



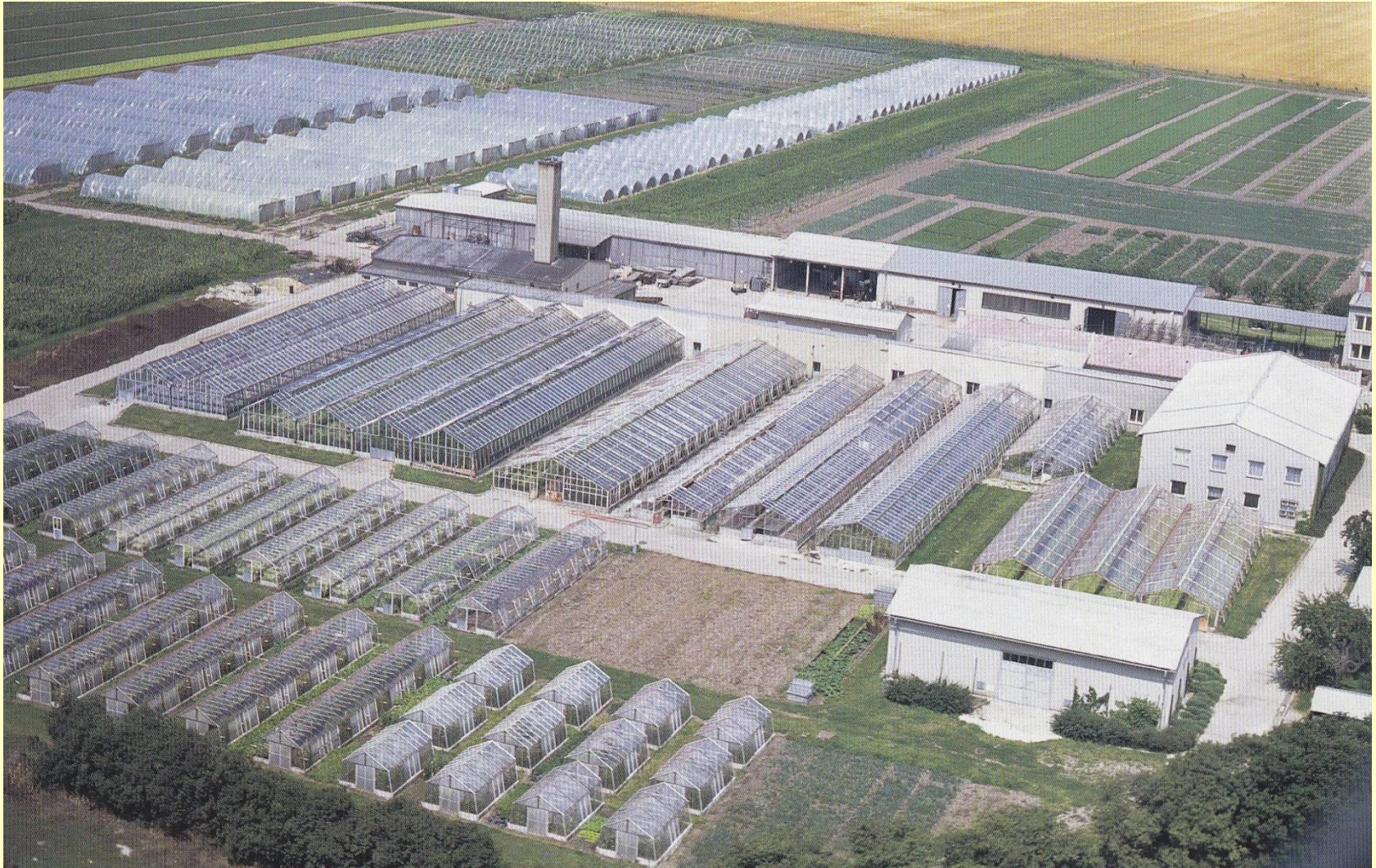
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ



Inovace studijních programů AF a ZF MENDELU  
směřující k vytvoření mezioborové integrace  
CZ.1.07/2.2.00/28.0302

**Tato prezentace je spolufinancovaná z Evropského sociálního fondu  
a státního rozpočtu České republiky**

# Constructions for vegetable forcing and their current use



# Development

## •1992

- **237ha** of spaces for forced growth dedicated to forcing of vegetables

•**Restitution in 1993** – many of claimants have not seen their greenhouses yet, got to use them, so they usually wanted to get rid

- significant decrease of areas

## •2010

- **18.5ha** spaces for forced growing
- Very high heat costs

- All kinds of vegetables were forced in the past – cauliflower, lettuce,... imports are now cheaper
- Climate is different in **Spain or France** – no problem to transport anything (open borders)
  - example - cauliflower:
- Cauliflower head would cost **80 CZK** from grower's greenhouse in CR, and through the dealer: **150CZK**

- Spaces for forcing in CR are now used for:
  - **pre-growing of seedlings**
  - **forcing of vegetables** of economically attractive species  
(tomatoes, cucumbers, marginally: radishes, lettuces, kohlrabies)

Forced:

- |                        |                |                        |
|------------------------|----------------|------------------------|
| <b>1. tomatoes</b>     | <b>30–45kg</b> | <b>.m<sup>-2</sup></b> |
|                        | <b>harvest</b> |                        |
| <b>2. cucumbers</b>    | <b>20–25kg</b> |                        |
| <b>3. bell peppers</b> | <b>10–11kg</b> |                        |
- chicory, endive, lettuce

- **Ventilation** is a must in a greenhouse

- Good greenhouse must have a **ridge ventilation**– at the top, temperature

Greenhouse without ridge ventilation: insufficient, electric fans were in

- Currently, foreign companies build greenhouses

- Automatic regulation of temperature and moisture by computer

- Fully automated greenhouses

- Many greenhouses are not built



## •Types of constructions for forcing

### •Heated spaces for forcing

–Temperature should reach **15°C and more**

-Most demanding on investments

– must be used **year round** to return investment costs

–Built in the proximity of sources of heat (waste heat):

- Nuclear power plants
- Gas compression stations
- Geothermal water (Slovakia)

## **Semi-heated constructions for forcing**

- Temperature should reach **10°C and more**
- Should be used for **9–10 months** per year; out of service in December and January



## Unheated spaces for forcing

- Temperature should reach **10°C and more**
- Should be used for **8–9 months** per year
- Without a source of heat –no boiler room, less demanding on investments
- Solar energy is the only source of heat
- Cultures easy on temperature are grown first:
  - Radish (seeding in beginning of March, or twice in a row)
  - Carrot with haulm
  - Spring onion
- End of season in **October**, new season starts at the beginning of **March**

# Durability of constructions for forcing

- 50 years with 1 planned general repair
- Return on investments: ca. 20–30 years

# TYPES OF CONSTRUCTIONS FOR FORCING

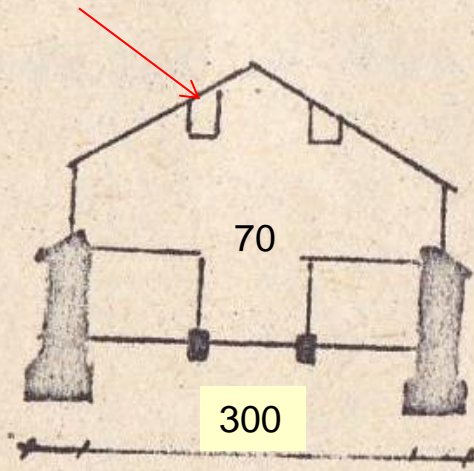
## Greenhouses built between 1950 to 1962

