Development Status of protected Vegetable and High-yield Cultivation Technology

JIANG, Wei-jie Professor, Ph D

Institute of Vegetables & Flowers,

Chinese Academy of Agri. Sciences
Beijing, China

Email:jiangweijie@caas.cn

Contents

1、Different type of protected vegetables

2、Technology of nutrient and water management

3、 Carbon dioxide (CO_2) enrichment

4、 Artificial lighting

5、 Soilless cultivation

Type of Protected Cultivation

- **Low tunnel, High tunnel (Plastic)**
- **Multi-span greenhouse（Plastic、Glass）**
- **Solar lean-to greenhouse, Energy saving solar-heated lean-to greenhouse (Plastic)**

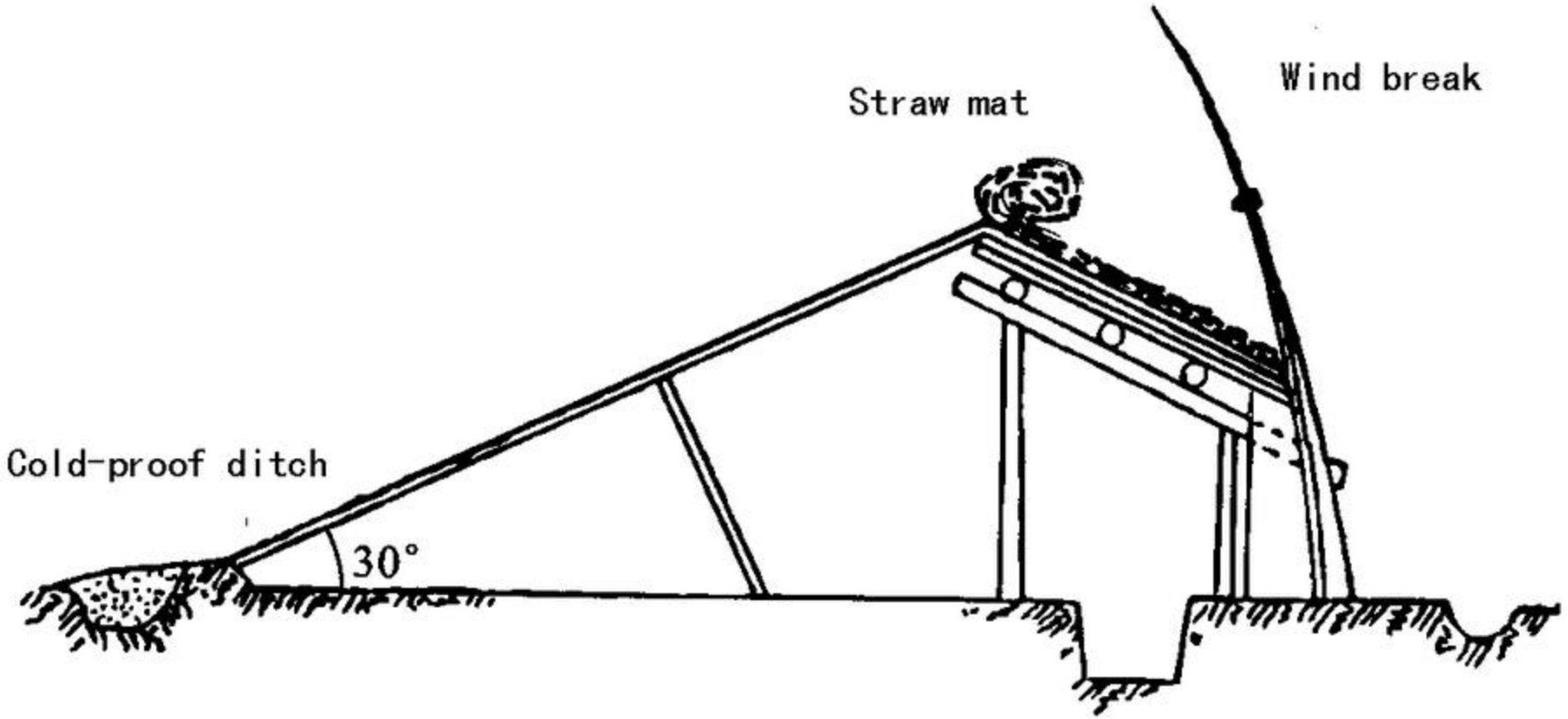
Soil covered with gravel, Very ancient type





