Protected Cultivation for Vegetable Crop Production

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Department of Horticulture
Faculty of Agriculture at KPS.

Topics

- What and Why
- Merits and demerits
- Greenhouse structure and types
- Greenhouse location selection
- Greenhouse environments
- Greenhouse cooling
- Greenhouse crop growing techniques
- Net-house crop production in Cambodia

Where does the term Greenhouse come from ?

What is Greenhouse ?

- Structure covered with a transparent material for the purpose of admitting natural light for plant growth. (it should be sufficiently high to permit a person to work within (Nelson,1985).

Which structures are Greenhouse?

1

2

3

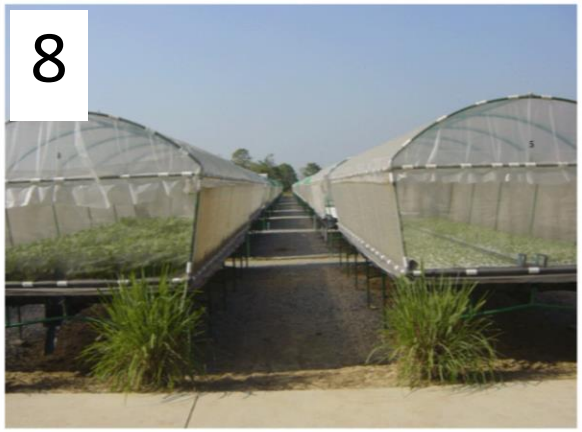
4

5

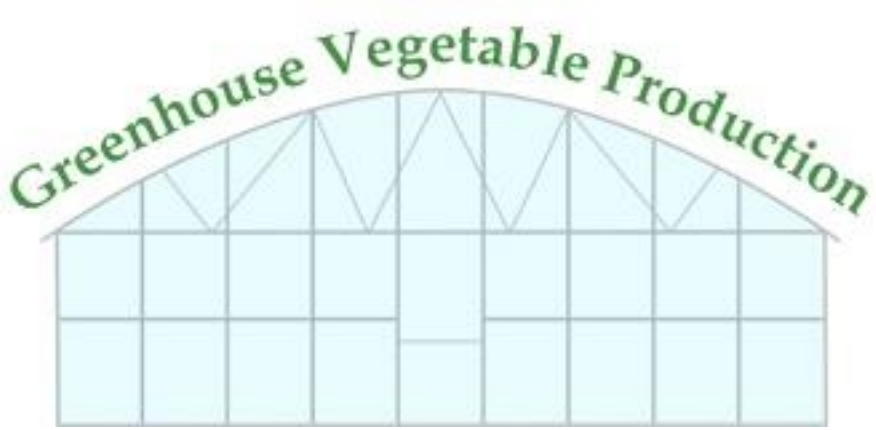
6

7

8



Why Greenhouse ?



1. To protect crops from the unfavorable conditions.

- Coldness
- Heat
- Dangerous phenomena (frost, snow, hail, heavy rain, storms, winds)
- Pests (insects, disease, animals)

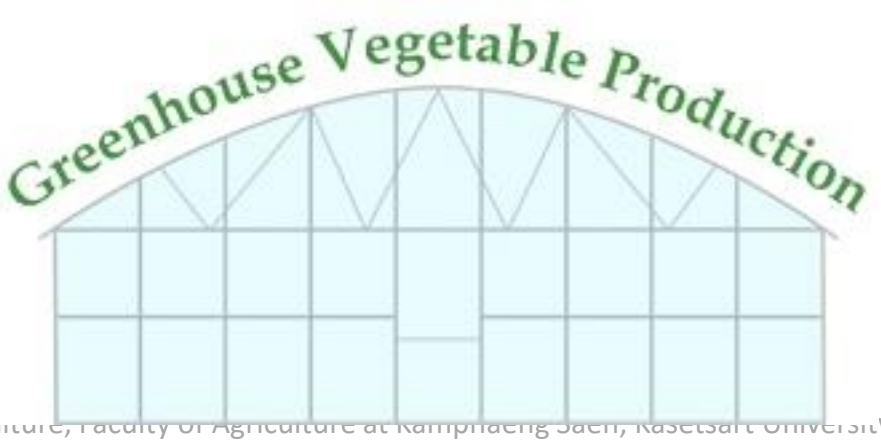
2. To be able to control environmental condition affecting plant growth

- Light
- Temperature
- Humidity
- CO_2

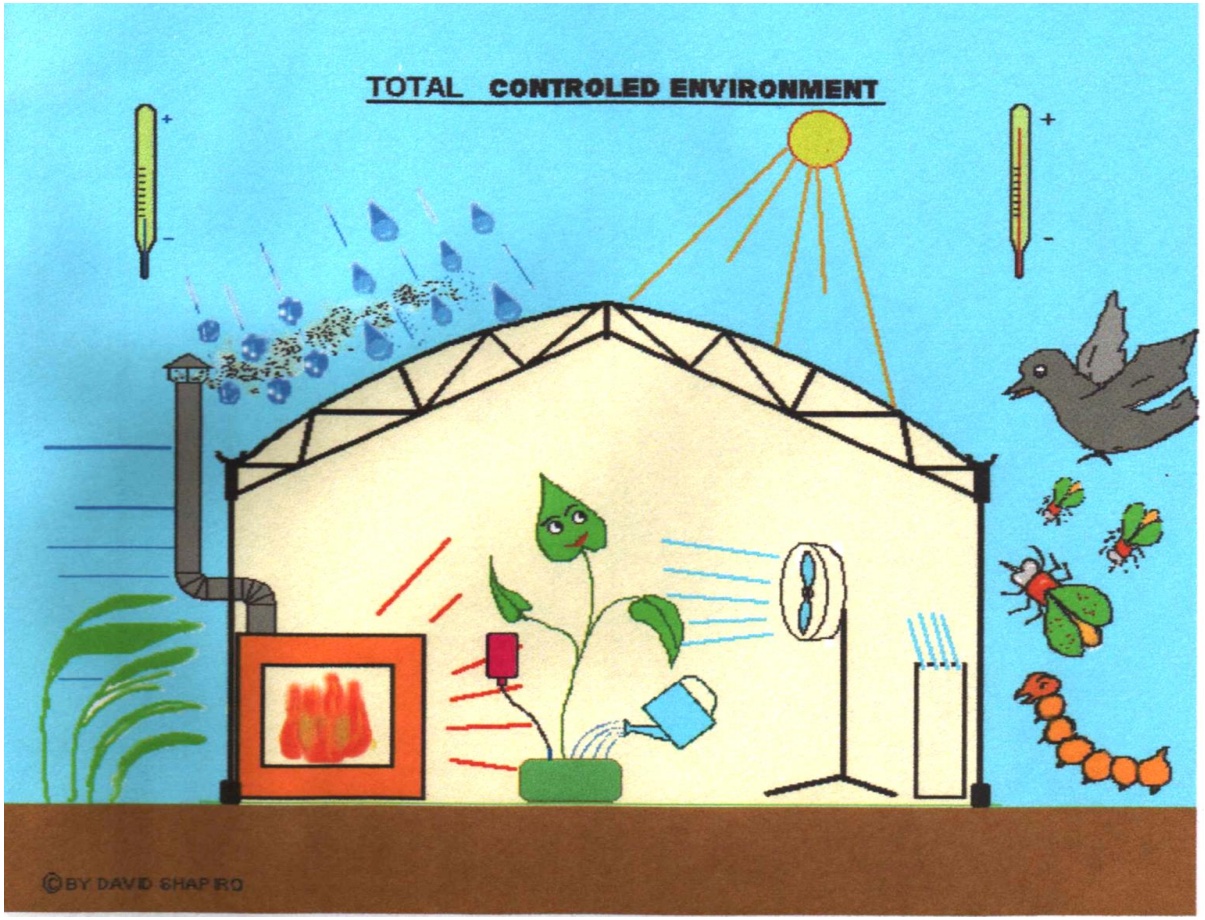
3. To be able to increase efficiency of growth inputs

- Water ----→ Irrigation

- Nutrients --→ Fertilization



Roles of Greenhouse for Crop Production



The nutrient management of greenhouse-grown melon

A timer

Water pump

Fertilizer mixing tank

Drip irrigation system

Soil fertility analysis before management

Analysis result	OM (%)	Total N (%)	Available P (mg/Kg)	Available K (mg/kg)
Sufficient level	> 5	-	> 60	> 200
Found	0.25	0.18	357.34	534.35

Over-doze fertilizer application behavior of the grower

Vegetative growth

20-20-20

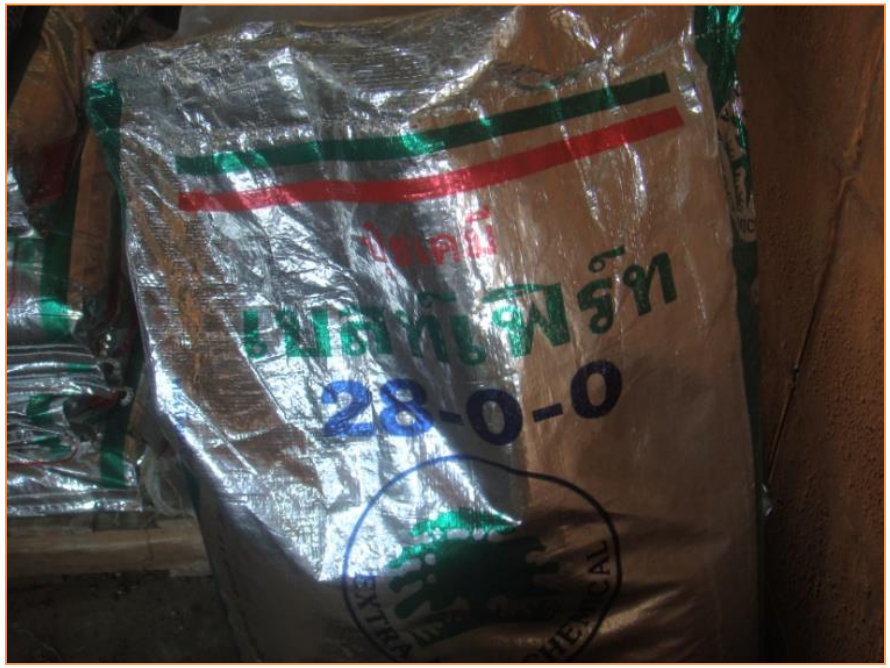
20-10-30

Reproductive growth

20-10-30

0-0 60

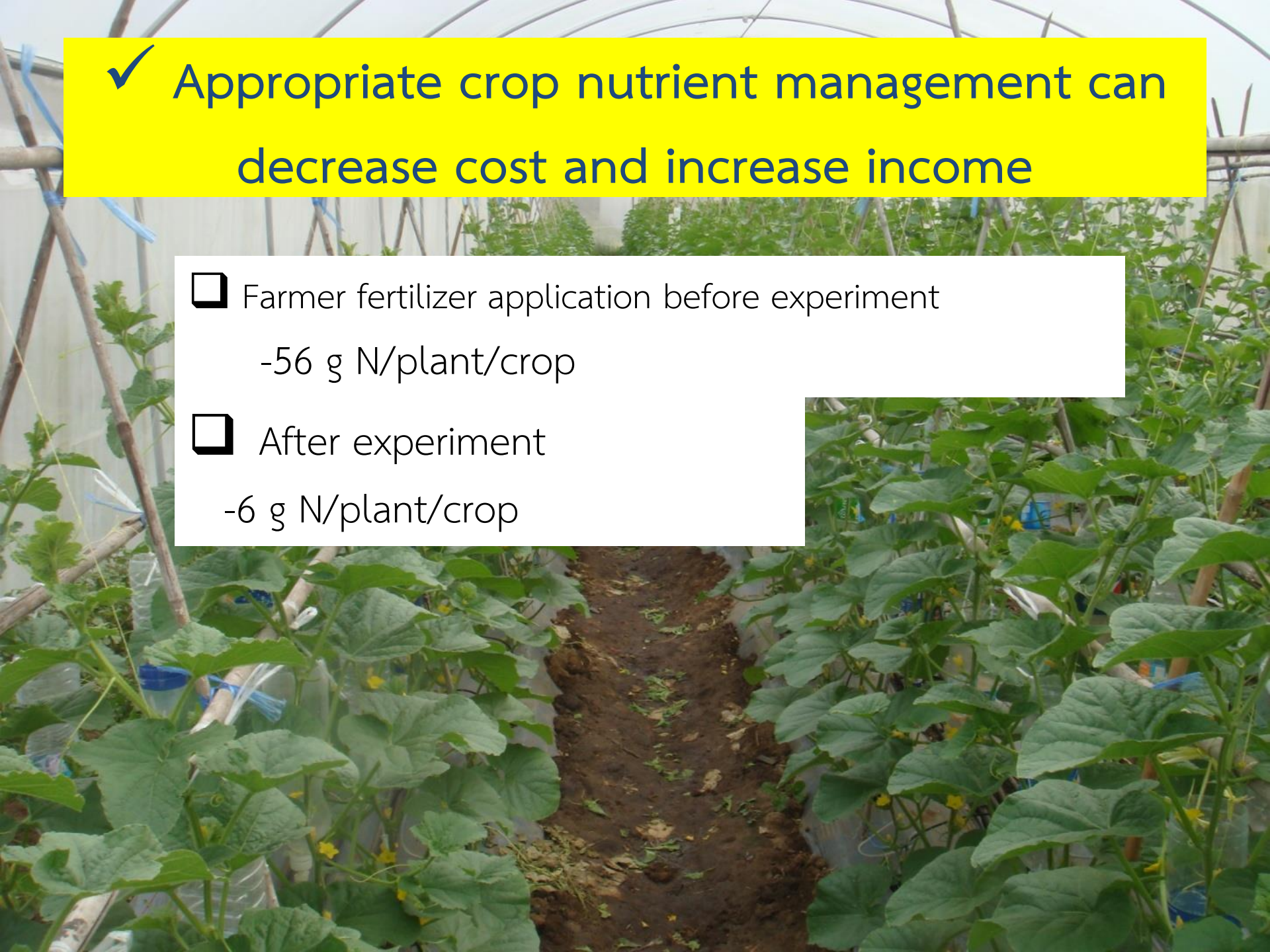
The available NH_4SO_4 was used solely to supply only N



Vegetative stage (mg/L)	Reproductive stage (mg/L)
100	100
	200
200	200
	300
300	300
	400

Growth and yield of melon as affected by different N concentration

Development stage		Stem Fresh Wt (g)	Stem Dry Wt (g)	Fruit Wt (g)	Fruit TSS (Brix)
Veg. Growth	Repro. Growth				
100	100	853 b	91 ab	1,612 ab	10.9 d
200	200	978 a	94 a	1,722 a	11.7 b
300	300	933 ab	85 c	1,623 ab	11.6 bc
100	200	842 b	87 bc	1,506 b	11.6 bc
200	300	876 ab	87 bc	1,662 ab	11.5 c
300	400	913 ab	85 c	1,598 ab	12.2 a
F-test		*	**	*	**



✓ Appropriate crop nutrient management can decrease cost and increase income

- ❑ Farmer fertilizer application before experiment

  -56 g N/plant/crop

- ❑ After experiment

  -6 g N/plant/crop

4. To able to lengthen growing season and grow the exotic crops

- Short-day plant/ long-day plant
- Warm season
- Cool season

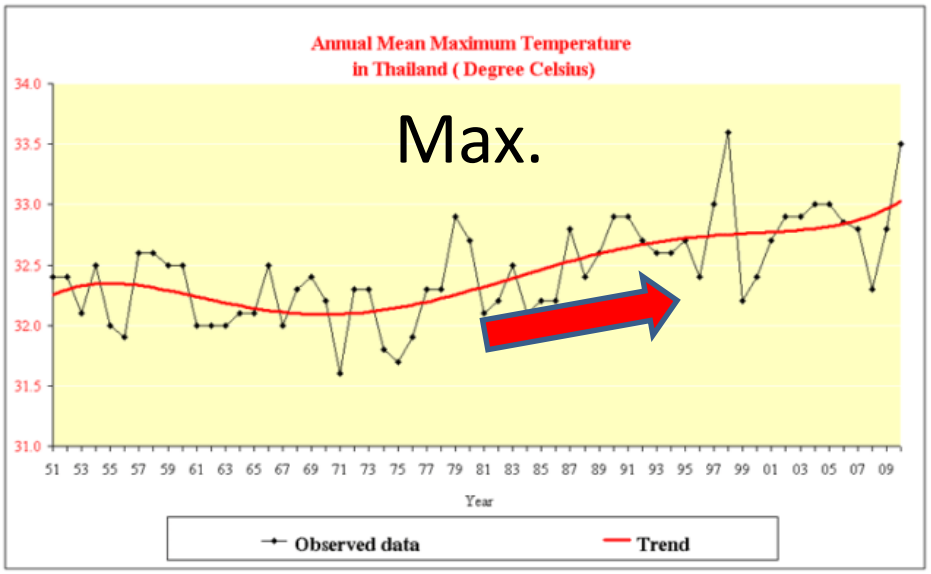
Chrysanthemum grown under supplemented light inside the greenhouse to prolong vegetative growth in winter season