### Saddle greenhouses S-3, S-6, S-9

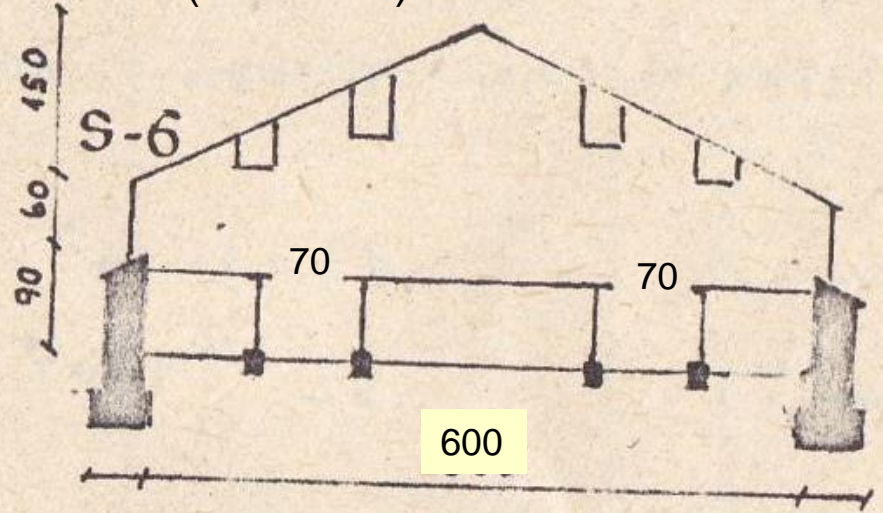
- **Warm greenhouses**, year round use
- Height of ridge: S-3 = 2.54m / S-6 = 2.7m / S-9 = 3.2m
- Massive, heavy constructions, riveted joints – not transferable, cemented glasses
- Heated with hot water or steam
- **Table equipment**
- **Pre-growing of seedlings**
- **Growing of pot flower cultures**
- **Forcing of haulm vegetable in containers** (chive, spring onion, etc.)

Hanging shelves – mother flower cultures (ficus tree)

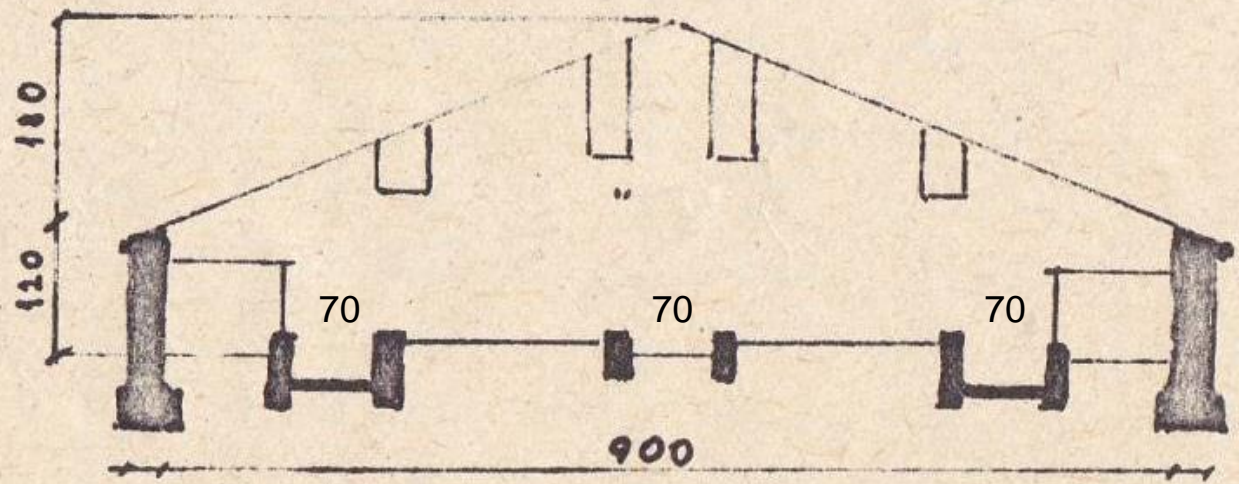
S-3



S-6



S-9

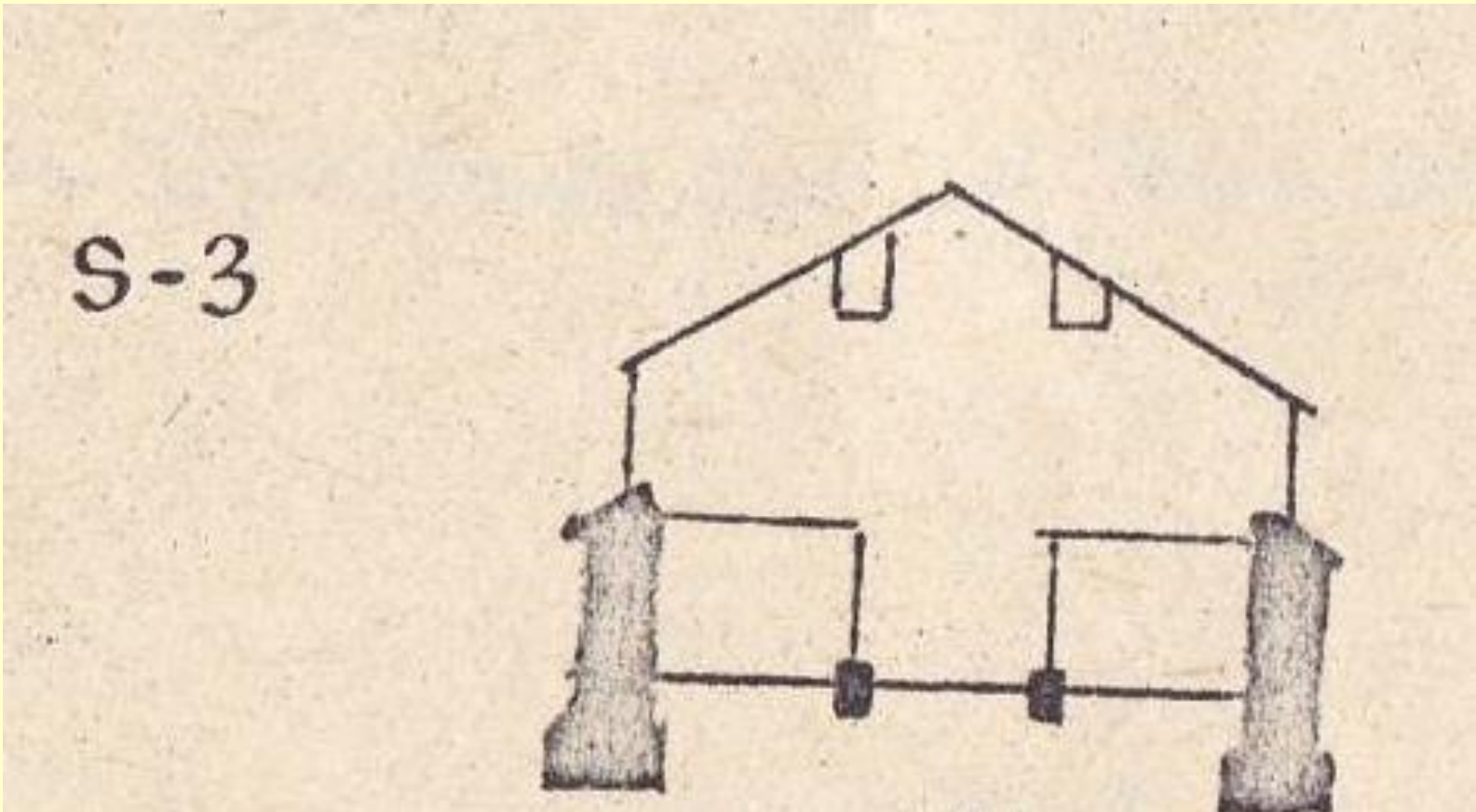


## Growing area S-3

- One-body structure, 30m long (number indicates the width of body)

Width of table:  $2.3\text{m} = 3\text{m} - 0.7\text{m}$  (aisle)

