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Options for Greenhouse Horticulture in Malaysia

Trip report March 2008

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Picture front cover: Greenhouses in the Cameroon Highlands of Malaysia. The options for expansion are limited, and environmental concerns great.

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1 Summary

Protected greenhouse horticulture is a growing activity in Malaysia 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. Traditional horticultural production takes place in the highlands, where land is scarce and production competes with tropical rainforest. However, there are opportunities in the lowlands. For example, in Terengganu, greenhouses that are modern to Malaysian standards have been successfully realized in 2007. Most relevant crops are currently cucumber, chillies, sweet pepper and tomato. 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 where the majority of horticultural production is located.

We visited Malaysia to assess the situation with regards to greenhouse design and cultivation techniques, to identify components that can be improved, and to discuss with stakeholders various issues of a research and development plan. Our main findigs are:

- **Knowledge and management skills.** Greenhouse horticulture is a very knowledge-intensive activity that requires adequate management skills to effectively apply this knowledge. Knowledge does not seem to be available in sufficients amounts at various levels (manager, technicians). This implies that a major training effort must be implemented. Projects with new technology require supervision by an expert manager and grower for a considerable time, while providing on-the-job training to future managers and growers.

- **Greenhouse design.** The environmental of the tropical lowlands is characterized by high temperatures, high humidity, and during noon low wind speeds.This requires a special greenhouse design. The design uses nets in the side walls to permit the entry of air while preventing the entry of insects. A chimney that is open at two sides to stimulate air to rise and to leave the greenhouse, a process that is stimulated by the wind passing through the two open sides of the chimney. Foil that blocks UV and transforms direct light in diffuse light further contributes to lowering the inside air temperature.

- **Fertigation.** Potential transpiration is high in hot tropical environments. Water and nutrients must be applied in ample amounts, while nutrient build-up in the root zone must be prevented by draining. However, nutrients are expensive. The introducing of a recirculation system with a water treatment unit is therefore recommended in combination with drippers that are uniform in size, and that are clean, and in combination with good filters.

- **Crop management.** The chilli crop should be pruned much better, and lower numbers of stems per plant must be maintained. Fewer, but greater fruits are likely more profitable over-all; a good accessible crop reduces labour costs and enables the manager and workers to monitor all aspects of the crop and therefore take better decisions; and a less humid climate with greater air movement is good for both the crop and the workers. Also, the use of polybags that are black on the inside and white on the outside, and that are impenetrable for light is recommended.

- **Pest and disease management.** It is recommended that the growers move away from calendar-spraying and gradually introduce integrated pest management: better spraying techniques, spraying based on observations, at very precisely determined rates of active ingredients. In the longer run, biological pest management can be introduced.

- **Demonstration trial.** We strongly recommend to demonstrate the above-mentioned aspects in a demonstration trial. Elements of such a demonstration trial would be:
  - Learning faciltities.
  - Expert support (manager, grower) in the initial phase.
  - A 'tropical' greenhouse design.
  - Optimal fertigation technology and strategy.
  - Optimal crop management practices.
  - Pest and disease management with reduced chemical input.
  - On-farm experimentation.
  - Use of sensor technology.
  - Acquisition of all relevant key-data, and utilizing these to further optimize the system.
  - Experiment with new technology and cropping systems.
  - Room for making mistakes.
  - Open to other growers, entrepreneurs, governmental representatives, broad public, etc.

We thank Mr. Adrie de Roo, Mr. KC Chong and Mr. Luuk Runia for their hospitality and great help during our visit. We thank all persons who whom we met – growers, traders, researchers, policy makers - for showing interest in us, and for making available their valuable time.

Wageningen, April 2008.

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2 Introduction

This report results from the project "Tropical Horticulture in Malaysia", funded by The Netherlands Minsitry of Agriculture, Nature and Food Quality with project number BO-10-005-088.

2.1 Problem statement

Protected greenhouse horticulture is a growing activity in Malaysia 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. Traditional horticultural production takes place in the highlands, where land is scarce and production competes with tropical rainforest. However, ther are opportunities for modern horticultural production in the lowlands. For example, in Terengganu, greenhouses that are modern to Malaysian standards have been successfully realized in 2007. Most relevant crops are currently cucumber, chillies, sweet pepper and tomato; 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. Business can be generated with protected greenhouse horticulture since is potentially allows to produce high-value per area surface. In order to achieve this, 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;
- 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 in terms of farm management and production technology.

2.2 Planned output and activities in 2008

The planned outputs for 2008 are as follows:

1. An inventory of needs, possibilities, and requirements with regards to greenhouse designs and cultivation techniques that are suitable for Malaysian conditions.
2. Specify opportunities and possible roles for public and private partners, both Malaysian and Dutch.
3. Produce a research and development plan.

The envisaged approach and activities in 2008 are as follows:

1. Assess the situation in Malaysia with regards to greenhouse design and cultivation techniques.
    a. Visit both lowland and highland regions, and meet with stakeholders (growers, supply industry, research, government).
    b. Speak with Dutch industry that is interested in investment in Malaysian horticulture.
    c. Develop a comprehensive overview of needs, possibilities, and requirements with regards to greenhouse designs and cultivation techniques that are suitable for Malaysian conditions.
2. Identify components that can be improved.
    a. Compare situation in Malaysia with situation in other countries, and build upon knowledge generated in those other countries.
    b. Identify components in the production system for improvement, and specify role of various stakeholders
3. Develop and discuss with stakeholders a research and development plan, with the following components:
    a. Enabling environment
        i. Developmental priorities set by federal and regional governments.

ii. Rules and legislation with regards to, *e.g.*, the import of greenhouse hardware, planting material, and predators for IPM.

b. Research
   i. Greenhouse design
   ii. Planting material
   iii. Cultivation techniques
   iv. Integrated Pest Management

c. Knowledge exchange
   i. Between growers and researchers (informal and formal)
   ii. Growers' study groups
   iii. Strengthening of formal training and research sector.

