objectives

By the end of the training session, participants will be able to:

- Explain what scouting is
- Demonstrate how to carry out scouting in any greenhouse with help of greenhouse map
- Based on observations make a decision on whether control measures are necessary, and if yes, what kind

Structure for training session

1. Introduction to scouting in classroom (15 minutes)
2. Introduction of exercise in classroom (15 minutes)
3. Visiting greenhouse, scouting (45 minutes)
4. Reflection on exercise in classroom (30 minutes)

Background information

The primary goals of scouting are to locate and identify pests and diseases, and to observe changes in the severity of infestation. Early detection increases the chances of success of integrated pest management (IPM). On the basis of weekly scouting you decide whether a pest control measure is necessary, when to run and (in case of some spots) where should be corrected. You also determine which pesticide, a method, a natural enemy you use. After treatment you determine whether this has been effective and whether this should be repeated.

Scouting methods

- regularly check your crop by random plant inspections throughout the production area.
- scouting should be performed weekly
- scouting procedures should be as routine as possible
- scout as much plants as possible;
- special attention to plants around any openings (e.g. doors) in the greenhouse
- a daily inspection of the sticky traps and/or indicator plants is ideal. If that is not possible than weekly on the same day
- replace the sticky traps regularly
- yellow sticky traps attract whiteflies, flying aphids, leafminers, trips etc.
- blue sticky traps attract mainly trips
- place them in the same position every time
- this is for determining the increase or decrease of pest population
- the first diseased, or pest-infested plant found on a bench becomes an indicator plant
- this plant is marked with a tag (or cloth peg), so that the monitor can check the same plant daily
- In this way you can follow the development of pest problem
- keep record of data
  - observe trends (increases or declines)
  - compare one season (year) to another

Tools for IPM scouts

- 10x magnifying glass
- traps
  - sticky colour traps (yellow, blue), at least 10 per ha and 10 cm above the top of the plant
  - light traps
  - pheromone traps
- Indicator hosts
- insect pooter and collecting vials
- colour tags (or simple cloth pegs)
- books with pictures for proper identification of pests
- map of greenhouse

Exercise on scouting

Objective of exercise: to make a decision on what control measures to apply in case of pests and diseases in a selected greenhouse

Preparation for exercise by facilitator:
- placing sticky traps into greenhouse minimum a week prior to training.
- Place sticky traps (yellow and blue) in the neighborhood of the top of the plants, maximum 20 cm. This is very important because the flying insects are in the top of the plants. Therefore, do not place sticky traps in the lower part of the plant. The yellow sticky traps attract all kinds of insects, e.g. aphids, white fly, leaf miners, and including thrips. The blue sticky traps are special for thrips. If you expect many thrips you need to place more blue colored traps. Prepare map the day before; bring in pictures to learn from

Needed tools

- Map of greenhouse: indicate each plant on the map in the greenhouse
- Magnifying glass: 10x
- Booklet with pictures on diseases and pests that could be found in greenhouse
- Score card on data of pests and diseases
- Different colored clothes pegs (colored papers), e.g.
  - Pink: Thrips
  - White: White fly
  - Black: Aphids
  - Yellow: Leafminer
  - Red: Mites
  - Green: Powdery mildew
  - Brown: Fusarium wilt
  - Blue: virus

Explanation of the exercise

Participants go into the greenhouse in group of maximum 5. Each participant takes one row of plants with a map of the row, coloured clothes pegs and a magnifying glass and a pen to write. Participants are requested to:

1. Carry out general observations of the plants; how healthy are they?
2. If symptoms can be seen on plant; participants check whether they are caused by a fungus or a virus. Use booklet with pictures to identify fungus and / or virus
3. If they do not see any remarkable symptoms, they will have to look at some leaves both sides. First look without and then with magnifying glass.
4. If participants find insects, they identify insects with help of booklet, and they count on two leaves on both sides the number of the different insects.
5. Participants check and count insects on blue and yellow sticky traps
6. Participants fill out the map of the greenhouse; indicate which are infected with what and how much: e.g. how many aphids there are on the aphid infected plants.
7. Based on the map results, participants fill out the data of pests and diseases score card.
8. Based on the findings during the exercise, participants are requested to make a decision of whether any control measures are necessary.

Reflection on the exercise

In classroom, participants are requested to share their findings (map, score card, decision) in plenary session with the others. In addition, facilitator can pose reflection question, such as: What did you find challenging in the exercise?

It takes time to become good at scouting. It is best to scout twice a week; starting immediately after transplanting. Sticky traps must be placed 1 week before plants are brought into greenhouse, this way, it can be easily determined whether there are insects in the empty greenhouse. Scouting twice a week ensures continuous monitoring of symptoms, and early detection and spread of problems, which helps decision making on spraying.

If you see e.g. 5 flying insects on a sticker trap, spraying is necessary as there are more flying insects in the greenhouse than the ones that get stuck to the paper. Spraying in time is essential to prevent more problems. If only 1 or 2 insects can be seen, spray.

- Only those plants need to be sprayed that are infected and the plants in their neighbourhood.
- Check effect of control during the next scouting session (assuming scouting is carried out twice a week)

It is very difficult to determine what neighbourhood plants mean. You need to scout very well on the surrounding plants. You have to be able to scout very well if you decide to go with spraying specific problem areas. If you are not a good scouter, it is better to spray the whole greenhouse.

Some insecticides cannot be used in combination with certain biological control. Also, attention is needed when bees are placed in the greenhouse for pollination.

You have to break the life cycle of the insect; some insecticides are good for flying, others are good for eggs. You will need to prevent resistance by alternating insecticides or fungicides. After 3 applications, chose another agent.

See Appendix 7 (Visual material for crop protection) for an example of a life-cycle (thrips).

19 Training session on crop protection
3. - IPM

Learning objectives

By the end of the training session, participants will be able to:

- Explain why hygiene measures in the greenhouse are essential
- Define list of hygiene measures for tropical lowland greenhouse
- Demonstrate how to implement hygiene measures in lowland greenhouse
- Check whether hygiene measure are properly implemented in greenhouse

Structure for training session

1. Introduction to hygiene measures in classroom (30 minutes)
2. Participant define list of hygiene measures (40 minutes)
3. Visit greenhouse, identify hygiene measure used in greenhouse; compare with own list prepared (45 minutes)
4. Reflection on exercise in classroom (30 minutes)

Background information

Integrated Production – is a concept of sustainable agriculture developed in 1976 which has gained international recognition and application. The concept is based on the use of natural resources and regulating mechanisms to replace potentially polluting inputs. The agronomic preventive measures and biological/physical/chemical methods are carefully selected and balanced taking into account the protection of health of both farmers and consumers and of the environment.

What is integrated pest management (IPM)?

IPM is control of pest (or diseases) with a combination of chemical and biological agents

- Components of IPM
  - Pesticides
  - Natural control
  - Biological control
- IPM is thus not in contradiction with chemical control but is rather a chemical control strategy, that tries to control a pest (complex) without eliminating its natural enemies
- Modern insecticides (f.e. IGR's) fit better in IPM schemes than broad spectrum biocides formerly used

Why IPM?

- Pest resistance management
  - Spider mite
  - Leafminers, trips, aphids
- Control of secondary pests, lacking selective chemicals
- Marketing
  - Environmental labels (minimal damage to nature)
  - People's health

How to reduce residues?

- Inventarisation of the problematic chemicals
- Supervised control
  - Scouting
- Replacing insecticides
  - Registration procedures
- Developing IPM programmes per crop
  - scouting & monitoring
  - Monitoring pest AND natural enemies
- IPM programmes are very specific
  - Crop, variety
  - Region, climate, season
  - Initial pest density, pest immigration
  - market
  - Available tools
  - Avialable expertise
- ... But do NOT copy
- → develop your own programmes

Tools of IPM scouts

- 10x magnifying glass
- Insect pooter[2] and collecting vials.
- Traps
  - Sticky traps (yellow, blue)
  - Light traps
  - pheromone
- Colour tags

Introducing natural enemies

- Numbers/ha
  - Should be pest related
  - Actually cost related
- Timing, frequency
  - Single inoculative release
  - Continuous inundative releases
- Grid (release points/ha)
  - 25/ha for very mobile species
  - 500/ha for slow flyers
  - 4,000/ha for walking predators

[2] An insect pooter is a little vacuum cleaners for sucking up insect.

Exercise on IPM

Objective of exercise: to make a decision on what control measures to use to reduce pests and diseases.

Preparation for exercise by facilitator:
- Develop a list of pesticides (insecticides and fungicides) used in Malaysia which are compatible with biological control, including bees.
- Collect pictures of insects and symptoms of fungus, bacterial and virus disease (for melon)

Needed tools

- Pen
- Pencil

Explanation of the exercise

Participants will have to evaluate what control measure to take in difference scenarios (classroom activity)

1. Participants will form groups of 4
2. Facilitator hands out scenarios, pictures of symptoms and insects
3. Participants discuss what measures to take
4. Participants present outcome of exercise in plenary session, and discuss

<u>Scenarios</u>

Scenario 1

1. After scouting, 1 insect is found on 1-2 leaves on top of plant in very low concentration

2. A few days after spraying the same insect is found on more plants, and another insect appeared as well.

Scenario 2

An insect is found; production manager decides to place a natural enemy against that insect.. By regular scouting, impact is monitored. Everything is going well. 1 week later, a fungus appears on a few plants. What to do?

Scenario 3

Step 1: There are bees for pollination in the greenhouse; the same insect is found at many places in the greenhouse. What to do?

Step 2: A week later, the number of the same insects increased. What to do?

Scenario 4

Step 1: you see symptoms on a plant; define what it is. It turns out it is a virus spread by an insect. Insect is found in low concentration but spread all over the greenhouse, where there are also bees.

Scenario 5

Go into greenhouse; define IPM control measures

Solution to scenarios

Scenario 1

1. Spray plant and surroundings.

2. Spray the whole greenhouse; as the two insects are quite different, different insecticides are needed. It is not allowed to mix pesticides; leave 1 day pause between spraying. 3 days later scout for insects.

Scenario 2

If infected plants are close to each other, spray only plants. If they are further away, spray the whole greenhouse with an fungicide that is compatible with biological control.

