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A demonstration greenhouse for Malaysian Horticulture

Trip report February 2011

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Wageningen UR Greenhouse Horticulture
Centre for Development and Innovation, Wageningen UR
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Picture front cover: one of the three-span greenhouses at Serdang.

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Contents

1 Summary

This report results from the project "Tropical Horticulture in Malaysia", funded by The Netherlands Ministry of Economic Affairs, Agriculture and Innovation with project number BO-10-010-106.

Modernization of the greenhouse horticulture sector in Malaysia is required in order to realize better quality of the product, higher yields and less production costs.

Construction of a demonstration greenhouse on the basis of this design has been started early April 2010 at Serdang by the Malaysian Department of Agriculture (DoA), and was completed by September 2010. Rock melon was planted early October 2010 as a first crop.

The focus in 2011 was on further evaluation of the greenhouse and crop management, and on knowledge transfer to growers.

The Terms of Reference of the February 2011 mission follow directly from the planned activities:

1. Discuss with high-level DoA management strategic project planning and mutual roles.
2. Evaluate with DoA staff the first production season and formulate learning points.
3. Plan with DoA staff the second season.
4. Discuss with stakeholders options and preferences for knowledge transfer.

The mission was conducted by Anne Elings, Wageningen UR Greenhouse Horticulture (project leader, greenhouse horticulture specialist) and Monika Sopov (Centre for Development and Innovation, Wageningen UR, senior expert in agricultural chains and capacity building.

The major outcomes of the mission were:

1) Lessons were learned from the first season, in terms of commitment, communication and reporting, data collection, computer use, greenhouse maintenance, staff stability, promising crops, and knowledge transfer.
2) Full commitment for the demonstration project was guaranteed both in management and operational terms.
3) Operational details were decided upon, and collaboration protocols between Malaysian and Dutch staff were streamlined.
4) Knowledge exchange between staff with the demonstration trial, growers (nearby growers, growers at a larger distance, commercial growers), and WUR staff was discussed and planned. By the end of the year 2011, the greenhouse construction and the cultivation system should be known to the Malaysian horticultural sector.
5) Costs and benefits of the greenhouse were estimated. The pay-back time of a 3.5 ha greenhouse is approximately 3.5 years.

The next visit will be paid by Ms. Monika Sopov and Ms. Ineke Stijger (crop protection expert) approximately a month after transplanting the second crop. They will concentrate on knowledge transfer and crop protection, respectively.

Kuala Lumpur, Wageningen, February 2011

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2 Introduction

This report results from the project "Tropical Horticulture in Malaysia", funded by The Netherlands Ministry of Economic Affairs, Agriculture and Innovation with project number BO-10-010-106.

Protected greenhouse horticulture in Malaysia has traditionally been concentrated in the highland regions of the Cameron Highlands, where land is scarce and production competes with tropical rainforest. Protected greenhouse horticulture is a growing activity that has been prioritized by the Malaysian government as an area of cooperation with The Netherlands. Also, the private sector sees business opportunities and initiates modernization. Most relevant crops are currently rock melon, tomato, cucumber, chilies and sweet pepper; however, consumer's demand or export opportunities may lead to the introduction of other crops. It is desired that these first developments are taken further, also for the highland regions in the Cameron Highlands where the majority of horticultural production is located. Protected greenhouse horticulture is therefore a promising area where public and private partners meet, that can contribute to employment.

Modernization of the sector is required in terms of:

- location-specific greenhouse designs, taking into account climatic conditions and required cooling system, and crop requirements;
- improvement of planting material;
- optimization of cultivation techniques;
- introduction of integrated pest management to substantially reduce use of pesticides and contribute to a lower environmental impact;
- design of above-mentioned components such that they form a well-balanced technology package;
- better quality of the product, higher yields and less production costs;
- an enabling environment (government, research) that is conducive to the further development of the Malaysian horticultural sector;
- a Malaysian training and research capacity that can support the local horticultural industry.

Operating a modern greenhouse requires a high level of knowledge with regards to general management, climate control, water and nutrient application, pest and disease management, crop management, etcetera. A serious training effort is required here. Only then, sustainable modernization of the Malaysian greenhouse horticulture sector can further develop. Close interaction between the Malaysian Department of Agriculture (DoA) and growers is crucial to this development, and is therefore a 2011 focus.

WUR met with a wide variety of stakeholders in 2008 and identified the major obstacles and options for the further development of greenhouse horticulture in Malaysia. Subsequently, WUR designed in 2009 a greenhouse for the tropical lowlands in Malaysia. Construction of three demonstration greenhouses on the basis of this design was started early April 2010 at Serdang by the Malaysian Department of Agriculture (DoA), and was terminated by September 2010 (except for some last finishing touches). Dutch supply industry (Priva) provided the greenhouse installation and computer, and climate and substrate sensors. Melon crops were planted to the greenhouses early October 2010, and harvested in January 2011.

