

# Controlled Environment Plant Production Engineering/technology Education Modules

Developed and Presented by



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## The Worldwide Technology for Controlled Environment Plant Production

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**The Worldwide Technology for Controlled Environment Plant Production**

**The Big Picture of How CEA Will Help Resolve Global World Issues related to Food, Water and Energy**

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**The world has developed controlled environment technology in the form of greenhouses to meet their needs**

Greenhouses provide food and ornamental crops

Greenhouses conserve resources

Greenhouses reduce the environmental impact of agricultural production

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## Objectives of this presentation are to provide an Understanding:

Why Greenhouses are built with their specific components for crop production

How Greenhouse designs are influenced by crop produced and local environment

That a workable Greenhouse design includes a structure, a plant growing system and an environmental control system. It then requires proper management procedures

That an economic Greenhouse design is a workable design integrated with market demand

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## Procedure

**Demonstrate through worldwide examples the production designs and practices for vegetable and fruit crops, emphasizing the following:**

Region or Country

Climate

Market

Structure and Growing System

6

## Recent Shift in Technology and Business Behavior

### 50 years ago...

- Shift towards modern CEA and soilless culture production practices

### 20 years ago...

- Meeting market demands for consistent, safe, high quality foods & ornamentals, year around

### Today...

- CEA and Soilless Culture/Hydroponics established in production agriculture

### Future...

- “Sustainable” plant production systems

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## Controlled Environment Agriculture

**Production systems for vegetable, fruit and ornamental crops which are environmentally, economically, and socially sustainable, using controlled environment & soilless culture technologies**

Meet market demand

Based on Science and Technology

Improved resource utilization

New crops

Reduce environmental impact

Improved labor conditions

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## The Universality of CEA

"As we learn from studies to support human presence within extreme conditions on other planets, we can apply such knowledge to improving the water, energy and labor efficiency to food production and life support on planet Earth"

Plants are directed by their genetics and respond to their environment, wherever they are grown

Humans require plants for life support on Earth, or wherever they go.....

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## The Worldwide Application of CEA

European Greenhouses

# The Worldwide Application of CEA

from  
**Current Status of Plasticulture in Europe**  
**Dr. Giacomo Scarascia Mugnozza**  
**PROGESA Department, University of Bari, Bari, Italy**



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### Area of agricultural plastics in Europe (2009)

Country	Greenhouses and large tunnels (ha)	Low Tunnels (ha)	Mulching (ha)	Direct covers (ha)
AUSTRIA	450			
BELGIUM	350		3,400	3,000
BULGARIA		2,500	13,000	500
CYPRUS	235			
CZECH. REP. - SLOVAKIA	4,900		2,000	
DENMARK	20			
FINLAND	200			
FRANCE	9,200	15,000	100,000	11,000
GERMANY	700	1,000	15,000	11,200
GREECE	3,000	4,500	5,000	400
HUNGARY	6,500	2,500	2,400	4,000
ITALY	25,000	26,000	85,000	12,000
MALTA	100			
NETHERLANDS	400			1,300
NORWAY			2,800	
POLAND	2,000	800		4,000
PORTUGAL	2,700	450	23,000	
SPAIN	53,235	14,641	120,039	1,400
SWEDEN	60			
SWITZERLAND			2,800	1,000
UK	2,500	1,400	10,000	12,000
UZBEKISTAN			620	
RUSSIAN FEDERATION and other EUROPEAN COUNTRIES			42,000	
<b>EUROPE</b>	<b>111,550</b>	<b>68,991</b>	<b>427,059</b>	<b>61,800</b>

From Current Status of Plasticulture in Europe  
Dr. Giacomo Scarascia Mugnozza, PROGESA  
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**Greenhouses/Large Tunnels**

**Italy 25,000**

**Spain 53,000**

**Europe total 112,000 ha**

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<b>EUROPE</b>	<b>111,550</b>	<b>68,991</b>	<b>427,059</b>	<b>61,800</b>

Low Tunnels  
Italy 26,000  
Spain 15,000  
France 15,000  
Europe total 69,000 ha

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## The Worldwide Application of CEA

Italian Greenhouses

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### Flower grower between Nettuno & Aprilia, Italy



