Protected Cultivation for Vegetable Crop Production

Topics

- What and Why
- Merits and demerits
- Greenhouse structure and types
- Greenhouse location selection
- Greenhouse environments
- Greenhouse cooling
- Greenhouse crop growing techniques
- Low cost greenhouses

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

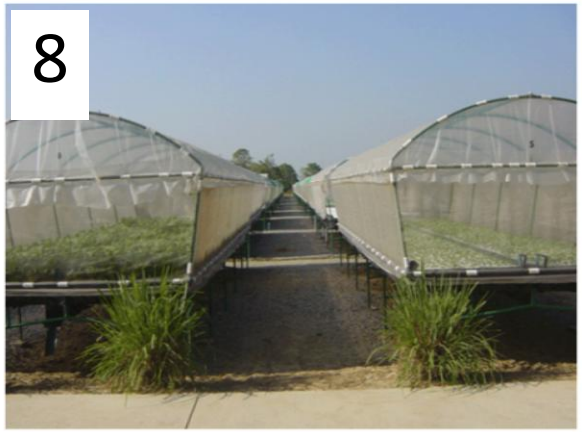
4

5

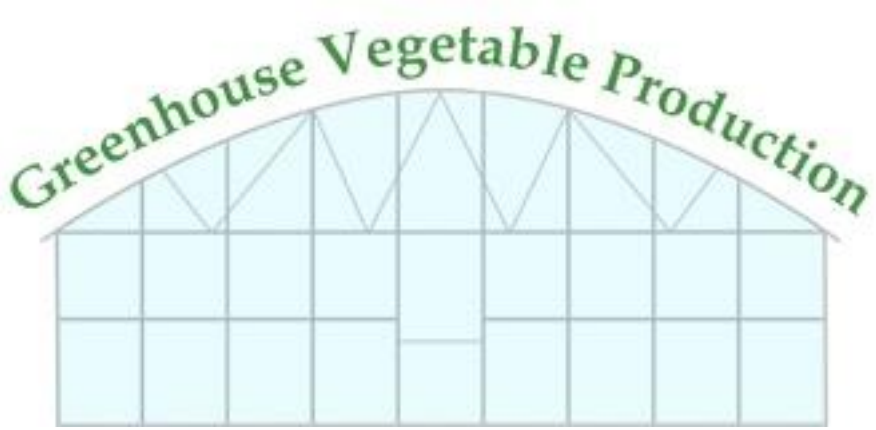
6

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 environment affecting plant growth

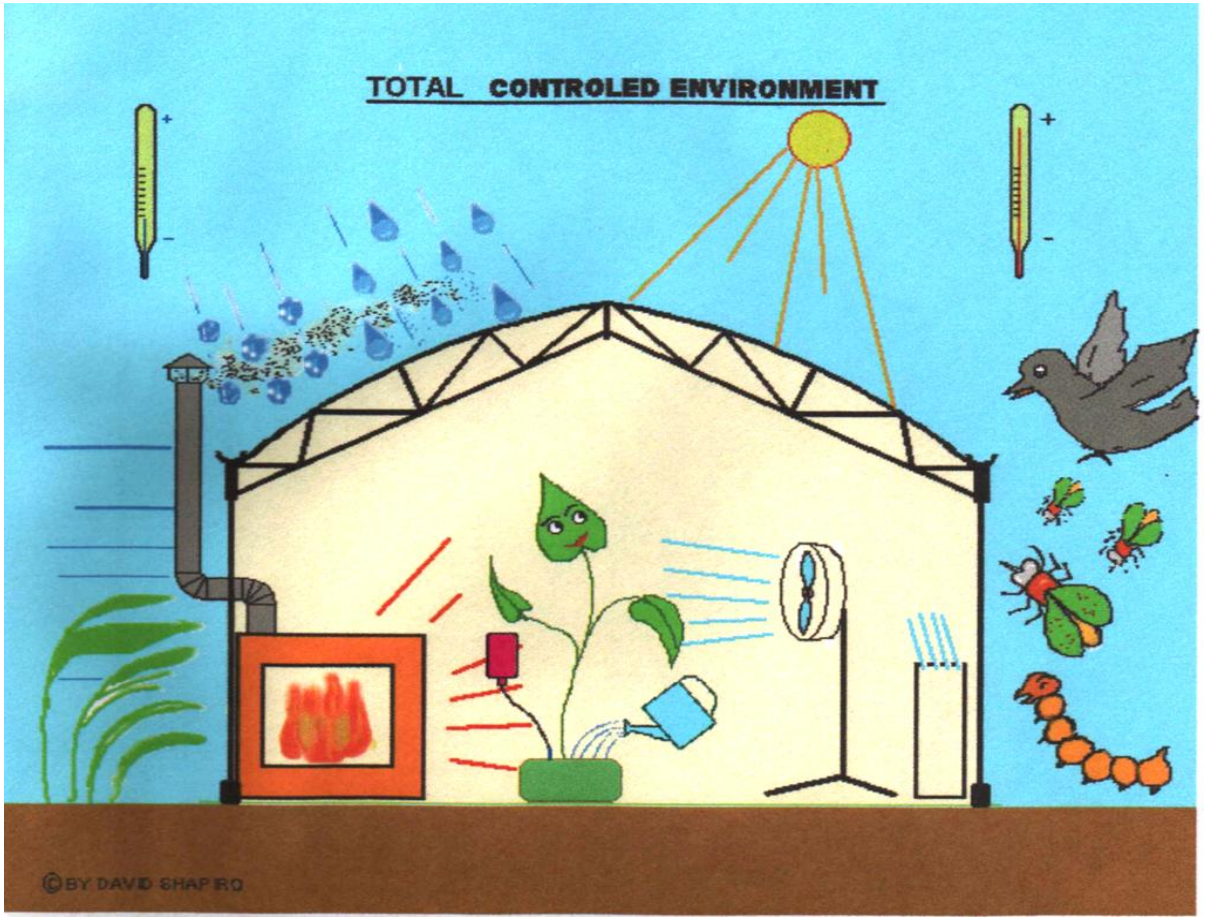
- Light
- Temperature
- Humidity
- CO_2

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 farmers

Vegetative growth

20-20-20

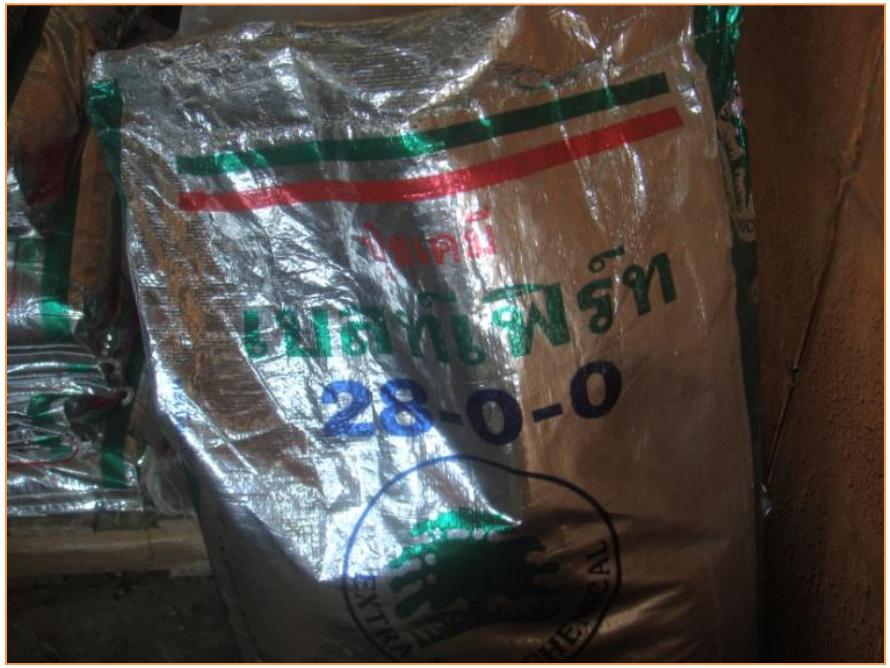
20-10-30

Reproductive growth

20-10-30

0-0 60

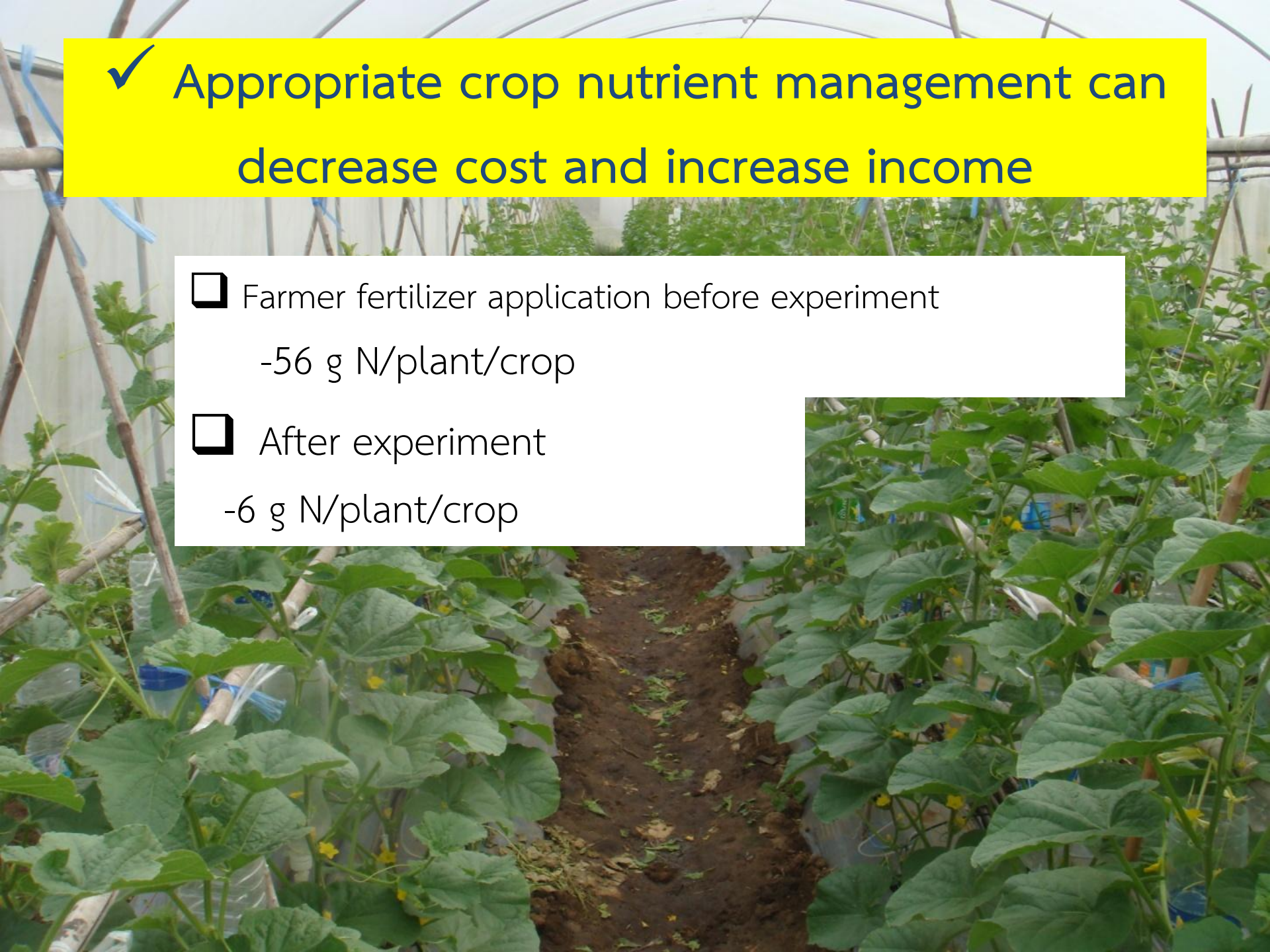
The available NH_4SO_4 was used solely to supply only N