The 2011 project objectives are:

1 Training of trainers (DoA staff, innovative farmers)
2 Development of demonstration site towards a training location.
3 Commercialize the greenhouse design as a tested and approved principle for horticulture in tropical lowlands.

To achieve this, the following activities are planned:

1 Starting workshop with DoA, growers and WUR: develop shared agenda and joined commitment
2 3-5 visits by WUR staff with different expertise to train the trainers (on-site), hold dialogues and seminars. Main issues are: cro management, pest and disease management, climate management, fertigation.
3 Periodic open days for larger groups of growers.
4 Regular visits by a small groups of committed growers to the greenhouse, to discuss horticultural farming in general, and the crops in particular.
5 Periodic evaluation of progress, identification of knowledge needs.
6 Registration of key parameters of crop production, including economic data, to demonstrate the economic viability.
7 Assistance to growers and entrepreneurs who want to adopt technology.

2.1 Terms of Reference Mission

The Terms of Reference of the October mission follow directly from the planned activities:

1. Discuss with high-level DoA management strategic project planning and mutual roles.
2. Evaluate with DoA staff the first production season and formulate learning points.
3. Plan with DoA staff the second season.
4. Discuss with stakeholders options and preferences for knowledge transfer.

3 The first season

3.1 Climate

The greenhouses are equipped with a variety of sensors that enable monitoring of the climate, soil moisture content, drain, and fertigation regime.

At the moment of writing of this report, climate data are not available yet, due to the fact that the climate computer is temporarily out of function. The most relevant climate factor is radiation, followed by humidity.

3.2 Greenhouses

Three new greenhouses were available, in which different fertigation techniques can potentially be evaluated:

- Greenhouse 1 has a recirculation system, and can for example focus on saving of nutrients. Drain water will be in a underground tank a pumped back to pump house to be used and mixed in the next irrigation.
- Greenhouse 2 is a more simply type than greenhouse 1 and can focus on the minimization of the amount of irrigation water drained.
- Greenhouse 3 pumps water through the system (to flush previous warm irrigation water) and can evaluate the effect of a lower temperature of irrigation water.

In order to keep the first demonstration trail manageable, all systems followed system 3.

3.3 Crop

Rock melon crops, variety 'Glamour' were sown on October 10th, November 11th, and November 18th, respectively, for greenhouse 1, 2 and 3. The first crop of rock melon was sown on October 6th in greenhouse 1. Each greenhouse contained 880 plants, each plant having two stems.

The prime goal was to attempt to grow a good crop and achieve a good production with a nice quality. This is most convincing towards growers. This was supported by a number of measurements on the crop, climate, and fertigation.

Pollination was successfully assisted by humble bees.

Plants in Greenhouse 1 were attacked by thrips, cucumber mosaic virus, downy mildew and powdery mildew. As only 80 plants survived, these were transferred to greenhouse 3 to fill gaps (comment: this is potentially very risky as in this manner, pests and diseases are easily spread from one greenhouse to the other). Also plants in the other two greenhouses were infested by the same pests and diseases.

Table 1. Production summary (see for further details '1st Report Tropical Greenhouse Model Project Under Malaysia-Holland Bilateral, January 2011').

Green-house	Grade A	Grade B	Grade D	Total	Damaged	Grand total
1		-	-	-	-	-
2	40 kg; 24 fruits; 1.67 kg fruit^{-1}	250 kg; 210 fruits; 1.19 kg fruit^{-1}	170 kg; 210 fruits; 0.81 kg fruit^{-1}	460 kg; 444 fruits; 1.04 kg fruit^{-1}	236 fruits	680 fruits; 0.77 fruits per plant
3	280 kg; 175 fruits; 1.60 kg fruit^{-1}	120 kg; 106 fruits; 1.13 kg fruit^{-1}	170 kg; 206 fruits; 0.83 kg fruit^{-1}	570 kg; 487 fruits; 1.17 kg fruit^{-1}	367 fruits	854 fruits; 0.97 fruits per plant

On average, less than one fruit per plant (including damaged fruits) were harvested. It should be possible to harvest more fruits per plant and therefore further increase production. The most important factor to increase production is good pest and disease management. For that reason, Ineke Stijger (Crop Protection Specialist Wageningen UR Greenhouse Horticulture will visit the demonstration site early next season.

3.4 Evaluation and planning

The first season was evaluated, and the second season was planned in two meetings:

- On Wednesday February 16th, we met with the DoA staff at Serdang to reflect on the first season and identify learning points. This meeting was attended by Mr. Nordin bin Mamat, Mr. Ramli Md. Affandi, Ms. Khasana Ibrahim, Mr. Khairul Izhar Lafasa Rais, Ms. Alina Bt. Abdul Aziz, Ms. Beverlien Christine, Mr. Helmi, Ms. Monika Sopov, Mr. Anne Elings and Mr. Luuk Runia.
- On Thursday February 17th, we met with DoA management at DoA headquarters for strategic planning of the coming seasons. This meeting was attended by Mr. Dato' Sulaiman Bin Md Zain, Mr. Rahman Bin Ismail, Mr. Nordin bin Mamat, Ms. Khasana Ibrahim, Mr. KC Chong, Ms. Monika Sopov and Mr. Anne Elings. Mr. Luuk Runia was not feeling well and had to apologize.