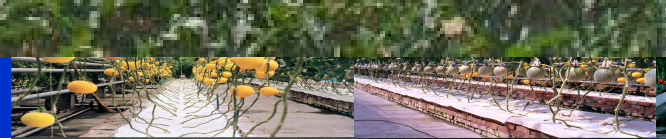
Softening cultivation

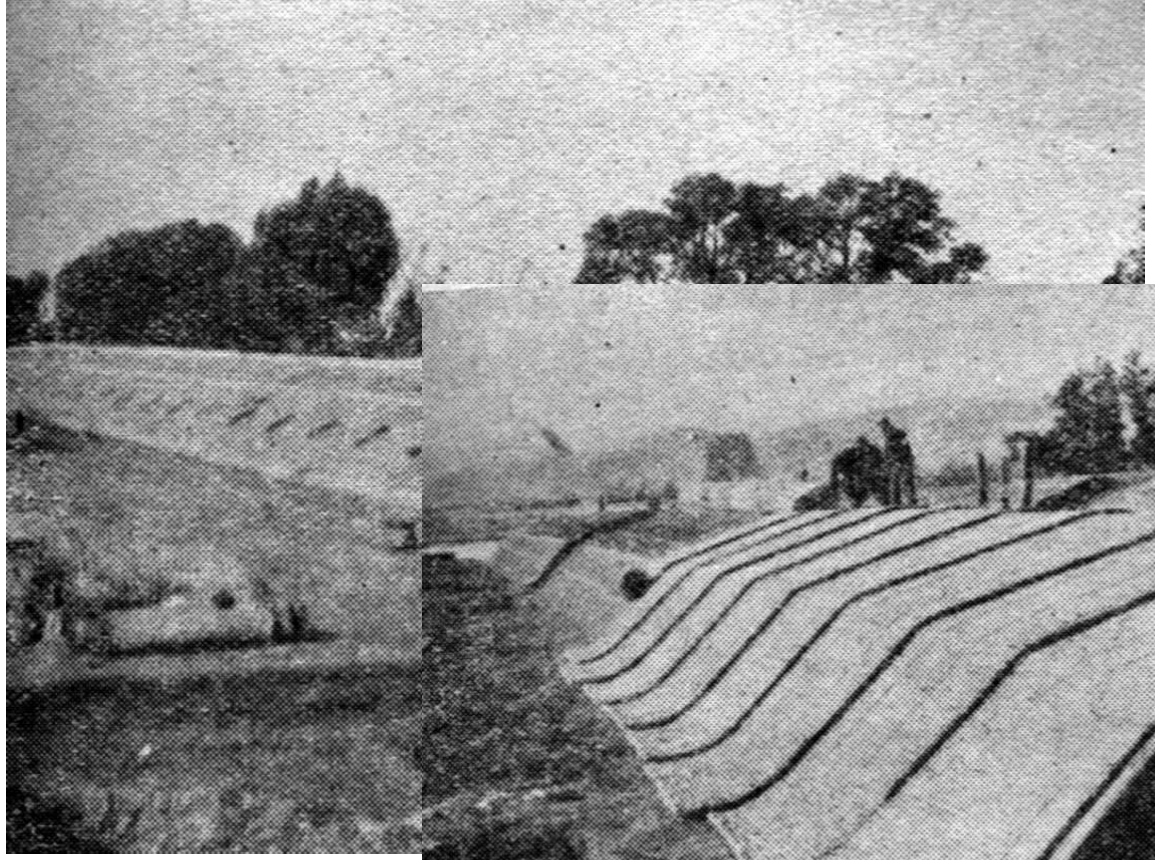
Yellow Chinese leek

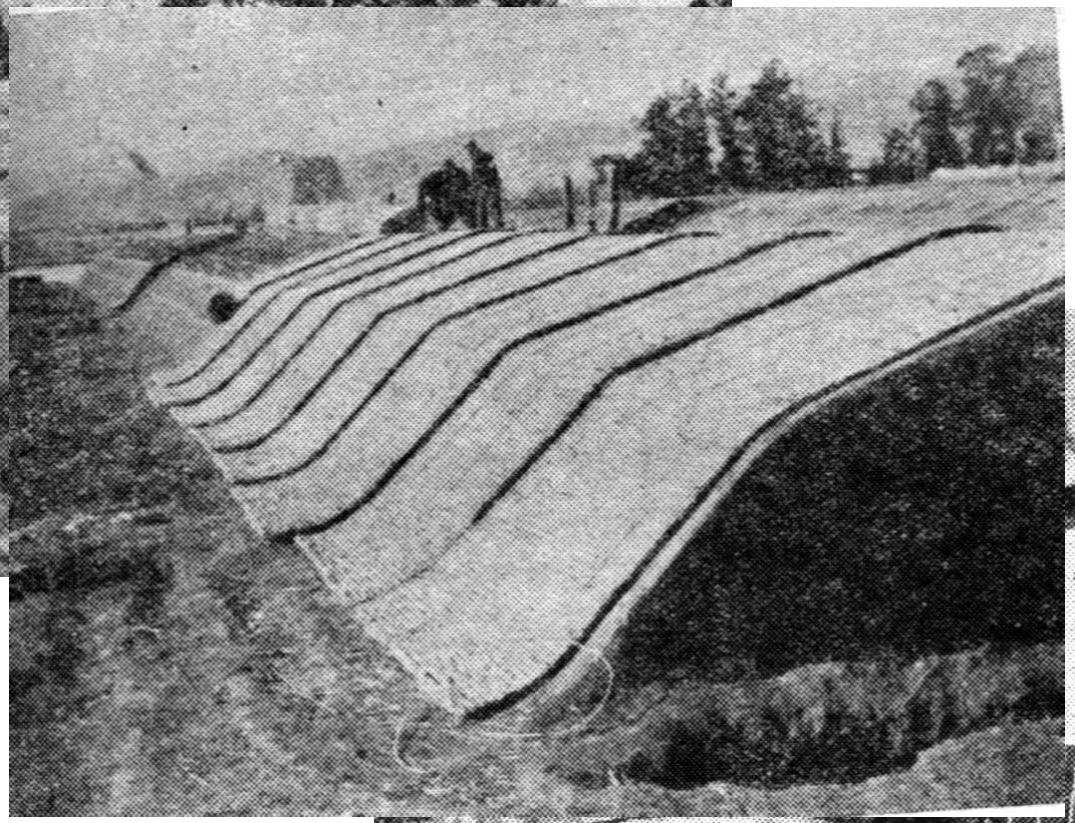


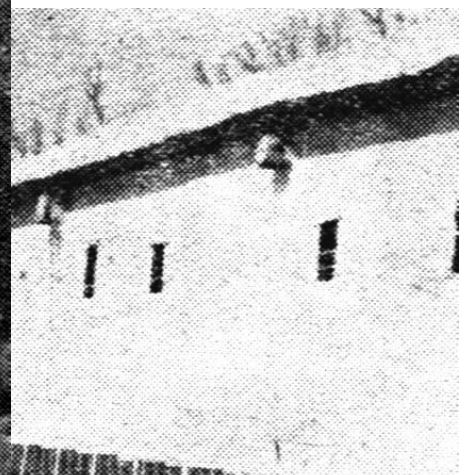
Old type of protected cultivation

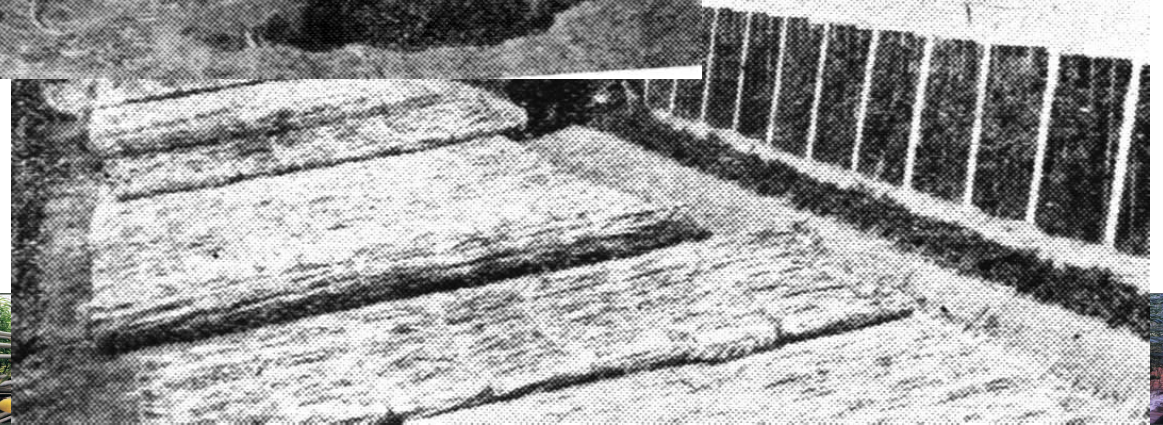


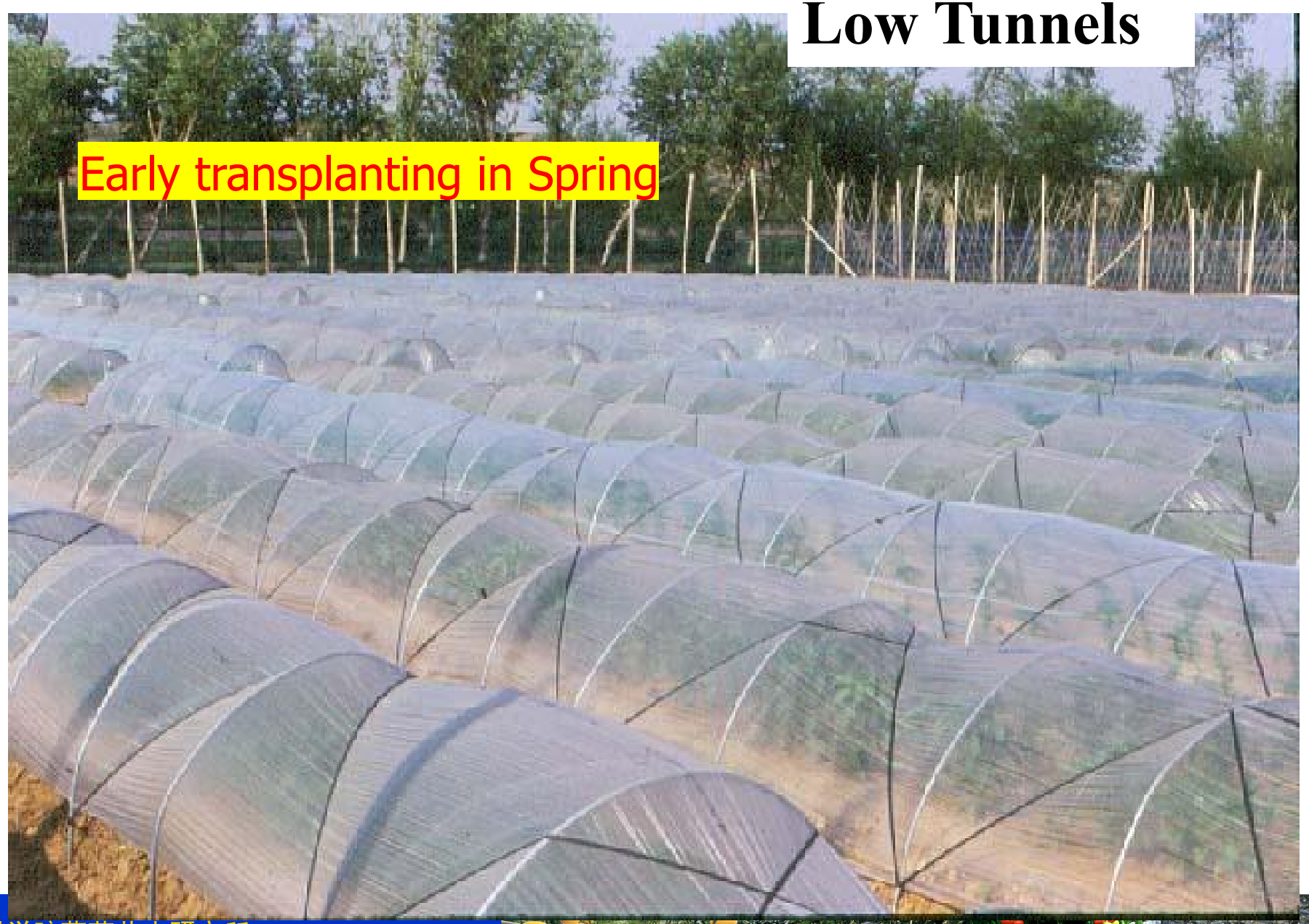





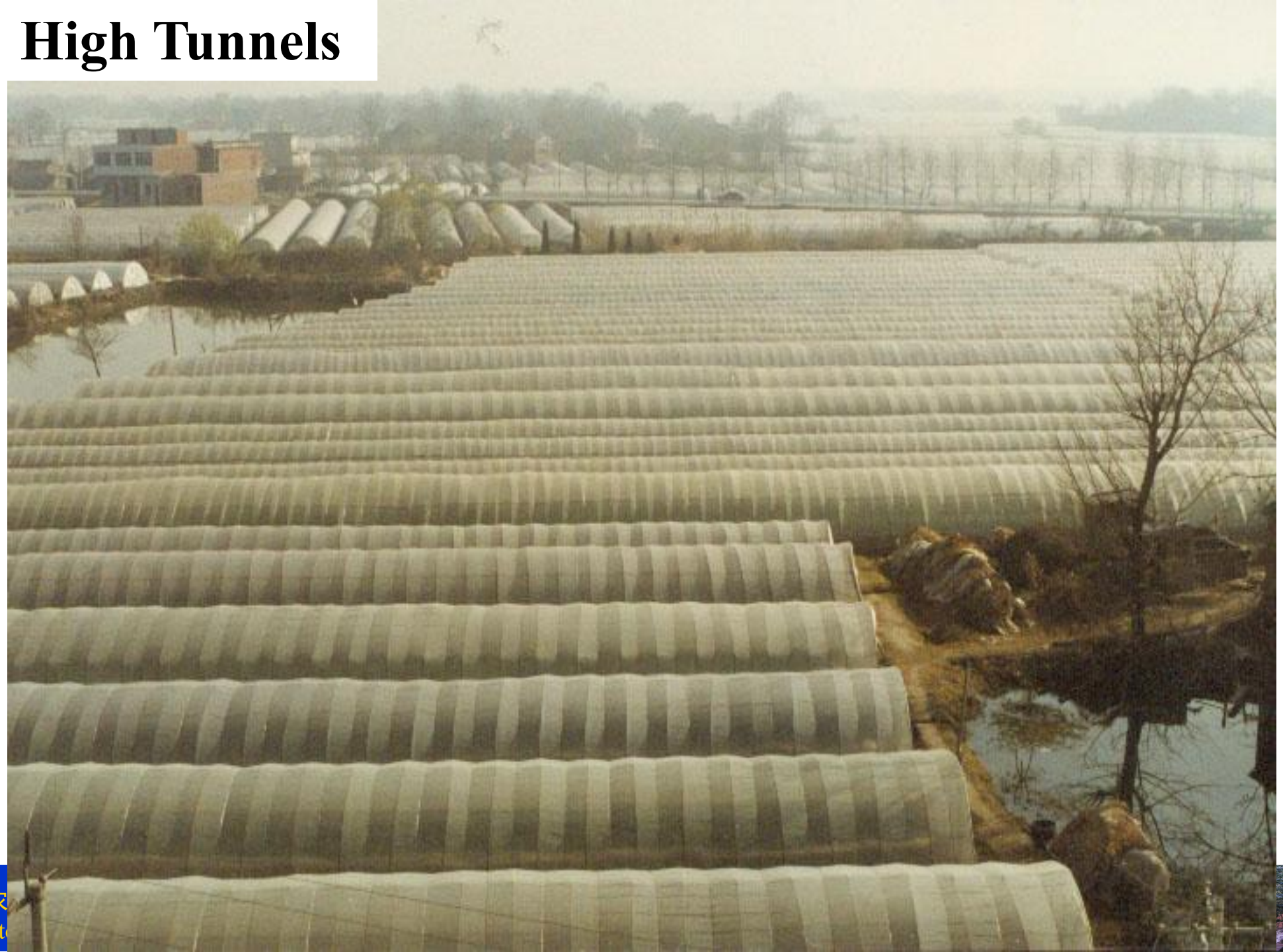




Low Tunnels

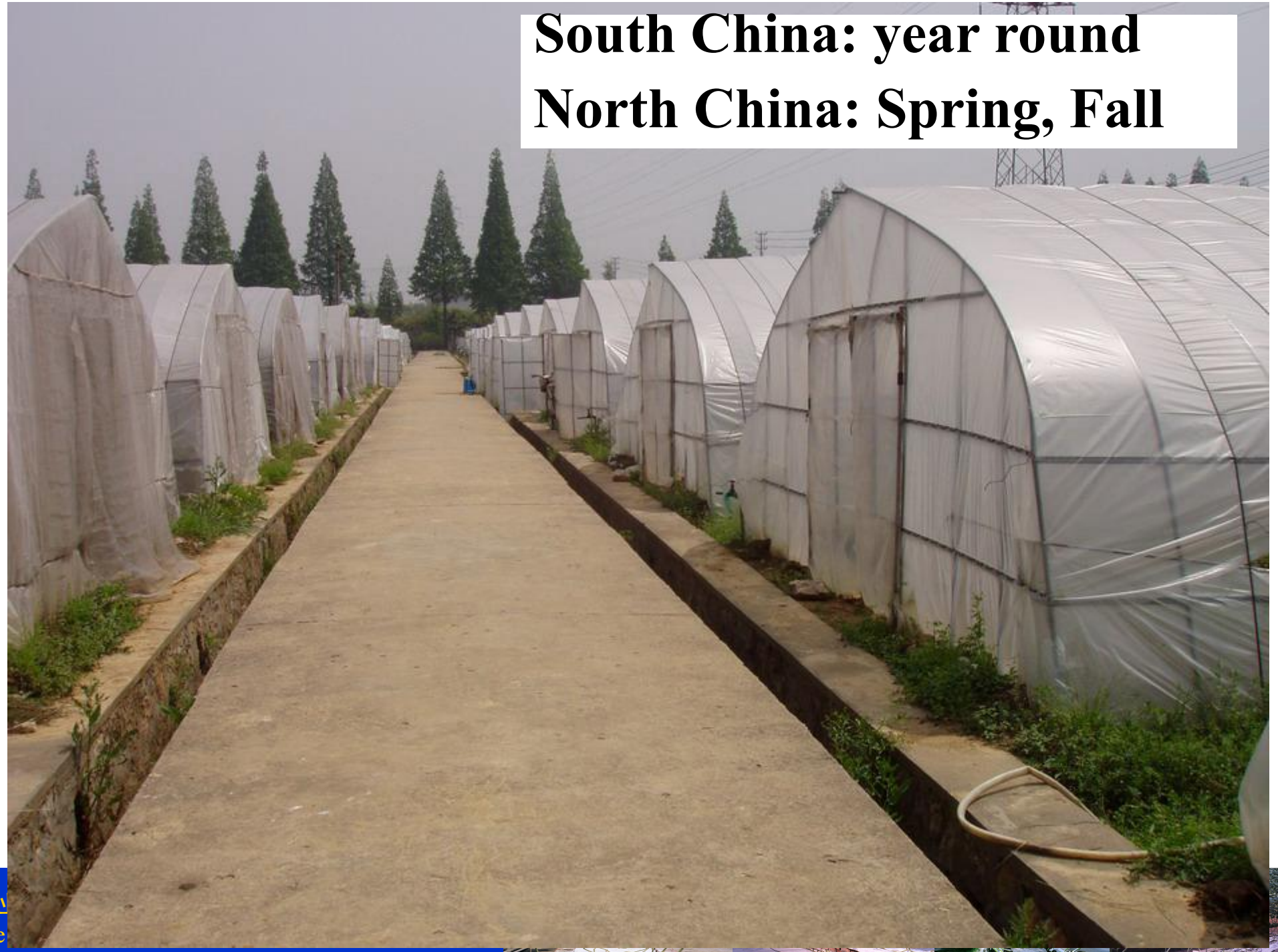


High Tunnels

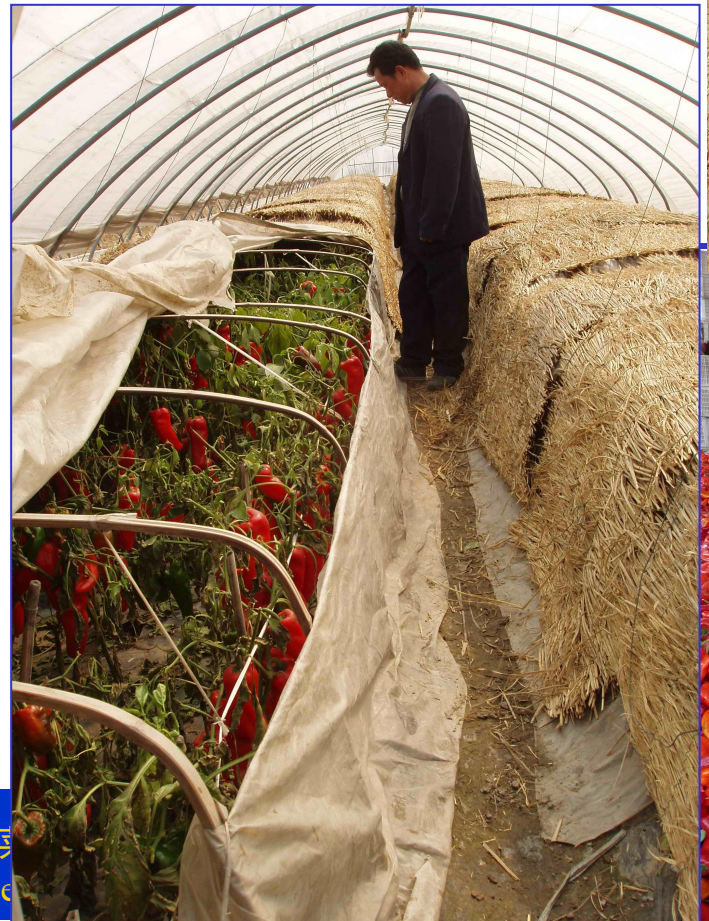


Tunnel Frames made by different materials


Melon


South China: year round
North China: Spring, Fall

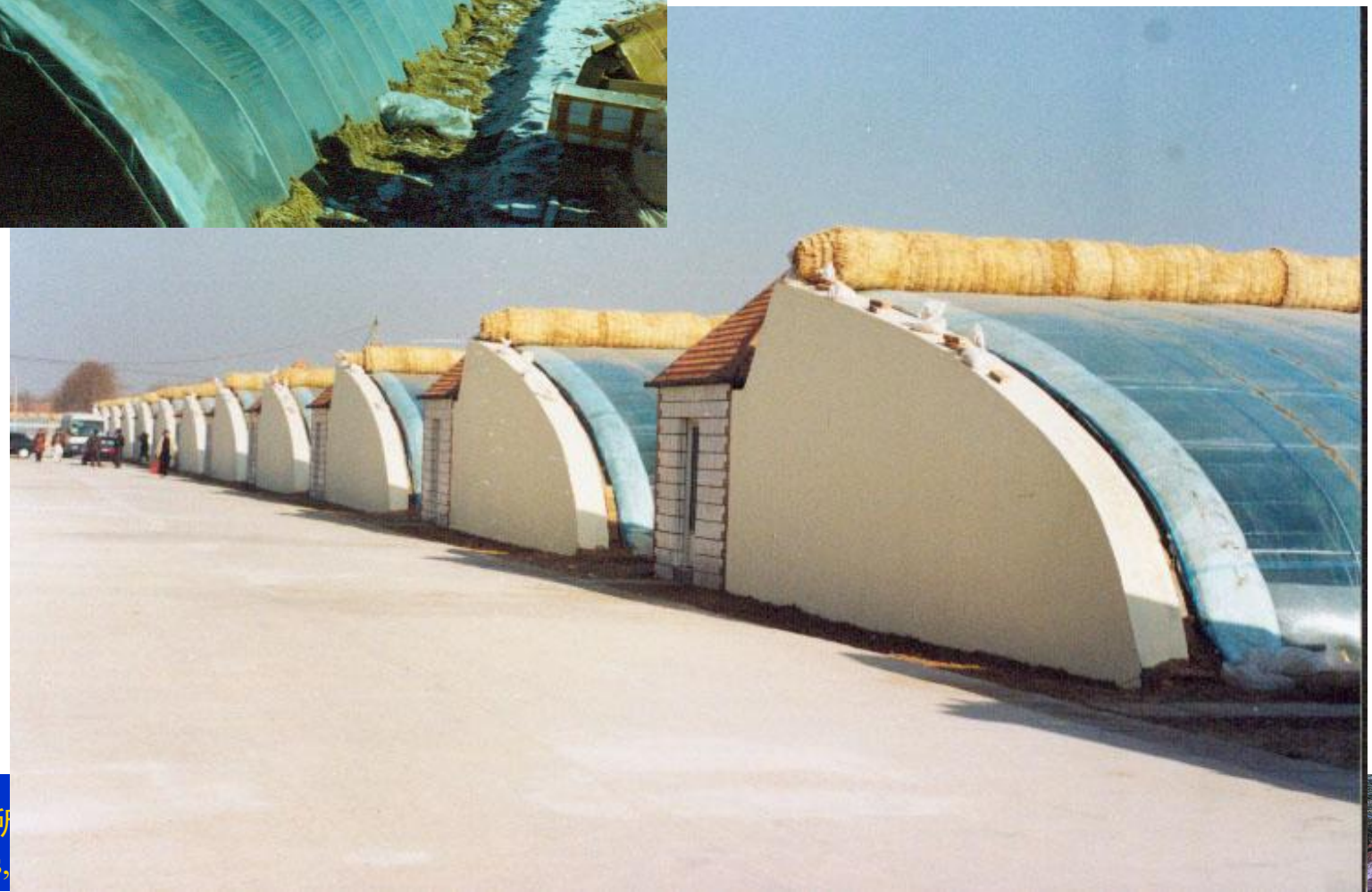
Multi-layer covers for hot pepper production