2.3 Terms of Reference Mission

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

1. Assess the situation in Malyasia with regards tot greenhouse desing and cultivation techniques.
   a. Visit both lowland and highland regions, and meet with stakeholders (growers, supply industry, research, government).
   b. Develop a **draft** (draft, as it has to be discussed by Malaysian stakeholders) overview of needs, possibilities, and requirements with regards to greenhouse designs and cultivation techniques that are suitable for Malaysian conditions.
2. Identify components that can be improved.
   a. dentify components in the production system for improvement, and specify role of various stakeholders.
3. Discuss with stakeholders various issues of a research and development plant, with the following possible components:
   a. Enabling environment
      i. Developmental priorities set by federal and regional governments.
      ii. Rules and legislation with regards to, *e.g.*, the import of greenhouse hardware, planting material, and predators for IPM.
   b. Research
      i. Greenhouse design
      ii. Planting material
      iii. Cultivation techniques
      iv. Integrated Pest Management
   c. Knowledge
      i. Farm Management
      ii. Exchange between growers and researchers (informal and formal)
      iii. Growers' study groups
      iv. Strengthening of formal training and research sector

2.4 Further activities

Envisaged activities after 2008 visit comprise the following:

1. Assess the situation in Malaysia with regards to greenhouse design and cultivation techniques.
   a. Speak with Dutch industry that is interested in investment in Malaysian horticulture.
   b. Develop a **final**, comprehensive overview of needs, possibilities, and requirements with regards to greenhouse designs and cultivation techniques that are suitable for Malaysian conditions.
2. Identify components that can be improved.
   a. Compare situation in Malaysia with situation in other countries, and build upon knowledge generated in those other countries.
3. Finalize with stakeholders a research and development plan, with the following possible components.

3 Current Situation of Greenhouse Horticulture in Malaysia

We describe the current situation of greenhouse horticulture in Malyasia on the basis of the visits we paid to farmers and other stakeholders.

3.1 Farm visists

Our host's strategy was to introduce us to a few selected farms where greenhouse horticulture is at a, to Malaysian standards, high level. The development goal is to make big steps forward, and therefore, it was not necessary to obtain knowledge regarding relatively low technology levels in Malaysia. Our presence was aimed at looking ahead.

All our visits were made in the presence of Mr. Luuk Runia, consultant to the Malaysian Agrifood Corporation Berhad.

3.1.1 Cameron Highlands

March 25:
After being collected from the airport by Mr. Luuk Runia early morning March 25th, we moved to the Cameron Highlands where we visited in the afternoon the farm of **K.C. Kwan & Sons Sdn. Bhd** (Figures 1 and 2). Here we met father and son, **Mr. Kwnag Keh Chong** (Chairman) and **Mr. Kwang Ting Woon** (Director), respectively. Mr. Woon is in charge of day-to-day affairs.

Some observations:
General
- The company produces several vegetables (cucumber, tomato, sweet pepper and several other vegetables) at a number of locations in the Highlands (Bertam Valley,Ringlet,Bringchang, Kuala Terla, Kampong Raja, Loijing Highlands). The total farm acreage is about 60 ha. The company produces for both Singapore and Malaysia, with top quality going to the more demanding market of Singapore.
- The nearby state of Kelantan (Figure 3) permits deforestation to attract horticultural investments. In addition to deforestation, high amounts of grounds are moved to level (parts of) hills. This approach results large risk for soil erosion at the points where slopes are steep. To some extent, this is prevented by the use of plastic to cover the soil. This results in a very characteristic landscape.

Greenhouse construction
- Different greenhouse constructions are in place, viz., open-top lifted, open-top asymmetrically alternated, and closed-top. The foil is produced in Malaysia. Mostly, rain shelters are used. Somtimes nets are only used in parts of the side-walls. This makes the side-walls ineffective as insect barrier. A first greenhouse with totally closed nets (mesh 32) in the side-walls is under construction. The land is leveled before the greenhouse is constructed to improve irrigation and handling. At other farms, this is normally not done, and greenhouses are build on the hill with the natural slope.

Crop management
- The sweet pepper cultivation system uses 4 main stems per plant, but as no serious pruning is applied, the growth habit is quite bushy.
- The tomato plants are grafted on aubergine by the company itself.
- Depending on the crop, production either takes place is the ground (leafy vegetables), covered with a white thin plastic film in between the plants, or in pots placed on a concrete floor.
- Climate data are not registered and used in management.
- Crop data are not registerd and used in management.

Fertigation
- Plants are grown on cocopeat in white poly bags. Drip irrigation is normally applied; water is drained through small gutters made in the concrete or digged in the ground; the drain subsequently flows in the river. The irrigation system is open: water is not recirculated. Irrigation management is fairly simple with the usage of three different irrigation frequencies: one for rainy days, one for cloudy days, and one for sunny days.
- Nutrients are expensive, which is the cause of very low drain. Usage of the A/B system is normal.
- Water is obtained free of charge from mountain rivers. The only investments here are low costs for water pipes. The water itself is free of charge.

Pest and disease management
- The main pests are thrips and white fly. The main disease is Botrytis (mould). A list of permitted chemicals can be found at: www.moa.gov.my.

3.1.2 Terengganu

March 26 & 27:
Mr. Runia transported us in the morning of March 26th to the state of Terengganu, which is a coastal state in northeast of Malaysia. Here we visited in the afternoon of March 26th and in the morning of March 27th **TRG Sutratani Sdn. Bhd**. in Kuala Terengganu. In the recent past, Mr. Runia has as an advisor been involved with the establishment of TRG Sutratani. We met with Mr. **Khairul Adzhar Bin Darus** (Chief Operation Officer) and Mr. **Adnan Md. Isa** (Farm Manager). We also met with Mr. **Mazri Mansor**, who is Managing Director of **JPB Asia Pacific**, which is the trading company that was involved in the establishment of TRG Sutratani.

TRG Sutratani is presently owned by the Terengganu Agricultural Development Corporation (TADC), a state-owned investment agency. Discussions are on-going with regards to continue ownership by TADC or a take-over by MAFC, or a form of joint management

Some observations:
General
- The farm produces chili in tropical lowlands. There is in Malaysia a high demand for fresh chillies for the daily production of sambal, which fetch a much higher price than dried chillies. Red chillies fetch a three times higher price than green chillies (Figure 4).
- Winds come in the morning and evening, while during mid-day the weather is relatively hot and sticky.
- Climate data are not registered and used in management.
- The production costs of chillies are 1.66 Rg kg^{-1}, and selling price is 3 Rg kg^{-1}. This is based on a seasonal production of 7 kg $plant^{-1}$. The cultivation system therefore is potentially profitable.
- We have the impression that not much room for error is available. However, we feel that a number of years is required to prove the potential of a new production system, and that part of the learning process is making mistakes.

