Selection of Structures and Equipment

Climax Conseils and Gobeil Dion & Associés Training Course

GOBEIL DION & ASSOCIÉS INC
Ingénierie, énergie & environnement

CLIMAX CONSEILS

Choosing a greenhouse is like choosing a home; along with the many possibilities come just as many needs and financial capabilities.

Part 1: Structures and Equipment

SELECT YOUR STRUCTURE

Tunnel greenhouse

Gothic-arch gutter-connected greenhouse

Gothic-arch individual greenhouse

Venlo greenhouse

Area in production and installation type

Installation type	Size
Individual greenhouse	± 300 m^2
Gutter-connected greenhouse	800–3,000 m^2
Greenhouse complex	10,000 m^2
Large complex	50,000 m^2

Adapted from Climax Conseils

Structures

- Individual greenhouse

Source : GDA et Climax Conseils

Structures

- Gutter-connected greenhouse

Structures

- Greenhouse complex

Source : GDA et Climax Conseils

Structures

- Large complex

Source: Gobel Dion et Associés and Climax Conseils

Production in a controlled environment How to choose:

- Capital investment
- Target market
  - Retail
  - Retailer
  - Wholesaler or sales channel
- Growing season
- Crop selection

Capital investment vs. installation costs

Installation type	m^2	$/m^{2**}$	$
Individual greenhouse	300	$200	$60,000
Gutter-connected greenhouse	800	$400	$320,000
Greenhouse complex	10,000	$650	$6,500,000
Large complex	50,000	$350	$17,500,000

**Additions possible

Adapted from Gobeil Dion & Associés and Climax Conseils

Capital investment vs. installation costs

- Greenhouse options
  - Add \$50-\$150/m^2 for biomass
  - Add \$100-\$150/m^2 for HPS
  - Add \$200-\$250/m^2 for LED

Source: Gobeil Dion & Associés

Target market

Installation type	Retail	Retailers	Wholesalers	Sales channels	Other
Individual greenhouse	X	X			X
Gutter-connected greenhouse	X	X	X		X
Greenhouse complex			X	X	X
Large complex			X	X	X

Adapted from Climax Conseils

Production schedule according to structure type

Installation type	Seasonal	Year-round (unlit)	Year-round (lit)
Individual greenhouse	X	Greens	Lettuce, strawberries
Gutter-connected greenhouse	X	X	X
Greenhouse complex		X	X
Large complex			X

Adapted from Climax Conseils

Choosing crops according to structure type

Installation type	Tomatoes	Cucumbers	Peppers	Eggplants	Leafy greens and herbs	Strawbarries
Individual greenhouse	X	X	X	X	X	X
Gutter-connected greenhouse	X	X	X	X	X	X
Greenhouse complex	X	X	X		X	X
Large complex	X	X	X		X	X

Adapted from Climax Conseils

Choosing structures according to operational and functional needs

Technology	Criteria	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Gutter-connected greenhouse 800 m^2?	Heating												
	Labour												
	Management												
	Yield												
	Artificial light												
Low-crop individual greenhouse	Heating												
	Labour												
	Management												
	Yield												
	Artificial light												
High-crop individual greenhouse	Heating												
	Labour												
	Management												
	Yield												
	Number of installations												
	Separation												

Excellent, good, ok, unwise, to avoid

Structure: Height

Why is height important?

- What it helps with:
  - Maintaining better thermal stability
  - The use of certain technologies (e.g. lighting, air circulators, etc.)
  - Labour cost savings
  - Creating a buffer between the crops and cold winter air; and
  - Keeping the crops on the cool end of the temperature gradient during the summer.
    - Greenhouses in warmer regions (Leamington) are taller than greenhouses in colder regions (Quebec)

Structure: Height

Different greenhouse heights (from ground to gutter)

Height required by crop

- Peppers: 6’ to 27’
- Cucumbers: 7’ to 21’
- Tomatoes: 10’ to 21’
- Lettuce: 12’ to 18’

- Temperature at the crop canopy

  Light uniformity

Structure: Height

According to crop type

- Crop height
  - **Low:** lettuce, strawberries, vining cucumbers, peppers (short season)
  - **High:** tomato, vining cucumbers, peppers (long season)
  - What height do you need according to your equipment?
  - Do you need electric trolleys for working at heights?