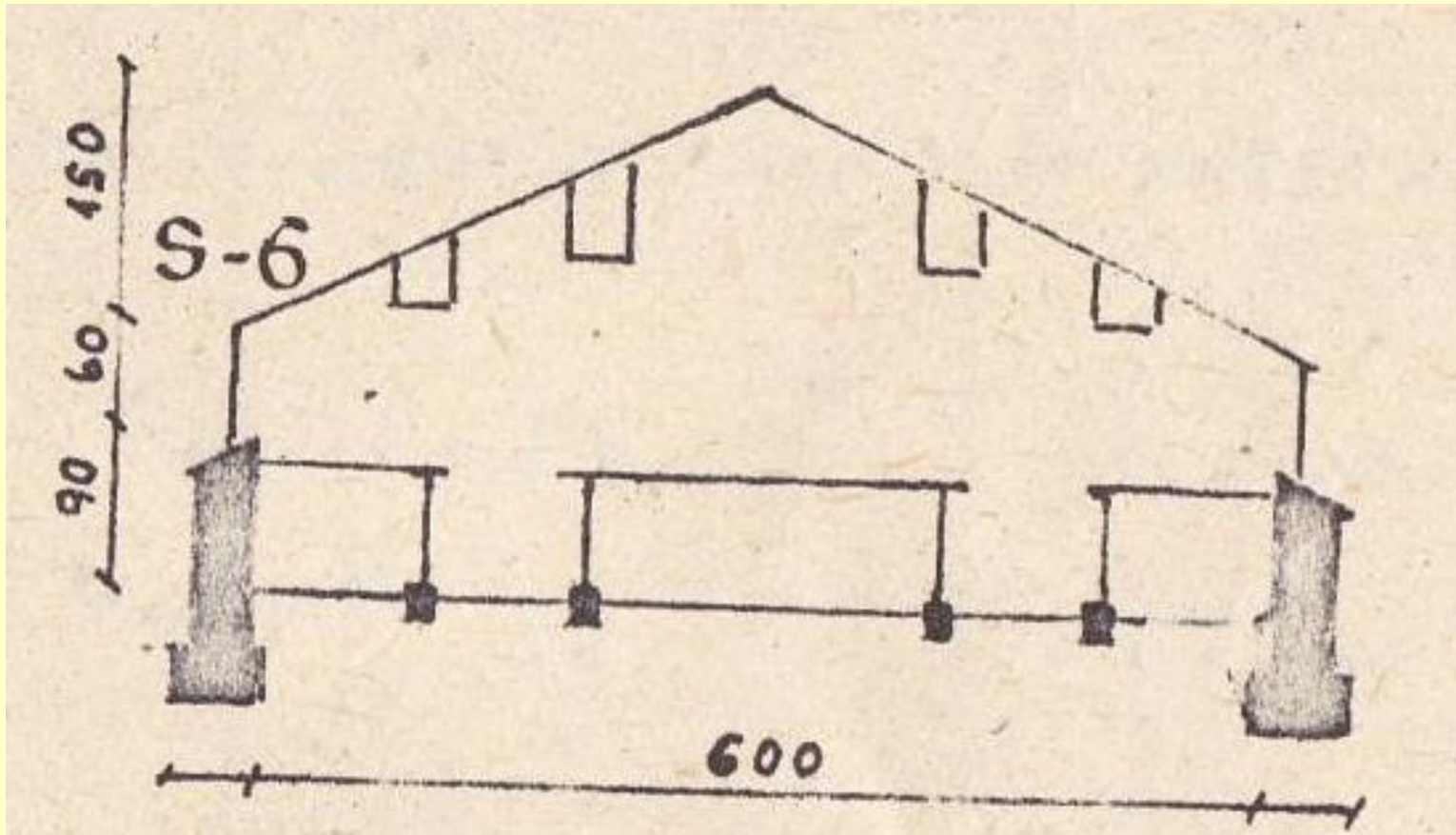
$2.3 \times 30\text{m} = 69\text{ m}^2$  (1 aisle has 70 cm)



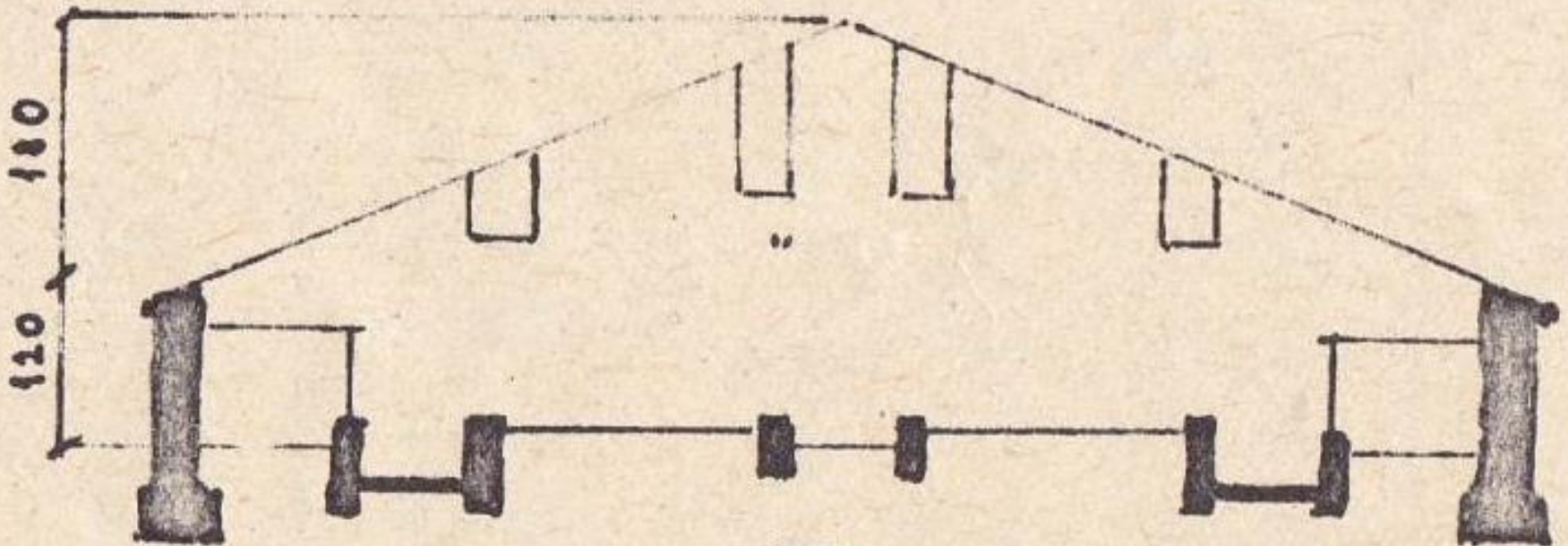
- **Growing area S-6**

- One-body, 50m long (number indicates the width of body)
- S-6 two aisles of 70 cm

$$6 - 2 * 0.7 = 4.6 \text{ m} * 50 \text{ m} = 230 \text{ m}^2$$



- **Growing area S-9**
- One-body, 50m long (number indicates the width of body)
- S-9 three aisles 9m –  $3 \times 0.7 = 6.9$  m \* 50m = **345m<sup>2</sup>**