Scenario 3

Step 1: Because of bees no spraying is recommended; biological control is brought in. By scouting define whether biological control is effective against insects.

Step 2: Spray once with insecticide that is compatible with biological control. By scouting define whether number of harmful insect has been decrease and whether bees are still multiplying in sufficient numbers. Have to use the proper insecticide carefully.

Scenario 4

Have to spray with insecticide which is compatible with bees; scout 3 days after spaying. Decides if it is necessary to spray again. Look at the symptoms of the virus whether is spread and what way: low spread / quick spread.

Facilitator can define scenarios similar to the ones above, but use only pictures for insects and fungus.

Reflection on the exercise

Using the right insecticide and fungicide is extremely important when using biological control and bees.

Finding balance between the biological control and harmful insects is challenging.

20 Training session on cost-benefit analysis

Learning objectives

By the end of the training session, participants will be able to:

- Compute in a simple manner the costs of a greenhouse
- Compute in a simple manner the benefits of a greenhouse
- Compute in a simple manner the net profit of a greenhouse
- Compare the net profits of different greenhouse types.

Structure for training session

1. Introduction to a cost-benefit analysis in the classroom (30 minutes)
2. Participants compute costs, benefits and net profit (60 minutes)
3. Reflection on exercises in the classroom, comparison of greenhouse types (60 minutes)

Background information

Greenhouses seem expensive, but the returns can also be high. The net earnings must be considered. It is not wise to cut too much on the costs, as this will lead to lower returns if the production decreases. For instance, saving on nutrients is not wise. Of course, money for investments must be there; a (micro-) financing programme may help.

Greenhouse types. Three types of greenhouses are considered for Malaysia, all with an area of 600 m^2. The traditional greenhouse without a computer and a low and closed greenhouse cover, a tropical greenhouse with a simple computer, and a tropical greenhouse with a more advanced computer.

Investment costs. Investments costs consist of the construction, the installation, the computer system, the storage and packing house, and the water storage system. Because of the small size of the greenhouse, all work can be done by one person and no housing for additional labour is needed.

Operational costs. Operational costs consist of sowing seed, electricity, fertilizers, chemicals (or predators), packaging, humble and bees. It is assumed that in Malaysia, in case of small greenhouses, the land can be used for free. Also water is for free. No salary for labour or a supervisor needs is required.

Maintenance costs. With regards to maintenance, most is spent on repairs of the plastic cover and of the computer system.

Interest. We assume in our exercises an annual interest rate of 11%. Money can be lend to a bank where interest would have been earned. And if money has to be borrowed from the bank, then certainly interest will have to be paid. Therefore, interest is a component in the computation of the total costs.

Total costs. The total costs of a greenhouse consist of the investment costs, the operational costs, the maintenance costs, and the interest. The costs of a tropical greenhouse with an advanced computer are highest, and those of a traditional greenhouse lowest. The difference is mainly caused by the investment costs, and the interest on the investment costs. Operational and maintenance costs do not differ much.

Returns. All financial returns have to come from the harvest. In the case of rock melon, grades A, B and C are harvested. Grade A gives about 9200 kg per year for a tropical greenhouse of 600 m^2, grade B about 2860 kg per year, and grade C about 1140 kg per year. They fetch prices of about 4, 2.5 and 1.5 Ringgit per kg. In total, this gives a return of approximately 50,260 Ringgit per year for the greenhouse.

Net earnings and pay-back time. To compute the net earnings of a greenhouse, both the costs and the returns must be taken into consideration. The result very much depends on the interest rate assumed. The pay-back time for a tropical greenhouse with an advanced computer is estimated at 2.5 years if no interest is assumed, and 4 years if 11% interest is assumed. The pay-back time for a tropical greenhouse with a more simple computer is estimated at 3.3 years if no interest is assumed, and 6.2 years if 11% interest is assumed. And the pay-back time for a traditional greenhouse is estimated at 9.9 years if no interest is assumed. If 11% interest is assumed for a traditional greenhouse, then no profit is made: the earnings are not sufficient to return the loans with this level of interest.

The more advanced greenhouses cost more, but their returns are even higher. This leads to a shorter pay-back-time.

See Annex 6 for detailed tables.

<u>Tools</u>

- The EXCEL file from the CD-rom that goes with this manual.

Preparation moderator:

Preparation participants: Acquire, if possible, financial data from your own greenhouse.

<u>Exercises</u>

1. The EXCEL file from on the CD-rom that goes with this manual contains three sheets: one with data that can be modified, one that makes the computations, and one with the results of the computations.
2. With the moderator, it is as a preparation discussed what data will be varied.
3. Participants work on their own or in groups, and vary the data that can be modified. For instance, the interest rate is modified, or the investment costs. The results are carefully recorded on a separate sheet.
4. The results are discussed in the group.

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For more information about IPM: http://www.iobc-global.org/rs_aprs.html

For more information in biological control agents: http://www.koppert.nl

Appendix 1 – Illustrations General Introduction

Picture 1. Outside view of the tropical greenhouse at the premises of the Department of Agriculture at Serdang, Malaysia.

Picture 2. Inside view of the tropical greenhouse at the premises of the Department of Agriculture at Serdang, Malaysia.

Picture 3. A young rock melon plant with a dripper.

Picture 4. A growing rock melon on an adult plant.

Appendix 2 – Illustrations Greenhouse Construction and Installation

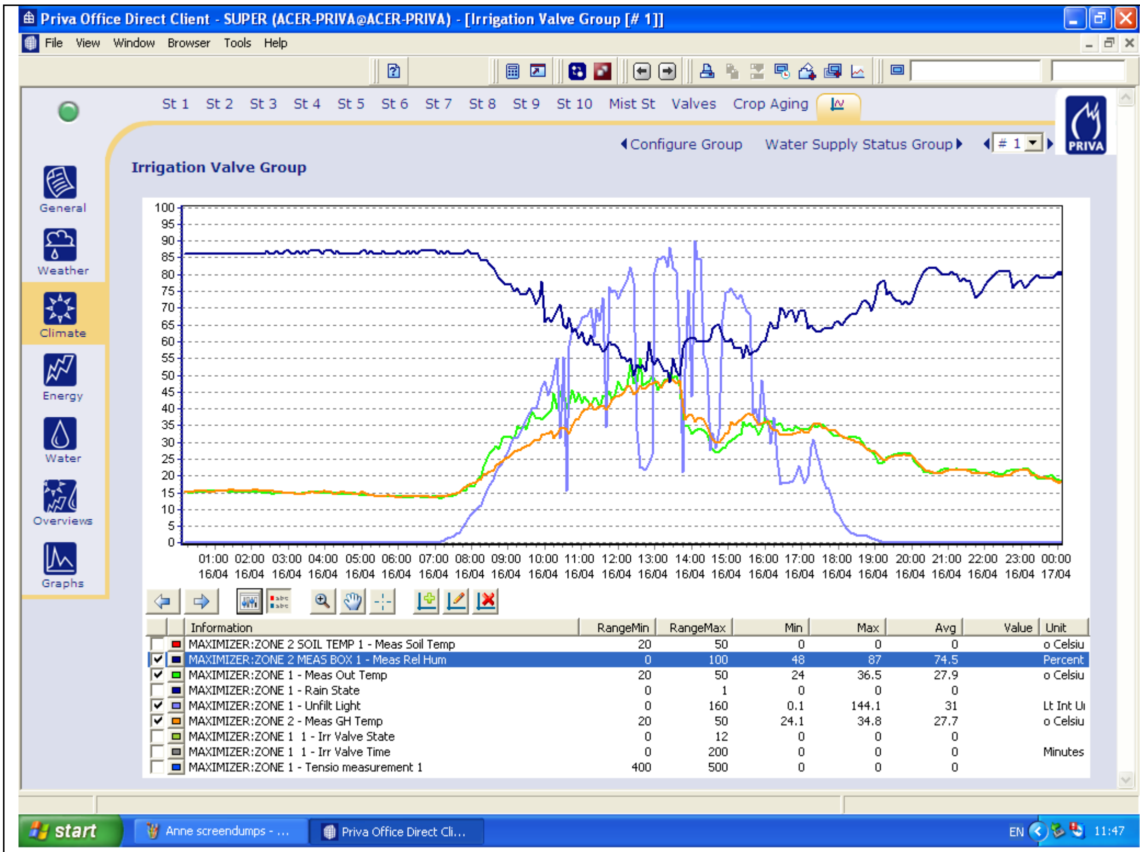





Various phases in the construction of the greenhouses at the Serdang site, Malaysia.

Appendix 3 – Illustrations Computer and Fertigation Systems

Figures 1- 5 are screen dumps of the Priva Maximizer display. They show a variety of climate variables and fertigation details. The values along the vertical y-axis are relative. [For those really interested: Below the figure are two columns: RangeMin and RangeMax. They tell for instance that the measured outdoor temperature varies between 20 and 50 °C. This range of 20 to 50 °C is distributed over the vertical y-axis.]