Operational details were discussed in a follow-up meeting on Friday February 18th.

The first season can be considered a learning season, on which the following seasons can be built. The following issues were raised:

- Commitment.
    - DoA management stressed its full commitment to the demonstration greenhouse, technology transfer, and gave high priority to ensuring a successful and smoothly run project.
    - This commitment will be reflected in:
        - Sufficient budget is required, which will be made available
        - The involvement of three commercial growers in season 2 in production of produce in the greenhouses. These growers are associated with the TKPM training programme, in which commercial growers are trained. The three growers will be rewarded by the production of the crop.
- Communication, reporting.
    - It was recognized that communication should be more frequent, preferably on a weekly basis, and that in case of urgent matters, telephone contact should be considered (phone call to be made by WUR). If there is any urgent issue, an email or sms can be sent instantly (if necessary through Luuk Runia).
    - At the end of the season, a report is written.
- Data collection.
    - It appeared that more data have been observed than have been reported. This issue therefore is more a matter of communication than data collection itself.
- Computer use.
    - The computer is at the heart of the greenhouse. Its settings should be checked periodically, just as to whether the installation does what it is expected to do.
    - Computer skills will be developed by the three technical assistants (Khairul, Alina, Akmal) and two of the three growers. Luuk Runia will provide training.
    - It was requested that a staff member of Luuk Runia is also frequently around.
- Greenhouse maintenance.
    - Greenhouse maintenance is very important, for instance in case of repairing holes to prevent insects from entering.
    - Weeding in and around the greenhouse should receive continuous attention.
    - It is important that a good level of technology is displayed to the sector.
- Staff stability
    - Greenhouse cultivation is knowledge intensive by nature. Staff members that have built up experience and have received training must therefore be kept in the project.
    - Also Mr. Luuk Runia can contribute to stability of the demonstration trial.
- Crop management.
    - Experience is required to grow a good, high yielding crop. Experience will be supplied through the involvement of three commercial growers.
    - A good work plan is very useful. However, most actions can not be captured in a SOP (Standard Operational Procedure), as horticulture is characterized by flexibility that can only be addressed by good understanding, observing and decision making. This is why experience and training is so important.
    - Pest, diseases, and viruses have been seriously affecting the crops during the first season. Crop protection therefore requires top priority in terms of management and training.
        - Anne and Ineke will develop a basic SOP for pest and disease control.
    - Temperature fluctuations may be the cause for the high degree of fruit cracking.

- Promising crops.
    - In the first season, rock melon has been grown as DoA staff was familiar with this crop.
    - Rock melon will also be grown in the 2nd season.
        - The Dutch breeding company RijkZwaan offered to supply virus-free sowing seeds. They can utilize one greenhouse. Anne Elings will contact Mr. Jan Doldersum of RijkZwaan.
    - Bell pepper and tomato will be grown in the 3rd season, which will roughly last to the end of 2011. These two crops are elements of the National Key Economic Programme.
    - After that, the greenhouse will be commercialized: local growers will be offered the opportunity to take over the operation of the greenhouse.
- Knowledge transfer
    - According to previous agreements, only very limited attention had been paid to knowledge transfer to commercial growers, and involvement of commercial growers. There are two season left, and therefore, knowledge transfer processes have to be initiated. It was agreed that this process would start with small-scale growers from nearby, and end with larger-scale commercial growers. See also Chapter 5.
- There came a request for Dutch support for an irrigation/drainage system for the outdoor fields. Mr. KC Chong replied that Dutch support focuses on software (meaning human support), not on hardware.

4 Further planning

On Friday 18th, we met with DoA staff at Serdang for operational planning of the 2nd season. This meeting was attended by Mr. Ramli,Ms. Khazana, Mr. Khairul, Ms. Alina, Mr. Akhmal, Mr. Ooi, three farmers, Mr. Luuk Runia, Ms. Monika Sopov and Mr. Anne Elings.

4.1 Distribution of responsibilities

In terms of operating the 2nd demonstration trial, three technical assistants and three growers are responsible. The distribution of the activities and roles over the growers and technical assistants is summarized in Table 2. In general terms, the growers are responsible for the day-to-day activities that are related to the crop and the greenhouse, whereas the technical assistants are responsible for providing sufficient support to the growers and have to serve as an intermediate to the higher management.

Table 2. Summary of activities and roles, assigned to the three growers and the three technical assistants.