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### Greenhouse tunnel design Vegetable grower (Nettuno & Aprilia)



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Vegetable grower (Radish) in Latina



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Vegetable grower (Zucchini) in Latina



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### Vegetable grower (Zucchini) in Latina



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## The Worldwide Application of CEA

Spanish Greenhouses

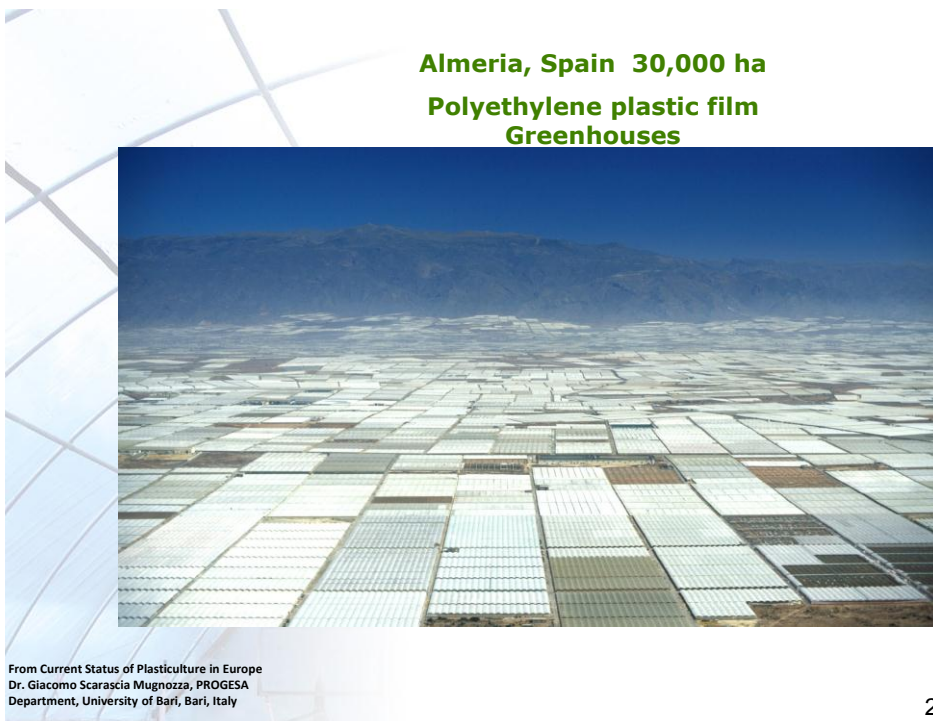


### Almeria area Province



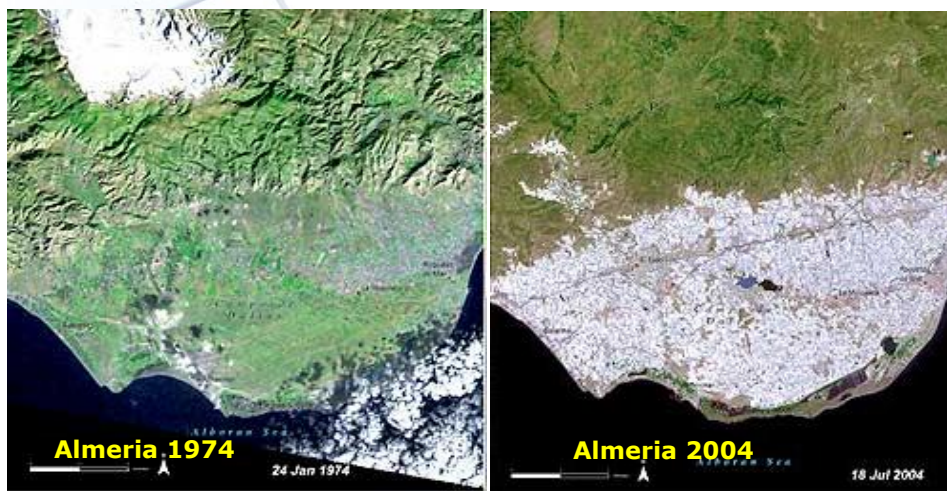
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### Almeria, Spain 30,000 ha Polyethylene plastic film Greenhouses



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## Almeria, Spain



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## The Worldwide Application of CEA