Greenhouse construction
- Production takes place in six greenhouse units of 120 by 40 m (0.5 ha each; total 3 ha). The geenhouses are covered with plastic in the top and have nets (mesh 50) in the side-walls. However, the nets are not closed to improve ventilation.
- Inside air temperatures are high. This could probably be avoided by using top ventilation openings, which are absent in the present construction. Increased ventilation is absolutely necessary, not only to lower inside air temperature, but also to increase crop transpiration (Figures 5-7).
- It should be investigated whether film pipes inside the greenhouse (like CO_2 pipes) for increased ventilation could be used.
- The plastic film used does not transform direct radiation in diffuse radiation. The latter type would reduce crop temperatures and would cause a deeper light penetration in the crop canopy, favouring crop photosynthesis and growth. The light scattering properties of the film should be 50-80% haze.
- Analysis of the plastic films shows that in general the light transmission is reasonable with 86% (for comparison: in Europe such films have a light transmission of 90%). Dust can reduce the light transmission, cleaning should be done frequently (every 3 month) (Figure 8).
- Possible improvents in greenhouse design were elaborately discussed on the basis of knowledge gathered in Indonesia.

Crop management
- Seed is obtained from Korea, Japan and Taiwan.
- Plants are grown in polybags filled with coco peat. Larger polybags contain a larger water buffer than smaller polybags, and are therefore safer. Transparent polybags suffer from penetrating radiation which causes algae growth and higher root temperature. It is therefore recommended to use not-transparent polybags (white on the outside, black on the inside). Polybags must also have holes at the bottom to avoid standing water. Standing water may be considered as a water buffer, but it will not permit root growth in this area.
- The crop is not pruned, and the many shoots give a very bushy and dense crop. The consequences are many:
    - The crop can physically not be entered for inspection, spraying, harvest, and any other activity.
    - Many fruits are formed, which remain relatively small. If the strategy is to produce large fruits (large fruits: 7 Rg kg^{-1}; small fruits: 4 Rg kg^{-1}), then pruning is required.
    - The air movement below and in the crop is very low, which is inducive to diseases such as Botrytis.

- We demonstrated roughly how a plant should be pruned, and recommend that some on-farm experimentation is done to establish the best way of pruning. More pruning reduces the amount of shoots, but increases total crop height. Labour-wise, crop height should be limited.
- Capsicum species are both self and cross-pollinating, the latter being about 16% (Purseglove, 1977). For both, the presence of bees or ants is necessary. The pollination process is sensitive to high temperatures, and temperatures above 30 °C should be avoided (Sato et al., 2000). Side wall closure with plastic leads to both fewer insects for pollination and very high temperatures (due to low ventilation), which both can negatively influence the pollination.
- The crop is envisaged to stand for a period of 8 months. The total crop production is hard to estimate at this moment since the project in the lowlands just runs for a year and data have yet to be confirmed.

Fertigation

- Because chemical fertilizers are very expensive, the strategy is to avoid drain which would imply a loss of nutrients in the absence of a recirculation system. Limited amounts of water are given, approximately 5 times per day. This leads to a dry substrate and probably high EC values in the root zone. A dry substrate limits transpiration and crop growth, and a high EC value in the root zone can at some point severly affect crop growth.
- There is no uniformity in water release by the irrigation system. The drippers are not truly uniform is size, the may be contaminated at the inside, and the pressure changes over the length of the row. It is better to supply water from the middle of the greenhouse, which halves the length of the row and the difference in pressure. The use of pressure-regulated drippers (cost 1 Rg per piece) is recommended.
- To achieve a good crop growth, substantial higher amounts of water must be given. Leaves, especially those of young plants, were visibly hanging due to water shortage. In principle, frequent application of small amounts is better than few applications of large amounts.
- Foliar application of some nutriets, viz. calcium and boron, takes place. It is correct that kathions can by taken-up by the leaf. Folair application of N (in organic form) and Fe are examples. However, care must be taken not burn the crop. We doubt whether these nutrients are in shortage, and recommend to apply nutrients through the root system, which is cheaper and more robust.
- Night-time transpiration may be 30% of day-time transpiration (this value should be checked in future).
- EC of the irrigation water is 2.6 in the morning, and 2.8 in the evening.

Pest and disease management

- The greenhouses have a sluice to limit the entrance of pests. However, the double doors of the sluices appeared not to be used (Figure 9).
- Main pests are thrips, mites and whity fly (in descending order of importance). Main diseases are botrytis, mosaic virus and wilt.
- (Frequent) application of chemicals is the only pest treatment. Spot spraying is applied.

3.1.3 Kuala Lumpur Region

March 28:

With Mr. Runia and Mr. KC Chong we visited in the afternoon of March 28th **Sime Fresh Aeroponics Park** (Figure 10) at Seremban, where we were received by **Mr. Gene Goh**, Assistant Manager of Sime Darby Technology Centre Sdn. Bhd. The farm is unique in Malaysia in its usage of aeroponics.

Some observations:

General

- The main crop is lettuce; some other leafy vegetables are also grown. Due to pest problems, the cultivation of tomatoes and chillies was abandoned.
- The farm was established in 1998 and measures 4 ha.
- Currently, the farm is not profitable due to the high costs of energy and logistics.

Greenhouse construction

- The greenhouse design consists of an asymmetrical roof with plastic cover and nets in the openings. The ventilation openings are closed automatically during heavy rains.
- As a consequence of limited ventilation, the temperature distribution is poor: in the middle of the greenhouse complex high temperatures up to 40 °C are easily reached, whereas outside temperature is only 32 °C degrees. Ventilators in the greenhouse skin or inside the greenhouse could improve the current structure. Another possibility is to split up the greenhouse area. For both solutions the economic consequences should be calculated.
- Light intensities inside are very low due to construction, dirty film and use of black nets as a shading screen. This hampers crop growth.
- The main problem is high amount of energy to cool down irrigation water from 30-40 °C (originating from the greenhouses, the water temperature has risen) to 24 °C. Currently, a heat exchanger is used, but the farm management wishes to reduce energy costs.

Crop management
- Seed is obtained from RijkZwaan in The Netherlands.
- Plants are raised in the own nurserly, where temperature is kept at 25-28 °C. Air is water-cooled at the inlet point.
- Overall, a lot of algae (both nursery and greenhouse) growth was observed.

Fertigation
- Roots are sprayed for 30 seconds with the nutrient solution every 1 minute during daytime. At nighttime, roots are sprayed every 45 minutes for a period of 15 minutes.
- Every two months the nutrient tank is totally emptied for disinfection. It might be better to disinfect the water with ozone or low sand filtration

Pest and disease management
- Various leaf and root diseases (stem rot), white fly and mites are the main problems.
- Application of chemicals is the main disease management method.
- The farm is interested in biological control.
- Sanitation could be better. Only styropor coverings are cleaned with high pressure water. Tables are dried and brushed. But still, much algae presence was observed.