ระยะสร้างลำต้นและใบ (mg/L)	ระยะติดผล (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

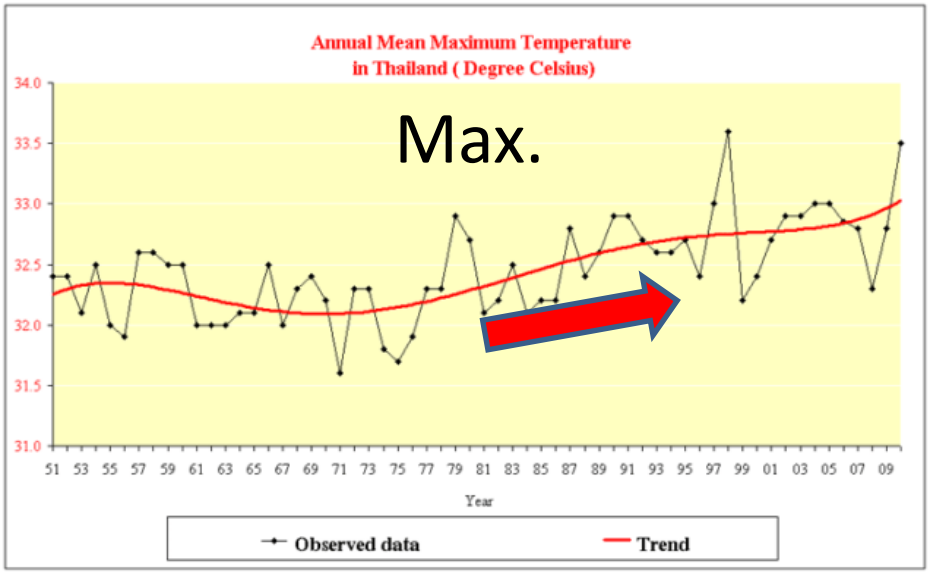
Chrysanthemum grown under supplemented light inside the greenhouse to prolong vegetative growth in winter season

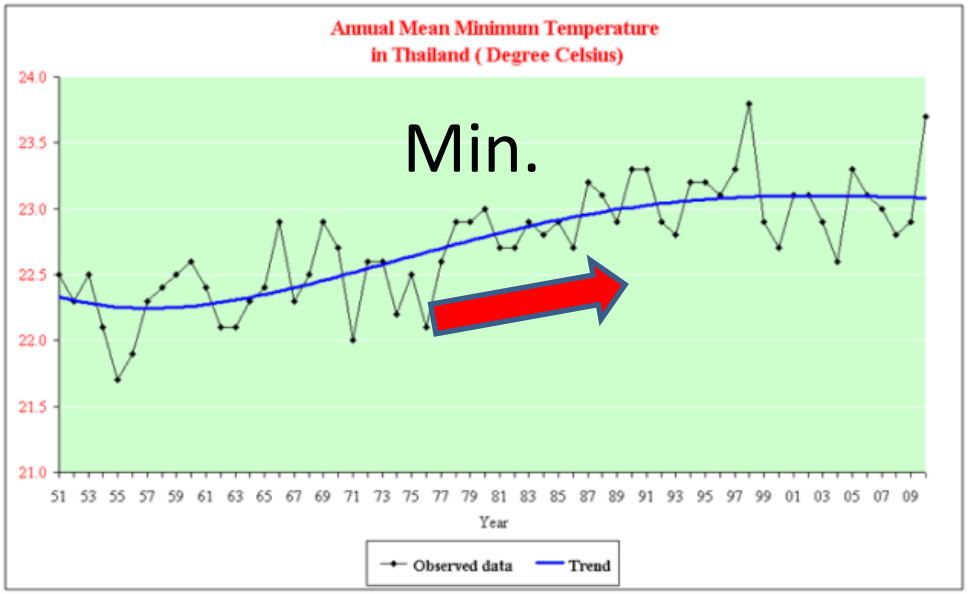
Cool-season vegetables grown in the tropics under a greenhouse

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

Pests in tropic region can destroy crop all-year

Over MRL Pesticide residues in produces is an international issues

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'อียู' สั่งระงับนำเข้าพืชไทย

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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Consumer demand for high quality food is increasing

makro

FOODLAND Supermarket Co.,Ltd

Tops ท็อปส์

VILLA MARKET THE ORIGINAL SUPERMARKET SINCE 1974

TESCO Lotus

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Public Food Safety Awareness

"Safe, Clean and Green food"

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New generation growers need a better crop growing system

Safety

GH crop production

Quality

Continuity

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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.

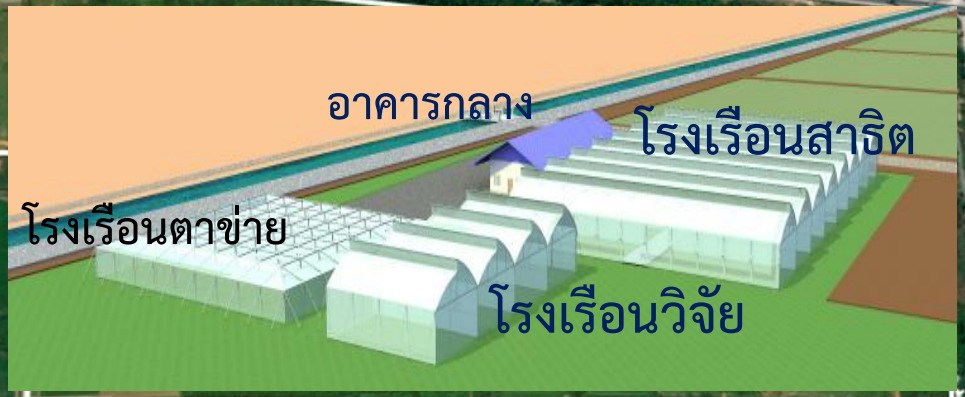
Demerits

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

NFT crop failure after power break down

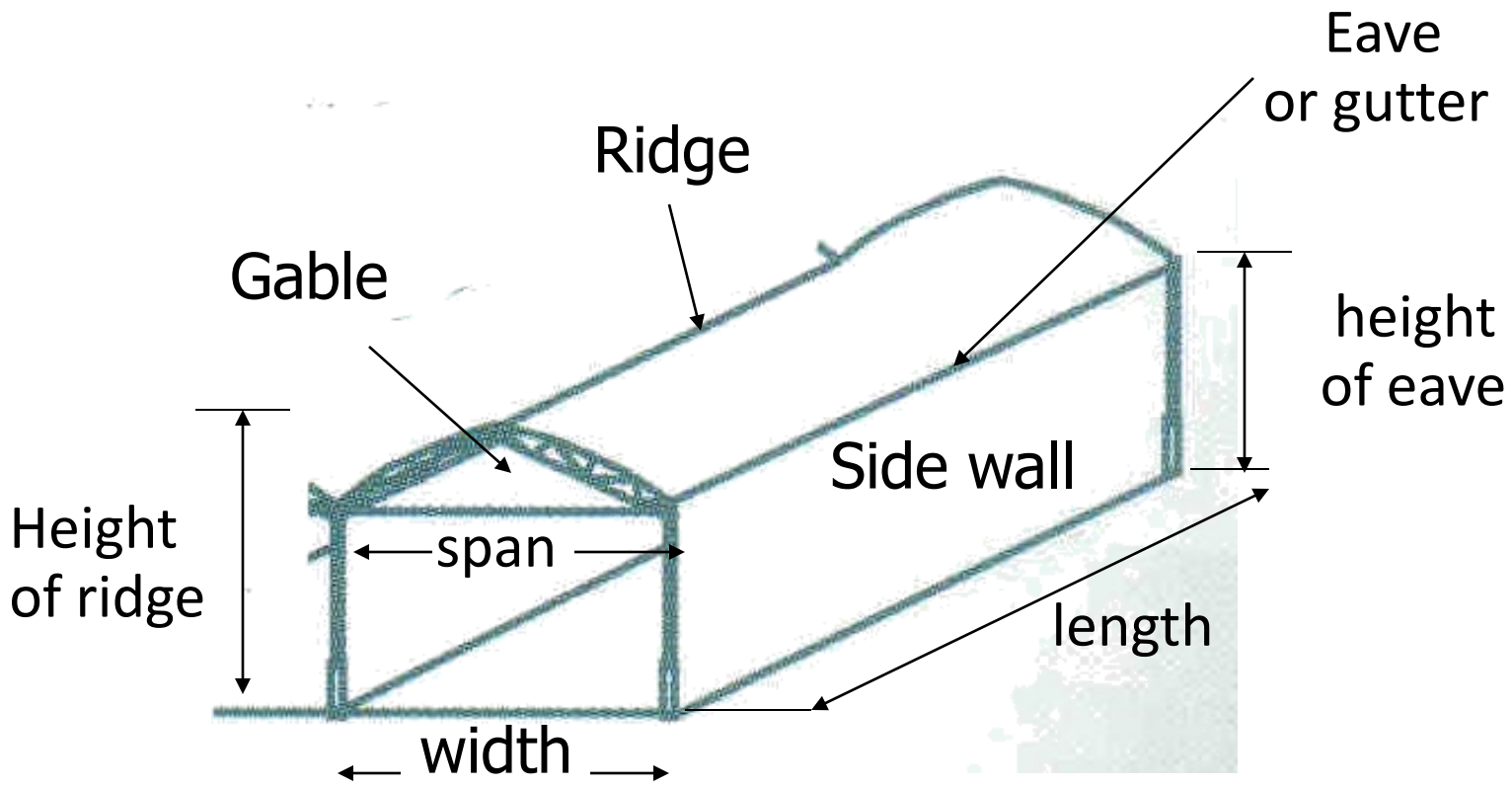

Vudtechai Kapirakanchana

Greenhouse Complex, ม.เกษตรศาสตร์ กำแพงแสน



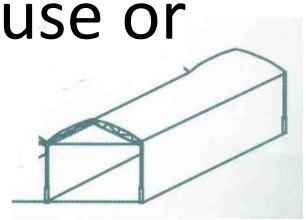
Greenhouse structure

BASIC GREENHOUSE STRUCTURE

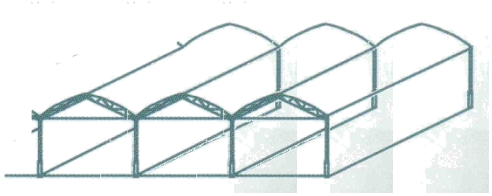


Types of greenhouse

- 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



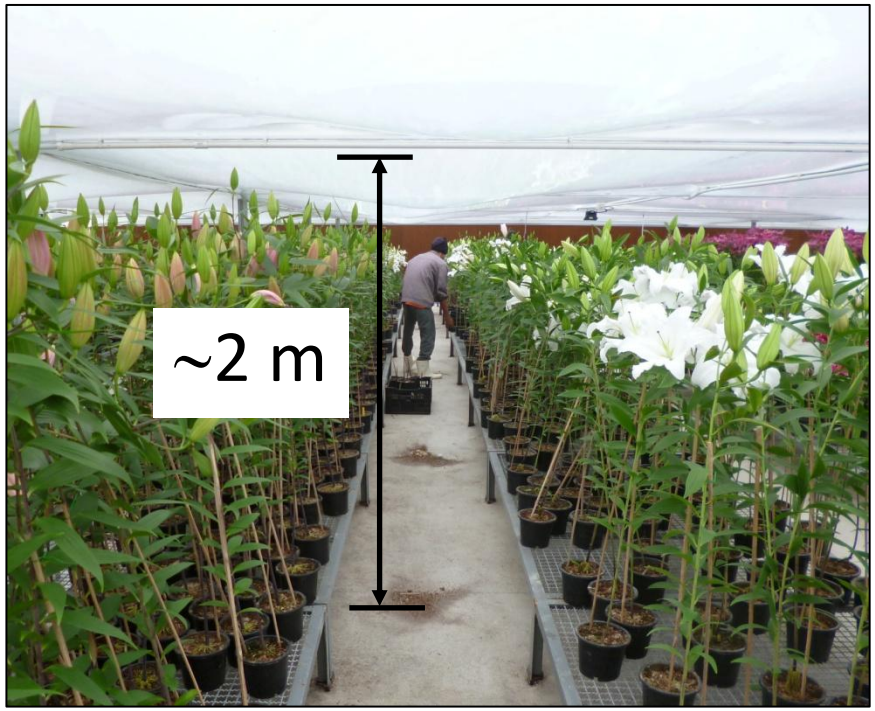
Double-arch roof

Saw-tooth roof

Over-lapping roof

Natural cooling greenhouse

Evaporative cooling greenhouse



Greenhouse strength

- Greenhouse must be design 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) use wood frame to be side post and column.
- GH with 6-12 m use galvanized pipe frame.
- GH with > 12 m use 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