Minimum height clearance under the trust related to crop and technology (12 months)

Height	Tomato	Pepper	Cucumber		Lettuce strawberry
(feet)			Umbrella	High wire	
25					
24					
23					
22		Screen			
21		Plants + HPS			
20	Screen			Screen	
19	HPS			HPS	
18					
17					
16					
15					
14		Plants	Screen		
13			HPS		
12	Layering			Layering	Screen
11	Plants			Plants	HPS
10					
9					
8					
7					
6			Plants		
5					
4					Plants
3	Work at the base of the plant			Work at the base of the plant	Growing gutter
2					
1					

Source : Climax Conseils

Cover types: Factors

Parameter	Double poly	Polycarbonate single layer (8 mm)	Polycarbonate twin-wall (16 mm)	Glass
Light transmission (%)	80%	83%	75%	90%
Heat loss ($W/m^2 * K$)	4,0	3,3	1,9	5,7
Insulation R-value	1,5	1,7	2,5	0,2
Average cost ($/pi^2)	0,35 $	2,25 $	4,00 $	1,10 – 1,50 $
Energy saving (%)	50% more than single polyethylene	20% more than double poly	30% more than polycarbonate single layer	

★ **The higher the R-value, the better the material insulates!**

Cover types: POLYETHYLENE PLASTIC

- Needs to be replaced every 3 to 4 years
- Double polyethylene
  - Light transmission: 83%
  - Inflatable
  - More insulating that a single layer
  - Good light scattering
- Films
  - IR
  - Anti-condensation
  - Bee friendly

Double polyethylene open roofing

Insulation: Insulating walls

- Insulated metal panels

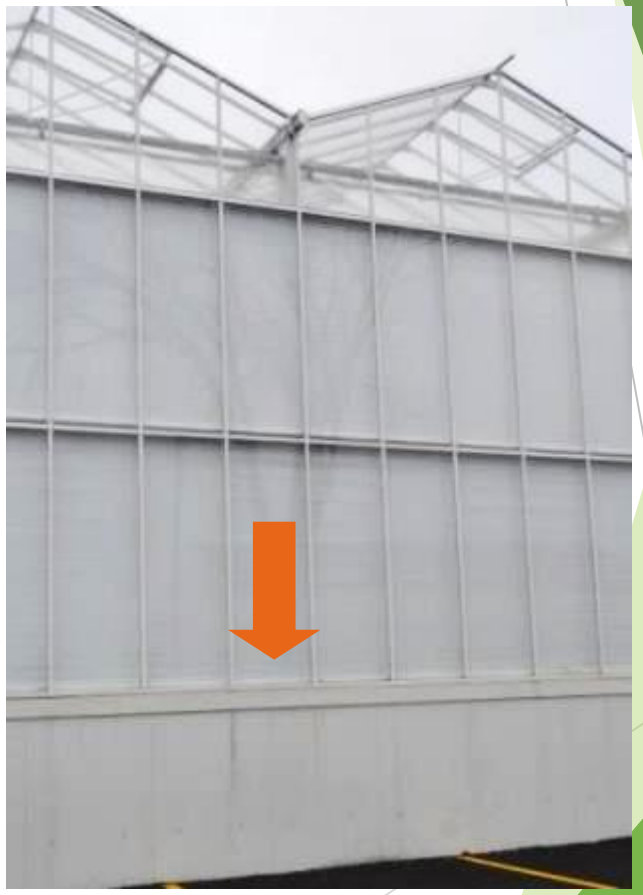
Characteristics	Dimensions
Thickness	2-4 in.
Depth	1-2 ft.
Height	3-6 ft. (depending on crop)

Advantages:

- ↑ Insulation and sealing of perimeter
- ↓ Loss of heat from radiant heating pipes

Disadvantages:

- Requires excavation work
- Cost: Norlam 4” = $5.70/sq. ft



Insulating wall made of Norlam 3” panels

Insulation: North wall — Be sure it's the right north!