March 28:
Returning from Sime Fresh, we visited the **Commodity Development Centre** of the Department of Agriculture in Serdang, where we were shown around by **Mr. Kadir Bin Zainal** (Agricultural Officer).

Some observations:
- The Australian autopod system is used.
- Fertigation is applied four times per day.
- Root growth appears OK.
- Strong algae growth. Experiments with stone covering of the water layer to block radiation are on-going.

March 29:
In the company of Adrie de Roo, KC Chang and Luuk Runia, we visited the Lanchang Papaya Farm of MAFC at Tamerloh. We were shown around by Mr. Lee Hoon Kok (Farm Manager) (Figure 11).

Some observations:
- The farm produces a small papaya that, once sliced through, can be spooned empty from the hand. Production is currently for the local market, but options for export are sought.
- Farm acreage is 16-20 ha. Plans are to expand with 400 ha in 2009, and another 1000 ha in 2010.
- The major problem is fruit fly. Fruits are harvested relatively green (lower pest incidence), and chemically treated before packaging.

3.2 Stakeholders

3.2.1 Ministry of Agrciulture

March 28:
In the company of Mr. Adrie de Roo and Mr. KC Chong we met with a delegation of the Horticultural Division of the Department of Agriculture Malaysia in Putrajaya:
- Mr. Cheah Lee Shen (Deputy Director of Horticulture, Fruit)
- Mr. Kadir Bin Zainal (Agriculture Officer, Serdang Research Station)
- Mr. Zain (Fertilization Specialist)
- Ku Asma (Vegetable Seed Production)

Mr. Cheah Lee Shen apologized that the Director General, nor the Deputy Director General for Development could not be present at the meeting.

We briefed the delegation with respect to the findings of our mission, which very much resemble the overview given in Chapter 3.

It was agreed to propose the following steps:
- develop horticultural business, develop overall concept
- technical improvement of the greenhouse at Terengganu
    - together with the Dutch industry

    - management
    - training
- Improved management and training
- implementation of technology at other locations
    - 'Permanent Food Production'
    - At various locations spread over Malaysia
    - Develop linkeages with Fertigation Projects at various locations
    - Provide alternative for areas with poor soils
- Attract investors
- exploration of home and export markets
- Upgrading of education to support improvement of farm management

Mr. Cheah Lee Shen is willing to set up a bilateral co-operation between Malaysia and The Netherlands. He will report to the DG, and recommend further collaboration

3.2.2 Malaysian Agrifood Corporation (MAFC)

March 25:
At the end of the afternoon on March 25th, we met some members the Khazanah Research and Investment Strategy, and of the board of the Malaysian Agrifood Corporation Bhd.:

- Abu Bakar Ibrahim (Director, Khazanah)
- Azizi Meor Ngah (Chief Executive Officer, MAFC)
- Mohd Pahmi Mohtar (Executive Director, MAFC)
- Chan Ying Kwok (Senior Fice President, Crop Science & Production Technology, MAFC)

The Khazanah Research and Investment Strategy is a government-likend investment agency that invests in the Malaysian Agrifood Corporation.

MAFC plans 200 ha of greenhouses in Cameron highland. Part of the land is leased from MARDI. The major goal of these greenhouses are to demonstrate technology and feasibility of new greenhouses to local farmers. Keywords are: new greenhouse design, fertigation systems, modern equipment, economic feasible, improvement of production, business opportunities. Possible crop are tomato, sweet pepper and lettuce.

We visited with Mr. Runia the new sorting and packing station of MAFC for vegetables where they pack and sort tomatoes, cabbages, salads and beans. The intention is to integrate the sorting and packing with marketing and sale. Currently, 8 growers make use of the facilities; extension is planned.

March 28:
In the afternoon of March 28th, we met with MAFC representatives to discuss several issues on horticultural development in Malaysia:

- Mohd Pahmi Mohtar (Executive Director, MAFC)
- Felix Miller (Senior Vice President, ICT, MAFC)
- Jack (Associate Assistant MAFC Cameron Highlands)

Some of the main points:

- The idea is to realize in Terengganu one good demonstration greenhouse, where for a number of years various aspects of greenhouse construction and production are demonstrated to local investors and farmers.
- For a previous project, WUR designed a greenhouse that is suitable for tropical lowland conditions. This greenhouse design has been locally copied, illustrating its suitability. The design of such a greenhouse was extensively discussed.
- We will bring MAFC in contact with Mr. Rien Rodenburg of PT East West Seed Indonesia (EWINDO) in Purwakarta, Indonesia.
- CO_2 enrichment is not usefull in Malaysia, as greenhouses can not be closed.
- Integrated Pest Management should be implemented, but is currently hampered by legal laws and regulations. The perspectives should be made clear and further discussed. Where appropriate, other WUR scientists can be involved.
- The mesh size has consequences for the insects species that can enter the greenhouse. A very small mesh size, however, will limit ventilation.
- Main crops are capsicum (chilli) in the lowlands, and capsicum, tomato and lettuce in the highlands.
- Production will initially be for the Malaysian market. Only later, export may be explored.

- Competition between greenhouse horticulture and oil palm is not really an issue. Greenhouse horticulture uses small acreages of land, while oil palm plantations are very large in size. It are simply two types of land use that can very well exist along side each other.

3.2.3 TADC

Attempts were made to arrange a dinner with ir. Adnan Ghazali, the executive director of the Terengganu Agricultural Development Corporation (TADC), which owns the **TRG Sutratani Sdn. Bhd**. in Kuala Terengganu. Unfortunately, however, this meeting could not be arranged.

3.2.4 Horticultural Education and Research

We were informed that Malaysia does not know any longer an Agricultural University, since a transformed to a general university has been implemented some years ago.

The Malaysian Agricultural Research and Development Institute (MARDI) has a Horticultural Research Centre in Serdang. MARDI also has an AgroTechnology Park in the Cameron Highlands. We were not in the position to visit the latter location, and would like to do this during a next visit (if there is one). Speaking to the horticultural industry, we conclude that there is not much interaction with MARDI. This points to a mismatch between demanded and conducted research.

3.2.5 Netherlands Embassy

March 27:
We had dinner with Adrie de Roo, Counsellor for Agriculture, Nature and Food Quality of the Embassy of the Kingdom of the Netherlands Agricultural Office in Kuala Lumpur and K.C. Chong, technical assistant Embassy of the Kingdom of the Netherlands Agricultural Office in Singapore. We discussed our first findings and prepared next day's meeting at the Ministry. The first findings very much resemble the overview in Chapter 3.