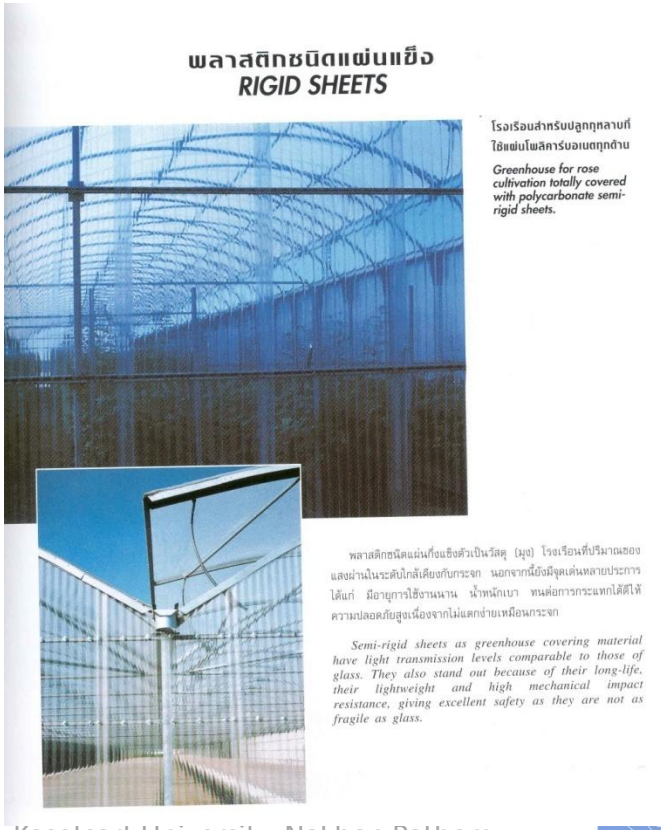
- Thickness : 100, 150, 200 and 250 µm
- Width : Domestic 6 m, Import 9 m or more
- Length : 100 m/ roll
- UV stabilizer concentration : 0.05 – 2%

UV stabilzers in plastics

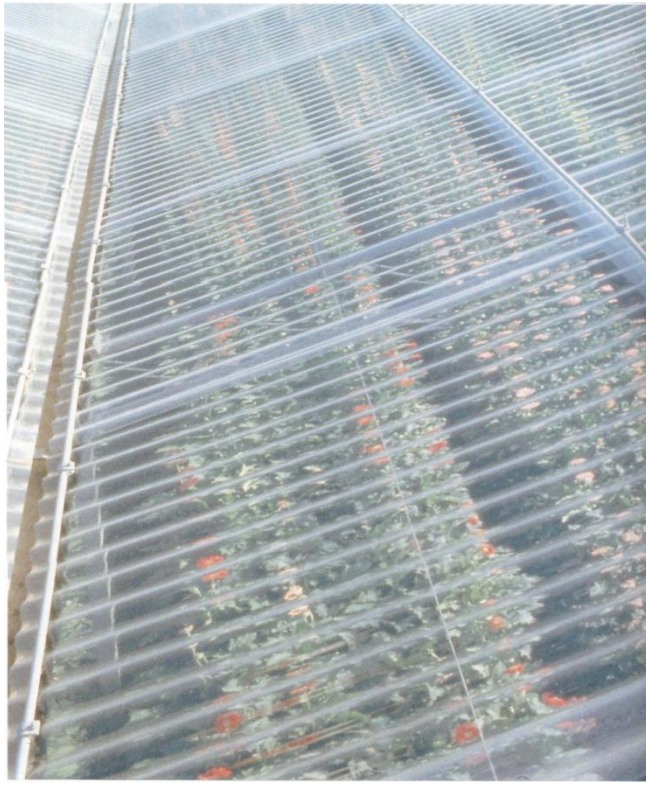
- UV stabilizers, such as benzophenones, work by absorbing the UV radiation and preventing the formation of free radicals.
- Concentrations normally range from 0.05% to 2%, with some applications up to 5%

Polycarbonate sheet

- Good light transmittance (70-80%)
- Light weight
- Lifetime ~ 10 y
- Expensive but cheaper than glass
- Resistant to moderate impact
- Vulnerable to sharp object



Fiberglass-Reinforced Plastic (FRP)



-Fairly high light transmittance, less than glass and PE

-Light weight

-Inexpensive but more than PE

-Sensitive to UV but lifetime slightly longer than PE

Glass VS Polyethylene

Glass	Polyethylene
1. High initial cost	1. Much cheaper
2. High maintenance and operation cost	2. Lower (40% less for heating cost)
3. Heavy in weight	3. Lighter in weight
4. Higher light transmission	4. Slightly less
4. Long life expectancy	4. Short life expectancy

Screen and net

- Use high resolution net
  - 32, 40 and 50 mesh resolution
  - Retard air movement >>>> heat build up

- Use new innovative insect-control net
  - Optinet® 0.71 x 0.41 mm or 0.71 x 0.25 mm
  - Chemical protection : repelling insect by additives.

Greenhouse insect pests

- Caterpillar > 5 mm
- Aphids 1-2 mm
- White fly > 1 mm
- Spider mite
- Thrips > 1 mm
- mealy bug
- Flea beetle

How insects entering the greenhouse

- Through the opening
  - Ventilator
  - Damaged net
  - Open Door
  - Through the net opening (very small insects)
- Through infected plant materials

Grit	Mesh	Microns	Inches
	USS**	(Average)	(Average)
4	3.5	5600~4750	0.187 (nom.)
5	4	4750~4000	0.157
6	5	4000~3350	0.132
7	6	3350~2800	0.111
8	7	2210	0.087 (av.)
10	8	1854	0.073
12	10	1600	0.063
14	12	1346	0.053
16	14	1092	0.043
20	16	940 (0.9 mm)	0.037
24	20	686	
30	25	559 (0.6 mm)	0.022
36	30	483	0.030
46	40	356	0.014
54	45	305 (0.3 mm)	0.012
60	50	254	0.010

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GH Location selecting criteria

- Topography
  - Level site is desirable
  - Well drain soil
  - Natural wind break
  - No object casting any 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

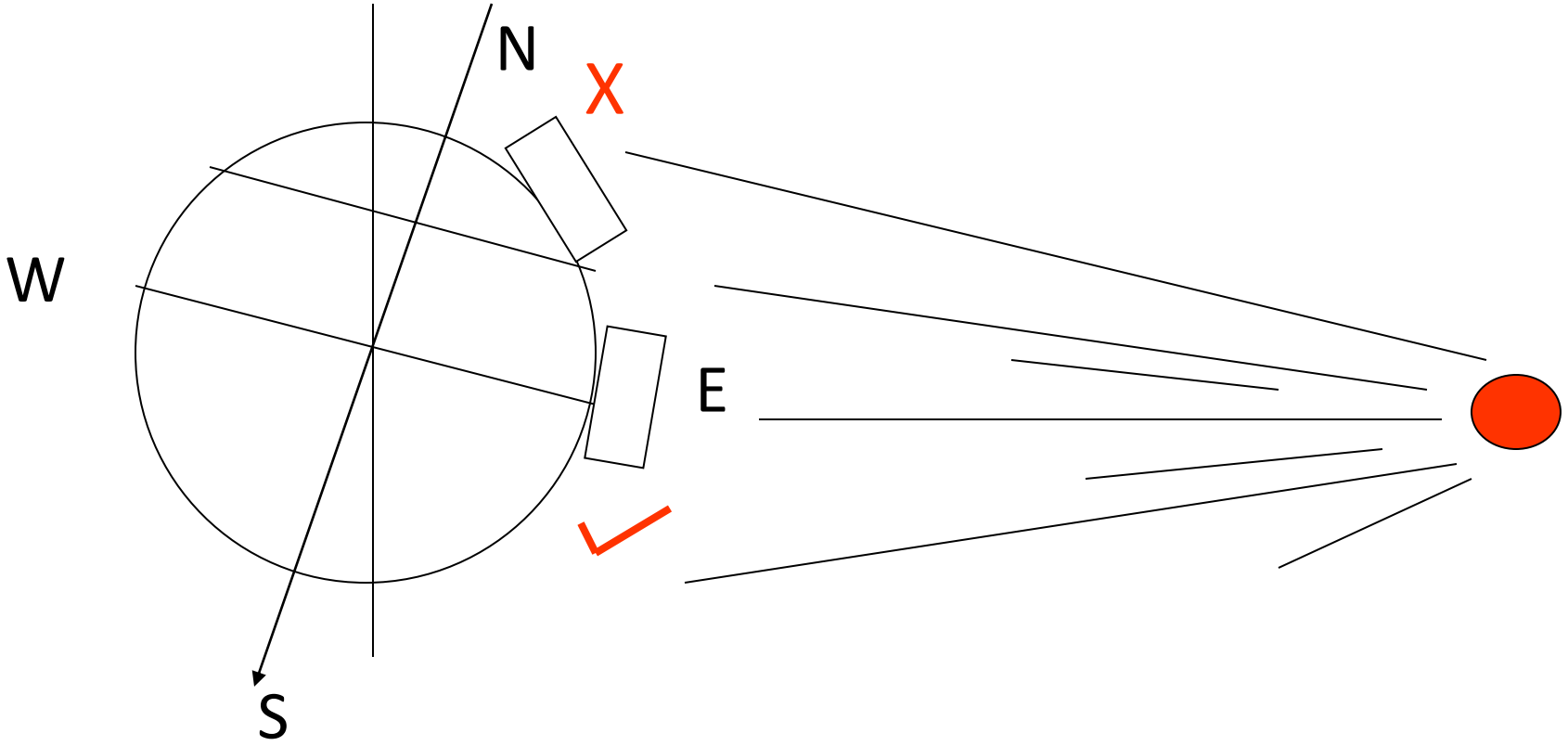
GH Location selecting criteria (cont.)