Dutch  
Greenhouses

### Classical Greenhouse Hydroponic “High” Technology



Credit: John Hoogeboom

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## The Worldwide Application of CEA

Turkish Greenhouses





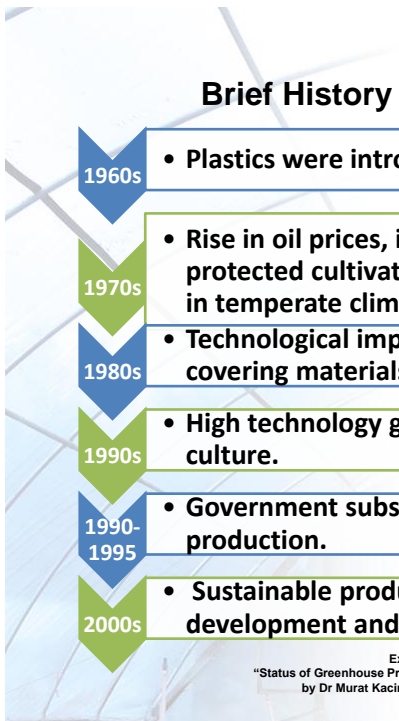
Excerpts from

**“Status of Greenhouse Production and Technology in Turkey”**

by  
**Dr Murat Kacira**  
The University of Arizona



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### Brief History of Protected Cultivation

1960s

- Plastics were introduced to agriculture.

1970s

- Rise in oil prices, increased heating costs, protected cultivation under simple shelters in temperate climates.

1980s

- Technological improvements in plastic covering materials.

1990s

- High technology greenhouses with soilless culture.

1990-1995

- Government subsidies for greenhouse production.

2000s

- Sustainable production techniques in development and application.

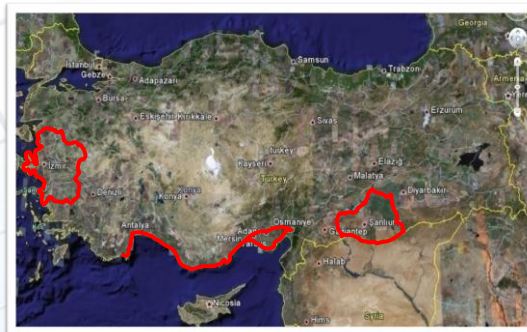


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## Regional Distribution of Protected Cultivation



Excerpts from  
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## Greenhouse Technology Level

### Low-Technology Greenhouse

- Simple structure
- Little, no or poor climate control
- Anti-frost heating
- Traditional soil production practices
- Intensive use of synthetic chemicals.



Excerpts from  
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## Greenhouse Technology Level

### High Technology Greenhouse

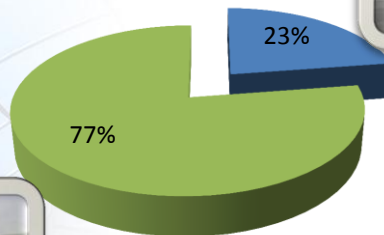
- High investment cost
- Steel structure with glass or PE cover
- Soilless culture crop production
- IPM techniques
- Eurepgap protocols with certifications
- Climate control, automation and mechanization systems



Excerpts from  
 "Status of Greenhouse Production and Technology in Turkey"  
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## Greenhouse Covering Materials

Plastic



Glass



Excerpts from  
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## MAJOR VEGETABLE CROPS PRODUCED (TurkSTAT, 2007)

(per type of protected cultivation; per type of veg crop; by weight)

Type: 1<sup>st</sup>



**Plastic Greenhouse**

2<sup>nd</sup>



**Glass Greenhouse**

3<sup>rd</sup>



**High Tunnel**

4<sup>th</sup>



**Low Tunnel**

**Crop Type**

1 <sup>st</sup>	<b>Tomato</b>	<b>Tomato</b>	<b>Tomato</b>	<b>Watermelon</b>
2 <sup>nd</sup>	<b>Cucumber</b>	<b>Cucumber</b>	<b>Cucumber</b>	<b>Tomato</b>
3 <sup>rd</sup>	<b>Pepper</b>	<b>Pepper</b>	<b>Pepper</b>	<b>Melon</b>
4 <sup>th</sup>	<b>Eggplant</b>	<b>Eggplant</b>	<b>Eggplant</b>	<b>Squash</b>
5 <sup>th</sup>	<b>Others</b>	<b>Others</b>	<b>Others</b>	<b>Eggplant</b> <b>Cucumber</b>