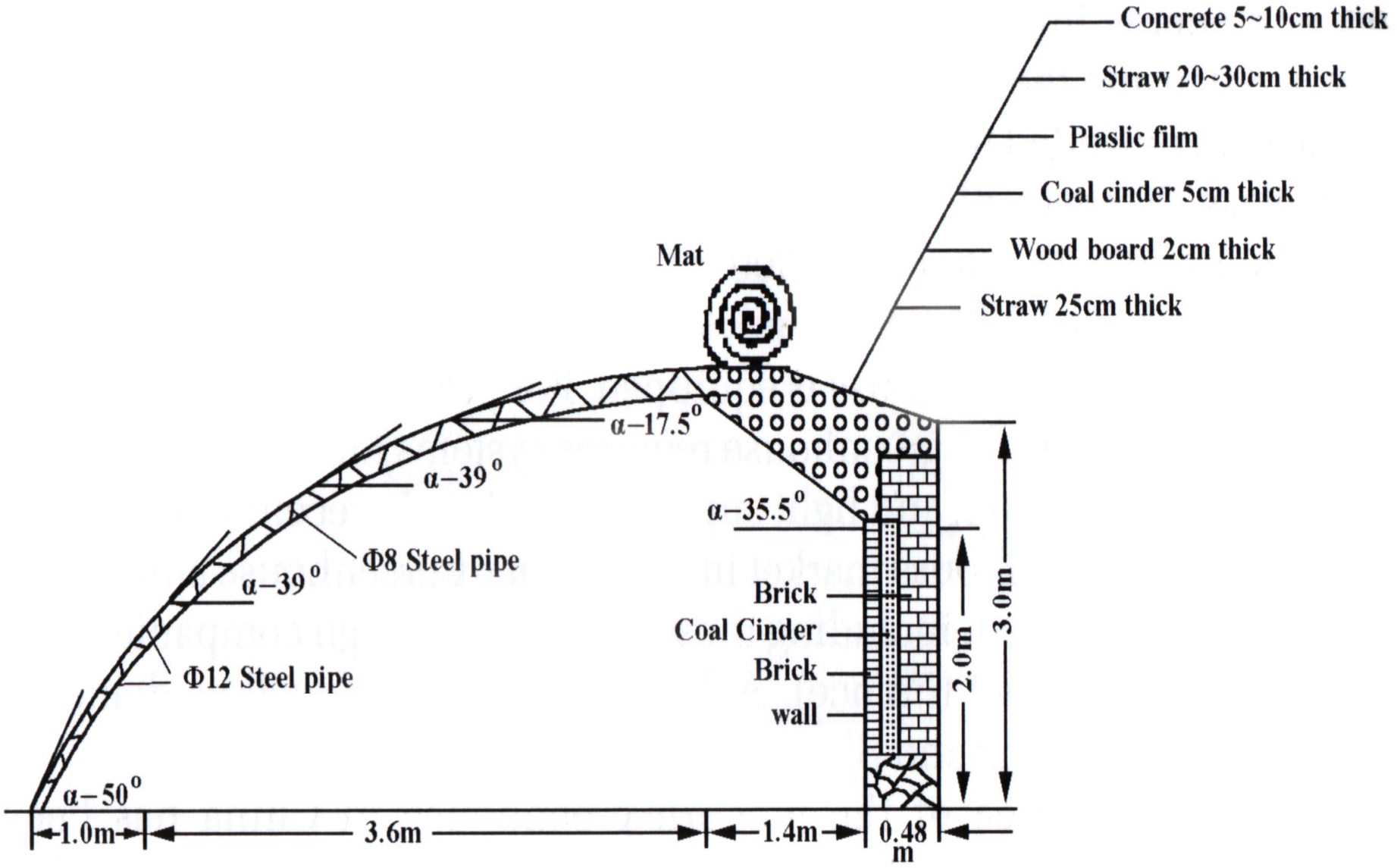
Rainproof cultivation

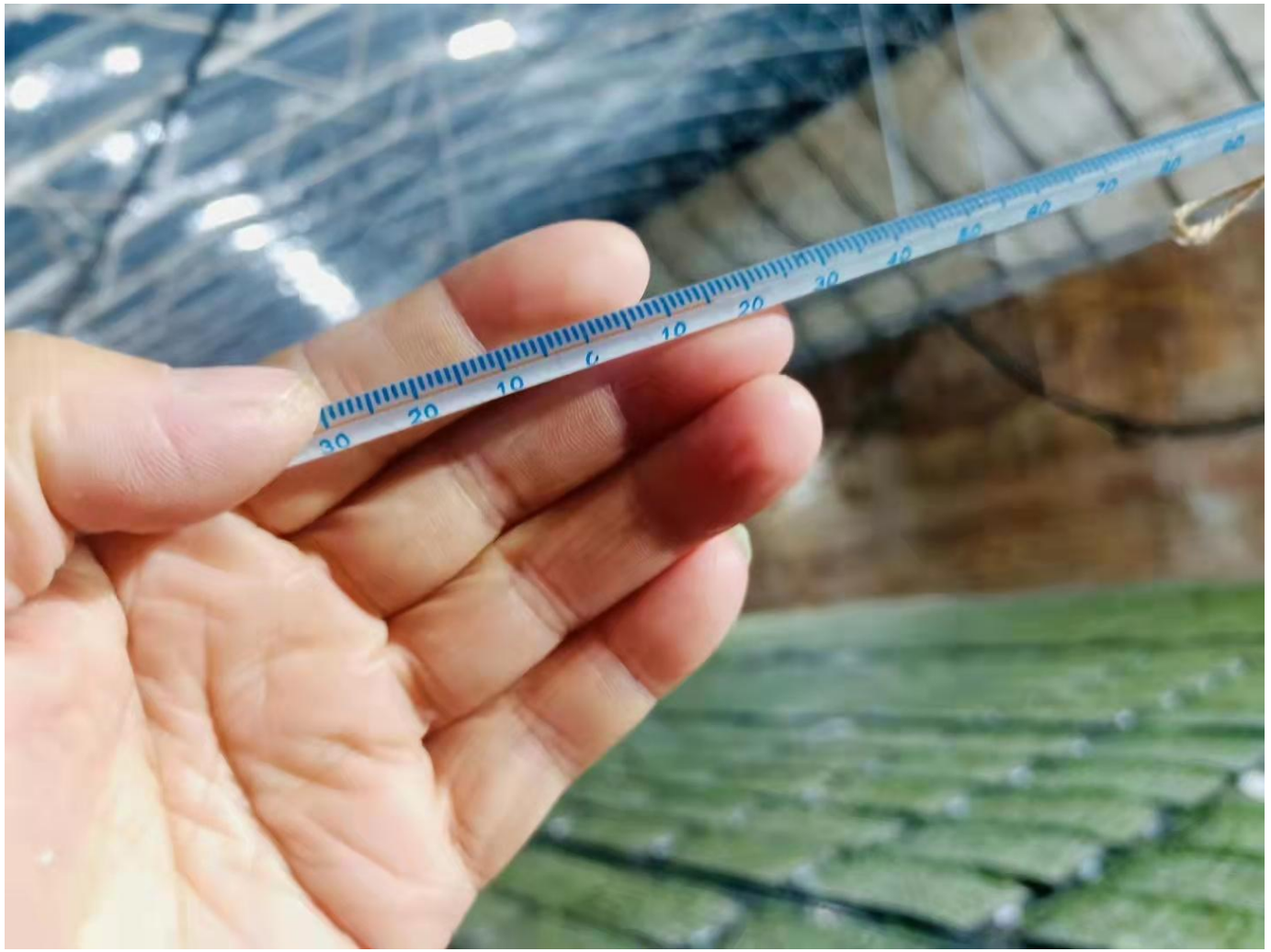
中国农
Institut

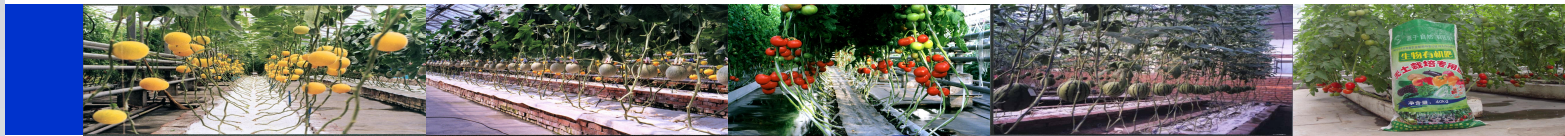
Solar-heated greenhouse



Basic structure of a typical energy-saving, greenhouse







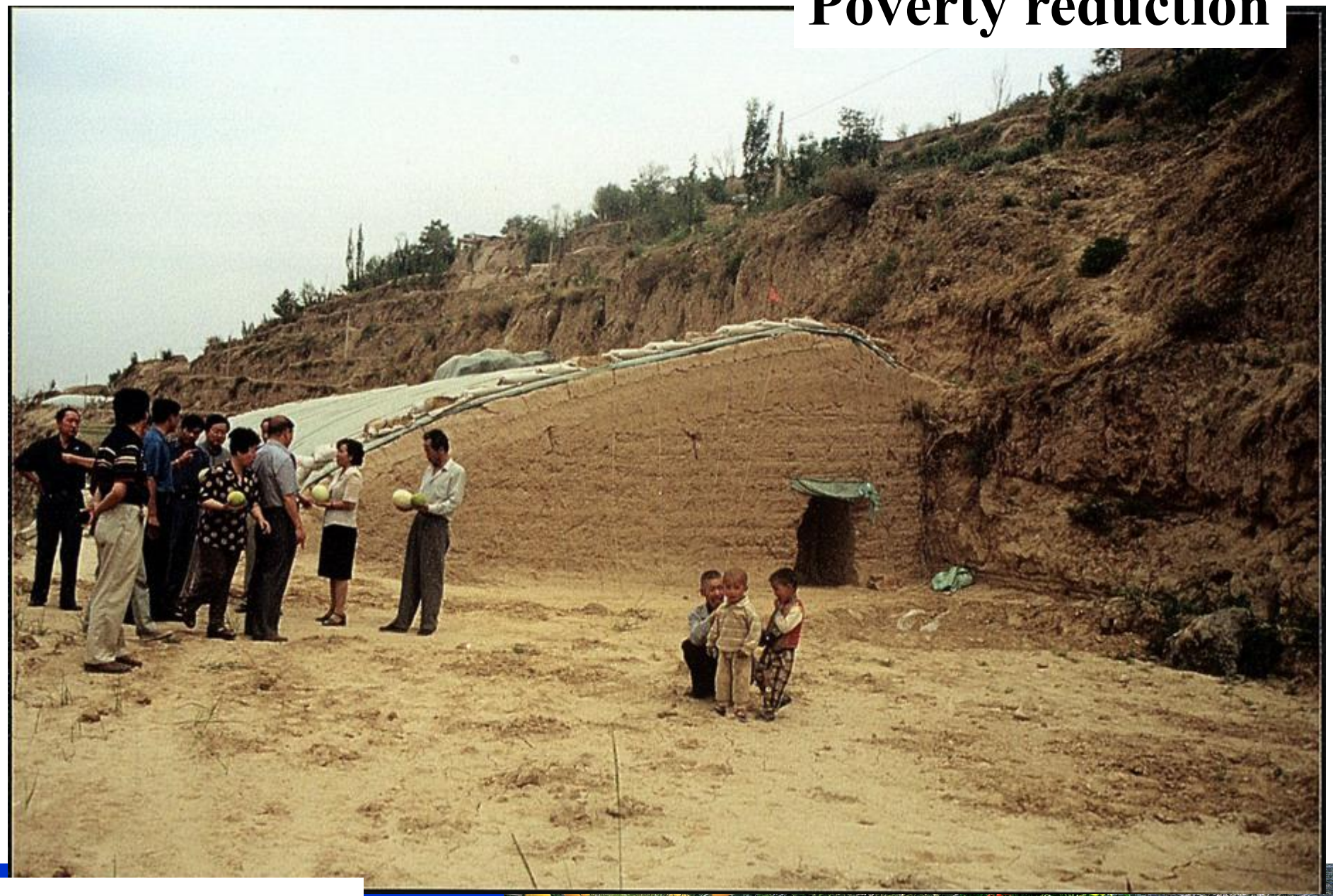

Small span

Large span


Straw mat

Remote area

Poverty reduction



Rain collection

Mushroom plus horticultural crops

日光温室群

Large area of solar heated greenhouse





辽宁朝阳丘陵山地温室

Greenhouse in mountain area

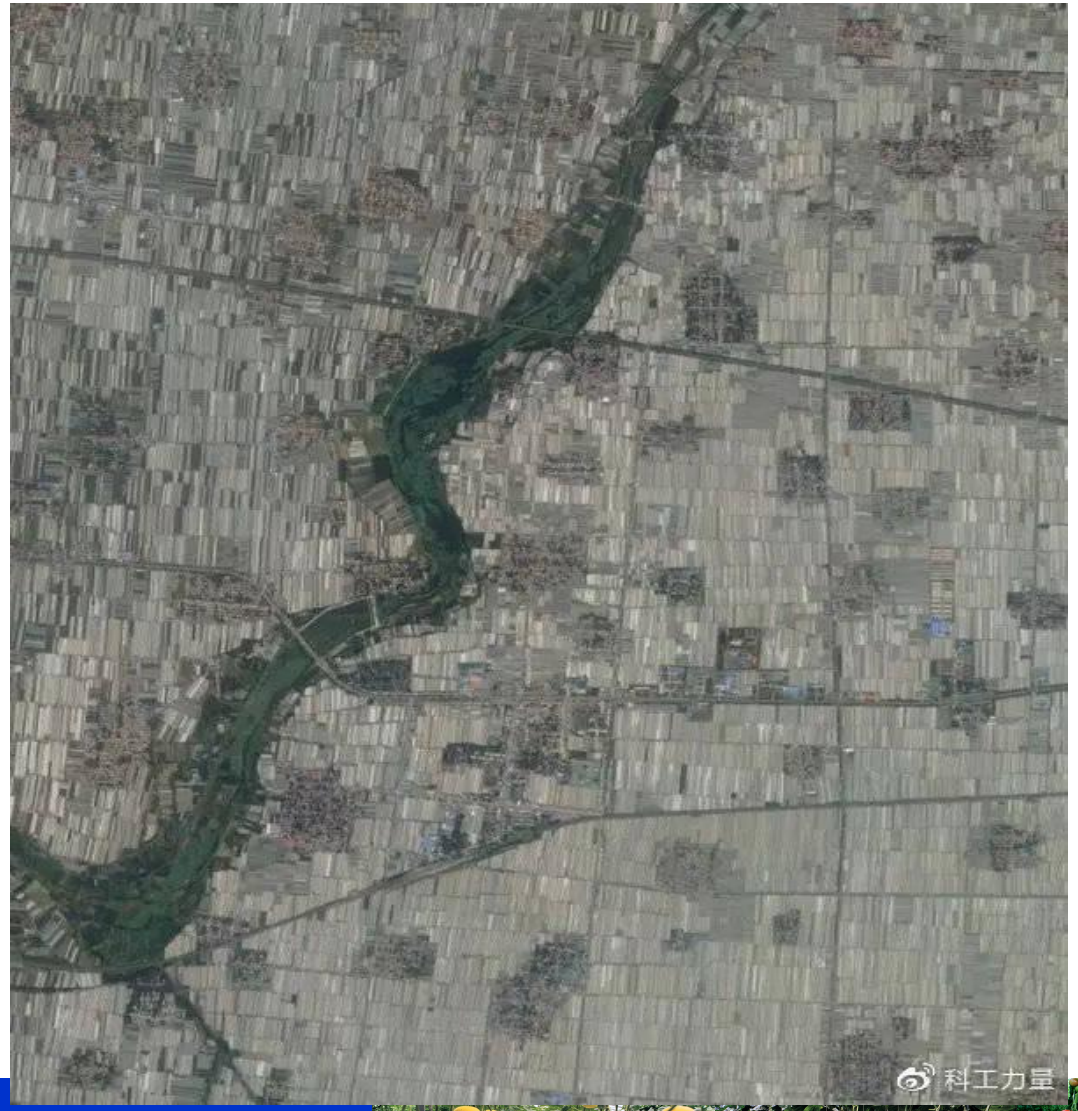
Greenhouse in desert area

宁夏沙漠温室


© 视觉中国
科工力量

Photo from satellite

Photo from satellite







Multi-span greenhouse

High production cost

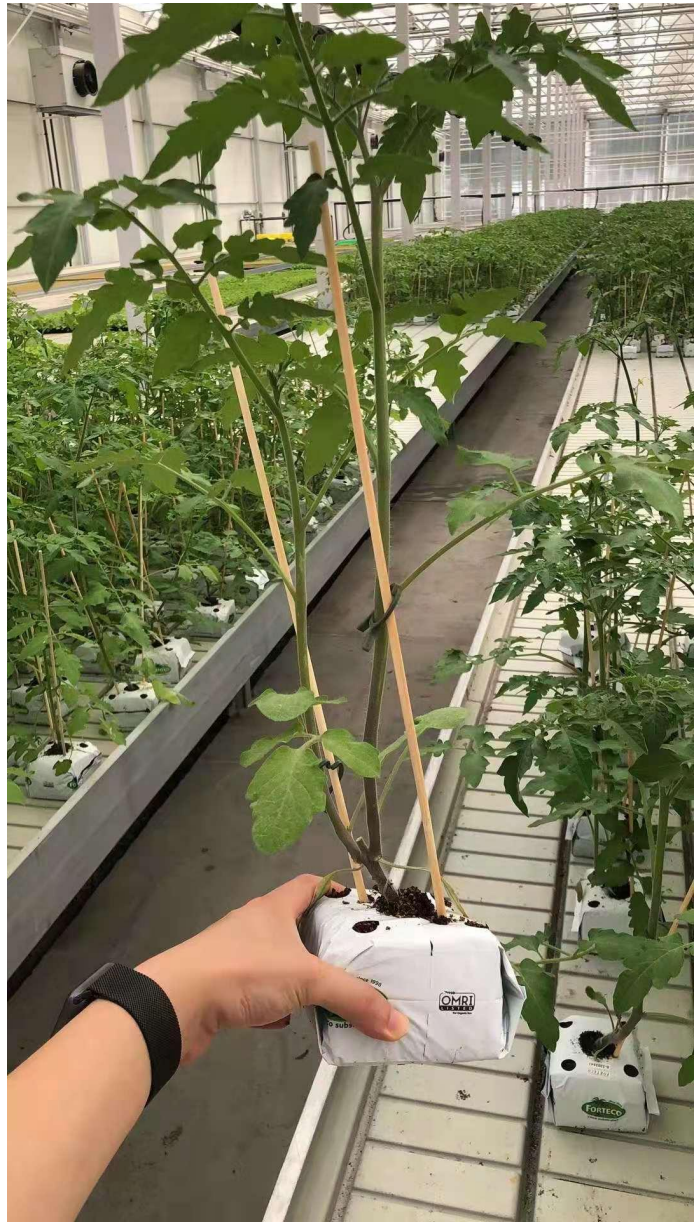
Multi-layer of thermal screen

Heating system

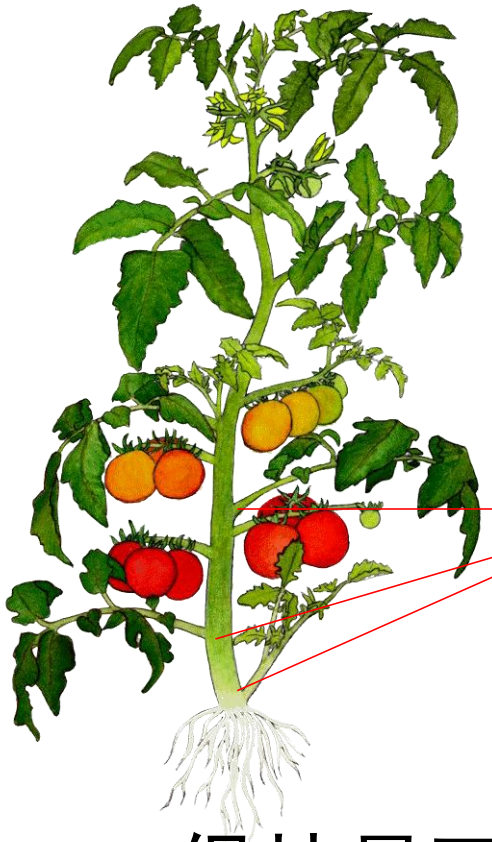
Water heating system

In recent three years, Giant companies are interested in investing and operating greenhouse vegetable production