- 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

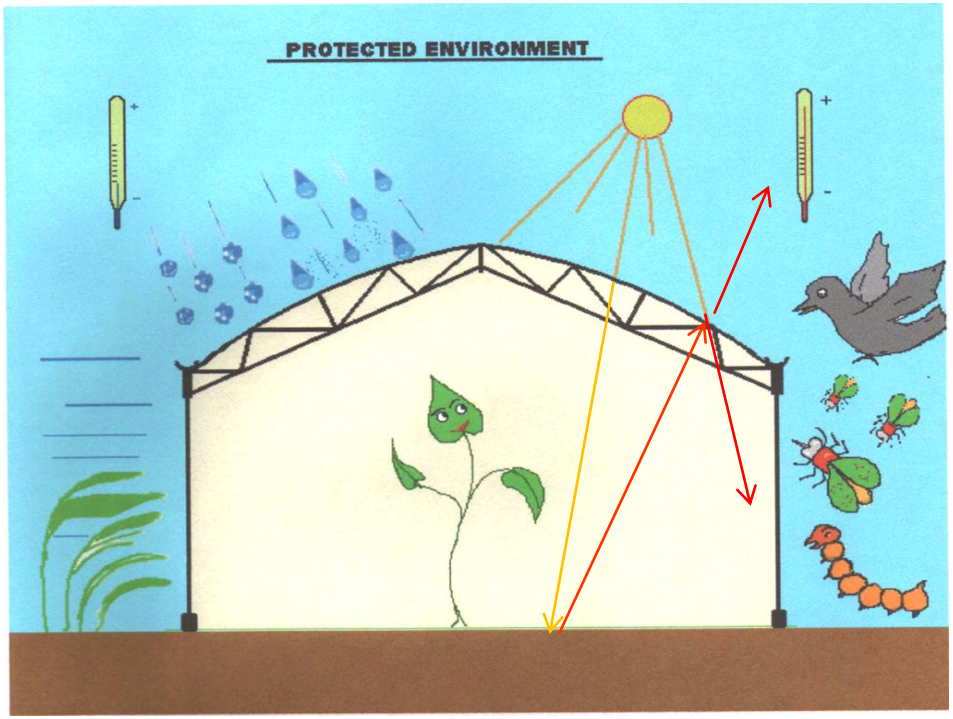
Orientation	Percent Transmission	
	Summer	Winter
N-S	64	48
E-W	66	71

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%

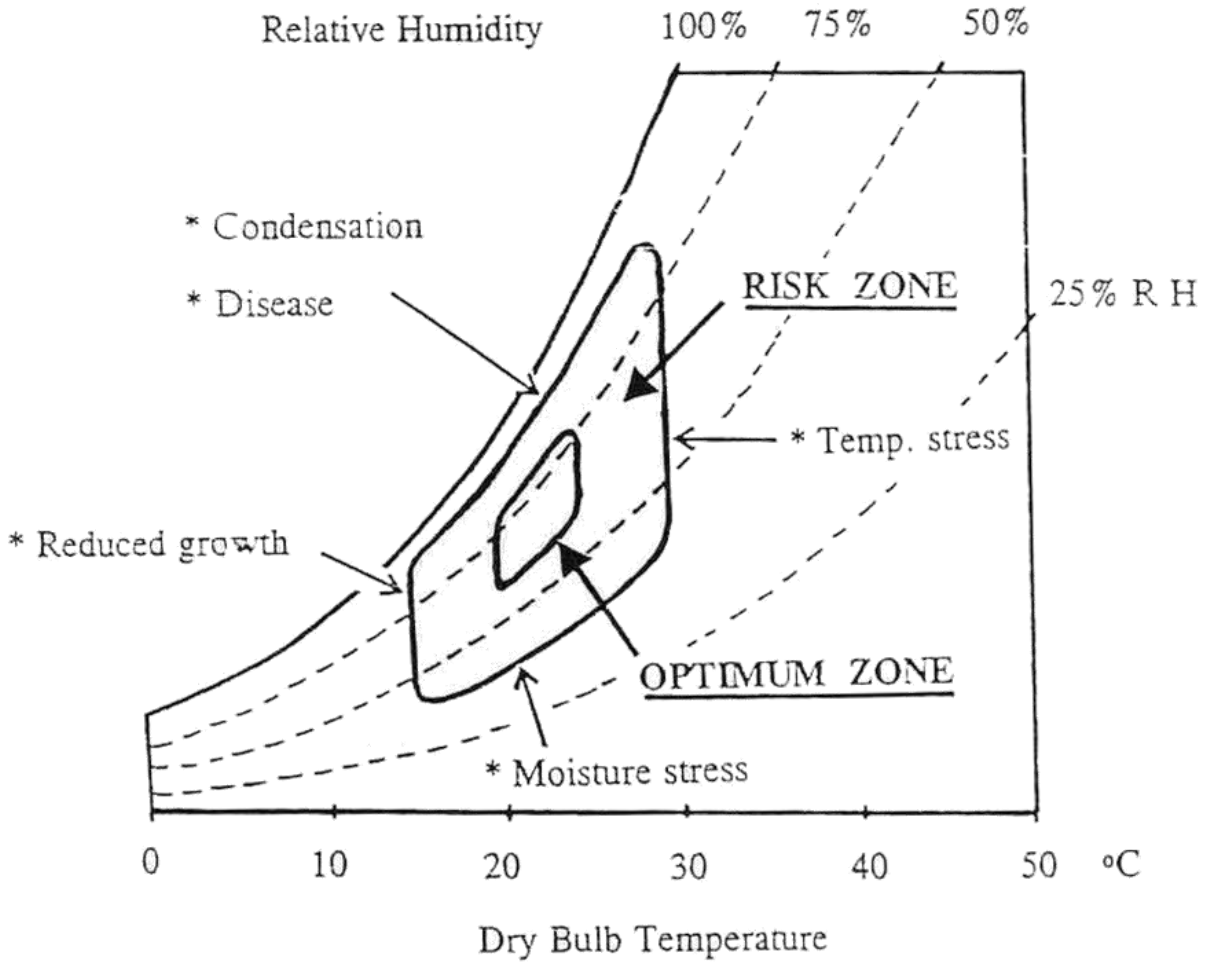
3. Light

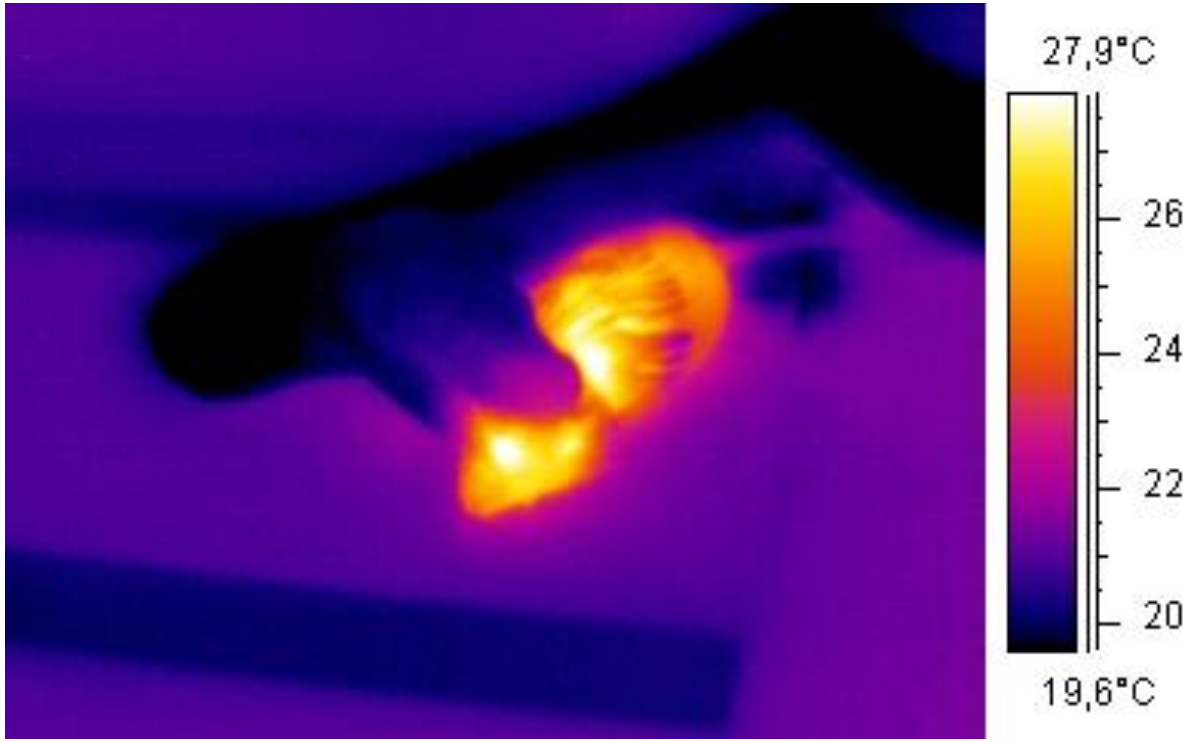
   -intensity 0.9-2.0 mMol m^{-2} s^{-1} (50-100% full sunlight)