	Activity, role	**3 growers**	**3 technical assistants**
1	crop management	responsibility	
2	computer	learn	learn, responsibility
3	decision making in crop management	follow planting manual	responsibility for decisions (3 officers and growers)
4	strategic management (variety, etc)		responsibility (after discussing internally)
5	maintenance of greenhouse	grower (initial step to call officers)	responsibility to call appropriate help
6	cleaning the whole area (plateau, including slope)	responsibility	supervise
7	ensure for supply 1st season		responsibility (bear costs)
8	ensure supply for 2nd season	responsibility (bear costs)	
9	sanitation, farm hygiene	responsibility (implementation, monitoring)	final responsibility (rules, regulation, monitor, control)
10	number of working hours spent on activities	record	report
11	data (plant length etc.)	record	report
12	Scouting	scouting, report results to officer	final responsibility to make decision; check data if needed
13	water supply	responsibility	
14	all activities	participation	supervision

4.2 Observations: crop growth and development

The list of observations that was developed in advance of the first season, was reconsidered (Table 3). Most observations are recorded on one plant per row, but a smaller number (that have to do with the final harvest) are recorded for the entire crop. The responsibility of recording data is with the growers, while reporting and decision making is the responsibility of the technical assistants (see Table 2).

Data will be computerized by Khairul. He will send a report every Wednesday to Anne with a copy to Ramli. Note: it concerns data, not a report!

Table 3. Summary of observations on crop growth and development to be taken. For comparison, the procedure for the 1st season is added. The same information for season 2 is presented systematically below the table.

Activity	Season 1	Season 2	How
One plant per row			
Plant length	daily	every Monday, Friday	From the bottom of the stem to marked height
Number of leaves	weekly	weekly	Counting
Leaf area 1*	monthly	monthly	Every alternate leaf (length and width)
Counting number of flowers	25 -30 days after transplanting	skip	Counting at node area
Fruits			
final number	after pruning when they have reached egg size	after pruning when they have reached egg size	Counting (after pruning, and at excise)
location		skip	Indicated by leaf number
Number of shoots		record number of shoots	crop management decision
Fruits harvested			
number	harvest	harvest	Counting
freshweight	harvest	harvest	Weighing
For the whole greenhouse			
Fruits			
final number	harvest	harvest	Counting
Fruits harvested			
number	harvest	harvest	Counting
freshweight	harvest	harvest	Weighing
quality (brix, netting, skin colour, flesh colour, malformation, flesh thickness)	harvest	harvest	take a sample (5+ frutis), each grade represented; brix (A, B, C)

* The protocol is found in Annex 4.

Crop development

Observations on crop development are taken on 1 plant per row. This provides sufficient information.
There are two exceptions to this: observations on the number of fruits and the number of shoots are taken on all plants.

- Take observations on 1 plant per row, so 13 plants in total
  - Select these plants randomly
  - Mark them well
  - Develop a registration form on the computer
- Plant length
  - Every Monday and Friday
  - From the bottom of the stem
- Number of leaves
  - weekly
- Leaf area
  - monthly
  - every 2nd leaf
  - the protocol is found in Annex 4.
- Number of fruits
  - Final number (after pruning at egg size)
  - On all plants
- Number of shoots
  - This is a crop management decision, taken very early in the season.
  - On all plants

Crop harvest
Data on crop harvest are naturally taken at the end of the season (for other crops this might be different!).

- Total number of fruits harvested.
  - From all plants in the greenhouse
  - From the 13 plants selected for development observations
- Fresh weight of fruits harvested
  - From all plants in the greenhouse
  - From the 13 plants selected for development observations
- Quality characteristics of the fruits harvested
  - Brix
  - Netting
  - skin colour
  - flesh colour
  - grading
  - malformation
  - flesh thickness

4.3 Observations: crop protection

A summary of the essentials of pest and disease management is given in Appendix 2. There are two leading concepts:

1) Sanitation prevents the introduction of pests and diseases in to the greenhouse, and also the spread of pests and diseases from an infected greenhouse to a different one. Examples of good sanitation are:
   a. remove diseased plants
   b. do not move plants from one greenhouse to another greenhouse
   c. open the doors of the sluice one by one
   d. enter only one greenhouse per day
   e. in principle, no one enters the greenhouse if not absolutely necessary
   f. keep the greenhouse locked
   g. visitors are only permitted to enter the greenhouse early morning, when they have not yet visited another greenhouse
   h. if clean clothing can not be guaranteed, for example overalls should be present
   i. use clean, disinfected materials (scissors, knives, etc.)
   j. repair damages to the net and other parts of the greenhouse
   k. remove weeds around the greenhouse
2) Base spraying on observations. Only spray if the pest level is sufficiently high, and also consider spot spraying. Avoid calendar spraying, as this practice leads to spraying too early or too late, and mostly with too much chemicals.

Table 4. Summary of observations on crop protection to be taken. For comparison, the procedure for the 1st season is added. The same information for season 2 is presented systematically below the table.