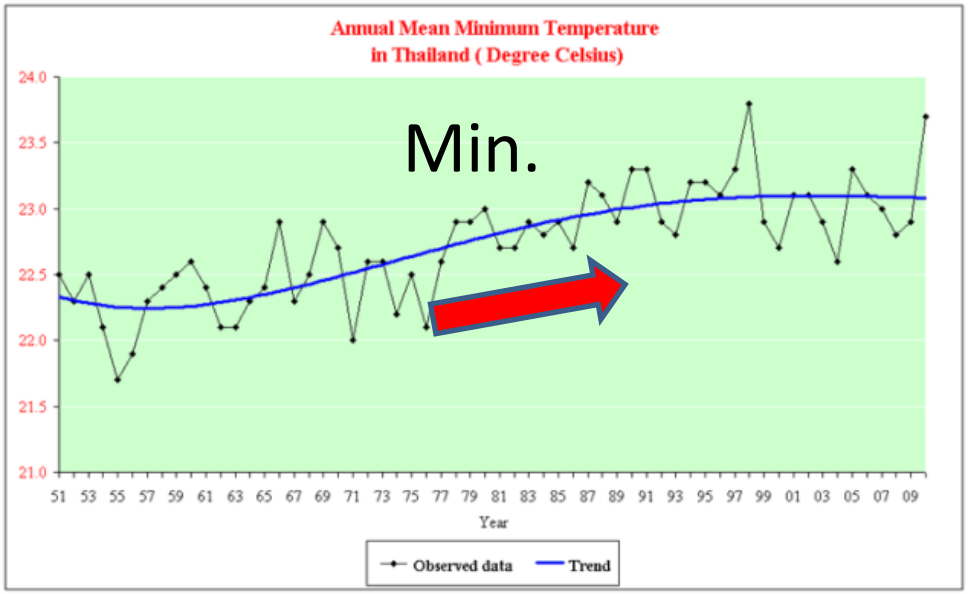
Cool-season vegetables grown in the tropics under a greenhouse

Factors enhancing greenhouse needed for crop production

- Unfavorable climate condition increasing
  - Daily temperature increasing
  - Pest infestation increasing
- Consumer demand for
  - Food safety
  - Exotic crop
  - Provision continuity
- Natural resource diminishing (soil, water, etc)
- Labor deficiency

Max and Min temperature during 1951-2049





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Positive proof of global warming.
18th Century
1900
1950
1970
1980
1990
2006

Over MRL Pesticide residues in produces is an international issues

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'อียู' สั่งระงับนำเข้าพืชไทย

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นายศุภชัย โพธิ์สุ รัฐมนตรีช่วยว่าการกระทรวงเกษตรและสหกรณ์ เผยถึงปัญหาการระงับส่งออกสินค้าพืชผัก 16 ชนิด อาทิ กะเพรา โหระพา พริกขี้หนู ไปยังกลุ่มประเทศสหภาพยุโรป (อียู) ชั่วคราว ตั้งแต่วันที่ 1 กุมภาพันธ์ 2554 เป็นต้นไป

โดยนายจิรากร โกศัยเสวี อธิบดีกรมวิชาการเกษตร ได้มาชี้แจงข้อเท็จจริง และได้รับการยืนยันข้อมูลว่า อียูได้มีมติสั่งระงับการนำเข้าสินค้าเหล่านี้ตั้งแต่เดือนธันวาคม 2553 แล้ว แต่ยังไม่ได้มีการออกประกาศออกมาและแจ้งเวียนไปให้ทั่วโลกรับทราบอย่างเป็นทางการ

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Public Food Safety Awareness

"Safe, Clean and Green food"

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Consumer demand for high quality food is increasing

makro

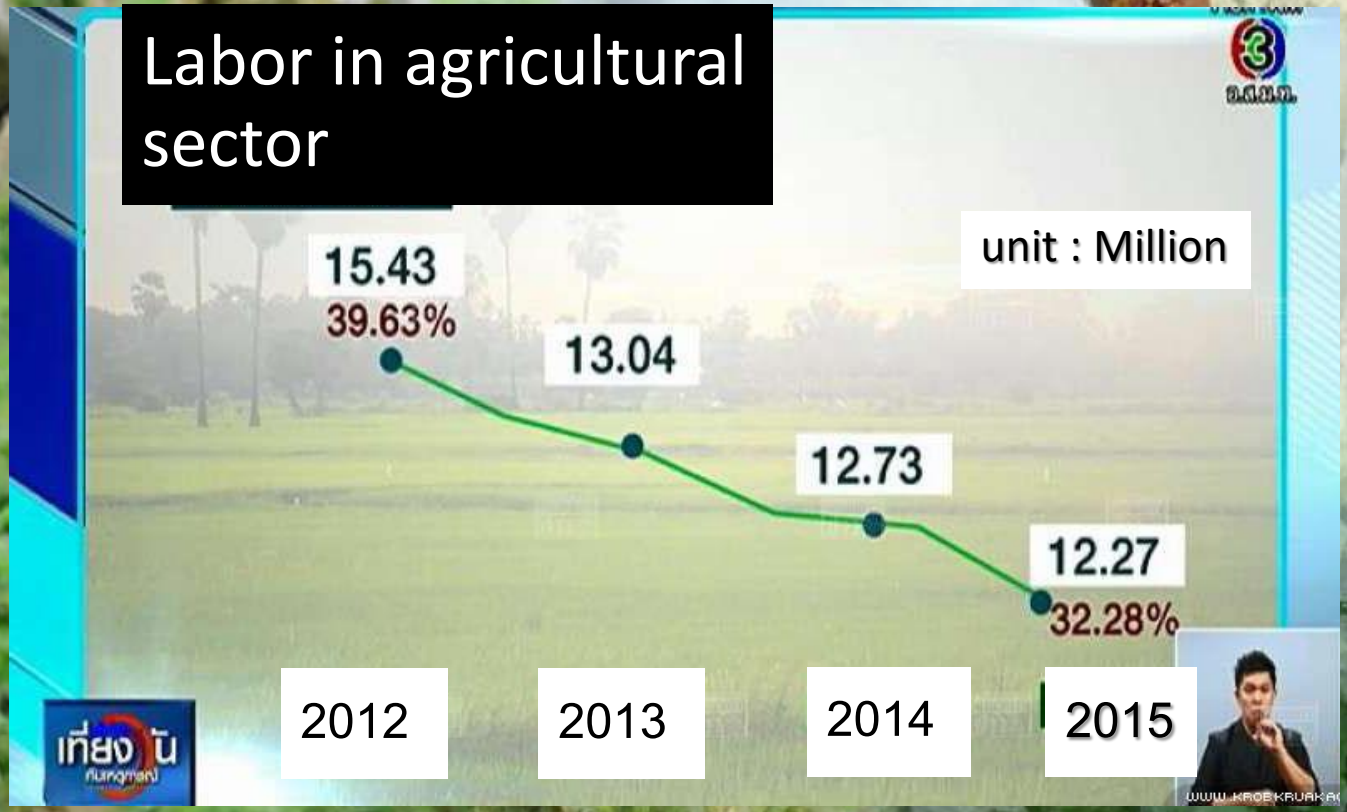
FOODLAND Supermarket Co.,Ltd

Tops ท็อปส์

VILLA MARKET
THE ORIGINAL SUPERMARKET SINCE 1974

TESCO Lotus

AGRI.-LABOR CIRCUMSTANCE



New generation growers need a better crop growing system

Protected cultivation can be a solution !

- **Climate independent.**
- **Protecting plant from pest.**
- **Increasing supply-use efficiency.**
- **Be harmless to the environment**

Safety

GH crop production

Quality

Continuity

Merits & Demerits

Merits

- Crops can be grown all year-round.
- Maximum yield can be obtained.
- High quality can be controlled.
  - Taste
  - Nutritional values
  - Safety
- Maximum profit is achieved.
- Production system is sustainable.

Productivity (kg/m^3) of greenhouse vegetables

Crop	Out-door (Spain)	Greenhouse (Netherlands)
Tomato	10-12	42
Pepper	6-7	26
Cucumber	8-9	58
Snap beans	5	32

Comparative cost and profits of soil and greenhouse tomato in Spain (1998)

Items	Soil	Greenhouse
Yield (25#/Acre)	1,554	4,607
Price ($/25#)	$9.15	$6.40
Total revenue	$ 14,219.10	$ 29,506.16
Fertilizers ($/Acre)	$ 326.22	$ 2,124.46
Pesticides ($/Acre)	$ 1,134.18	$ 767.20
Seeds ($/Acre)	$ 224.00	$ 683.22
Water ($/Acre)	-	$ 709.89
Labor ($/Acre)	$ 462.64	$ 4,319.48
Others	$ 1,217.55	$ 588.59
Total cost ($/Acre)	$ 3,373.59	$ 9,192.84
Gross Margin ($/Acre)	$ 9,436.41	$ 20,313.32

Sustainable Agriculture !

- The manner of crop production by which it sustains the agricultural resources.
  - Sustainable utilization of agricultural resources : land, water.
  - Protect forest and soil from deforestation, degradation, erosion and desertification.
  - Prevention and control environment pollution and restore damaged and polluted environment.
  - Protect all life supporting system, ecosystem and biodiversity.
-

Is greenhouse production sustainable ?

Sustainable agriculture	Greenhouse production
Safe use of land and water	Uses media and limited water
Protect forest and soil	Highest yield per land unit.
Prevent pollution of environment	Volume and quality of waste can be controlled
Protect bio-system	Use least harmful chemicals.

Demerits

- High initial and operation costs.
- Knowledgeable and skilled labors are required.
- Energy required

NFT crop failure after power break down

History of Greenhouse Crop Production in Thailand

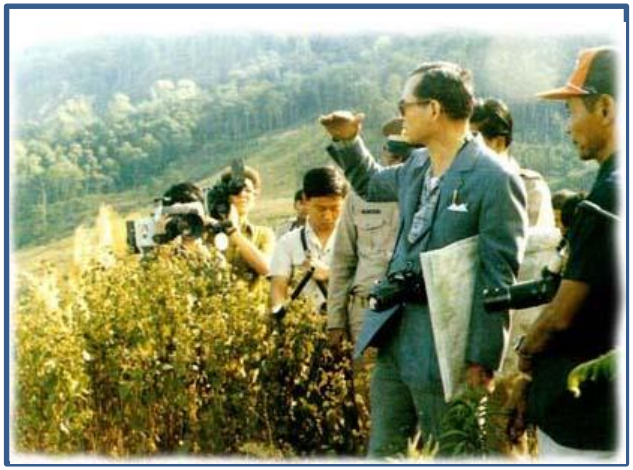
History of Greenhouse Crop Production in Thailand

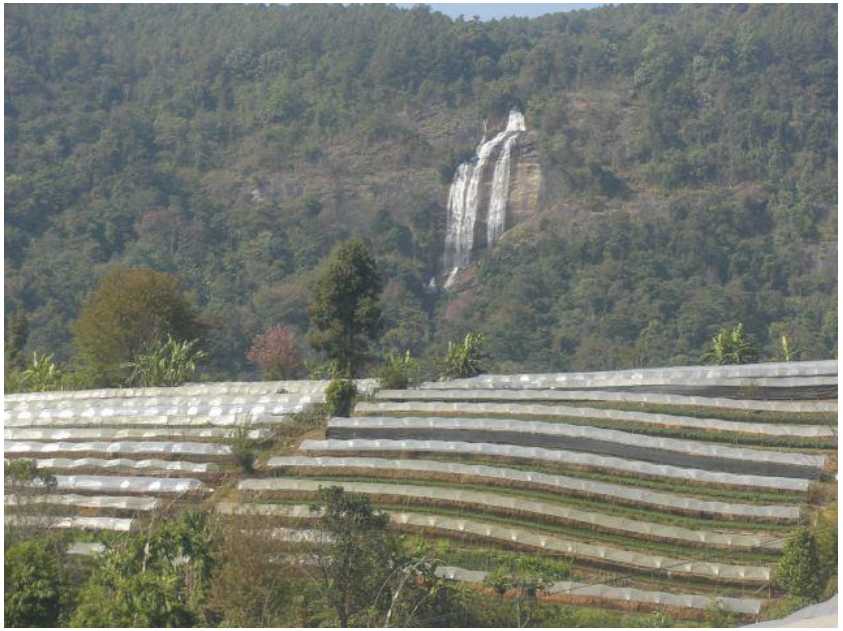
Pressure from health-concern consumers since the last decade.

Emerging of soilless culture industry in mid 1990s

Introduction to Greenhouse crop production by “Doi-kham” foundation in early 1990s

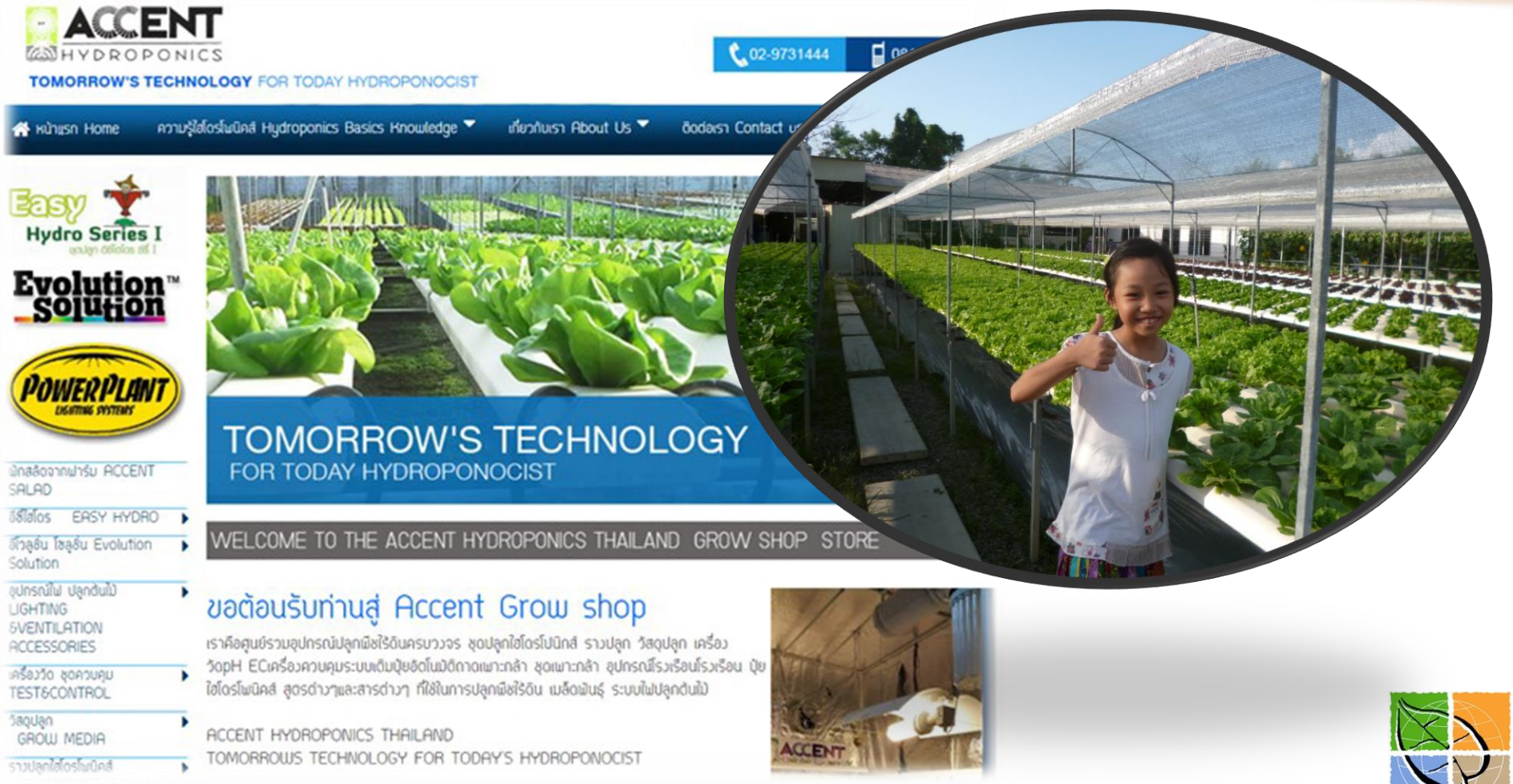
มูลนิธิ
โครงการหลวง
-ROYAL PROJECT FOUNDATION-





PAST & PRESENT

NFT hydroponic sytem was firstly introduced to Thailand in 1997.



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Consumer's demand has been increasing

Greenhouses have been used to support all-year round the exotic lettuce production.