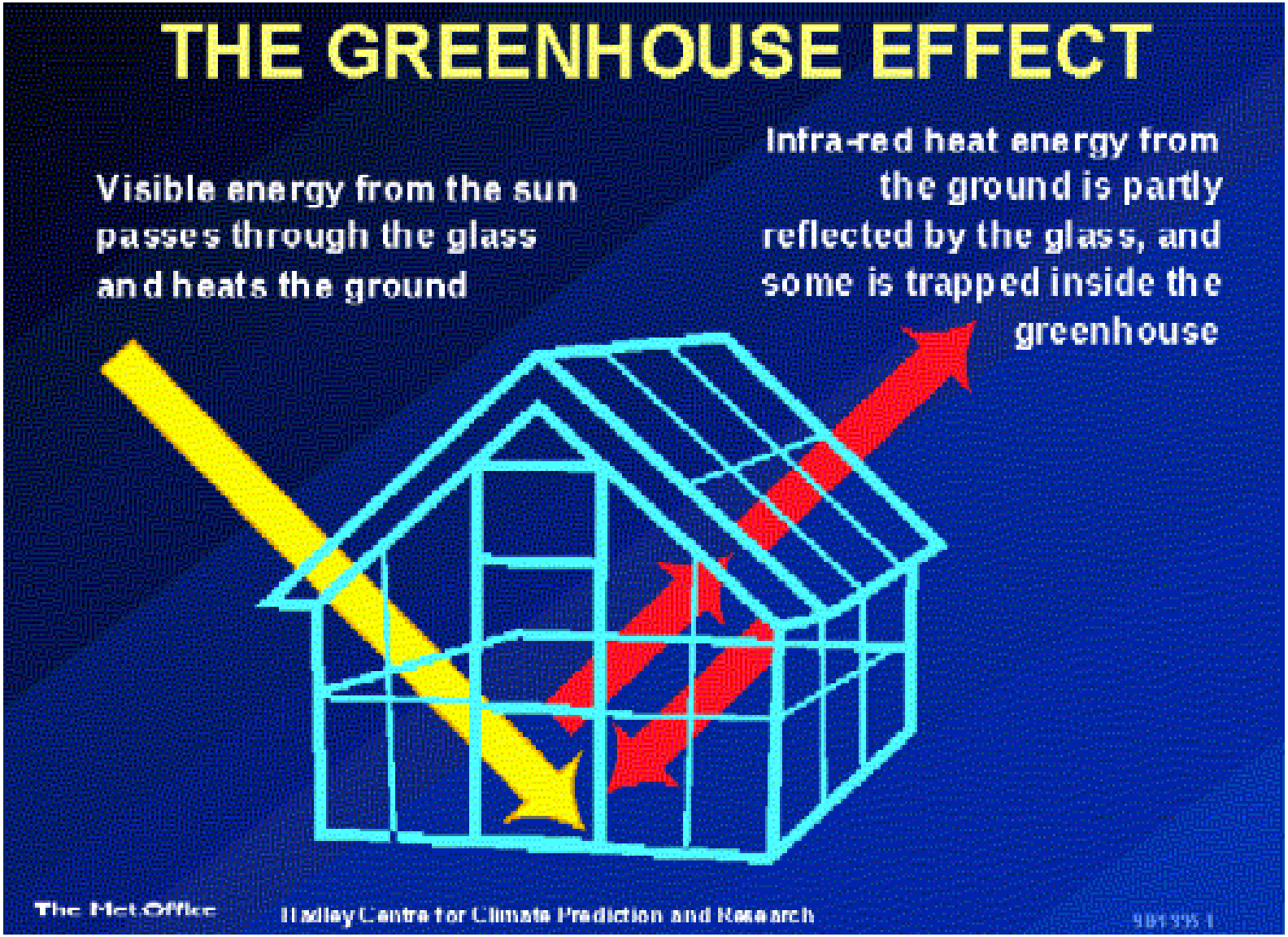
   -Light duration > 6 hr/day

4. Wind 1-2 m S^{-1} or 360-720 ม./ชม.

Optimum zone and Risk zone




27,9°C
26
24
22
20
19,6°C

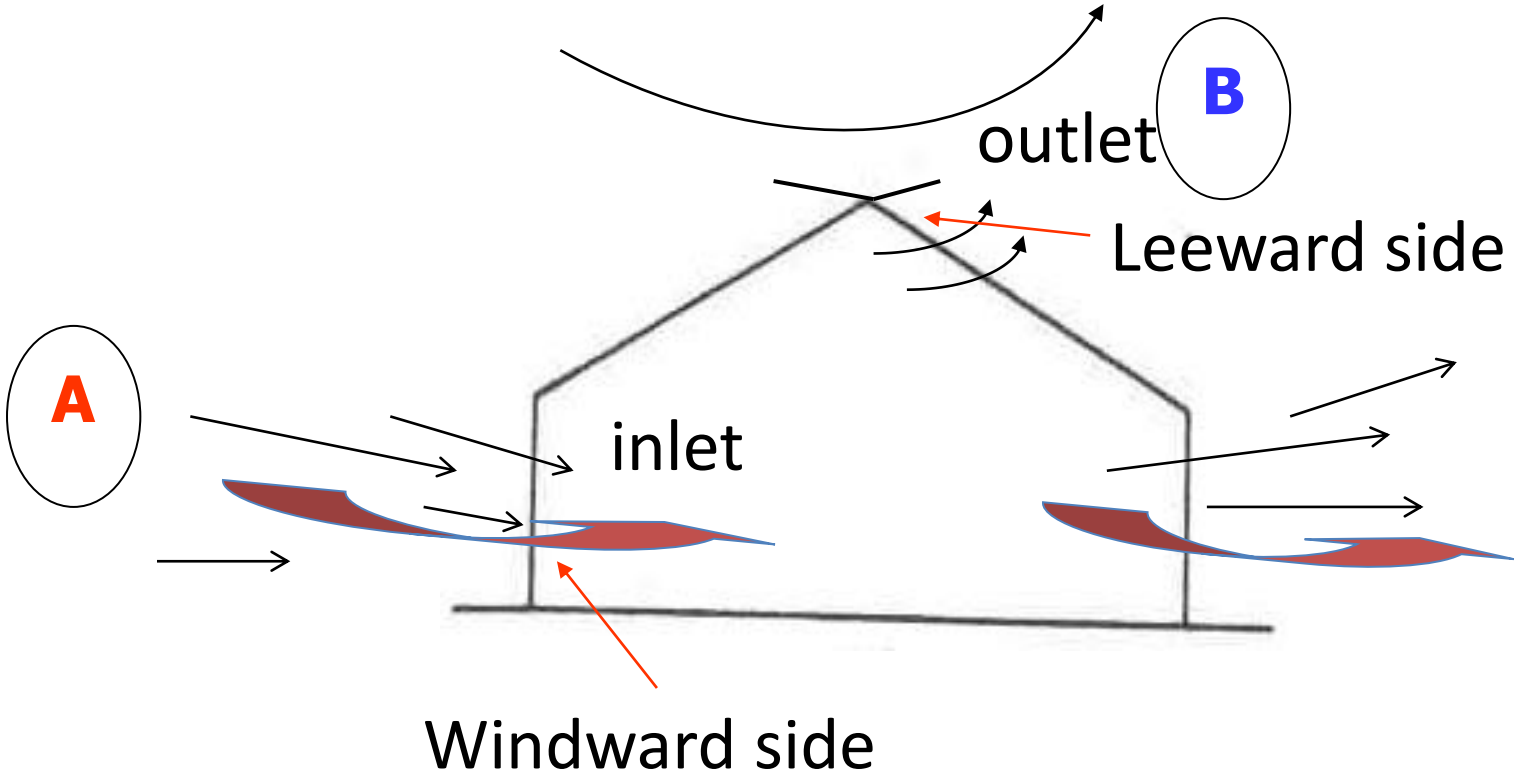

THE GREENHOUSE EFFECT
Visible energy from the sun passes through the glass and heats the ground
Infra-red heat energy from the ground is partly reflected by the glass, and some is trapped inside the greenhouse
The Met Office
Hadley Centre for Climate Prediction and Research

Greenhouse cooling

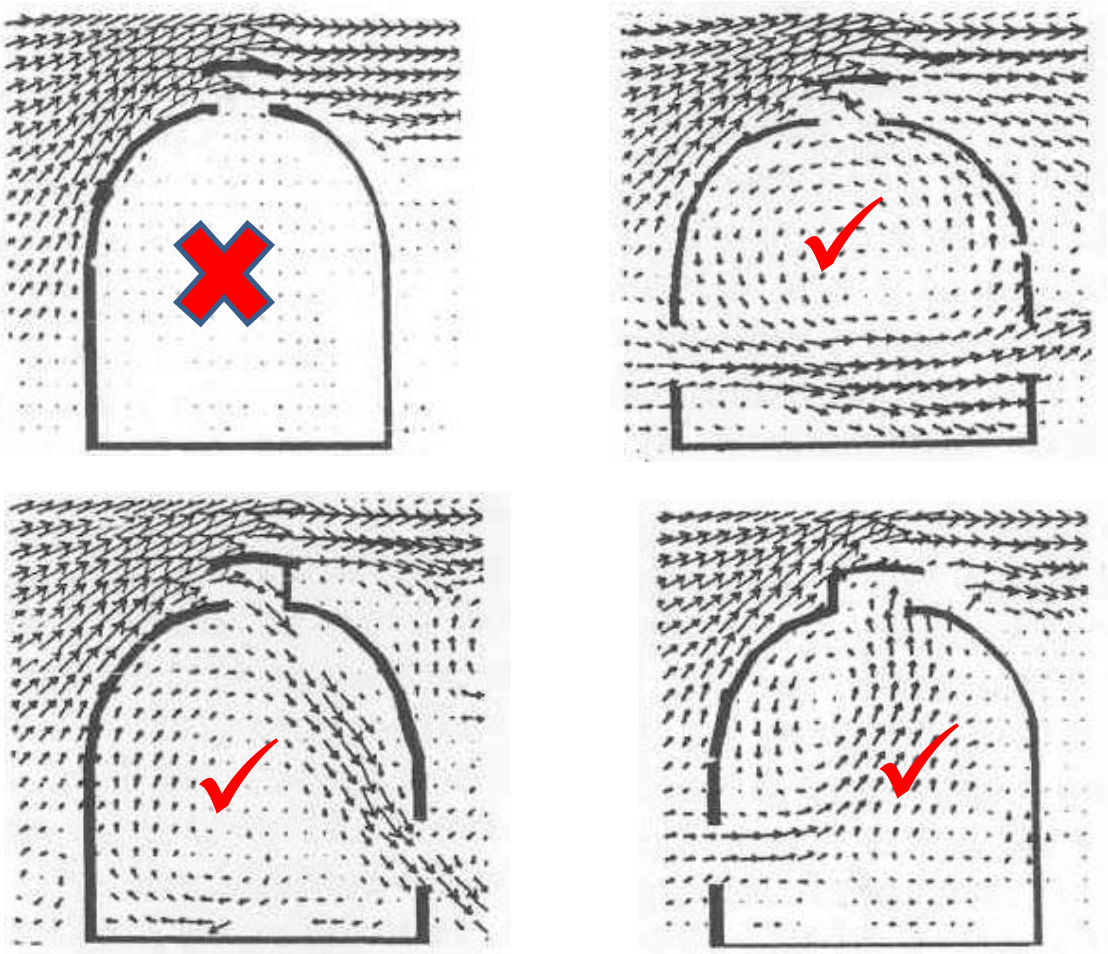
1. Natural method
   - 1.1 Wind cooling
   - 1.2 Stack effect

2. Artificial method
   - 2.1 Evaporative cooling system
   - 2.2 Mist spray
   - 2.3 Shading
   - 2.4 fan cooling
   - 2.5 Plastic technolgy

Wind cooling



The inlet and outlet opening required for wind cooling greenhouse



Factors affecting wind cooling efficiency

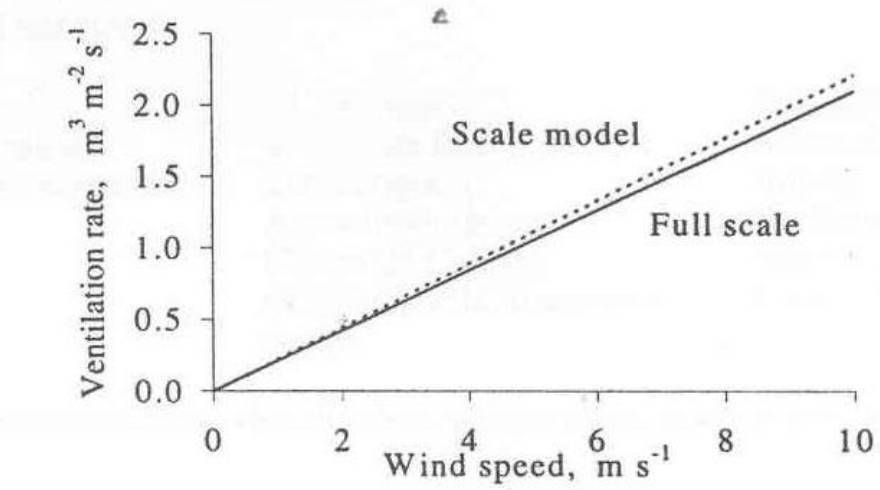
1. Wind speed
2. Wind direction
3. Ventilation area