# Hangars H 1, H 2

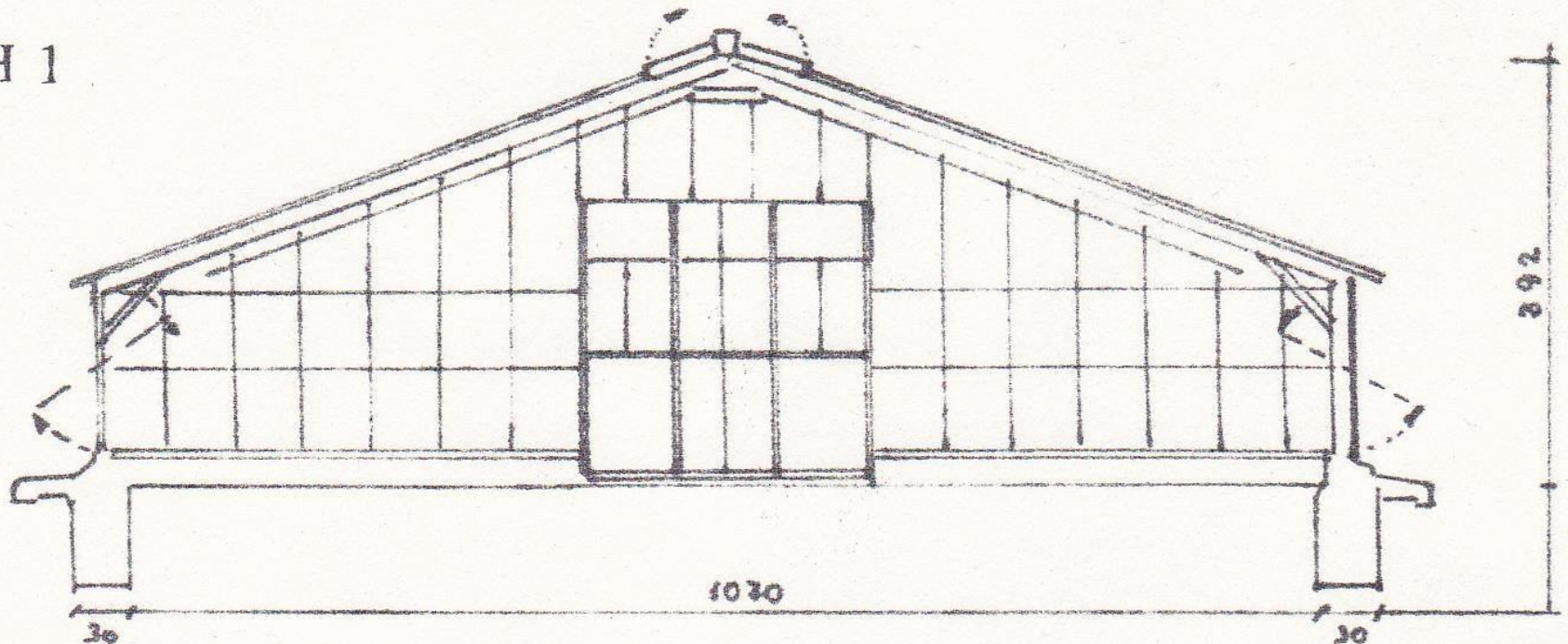
• Better than S, investor determines:

**warm** (double heat distribution)

**Semi-warm** (one heat distribution)

Excellent considering that time

H 1





- Height of ridge: 3.85 m – to calculate heat demand
  - Riveted joints – not transferable, cemented glasses
  - One- or two-body (number: number of bodies, only a barrier between)
- Growing area  $H1 = 502\text{m}^2$ ,  $H2 = 1,092\text{m}^2$
- **Same conditions in both bodies** – same or related culture
  - Lettuce + kohlrabies + cauliflower + radish (up to 10°C),  
not together with cucumbers (20°C)

H 2



Same conditions on both bodies

- Greenhouses **with free ground** without table equipment
- Used all-year round
- **Forcing of vegetables and flowers on free ground**  
(cucumbers, tomatoes, bell peppers, roses, carnations)
- **Pre-growing of seedlings**
- **Use of mechanization**
- Coarse furrows are left to freeze once every 2-3 years  
(ground used to be steamed in past)

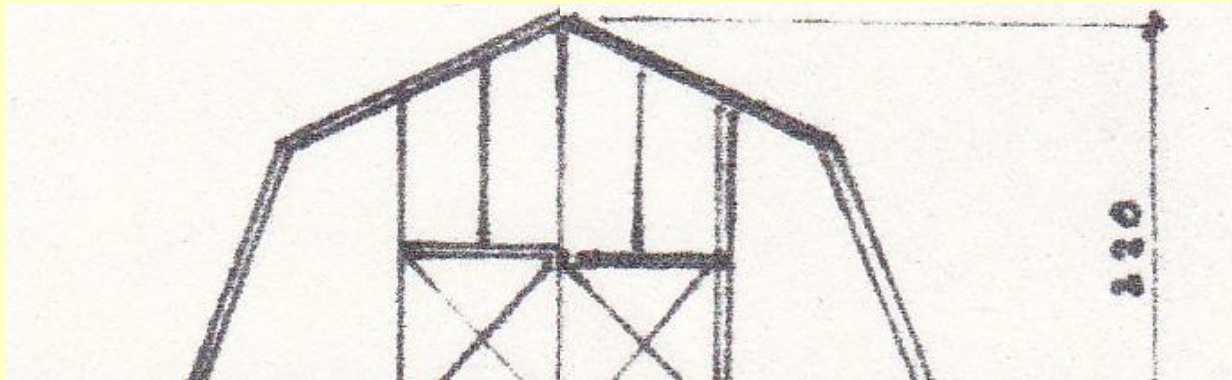
## Glass greenhouses (“Japanese structure”)

- **Semi-heated or unheated**
- Originally **wooden hotbed glasses** (1 x 1.5m) connected with **metallic angle bars – couplers**  
(community of Bulgarians during Czech First Republic)

- Only free-standing, on the ground

Later, one- and multi-body greenhouses with strong metallic construction screwed to concrete rims

### Cheap greenhouses

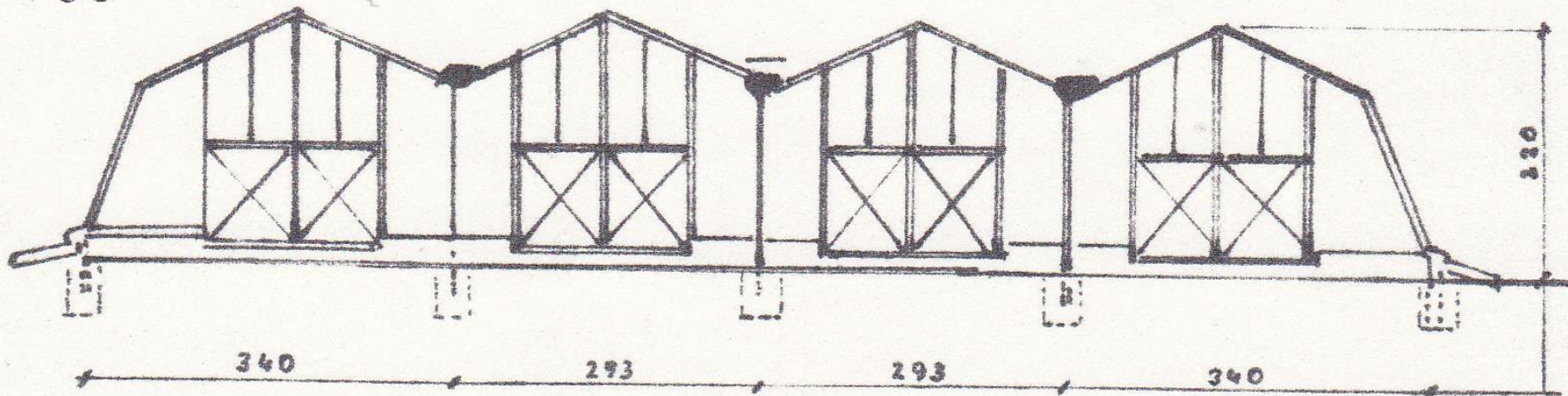


# Greenhouses built between 1960 to 1972

## Panel Japanese greenhouses PJ – 4 – 50

- Semi-heated or unheated
- Lower types of greenhouses with free ground, 4-6 bodies
- Greenhouses with metallic construction (metallic panels) screwed to concrete rims – cheap greenhouses • **glazed into U profile rubber**