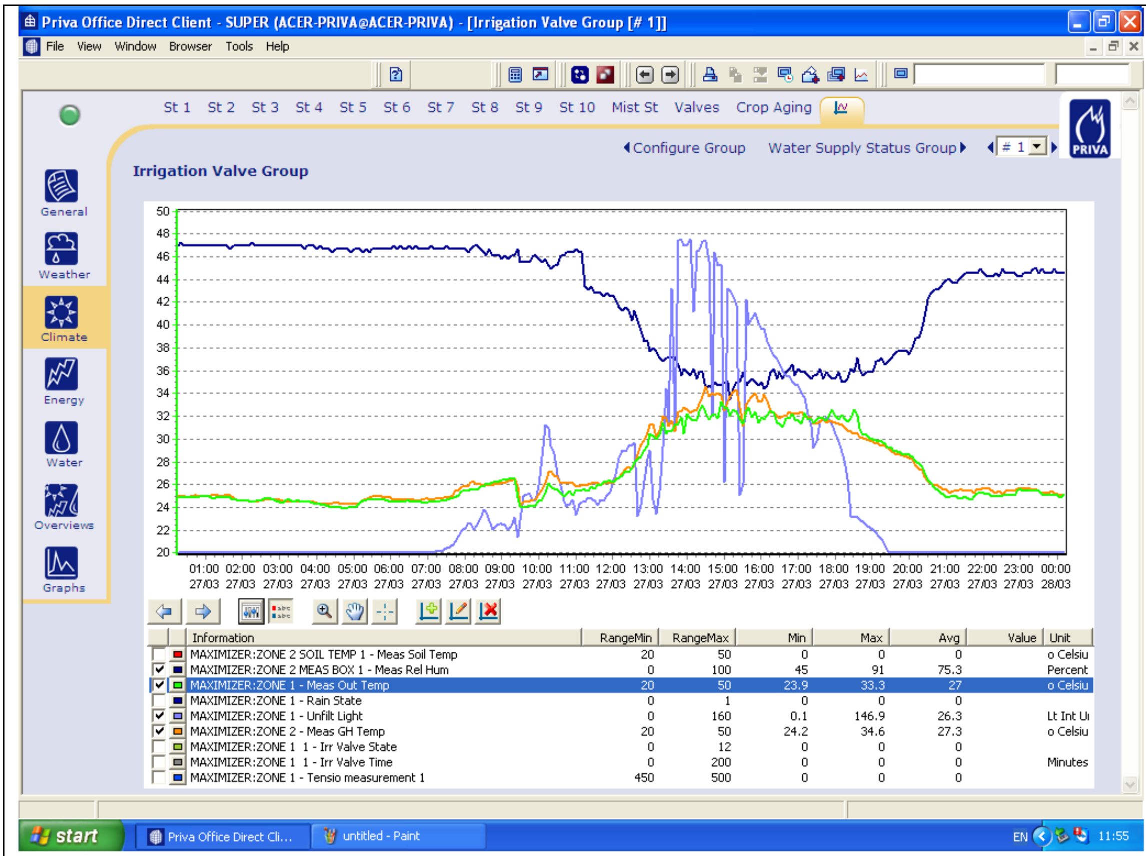


Picture 1. The climate at April 16 2012, Serdang, Malaysia.

Picture 1 shows the climate at April 16th, at Serdang, Malaysia, from midnight to midnight.

- The light blue line shows the radiation, which is zero at night time and peaks during noon. Downward peaks are caused by clouds.
- The green line shows the outdoor temperature, which rises at the moment the sun rises, and gradually decreases in the late afternoon and evening. There is a sharp drop in temperature around 14:00 hours, which may have been caused by rainfall as at that moment the relative air humidity (dark blue line) rises.
- The orange line shows the temperature in the greenhouse. In the morning and in the afternoon it is lower than the outdoor temperature, which is caused by the transpiration of the canopy. During night time, transpiration is much lower than during day time, and therefore, indoor and outdoor temperatures are similar.

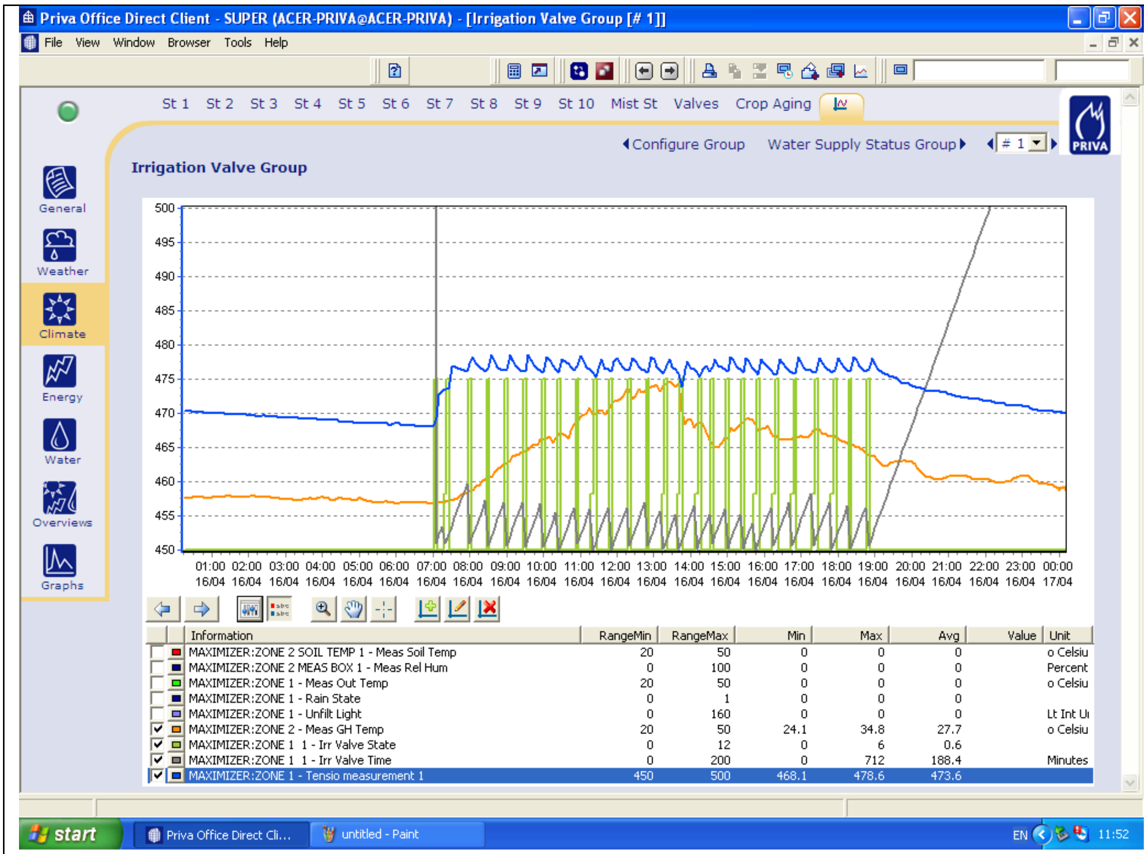
- The dark blue line shows the relative air humidity. It follows the inverse pattern of radiation. When radiation is high (day time), relative air humidity is low.



Picture 2. The climate at March 27 2012, at Serdang.

Picture 2 shows the climate at March 27th, at Serdang, Malaysia, from midnight to midnight. The greatest difference with the climate at April 16th (Picture 1) is the cloudiness in the morning. This has had consequences for the fertigation regime (see Pictures 4 and 5).

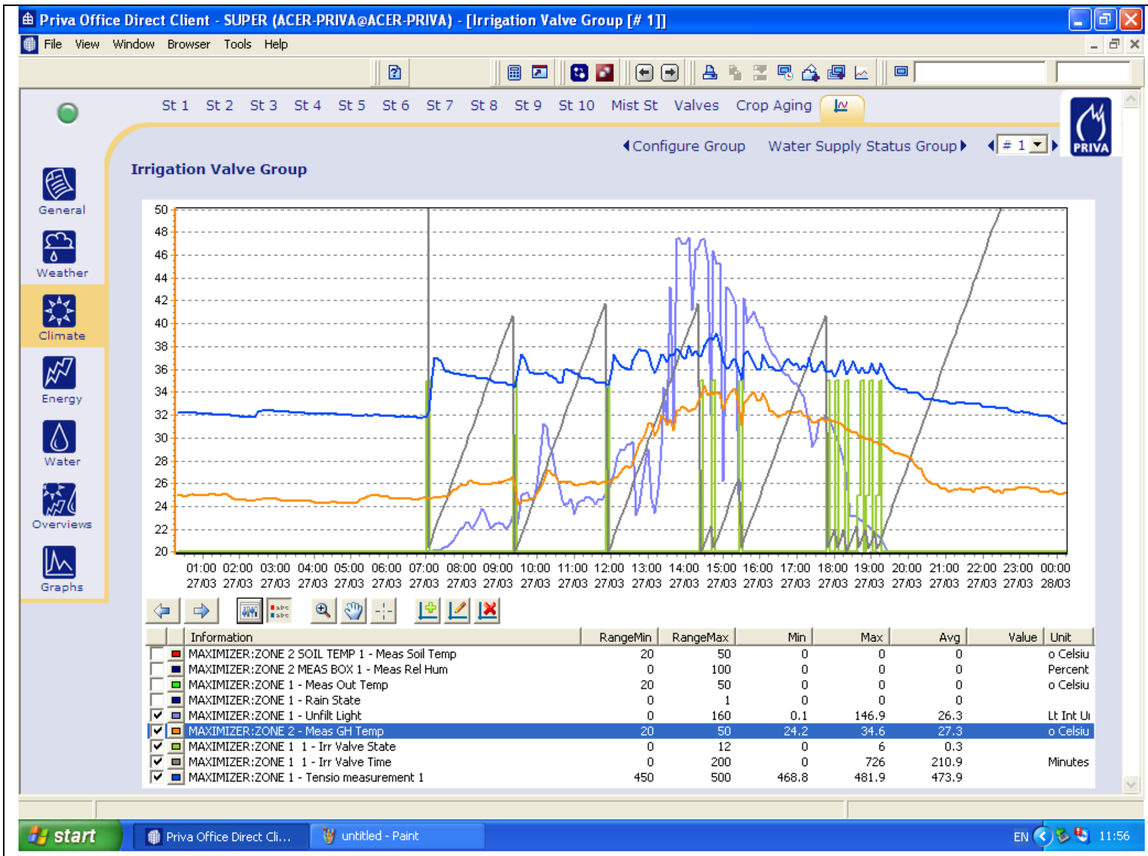
- The light blue line shows the radiation, which is zero at night time. It is low in the morning due to cloudiness, and is high in the afternoon, when the weather has become sunny. Downward peaks in the afternoon are caused by clouds.
- The green line shows the outdoor temperature, which rises at the moment the sun rises in the early morning, and increases more when the sun breaks through in the afternoon. Downward peaks in radiation and outdoor temperature go hand in hand. The outdoor temperature decreases gradually decreases in the late afternoon and evening.
- The orange line shows the temperature in the greenhouse. The greenhouse temperature was most of the day a little higher than the outdoor temperature, which probably was caused by the low transpiration (Picture 4). During night time, transpiration is much lower than during day time, and therefore, indoor and outdoor temperatures are similar.
- The dark blue line shows the relative air humidity. It follows the inverse pattern of radiation. When radiation is high (day time), relative air humidity is low.



Picture 3. The fertigation regime at April 16 2012, Serdang, Malaysia.