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## Fruit Production

(Turkstat, 2007)



from 1999 to 2007 (tons per year)

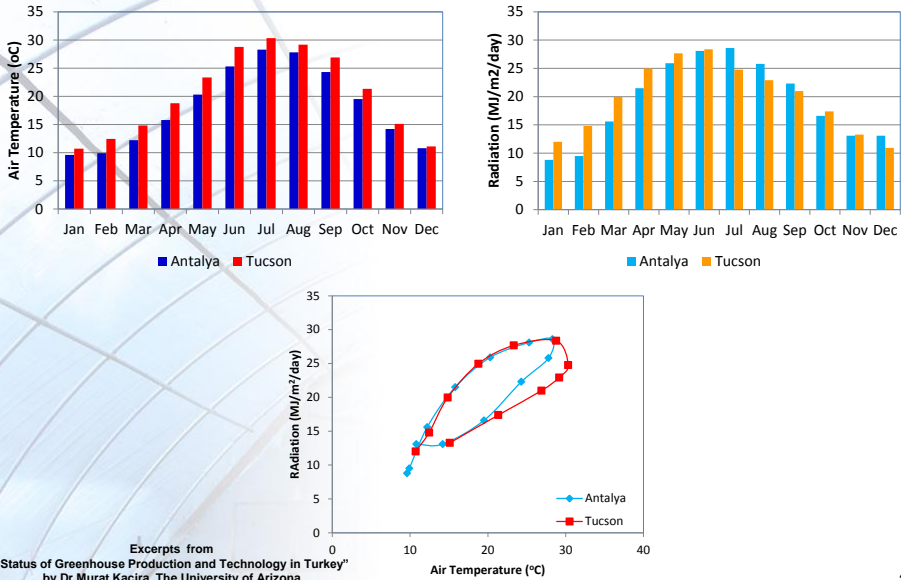
**Banana 16,000 to 130,000**

**Strawberry 15,000 to 100,000**

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## Comparison of Climate Antalya, Turkey and Tucson, Arizona



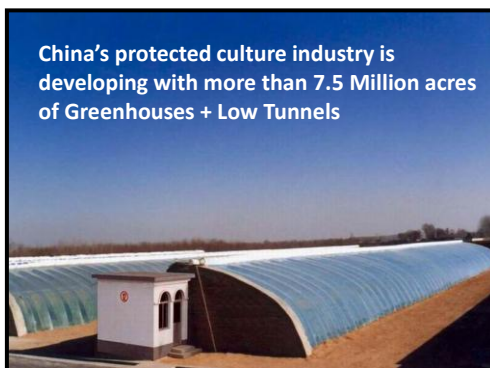
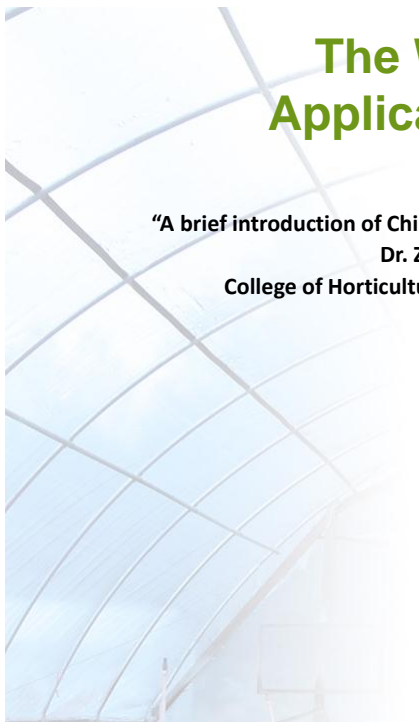
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## The Worldwide Application of CEA