Raise big seedlings



Remove elder leaves



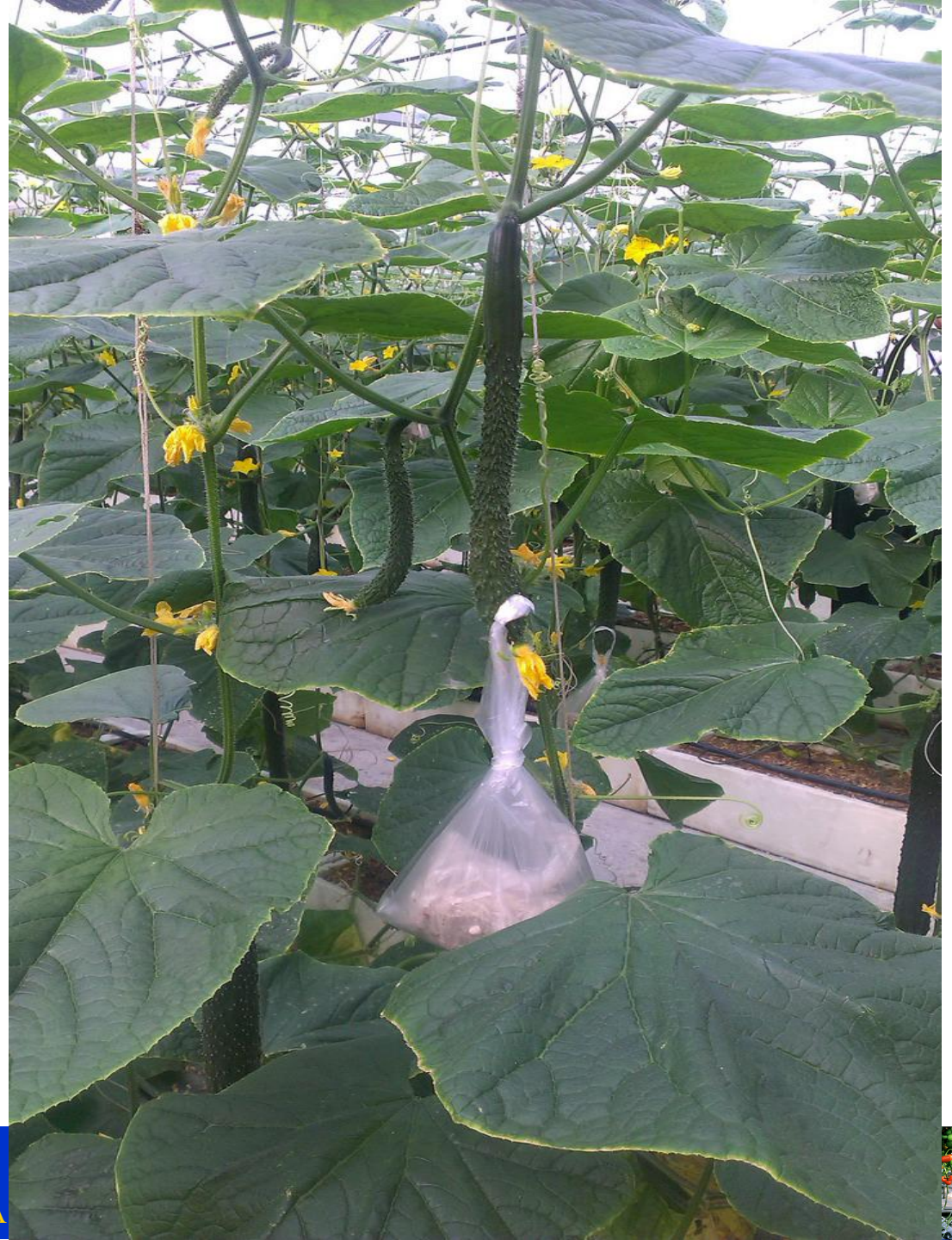
打掉的叶

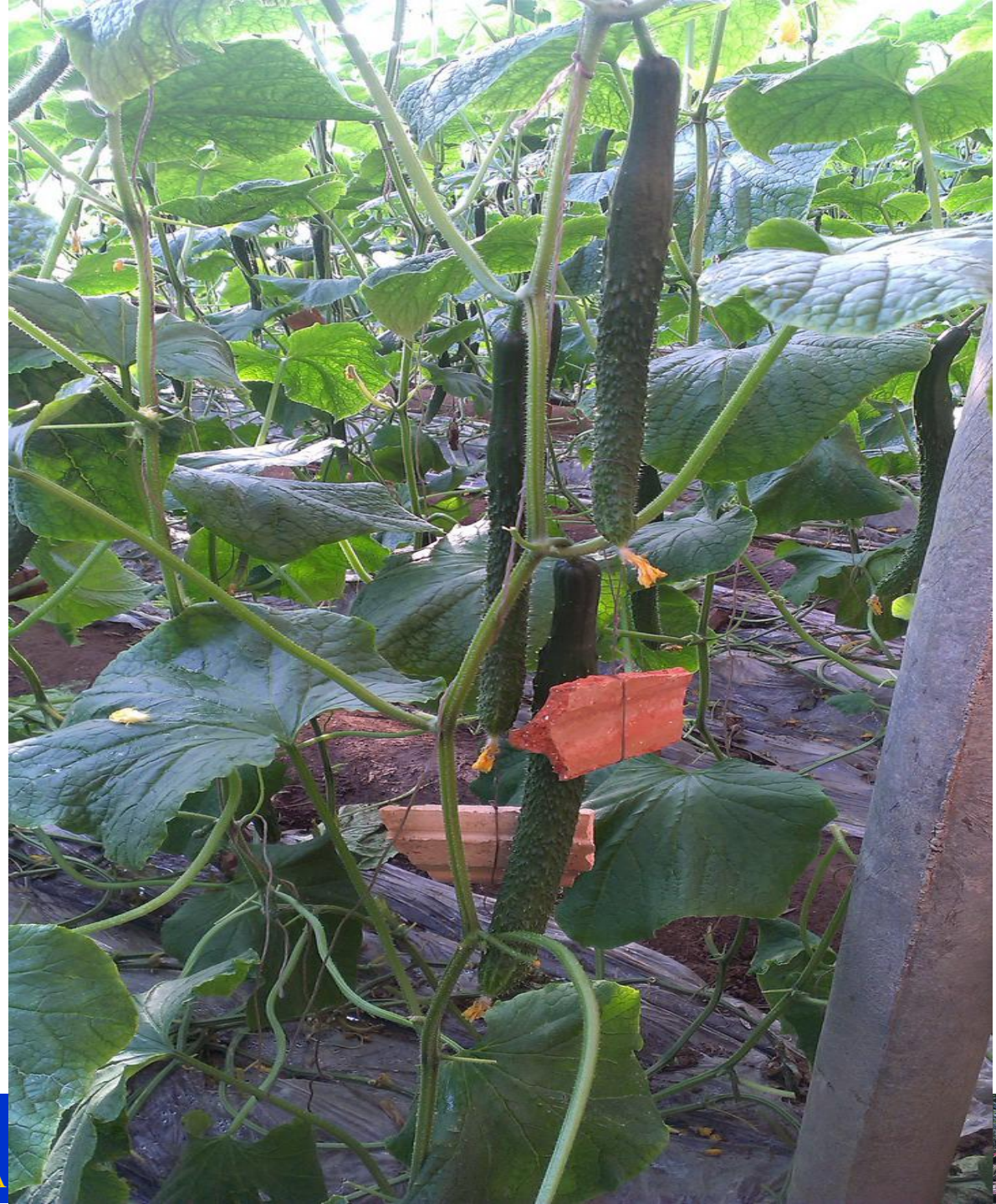
保持最下面3串果实没有叶子遮挡

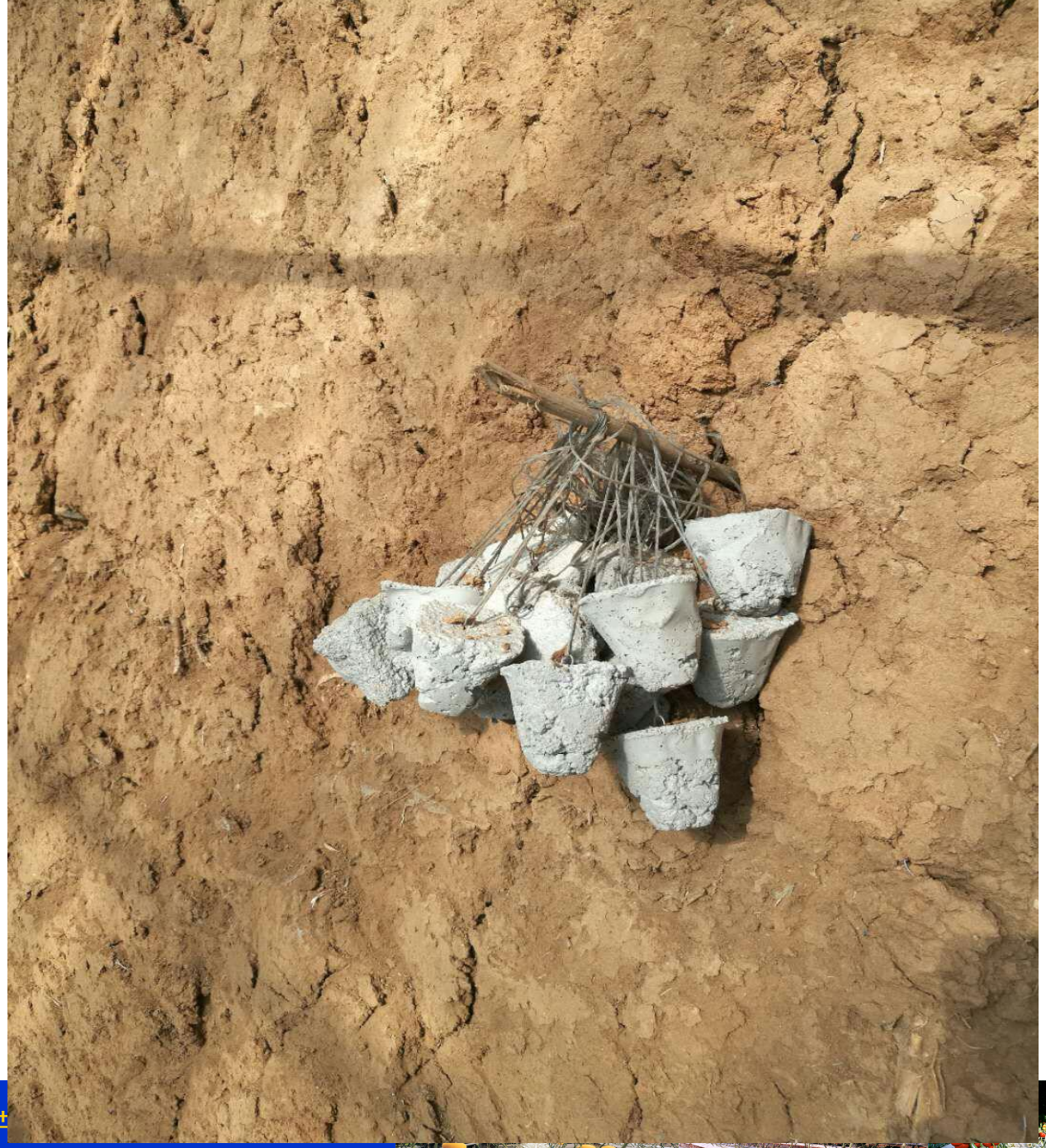
Before removing leaves
打叶前

After removing leaves打叶后

Increase sunlight to fruits
增加果穗接收到的光照







dishcloth gourd

- Roof: Electricity gerneration
- Inside： Crop production

Photovoltaic (PV) Greenhouse

PV Greenhouse

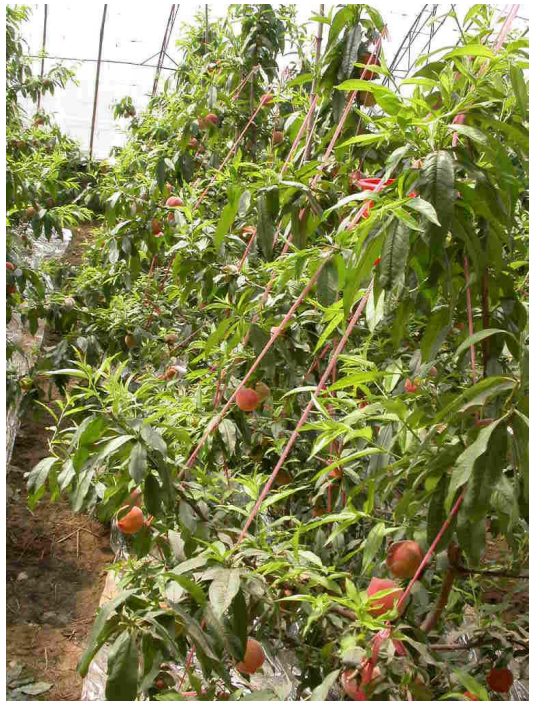
fruit tree in greenhouse

Grape

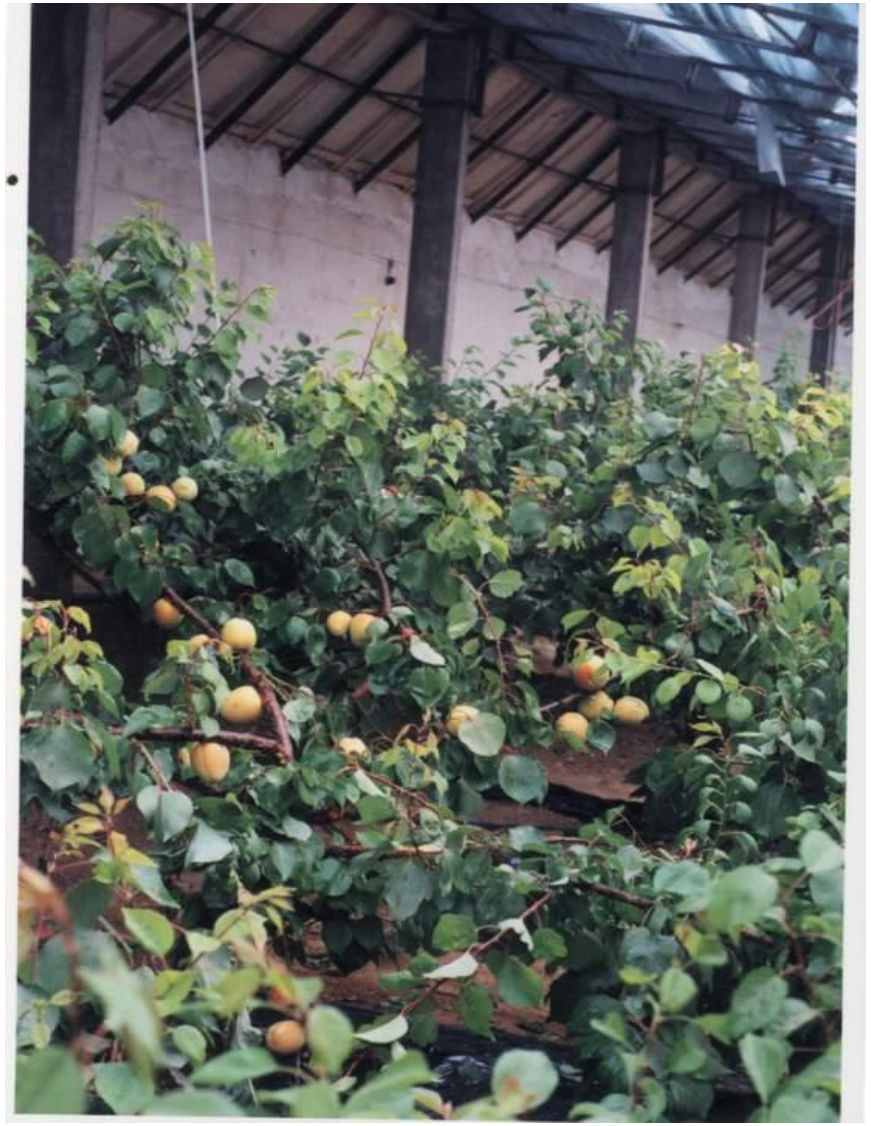
Grapes

Strawberry

Peach



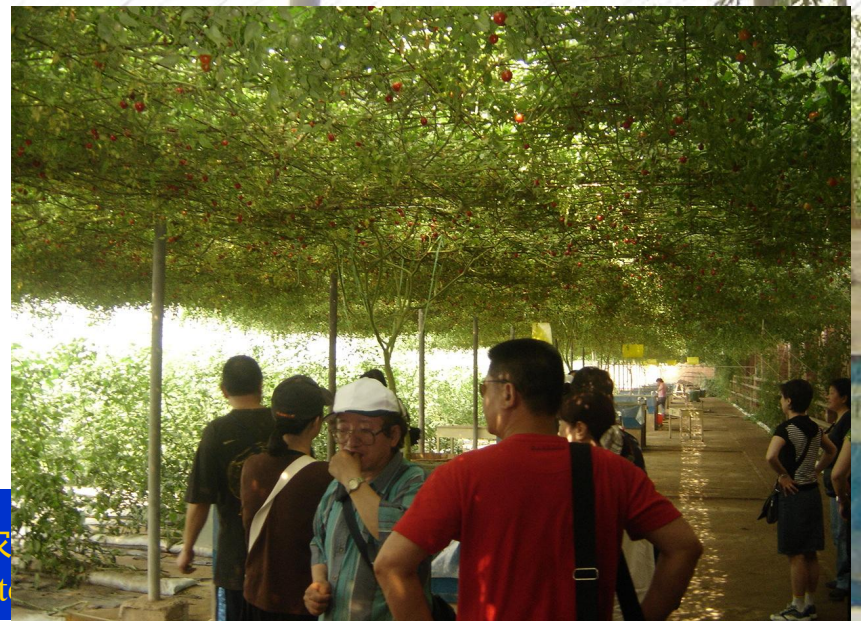
Cherry



Appricote

Papaya

Agricultural tourism



Tomato tree


Tomato tree

Tomato tree





Sweet potato in air


Edible flower

Crop rotation

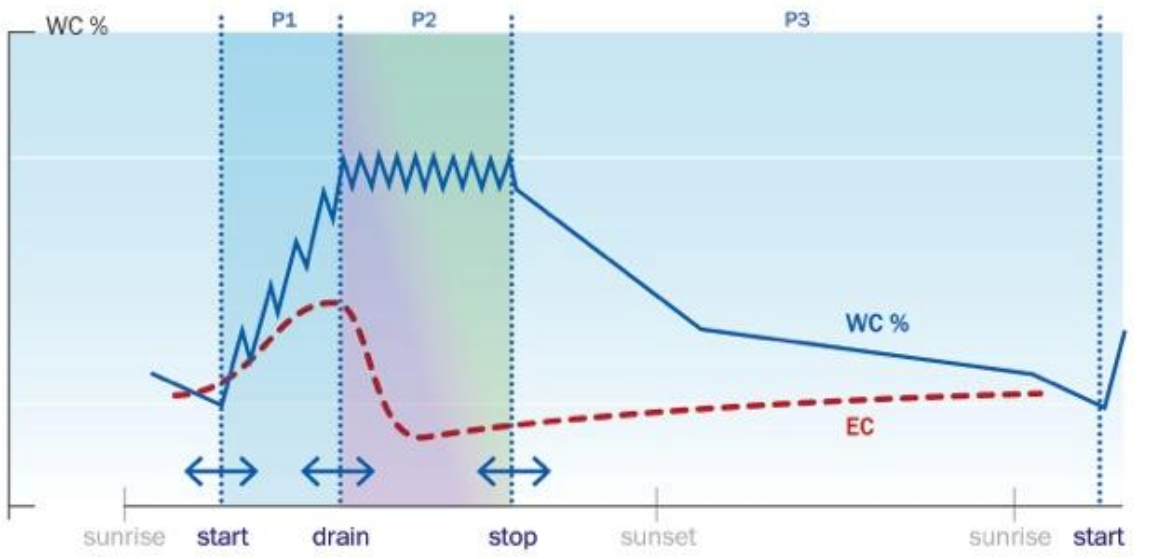
中国农
Institut

Irrigation

3 phase in one day

Phase1

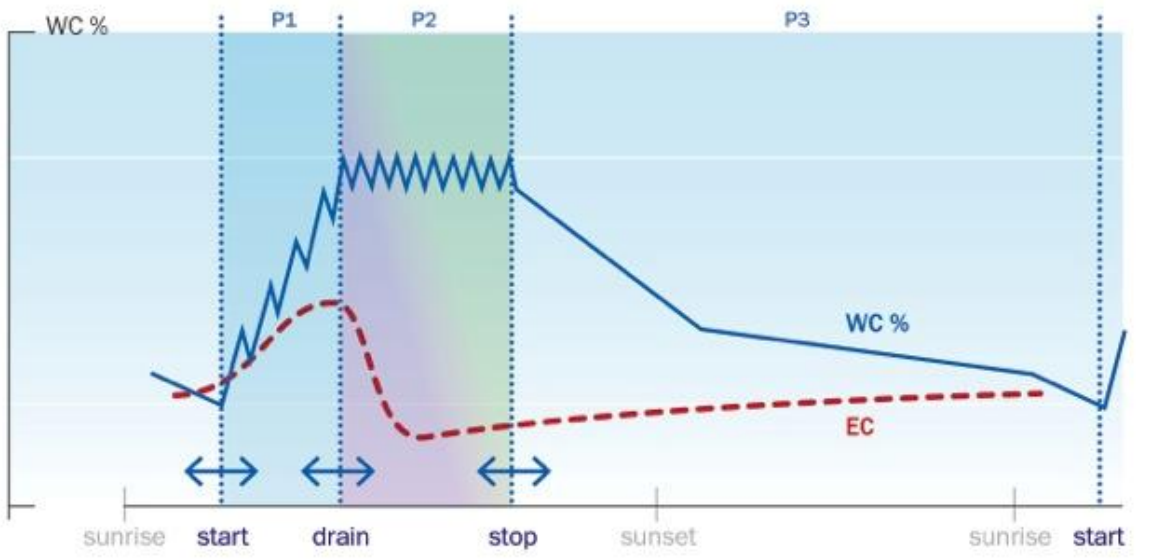
- First irrigation to first drain
- WC increase
- EC increase



Development of substrate WC & EC in 24 hours

Phase 2

- Drainage time
- WC stable
- EC decrease

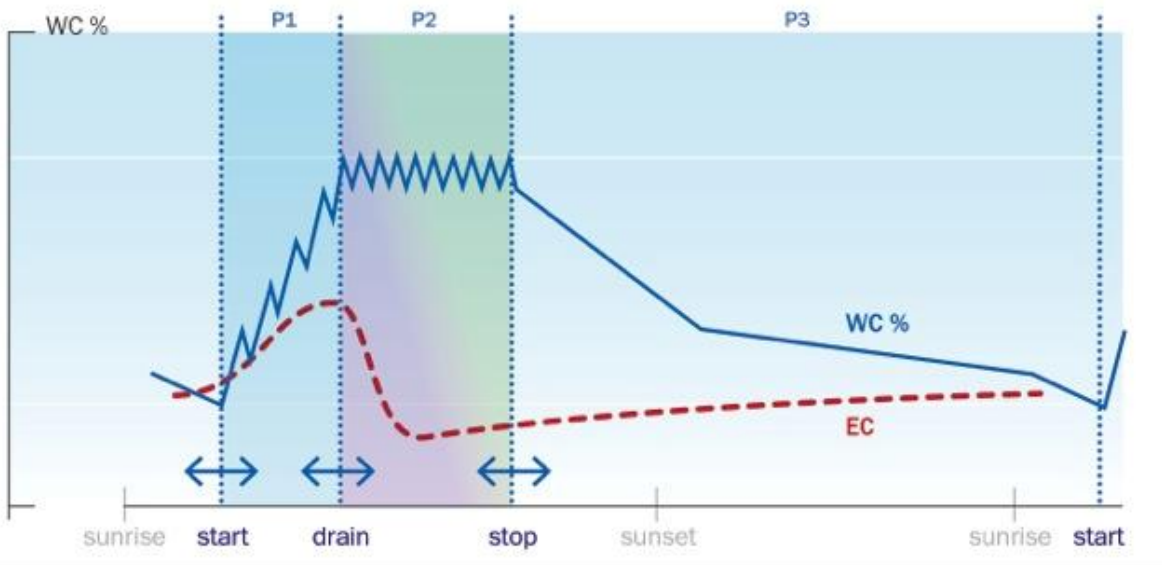


Development of substrate WC & EC in 24 hours

Phase 3

- Irrigation stop to first irrigation next day

- WC decrease
- EC increase



Development of substrate WC & EC in 24 hours

Starting and stopping irrigation
起始和最后一次灌溉时间

First irrigation

Transpiration then irrigation.
蒸腾然后灌溉

- Why important to start on time?
- 为什么按时灌溉这么重要
  - EC control in time.及时控制EC
  - Maintain plant, root & fruit quality
  - 保持植物、根系及果实的质量.
- Factors which affect rate of resaturation to point of drain影响基质再饱和到出回液速率的因素
  - Size of irrigation session /m^2.单位面积内灌溉量
  - Frequency of irrgation sessions. 灌溉频率

Irrigation start time in relation to sunrise	Start time in relation to sunrise and increasing plant activity
0 – 1 hour	Early
1 – 2 hours	Standard
2 – 4 hours	Late

Typical start conditions

出回液阶段

Radiation highest EC lowest irrigation.

- 光照最强，电导率最低
- Why important for EC control in time?
- 为什么及时控制Ec这么重要
  - Stability of EC in a particular growing phase.特定生长阶段稳定的EC
  - Maintain plant and fruit quality.
- 保证植株和果实质量
- Factors which affect stability of EC and WC.
- 影响Ec和含水量的因素
  - Frequnecy of irrigation (ml/J)
  - 灌溉频率
  - Minimum rest time最小间隔时间

Time of 1st drain in relation to irrigation start time	Start time in relation to sunrise and increasing plant activity
1 – 2 hours	Early
2 – 3 hours	Standard
3 – 4 hours	Late

Typical drain conditions

Stop irrigation
结束灌溉

Irrigation stop to relative to sunset	Stop time in relation to sunset and decreasin plant activity
0 – 2 hours	Early
2 – 3 hours	Standard
3 – 6 hours	Late

VEGETATIVE	GENERATIVE
Ca^{++}, NO_3^-	K^+, SO_4^-, Cl^-
Low EC	High EC

	Vegetative	Generative
Water content	high	low
First irrigation	Early	late
Stop irrigation	Late	early

（2）volume per dripper

litres per hour（升/小时）	ml per minute（毫升/分钟）
1	17
2	33
3	50
4	67

番茄/黄瓜3L/h，辣椒2L/h。

Tomato/cucumber 3L/hr, hot pepper 2 L/hr

THANK YOU
FOR YOUR ATTENTION!