Activity	**Season 1**	**Season 2**	**How**
Observe plants	daily	growers and officers	
Identify affected plants	as needed	growers and officers	put tags on plants
Identify location of plants	after detecting pests, diseases, viruses	growers and officers	indicate on map
Identify level of pests, diseases, viruses	daily	growers and officers	Use scouting forms
Remove infected plants		growers	Cover with plastic bags, burn
Register location of removed plants		growers and officers	indicate on map
Register timing of removal of plants		growers and officers	indicate on map
Spray on basis of monitoring	as needed	growers	
Invite crop protection expert (Mr. Ooi)		once a week	

Crop Protection

- One person should observe all plants.
- Use tags to indicate affected plants
- Indicate on a map the precise locations of plants with pests, diseases and viruses
- Use the monitoring form sent by Ineke Stijger
- Record the levels of pest, diseases and viruses
- Remove plants that are infected (especially if the disease spreads easily), and register the location of the removed plant.
- Spray on the basis of the monitored data

4.4 Contingency

It is very difficult to prepare Standard Operational Procedures for greenhouse horticulture (for any form of agriculture and horticulture, actually). The reason is the wide variation in weather, crop growth, results of human intervention, market mechanisms, etc. An experienced farmer has great knowledge and is flexible. New circumstances can be dealt with on a case-to-case basis, depending on the circumstances. A good example is crop protection: observe the level of infection, consider the option and consequences of various crop protection measures, make a decision, and only then act. This is quite different form acting (e.g., spraying) just because it is Monday morning = calendar spraying.

There are few routines that must be followed, however:

1) **Power cut**: Immediate action must be taken in case of a power cut. Greenhouse crops will die very fast if water is not supplied. Power must be restored immediately. This means:
    a. **Contact Helmi.**
    b. **What is the problem**? Is the network down? Is the wiring broken?
    c. **Solve the problem**. Start the generator, fix the wiring, etc.
2) **No water supply**: as plants will die if no water is applied, water supply must be restored immediately.
    a. **Contact Khairul.**
    b. **What is the problem**? Is there a power cut? Is the pump broken? Is the computer down?
    c. **Solve the problem**. Restore power (see above), get a mechanic to fix the pump (make sure that a telephone number is displayed on the pump), restore the computer (call Luuk).
3) **Computer break-down.**
    a. **Contact Khairul, who contacts Luuk.**
4) **A pest break-out.** Here, the usual routine applies: observe the level of infestation, taken an appropriate dicision, and spray.

There should always be one of the technical assistants be available to deal with emergencies, also over the weekend and during holidays. Everyting may go smoothly, but only one small hick-up can destroy the entire season.

Make a list of necessary telephone numbers, and display these clearly visible at a number of places: greenhouses, computer room, pump house.

5 Knowledge transfer

5.1 Growers

Three groups of growers can be distinguished in terms fo knowledge transfer:

- Relatively small-scale growers that live nearby
- Relatively small-scale growers that live further away
- Relatively large-scale commercial growers

Contact persons are Alina and Khairul

Small-scale growers living nearby

Growers that live nearby can be introduced in an informal manner to the greenhouse actually any moment. Group size should not be too large, for instance 5 persons, and during one or two hours various issues of the crop and the greenhouse can be discussed. From the project side, a grower and a technical assistant should be present.

It was decided that with an interval of approximately two weeks, small groups will be invited. Starting from transplanting onwards, so, when Ms. Monika Sopov visits the project about 8 weeks after transplanting / 6 weeks after sowing, some experience with knowledge transfer has been obtained.

This process of regular informal get-togethers can be continued throughout the season.

Small-scale growers living further away

Growers that live further away should be invited to the greenhouse in a more organized manner, but still in an informal structure. The goal is to discuss the crop and the greenhouse, not to have a large group walk through the premises.

The structure of this will be discussed during the next visit of Ms. Monika Sopov.

Large-scale commercial growers

Large-scale commercial growers can learn a lot from the greenhouse construction and installation, and the associated crop management. In an informal setting, also much can be learned from these growers.

It was decided that is would be most appropriate to invite the commercial growers during the third season, when more experience has been gained.

Planning of involvement of the three different target groups:

Type of grower	Time of involvement
Small-scale close by	On-going
Small-scale further away	Third season
Large-Scale growers	End of year (official opening)

5.2 Linking to other educational programs

Apparently, there are several agricultural oriented educational programs are running in Malaysia. It should be explored where linkages could be made between the greenhouse project and those educational programs to enhance knowledge transfer.
One already discussed idea is to link more closely to the program where the three growers are from, who will be growing the produce in the greenhouses.

5.3 Planning for next visit

1) During the next visit the following capacity building will take place in relation to DOA staff

- What is learning? (adult learning)
- What is facilitation? How is that different from teaching? What methods are there?
- Knowledge transfer
    a. Who and to whom?
    b. What? (different kinds of objectives)
    c. How? (methods, forms)
    d. When?