Chinese  
Solar  
Greenhouse

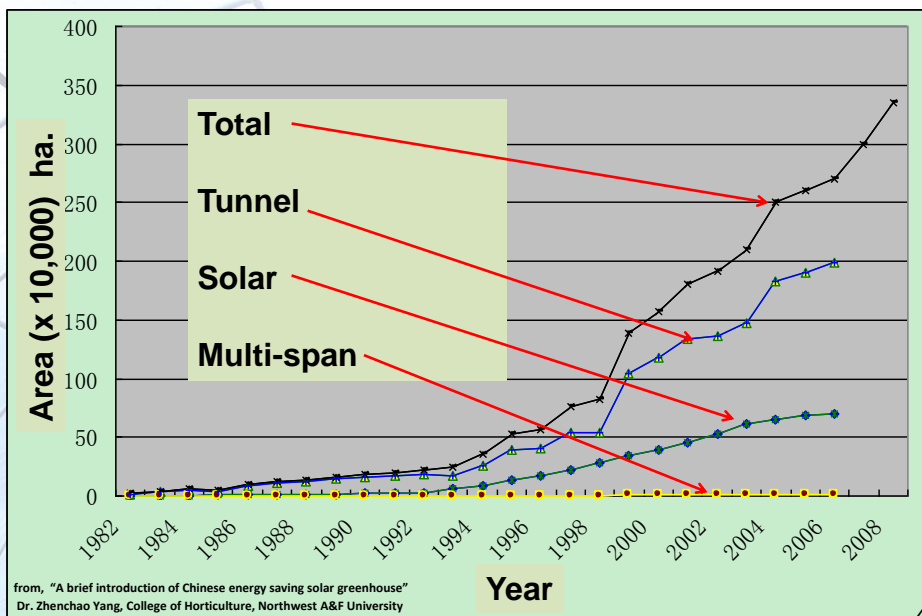
# The Worldwide Application of CEA

from  
 "A brief introduction of Chinese energy saving solar greenhouse"  
 Dr. Zhenchao Yang,  
 College of Horticulture, Northwest A&F University



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## Growth of Solar, Multi-span and Tunnel Greenhouses in China



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## Area of Solar, Multi-span and Tunnel Greenhouse

By 2008, there were total of 3.35 million hectares

Plastic house 2.3 million Ha



Solar greenhouse 1 million Ha



Glasshouse 0.012 million Ha



from, "A brief introduction of Chinese energy saving solar greenhouse"  
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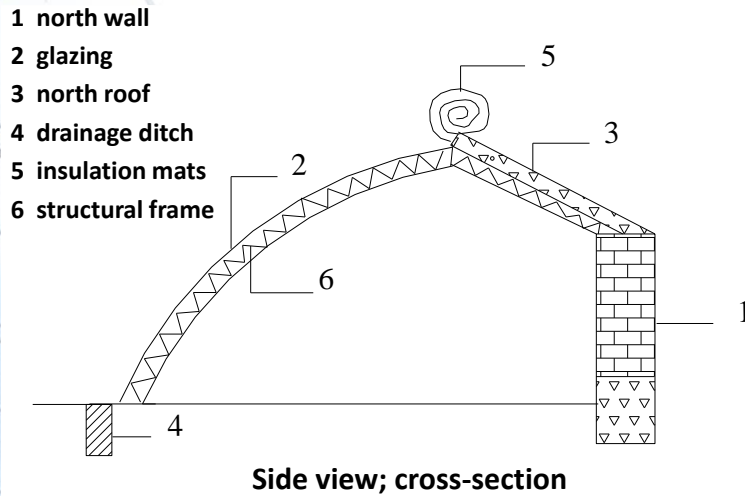
The solar greenhouse structure is built either as a stand alone, or is attached to a small building on the east or west end



from, "A brief introduction of Chinese energy saving solar greenhouse"  
Dr. Zhenchao Yang, College of Horticulture, Northwest A&F University

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## Basic structure of Chinese solar greenhouse



from, "A brief introduction of Chinese energy saving solar greenhouse"  
Dr. Zhenchao Yang, College of Horticulture, Northwest A&F University

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## The basic structure of Chinese solar greenhouse

Walls - North wall (back wall), and east/west walls are opaque

Back roof - opaque

Frames - Arch or incline structure, of steel or bamboo sticks for supporting glazing material