Picture 3 shows the fertigation regime at April 16th, at Serdang, Malaysia, from midnight to midnight. It was a day with high radiation, and with only some cloudiness during short spells (Picture 1).

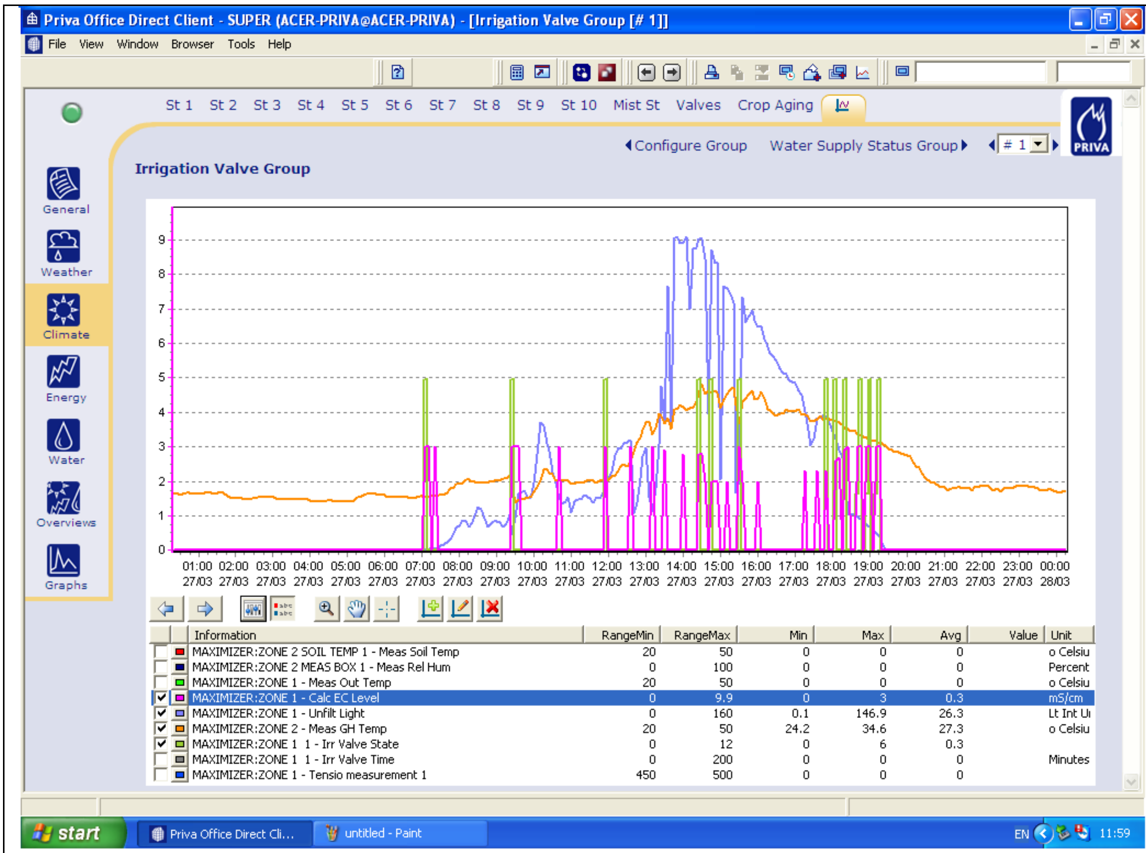
- The orange line shows the temperature in the greenhouse. The drop in the afternoon was probably caused by rainfall (see Picture 1).
- The dark blue line shows the measurement of the soil tension meter. The value fluctuates between 477 and 479. If the value drops to 477, an irrigation is give, which leads to a value of 479. The water is taken up and transpired by the crop, the soil tension reading falls, and new water is given.
- The green line shows the irrigation valve status, which is essentially yes/no opening of the irrigation valves. A peak simply indicates that at that moment water is given. Because of the relatively stable weather conditions during the day, the frequency of fertigation is fairly stable. There are 26 fertigations during 12 hours.
- The purple line shows the duration between two fertigations.



Picture 4. The fertigation regime at March 27 2012, Serdang, Malaysia.

Picture 4 shows the fertigation regime at March 27th, at Serdang, Malaysia, from midnight to midnight. It was a day with low radiation in the morning and high radiation in the afternoon (Picture 2).

- The light blue line shows the radiation.
- The orange line shows the temperature in the greenhouse. It follows the low radiation in the morning and high radiation in the afternoon (see Picture 2).
- The dark blue line shows the measurement of the soil tension meter. It fluctuates during the day. When it is low, an irrigation is given.
- The green line shows the irrigation valve status, which is essentially yes/no opening of the irrigation valves. A peak simply indicates that at that moment water is given. Because of the cloudy weather in the morning, the crop uses relatively little water for transpiration, and few irrigations need to be given. In the afternoon the irrigation frequency increases because of the higher radiation and transpiration.
- The purple line shows the duration between two fertigations.



Picture 5. The fertigation regime, including EC, at March 27 2012, Serdang, Malaysia.

Picture 5 shows additional details of the fertigation regime at March 27th, at Serdang, Malaysia, from midnight to midnight. It was a day with low radiation in the morning and high radiation in the afternoon (Pictures 2 and 4).

- The purple line is the EC of the irrigation water. During the morning and late afternoon it has a value of 3. In the afternoon it has a lower value of 2 – 2.2. The reason for this is that in the afternoon more water is given because the crop transpires more (Pictures 2 and 4). But the same amounts of nutrients are given. With more water, the concentration of nutrients decreases, and thus also the EC.

Appendix 4 – Illustrations Introduction to Crop Management

Picture 1. Just emerged rock melon plants in sowing bed (courtesy DoA).

Picture 2. A very young rock melon plant, recently transplanted, in a white polybak with cocopeat and a soil tensio meter.

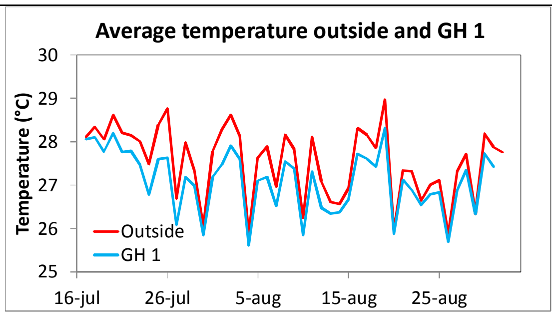
Picture 3. Removal of the growing tip to induce the growth of 2 stems per plant.

Picture 4. Young fruits on an adult rock melon plant. Notice the hanging leaves associated with a transpiration shortage.

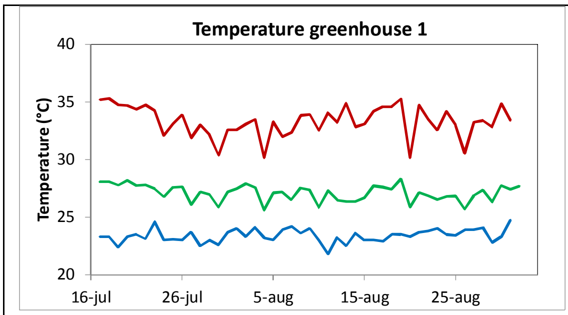
	
Picture 5. An adult crop melon plant with fruits.	Picture 6. Fruit harvest (courtesy DoA).

Appendix 5 – Illustrations Climate Management

Picture 1. Use of high greenhouse foil with high transmissivity and diffuse properties.



Picture 2. In July – August 2010, the average daily air temperature inside the greenhouse was lower than the outside air temperature.



Picture 3. Daily values of minimum, average and maximum greenhouse air temperature in July – August 2010.

Appendix 6 – List of pesticides compatible with biological control

Name	**active ingredient**	**insectice/ fungicide/ acaricide**	**compatible with biological control**
Aliette	fosethyl-aluminium	f	yes
Antracol	propineb	f	yes
Daconil	chloorthalonil	f	yes
Flint	trifloxystrobine	f	yes
Forum	dimethomorph	f	yes
Kochide	copper-hydroxide	f	yes
Polyram	metiram	f	yes
Previcur	propamocarb	f	yes
Ridomil G	metalaxyl + maneb	f	yes
Rovral	iprodion	f	yes
Admiral	**pyriproxyfen**	**i**	**risky**
Confidor	**imidacloprid**	**i**	**no**
Mospilan	**acetamiprid**	**i**	**risky**
Succes	**spinosad**	**i**	**risky**
Sumi Alpha	**esfenvalerate**	**i**	**no**
Trigard	cyromazine	i	yes
Pegasus	**diafenthiuron**	**i/a**	**risky**
Abemectin	**abamectin**	**i/a**	**no**

Appendix 7 – Visual material for crop protection

Pictures of insects, of symptoms fungi, bacterial and viral diseases and of scouting methods

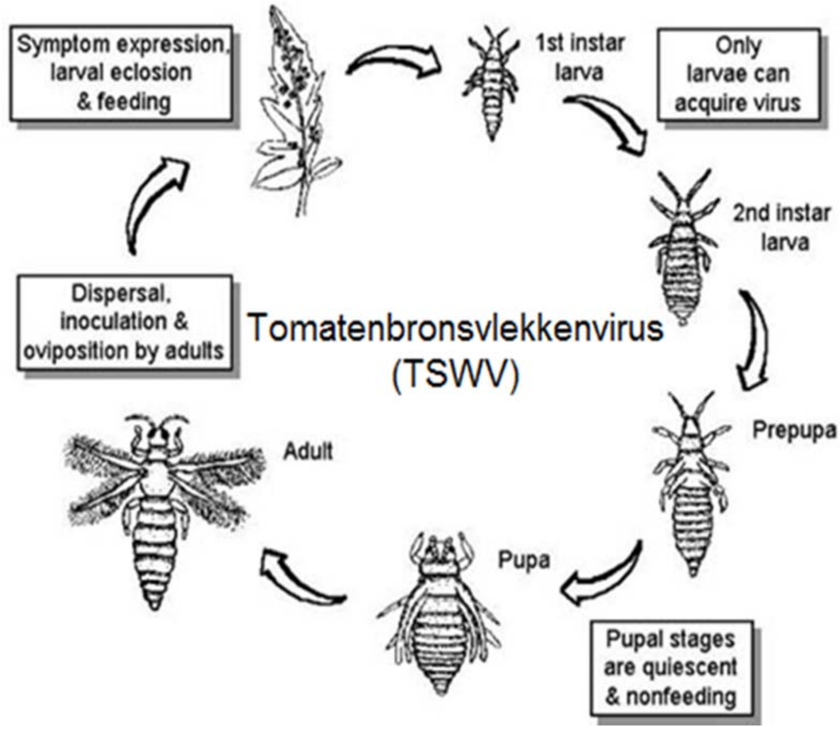
Picture 1. White fly

Picture 2. Thrips

Picture 3-4. Melon yellow spot virus

Picture 5-6. Placing sticky traps on plants

On the picture on the left, yellow sticky trap has not been placed correctly; blue sticky trap is place well on top of plants. Flying insects will find the sticky traps on top of plants, but not on the bottom.