Greenhouse melon growing is in a rising trend

Substrate grown melon in modern greenhouses

10,000 **plants/3600 m**^{2}

150 MT/crops

3 crops/year

Soil-grown melon in simple polyhouses

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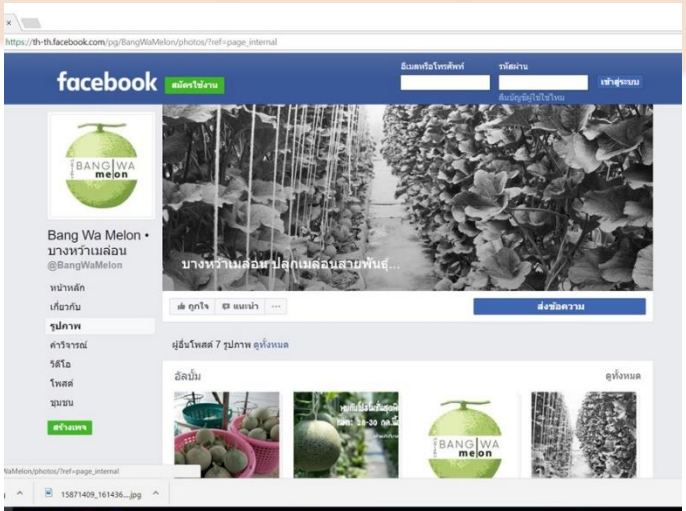
Melon grown in a DIY greenhouse in urban BKK

Mr.Sravut,
Former civil engineer



400 fruits/gh x 3 crops/year

600 kg/crop x US$ 6/kg

(US$10,800 /year/gh)

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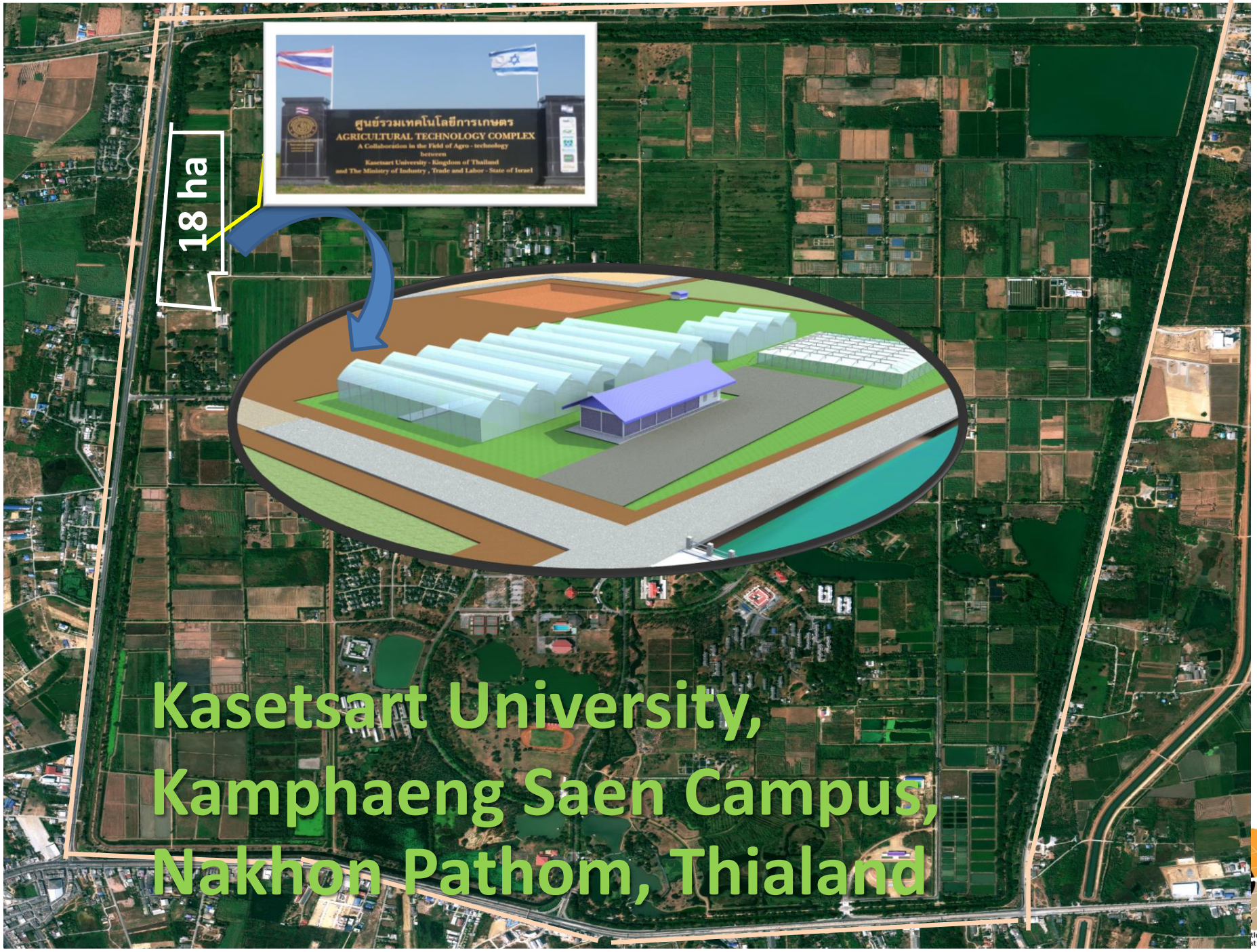
MoA signing ceremony between KU and Israel Government


ศูนย์รวมเทคโนโลยีการเกษตร
AGRICULTURAL TECHNOLOGY COMPLEX
A Collaboration in the Field of Agro - technology
between
Kasetsart University - Kingdom of Thailand
and The Ministry of Industry , Trade and Labor - State of Israel
18 ha
Kasetsart University,
Kamphaeng Saen Campus,
Nakhon Pathom, Thialand

TAP
Teshuva Agricultural Project

METZERPLAS

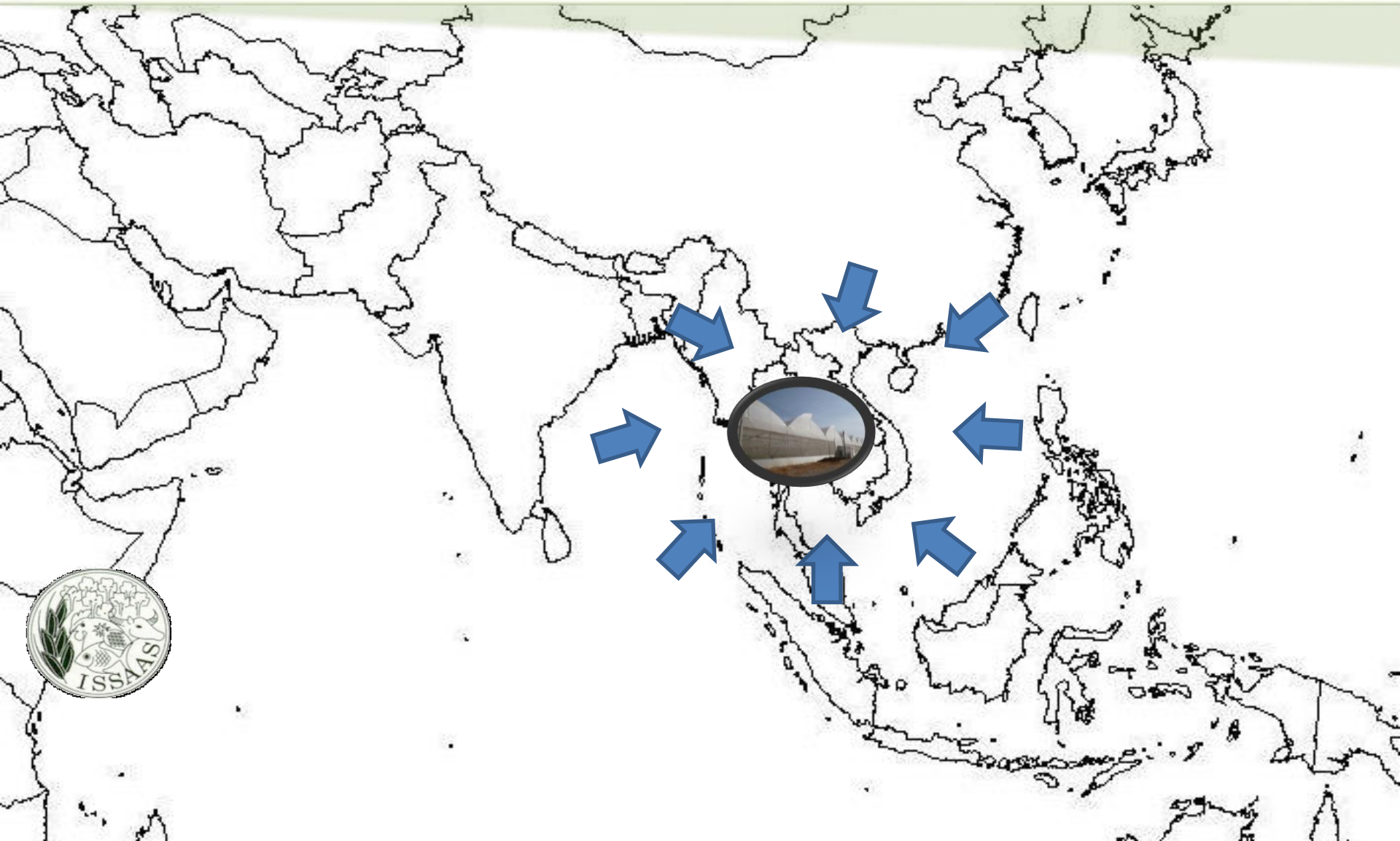
Top
ses Ltd.

A G A N
The art of agriculture.

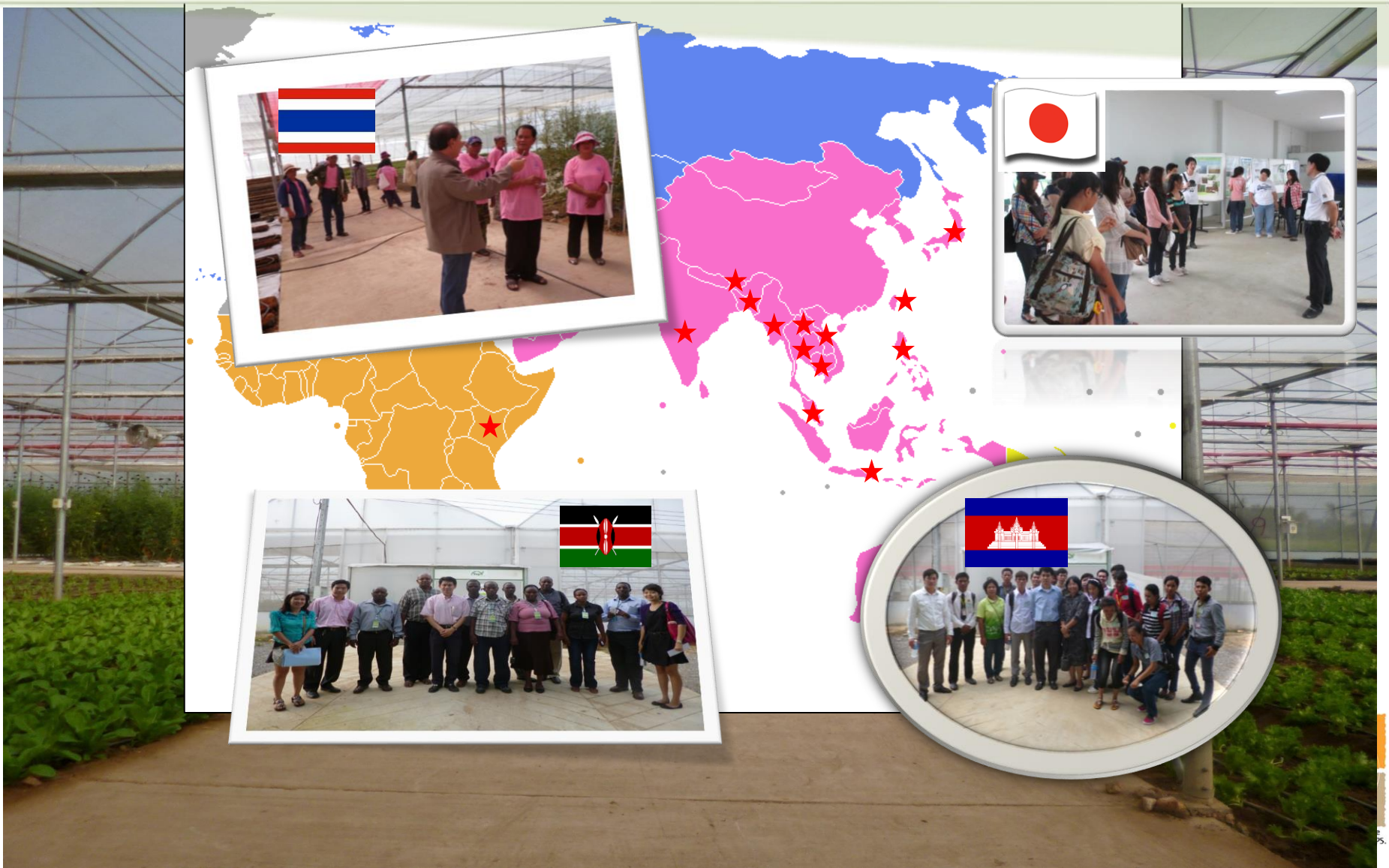
galcon

ATC Demo. Greenhouse

ATC-The Agro-tourism and Training Center for South East Asia



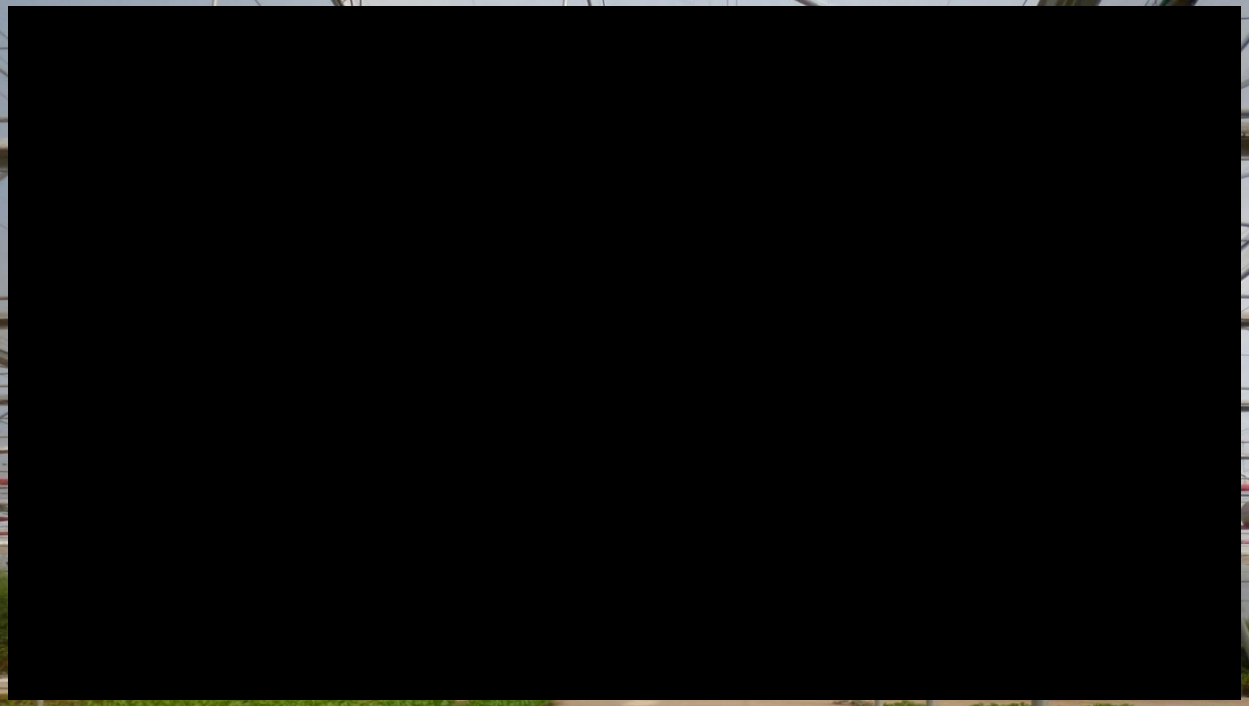
Visit of visitors to ATC, KU



Seminar & workshop in 2013-15

Seminar & workshop Activity

Participant feelings



From training to commercial

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From training to agro-tourism business

Types of greenhouse technology

Low-technology greenhouse / US$ 15-25 m^2

Medium-technology greenhouse /US$ 35-60 m^2

High-technology greenhouse /US$ 80->120 m^2

Low-technology greenhouses
(US$ 15-25/m^2)

Medium-technology greenhouse

(US$ 35-60/ m^2)

High-technology greenhouse (US$ > 80 m^2)

Fan-pad greenhouses

Commercial application of greenhouse in Thailand

For producing fresh produces

For producing seeds

For producing transplants

For agro-toursim

High-valued and chemical-free crops are grown in greenhouses nowadays
















Thyme

Rosemarry

watercress


Greenhouse tomato production by farmer's community enterprise

Greenhouses are used to ensure the success of seed production in term of quantity and quality.

Transplant production is a rising agro-business

Locally developed a semi-automatic seeding machine

Farm visit during holidays is newly popular agro-toursim.

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Use of greenhouse for agro-tourism in the resorts.