CO_2 Enrichment

light

- $CO_2 + H_2O \longrightarrow CH_2O + O_2$

Carbohydrates

CO_2 compensation point,

- C3 pathway: about 50ppm
- C4 pathway less than 10ppm

CO_2 content in air: around 400ppm

Suitable CO_2 content for photosynthese: CO_2 1000ppm

Time of CO_2 Enrichment

- Light intensity higher than 5000Lux,

Effect of CO_2 on tomato growth

Treatment	Plant height (cm)	Number of leaves	Date of flowering	Date of fruit setting	Number of fruits in different cluster				
					I	II	III	IV	Total
+CO_2	42.4	11.7	May 20	May 25	3.9	4.0	4.0	3.1	15.0
−CO_2	43.6	11.8	May 25	May 30	3.5	4.0	3.1	1.7	12.3

Effect CO_2 on hot pepper growth

Treatment	Plant height (cm)	Number of leaves	branch	Number of flower	Roots	Up plant		Roots	
						Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight (g)
$+CO_2$	15.66	23	6	6	13.5	6.98	0.93	2.69	0.40
$-CO_2$	12.80	16	4	6.4	8.8	4.72	0.60	1.70	0.25

Effect of CO_2 on cucumber yield

Treatment	Date	Number of Fruits		
		Total	Class 1	Class 2
$+CO_2$	April 15— May 10	1,070	766	304
	May 11—June 5	2,295	1,321	978
	June 6—June 30	1,552	676	878
	Subtotal	4,917	2,763	2,156
$-CO_2$	April 15— May 10	770	521	249
	May 11—June 5	1,150	461	269
	June 6—June 30	1,284	519	765
	Subtotal	3,209	1,501	1,273

Effect of CO_2 on tomato yield

Early yield (June 1, Kg/m²)			Total yield (Kg/m²)		
$+CO_2$	$-CO_2$	Increase (%)	$+CO_2$	$-CO_2$	Increase (%)
5.14	3.23	159.1	11.74	10.86	108.1
4.23	3.47	121.9	12.39	12.10	102.4
3.75	2.40	148.8	10.32	10.07	102.5
1.80	1.20	150.0	9.11	6.94	131.3

Different time of CO_2 enrichment on ^{14}C distribution of cucumber organs

Time of $^{14}CO_2$ enrichment	^{14}C distribution(%)				
	leaf treated (leaf No. 10)	leaf untreated	Stem	Fruit	Roots
8:00	47.3	17.8	8.2	13.2	13.5
10:00	50.1	18.2	6.1	11.5	14.1
12:00	63.5	19.0	10.1	8.9	8.5
15:00	72.7	8.5	6.9	7.7	4.2
17:00	61.6	9.8	3.8	9.4	5.4

Effect of wind speed on photosynthesis of tomato leaf

Wind speed (cm/s)	photosysthesis($mm^3CO_2/cm^2/hr$)
10	79
16	88
42	101
100	109
300	114
1,000	118

Source of CO_2

Burn Fossil fuels, including wood; composting organic mater。Wine industry,CO2 is by product。

Method of CO_2 enrichment

1、Pure **CO2**：① Solid CO_2, ② liquid CO_2, by product from wine industry 。

2、Burning nature gase、coal

Chemical method

H_2SO_4

Sulphuric acid

NH_4HCO_3

Ammonium bicarbonate

$$H_2SO_4 + NH_4HCO_3 \longrightarrow NH_4SO_4 + H_2CO_3$$

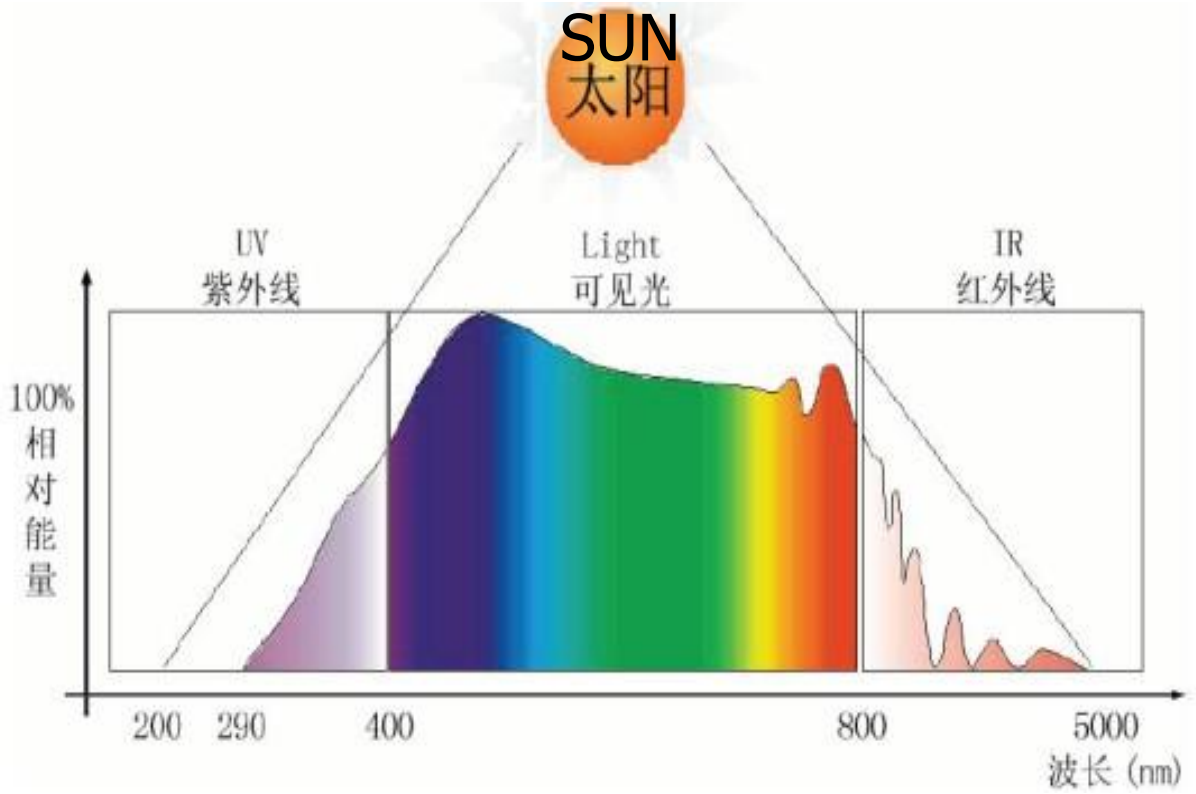
$$H_2CO_3 \longrightarrow H_2O + CO_2\uparrow$$

中国农
Institut


上海石化岩谷气体开发有限公司


PHOTON
二氧化碳发生器
CO2 Generator

Supplemental lighting



低温弱光克服是设施喜温作物高产的瓶颈
Low temperature and weak light is bottle neck for high yield production for protected cultivation

加温补光 Suplemental heating and lighting

弱光 Weak light 30-100 μmol/m²/s

低温 0-10 ℃ low temperature <0 ℃

Effect of light on plant

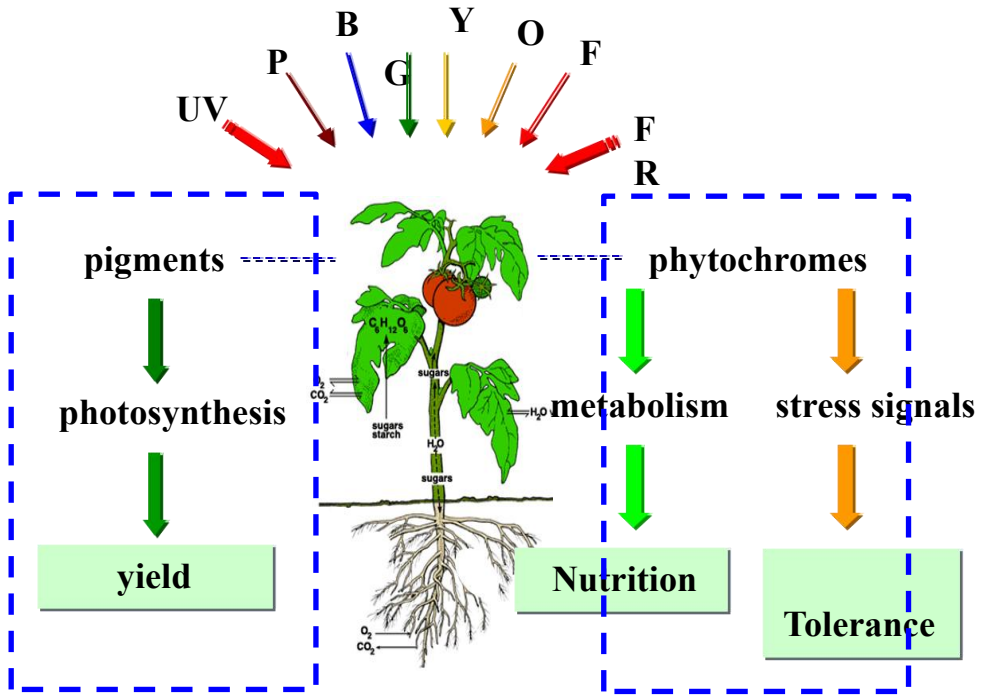
- Signal for plant growth and development
- Energy source for plant photosynthesis
- Stress resistence for plant
- Insect activity

Photosynthesis

Growth

Photoperiod

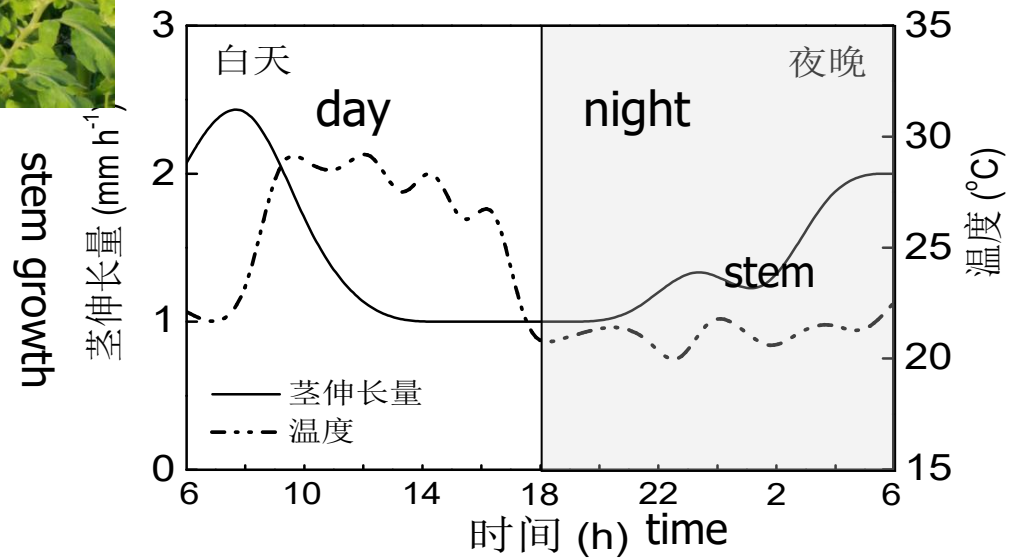
Plant process	Light or radiation
Photosynthesis (uptake of CO2 and formation of sugars)	+ + +
Respiration (burning sugars for plant maintenance)	
Uptake of water and nutrients	+ + +
Transpiration (loss of water through the leaves)	+ + +
Development (appearance of new leaves and flowers)	
Flowering	+ +
Fruit set	+ +
Dry matter distribution (spreading sugars to all plant parts)	
Formation of plant tissue (conversion of sugars, incorporation of water)	
Stretching (cells and organs getting larger)	+ +
Fruit ripening	+ +



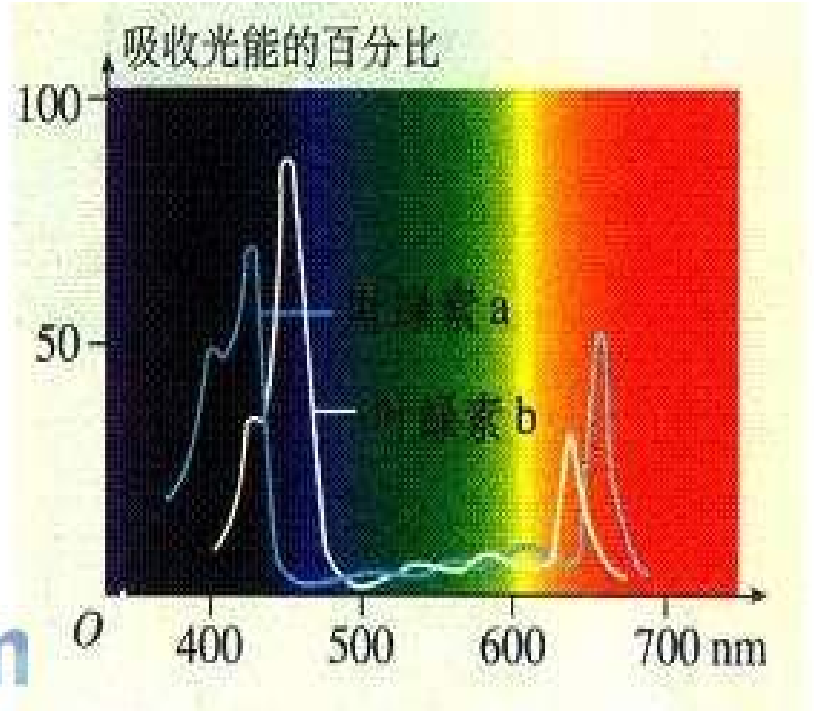
能量
energy

光信号
signal

光是植物伸长的抑制因子
Effect of light on stem growth

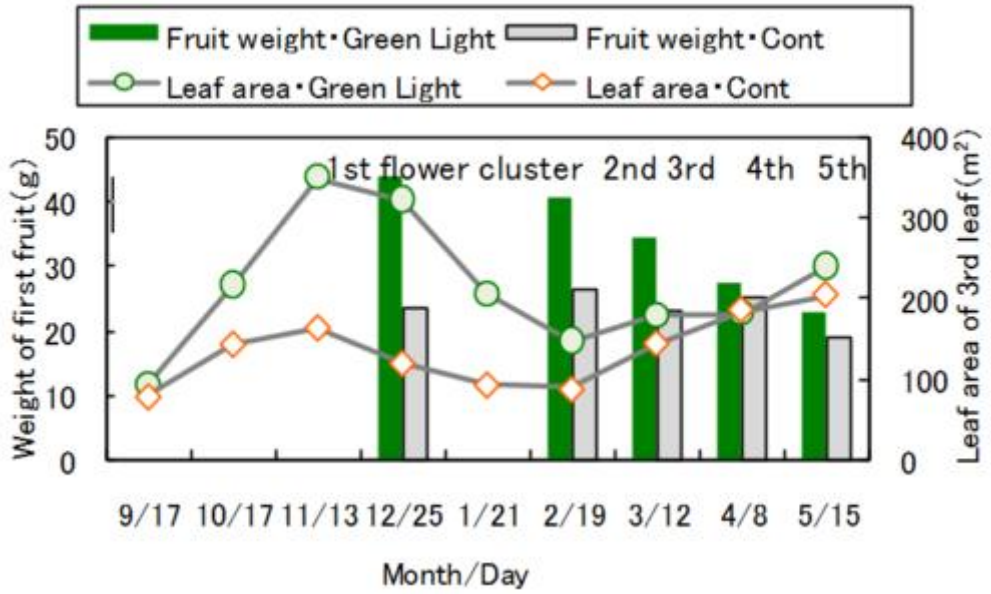


绿光对植物的影响
Greenlight on plant



夜间照射绿光有利于草莓叶片面积和果实体积的增加

Effect of greenlight on strawberry leaf and fruit



Effect of supplemental greenlight during night on strawberry,21:00--23:00. 80 μmol $m^{-2}s^{-1}$

Supplemental lighting in overcast day on tomato
阴天补光时长对番茄的影响

- start：Oct. 23, 2016
- supplemental lighting period：6:00am～20:00pm

- Treatments：（When sunlight intensity less thanfollowing set value, supplemental lighting turn on 当光强低于设定值时开始补光）
  - T1：≤2000Lux
  - T2：≤4000Lux
  - T3：≤6000Lux
  - T4：CK

Supplemental lighting on tomato height (cm)

set value (Lux)	Nov.8	Nov.23	Dec.7	Dec.22	Jan.4	Jan.19	Feb.7	Mar.7
2000	73.35 a	101.55 bc	121.12 c	151.27 b	170.13 c	198.87 c	230.93 b	280.53 c
4000	73.07 a	103.32 b	127.47 b	151.67 b	175.53 b	203.73 bc	234.27 b	294.92 b
6000	72.02 a	99.76 c	123.45 c	148.53 c	178.80 b	208.90 b	241.00 b	295.92 b
CK	72.43 a	112.20 a	146.67 a	179.93 a	206.00 a	233.00 a	264.27 a	313.89 a

Supplemental lighting on tomato stem diameter(mm)

(Lux)	Nov.8	Nov.23	Dec.7	Dec.22	Jan.4	Jan.19	Feb.7	Mar.7	Apex (Jan.4)
2000	8.50 a	9.21 a	8.45 a	8.75 a	8.68 b	8.55 b	8.77 a	8.74 b	1.66 a
4000	8.32 a	8.44 b	8.70 a	8.13 b	8.41 bc	8.42 b	9.04 a	9.23 a	1.39 b
6000	8.66 a	9.03 a	8.71 a	8.72 a	9.33 a	9.11 a	9.28 a	9.60 a	1.57 a
CK	7.69 b	7.41 c	7.73 b	7.85 c	7.90 c	7.77 c	7.87 b	8.53 b	0.93 c

Supplental lighting in overcast day , plant stronger

Supplental lighting on tomato fruit quality

set value (Lux)	acid (%)	S.Sugar (%)	VC (mg/100g)	S. Solid (%)
2000	0.30 a	2.15 a	26.96 ab	4.50 a
4000	0.30 a	2.18 a	27.10 ab	4.53 a
6000	0.30 a	2.07 a	30.55 a	4.60 a
CK	0.27 b	1.86 b	26.52 b	3.93 b

Supplental lighting on tomato yield

set value (Lux)	yield per plant (kg/plant)	yield increase (kg/plot)
2000	1.94 a	10.41
4000	1.95 a	10.54
6000	2.25 a	19.02
CK	1.57 b	-

Supplemental lighting in overcast day on tomato
阴天补光对番茄的影响

- start：Mar. 23, 2017
- supplemental lighting period：7:30～17:30

- Treatments：（When sunlight intensity less thanfollowing set value, supplemental lighting turn on 当光强低于设定值时开始补光）
  - T1：≤5000Lux
  - T2：≤10000Lux
  - T3：≤15000Lux
  - T4：CK

Supplemental lighting on tomato height (cm)

set value (Lux)	April.14	May.2	May.18	June.8	June.27
5000	134.56 b	176.33 b	222.17 a	269.28 a	315.67 a
10000	129.86 c	166.56 c	210.72 b	238.44 b	296.27 b
15000	116.44 d	148.44 d	192.06 c	229.83 c	287.78 b
CK	147.11 a	191.06 a	230.39 a	272.89 a	324.61 a

Supplemental lighting on chlorophyll

set value (Lux)	April.14	May.2	May.18	June.8	June.27
5000	51.19 b	49.13 b	51.91 b	50.04 c	51.17 b
10000	52.35 b	51.78 a	52.77 b	51.77 b	51.42 ab
15000	54.68 a	53.53 a	54.53 a	53.43 a	53.86 a
CK	48.15 c	48.34 b	48.81 c	45.41 d	46.27 c