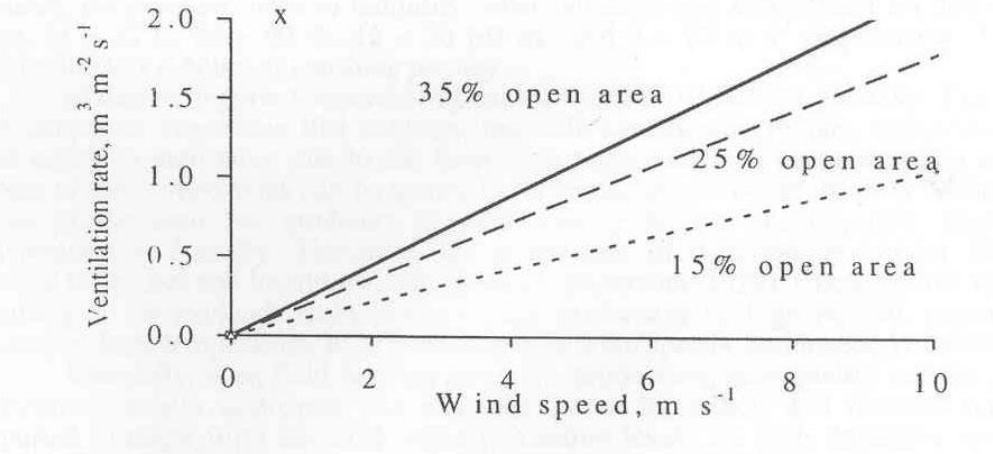
Vwind = K x A x V, where

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

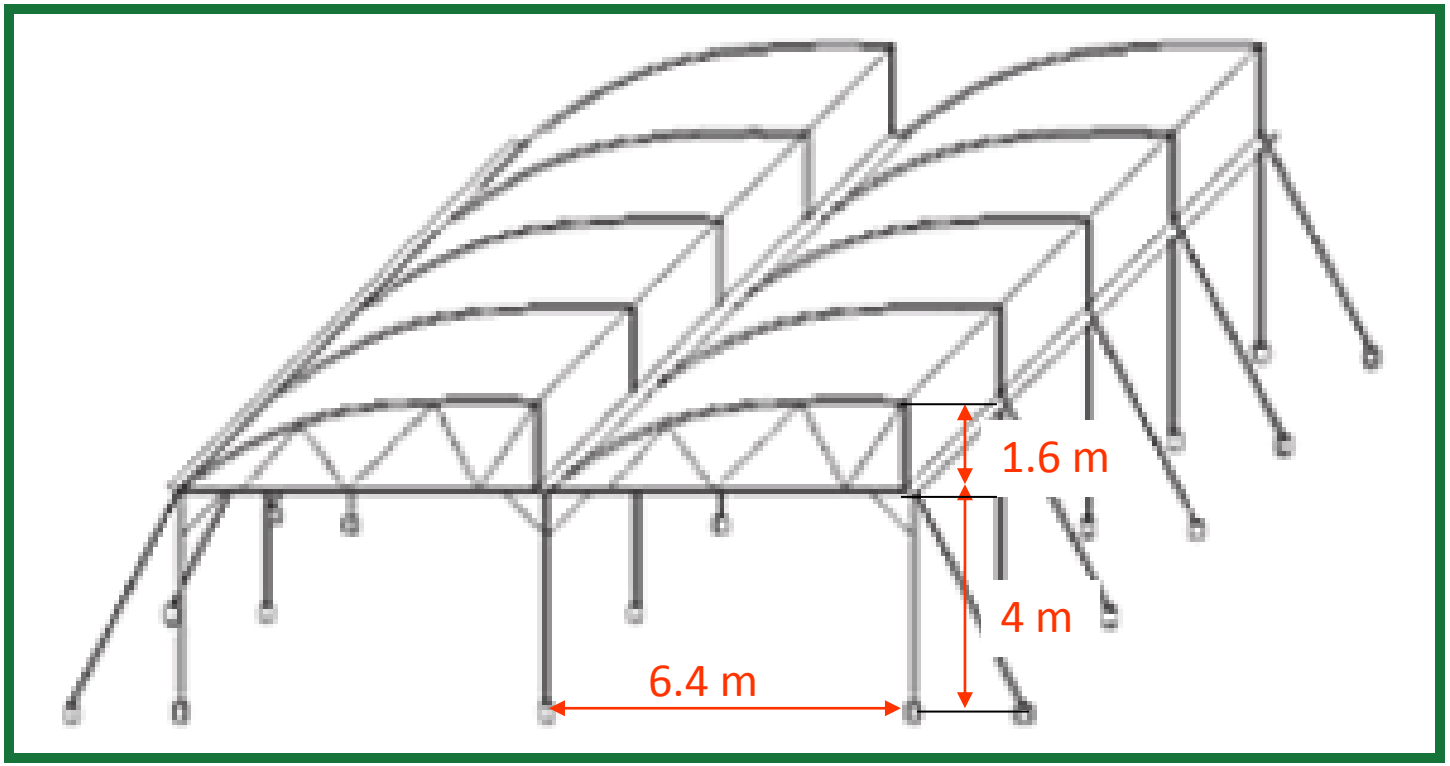
(Abright, L.D., 1990: Acta Hort. 578 ISHS 2002)

Effects of wind speed and vent area on ventilation rate





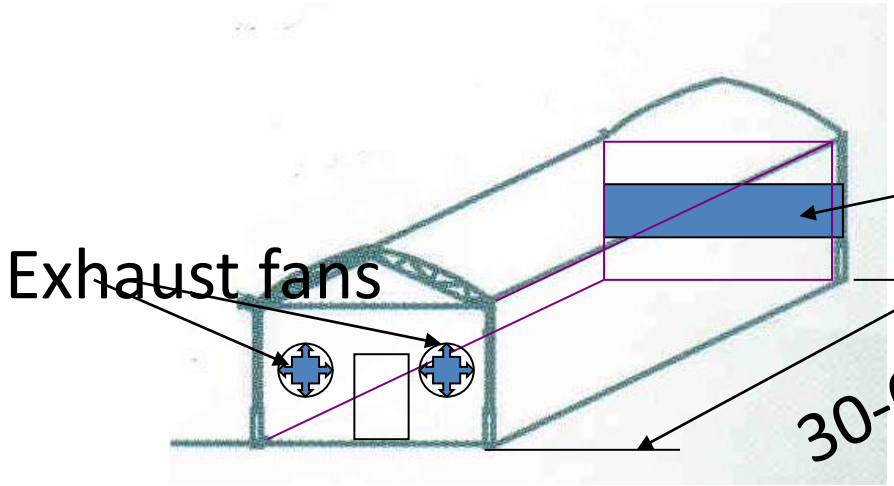
Saw-tooth greenhouse has a optimum ventilation for wind cooling

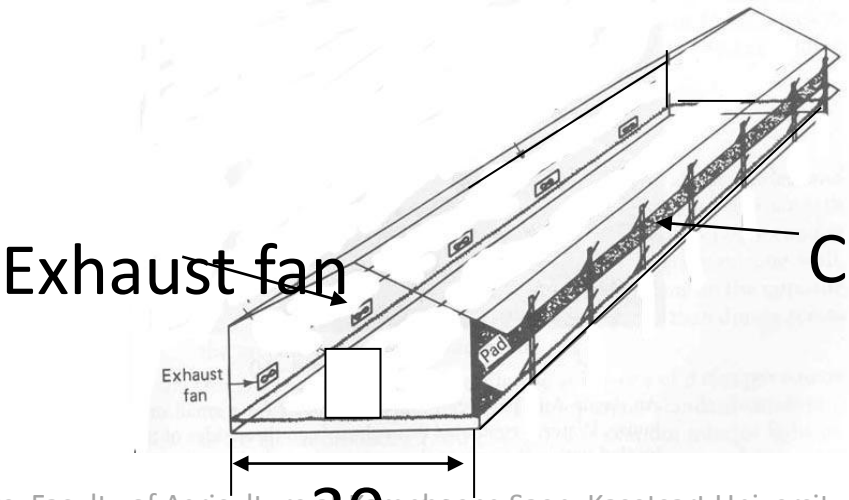


Roof ventilation ≈ 25% of surface area

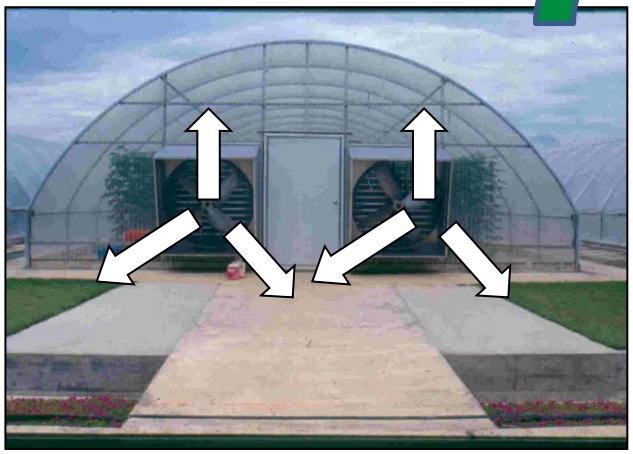
Evaporative cooling system

Fan and Cooling pad

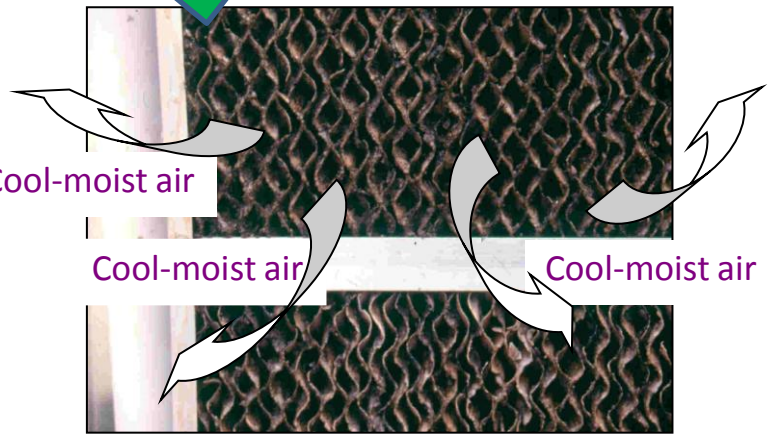




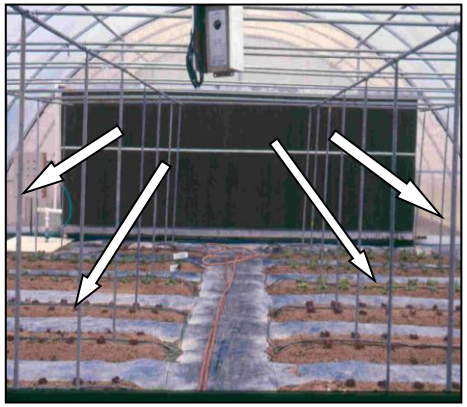
Evaporative cooling system



Exhausted fans pull air out of GH

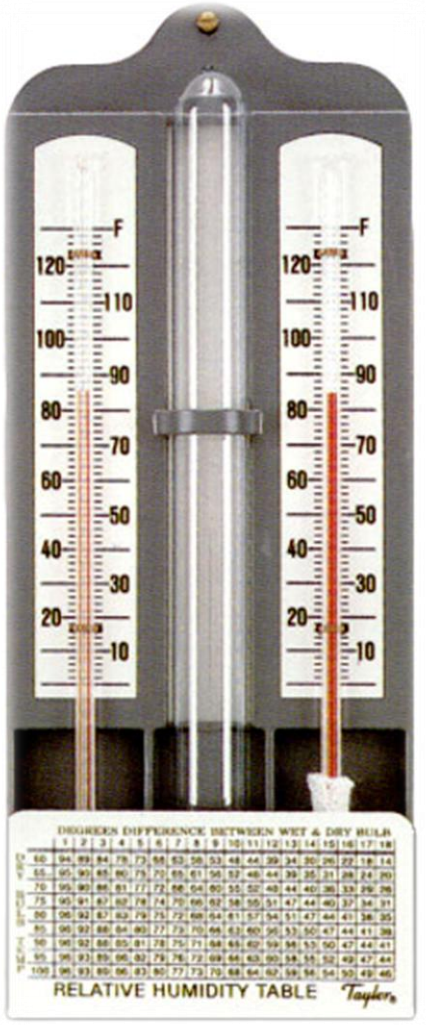


Warm air was pulled passing wet cooling pad, moisture evaporates by Using heat energy from air



Cooled air is pulled from pad end to fan end

Dry buld temp.