DASADA RESORT, THAILAND

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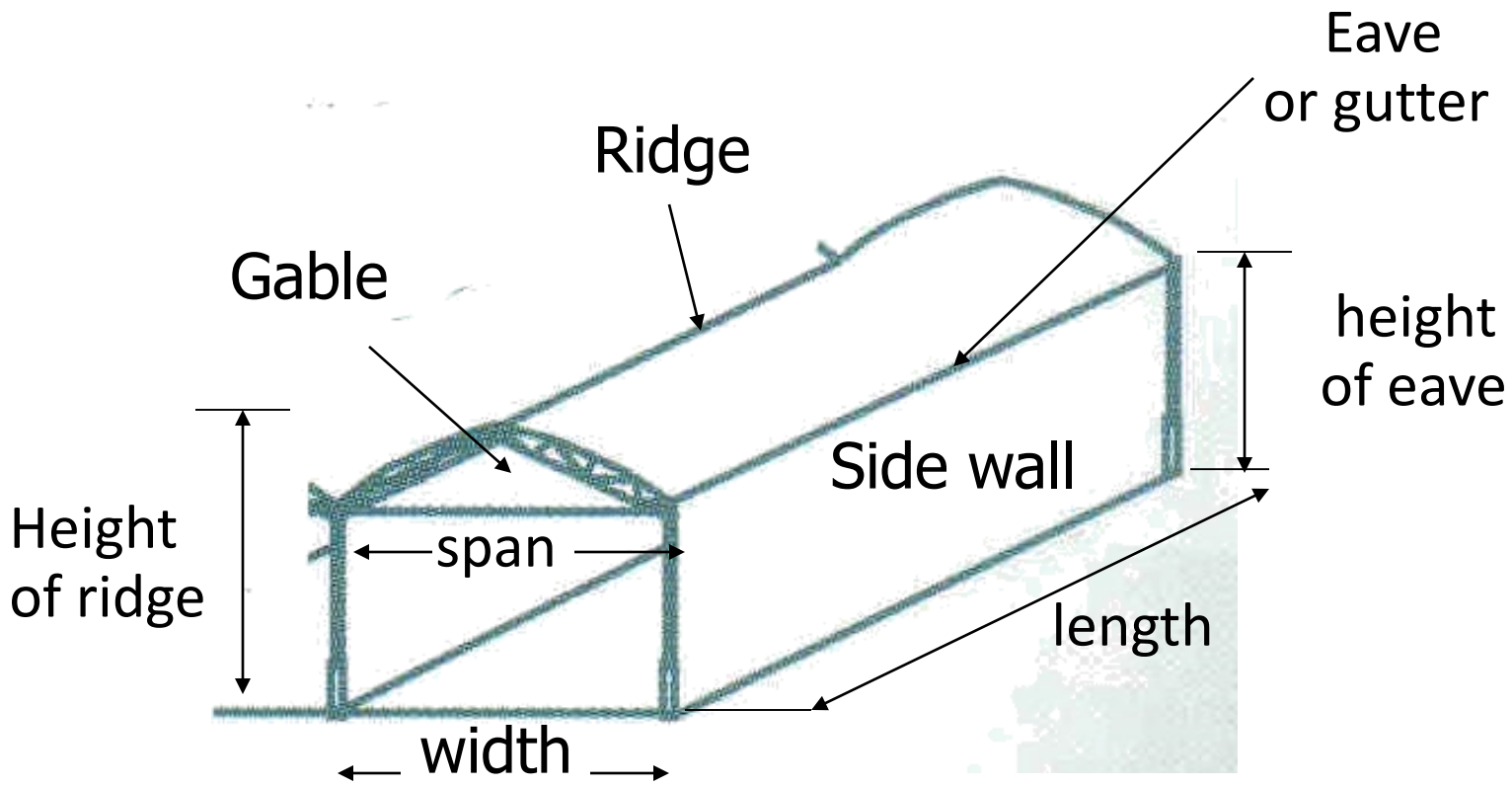
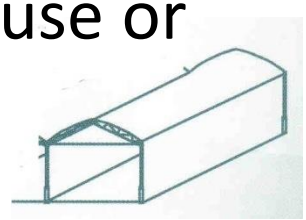
Greenhouse structure

BASIC GREENHOUSE STRUCTURE

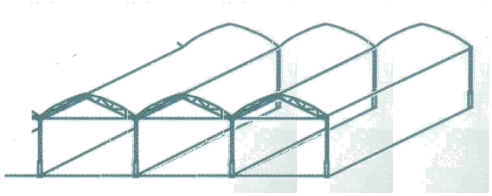


Types of greenhouse

- By number of roof
  - Single-roof or stand-alone greenhouse or
  - Multiple-roof or greenhouse range



- By roof shape
  - Gable
  - Arch
  - Saw-tooth
  - Over-lapping roof



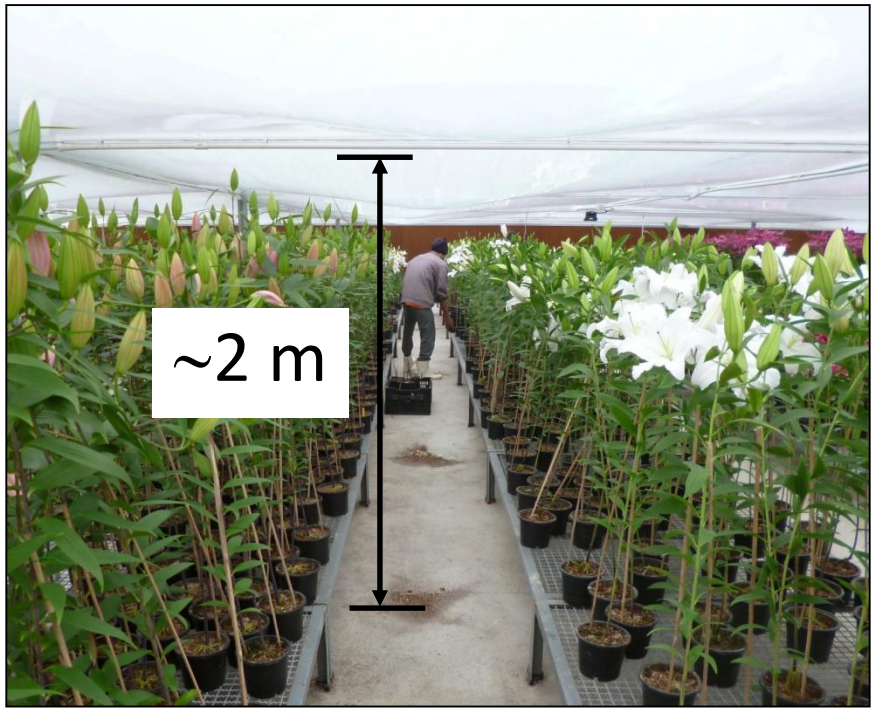
Double-arch roof

Saw-tooth roof

Over-lapping roof

Natural cooling greenhouse

Evaporative cooling greenhouse



Greenhouse strength

- Greenhouse must be designed to withstand the loads that will be imposed on it during normal use
  - Environment load : wind, rain, snow
    - For wind load, at least 60 km/h
    - For snow : 125 kg /m^2:
  - Work load : weight of hanging plant 40 kg/ m^2:

Poor greenhouse structure can cause damage by prevailing strong wind (> 30 km)

Frame materials depends on width of greenhouse

- Narrow GH (6 m) uses wood frame to be side post and column.
- GH with 6-12 m uses galvanized pipe frame.
- GH with > 12 m uses truss frame made by steel.

covering (glazing) materials

- Glass greenhouse
- Plastic greenhouse : Polyethylene (PE)
- Others
  - Fiberglass
  - Polycarbonate sheet (lexan)
  - Acrylic sheet (Plexiglass),

Glass

-The first material used.
-Very good light transmittance (90%).
-long lifetime.
-Resistant to sharp object but vulnerable to impact
-high weight
-Most expensive
-High operation
cost for heating
and cooling

Polyethylene (PE) plastic

-Good light transmittance (80-90 %)
-Light weight
-Short life-time 3-5 y
-Vulnerable to sharp object
-Easy to attach with dust
-Inexpensive
-Cheaper operation cost for heating and cooling

Properties of GH PE plastics

- Thickness : 100, 150, 200 and 250 µm
- Width : Domestic 6 m, Import 9 m or more
- Length : 100 m/ roll
- UV stabilizer concentration : 0.05 – 2%

UV stabilzers in plastics

- UV stabilizers, such as benzophenones, work by absorbing the UV radiation and preventing the formation of free radicals.
- Concentrations normally range from 0.05% to 2%, with some applications up to 5%

GH Location selecting criteria

- Topography
  - Level site is desirable
  - Well drain soil
  - Natural wind break
  - No object casting shadow on East side

Poor greenhouse location

GH should not be near a tree

Wind break can protect greenhouse form storm

Flooding can occur if greenhouse sitting on low land level

Greenhouse should not be closed to a road with high traffic

Well-drain soil is desirable

GH Location selecting criteria (cont.)

- Land-use law
  - Agriculture land or industrial land regulation
- Labor supply
  - Available
  - Cheap

GH Location selecting criteria (cont.)

- Accessibility
  - Near markets as possible
  - Shipping facility : transportation and road

- Water & Electricity
  - High quality
  - Available all year-round

GH Location selecting criteria

- Room for future expansion
  - Greenhouse
  - Service building (~ 8-13% of greenhouse area)
  - Storage room
  - Access drives
  - Unforeseen requirement

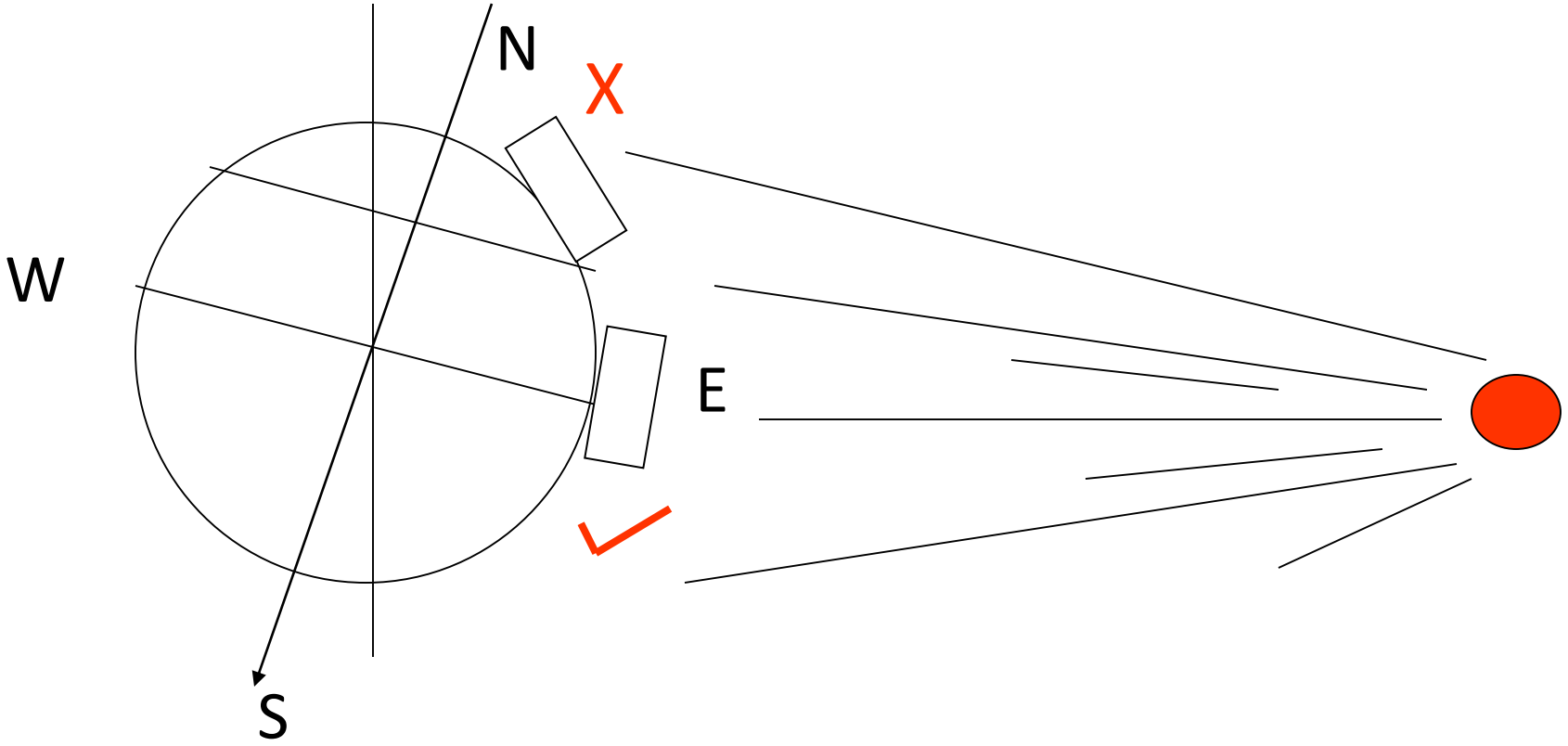
GH Location selecting criteria (cont.)

- Orientation
  - Latitude 40°N - 40°S use orientation N-S
  - Latitude above 40°N and below 40°S use orientation E-W

Effect of greenhouse orientation on light transmission at latitude 50° N

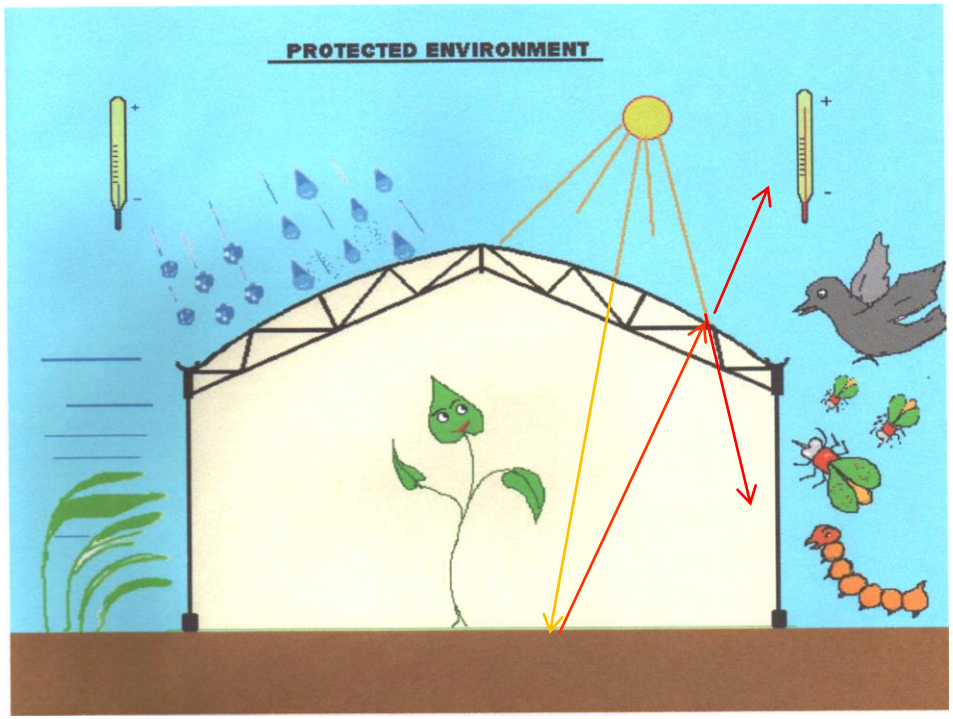
Orientation	Percent Transmission	
	Summer	Winter
N-S	64	48
E-W	66	71