Picture 7. Life-cycle of thrips

(Tomatenbronsvlekkenvirus translates as *Tomato spotted wilt virus* in English)

In the left hand upper corner eggs can be seen on the leave. From the eggs, first instar larva then later second instar larva form, which will turn into prepupa. Pupa will hide in the soil, and can survive depending on the humidity and temperature of the soil. As adult, thrips will lay eggs closing the circle.

The larva can carry the virus, but only as adults can spread it, as larvae cannot move around. As larvae grow, virus multiplies inside them. As adults can fly, they can easily spread the multiplied viruses. You want to spray already in the larva phase to prevent larvae from becoming adults. Bear in mind that some pesticides are larva and adult specific, but not all pesticides destroy the eggs.

It is essential to prevent pupa being left in the soil between in-between crops phase. If you know that there is problem with thrips, spray before you remove plants from greenhouse, as spraying is more effective while plants are still in house with trips on them. 2-3 days later, you remove plants from greenhouse. You can places small host plants into greenhouse to check whether treatment with pesticide was effective by monitoring presence of thrips on host plants. If there are many thrips, you need to spray the greenhouse again.

Picture 8-9-10. Powdery mildew on tomato, cucumber and sweet pepper (from top down)

Picture 11. Aphids

Picture 12. Botrytis on the stem

Picture 13 Thrips

Appendix 8 – Crop management protocol for melon

For a tropical greenhouse in Malaysia

No.	Component of technology	IPM Treatment
I	**Crop planning**	
1	Variety	Glamour
2	Number of seed	900
3	Source of seed	
4	Growing container	Plastic growing bags
5	Size of growing container	10 litre
6	Growing media	cocopeat
7	Number of plants per growing container	1
8	Number of stem per plant	2
9	Distance between rows	1.3 meter
10	Distance in row	35 cm
11	Fertigation system	Priva and pressure control dripper 2l/h
12	Source of AB Mix fertilizer	Pre mixed sets
II	**Cleaning of nursery house and greenhouse for production**	
1	Cleaning the plastic roof of nursery house	One week prior to sowing
2	Cleaning the plastic roof of greenhouse for production	– First cleaning, one week before planting – Second cleaning, 14 weeks after planting
3	Materials for cleaning the plastic roof of nursery house and greenhouse for production	With soap and clean water soft brush broom
4	Materials for cleaning the screen of greenhouse	– Clean water + soap – Water + insecticide profenofos (2ml/L) + fungicide propamokarb-hydrochloride (1 ml/L) – The screen is washed with soap and water, then sprayed with insecticide and fungicide solution
5	Sterilization of greenhouse: a. Materials for sterilization: b. Formulation concentration: c. Methods of sterilization:	Lysol 1 ml per 1 litre water The floor is sprayed with Lysol solution
6	Sterilization of fertigation equipment	Dripper stick and PE hose are dipped in a solution of HNO_3 (1ml/l) for 24 hours and then rinsed with clean water
III	**Nursery**	
1	Sowing container	Sowing tray
2	Sowing media	cocopeat
3	Sterilization of sowing equipment	Sowing equipment (trays, tweezers and sowing cabinet) were sprayed with fungicides propamokarb-hydrochloride (1ml/L)

4	Seed treatment:	
	Type of treatment if need to be done	Seeds were soaked in a solution of fungicide propamokarb-hydrochloride (1ml/L) for 30 minutes or sodium phosphate (Na3PO4) 100 g per litre for maximum 2 hours.
5	Media treatment in nursery:	
	a. Type of treatment	Media is sprinkled with a solution of bactericide oxitetracyclin (1ml/l)
	b. Volume	1 litre per 1000 litres
6	Saturation of sowing media	With clean water
7	Remove foreign object from media	By hand
8	Watering seedling media	
	a. Before germination	
	a.1 Frequency of watering	Every day
	a.2. Volume watering	Until evenly
	a.3 Material watering	Clean water
	b. After germination	
	b.1 Frequency of watering	Every day
	b.2 Volume watering	Until evenly
	b.3.Material watering	AB Mix fertilizer solution
	b.4 EC water ingredients	1.0
9	Containers and media for transplanting of seedlings	
	a. Polybag size	15 x 25 cm
	b. Media for transplanting of seedlings	cocopeat
10	Treatment of media treatment for seedling transplanting if suspect infection	
	a. Type of treatment	Sprinkled with a solution of fungicide propamokarb-hydrochloride (1ml/l) or mankozeb + mefenoksam (2.5 to 5 g/l)
	b. Volume	50 ml/polybag
11	Saturation of media for seedling transplanting	
	a. Material of solution for saturation	AB Mix fertilizer solution
	b. EC and pH solution	EC 1.0 and pH 5.8
	c. Volume of solution	400 ml/polybag
12	Age of seedlings transplanting to polybags (12 cm x 15 cm) in the nursery (days)	8 -11 days after sowing
	Watering nursery:	
	a. Frequency of watering	Tension meter controlled
	b. Volume watering	50 -100 ml/day
	c. Material for watering	AB Mix fertilizer solution
	d. EC and pH solution	EC 1.0/1.5 and pH 5.8
13	Pest control in the nursery if discovered	
	a. Thrips	Sprayed with insecticide abamectin (0.5 ml/l) or spinosad (0.5 to 1 ml/l)
	b. leafminer	Sprayed with insecticide cyromazin (0.15 to 0.3 g/l)
	c. Sercospora disease	Difenokonazol sprayed with fungicide (0.5 ml/l) or azoxistrobin + difenokonazol (0.5 to 1 ml/l)
	Age of transplanting of seedling to greenhouse	8 – 10 days weeks after sowing

IV	**Planting in the greenhouse**	
1	a. Growing container	polybag
	b. Size of growing container	15 cm x 25 cm
	c. Growing media	cocopeat
	d. Washing of cocopeat	With clean water 2-3 days before planting
	e. Saturation of growing media before planting	AB Mix with fertilizer solution(EC 1.0, pH 5.8)
	f. Volume of saturation	2.0 litres/polybag
	g. Planting distance	30 cm (within row) x 130 cm (between rows)
	h. Planting time	Late Afternoon
	i. Watering after planting	2.0 litres/polybag
V	**Fertigation**	
1	Making fertilizer solution ready for fertigation (see details at the end of this appendix)	– Fertilizer A and B, each dissolved in 300 litres of water in a separate container – Prepare clean water in the tank (water storage tank) – Measure the pH of the water. If the water pH >6, add HNO3 solution gradually and mix well, let stand for 2-3 hours and the measuring the pH again. If the pH of the water has not dropped add HNO3 solution again to obtain the desired pH of 5.8 – If the water pH < 5. Add KOH solution gradually while stirring until blended. Leave it for 2-3 hours, then measuring its pH again. If the pH of the water has not climbed add KOH solution again to obtain the desired pH of 5.8
2	Watering and fertilizer (fertigation)	– Volume of fertigation: is based on observations the tensio meter. – At vegetative phase (0-3 weeks after planting – At generative phase (>3 weeks after planting – Fertigation times are decided by tensio meter with the EC steadily increase from EC fertilizer 1.0 to 2.7 with pH 5.8
3	EC out in the drain container	– If the EC out <EC in and the difference is>1, then the EC in should be increased by adding concentrated fertilizers A and B in the fertilizer solution – Example: the EC in is 2.2 and EC out is 0.9, thus the difference is 2.2-0.9 = 1.3 (greater than 1), then the value EC should be increased by adding concentrated fertilizers A and B in the fertilizer solution – If EC out > EC in and the difference is > 1 for three consecutive days, then the thing to do is: – Lowering the value of EC in by reducing the volume of concentrated fertilizer solution A and B on the water container – Washing the media in the polybag with fertilizer solution (lower EC 1.0 to 1.5) with a volume of 2-3 litres per polybag – Example: EC in is 2.2 and EC out is 3.3, thus the EC out (3.3)> EC in (2.2), and the difference is: 3.3 – 2.2 = 1.1 (greater than 1), the EC in should be reduced

VI	**Putting yellow sticky trap and sulphur evaporator**	
1	Yellow sticky traps	At planting time the yellow sticky traps are placed as many as one piece per 60 m^2, and should be renewed every two weeks
2	Sulphur evaporator (if available)	Starting from planting the sulphur evaporator should be run every day for 6 to 10 hours starting at 18.00
VII	**Maintaining the plant**	
1	Putting the rope to hold the plant	At the age of 2 weeks after planting with a rope to a wire rack on the top and to the wire that is placed on top of polybag
2	Establishment of main branches	Formation of the main branch is starting at 2 weeks after planting i.e.: – At one plant per polybag, 2 main branches are established – The main branches are selected from the strong branches
3	Removal of shoots ('pruning') and maintenance of leaves on each node	Starting from age 2 weeks after planting i.e.: – Shoots are remove at every node – If the average daily(morning) temperature in the greenhouse <35°C, the amount of leaves maintained at every node is two pieces, however, if the average temperature >35°C, the number of leaves that are kept in each node is 3 pieces – Interval of pruning 5 days – Worker's hand sterilized after every row
4	Selection of thinning the flower	Is started 3-4 weeks after planting, and the flower at node no. 0, no. 1 and no. 2 should be discarded
5	Fruit selection	Conducted from 4-5 weeks after planting, 2 fruits will be maintained per stem
6	Removal of petals	Removal of petals can be done if the fruits already formed
VIII	**Observation and control of pests and diseases**	
1	Observation of pest and nutrient deficiency	Carried out since one week after planting with one-week intervals, i.e.: – The population of thrips on one leaf tip, one top leaf, and one flower per sample plant. Aphids population on one leaf tip, per sample plant – The percentage of thrips attack, aphids, and mites per sample plant – The number of plants attacked by the fusarium wilt, bacterial wilt and virus disease. – Number of plants showing nutrient deficiency – Melon yellow spot virus