4 Future prospects

The future prospects of greenhouse horticulture in Malyasia are organized in a number of paragraphs that each deal with a specific field. We list our observations during our visit, and where possible, we indicate the way ahead and the partners that may be involved in this way ahead.

4.1 Greenhouse construction

#	Observation	Way forward	Suggested partners
	Greenhouse structure: - The construction elements used are from steel and very light, sometimes pipes are bending, however, no serious break-downs of structures have been reported to us, during strong winds mainly the plastic breaks, not the struture	Current situation is tolerable.	Malaysian growers: provide specifications. Malyasian industry: fabrication and installation.
	Greenhouse design: - The design is not the best for tropical lowlands. - Inside temperatures and insect pressure are too high.	Develop a new design on the basis of the Indonesia and Bangkok designs, with fine-tuning on the basis of current local designs (highland and lowland).	WUR + MAFC: expand available studies towards design. Local industry + farmers: production of structures.
	Greenhouse cover: - Film transmits direct light, leading to high temperatures and sub-optimal light penetration in crop canopy. - Lifetime is OK (3 years).	Use locally produced diffuse and possibly UV-block films.	WUR: provide film specifications. Local plastic producers: film production.
	Greenhouse sides - Sides are either fully closed, or totally open. - Closed sides cause high temperatures, totally open sides cause high pest pressure. - Holes in the side nets are deliberately created, or not repaired.	Greenhouse sides made of nets must be installed (50mm * 50mm). ALL holes in the sides must be closed.	WUR: provide detailed advice with regards to closing holes. MAFC: ensure proper placement and closing holes. Farm manager: maintain quality of side walls.
	Greenhouse entrance: - In most cases, single doors are installed. This is not sufficient to limit the entrance of insects.	A sluice with double doors must be installed and used.	WUR: provide the design. Local industry: production. MAFC + farm manager: ensure that sluice is used properly.

4.2 Crop Management

#	Observation	Way forward	Suggested partners
	Inside air temperature is high.	Use a better greenhouse design.	See above
	Pollination requires to some extent insects and/or ants. Plastic greenhouse sides limit the entrance of insects.	Nets may improve the entrance of insects. This issue requires some further investigation.	MAFC/WUR: carefully monitor fruit set.

	Pruning is not sufficient. The crop is very dense, leading to: - Many, small fruits that fetch a low price - Inability to enter the crop, and consequently more labour costs - Standing air, low ventilation, high humidity	Apply a different pruning strategy, with only 2-4 shoots per plant. The exact number has to be determined in small experiments, and may vary over farms. Fewer stems lead to a higher plant, which should also be controlled.	Farmers: conduct on-farm experiments. Trainers/growth expert: provide advice (Figure 13).
	Improper polybags are used (Figure 12): - Transparent polybags suffer from penetrating radiation which causes algae growth and higher root temperature. - No holes at the bottom cause standing water, which stops root growth. - Standing water may be considered as a water buffer, but it will not permit root growth in this area.	Use proper polybags (black on the inside, white on the outsde, impenetrable for light, with holes in the bottom). Larger polybags contain a larger water buffer than smaller polybags, and are therefore safer. Standing water must be avoided.	Local industry: production of suitable polybags.
	The water holding capacity of the substrate is rather low.	Try to amend the cocopeat subtrate, which in itself is OK, to increase the water holding capacity.	

4.3 Fertigation

#	Observation	Way forward	Suggested partners
	Fertilizer costs are high, therefore drain is avoided, and limited amounts of water are applied (e.g., only 5 times per day).	Substantially more water must be applied, and application frequency must be increased. It is better to apply more frequently a small amount of water, than a few times a lot. Drain must be permitted to flush away excess of nutrients from the root zone. A recirculation system can recover nutrients (and water), for re-use. The recirculation system will require a water treatment unit and good filters.	Dutch industry: high-quality and knowledge-intensive irrigation and water management systems. Local production is difficult. WUR: provide scientific guidance with regards to calibration of fertigation system. Training: increase knowledge. Growers: increase skills, respond to crop needs.
	Limited water applications leads to water shortages in the plant, low transpiration, low cooling capacity by the crop, and high greenhouse temperatures.		
	Limited water application also leads to increased EC levels in the root zone, which at some point inhibit crop growth.		
	Fairly simple irrigation management (frequencies for rainy, cloudy and bright days).	Realize a more advanced fertigation control system.	
	There is no uniformity in water release by the irrigation system.	Use drippers that are uniform in size, and are clean. Reduce variation in pressure over the length of the row by supplying water from the middle of the greenhouse, and the use of pressure-regulated drippers.	
	Foliar application of nutrients, viz., Ca and B.	Under normal conditions, foliar nutrient application is not necessary.	
	Water is not applied at night-time.	In itself night-time irrigation is not required, if the water buffer is sufficient to maintain the night-time transpiration (possibly up tp 30% of day-time transpiration).	

	No closed water / fertigation system is used, and leakage of nutrients occur	Closed water cycles should be tried, water should be recycled, disinfected and re-used.	More technology is needed, collaboration with Dutch industry

4.4 Pest and Disease Management

#	Observation	Way forward	Suggested partners
	Sluices are either not present, or are not used, permitting the entrance of insects.	Creating awareness with regards to strict sanitation. Realize greenhouse construction with sides closed by nets.	See greenhouse construction. Training: create awareness and skills.
	Side nets are not closed, permitting the entrance of insects.		
	Greenhouse sides and roof showed holes, permitting the entrance of insects.		
	Spot spraying is applied.	OK	Training of scouts and farmers: create awareness and skills.
	Calender spraying, without proper justification by insect incidence.	Replace by observation-base spraying, if threshold is reached.	
	Wrong and therefore ineffective spraying (e.g., the upper side of the leaf, when insects are hiding at the botoom side of the leaf).	Improve knowledge and skills with regards to insect behaviour and spraying techniques.	
	Diseased plants are not removed.	Improve knowledge with regards to infection processes.	
	No use of mouth caps.	Use of protective clothing must be strictly implemented.	Grower: follow regulations and certification requirements.
	Legislation and rules do not enable the import of beneficials (natural enemies). This prevents the use of biological crop protection.	Discuss with stakeholders need for new rules and legislation. Define process to achieve such. Make possible the import of beneficials.	WUR: facilitate discussion. Government: develop policy. Private industry: production and import of beneficials.
	The desire to build up a local industry for biological control.	Conduct a feasibility study	WUR: expert knowledge MAFC: local knowledge

4.5 Knowledge and Management

#	Observation	Way forward	Suggested partners
	Horticulture already exists since many years in Malaysia, however, no real technological improvement can be observed	Improve the knowledge level. Realize a demonstration trial. Show economic value of horticulture.	WUR, MAFC, industry: realize the demonstration trial. In the demonstration trial, room for error must be permitted.
	Farmers seem to be content with the present production, and do not see the need for improvements. They look at previous or existing experiences, and do not move forward. This mentality results in a lack of expertise / low knowledge level, and uncertainness.		