PJ-4-50



- **Low ridges - 2.22m**
  - Not for cucumbers and tomatoes
- 20–50 m long

**Pre-growing of seedlings  
and forcing of low  
vegetables**  
(lettuce, cauliflower, etc.)

**Similar cultures in all bodies of  
the greenhouse** – only beams  
between bodies

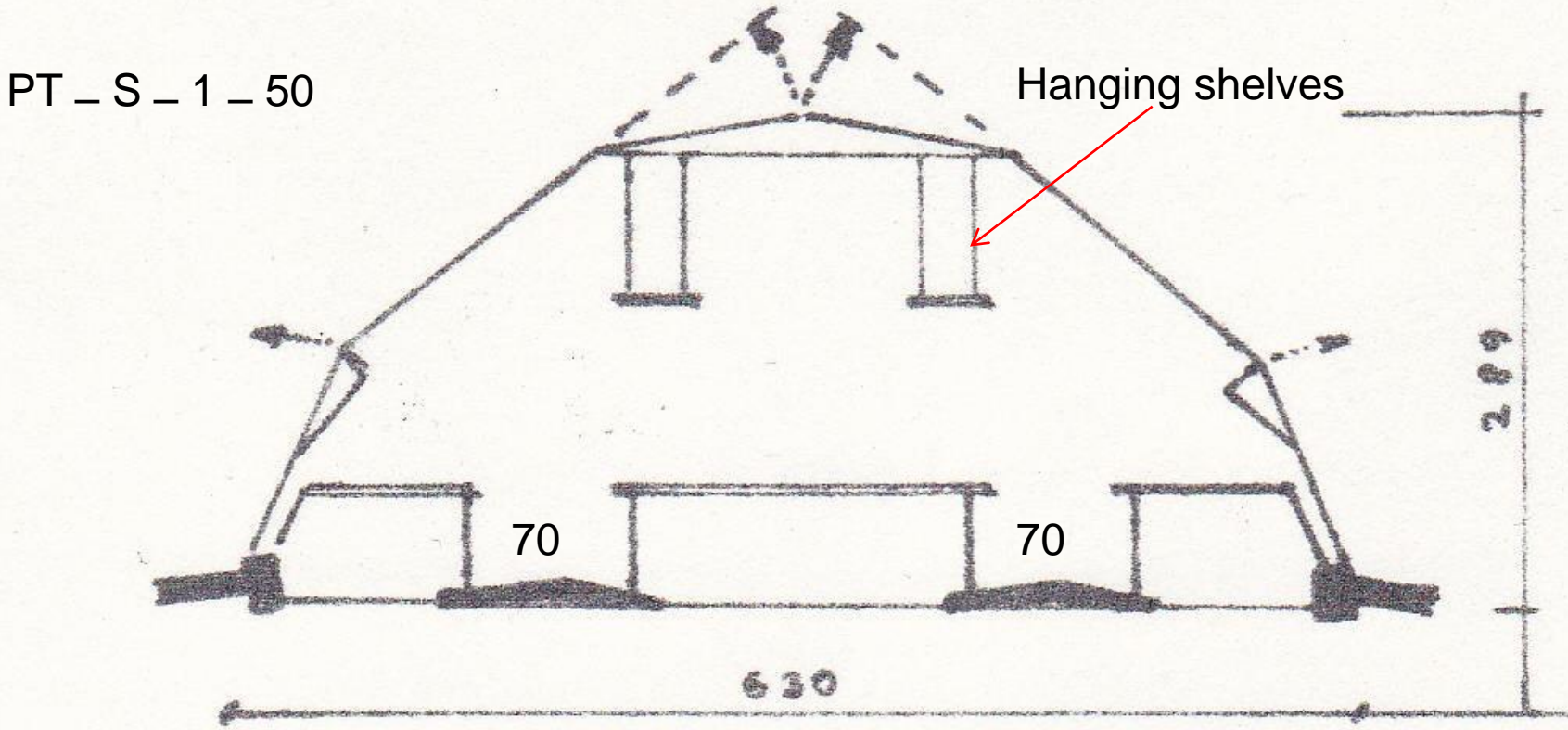
# Panel tunnel greenhouses

PT – S – 1 – 50 (table)

PT – M – 1 – 50 (reproducing – intensified heating under the table)

•2x angular roof – similar to a tunnel

Heated greenhouse, without table equipment and semi-heated





- Ridge: 2.89 m high (tomatoes and cucumbers – no problem) • One or three-body
- Galvanized full metallic construction, **units are metallic panels 150 x 179.6cm screwed together**, foundation - concrete rim
- Construction is lighter, structure is brighter
- Glazed into **rubber of U profile, galvanized lug**
- Heating:
- Warm-water: good
- or warm-air (bad, fungal diseases, uneven temperature – did not prove to be good)

# Light universal spaces for forcing - LUSF

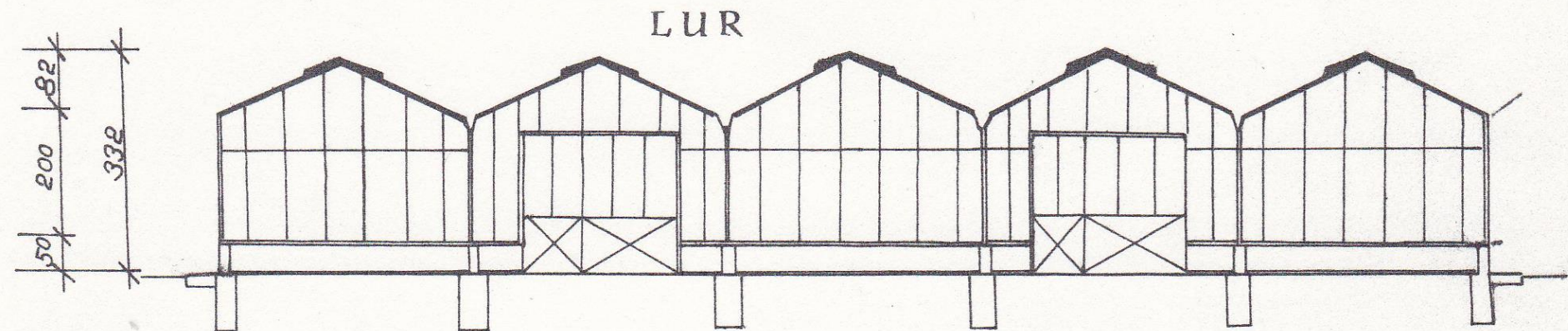
## •Heated greenhouses

Two- and four-body or nine-body (also eleven- body)

•Table-arrangement, mostly with free ground

•Screwed construction, vertical side walls

Ridge: 3.93 m high



- Roofs are steeper and ridges are higher, compared to tunnel greenhouses
- Ideal **for growing of high plants:**
- tomatoes, cucumbers, carnations, roses, anthuriums, etc.
- Warm-water heating, **glazing with help of putty**

## Greenhouses built after 1972

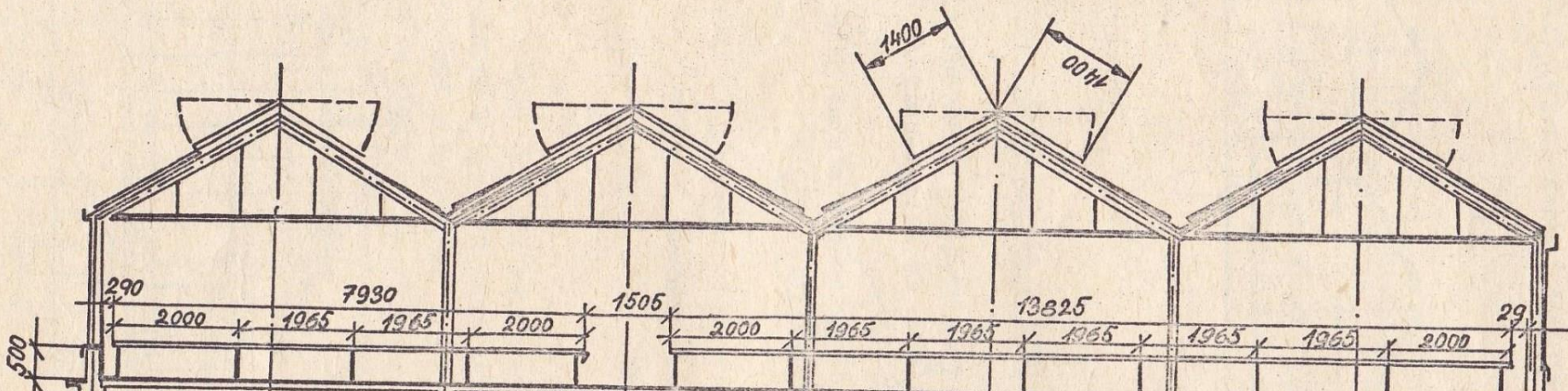
### Light universal spaces for forcing LUSF II

#### Heated greenhouses

- Table-arrangement as well as free ground
- Four- up to twenty-body constructions