Supplemental lighting on tomato stem diameter (mm)

set value (Lux)	April.14	May.2	May.18	June.8	June.27
5000	11.00 b	9.25 ab	8.80 a	7.96 a	9.07 a
10000	10.93 b	8.80 b	8.33 b	7.23 a	7.76 b
15000	12.55 a	9.63 a	8.80 a	7.55 a	8.53 a
CK	8.47 c	7.74 c	7.09 c	5.21 b	6.84 c

Supplemental lighting on tomato hstem apex diameter (mm)

set value (Lux)	May.2	May.18	June.8	June.27
5000	2.18 b	2.33 a	2.39 a	2.73 a
10000	2.13 b	2.21 a	2.19 a	2.41 a
15000	2.74 a	2.33 a	2.23 a	2.41 a
CK	1.86 c	1.59 b	1.41 b	1.90 b

Supplemental lighting on tomato fruit quality

set value (Lux)	acid (%)	S.Sugar (%)	VC (mg/100g)	S.Solid (%)	Sugar/ Acid	Solid/ Acid
5000	0.45 ab	1.81 a	28.71 ab	5.00 a	4.03	11.10
10000	0.48 a	1.82 a	28.28 ab	5.10 a	3.80	10.68
15000	0.48 a	1.89 a	30.55 a	5.00 a	3.95	10.46
CK	0.42 b	1.48 b	26.73 b	4.57 b	3.49	10.79

补光临界值为5000Lex的糖/酸、固/酸比最高。

Set value 5000lux had highest Sugar/Acid, Solid/Acid

Supplemental lighting on tomato yield and benefit

Setvalue (Lux)	Yield per plant (kg/plant)	Yield increase (kg/plot)	electricity used (KW/plot)	output/ input
5000	3.12 b	17.70	41.00	3.45
10000	3.15 b	18.57	77.00	1.93
15000	3.49 a	28.71	90.00	2.55
CK	2.53 c	-	-	-

Supplemental lighting during night on tomato
晚间补光时长对番茄的影响

- Start：March 31, 2017
- End：July 24, 2017
- 基质：椰糠

- T1(A)：1h（23:00pm～24:00pm）
- T2(B)：2h（23:00pm～1:00am）
- T3(C)：3h（23:00pm～2:00am）
- T4(D)：CK

Supplemental lighting on tomato height

period	April.18	May.3	May.24	June.8	June.28
1h	153.83 b	197.97 a	257.99 b	289.98 a	327.47 bc
2h	155.86 ab	200.67 a	263.11 a	281.28 b	325.22 c
3h	155.80 ab	198.56 a	251.44 c	289.59 a	341.48 a
CK	159.11 a	200.72 a	254.22 c	287.09 a	336.59 ab

Supplemental lighting on tomato leaf chlorophyll

period	April.18	May.3	May.24	June.8	June.28
1h	51.04 a	53.53 a	54.58 a	54.28 a	53.03 a
2h	50.01 a	52.10 b	54.18 a	52.78 b	51.44 a
3h	51.03 a	52.08 b	52.63 a	51.24 c	54.51 a
CK	47.34 b	48.52 c	45.32 b	50.32 d	48.77 b

Supplemental lighting on tomato stem diameter

period	April.18	May.3	May.24	June.8	June.28
1h	11.87 a	10.19 a	8.72 a	7.00 ab	6.04 b
2h	10.83 b	10.22 a	8.59 a	7.09 a	6.07 b
3h	10.67 b	9.63 b	8.44 a	7.39 a	6.90 a
CK	9.36 c	8.24 c	6.69 b	6.64 b	5.54 c

Supplemental lighting on tomato stem apex diameter

period	May.3	May.24	June.8	June.28
1h	2.48 a	2.05 a	1.82 b	1.64 b
2h	2.19 b	1.94 b	1.86 b	1.57 c
3h	2.14 b	2.06 a	1.96 a	1.71 a
CK	1.73 c	1.55 c	1.58 c	1.45 d

Supplemental lighting on tomato fruit quality

period	Acid (%)	S.Sugar (%)	VC (mg/100g)	S.Solid (%)	Sugar /Acid	Solid/ Acid
1h	0.43 a	1.78 a	26.18 a	5.00 a	4.16	11.69
2h	0.41 a	1.53 b	24.72 ab	5.00 a	3.70	12.09
3h	0.47 a	1.78 a	23.56 bc	5.00 a	3.78	10.63
CK	0.43 a	1.59 ab	22.50 c	5.00 a	3.68	11.58

supplemental lighting 1h had highest Sugar/Acid

Supplemental lighting on tomato fruit yield and benefit

period	yield per plant (kg/plant)	increase (kg/plot)	electricity used (KW/hr)	output/input
1h	2.91 a	18.20	24.00	10.11
2h	2.86 a	15.93	48.50	4.38
3h	2.98 a	20.56	70.00	3.92
CK	2.45 b	-	-	-

Artificial lighting----Plant factory

R/B 7：3

Intensity 〉100 umol $m^{-2}s^{-1}$

Protected cultivation ––supplemental lighting

3-10 kg /m²

40-50 kg /m²

70-80 kg /m²

+8 -15 %

露地火龙果补光

supplemental lighting in open field Pitaya

Strawberry

Supplemental lighting 2 hours， yield increase37%

overcast day

after sunset

Control treatment

40 days after pollination

Control

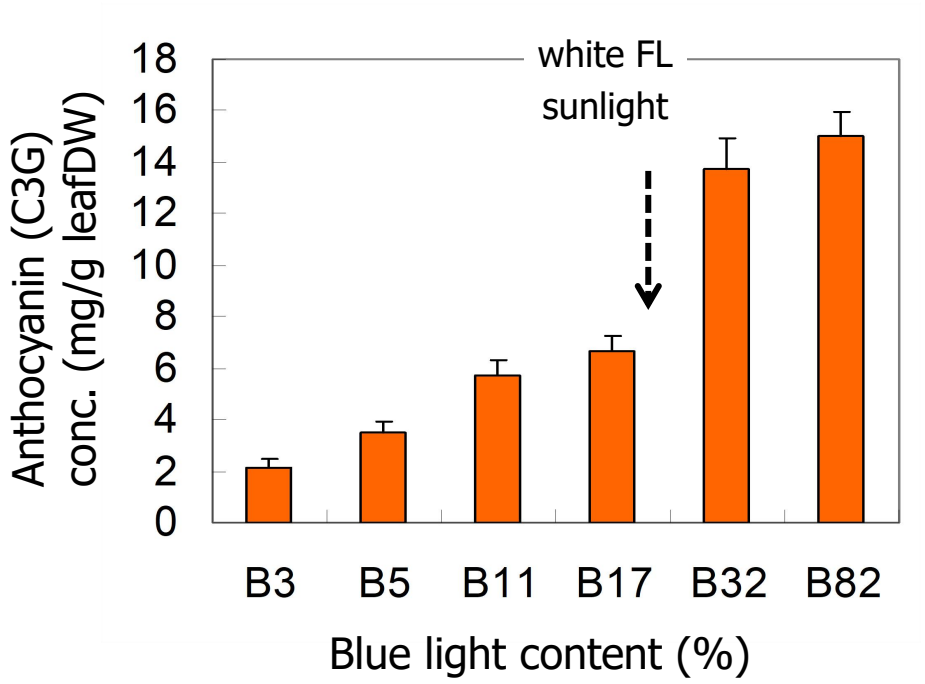
supple. lighting

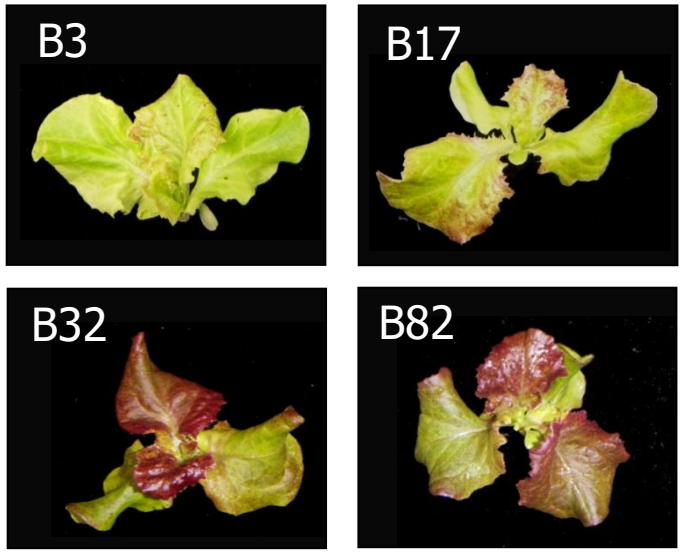
Sugar： 2~3 degree higher

energy： 10 KWh/day/mu

input/output： 1：5

Blue light increase anthocyanin content in lettuce





Intensity 150 μmol m^{-2} s^{-1} constant

Blue light and UV increase Functional Component

30 days

3 days before harvest

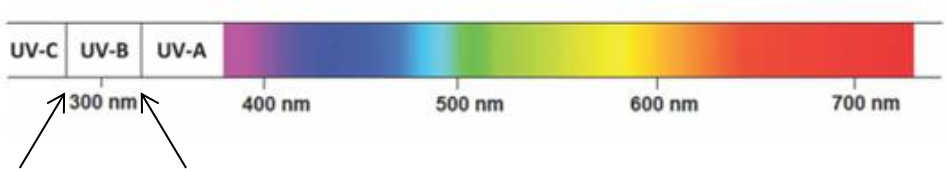
Promotion of photosynthesis by red light

Blue or UV light addition to synthesize secondary metabolites

Changes in growth, physiology and antioxidant systems of cucumber by UV-B radiation

Background

Ultraviolet-B radiation (UV-B) is a key environmental signal for plant growth and development. An excess or lack of UV-B can affect plant growth, physiology resistance.



280nm 315nm

Background

- Due to the covering materials (plastic film or glass) used ,photosynthetically active radiation transmittance is 80–90% and UV-B transmittance is 15–30%.

Background

- Wang et al. reported that 2.2 μmol·m^{-2}·s^{-1} of supplemental UV-B radiation could improve fruit quality in tomatoes in winter plastic greenhouses.
- Chen et al. reported that 6.91-10.37 μmol·m^{-2}·s^{-1} supplemental UV-B radiation could increase ascorbic acid (AsA) content in pakchoi leaves .

Materials and methods

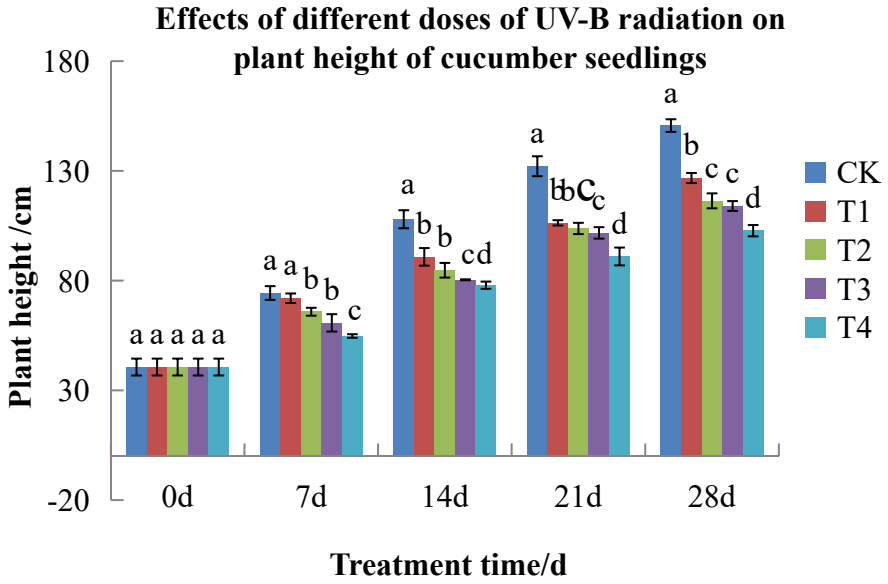
Table. 1 The experimental treatments

Treatment	Supplemental UV-B dose (μmol·m^{-2}·s^{-1})	Supplemental UV-B time (hour per day)
CK	0	4 (11:00 AM-2:00 PM)
T1	1.67	4 (11:00 AM-2:00 PM)
T2	3.33	4 (11:00 AM-2:00 PM)
T3	5.01	4 (11:00 AM-2:00 PM)
T4	6.67	4 (11:00 AM-2:00 PM)

Grow condition: 14 h photoperiod, 28/20℃, 60% relative humidity and 560 μmol·m^{-2}·s^{-1} photon flux density (400-700 nm) supplemented with high-pressure sodium lamps from 6:00 AM to 8:00 PM.

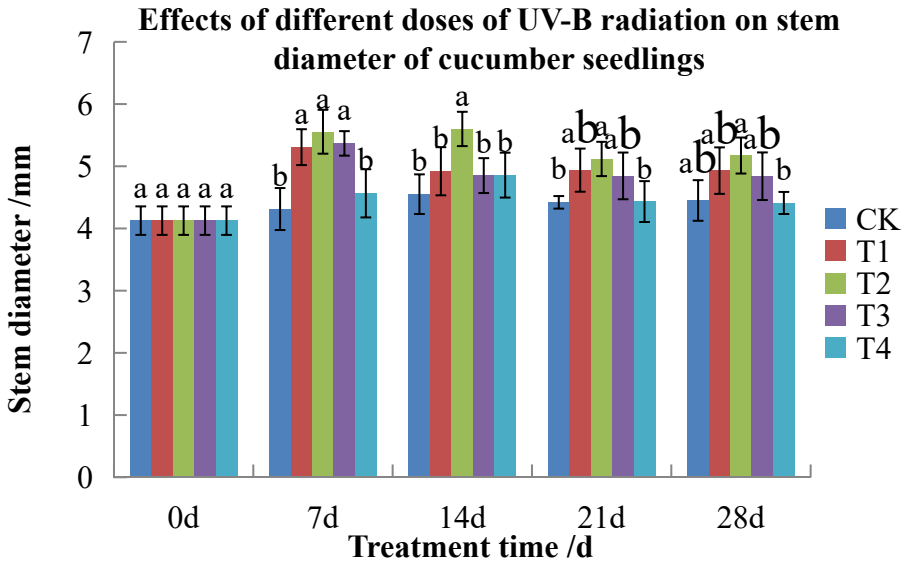
Samples were collected on 0, 7, 14, 21, 28d after treatment, and the dry weight was determined 28d after treatment.

Results



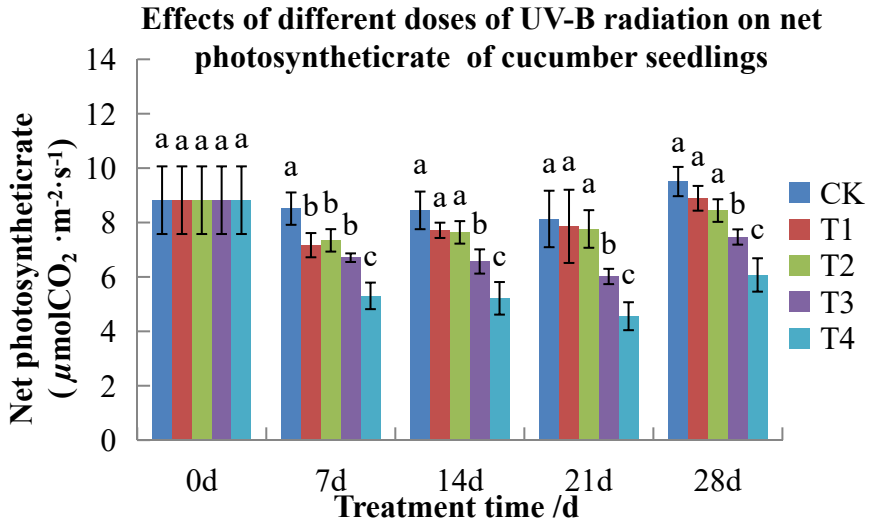
Plant height significantly decreased as UV-B radiation dose and treatment time increased. Specifically, plant height decreased by 4.2%-16.0%, 12.2%-22.6%, 18.9%-24.0% and 27.0%-32.0% for T1, T2, T3 and T4, respectively.

Results



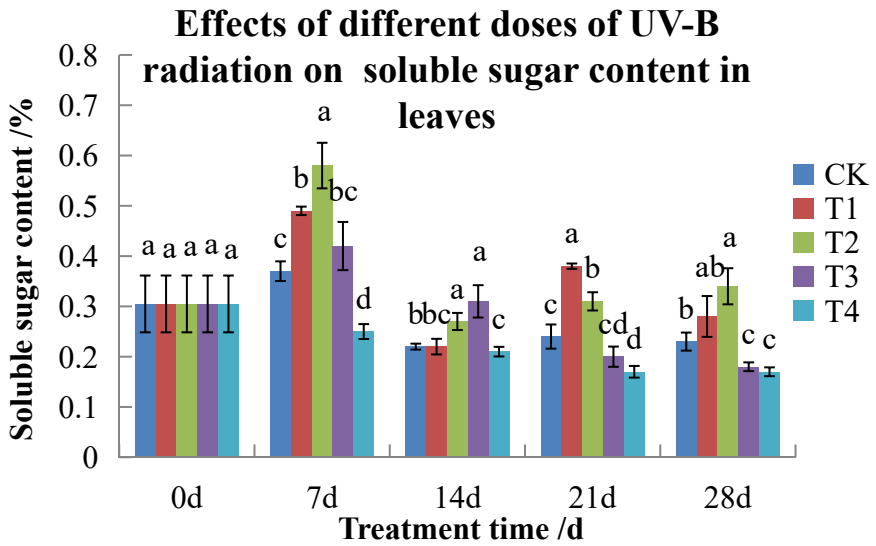
Stem diameter in the T2 group was significantly increased from days 7 to 28 .