Effect of latitude on greenhouse orientation



GH Environments

- Temperature
- Humidity
- Light
- CO_2
- Air movements



Optimum environment for plant growth

1. Temperature

   1.1 Warm season vegetables 18-30 ℃

   1.2 Cool-season 16-18 ℃

2. Relative humidity 60-75 RH%

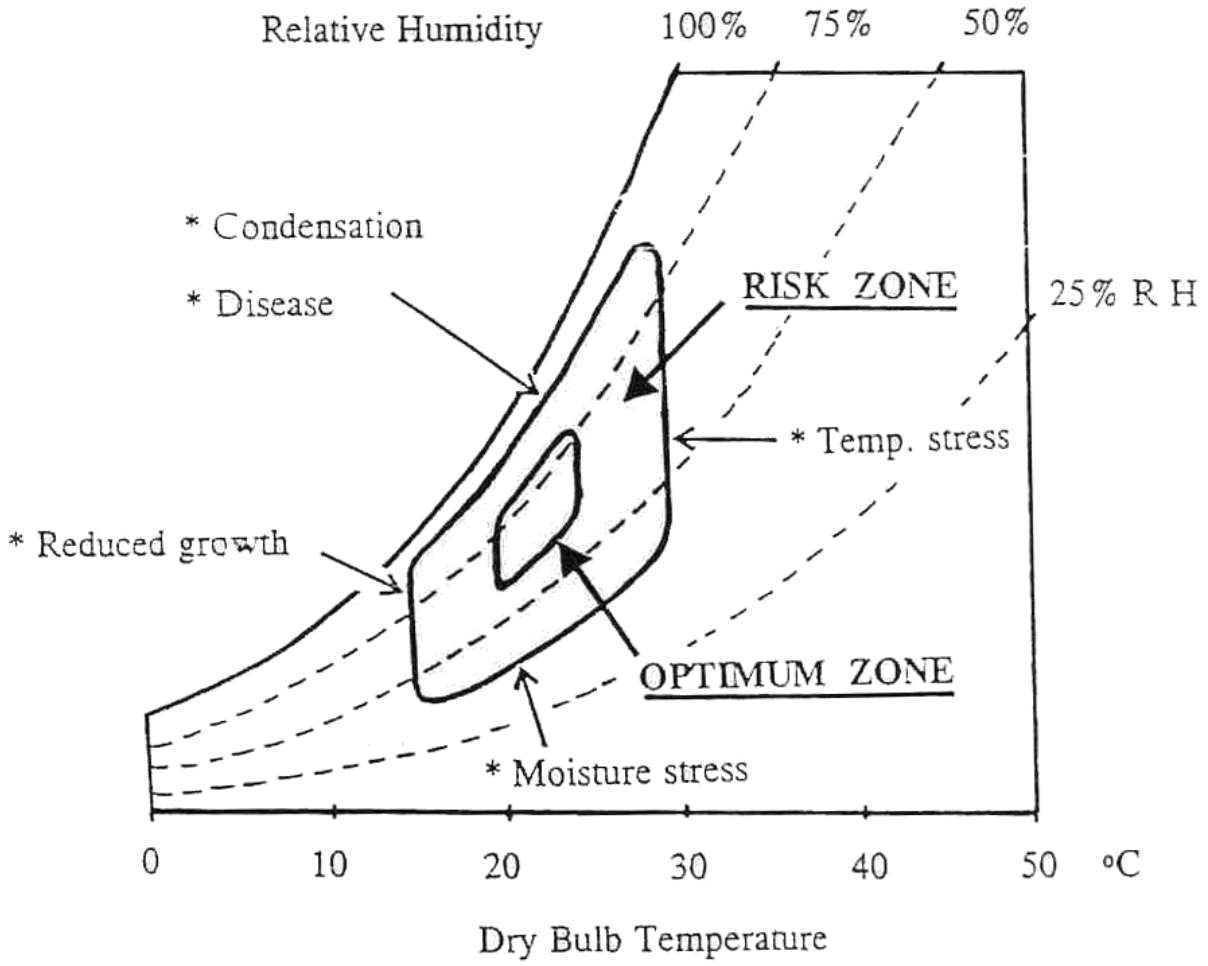
3. Light

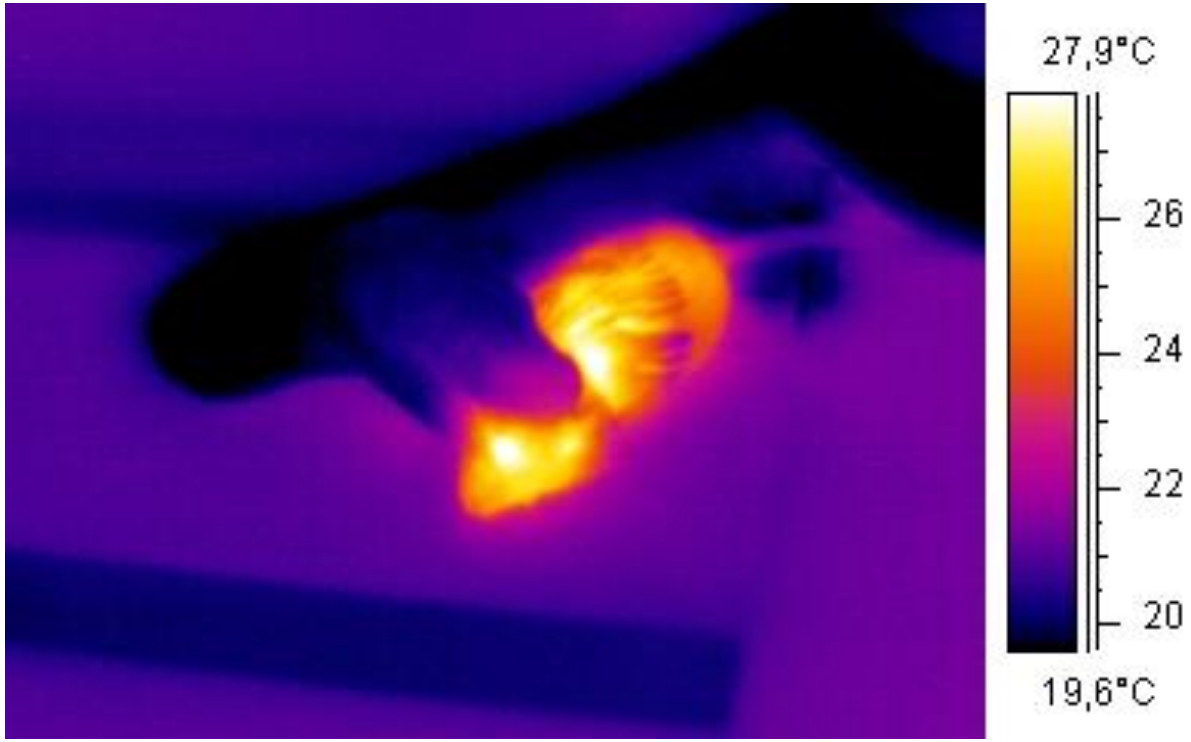
   -intensity 0.9-2.0 mMol m^{-2} s^{-1} (50-100% full sunlight)

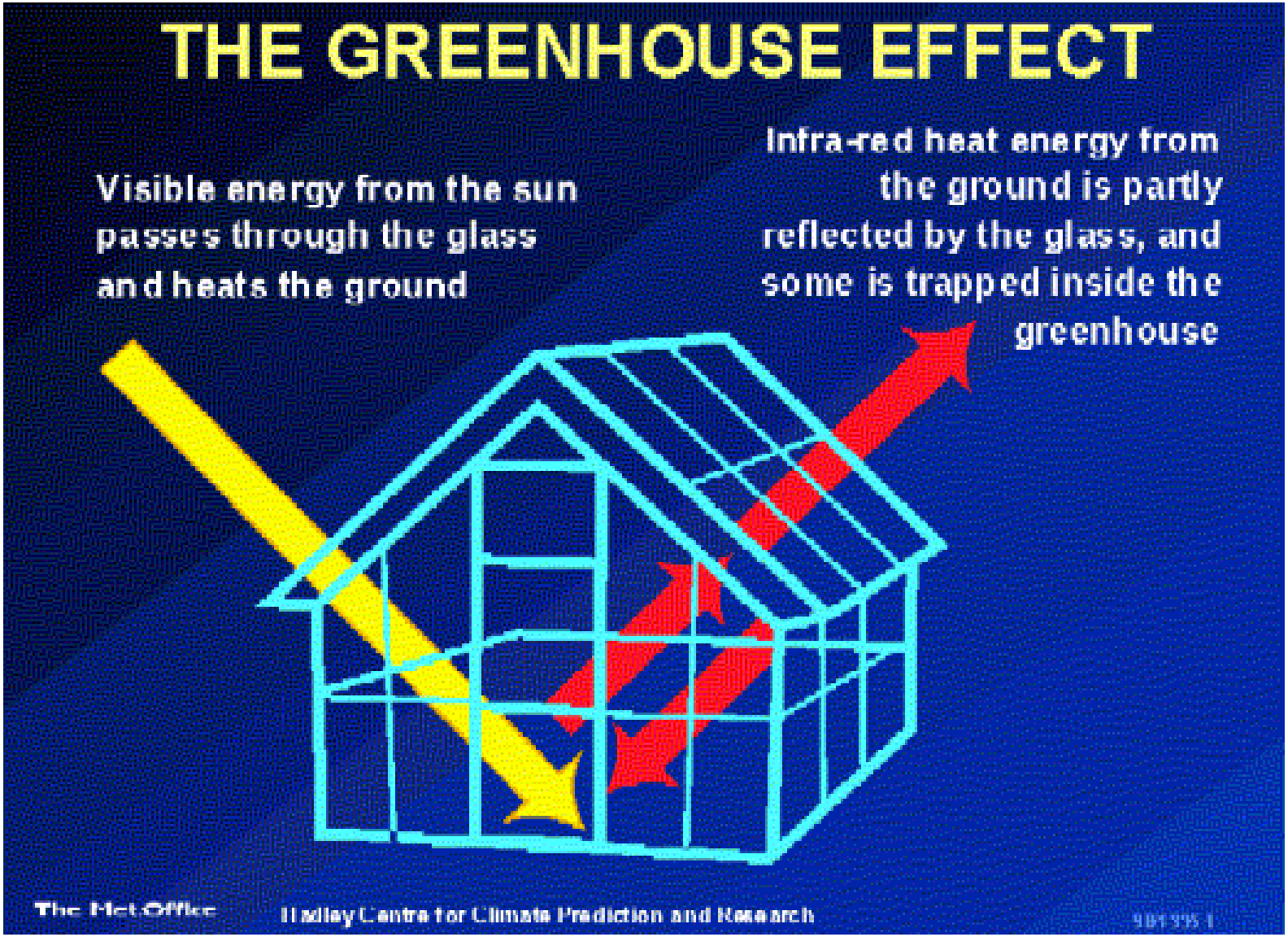
   -Light duration > 6 hr/day

4. Wind 1-2 m S^{-1} or 360-720 m hr^{-1}

Optimum zone and Risk zone




27,9°C
26
24
22
20
19,6°C


THE GREENHOUSE EFFECT
Visible energy from the sun passes through the glass and heats the ground
Infra-red heat energy from the ground is partly reflected by the glass, and some is trapped inside the greenhouse
The Met Office
Hadley Centre for Climate Prediction and Research

Greenhouse cooling technology

Natural ventilation :

Side-wall opening and roof ventilator

Light-shading

- Light shading net is the common and essential accessory in greenhouse in Thailand

Evaporative cooling

- Fogging/Misting is more common than fan-pad cooling method
- Fan-pad cooling

Forced air

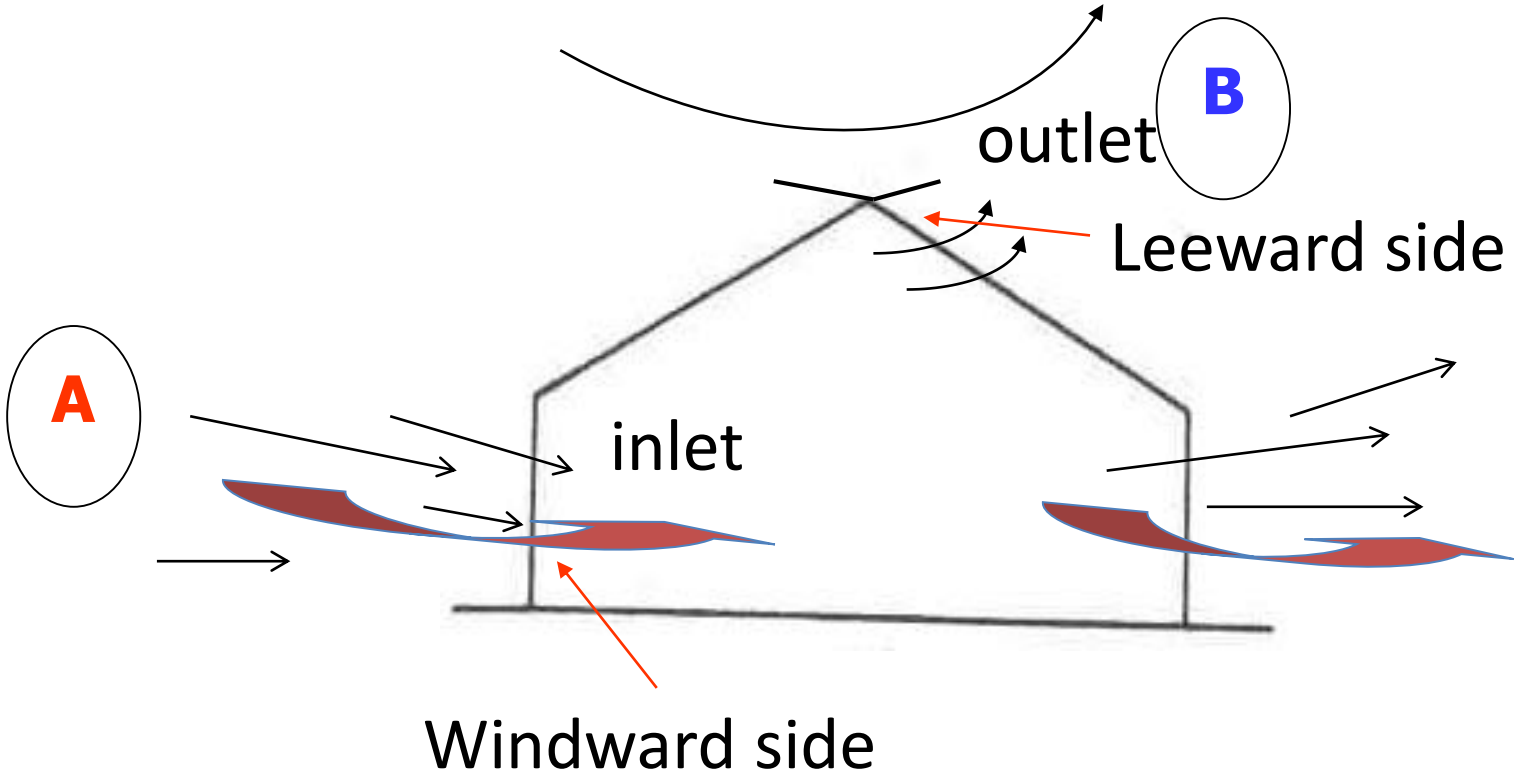
The natural ventilating through roof-ventilator is the most common greenhouse cooling method

Double-roof style

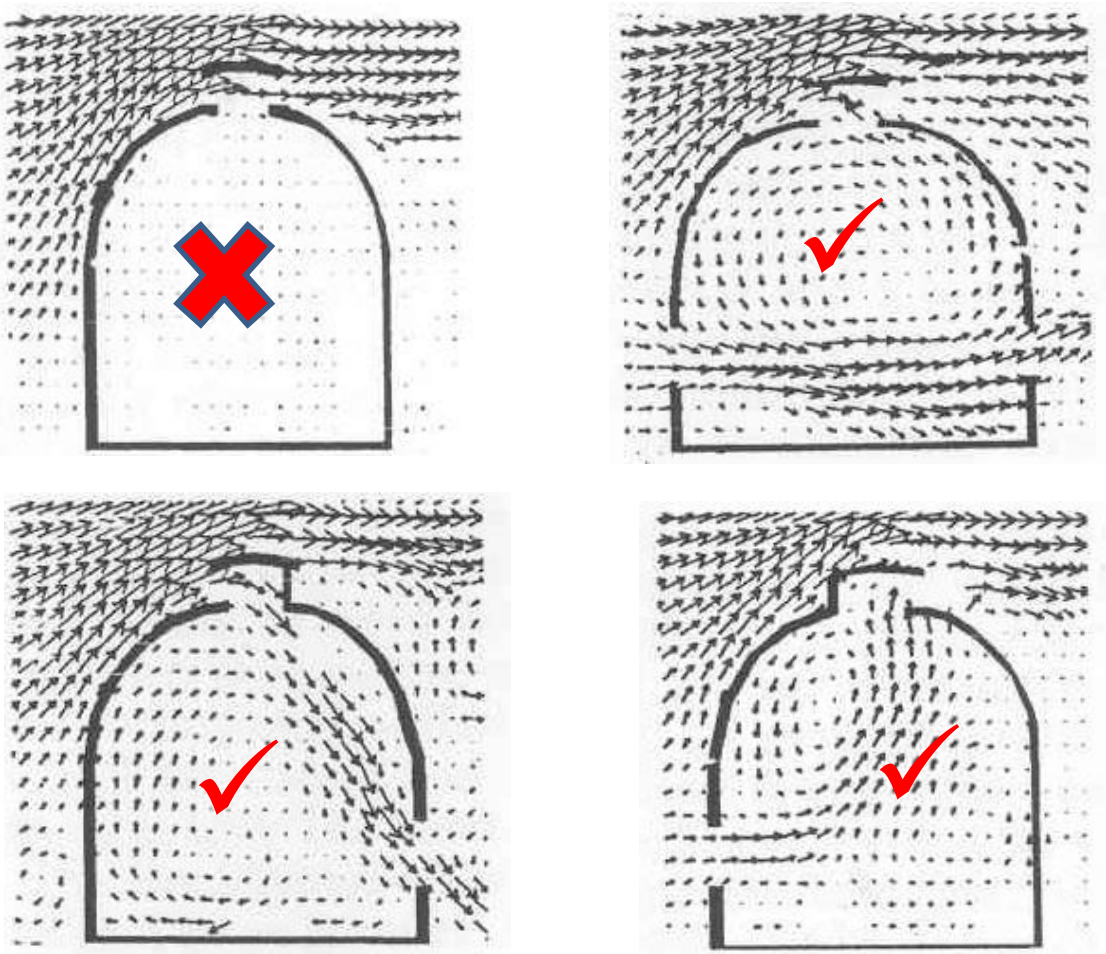
Saw-tooth style

Tropical style

Wind cooling



The inlet and outlet opening required for wind cooling greenhouse



Factors affecting wind cooling efficiency

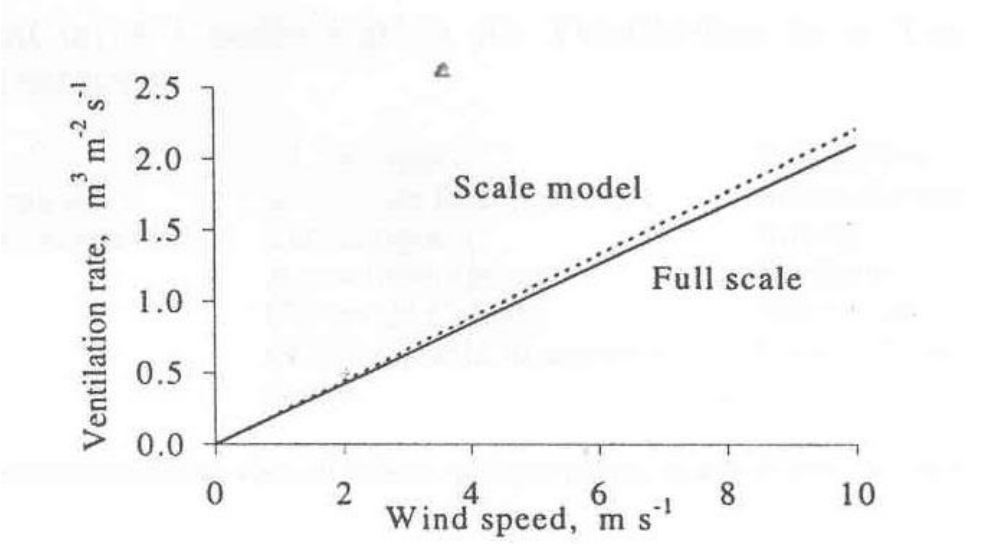
1. Wind speed
2. Wind direction
3. Ventilation area