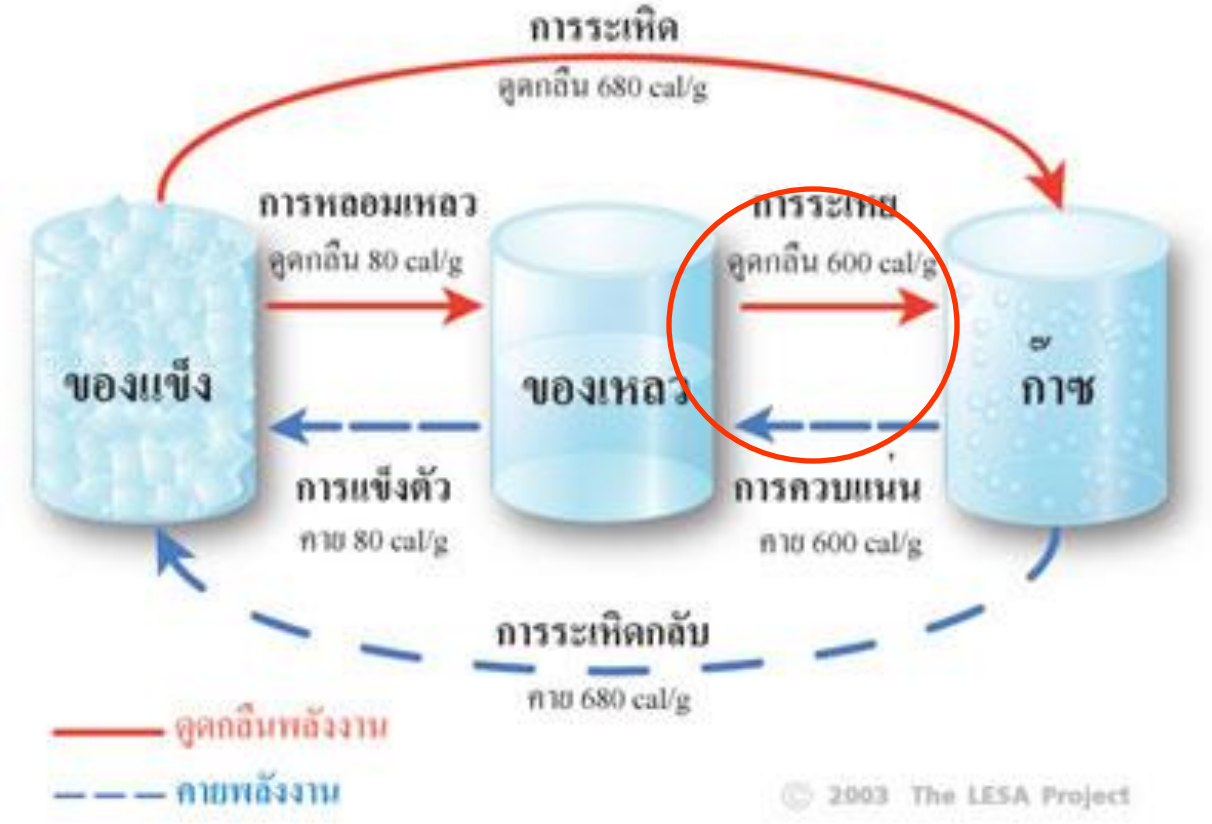


Wet-bulb temp.

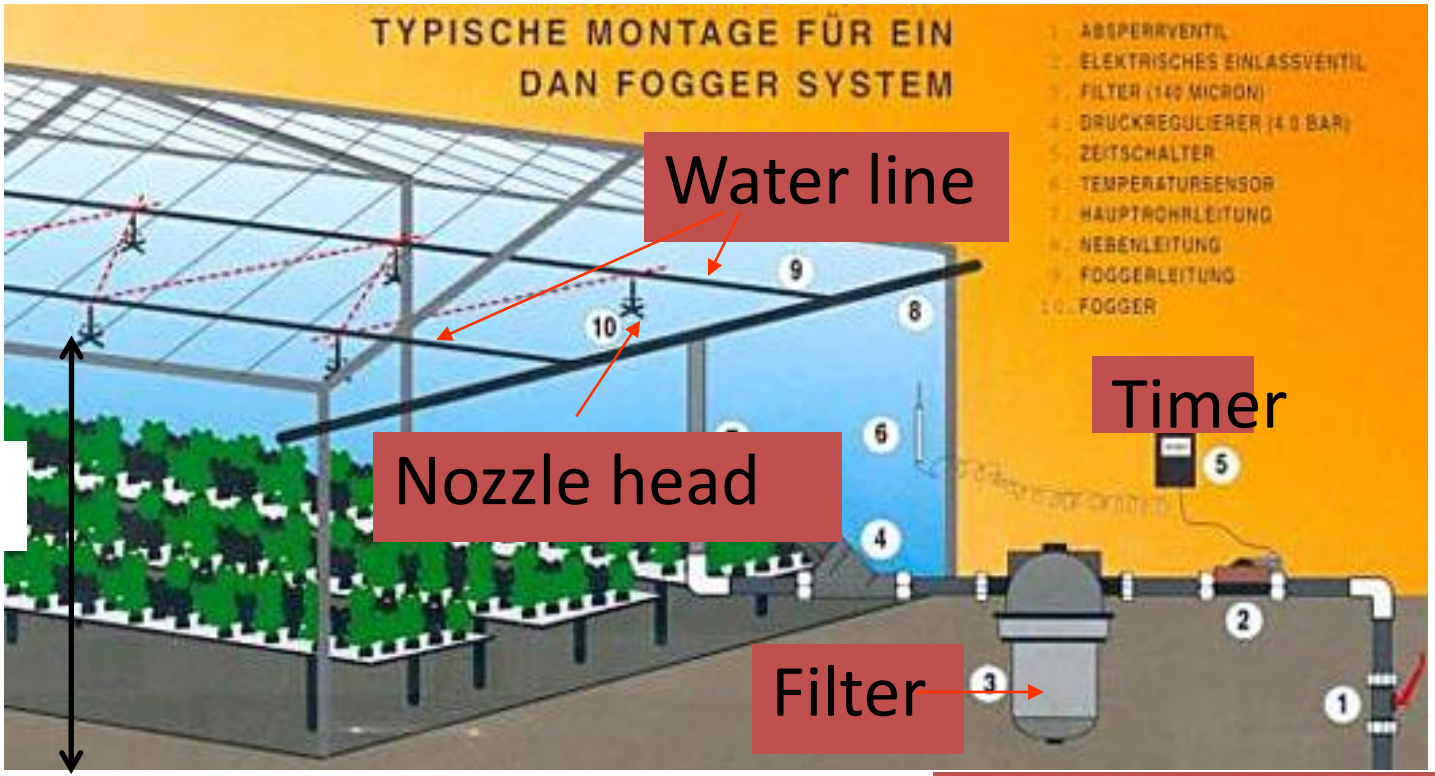
Efficiency of EVAP varies with RH%

Out-side GH			In-side GH	
Dry-bulb temp. (°C)	Wet-bulb temp. (°C)	RH (%)	Dry-bulb temp (°C)	Wet-bulb temp (°C)
35	26	50	28	87
35	29	65	30	92
35	32	80	32	93