Results



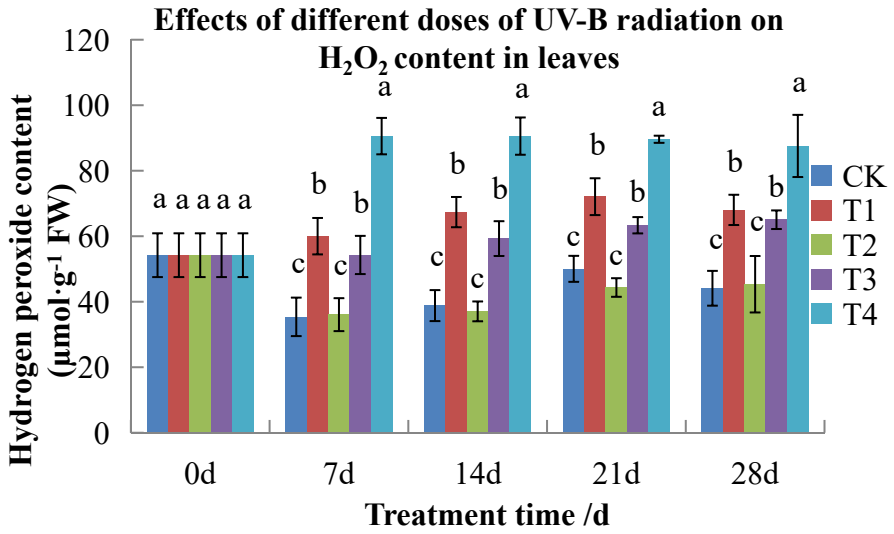
Net photosynthesis in cucumber leaves under 1.67 or 3.33 μmol·m^{-2}·s^{-1} did not change significantly from day 14th to 28th,

Results



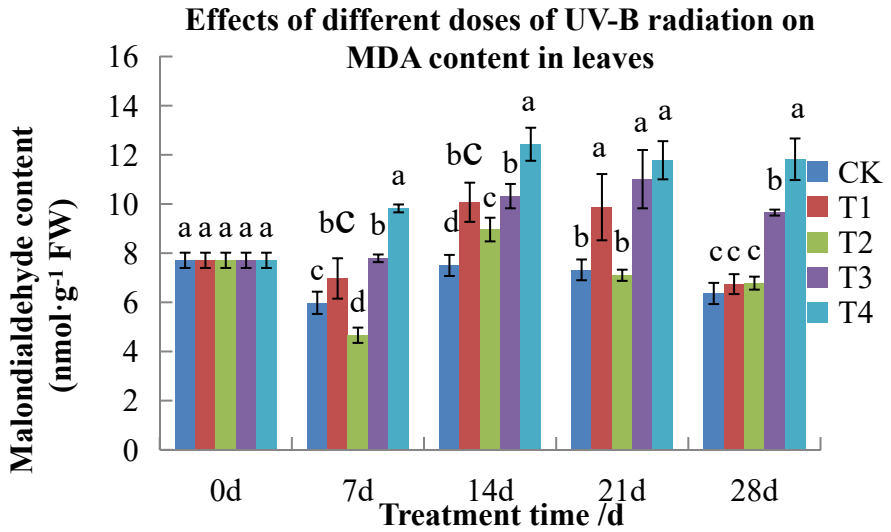
The level of soluble sugar in the T2 treatment group was higher than the control from day 7 to 28,

Results



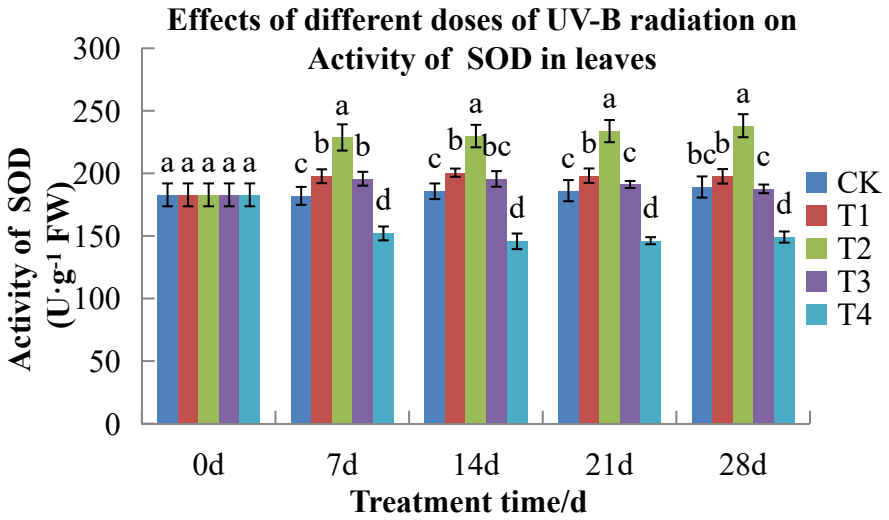
The content of H_2O_2 (Hydrogen peroxide) inT1, T3 and T4 was significantly higher than control during the whole treatment period, and the H_2O_2 content of T2 was not significantly different from control.

Results



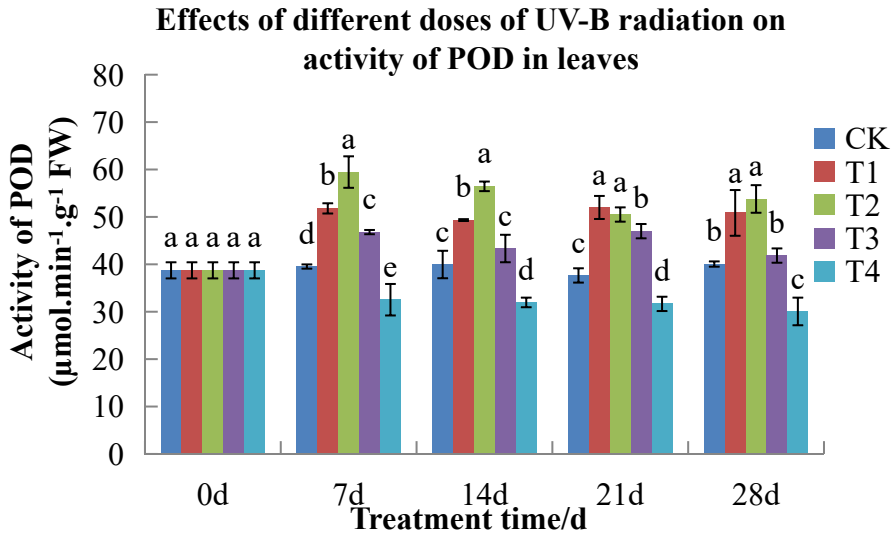
The level of MDA in T3 and T4 was significantly higher than control, whereas the level of MDA inT2 was no difference from control.

Results



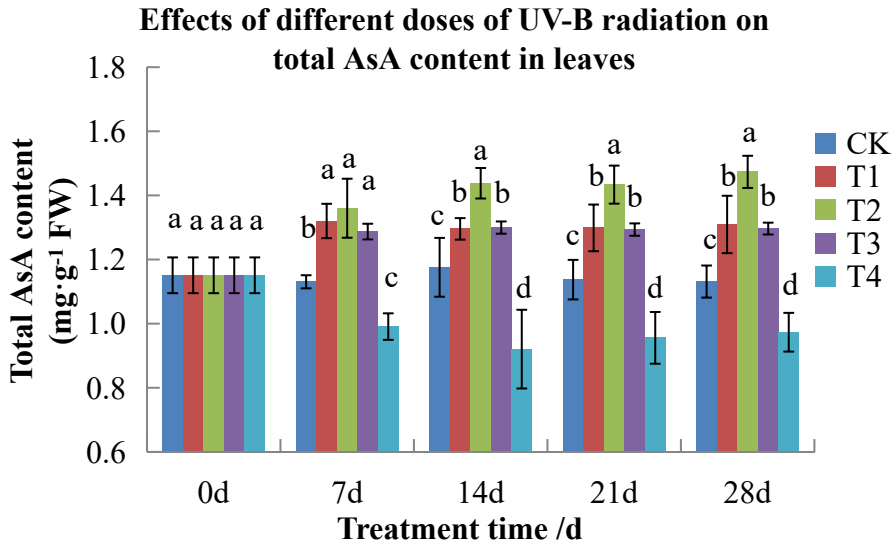
After treatment with UV-B, SOD activity in T2 increased,as compared with the control.

Results



After treatment with UV-B, POD activity in T2 increased,6.67 μmol·m^{-2}·s^{-1} UV-B decreased POD activity in leaves compared with the control.

Results



AsA content in the cucumber seedling leaves was significantly higher in the T1, T2 and T3 treatment groups than control. However, at the high dose of UV-B radiation, the total AsA content decreased significantly.

conclusions

- 3.33 μmol·m^{-2}·s^{-1} UV-B favored stem diameter growth
- 3.33 μmol·m^{-2}·s^{-1} UV-B increased soluble sugar content
- 3.33 μmol·m^{-2}·s^{-1} UV-B increased activation of the antioxidant system

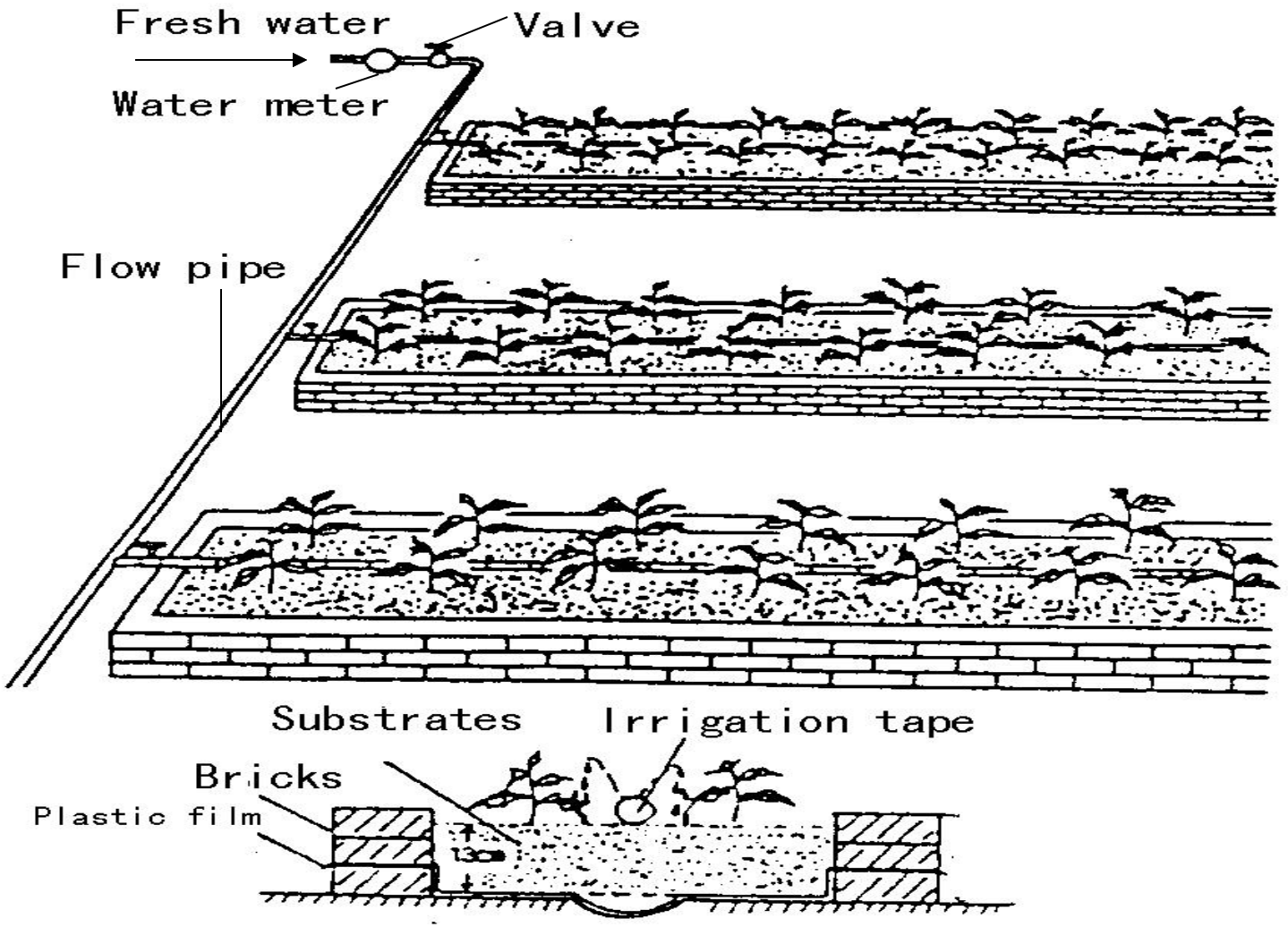
The results of this study indicate that 3.33 μmol·m^{-2}·s^{-1} UV-B promoted the growth and improved the stress resistance of cucumber plants in a plant factory.

Eco-organic Type Soilless Culture

This is a trough culture, local substrates were used such as coal cinder, peat moss, vermiculite, coir, sawdust, perlite, sand, rice husk,crop straws etc. Which can be used successfully and get very good results.

The system was first developed by Chinese Academy of Agricultural Sciences,

STRUCTURE


Fresh water
Valve
Water meter
Flow pipe
Substrates
Irrigation tape
Bricks
Plastic film

Eco-organic type soilless culture

- accounts for over 80% of total area of soilless culture
- Introduced the concept of organic agriculture into soilless culture
- Promoted the development of soilless culture

中国农
Institut

网纹甜瓜

MUSKMELON

中国农
Institut

哈密瓜

HAMI MELON

ADVANTAGES

Eco-organic type soilless culture

- **large percent of Solid fertilizer is used to feed crops, fertilization is divided into base fertilizer and top-dressing fertilizer. Organic fertilizer accounts for 80-100% of total fertilizer.**

ADVANTAGES

Eco-organic type soilless culture

- **Decrease fertilizer cost up to 60%; greatly simplify the rule of operation and improve the quality of vegetables.**

Soilless cultivation for vegetable production

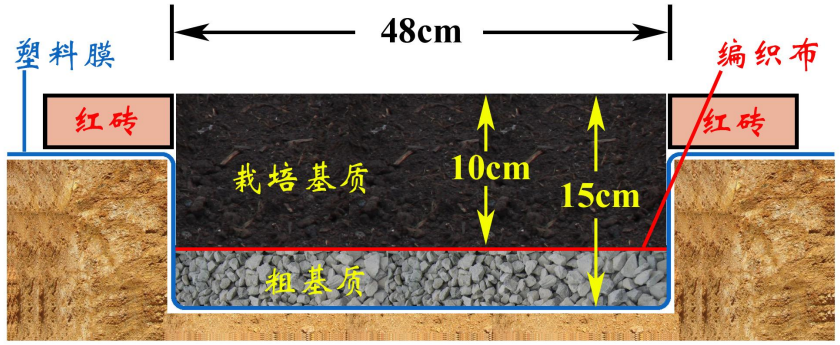




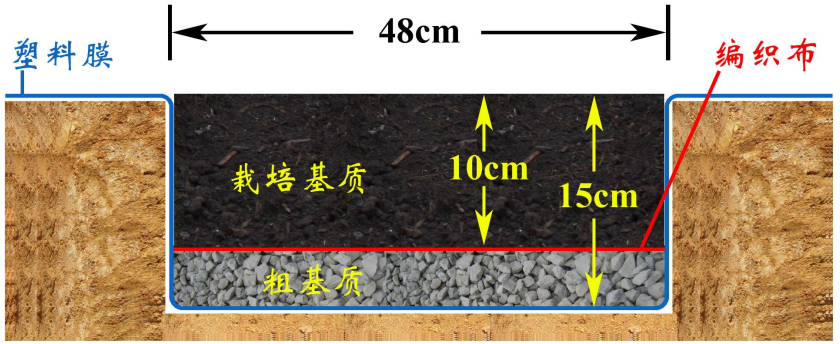
Sympliest soilless system

Developing soilless technology for growers who are not well educted!

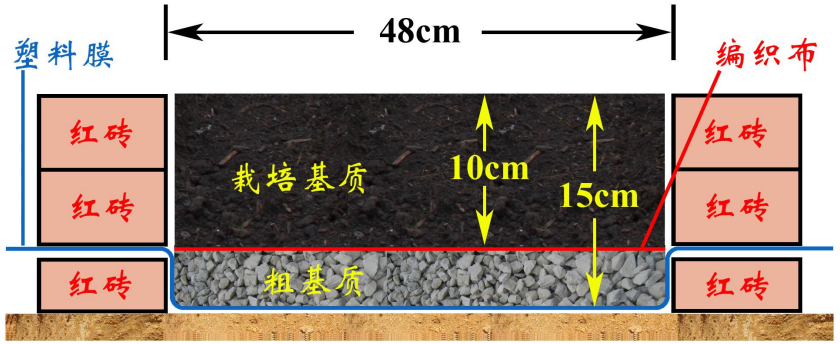
Three different type of trough for substrate cultivation



半地下式槽结构示意图



地下式槽结构示意图



砖槽结构示意图




Bag culture






15L

12L

8L

Bag culture, 8 litre substrates/plant with proper irrigation system, reduce amount of substrate。

Research activities

How to decrease the once over investment and improvement of production, producing high quality vegetables are the first priority in research work.

Agricultural waste used as Growing media for soilless cultivation

Progress on research activities

Research on substrates

- **Agriculture wastes (sunflower stem, corn stem, sawdust, coir, rice husk, mushroom waste and so on) for replacing peat/rockwool have gotten successful results and shown great potential in economy profit and environment protection. Cost reduced over 70%.**

Materials for Substrates

- **Organic：Peat、Coir、Sawdust、bark、Wood chips、Rice husk、Crop straw、Peanut husk、Weathering coal、Mushroom waste、 Herbal residues etc。**
- **Inorganic：Perlite、Vermiculite、Sand、Coal cinder、Rockwool、Zeolite、Ceramic particles etc。**

Materials for Growing media

Activities in untillable land

Building greenhouses with pebble stone and bags filled with pure desert sand

Vegetable production in un-tillabe land

Maize straw


Saw dust

Mushroom waste


Coal cinder


Rice husk


composted substrate by small scale grower

Casawa waste

Crop waste

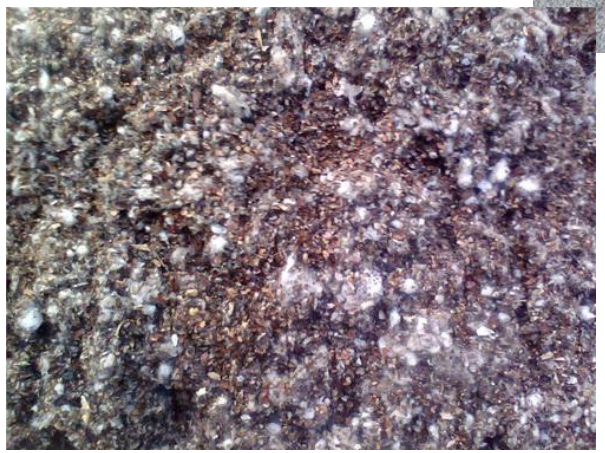
多种作物秸秆，如玉米、小麦、葵花、棉花、高粱、水稻等作物秸秆经过处理发酵后可作基质配料。

herb waste

中药渣大多是植物的根、茎、叶、花、实、皮，以及禽兽的肢体、脏器、外壳，还有部分矿物质，含有丰富的有机物和无机物质。经发酵处理后可以作为基质原料。但由于中药渣成分的复杂性和来源的多样性，需充分考虑其安全性。