	Agricultural education does not exist in the country.	Short-term: provide training. Long-term: Re-establish eduction, improve the image of horticulture. Involve, for a long intial period, expert manager and grower when establishing new projects	
	There are not sufficient specialists at the farm (e.g., entomologist, soil specialist, etc)		
	Very few records (climate, production, farm management) are kept (symbolic was that the planting date of the crop was not even known). - This leads to low level of knowledge with regards to climate, crop growth, production, profitability, etc - It also hampers the possibility to reflect on the effects of any event on crop production, and therefore the possibilities to learn.	Record hourly climate data, farm management practices, production data, etc. Reflect on these in combination with recent crop growth, and improve crop management in the future.	Industry: enable record-keeping with sensors, software, etc. WUR: support the learning process.
	Farms are not always clean. This is symbolic for the mental involvement with the farm.		
	Insufficient on-farm experimentation.	Experiment on a small scale with varieties, pruning strategy, plant density, etc. This is instructive and offers options for improvement.	Involve seed companies from the region (e.g., PT East West Seed Indonesia)

4.6 Feasibility

#	Observation	Way forward	Suggested partners
	In general high-value protected horticultural production is very profitable.	There is no reason why this should be different in Malaysia.	
	Farmers know very little about the economics of their farm (yields, total production, costs) and normally to not have any marketing concept for their products.	Subject farmers to an intensive training programme, aimed at changing the attituce.	
	Malaysia imported for RM 1796 and 921 million in 2006 and 2007, respectively, of horticultural products every year (DOA).	The products can be produced in Malaysia itself, moreover there is a chance of producing high-value crops for export.	
	Labour is scarce in Malaysia, and workers come from Indonesia, India, Nepal. Also farm managers come from abroad and stay maybe 5 years. Work in agriculture is not fashionable.	Pad image of the agricultural sector has to be improved to attract workers	
	Energy costs may be high?	Save energy. Convince the government that the horticultural industry is industry as other industries, and deserves a lower price.	

	Land is scarce in the highlands, new land is not available, and therefore it is expensive. Land use in the highlands can be illegal. Lease contracts can be for one year, which prevents investment in technology.	Move horticulture to the lowlands. Only use long-term lease contracts that justify private investment. Incrase the certainty by farmers with regards to their future.	
	Tropical forest is replaced by agricultural production, when that is done, first wood is economically used, then it is replaced with palm oil production. Greenhouse production has to compete with palm oil production.	Economic figures are lacking, an extended economic study should be carried out for highland and lowland situation including the competition with palm oil.	

5 Conclusions

Malaysia is investigating ways to expand horticultural greenhouse production, to meet on the one hand the demand for fresh products in Malyasia itself and few export countries, and on the other hand to offer opportunities to interested entrepreneurs. Options for expansion in the Cameron Highlands are limited, and therefore, options for expansion in the eastern tropical lowlands are considered. Land is abundantly available.

The major obstacles and solutions can be summarized as follows:

Knowledge and management skills. Greenhouse horticulture is a very knowledge-intensive activity that requires adequate management skills to effectively apply this knowledge. Malaysia does not know any form of agricultural or horticultural education – possibly triggered by the lack of interest by students – which is one of the causes of the absence of skilled personnel at the farms. The farm managers seem to rely on existing experiences and unstructured knowledge gathering, and do not seem to fully understand the interacting elements of a complex greenhouse production system. At a lower level, the absence of scouts with good entomological training, fertigation specialists with in-depth knowledge of soil processes, a quality specialist that understands the crop processes that influence product quality, etc. was striking.
This implies that a major training effort must be implemented. There are various options that compelent each other:
Short term:

- Extensive training is needed for all activities the farm, from farm manager down to the workers. Managers require general knowledge, but also management skills and horticultural economics, including marketing and sales. Specialists are needed in plant nutrition, pest and disease management, crop physiology and above all proper farm management.
- Realize a demonstration project (see below).
- Involve experts from the region. Growers and extensionists from nearby countries with similar climates may have an abundance of experience that is directly applicable under Malaysian conditions.
- Establish a system that ensure the recording of climate factors, farm management activities, costs of inputs, production figures, etc., and that ensures the reflection by growers on these data. This can be supported by other forms of knowledge transfer, software and experts.
- We offered to write contributions to 'Vegetable Farmer' (a Chinese magazine in Malaysia).

Medium term:

- Involve PTC+ (Practical Training Centre) from The Netherlands. They are specialized in very practical training courses.
- On-farm experimentation, with good support, yield valuable information with regards to the optimum management strategy at a particular farm (e.g., with regards to varieties, pruning strategy, fertigation regime).

Long term:

- Create a network of advisors.
- Intensify the interaction with MARDI, with the goal to raise the applied knowledge level at this institute. Wageningen UR can possibly build upon the Memorandum of Understaning between MARDI and Wageningen UR.
- Discuss with governmental authorities the options to re-establish horticultural education (e.g., at the university level in Kuala Lumper, at the applied level in the horticultural areas)
- Students can be sent abroad for MSc studies.
- Establish growers' study groups.
- If new projects are established, ensure for a long initial period the involvement of an expert manager and grower.

Greenhouse design. The environmental of the tropical lowlands, where the new greenhouses are envisaged, is characterized by high temperatures, high humidity, and during noon low wind speeds. The greenhouse that are used in the Malaysian highlands are not fully suitable for such conditions, as a greater ventilation capacity is required. For this reason, the current greenhouses in Terengganu open the side nets. Wageningen UR has designed greenhouses a few years ago for a similar climate in Indonesia (for the breeding company PT East West Seed Indonesia at Purwakarta, East Java) (Impron *et al.*, 2007a, 2007b) (Figure 7). The design uses nets in the side walls to permit the entry of air while preventing the entry of insects. A chimney that is open at two sides to stimulate air to rise and to leave the greenhouse, a process that is stimulated by the wind passing through the two open sides of the chimney. Foil that blocks UV and transforms direct light in diffuse light further contributes to lowering the inside air temperature. Research results showed that this design was effective in maintaining high ventilation rates and inside air temperatures that are similar to the outside air temperature. When the crop was fully mature and transpiring, inside air temperature could even be lower than outside air temperature.