2	Pest control measures – Thrips – Caterpillars – Mite – Aphids – Powdery mildew	
	– Fusarium	If found Fusarium disease symptoms, actions taken are: – Selective eradication, which is revoked by the sick and destroy crops by burning – Do watering solution of klorotalonil fungicides benomyl. Dissolve these fungicides with a concentration of 1 ml/l and splashed into the roots of plants 100 ml/polybag
	– Late blight	If found late blight disease: – Plants are sprayed with fungicides mangozeb + mefenoksam (1-2g/l) or klonotalonil (1-2g/l)
	– Bacterial wilt disease	If found bacterial wilt disease: – Eradication done selectively, that is by revoke and destroy the plants by burning the wilt plant – Perform active treatment with bactericidal concentration oxitetracyclin with formulations 1ml/l. bactericide is alternately srpayed on crops or splashed into the planting media, 50 ml/polybag
	– Melon yellow spot virus	– Remove the plant from the greenhouse, using a plastic bag to dispose the plant completely for the greenhouse
	– Other virus diseases	If found: – Mark with a red flag. – When finished doing the work in the greenhouse, labelled plants are removed from the greenhouse and then burned.
3	To reduce the symptom of nutrient deficiency	
	– Fe deficiency (Iron)	– Spray the plants with Fe-EDTA as much as 1 g/l water with one-week intervals until the plants recover
	– Mn deficiency (Manganese)	If found Mn deficiency: – Spray the plants with $MnSO_4$ or Mn Growmore of 1 g/l water with one-week intervals until the plants recover
	– Mg deficiency (Magnesium)	If found Mg deficiency: – Spray with $MgSO_4$ of Mg Growmore of 1g/l water with one-week intervals until the plants are healthy again
	– Ca deficiency (Calcium)	If found in plants that lack of Ca: – Spray with $CaNO_3$ of Growmore Ca as many as 1 g Ca/L water with one-week interval until the plants are healthy again

IX	Harvest and postharvest	
1	Harvest	– If the fruit will be harvested young or green color, hardness level of the fruit should be enough – Ripeness level is adjusted by distance time of delivery from the plantation to the consumer. Thus, the fruit will reach consumers in good condition. Generally the fruit is harvested when percentage of colour has reached 80-90% – Cutting the fruit stalk has to be right on the node
2	Postharvest	In place of postharvest handling, the same fruits are graded as follow: – Small (C), fruit Ø 6.5 to 8 cm, weight of 120 ≤160 g – Medium (B), fruit Ø > 8 to 9.5 cm, weight > 160-200 g – Large (A), fruit Ø > 9.5 to 11 cm, weight > 200 g – For the purposes of the local market, melons can be packed in larger cartons

Details A and B tanks (each 300 litres):

Bil.	NAMA BAJA	Berat (gm)
	Set A	
1	Calcium nitrate	18,000
2	Potassium Nitrate	3,000
3	Ammonium Nitrat	800
4	Ferum EDTA	200
	SET B	
1	Kalium Nitrat	9,000
2	Kalium Sulfat (SOP)	1,000
3	Magnesium Sulfat	11,000
4	MKP	4,000
5	Zink EDTA	50
6	Manganese EDTA	40
7	Cuprum EDTA	7
8	Asid Boric	140
9	Natrium Molibdat	4

Appendix 9 – Example for hygiene protocol for tomato for greenhouses in The Netherlands

Note:
This appendix is for greenhouses in The Netherlands. The text in this appendix has been written for greenhouses in The Netherlands, and has not been adapted for Malaysian circumstances. It is meant to serve as an example.

Disclaimers:
The authors do not accept any liability for damage that results from activities or decisions based on the information provided in this hygiene protocol.

The information provided in this protocol is based on a direct translation of the protocol from Dutch into English. Neither the translators and editors nor the Wageningen UR can accept any responsibility for inaccuracy or liability for loss, damage or injury from the application of any concept or procedure discussed.

HYGIENE PROTOCOL FOR TOMATO

PEPINO MOSAIC VIRUS and *VERTICILLIUM SPP.*

INTRODUCTION

This protocol outlines hygiene measures to be taken at all stages of the tomato production to protect the crop from pepino mosaic virus (PepMV). The measures described in this protocol may also be effective for the prevention of infection with other mechanically transmitted viruses, such as potato virus *X* (PVX) and other important diseases such as *Verticillium* spp. and *Clavibacter michiganensis* subsp. *michiganensis*.

The measures described in this protocol are aimed at the prevention or restriction of infection with the above pathogens. This protocol should be treated as a guideline to be applied at the nursery level. However, it is in the interest of all growers to eradicate these pathogens and this is only possible if everyone collaborates.

In the prevention of disease, a combination of protective measures should be used. Every single measure described in this protocol contributes to prevention of disease, and if the total package of hygiene measures is applied in the right manner, there is a good chance of succeeding in the prevention of infection and eradication of these diseases.

The advice described in this protocol is based on the latest views and results from research projects. Further research and changing views may lead to changes in the protocol in the future.

The eradication of a pathogen from your nursery and the prevention of infections with pathogens require a well-considered approach. It is important that each nursery has its own plan of action, in which special attention is paid to all aspects and all measures are taken in the right order. For the design of such a plan of action, we recommend that you consult a specialist whose knowledge of the nature and management of these pathogens is up-to-date.

The Dutch organisations mentioned below were involved in the compilation of this protocol. They do not accept liability for any damaging effects that may arise from the application of the measures described in this protocol, because these measures are not undertaken under the direct supervisions of these organisations.

- Wageningen UR Greenhouse Horticulture
- DLV Advisory Group
- Groen Agro Control
- LTO Groeiservice
- Naktuinbouw

Pepino mosaic virus
Pepino mosaic virus is a mechanically transmitted virus. The transmission of this virus occurs mainly during work involving handling the plants, such as nipping the side shoots, twisting and harvesting. In addition, the virus can be spread through contact with contaminated tools, clothing, jewellery and packaging. Research data indicated that bumblebees transmit the virus as well. The employment of bumblebees for pollination will, however, remain necessary, because the alternative, vibrating with a device involves a much greater risk of spreading the virus. Laboratory experiments showed that also *Macrolophus caliginosus* is capable of transmitting the virus to some extent. The virus may survive in plant material, such as leaves, roots or fruit. It was not until early 1999 that this virus was found in tomato crops in Western Europe, therefore our knowledge about this virus is not extensive.

***Verticillium* spp.**
Verticillium spp. is a mainly soil/substrate bound fungus, mostly dispersed through soil, substrate, infected plant parts, dust particles and occasionally also through the air and possible via water. *Verticillium* spp. may survive as resting spores in plant material. The fungus has a large number of hosts.

1. CROP SUCCESSION

General Glasshouse Practices

- **Remove all plants, tools and other material from the glasshouse.**
  This is important, because living and dead plant material can be a source of infection. Remember to also to remove the plastic floor covering and the CO_2 tubing

- **Do not shred plants**
  Shredding of plant material releases sap and tiny plant particles, which are difficult to see. The sap and the plant particles may contain a large amount of virus particles, fungus spores or bacteria. Plant material that is not removed is a potential infection source.

- **Prevent wind-spread of the plant material**
  This is important to prevent spread of the diseases to neighbouring nurseries or water supply (reservoir, gutter water or rainwater collector).

- **Prevent volunteer plants (germination of seeds from old fruit)**

- **Ensure that contractors do not spread infection.**
  All materials and machinery and also staff should be clean when arriving at the nursery and decontaminated on leaving the nursery. High pressure cleaning and hot water should be used to clean machines and materials.

- **Dispose of all plant material in a well-covered or closed refuse container from the premises within 24 hours.**
  Prevent leakage of infected water or plant sap. Request watertight refuse container.

- **Prevent contamination of surface water.**

- **Use a high pressure cleaner and hot water to clean the premises immediately after the refuse container has been disposed of.**
  The water should be as hot as possible. Remember - Do not use surface water.

- **Carefully remove substrate and CO_2 tubing.**
  Prevent dirt from the floor plastic falling onto the soil.

- **Remove leaves, fruits, other plant material and weeds from the soil.**

- **Remove weeds around the glasshouse.**
  Removal of weeds is important, because weeds may be hosts for pathogens.

- **It is highly recommended to use new substrate if the previous crop was infected.**
  If the substrate is to be re-used, take the following measures:
  - Steam the (as dry as possible) substrate for 15 minutes minimum at 100°C.
  - The temperature should be checked at the place that is most difficult to be reached by the steam.
  - Check the temperature several times using calibrated thermometers.
  - Prevent contamination through people, pallets and machinery while steaming the substrate.
  - Cover the pallets of steamed substrate with clean new plastic.
  - Separate steamed substrate from un-steamed substrate

- **Steam-clean the irrigation pipe supports.**

- **Clean the concrete paths with water.**

- **Clean the glasshouse and the remaining parts starting furthest from the entrance with large quantities of water. Never use surface water!**
  Reservoir water may be contaminated! Use mains or borehole water. Water in tanks may be contaminated by blown-in plant material. Detergents and other cleaning agents should only be used when all plant material has been fully removed. Do also clean the glass in this first cleaning round.

- **Take plenty of time for crop succession.**
  The glasshouses should be left free of plant material for at least 3 weeks, while the temperature is kept at 20°C. Research has shown that pepino mosaic virus is no longer infectious in infected leaf material if this had been stored under dry circumstances for three weeks. This measure is only effective against pepino mosaic virus.

- **Make sure the glasshouse is properly heated during the fallow period.**
  The glasshouse should be kept at a minimum temperature of 20°C.

- **Always work in the same direction**.