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

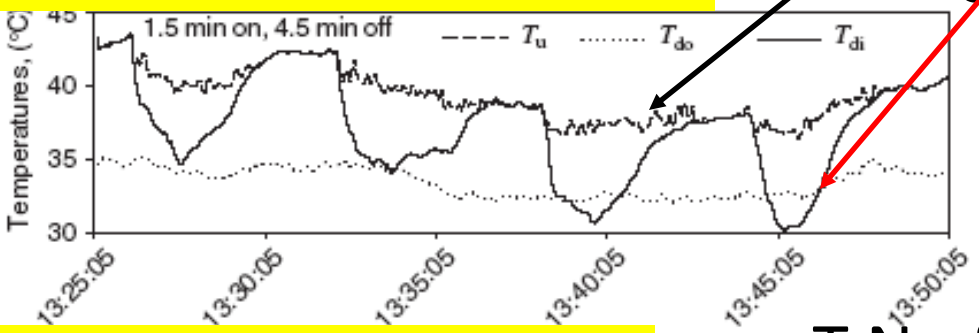
Fog components



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

Short-spray and high frequency spraying is better

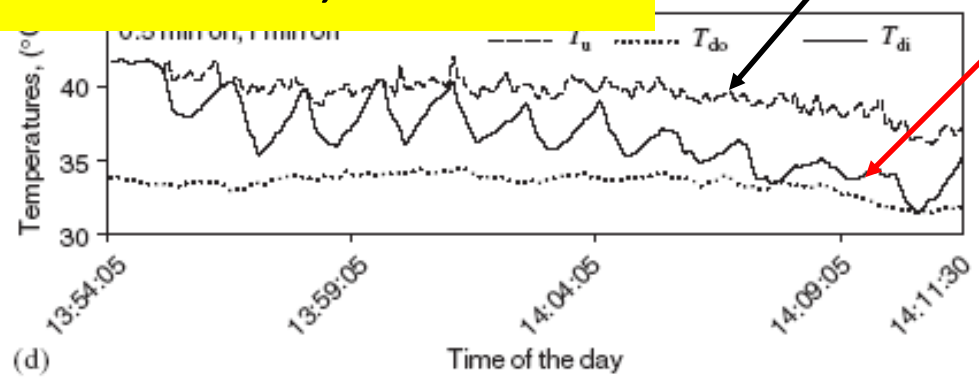
A) 1.5 min on, 4.5 min off



No fog

fogging

B) 0.5 min on, 1 min off



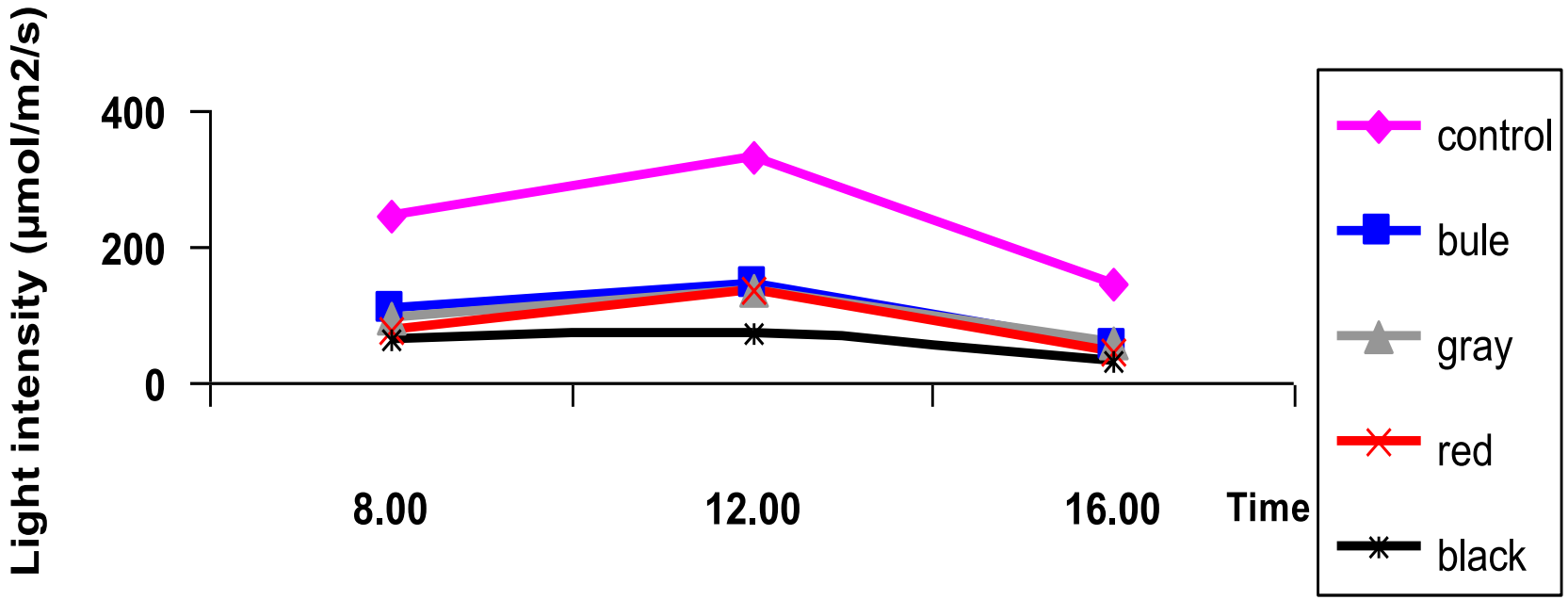
T No fog

T fogging

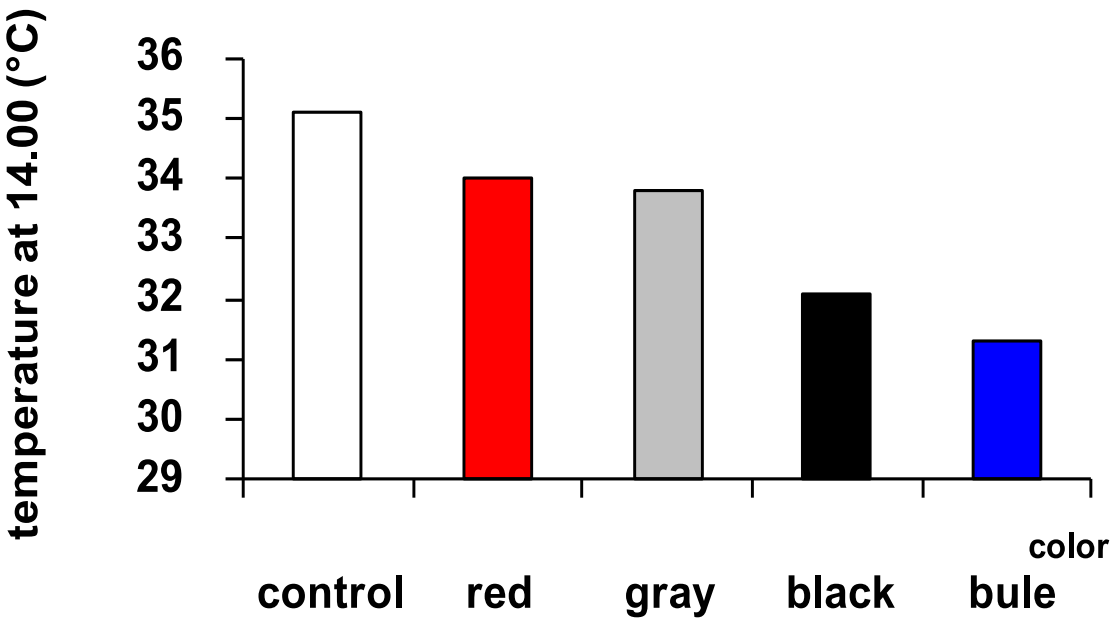
Light air movement during fogging is required

Light shading by a screen

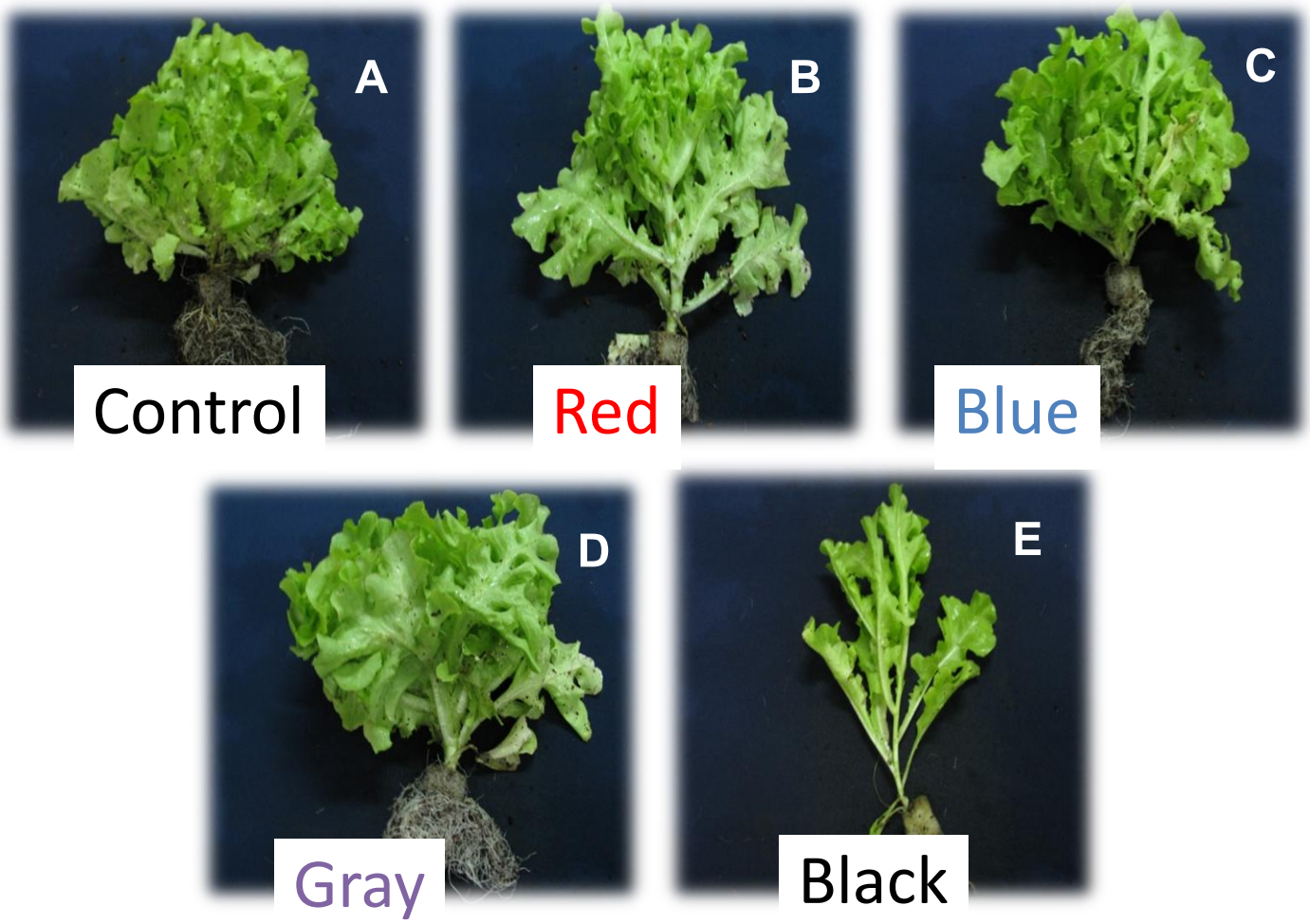
Effect of net color on light, temp and growth of lettuce


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



Greenhouse crop growing method

- Soil Culture
  - With fertigation technique
- Soilless Culture
  - With hydroponic technique
  - With substrate culture technique
  - With aeroponic technique

Soil growing with fertigation system

Deep Flow Technique

Nutrient Film Technique

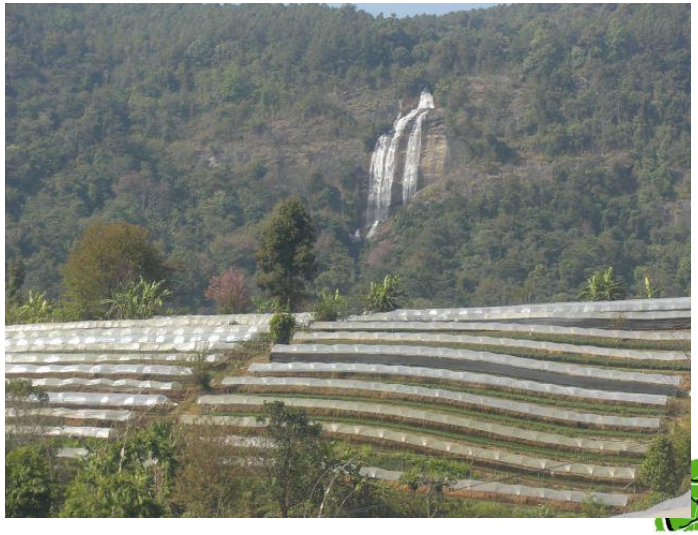
Rockwool culture

Cocopeat culture

Aeroponics

Greenhouse crop production of hill-tribe farmers under the Royal Project, Thailand

- The introduction of crop production can replace opium growing.
- The crop production under greenhouse allows year-round crop production and income.



Tomato can be grown all year-round under bamboo greenhouse by coco-coir husk substrate culture

Development of greenhouse structure of hill-tribe farmers

Bamboo-frame greenhouse

Galvanized frame greenhouse

Greenhouse sweet pepper grown under contract farming

Quality grading and packaging for export

Cherry tomato grown by coco-coir dust culture

Lettuce grown by NFT system inside EVAP greenhouse

The uniform growth of lettuce grown by NFT system inside EVAP greenhouse

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

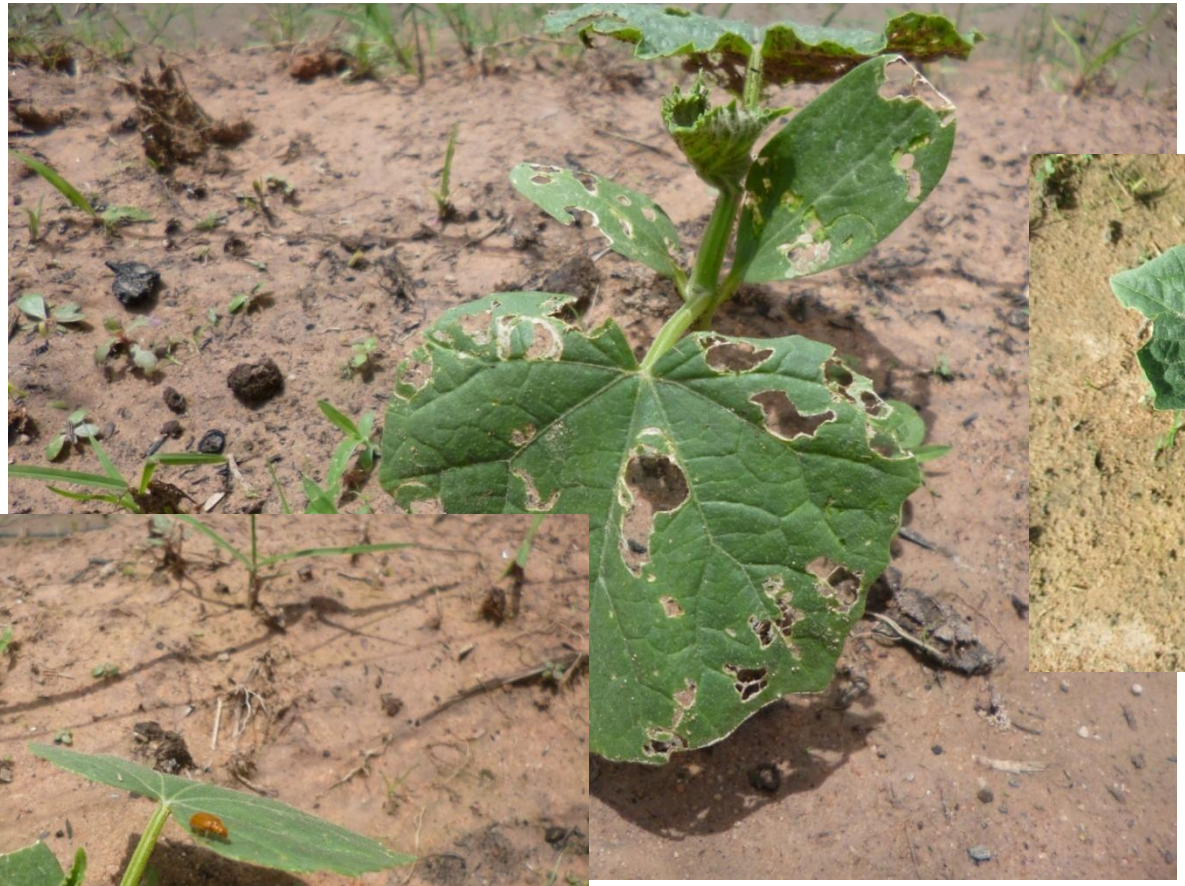
The introduction of low cost greenhouse at Siem Reap, Cambodia

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 nethouse

Cultural practice done in the day-time

Leafy vegetables was protected from insects inside the net-house

The pesticide-free vegetable was harvested

Choose wisely, live well.