Fertigation. Potential crop transpiration rates are high in a tropical environment. Water in the root zone must be available at all times to meet the demand for water. If not, stomata close, CO_2 exchange reduces, leading to lower growth rates and reduced production. In the ideal situation, water is applied in small amounts at high frequency. The amount per fertigation moment is higher if radiation is higher, due to the higher transpiration rate at that moment. This approach maintains a high water content in the substrate. Also, nutrients are supplied in the amounts that are required by the crop. If more nutrients are applied, the danger of nutrient bulld-up in the substrate exists, which can have negative effects on crop growth. Extra water is therefore given to flush out this excess of nutrients. This fertigation approach is very different from the ones currently practiced in Malyasia. Only approximately 5 times per day water is applied, leading to extended periods in which the substrate does not have sufficient water to meet de demand by the crop. Especially around noon, this problem leads to even hanging leaves. The reason for applying low amounts of water is the fact that fertilizers are expensive, and drain is avoided. The balance between fertilizer costs and yield loss is not clear. The impasse could be solved by introducing a recirculation system with a water treatment unit and good filters. Also, drippers that are uniform in size, and that are clean must be used. It is not acceptable that one particular plant receives double the amount of water than the other plant. This leads to wide variation in growth and plant height (as we observed). The variation in pressure over the length of the row can be recuded by supplying water from the middle of the greenhouse, and the use of pressure-regulated drippers.

Crop Management. After the proper climate has been realized, and sufficient amounts of water and nutrients are supplied to the crop, various crop management practices should be adjusted.

- With regards to hot pepper, it must be avoided that the crop is bushy and dense, as this leads to many, small fruits that fetch a low price; inability to enter the crop, and consequently more labour costs; and standing air, low ventilation, high humidity. The crop must therefore be pruned much better. Low numbers of shoots per plant must be maintained (2-4, the exact number must be determined in on-farm experimentation). Fewer, but greater fruits are likely more profitable over-all; a good accessible crop reduces labour costs and enables the manager and workers to monitor all aspects of the crop and therefore take better decisions; and a less humid climate with greater air movement is good for both the crop and the workers (Figure 14).
- Polybags that are white on the outside and black on the inside, and that are impenetrable for light, with holes in the bottom should be used. Transparent polybags suffer from penetrating radiation which causes algae growth and higher root temperature. The absence of holes in the bottom cause standing water, which stops root growth. Larger polybags contain a larger water buffer than smaller polybags, and are therefore safer.

Pest and Disease Management. The pest and disease management strategy is based on calendar-spraying in combination with some spot-spraying. Moreover, it appears that the spraying technique itself can be improved (spray at the location of the insects). It is very strongly recommended to base the spraying on observations of pests and diseases, at very precisely determined rates of active ingredients. This requires training of entomologists, good scouting, and availability of proper chemicals. Closure of the greenhouse side, as an element of the greenhouse construction, will reduce the insect pressure (Figure 15).
In the longer run, the strategy can switch to biological management, in wich predators (beneficials) are used. It is not clear to us whether the farming community is desiring this. Rules and legislation do not to enable the import of beneficials. A discussion with governmental bodies should therefore be started. It is to be expected that the maturing consumer market at some point will insist on products that are free from chemicals.
Establishment of an own beneficial-industry may seem attractive, to avoid the import of (supposedly alien) insects. However, it is stressed that such an industry is very complex, and may take more time than the horticultural industry can wait for.

Demonstration trial. We strongly recommend to demonstrate the above-mentioned aspects in a demonstration trial. Elements of such a demonstration trial would be:

- Learning faciltities.
- Expert support (manager, grower) in the initial phase.
- A 'tropical' greenhouse design.
- Optimal fertigation technology and strategy.
- Optimal crop management practices.
- Pest and disease management with reduced chemical input.
- On-farm experimentation.
- Use of sensor technology.
- Acquisition of all relevant key-data, and utilizing these to further optimize the system.
- Experiment with new technology and cropping systems.
- Room for making mistakes.
- Open to other growers, entrepreneurs, governmental representatives, broad public, etc.

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Annex I.

Itenary

Mo 24 March	morning	Departure from The Netherlands
Tue 25 March	morning	Arrival to Kuala Lumpur; pick-up by Luuk Runia, drive to Cameron Highlands; check-in at Centtury Pines in Tanah Rata
	afternoon	Visit to K.C. Kwang & Sons Sdn. Bhd. (Cameron Highlands) - Kwang Keh Chong - Kwang Ting Woon
	evening	Dinner and early sleep
Wed 26 March	morning	Drive to Telega Papan
	afternoon	Visit to TRG Sutratani Sdn. Bhd. (Telaga Papan) - Masri Manzor - Khairal Adzhar Bin Daruz - Adnan Md. Isa Introduction to Khazanah Nasional & MAFC Board: - Abu Bakar Ibrahim (Khazanah) - Azizi Meor Ngah (MAFC) - Mohd Pahmi Mohtar (MAFC) - Chan Ying Kwok (MAFC)
	evening	- Dinner with staff of TRG Sutratani (Luuk Runia, Mazri Mansor, Khairol Adzhar Bin Darus, JPB Asia Pacific Sdn. Bhd.)
Thu 27 March	morning	Visit to TRG Sutratani Sdn. Bhd. Visit to nearby chillifarm
	afternoon	Travel by plane to Kuala Lumpur
	evening	Dinner with Adrie de Roo (Agricultural Councellor), Maria de Roo and K.C. Cheng (Technical Assistant to Agricultural Councellor)
Fri 28 March	morning	Meeting with Horticulture Division, Department of Agriculture (Putrajaya) - Cheah Lee Shen - Kadir Bin Zainal - Zain - Ku Asma - Adrie de Roo - KC Chong
	afternoon	Visit to Sime Fresh Aeroponic Park (Seremban) - Gene Goh Visit to Commodity Development Centre, Department of Agriculture (Serdang) - Kadir Bin Zainal
	evening	Meeting with MAFC representatives - Mohd Pahmi Mohtar - Felix Miller Dinner with Luuk Runia & KC Chong
Sath 29 March	morning	Visit to Lanchang Papaya Farm (Tamerloh), with Adrie de Roo, K.C. Chong, Luuk Runia.
	afternoon	Lunch with Luuk Runia & KC Chong Free time
	evening	Free time
Sun 30 March	morning	Free time
	afternoon	Report writing
	evening	Departure to The Netherlands

Annex II.