**High ridges – 4.66 m**

LUR II-493



- Automatic regulation of temperature
- Warm-water heating
- Glazing with putty

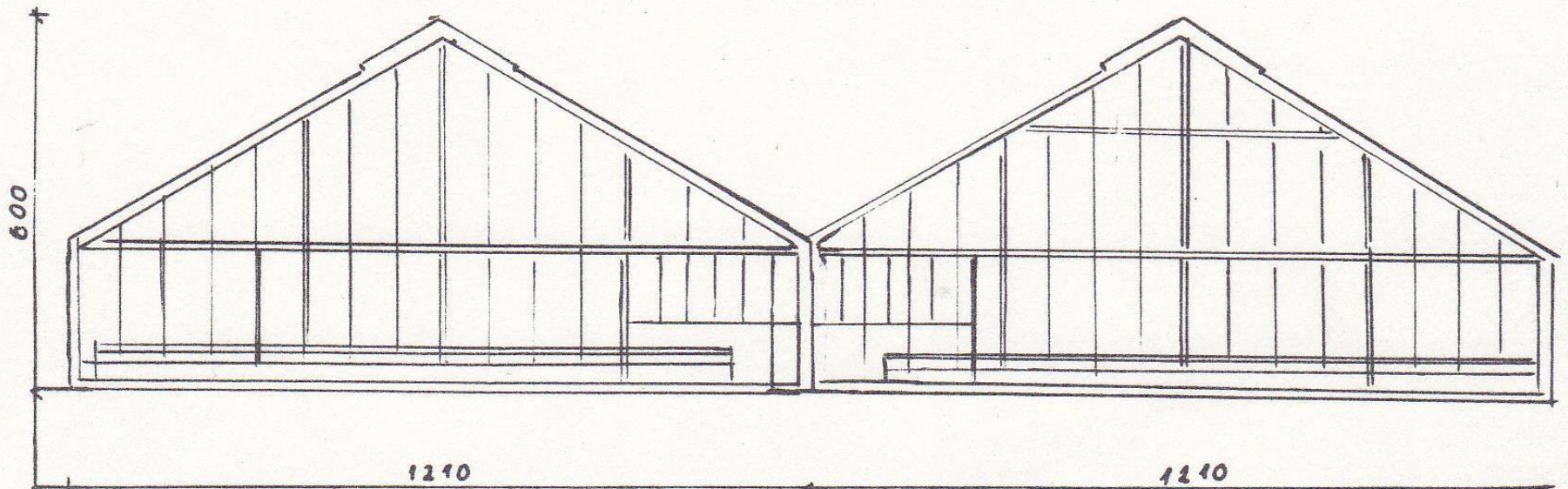
**Necessary all-year round service** – light roof construction cannot bear loading from wet and heavy snow

## Hangar 24/93

- Heated greenhouse

Two-body hangar, 12m wide, length of body: 93 m

- For all-year round use
- Height of ridge: 3.92 m
- Used as LUSF



## Overview of typified greenhouses built until 1962

Type	Surface area m <sup>2</sup>	Growing surface m <sup>2</sup>	Length	Width	Height of ridge	Height of gutter
S - 3	90	69	30	3	2.54	1.48
S - 6	300	230	50	6	2.7	1.55
S - 9	450	345	50	9	3.2	1.55
H - 1	535	502	50	10.7	3.85	1.94
H - 2	1,125	1,092	50	22.5	3.85	1.94
J - 1	106.8	96.1	30	3.56	2.35	1.75
J - 5	481.8	433.6	30	16.06	2.35	1.75

## Overview of typified greenhouses built until 1970

Type	Surface area m <sup>2</sup>	Growing surface m <sup>2</sup>	Length	Width	Height of ridge	Height of gutter
PT S 1-50	319.06	241.78	50.48	6.32	2.89	-
PT M 1-50	319.06	235.47	50.48	6.32	2.89	-
PT S 1-21	137	105	21.68	6.32	2.89	-
PJ 4-50	637	620	50.48	12.66	2.22	1.65
PJ 6-50	922.77	909.14	50.48	18.28	2.22	1.65
PJV 5-51	971.93	950	50.48	19.23	3.32	2.5
LUSF 4-93	2307	2,200	93.12	24.77	3.93	2.3
LUSF 4-93 TABLE	2307	1,516.72	93.12	24.77	3.93	2.3
LUSF 9-93	5100	4,890	93.12	54.77	3.93	2.3



## Overview of typified greenhouses built since 1971

Type LUSF II	Equipment	Surface area m <sup>2</sup>	Growing surface m <sup>2</sup>	Length	Width	Height of ridge	Height of gutter
245	table	552.6	172.8	45.15	12.24	4.66	2.76
445	table	1,094.43	752.4	45.15	24.24	4.66	2.76
445	free ground	1,094.43	1,067	45.15	24.24	4.66	2.76
293	free ground	1,098	712.8	93.15	12.24	4	2.76
493	table	2,258	1,584	93.15	24.24	4.66	2.76
193	free ground	2,258	2,211	93.15	24.24	4.66	2.76
693	free ground	3,375.75	3,323	93.15	36.24	4.66	2.76
1093	free ground	5,611.35	5,550	93.15	60.24	4.66	2.76
1093	with barriers	5,611.35	5,550	93.15	60.24	4.66	2.76
2093	free ground	11,200.35	11,115	93.15	120.24	4.66	2.76
2093	with barriers	11,200.35	11,115	93.15	120.24	4.66	2.76
H 22	free ground	2,096.55	2,016.5	93.15	22.73	3.92	2.76
S 6	table	332	212	48.85	6.6	2.7	2.76

# Greenhouses today

## Greenhouses in Netherlands, Denmark

- **Thermal insulation**

- **Double foils** filled with air

- Insulating **hollow plates from polycarbonate**

- Construction of greenhouse with **fully-opening roof**

- Very fast ventilation

- **Automation**

- Regulation of temperature, moisture, irrigation, computer

- Greenhouses should be used, not only to pre-cultivate seedlings and then leave empty, greenhouses have to be used: tomatoes 6-12 months









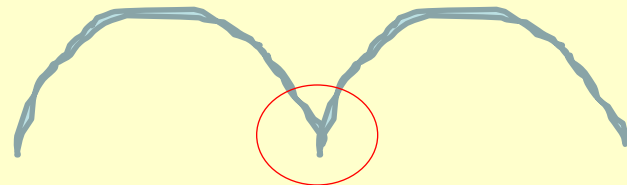


# PLASTIC GREENHOUSES

- Plastic greenhouses: light structures, semi-circular metallic construction
- Costs of construction are lower than for greenhouses, easier to build
- 20-90 m long

Covering material – **polyethylene foil**, 0.125-0.200 mm thick

- Usually 0.125-0.150 mm
- Degradation due to UV radiation is the same both for thicker and thinner foils
- Foils are sold per kg price: no need to buy thicker
- Last 1 veg. season, reinforced foil with UV filter: 4-5 years
- One- and multi-body, multi- body greenhouse – problem to anchor





- **Problem with ventilation** – cannot be ventilated by opening front windows only
  - Temperature in the middle section of the greenhouse is high
- Ventilation using front windows is sufficient for 30m long constructions
- Above 30m: 2m gaps in the sheathing – rods with removable foil across

Foil must be covered with soil at the ground so that wind does not get under it (Brno Slatina – 1ha of plastic greenhouse flew away)