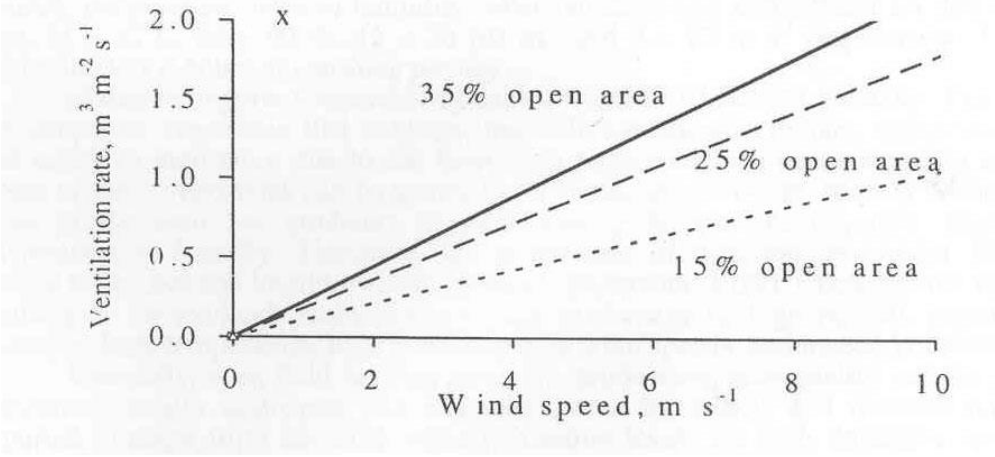
Vwind = K x A x V, where

Vwind = volume of airflow (m^3/h)
A = Gross vent area opening (m^2)
V = outdoor wind speed (m/h)
K = coefficient of effectiveness

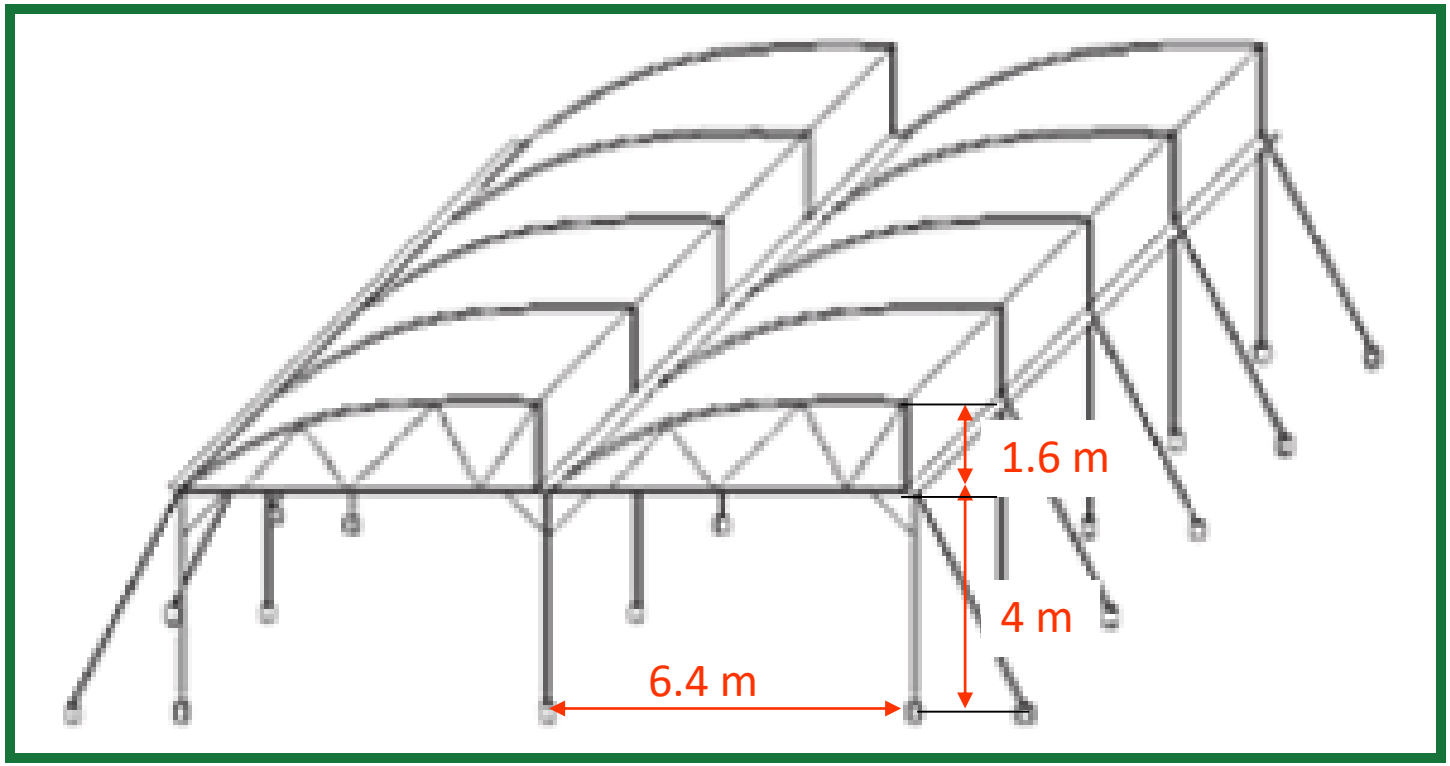
(Abright, L.D., 1990: Acta Hort. 578 ISHS 2002)

Effects of wind speed and vent area on ventilation rate



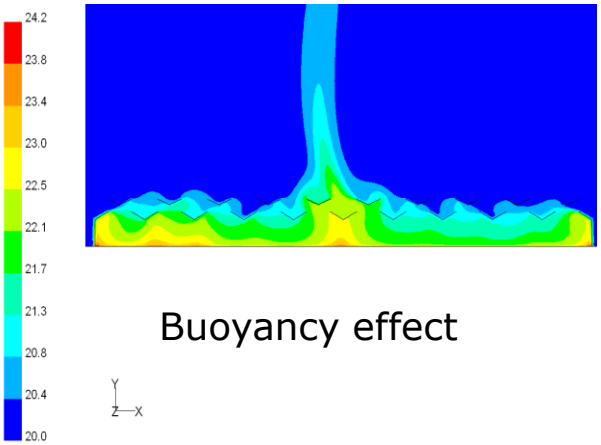


Saw-tooth greenhouse has a optimum ventilation for wind cooling

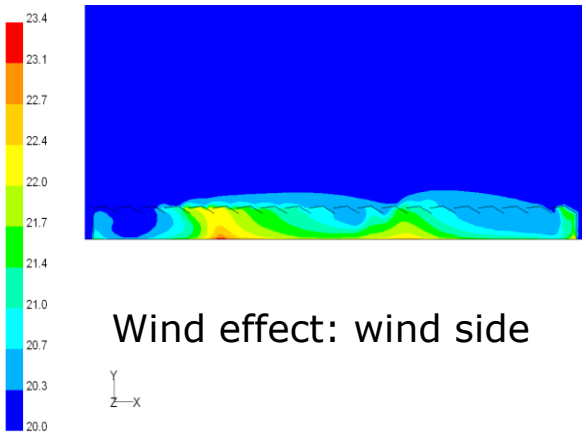


Roof ventilation ≈ 25% of surface area

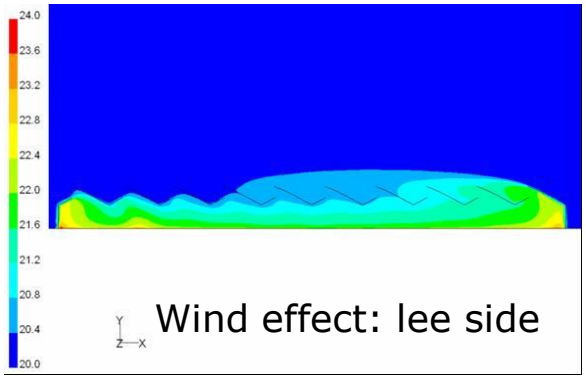
Role of wind direction in greenhouse cooling efficiency



Buoyancy effect



Wind effect: wind side



Wind effect: lee side

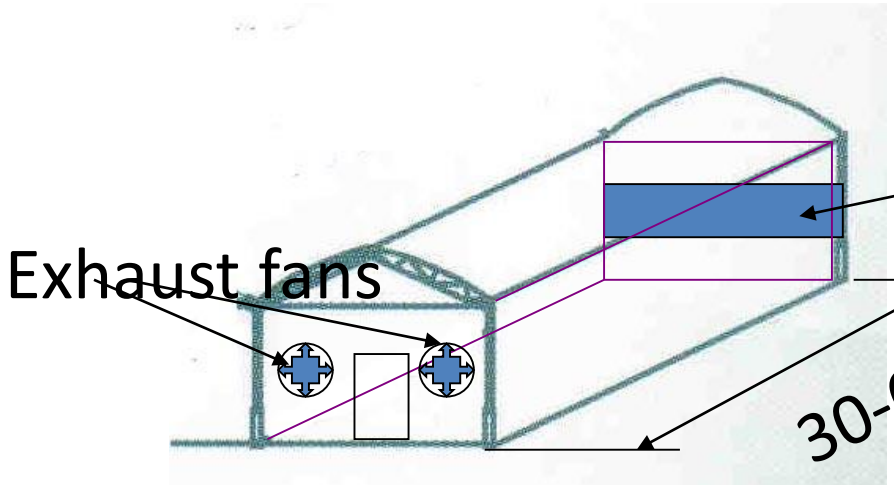
Evaporative cooling system

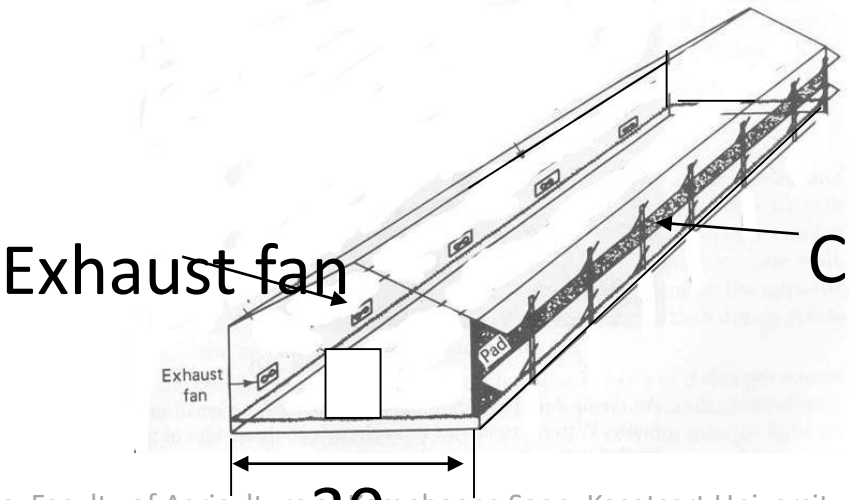
Evaporative cooling method

Fogging/Misting

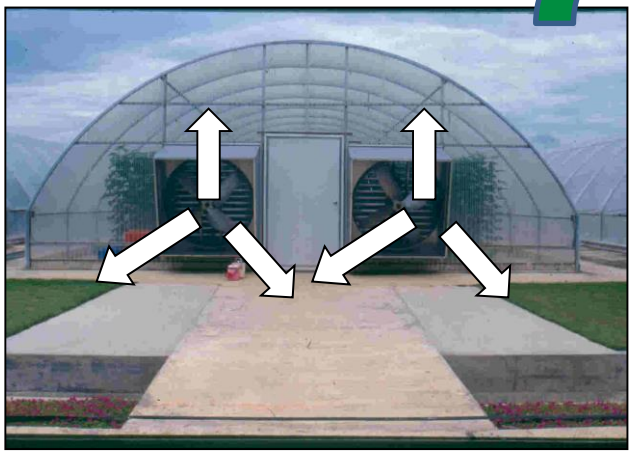
Fan-Pad Cooling

Fan and Cooling pad

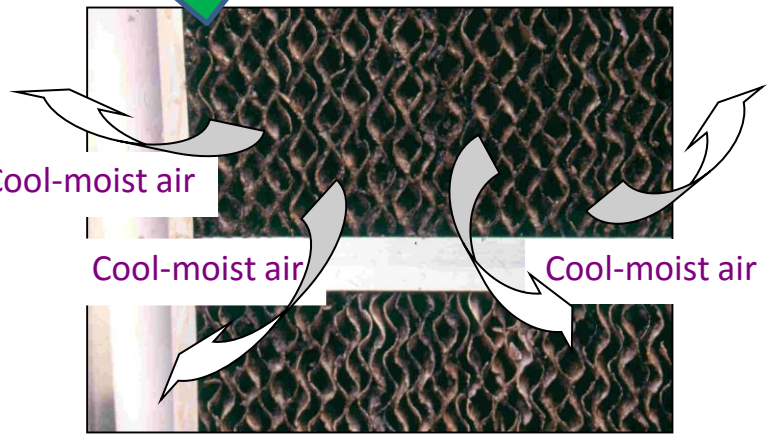




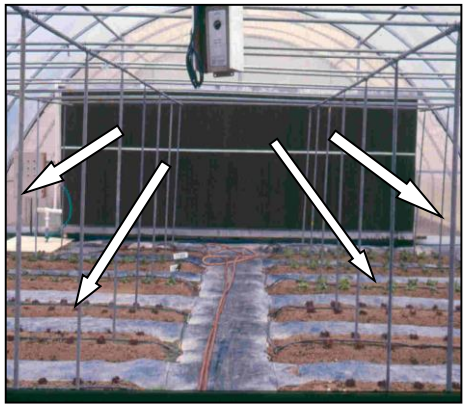
Evaporative cooling system



Exhausted fans pull air out of GH

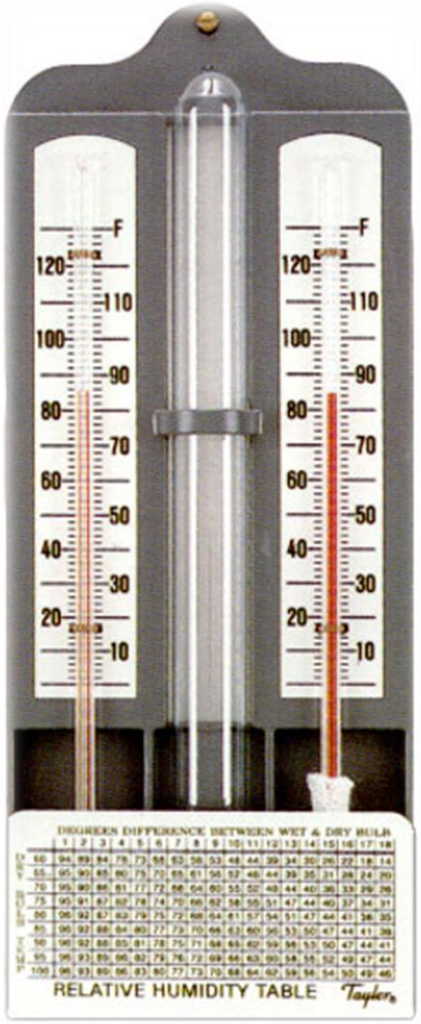


Warm air was pulled passing wet cooling pad, moisture evaporates by using heat energy from air



Cooled air is pulled from pad end to fan end

Dry buld temp.



Wet-bulb temp.