2) Reflection on the knowledge transfer that is taking place before visit of Monika Sopov
3) Detailed planning together with DOA staff in relation to knowledge transfer for the rest of the year

5.4 Official opening

An official opening of the facilities in the presence of high-level delegates from the Malaysian and Dutch sides is aimed for during the third season, when a prosperous crop can be displayed and the staff has gained further experience.

6 Costs and benefits

The greenhouse requires a high level of investments, which has to be paid from production revenues. Investing in a modern greenhouse is under Malaysian conditions only attractive if the pay-back time is relatively short. For this reason, costs and benefits were roughly analyzed.

Assumptions

Greenhouse acreage = 3.5 ha
Crop: rock melon
2 plants m^{-2}, 2 stems per plant
3 seasons per year

Effective interest = 11%
Loans for operational costs and maintenance are paid pack within one year at most.
Loans for investments are paid back over several years.
Land lease costs = 4500 Rm ha^{-1} $month^{-1}$

Various types of costs are considered:
- Operational costs
- Maintenance costs
- Interest

Benefits are obtained from harvest only.

The total costs in year are are 155 Rm m^{-2}, while the total benefits after one year are 57 Rm m^{-2}. The total costs over 2 years are a little higher than over one year, as more interest has to be paid: 168 Rm m^{-2}. The total benefits over 2 years are 114 Rm m^{-2}. After three years, total costs and total benefits are 181 Rm m^{-2} and 171 Rm m^{-2}, respectively, and after four years 194 Rm m^{-2} and 228 Rm m^{-2}, respectively.

It therefore takes approximately 3 to 3.5 years to play even, and make profit.

Operational costs

Item	**Description**	**Costs per m^2 (Rm m^{-2} y^{-1})**	**Costs per ha (Rm ha^{-1} y^{-1})**
Land lease		0.72	25200
Sowing seed	1000 seeds: 150 Rm	0.9	31500
Water		0	0
electricity	2500 Rm 3.5 ha^{-1} $month^{-1}$ 714 Rm ha^{-1} $month^{-1}$	0.86	30000
fertilizer	2000 Rm 3.5 ha^{-1} $month^{-1}$ 571 Rm ha^{-1} $month^{-1}$	0.69	24000
chemicals	2000 Rm 3.5 ha^{-1} $month^{-1}$ 571 Rm ha^{-1} $month^{-1}$	0.69	24000
Labour	15 persons for 3.5 ha @25 Rm day^{-1}	3.91	136875
Supervisors	2 persons @5000 Rm $month^{-1}$	3.43	120000
owner	1 person @10000 Rm $month^{-1}$	3.43	120000
packaging		6	210000
total		**20.62**	**721575**

Maintenance costs

Item	Description	Costs per m^2 (Rm m^{-2} y^{-1})	Costs per ha (Rm ha^{-1} y^{-1})
plastic	120000 for 3.5 ha, each 5 years	0.69	24000
other	80000 for 3.5 ha, each 5 years	0.46	16000
total		**1.14**	**40000**

Interest costs

Item	Description	Costs per m^2 (Rm m^{-2} y^{-1})	Costs per ha (Rm ha^{-1} y^{-1})
Operational costs + maintenance	1 year	3.03	105949
investments	1 year	13.0	454300
	2 years	26.0	908600
	3 years	38.9	1362900
	4 years	51.9	1817200

Total costs

Item	Description	Costs per m^2 (Rm m^{-2} y^{-1})	Costs per ha (Rm ha^{-1} y^{-1})
All costs	1 year	**155**	5653424
	2 years	**168**	6107724
	3 years	**181**	6562024
	4 years	**194**	7016324

Benefits from harvest

Item	Description	Costs per m^2 (Rm m^{-2} y^{-1})	Costs per ha (Rm ha^{-1} y^{-1})
Grade A	2.5 kg $plant^{-1}$ $season^{-1}$ 3 Rm kg^{-1}	45	1575000
Grade B	1 kg $plant^{-1}$ $season^{-1}$ 2 Rm kg^{-1}	12	420000
Grade C	0.5 kg $plant^{-1}$ $season^{-1}$ 0 Rm kg^{-1}	0	0
total	1 year	**57**	1995000
	2 years	**114**	3990000
	3 years	**171**	5985000
	4 years	**228**	7980000

Annex I.

Itinerary

Sun 13 Feb	Evening	Departure from The Netherlands
Mon 14 Feb	Afternoon	Arrival to Kuala Lumpur; Check-in at Lanson Place, Kuala Lumpur
	Evening	Dinner
Tue 15 Feb	Morning	Preparation of meetings
	afternoon	Visit to Hulu Yam Fresh Sdn Bhd., Ulu Yam.
	evening	Dinner
Wed 16 Feb	morning	Planning meeting with DoA staff at Serdang
	Afternoon	Meeting with Mr. KC Chong, Assistant Agricultural Councillor
	evening	Dinner
Thu 17 Feb	morning	Preparation of afternoon meeting
	Afternoon	Strategic meeting with DoA management
	evening	Dinner
Fri 18 Feb	morning	Operational meeting with DoA staff at Serdang
	afternoon	Report writing
	evening	Departure to The Netherlands
Sat 19 Feb	morning	Arrival to The Netherlands

Annex II.