Glazing - glass or plastic film for transmission of solar radiation

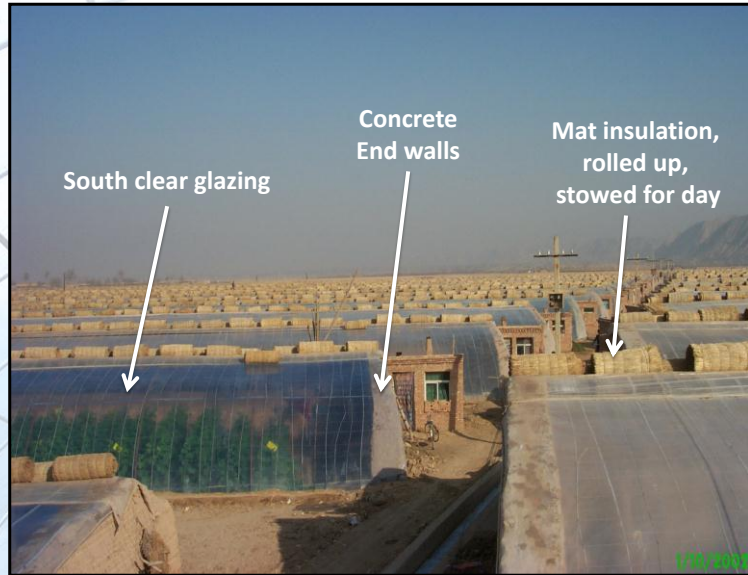
Drainage Ditch - along front glazing to remove water and prevent damage from freezing

Rush mats - outside insulation materials; rolled stowed in daylight and deployed at night

from, "A brief introduction of Chinese energy saving solar greenhouse"  
Dr. Zhenchao Yang, College of Horticulture, Northwest A&F University

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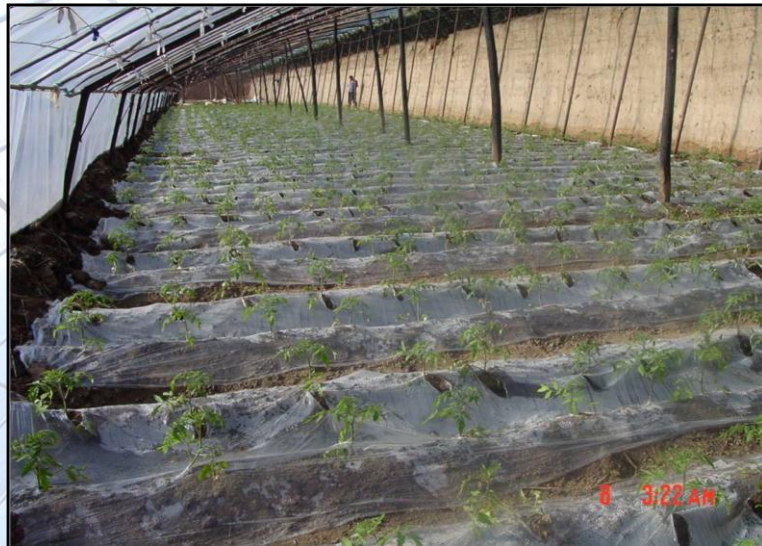
### Commercial greenhouse area



from, "A brief introduction of Chinese energy saving solar greenhouse"  
Dr. Zhenchao Yang, College of Horticulture, Northwest A&F University

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### Tomato seedlings transplanted, and with plastic film row cover inside solar greenhouse



from, "A brief introduction of Chinese energy saving solar greenhouse"  
Dr. Zhenchao Yang, College of Horticulture, Northwest A&F University

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## Greens planted directly in earth



from, "A brief introduction of Chinese energy saving solar greenhouse"  
Dr. Zhenchao Yang, College of Horticulture, Northwest A&F University