The potential efficiency of fan-pad greenhouse

Outside EVAP-Greenhouse			Inside EVAP-greenhouse		In-outside Temperature Difference (°C)
Dry bulb temp. (°C)	Wet bulb temp. (°C)	RH (%)	Dry bulb temp. (°C)	RH (%)	
35	24	40	25	90	10
35	26	50	28	87	7
35	29	65	30	92	5
35	32	80	32	93	3

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Effects of greenhouse cooling method on growth, fruit yield and quality of tomato (*Solanum lycopersicum* L.) in a tropical climate

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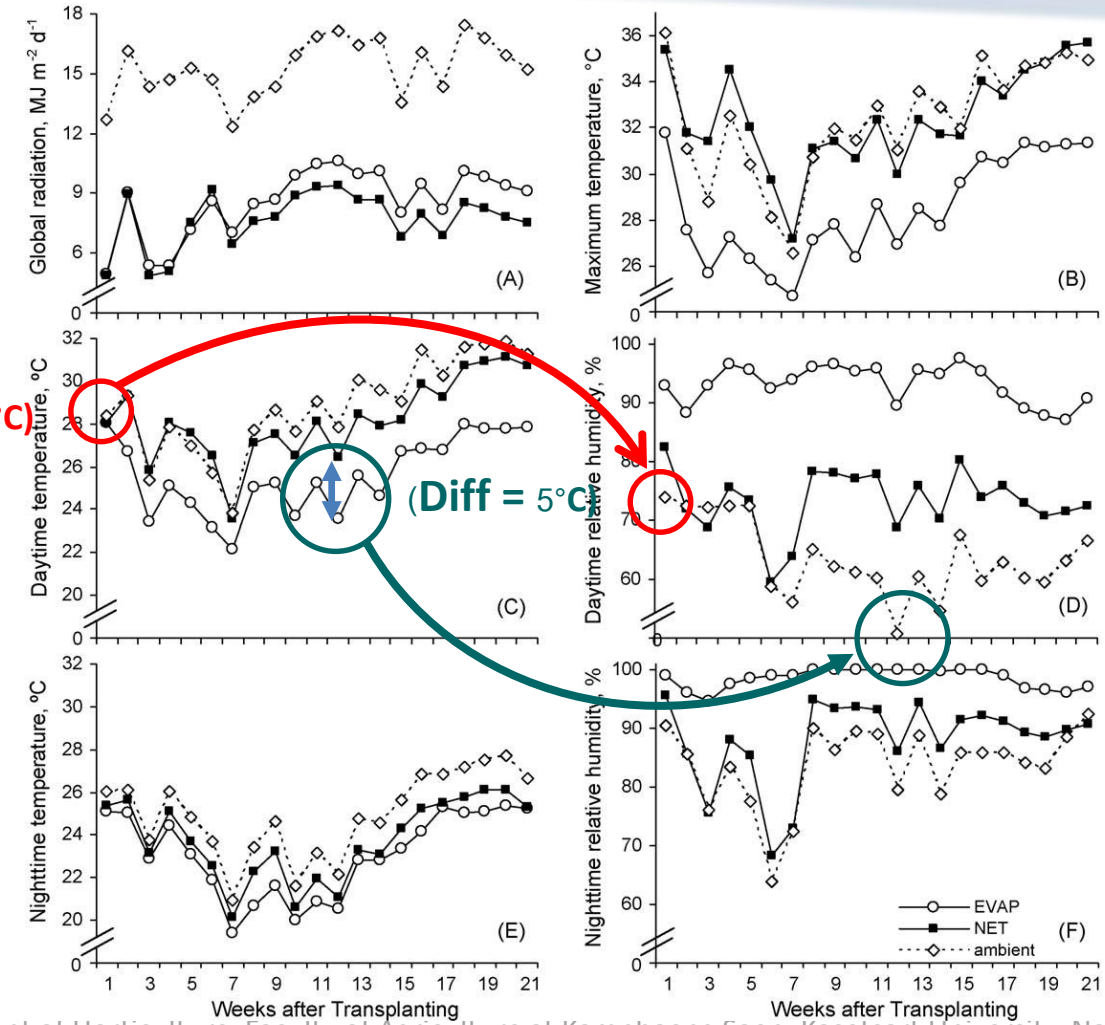
Efficiency of EVAP varied with ambient RH%



(Diff = 0.5°C)

(Diff = 5°C)

From Max *et al.*, 2009: Scientia Horticulturae 122 (2009):179-186

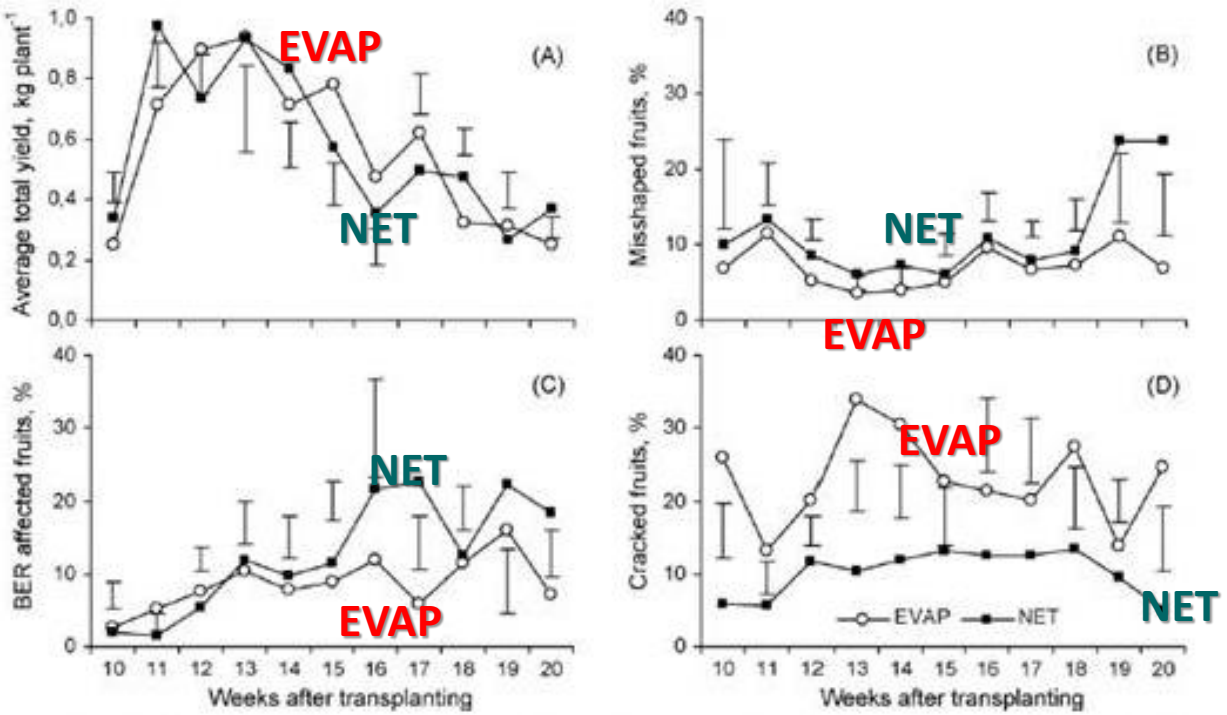
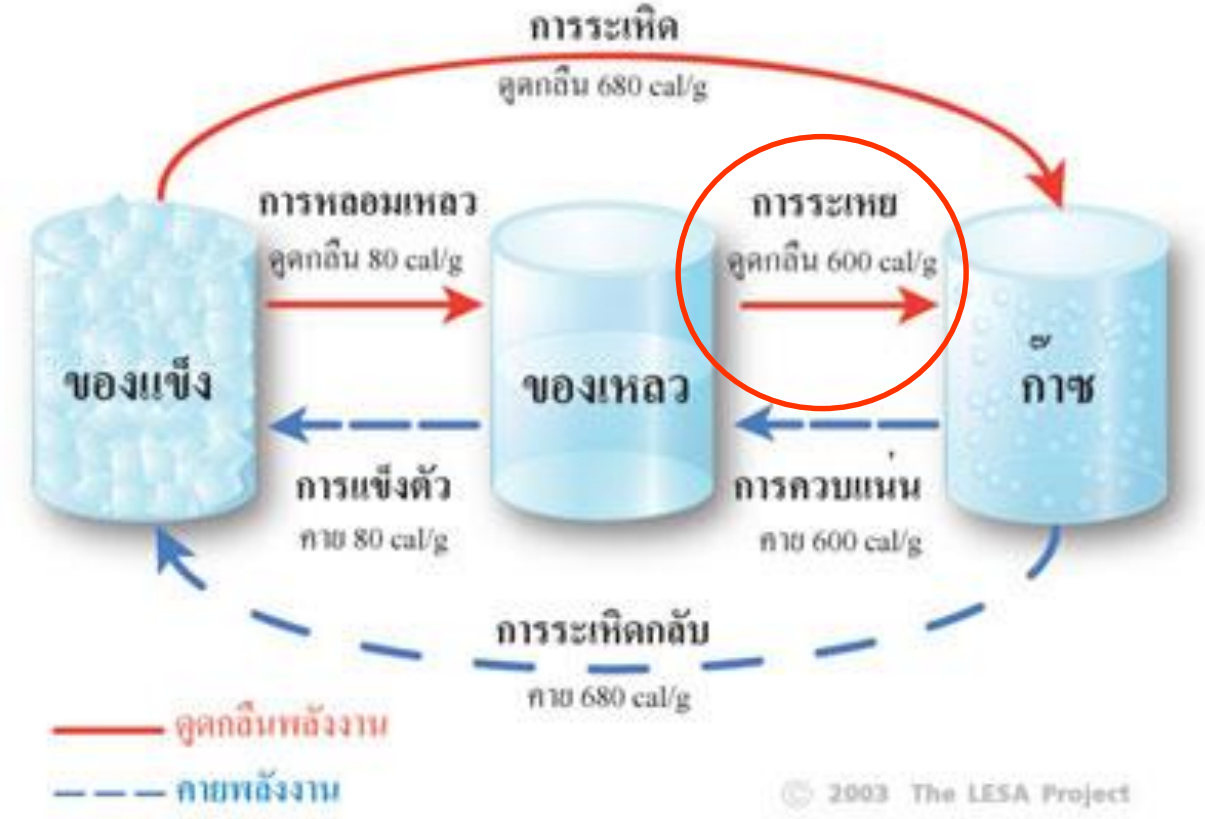


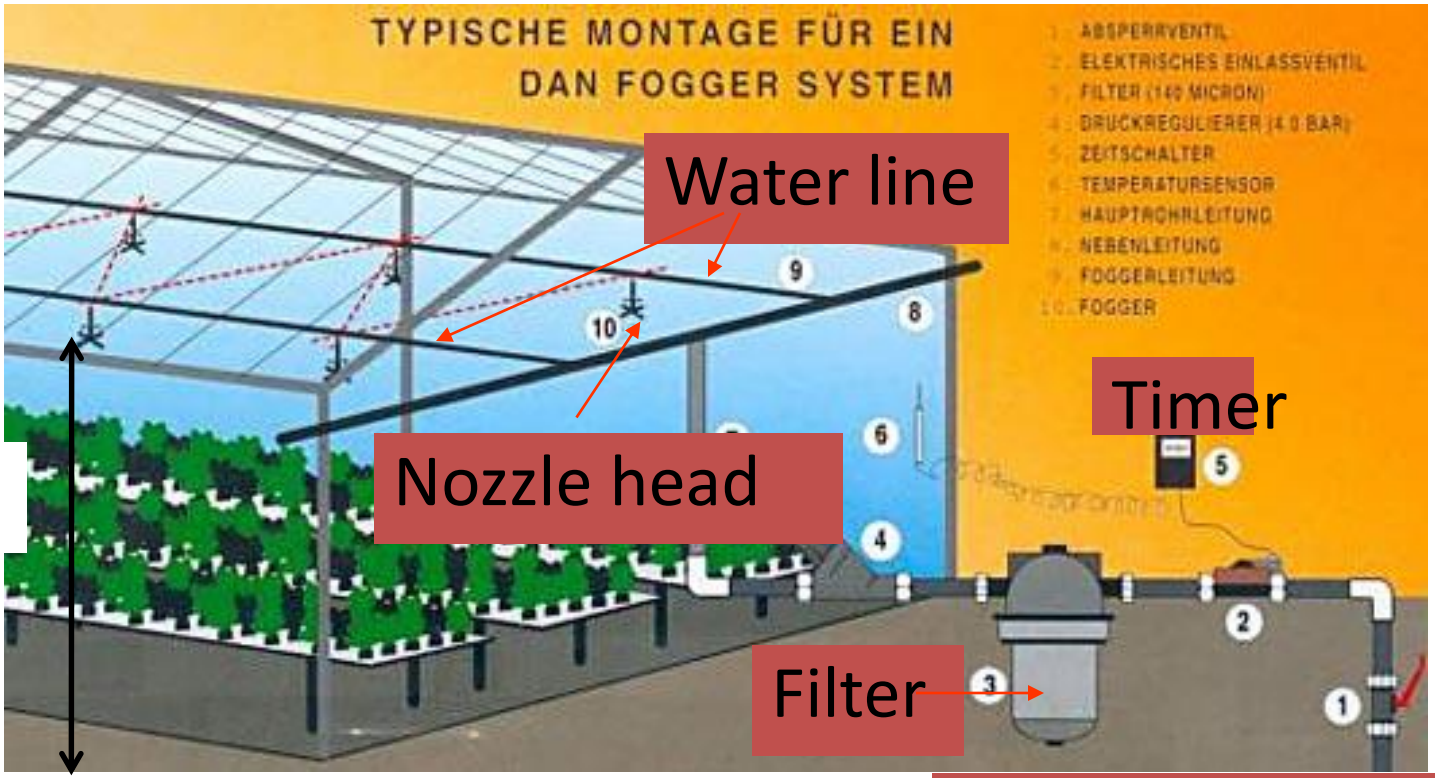
Fig. 4. Temporal development of weekly total yield (A) and the percentages (w/w) of misshaped and undersized (B), blossom-end rot-(BER-) affected (C) and cracked (D) fruits of tomato plants (cvs. FMTT260 and King Kong 2) grown in greenhouses during the dry season 2005/2006 in Central Thailand. Greenhouses were operated either evaporative cooled (EVAP) or naturally ventilated (NET). Error bars indicate $LSD_{(0.05)}$ (LSD-test, $\alpha < 0.05$, $n = 16$).

From Max *et al*., 2009 :Scientia Horticulturae 122 (2009):179-186

Fog cooling or Mist-spray cooling


การระเหิด
ดูดกลืน 680 cal/g
การหลอมเหลว
ดูดกลืน 80 cal/g
การระเหย
ดูดกลืน 600 cal/g
ของแข็ง
ของเหลว
ก๊าซ
การแข็งตัว
คาย 80 cal/g
การควบแน่น
คาย 600 cal/g
การระเหิดกลับ
คาย 680 cal/g
ดูดกลืนพลังงาน
คายพลังงาน
© 2003 The LESA Project

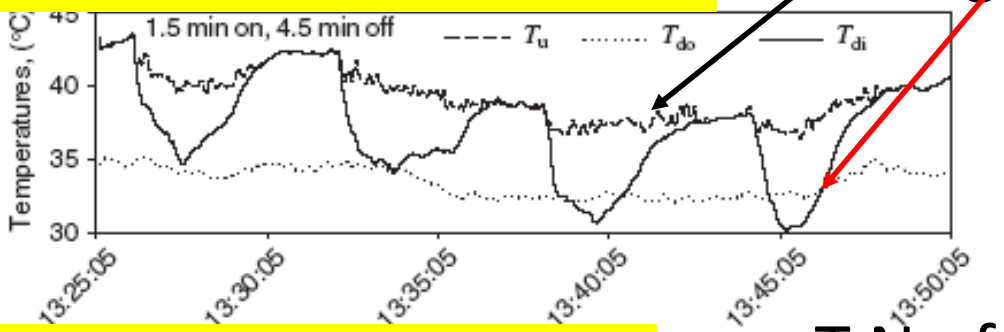
Fog components



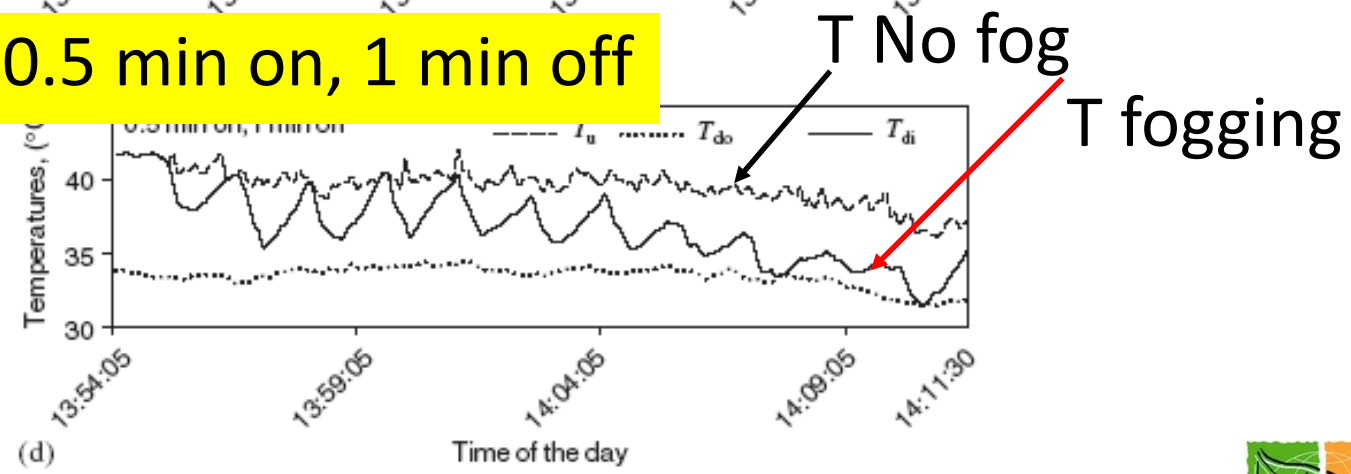
Minimum pressure 2.5 -4 bar mist and 150 bar for Fog

Short-time spray with high frequency is more effective !