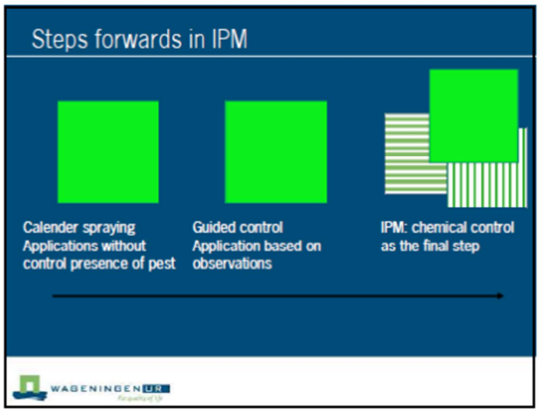
Persons met with

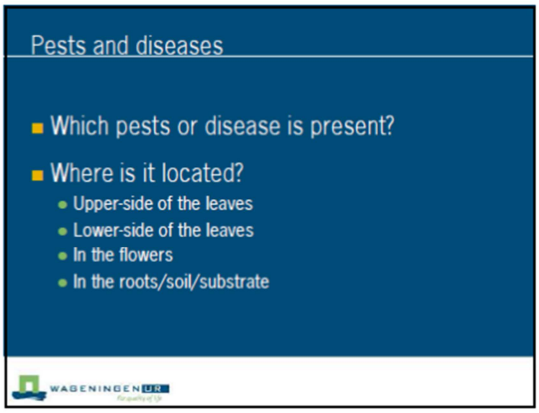
Name	Position	Address	Email / web	Telephone/fax
Department of Agriculture				
Mr. Dato' Sulaiman Bin Md Zain	Deputy Director General of Agriculture (Operations) Department of Agriculture Malaysia	10th Floor, Wisma Tani, Lot 4G2, Precint 4 Federal Government Administration 62632 Putraya	sulaimanmz@doa.gov.my www.doa.gov.my	T: +603 88703005/6 M: +60 12 4076600 F: +603 88888284
Mr. Rahman Bin Ismail	Director Horticulture Division Department of Agriculture Malaysia		rahman@doa.gov.my www.doa.gov.my	T: +603 88703412 M: +60 13 3486058 F: +603 88888319
Mr. Nordin bin Mamat	Deputy Director Horticulture Division Department of Agriculture Malaysia		nordin@doa.gov.my www.doa.gov.my	T: +603 88703407 M: +60 12 3683453 F: +603 88703462
Ms. Khasana Ibrahim	Principal Assistant Director Horticulture Division Department of Agriculture Malaysia		khazana@doa.gov.my www.doa.gov.my	T: +603 88703411 M: +60 12 6016669 F: +603 88703462
Mr. Ramli Md. Affandi	Site Coordinator, Serdang Station		ramliaff@doa.gov.my	+6019-2286771
Ms. Beverlien Christine	Secretary		beverlien@doa.gov.my	+6017-3145310
Mr. Khairul Izhar Lafasa Rais	Site Officer		Kishar80@yahoo.com	+6012-3849960
Ms. Alina Bt. Abdul Aziz	Site Officer		alinaabdulazis@yahoo.com	+6016-6656712
Helmi	Site Engineer			
Mr. Ooi	Crop Protectionist			
Ms. Beverlien Christine	Secretary		beverlien@doa.gov.my	+6017-3145310
Growers				
Chan Loy Onn	Executive Secretary	Persekutuan Persatuan-Persatuan Pekebun-Pekebun Sayur-Sayuran Malaysia	p-sayur@streamyx.com	T: +60 3 56371709 M: +60 12 2231402

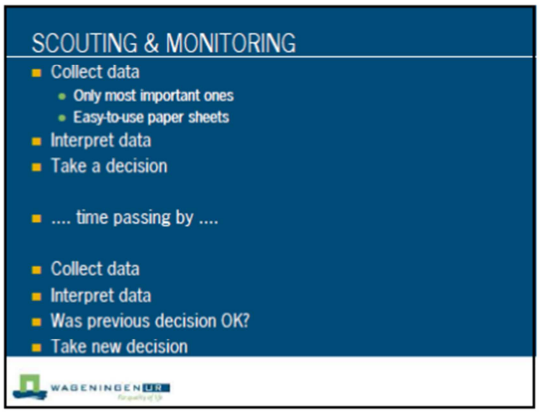
3 growers at Serdang				
Others				
Luuk Runia	Consultant to the project	Asian Perlite Industries Sdn. Bhd. 7B Persiaran Camellia 4 39000 Tanah Rata Cameron Highlands, Pahang	growsys@tm.net.my	T: +60135305566
K.C. Chong	Assistant Agricultural Council	Embassy of the The Netherlands Agricultural Office 541 Orchard Road 13-01 Liat Towers, Singapore 238881	Kc.chong@minbuza.nl	T: +65 67391121 M: +65 96311986 F: +65 67371940