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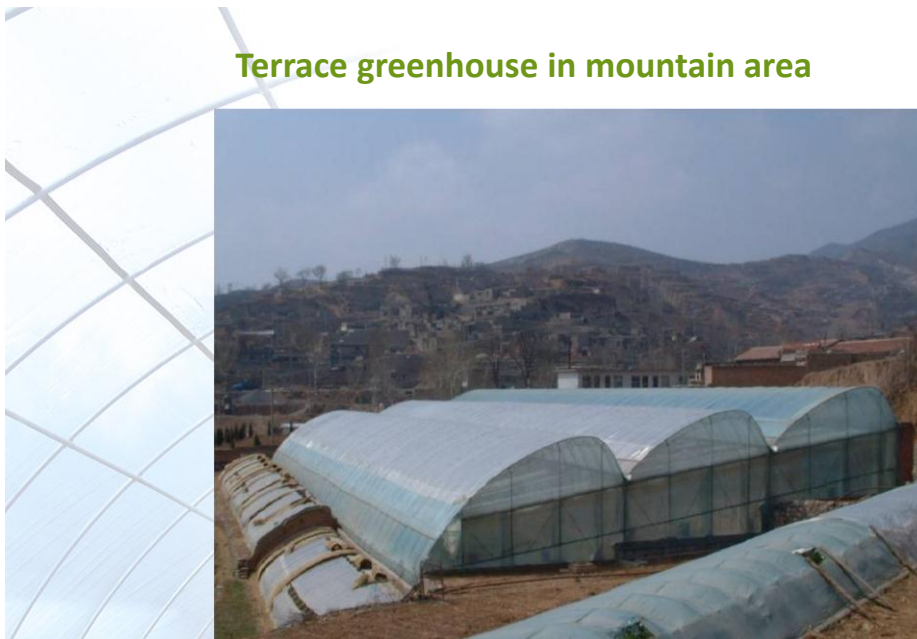
## Double-span solar greenhouse



from, "A brief introduction of Chinese energy saving solar greenhouse"  
Dr. Zhenchao Yang, College of Horticulture, Northwest A&F University

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## Terrace greenhouse in mountain area



from, "A brief introduction of Chinese energy saving solar greenhouse"  
Dr. Zhenchao Yang, College of Horticulture, Northwest A&F University

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## The Worldwide Application of CEA

USA  
Greenhouse



## USA Greenhouse Technologies

1

- High technology [ex EuroFresh Farms] – although EF is glass the other remaining high tech GH's are PE film [Village Farms, etc]

2

- Highest Technology Closed GH systems [ex Houweling and Village Farms] are glass but only a few acres at this time.

3

- Inter-planetary highest technology GH is the Lunar Greenhouse technology

4

- Medium technology [most of the larger gutter-connected PE film greenhouses in USA] about 600 hectares

5

- High Tunnel technology [most total area of smaller single free-standing GH's] about 1000 acres and growing!!

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## Eurofresh Farms, Arizona



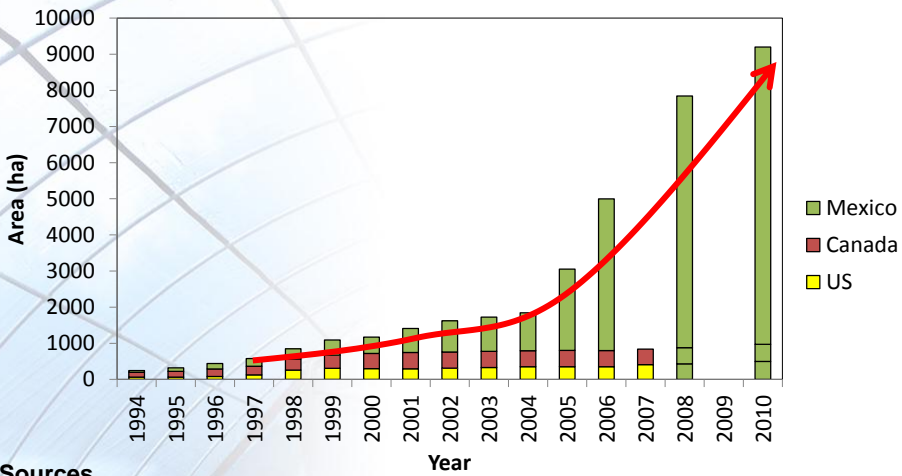
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## High Tunnel Technology



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## Greenhouse Tomato Production in North America



### Sources

Calvin & Cook, 2005 (ITC, AMPHI, Stats Canada)  
USDA, 2007  
AMPHI, 2008  
SAGARPA, 2010

Courtesy Murat Kacira

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# Acknowledgements

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