A) 1.5 min on, 4.5 min off



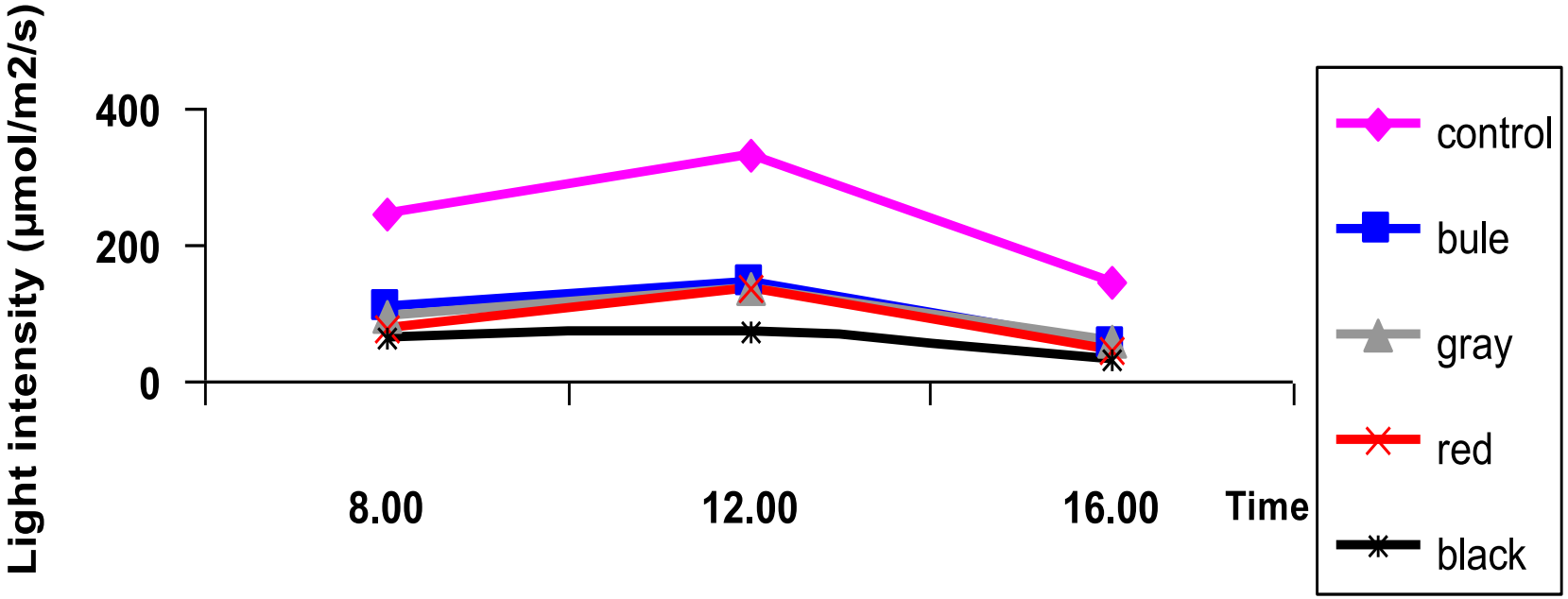
B) 0.5 min on, 1 min off



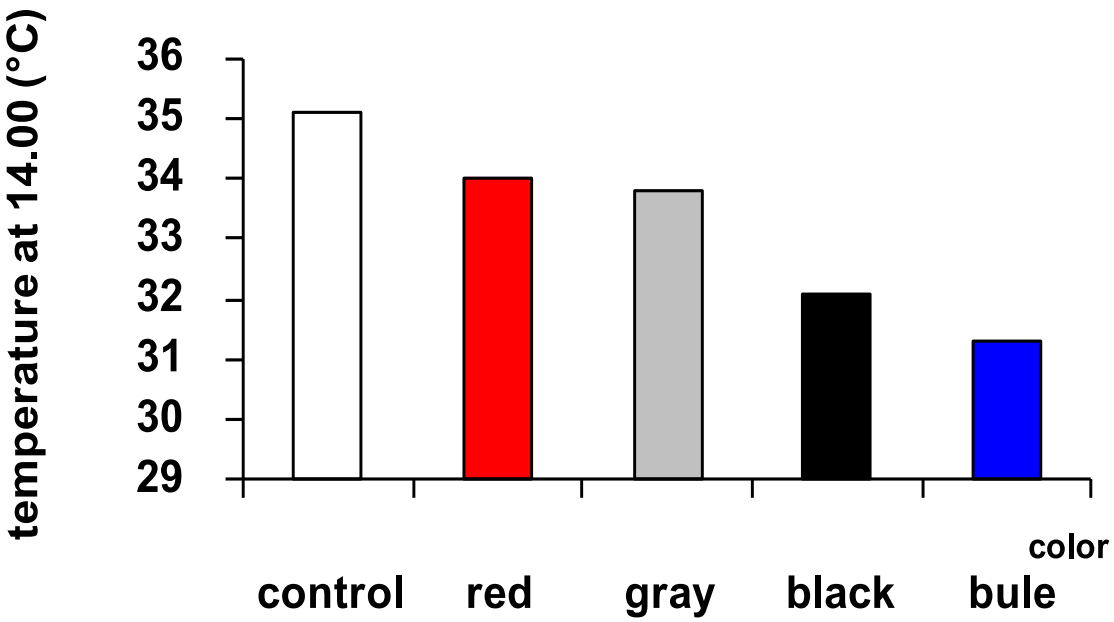
Light air movement during fogging is required

Light shading by a screen

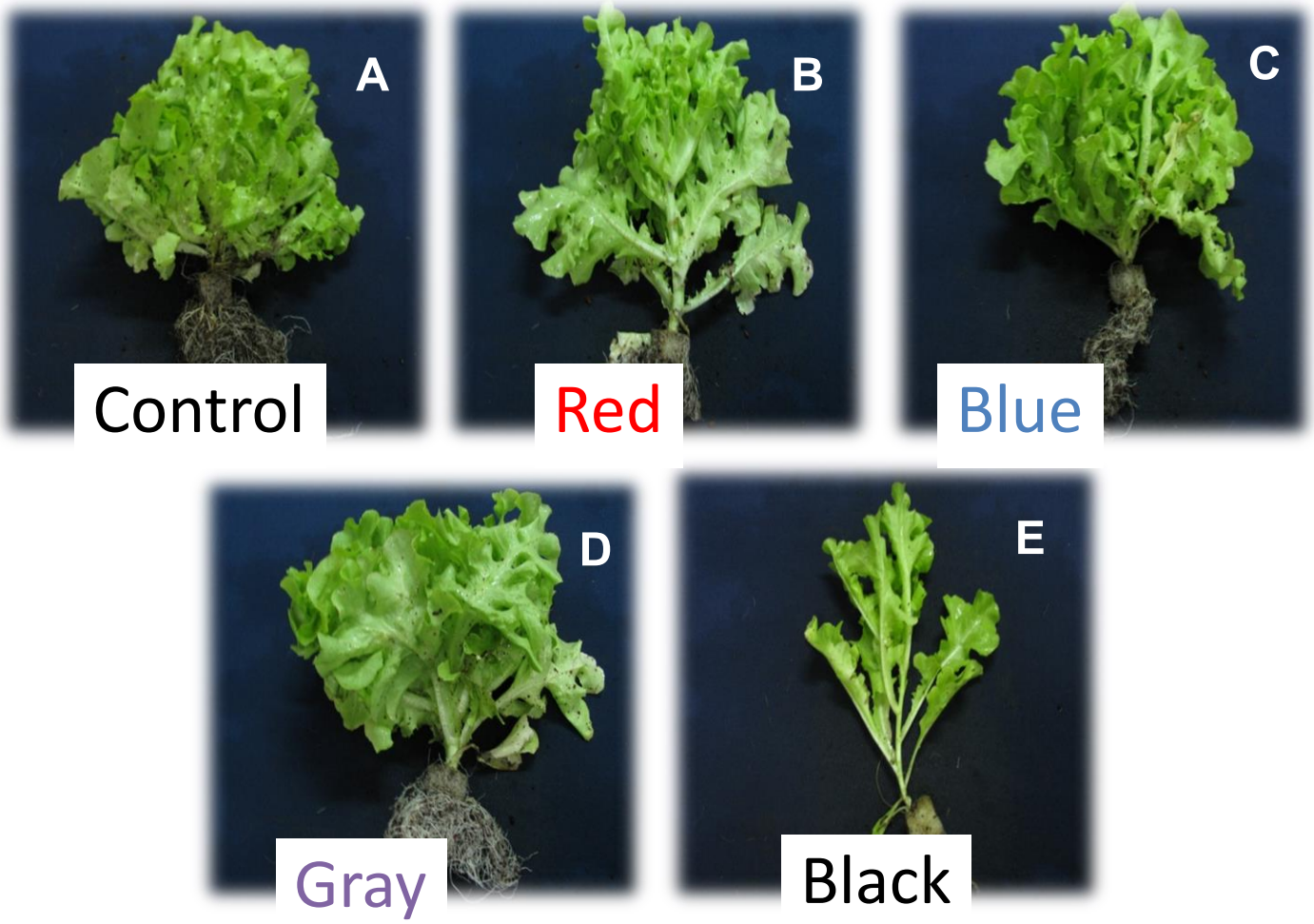
Effect of net color on light intensity, temperature and growth of lettuce


Light intensity (µmol/m2/s)
400
200
0
8.00
12.00
16.00
Time
control
bule
gray
red
black

Temp. under net at 14:00



Growth of lettuce under 24 hr shading



Growing techniques used in greenhouses

Soil growing

-Domestic leafy vegetables e.g. Brassicas, basil, Alliums, etc.

Fruit vegetables e.g. melon, cherry tomato, etc.

Soilless growing

Hydroponics:

lettuces, herbs, etc.

Substrate culture: sweet pepper, strawbery, tomato, melon, orchids, etc.

Soil growing with fertigation system

Leafy vegetable can grown well in soil under the net-house

Deep Flow Technique

Nutrient Film Technique

Rockwool culture

Substrate grown cropping

Cocopeat culture

Effect of accumulative growing time of coco-coir dust on growth of lettuce (Hossain,2016)

Treatments	Fresh weight (g plant^{-1})			Dry weight (g plant^{-1})		
	Shoot	Root	Total	Shoot	Root	Total
Time used						
1	76.92a	9.45a	86.36a	4.36a	0.86a	5.22a
2	76.03a	9.24a	85.26a	4.30a	0.85a	5.14a
3	75.28ab	9.05ab	84.34ab	4.22ab	0.83a	5.05ab
4	72.30b	8.50b	80.79b	4.02b	0.77b	4.79b
5	68.25c	7.82c	76.11c	3.75c	0.72c	4.47c
Nutrient (N)						
Fresh	74.50	8.96	83.46	4.18	0.82	5.00
Fresh+used	73.01	8.65	81.69	4.07	0.79	4.86
F test						
T	**	**	**	**	**	**
N	NS	NS	NS	NS	NS	NS
T×N	NS	NS	NS	NS	NS	NS
CV(%)	3.59	5.77	3.55	5.07	4.58	4.74

Aeroponics

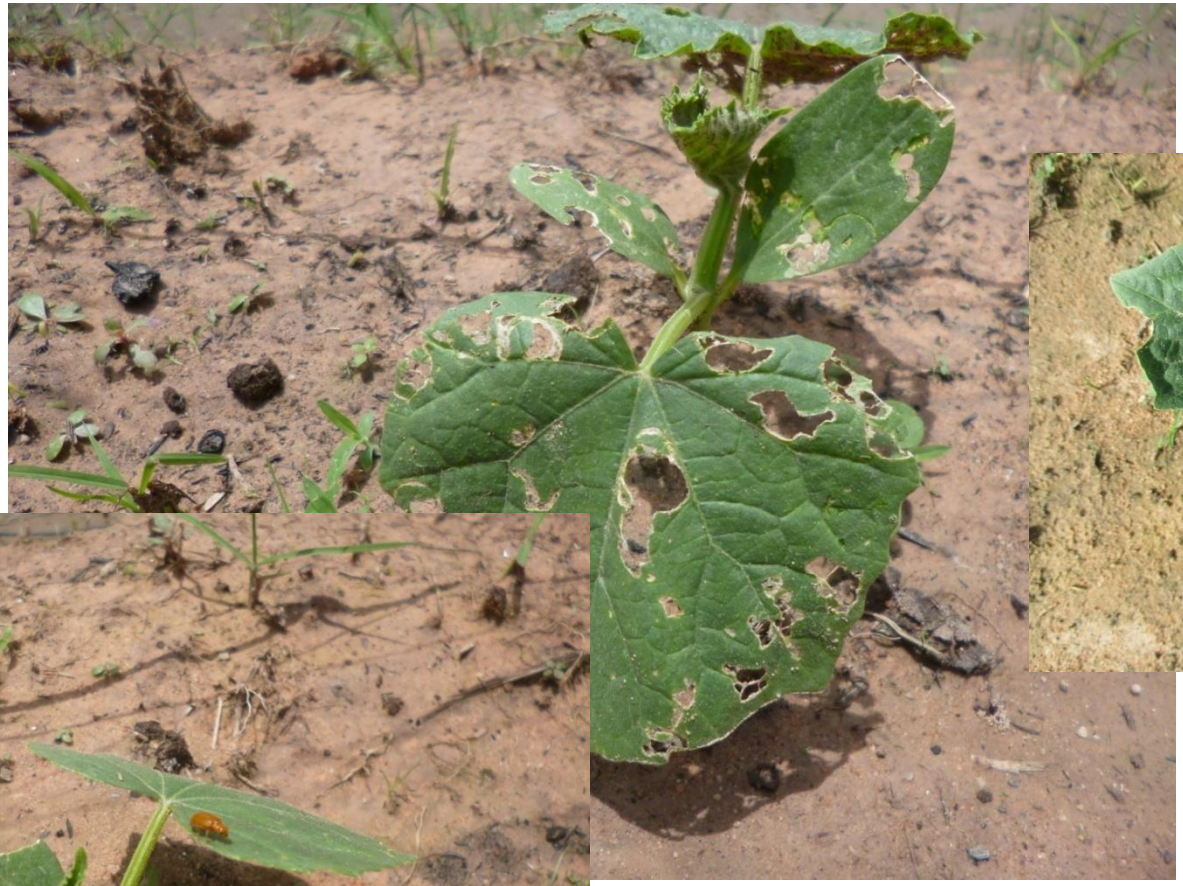
The introduction of low cost greenhouse at Siem Reap, Cambodia

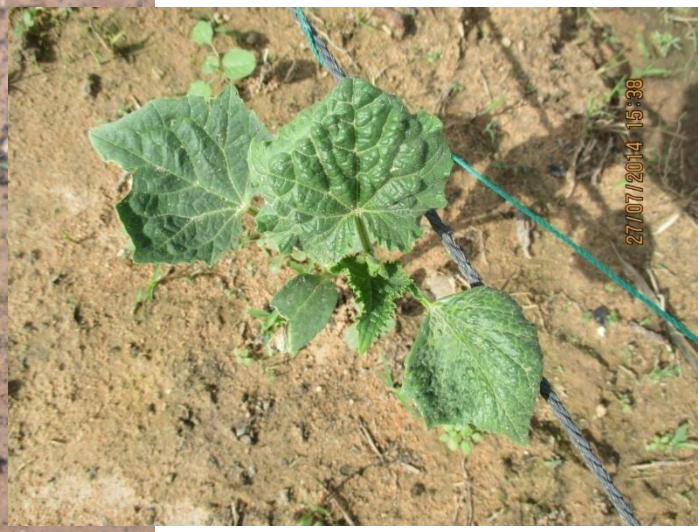
Problems

- Vegetable production is limited leading to malnutrition
  - Limit of water after rainy season
  - Lacking of agricultural knowledge
  - Over-doze application of pesticide !!!

The international project introducing the family drip irrigation for growing vegetables

Crop was destroyed when growing out-door





The construction of low cost greenhouse

6 x 12 sq.m

Galvanized frame

Bamboo-stick frame

Greenhouse crop production training

Seedling was infected by soil-born disease.

Clean seedling media locally available was introduced

Rice-hill charcoal

Rice-hull ash

Rice-hull charcoal making

The clean seedling media was generated by locally available material

Rice-hill charcoal

Rice-hull ash

Cow dunk

= 2 : 1 : 0.5 V/V

Department of Horticulture
Faculty of Agriculture at KPS.

Perfect germination !!!

Out-door grown cucumber

Greenhouse grown cucumber

Pollination problem inside the greenhouse

Low-tunnel net-house for leafy vegetable

Construction of low-tunnel net-house

Cultural practice done in the day-time

Leafy vegetables was protected from insects inside the net-house

The pesticide-free vegetable was harvested

KU-COCOPEAT


ซุปเปอร์
โคโค่พีท
วัสดุเพาะกล้าคุณภาพสูง
วัสดุเพาะกล้าของ สุโขทัยฟาร์ม จำกัด


อนุสิทธิบัตร
อาศัยอำนาจตามความในพระราชบัญญัติสิทธิบัตร พ.ศ. 2522
แก้ไขเพิ่มเติมโดยพระราชบัญญัติสิทธิบัตร (ฉบับที่ 3) พ.ศ. 2542
กรมทรัพย์สินทางปัญญาออกอนุสิทธิบัตรฉบับนี้ให้แก่
สำหรับการประดิษฐ์ตามรายละเอียดการประดิษฐ์ ข้อถือสิทธิ และรูปเขียน (ถ้ามี)


KU Cocopeat
Peat moss

Choose wisely, live well.