Persons met

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Annex III.
Photographs

Figure 1. A new greenhouse design with asymetrical (small) roof opening at K.C. Kwan & Sons Sdn. Bhd farm.

Figure 2. Grafting tomato plants on aubergine root stocks at K.C. Kwan & Sons Sdn. Bhd farm.

Figure 3. Land clearing in the Cameroon Highlands for greenhouse construction.

Figure 4. Sorting green and red chillies (TRG Sutratani farm in Ternengganu).

Figure 5. Terenganu greenhouses with gothic roof system and without top opening.

Figure 6. A traditional greenhouse design with a top opening (left), and a a traditional greenhouse design without a top opening, as found in most greenhosues in the highlands (right).

Figure 7. Greenhouses with a new foil type (high light transmission, transformation of direct in diffuse radiation, and reflection of heat radiation) and chimney ventilation constructed at East West at PT East West Seed Indonesia (EWINDO) in Purwakarta, Indonesia.

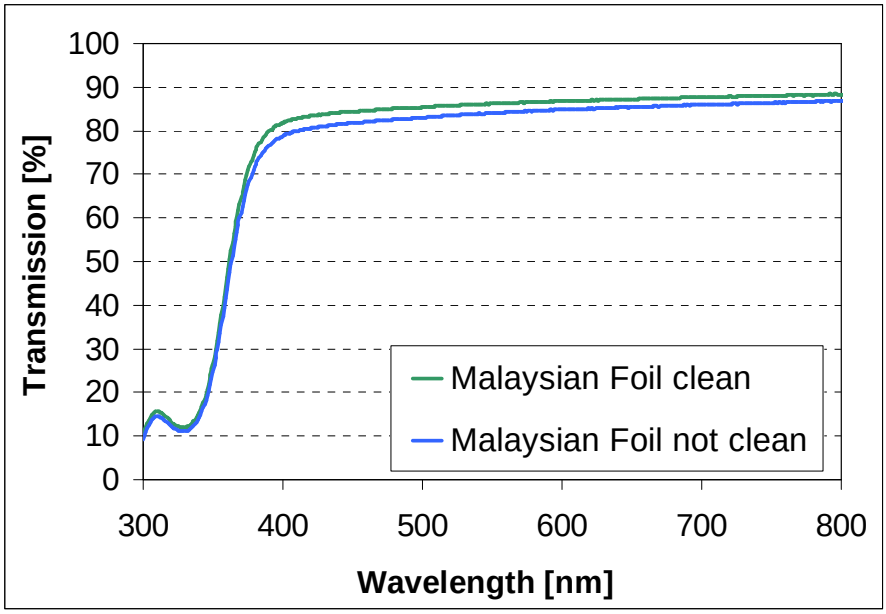

Figure 8. Transmission characteristics (86%) of the foil used at TRG Sutratani farm in Ternengganu.

Figure 9. Pest control at TRG Sutratani farm in Ternengganu. Top, left: a greenhouse sluice to limit insect entrance, however not used properly. Top, right: side-walls are not really closed with nets (holes), nets are opened and sluices are not used. Bottom, left: opening in the greenhouse construction that should be closed.

Figure 10. Impressions of the Sime Fresh Aeroponics Park at Seremban.

Figure 11. Papayas produced at the Lanchang Papaya Farm of MAFC farm in Tamerloh.

Figure 12. Poor root growth due to the use of a transparent polybag (left), and good root growth in a non-transparent polybag (right).

Figure 13. A demonstration of pruning a chillie plant to 4 shoots per plant (TRG Sutratani farm in Ternengganu).

Figure 14. Options for better crop management at TRG Sutratani farm in Ternengganu: a very dense chilli crop (leaft, and young plants suffering from water shortage, leading to hanging leaves (right).

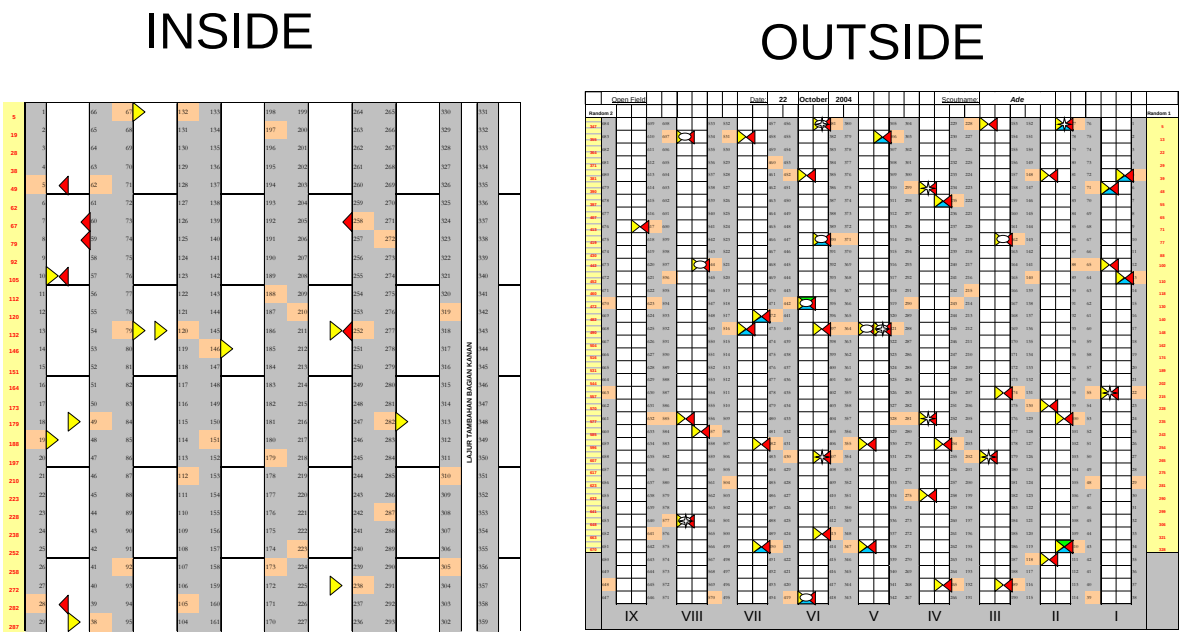

Figure 15. Illustrating the effect of closing the greenhouse sides: insect presence inside and outside the greenhouse (source: Indonesia project).