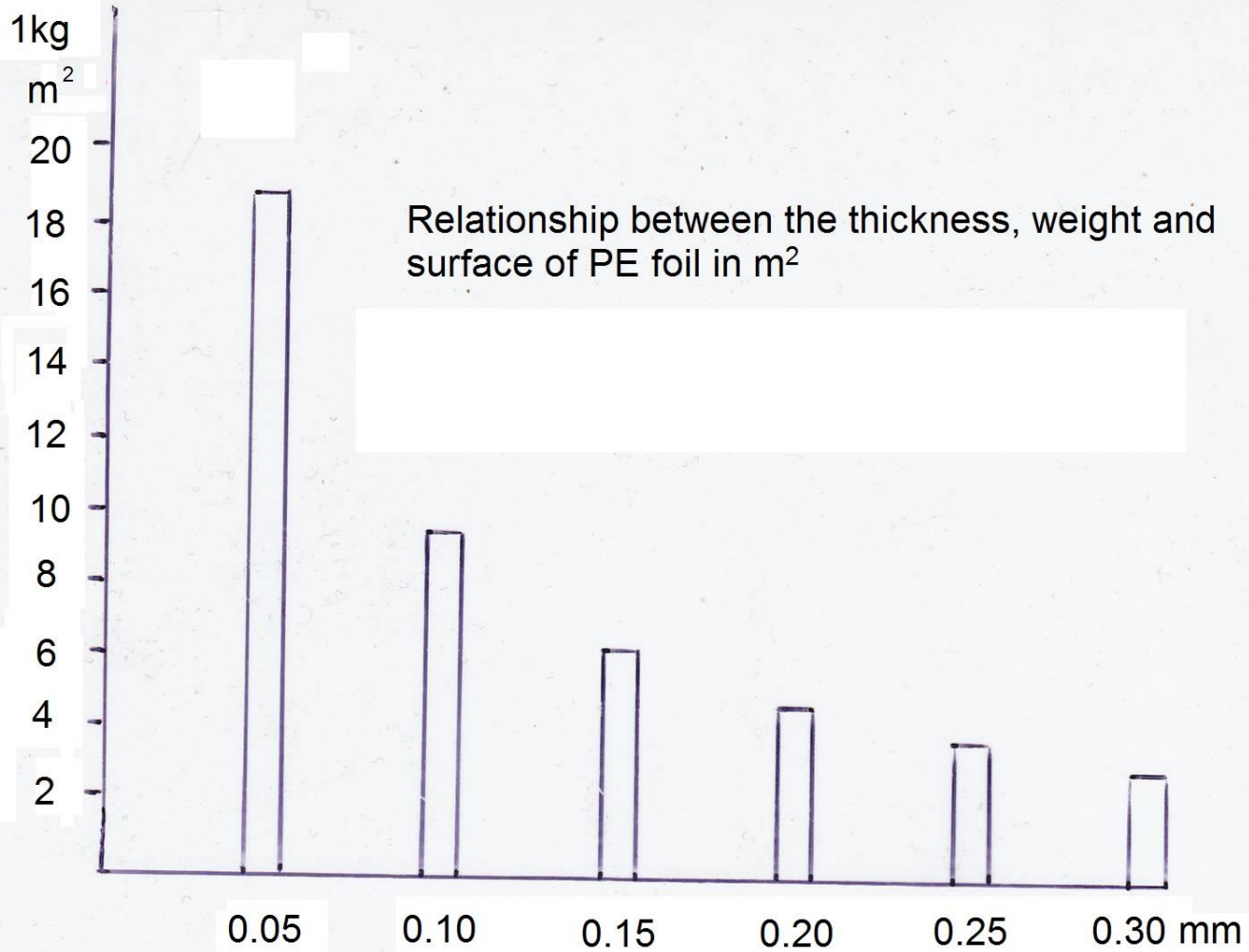
- **Foil retains only 40% of heat, 60% of heat escapes** – that is why these greenhouses are not heated

(There are no heated plastic greenhouses in the CR)

- Only for **forcing** in less appropriate climatic conditions (cucumbers, tomatoes at higher altitudes)

### **Growers who use plastic greenhouses today:**

- **Forcing of 1 vegetable** - lettuce, kohlrabies, radishes
- **which is followed by thermophilic plants:** tomatoes, cucumbers, bell peppers



## Plastic greenhouse FS 6x30 (STS Mělník)

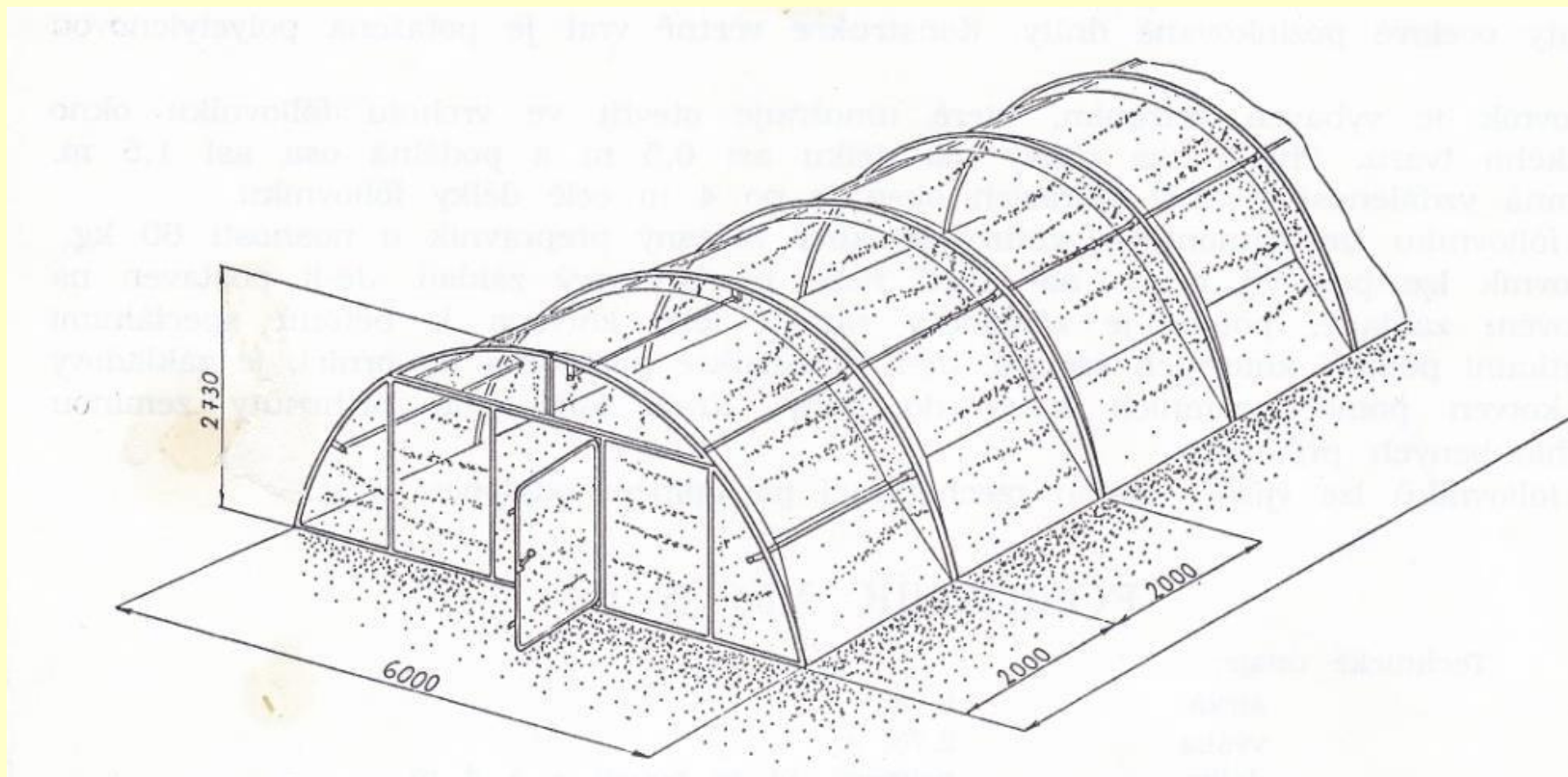
- Width: 6m, length: 30m, height: 3m

Fully metallic, galvanized **tubular construction**

• Basic frame is anchored in soil or **concrete**

- 23 arches + 2 frames for doors are installed

**Front ventilation + additional lateral ventilation**



- Growing surface: **150m<sup>2</sup>** (strips of land close to the foil are not used)
- **PE foil (Polyethylene) 0.125–0.200 mm** - most often 0.150 mm
- If foil is not be stabilized against UV radiation, it lasts only 1 vegetation period
- Long-lasting foil stabilized for UV radiation – we may keep lettuce over winter for overwintering as well as endive and others
- **(PVC is not appropriate – it softens by heat, sags down – creates pockets in the rain, and releases phenolic substances)**