Watering Systems

- **Clean the water drainage system by high pressure cleaning with hot water to remove roots.**

- **Fill drip-irrigation with nitric acid (pH 1) and leave for 24 h.**

- **Rinse the drip-irrigation with clean water after the nitric acid treatment.**

- **Use new laces for drip-irrigation system or clean by submerging in 10% tri-sodium phosphate (10 kg/100 l water) (pH 13) for 24 h.**

- **Replace drip pegs with new ones**
  Alternatively in the case of pepino mosaic virus infection, the drip pegs you may also clean by disinfecting with 10 % tri-sodium phosphate (10 kg/ 100 l water) (pH 13). Take care: not all irrigation systems are resistant to tri-sodium phosphate! Check with your supplier.

- **Clean drainage water reservoir thoroughly**.
  Ensure that all plant material is removed. Clean with high pressure cleaner and hot water.

- **Clean guttering**
  This can be done by draining all water and high pressure cleaning with hot water.

- **Have your water circulation system and disinfecting system maintained properly.**

- **Always work in the same direction.**

- **Clean the grading area including all machinery, including:**
  Grader
  Packaging material and trays
  Harvest trolleys
  Spraying equipment
  Tools
  Fork-lift truck
  Use a high pressure cleaner and hot water.

- **Clean the canteen, offices, working area and the nursery yard thoroughly**.
  Make sure you also clean tables, chairs, drink-dispensers, fridge's and waste bins. Use the high pressure cleaner and hot water.

- **Clean changing rooms, showers and lavatories thoroughly.**
  Clear these rooms, then clean with high pressure cleaner and hot water. Dispose of clothing and footwear used in the infected crop or wash thoroughly (95°C).

Other Points of Attention

- Make sure that waste has been removed prior to planting the new crop.
- Dispose of clothing and footwear or wash at 95°C.
- Do not grow any other plants in the glasshouse, these may be hosts.
- Make a plan of necessary re-construction work and ensure that this is completed before the planting of the next crop.
- **Do not eat tomatoes on the nursery. Fruits may be infected with pepino mosaic virus, which can be spread into the crop via hand contact.**
- Make sure that engineers do not require access to clean parts of the nursery.

2. PREPARATION OF GLASSHOUSES

Mark the clean glasshouse areas clearly, so that nobody contaminates the clean areas accidentally. A good plan of action and a thought-through and systematic approach is important.

- **Have a large containment mat at the nursery-entrance, where vehicles enter the premises.** Impregnate this mat with potassium hydroxide. Lorries and cars move from place to place, especially in the hectic period of crop rotation. Vehicles do not usually get cleaned on a regular basis, so they may be contaminated.

- **Place a tray or mat with disinfectant at every entrance to the nursery and at every entrance to the glasshouses.** Ensure that the mats or trays are large enough for the harvest trolleys. Ensure that walking or riding around the mat or tray is impossible. Staff should also disinfect footwear. Ensure that the mats or trays are kept wet. Fill with potassium hydroxide (pH 14) and ensure that they are kept clean.

- **Use new plastic sheets for paths.**

- **Do not allow people to walk on the soil, then on clean plastic**.

- **Cover the soil and the concrete paths completely in plastic sheeting.**

- **Tape polythene on overlap of floor on covering and floor support.**

- **Do not puncture the substrate slabs.** If plant-supports are accidentally put through the substrate slabs, then replace both plant-support and substrate slabs. Remove the plant and dispose of as if it were infected.

- **Use water from boreholes or mains. Never use surface water.** Water in reservoirs may also be contaminated (by *Verticillium* spp.). Water from tanks can only be used safely if it is disinfected with ozone, UV or by heating.

- **Drain capillary mats as a separate activity and use new knives.**

- **Ensure that the knives do not come into contact with soil**. If contact occurs accidentally, use a new knife and disinfect the (possibly contaminated) knife.

- **If substrate has been in contact with the soil, it should be replaced.**

- **Eradicate moles, mice and rats as well as other pests**.

- **Other pests include crickets and cockroaches in canteen, showers, lavatories, grading area and glasshouses.**

- **Ensure that pets (cats and dogs) do not enter the grading area or the glasshouses.**

3. PLANTING

- **Tomato seed should be free of fruit pulp and well cleaned. This is important for seeds grown for rootstock and main variety.**
  Ask your seed supplier and propagation nursery whether this has been done. Make a note of the batch number of the seeds received.

- **Take the necessary hygiene measures when visiting the propagation nursery.**
  Pepino Mosaic Virus is easily spread via clothing, footwear and jewellery. It is important that everyone takes strict hygiene measures. It is recommended <u>not to visit</u> the propagation nursery at all, as infected material may still be present at your nursery.

- **Request that the plants are delivered in single-use or well-cleaned trays.**

- **Use trays supplied by the propagation nursery for planting only, then return the to the nursery, free of containers and plant material.**

- **Collect plant containers and plant material separately and dispose of in leak proof refuse container.**

- **Prevent contact between trays and floor plastic or substrate**.

- **Cordon-off plants that appear to be infected and have them tested for the presence of pathogens.**

- **Make sure nursery staff are looking for plants that look different – e.g. small / weak etc.**
  Also ask the advice of the national plant protection service.

- **Move plants that start to look different during the growing season into separated part of glasshouse and have them tested for pathogens.**

- **Do not puncture the floor polythene with plant-supports.**

- **Never place plants directly on the concrete paths, but on trays or large sheets of plastic**.
  It is better to use large sheets of plastic, as the roots tend to grow rapidly over the edge of the trays.

4. DURING THE GROWING SEASON

- **All access doors should be locked at all times.**
  Change the door lock code and keep it secret. Receive visitors only by appointment. All visitors should report to the nursery-management. Family, friends and acquaintances should abide the same rules.

- **Make clear arrangements with contractors regarding company clothing.**

- **Casual staff should not work on more than one tomato nursery on a single day.**

- **Staff and visitors should not wear watches or jewelry.**

- **As few people as possible should be admitted to the crop. They should wear overalls (not dust coats), company footwear and gloves**.
  Clothing, footwear and gloves should not be tight and should cover the wearer completely. The rules should also apply to engineers, inspectors, glass fitters, etc.

- **Make sure that all trays with disinfectant are kept wet and replace the potassium hydroxide or the sodium-hydroxide solutions on a weekly basis.**

- **Have a separate set of clothing available for people who visit your nursery on a regular basis.**

- **Have coat hooks available for regular visitors. You or your staff should not use these coat hooks.**

- **Wash overalls worn by visitors weekly (95ºC) and disinfect footwear worn by visitors on a regular basis. Gloves and overboots are single-use only.**

- **Wash hands after arrival at and before departure from the nursery. Warm water and soap should suffice.**
  Note: watches and jewellery should also be cleaned. It is even better not to wear any.

- **For the prevention of pepino mosaic virus infection, use skimmed milk when handling the crop. Skimmed milk can prevent the spread of pepino mosaic virus in the early stages of tomato production.**
  Dip hands and knife in undiluted skimmed milk (minimum 3.5% protein) or in a solution of 100g skimmed-milk powder (35% protein) per litre. Replace milk regularly. Keep this practice up for as long as you can.

- **Always work in the same direction**.
  Note: make sure that left-handed staff works in the same direction as right-handed staff in rows as well as in the glasshouse.

- **Ensure that infection is reported as early as possible.**
  Mark abnormal plants and have them tested as soon as possible. The incubation period of pepino mosaic virus is depending on several factors, including plant size and growth conditions.

- **Train permanent and temporary staff (for example, show photographs of symptoms of the diseases).**

- **Do not use multiple-use trays that have not been disinfected on the nursery.**
  Use harvest trays for harvesting only!

- **When selling the product directly, make the buyer pay for the trays so that these trays are not returned.**
  Buyers often do not clean trays and can therefore contribute to spread of infection.

- **Prevent roots from coming into contact with the water circulation system or the glasshouse soil.**

- **Don't leave drippers on the floor polythene after plants are removed, but replace them.**

- **Disinfect re-circulated drainage water by means of heating, UV or ozone.**
  Ensure that machinery is calibrated and runs smoothly.

- **Ensure that visitors do not leave the path or touch the crop.**

- **Keep the path free of plant material.**

- **Prevent germination of seeds from discarded fruits**.
  If seeds from fruits do germinate, destroy these seedlings by spraying with concentrated fertilizer. (warning: be careful and wear gloves)

- **Take your own water samples.**
  Take water samples at dedicated places and do not puncture the floor plastic.

- **Have bumblebee hives placed by your own staff, not by the supplier.**
  Ensure that bumble hives and biological control is delivered to your prep rooms. They should be kept not too warm and not too cold and also not in direct sunlight. They should be placed near the entrance of the nursery.

- **Do not use surface water for watering or crop spraying.**
  Water from tanks can only be used safely for watering or crop protection after decontamination by heating, UV or ozone. For crop protection, it is recommended to use water from the mains, for a number of reasons.

5. WHAT TO DO IF YOUR CROP DOES GET INFECTED

- **Keep up the practices described in this protocol.**

- **Have suspected plants tested.**

- **Close paths that contain suspected plants and suspend all work, until experts have determined which pathogen is present.**

- **Completely remove infected plants, in the normal direction of work.**
  Remove the whole row or at least 20 plants either side of the infected plant. Depending on the situation, plants from adjacent rows should also be removed. Do not water the plants for a day before you remove them, to minimise the amount of plant sap released. Cut the string at approximately 30cm (12 inches) above the top of the plant. Put the plants in a plastic bag and dispose of infected plants separately. Remove plants at the end of the working day.

- **Trace the route of people who have worked with plants in infected rows.**

- **Mark paths where symptoms have been seen and the paths to the left and right of this path.**

- **Use a separate set of tools, harvest-trolleys and harvest trays in these rows.**

- **Carry out all handling of these plants, including nipping the lateral buds, twisting and harvesting after all other rows have been done.**

- **Clothing and materials used in suspected or infected rows should be used in these rows only.**

- **Alternatively, wear overalls, over-boots and gloves in these suspected/infected rows. Do not use these overalls for any other purpose.**

- **Ensure that any plant material that is removed during crop work does not spread to other paths.**

- **Replace rockwool slabs on which infected plants have been grown**.

- **Place the new rockwool slabs next to the old ones, as this prevents the roots to grow into old slabs**.

- **When taking a water sample from the rockwool slabs, care must be taken no to transmit the pathogen via needles. Make sure you do not puncture the floor plastic with sharp equipment. Take care with tensiometers and other tools that come into contact with several rockwool slabs.**

- **Use skimmed milk consistently in all crop-handling activities.**

- **Disinfect footwear on leaving the infected areas.**

- **Put a notice on the entrance door if infection is present**.