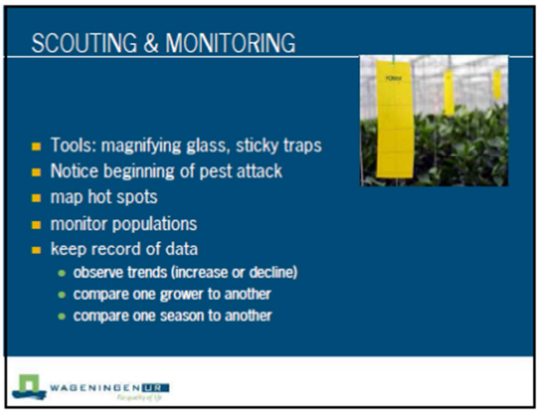
Annex III.

Crop protection









Knowledge

- Pest or disease
- Pesticide
- Mode of action
- Dosage
- Spray-volume
- Moment of application
- Application technique
- Resistance management

Virus diseases

- Zucchini yellow mosaic virus (ZYMV)
- Papaya ringspot virus-type W (PRSV-W)
- Squash mosaic virus (SqMV)

- Watermelon mosaic virus 2 (WMV2)
- Cucumber mosaic virus (CMV)

Control of viruses

- Destroy all old crops promptly once finished
- Clean greenhouse in between two crops
- Remove all weeds (also outside!)
- Remove plants with virus symptoms
- For SqMV:
  - Use virus-free seeds
- For ZYMV and PRSV
  - Use varieties with ZYMV and/or PRSV resistance if available
- Insecticides
  - Not a good virus management approach because insecticides do not act fast enough to prevent the rapid spread of these viruses by aphids and may increase rather than reduce virus spread

Weeds around greenhouses are hosts for pests and diseases and should be removed.

Old plant debris should be removed from the farm as it can act as a source of diseases and pests.

Clean water and disinfectants

- Always use clean water
  - Desinfect the water with heat treatment
- Desinfectants
  - Cannot kill pathogens inside plant material
  - Sterilize a surface
  - First remove all plant material and green stain on the material
  - Using brush & soap or a waterblaster
  - Then apply disinfectant on the clean area

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Clean your hands

Do not use this

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Clean footbaths are excellent for sanitizing workers' boots.

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Visitors

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discipline

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HYGIENE PROTOCOL

- Protocol outlines hygiene measures to be taken at all stages of the tomato production
  - CROP SUCCESSION
  - PREPARATION OF GREENHOUSES
  - PLANTING
  - DURING THE GROWING SEASON
  - WHAT TO DO IF YOUR CROP DOES GET INFECTED

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Annex IV.

Leaf area measurement

Leaf area is the amount of leaves in m^2 per plant. The leaf area index is the leaf area in m^2 per m^2 ground surface. The two can be related with plant density:

Leaf area per plant (m^2 $plant^{-1}$) * plant density (plants m^{-2}) = leaf area index (m^2 m^{-2}).

The leaf area is a very useful crop characters, as it is a good indicator for plant vigour, photosynthetic capacity and yield.

Leaf area can be measured with electronic devices, but in the absence of this, has to be measured manually. Here a description is given how this is easily done.

It is know from other crops that there exists a fairly stable relation between the length and the width of a particular leaf and the area of that leaf. This relation can be established by carefully measuring

1) the maximum length
2) the maximum width
3) the square millimetres of that same leaf.

The circumference of a leaf is drawn on millimetre-paper, and 1-3 are determined. It is important to draw fresh leaves, and to measure from the paper, not from the leaf (which can fold, tear, etc.).

Do this for approximately 30 leaves of different plants, age and size.

This will for example result is something like:

THIS ARE IMAGINARY DATA!

leaf	length (cm)	width (cm)	area (mm2)
1	20	15	20000
2	19	14	18000
3	21	16	22000
4	18.5	16.5	20000
5	15	10	9000
6	25	20	33000
7	22	18	26000
8	21.5	17	24000
9	19.9	21	18000
10	23	21	32000
11	22	19	18000
12	20.5	18	25000
13	16.5	14.5	16000
14	18	15.5	19000
15	24.4	19.5	32000
16	13	8	7000
17	23	15.5	24000
18	20.5	14	19000
19	17.5	10	12000
20	19.5	13	17000

21	22.5	16	24000
22	24	15.5	25000
23	23	14	21000
24	18	10	12000
25	22	13	19000
26	21	12	17000
27	20.5	13.5	18000
28	24.5	17	28000
29	25.5	20	34000
30	27	22	40000

The relation between leaf length, leaf width, and leaf area can usually be described by the following formula:

Leaf Area = Parameter 1 + Parameter 2 * Leaf Length + Parameter 3 * Leaf Width.

If the data are sent to Anne Elings, then he will develop the formula.