## Plastic greenhouse FS 9x48 (50)

- Width: **9m**, length: **48.5m**, height: 3.48m
- **Up to 70m** long
- Fully metallic, galvanized **tubular construction**
- Basic frame is anchored in soil or concrete
- 2 front arches, 14 simple arches, 8 twin arches, arches **2 ventilation arches**
- Two-piece arches, screwed
- Slovakia: foil greenhouses **are made from waste pipes – 40% decrease in costs, not galvanized**
- Used as **cold greenhouses** for finalization of growth of seedlings

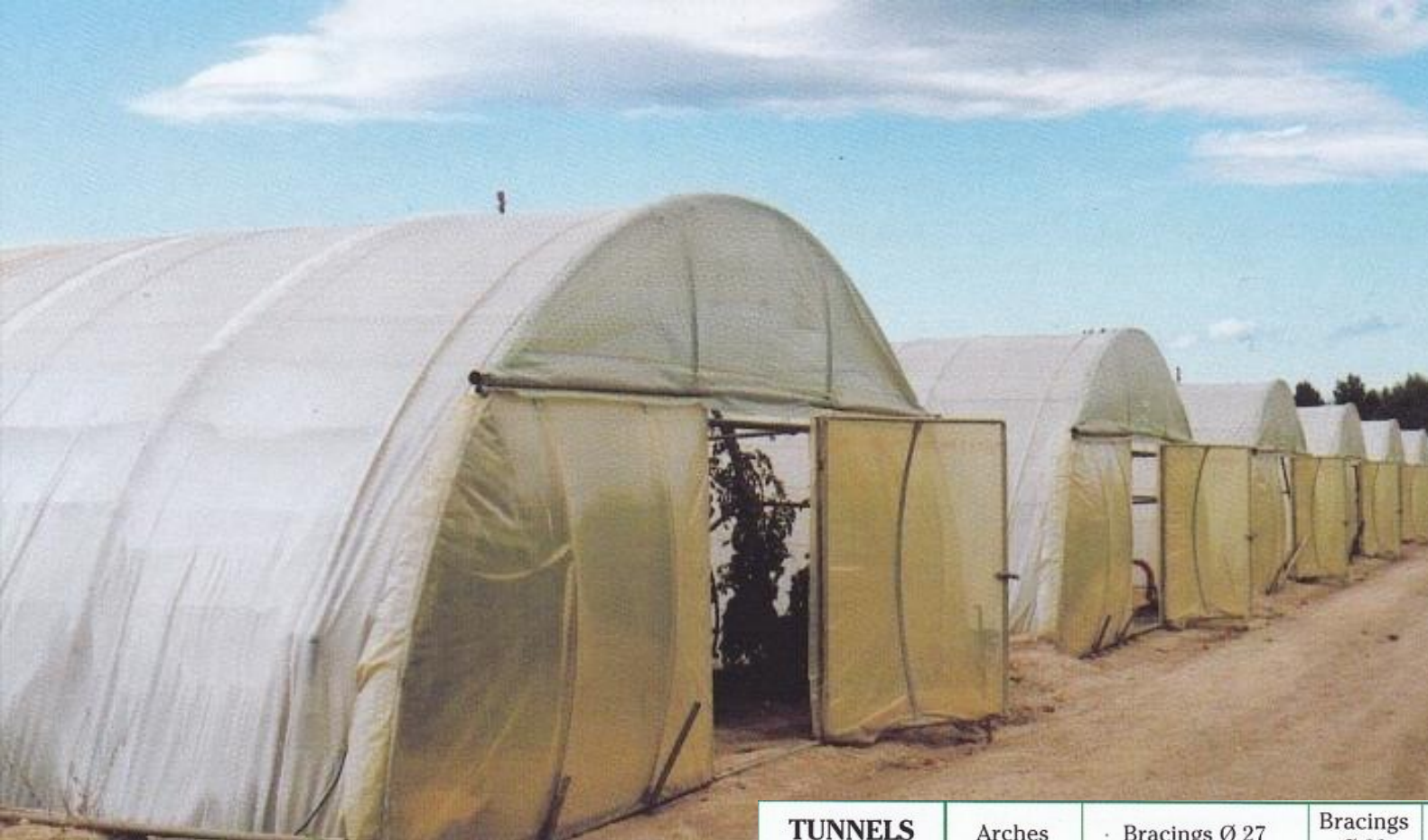
Thermophilic vegetables are grown over summer months (tomatoes, cucumbers, bell peppers)



Plastic greenhouse *FILCLAIR*  
France, modern plastic greenhouse



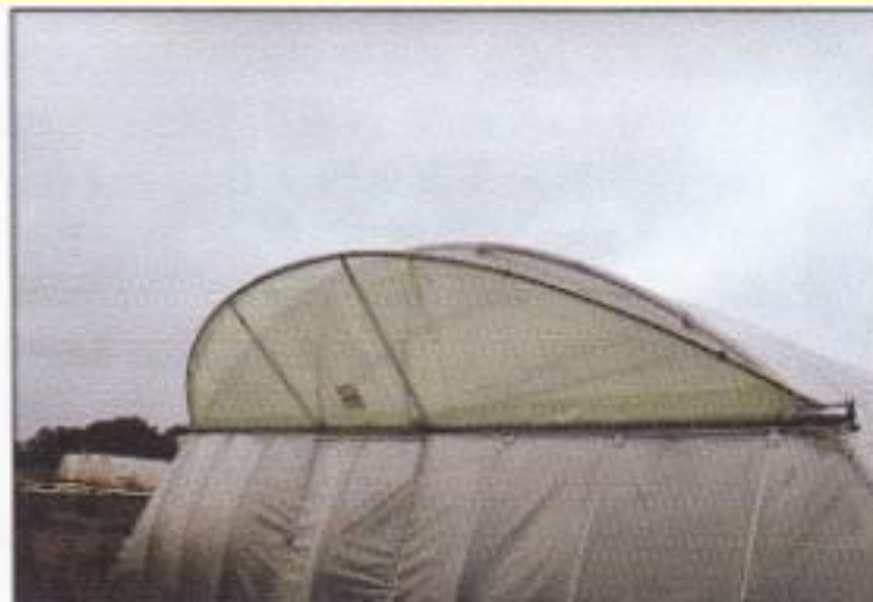




# FILCLAIR TUNNELS

TUNNELS	Arches		Bracings Ø 27		Bracings Ø 32	Distance between elements
	Nb	Ø mm	Regular	Cross	P.O. Type	
4.50	2	32				2
6.00	3	60				0.75/1/1.5/1.65/2/2.25/2.5/3
7 GM	3	60	•		•	0.75/1/1.5/1.65/2/2.25/2.5/3
7/78	3	60	•	•	•	0.75/1/1.5/1.65/2/2.25/2.5/3
8.00	4	60	•	•	•	0.75/1/1.5/1.65/2/2.25/2.5
8.50	4	60	•	•	•	0.75/1/1.5/1.65/2/2.25/2.5
9.00	4	60	•			0.75/1/1.5/1.65/2/2.25/2.5
9.30	4	60	•	•		0.75/1/1.5/1.65/2/2.25/2.5
9.30 CR	4	60			•	0.75/1/1.5/1.65/2/2.25/2.5





# HOTBED

- Basic element: **hotbed window 1 x 1.5 m**
- Concrete side walls, today also from plastic
- Low height, not suitable for high cultures**
- Ventilation is a problem** – window is too heavy, but today it is made from Polycarbonate
  - light (swab – oil – automatic lifting)
- Used to be filled with manure (30-40cm layer !), today **warm-water heated hotbed or solar heating**

- Applications:
  - **Production of seedlings**
  - **Growing of low cultures – lettuce, cauliflower, etc.**
  - July/August: cucumbers (covers the soil quickly, no need to remove weeds; only harvest),  
peppers: Anything is better than leave the hotbeds empty and infested with weed

Average size of vegetable farm up to 40ha: hotbed for production of seedlings