- **A notice on the outside door warns visitors and may thus prevent spread to other nurseries.**

- **Inform everyone who needs to know (buyers, contractors, advisers, suppliers, visiting groups etc.) that the virus has been found at your nursery.**

Appendix 10 – System check on computer and drip irrigation

For tropical and traditional greenhouses in Malaysia

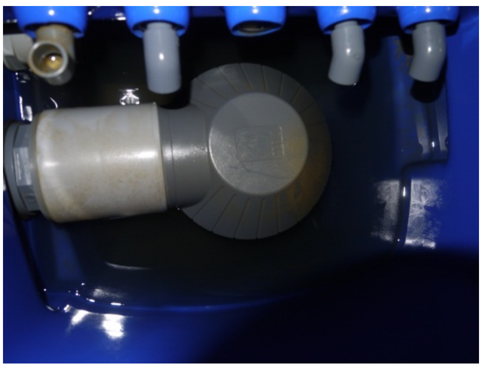
Before the new crop is planted in the greenhouse is planted a detailed check has to be done on the irrigation Maximizer computer system and its irrigation network.

1. Clean the filters for the in and out going water

- To clean the filters you need to turn anti clockwise to open them.
- After this you take out the membrane or the mesh filter and wash it until all the dirt has been removed from the filter part.
- Putting the filter part back in the filter housing make sure you check if the rubber seal is still situated at it correct position.
- Put on the cover and tighten it firmly turning clockwise.

2. Wash the mixing tank on the computer system

- Open the water tank of the irrigation computer.
- Remove all the water from the tank and after that clean the inside properly by using a soft cloth or sponge.
- Do not use any force while cleaning the measuring equipment located inside the bottom part of the tank.
- After cleaning rinse the tank until you are sure no soaps or other cleaning leftover in the tank
- Refill the tank until the pump flow sensor has been covered by water.



3. Check the pH meter in the system

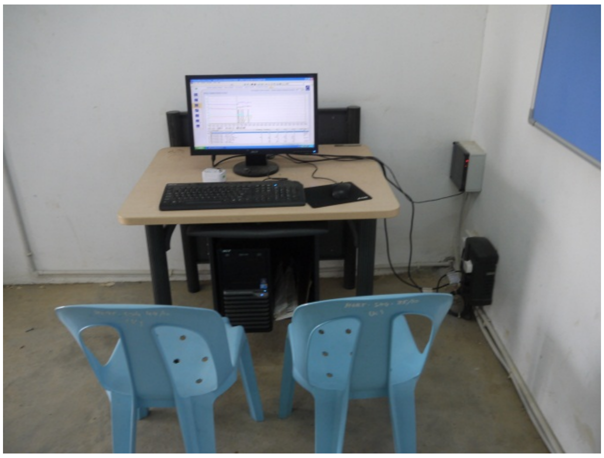
- When you checking the pH meters in the system you need to be very careful.
- Open the pH meter situated on the top of the irrigation computer.
- Make sure you place the probes on a soft cloth and do not leave them in the open more than 1 hour maximum.
- Clean the inside of where the probe is located with a soft brush.
- After this clean the probes by using a sponge slow cleaning it until the glass is clear and clean.
- After you have done this do a pH meter check/calibration. (see irrigation computer manual)
- After this has been done tighten the probes back into its original place and tighten them properly.

4. Check the wiring leading to and from the computer system

- Check all the wires leading from the computer to the Maximizer and all the wires from the Maximizer to the irrigation valves per greenhouse.
- In the case you notice wear and tear on the cables you need to replace them or contact the installer to replace them for you.

5. On the irrigation computer system

- Switch on the power buttons for the Maximizer computer and the irrigation unit.
- Check for any unusual sounds from all the different units.



6. Enter the greenhouses to service the measuring boxes in the greenhouse

- To clean the measuring boxes you need to bring clean mineral water 1 bottle 1 liter none cold, new wet sock for wet bulb probe, a wet cloth and a small cleaning brush.
- Open the measuring station with a special opener located on the box.
- Remove the water box and take of the wet sock remember the location of the wet probe the bottom one.
- Check if the sock is still in good condition otherwise replace the old with a new one.
- Take the water boxes outside and clean them fully and properly.
- Clean the boxes on the inside and remove all dirt from the inside of the box use a wet cloth to clean.
- Fill up the water box until the marked level and put the water box back into the measuring box.
- Reconnect the new sock to the wet bulb probe.
- Now open the measuring box from the other side and use a coin to open the front.
- Here you check if the fan is working and do some minor cleaning using a small brush.
- Close the measuring box again and make sure its hanging at the height of the planting level and use the wet cloth to wipe the outside of the measuring box.

7. Clean and fill up the tensio meter to the correct level as shown on the photo.

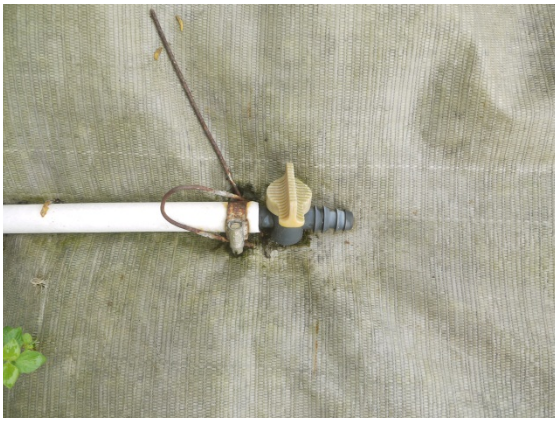
- Remove the tensio meter from the planting bag and unscrew it from the connected wires. Clean the probe by using clean mineral water none cold.
- Do not use any rough materials to clean this probe as it easy to damage .
- After you have cleaned it reconnect it to the wires after you filled up to the level halfway in the glass part of the probe.
- Re-enter the probe into the coco peat until the glass level is still visible.

8. Check the Solenoid valves if the wires are connected and if the valve are standing in the correct auto setting

- Checking the solenoid valves you need to check if they are positioned on the of side. Off is auto and on is manual in case you have a failing valve to open or want to use it for drenching the bags before planting.
- To adjust the pressure to the drippers turn clockwise to reduce the pressure and anti-clockwise to increase the pressure (photo).
- You want to create a dripping flow from the dripper and this exercise can be better archived by locating 1 person at the valve adjusting and 1 person in the greenhouse checking the flow.

9. Now the system is ready to be put to the test and preparations for the system check can be started.

- Set a longer time of irrigation (check computer irrigation manual) per plot. Flush the main pipe and the drip pipes by opening all the flush vales at the end of the lines flush until clean water is coming out of the pipe.
- When doing this al the dripper should be lying on the floor and not been inserted into the growing bag.
- Spread out 6/10 small water bottles throughout the greenhouse. Put the dripper in the bottle and make sure all the other dripper are also out of the planting bags still. Check the levels in the bottles after the test has been done. If uneven please check the pressure, if it is too strong reduce and test again, otherwise contact the installer.



10. Try certain different small EC levels to make sure the EC PH meter and the control valves are working.

- To make sure the system is working to the optimum before you transplant try some different EC settings and see if the A/B valves are working properly on the computer. (Check computer irrigation manual for settings)
- In the case you have some uncertainties regarding settings or functions of the system contact the installer to verify.
- Your system has been fully tested now and is ready for usage.

Appendix 11 – Cost-Benefit analysis

For tropical and traditional greenhouses in Malaysia

Table 1. Costs (Rm m^{-2}) of a tropical greenhouse with an advanced computer, a tropical greenhouse with a more simple computer, and a traditional greenhouse. It is assumed that the greenhouse measures 600 m^2.

Costs	Tropical greenhouse, advanced computer	Tropical greenhouse, more simple computer	Traditional greenhouse, no computer
Investment (upfront)	124.7	119.7	59.7
Operational (per year)	31.2	31.2	31.4
Maintenance (per year)	4.8	3.7	3.8

Table 2. Estimated returns of a tropical greenhouse with an advanced computer.

Grade	Number of seasons	Yield			Price	Returns	
		(kg m^{-2} $season^{-1}$)	(kg gh^{-1} $season^{-1}$)	(kg gh^{-1} $year^{-1}$)	(Rm kg^{-1})	(Rm $season^{-1}$)	(Rm $year^{-1}$)
A	4	3.83	2300	9200	4.5	10350	41400
B	4	1.19	715	2860	2.5	1787.5	7150
C	4	0.48	285	1140	1.5	427.5	1710
total	4	5.50	3300	13200		12565	50260

Table 3. Estimated returns of a tropical greenhouse with a more simple computer. It is assumed that yields are 15% less than in case an advanced computer is used.

Grade	Number of seasons	Yield			Price	Returns	
		(kg m^{-2} $season^{-1}$)	(kg gh^{-1} $season^{-1}$)	(kg gh^{-1} $year^{-1}$)	(Rm kg^{-1})	(Rm $season^{-1}$)	(Rm $year^{-1}$)
A	4	3.26	1955	7820	4.5	8798	35190
B	4	1.01	608	2431	2.5	1519	6078
C	4	0.40	242	969	1.5	363	1454
total	4	4.68	2805	11220		10680	42721

Table 4. Estimated returns of a traditional greenhouse, without computer.

Grade	Number of seasons	Yield			Price	Returns	
		(kg m^{-2} $season^{-1}$)	(kg gh^{-1} $season^{-1}$)	(kg gh^{-1} $year^{-1}$)	(Rm kg^{-1})	(Rm $season^{-1}$)	(Rm $year^{-1}$)
A	4	1.88	1125	4500	4.5	5063	20250
B	4	0.58	350	1400	2.5	875	3500
C	4	0.25	150	600	1.5	225	900
total	4	2.71	1625	6500		6163	24650

Table 5. Pay-back time in case of 0% and 11% interest, of a tropical greenhouse with an advanced computer, a tropical greenhouse with a more simple computer, and a traditional greenhouse.

Interest	Tropical greenhouse, advanced computer	Tropical greenhouse, more simple computer	Traditional greenhouse, no computer
0%	2.5	3.3	9.9
11%	4.0	6.2	No profit