corn waste

未经处理过的玉米芯



cotton seeds waste

未经处理过的棉籽壳

由于玉米芯、棉籽壳等是很好的食用菌培养基料，因此一般种植食用菌后的菇渣才用于作为基质原料。

Sugar cane waste

甘蔗渣是甘蔗制糖时压榨后的渣滓，质地粗硬，每生产出一吨的蔗糖，就会产生2～3吨的蔗渣。长纤维的蔗渣可以造纸，短纤维的蔗渣经处理发酵后可以作为基质原料。

Rice husk

稻壳约含40%的粗纤维和20%左右的五碳糖聚合物（主要为半纤维素），含20%灰分及少量粗蛋白、粗脂肪等有机化合物。稻壳可碳化后或直接作为基质的原料使用。

Peanut husk

处理发酵后的花生壳稳定性优于菇渣，棉籽壳和锯木屑，但花生壳基质的pH值偏酸，基质的物理性质仍然需要改良和提高，应与其他基质复配后使用。

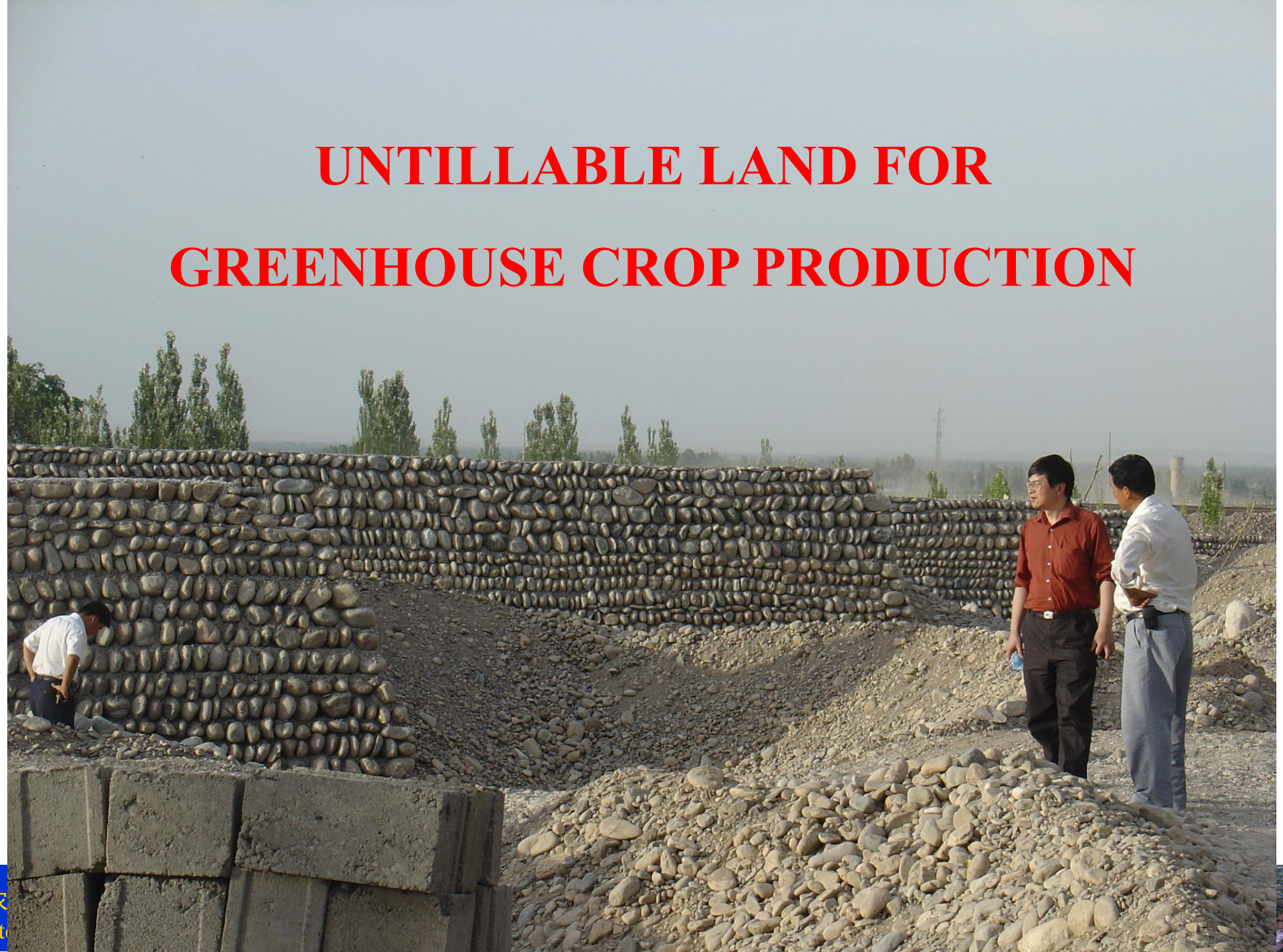
Physical Property of Coir

• Aparent density	g/ml.	0.055
• Real density	g/ml.	1.55
• Total Porse Space		96.7%
• Water holding Capacity		
10cm		70%
50cm		45%
• Air capacity		31%
• Easy availlable water		22.4%





UNTILLABLE LAND FOR GREENHOUSE CROP PRODUCTION



Greenhouse in stone land



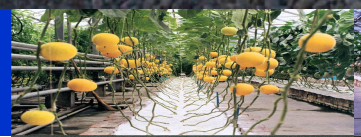


Greenhouse in gobi area

Greenhouse in desert area

甘肃 砂石温室与无土栽培

Soilless cultivation in stone land



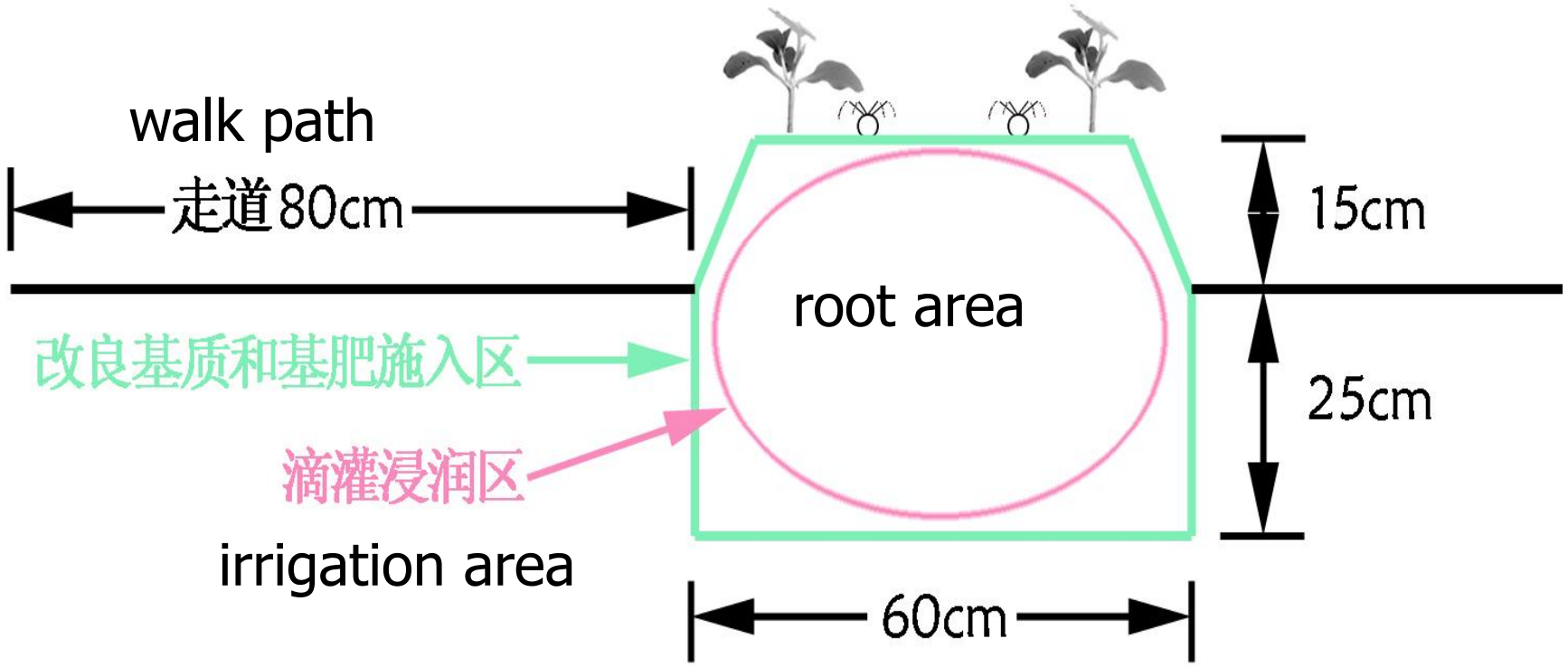


Irrigation control based on water content in substrate

Water saving technique

内蒙乌海 WUHAI in Inner Mongolia:

- Tomato soil cultivation + Furrow watering， 2000m^3/Year
- Tomato soil cultivation + drip irrigation， 800m^3/Year
- Tomato substrate cultivation + drip irrigation， 550m^3/Year
- Tomato substrate cultivation + drip irrigation with irrigation based on water content in substrate ， 400m^3/Year


walk path
走道80cm
root area
15cm
25cm
改良基质和基肥施入区
滴灌浸润区
irrigation area
60cm

Auto irrigation Vs tranditional irrigation

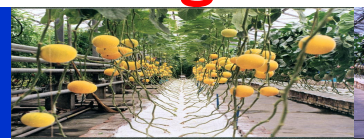
Items	Auto	CK	Reduced compared to CK
Orgaic substrate (M3)	4.48	0	-
Manure (T)	2.24	6.45	65.27%
Labor (day.person)	4	8	50.00%
water amount (T)	487.5	1078.0	54.78%(590.5m^3)
Yield (kg/row)	41.2a	42.4a	

Saving water means saving fertilizers under fertigation condition

Fertigation

Fertigation control

Auto irrigation

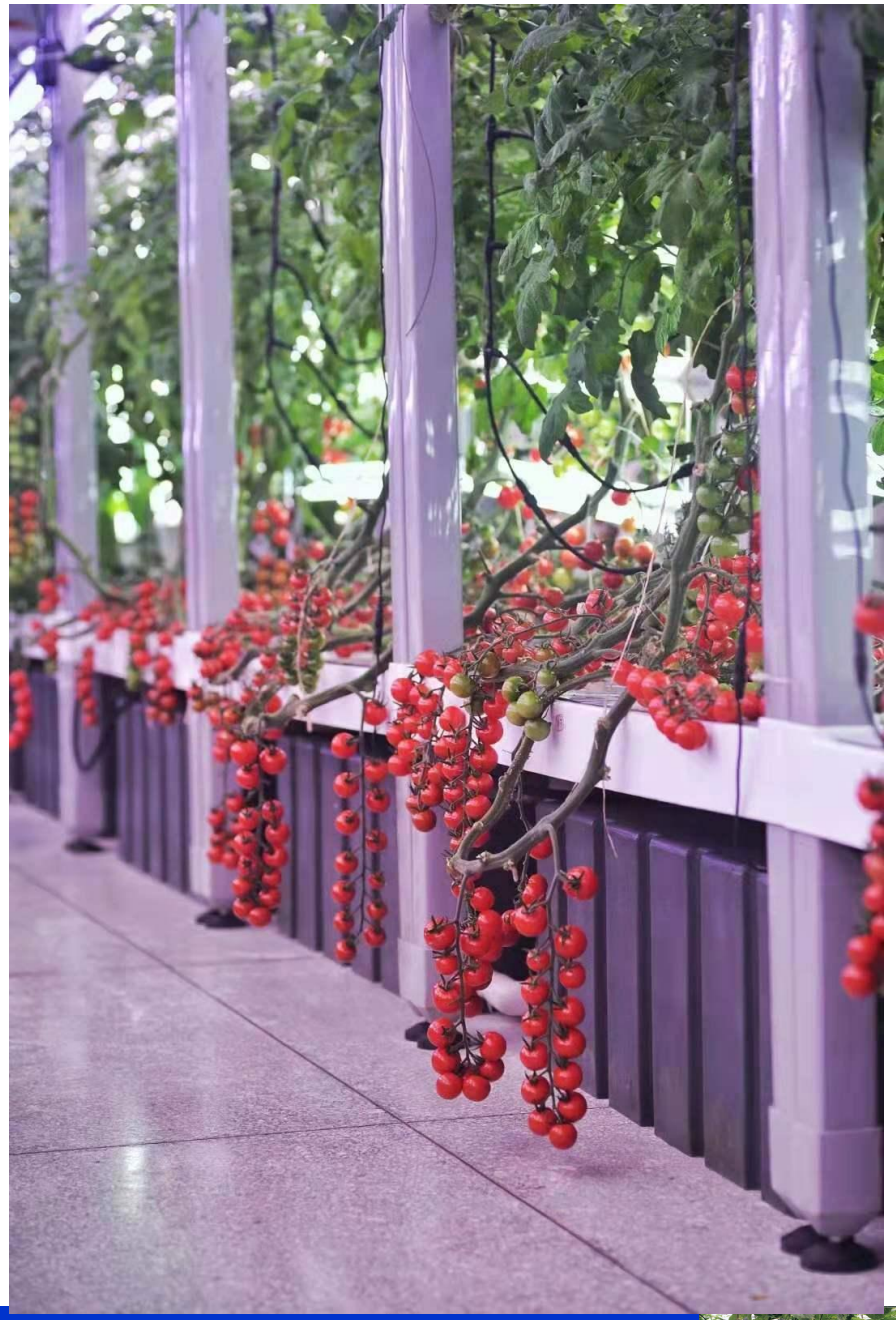


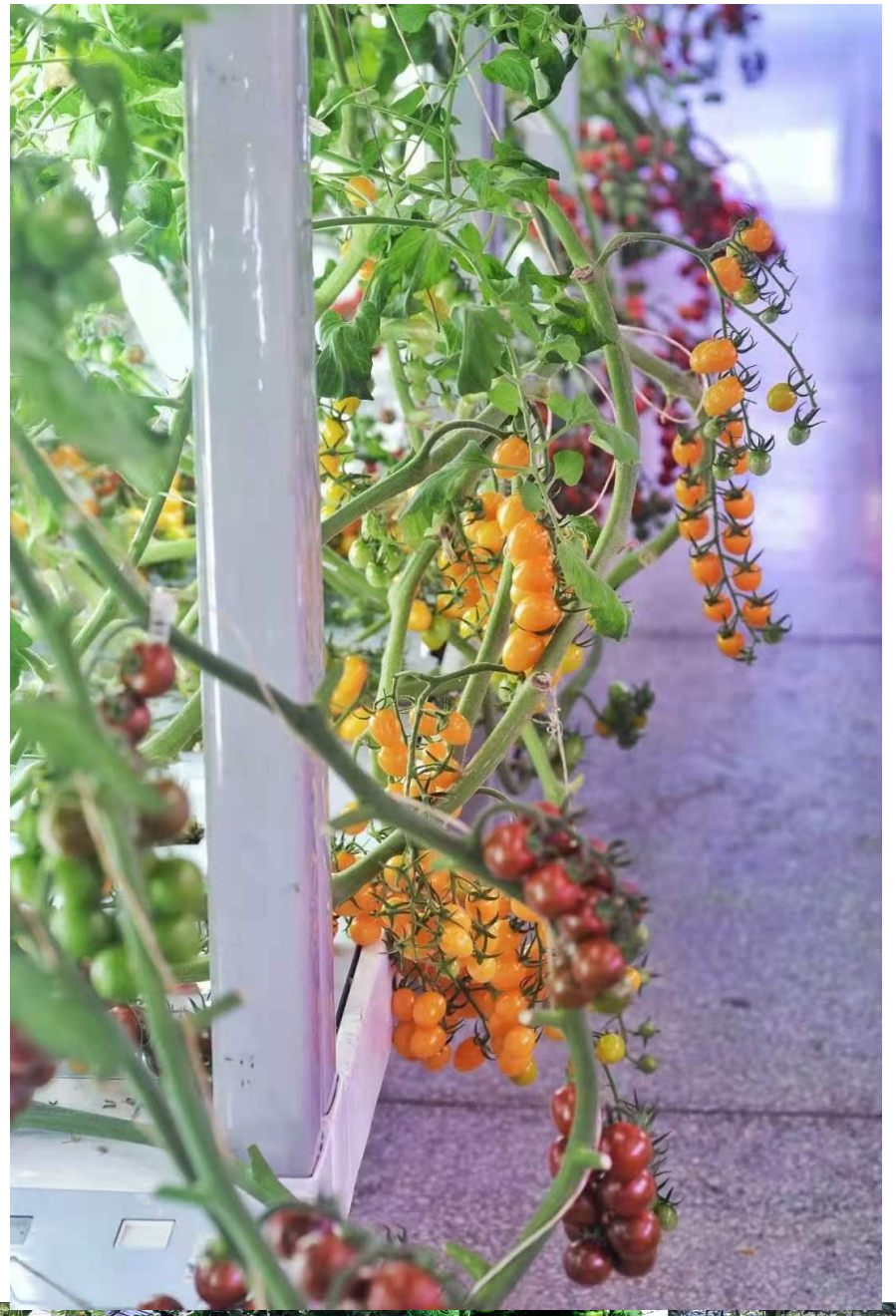


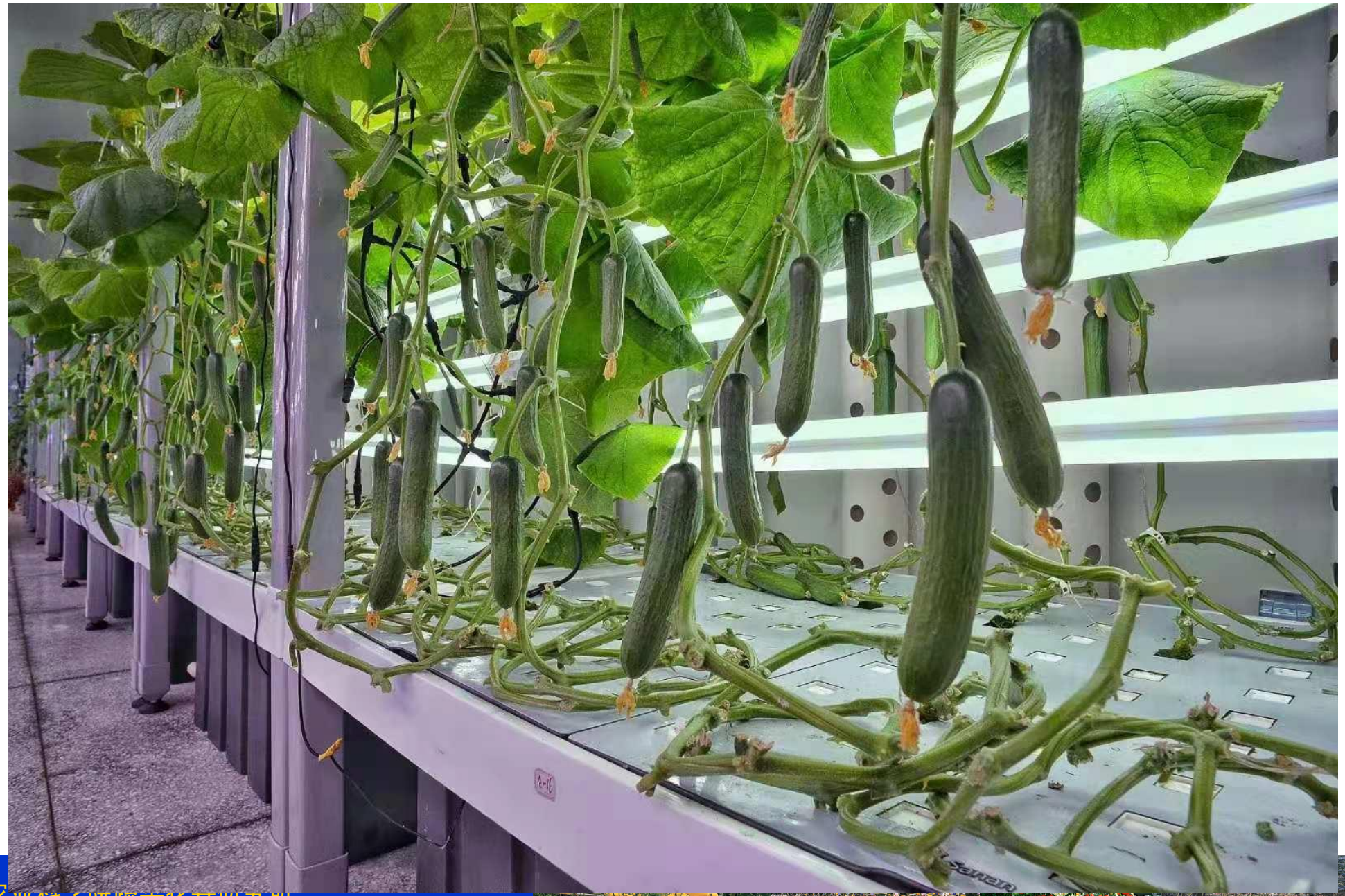
Developing soilless technology for growers who are not well educted!

Organic cultivation with soilless system

Plant factory 植物工厂







THANK YOU FOR YOUR COMING!