- **Total insulation of the north wall and service area**

Insulation: Perimeter

- Underground polystyrene boards
- Reduces heat loss at perimeter by half
  - 2.5 R-value of insulated perimeter (vs. 1.2 for non-insulated)
- Humidity resistant

Insulation: Recap

- Remember:
  - R-value → measure of insulation's ability to resist heat
  - Thermal screens
    - Beneficial if the greenhouse can accommodate their installation
    - 20–30% cost savings → ROI usually in 1–3 years
  - Insulation (walls and exterior)
    - Faster ROI with total insulation of north wall
    - Larger impact for smaller areas (ratio of perimeter to total area)
    - 5–10% energy savings
    - Crucial for crops in organic soil (when planting before April 1st and for winter crops)

Ventilation

Natural ventilation

- Typically, the least expensive option
  - Roof vents
  - Roll-up vents
  - Exposed or sheltered (lee) side
  - Determination of wind direction

According to type of greenhouse chosen

Roof vents

Roll-up vents

Ventilation

Natural roof ventilation

- Vent size
  - 15-20% vent m^2/floor m^2
- Exposed vs. sheltered
- Vent position
  - Consistent temperature
  - Snowstorm management

Ventilation

Natural ventilation

Roll-up vents

- Not adapted for colder conditions
- Ideally have a 25% opening size (opening size/floor size)
  - Must take restrictions imposed by insect screens into account
    - (Roll-up height to be determined)
- Allow wind to pass through (restricted by insect screens)
- Require attention to prevailing winds during warm season
  - Vent restrictions must be compensated for with mechanical ventilation

Ventilation

Natural ventilation

- Insect screens
  - Required for cucumbers (cucumber beetle)
  - Strongly recommended for peppers (lygus bug)
  - Used with air-lock entrances
  - Reduce ventilation area
  - Clogged by dust and pollen

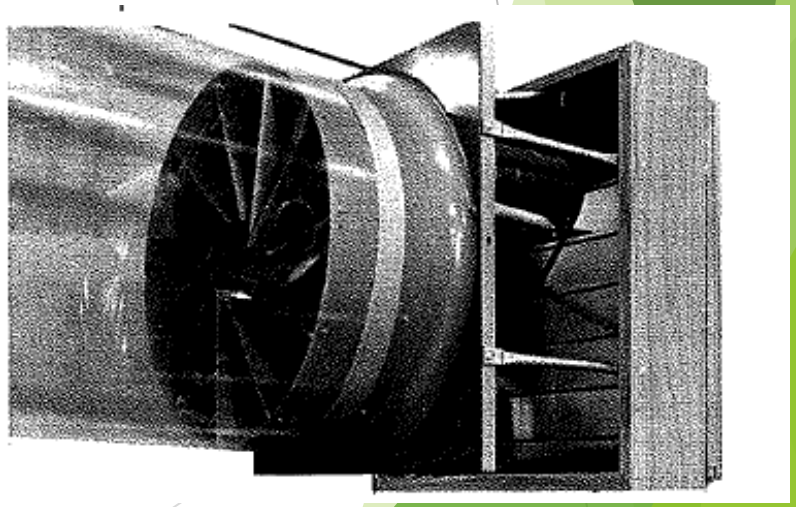
Ventilation

Mechanical ventilation

- More expensive option
  - Purchasing and operating costs
- Necessary for year-round production
  - Positive-pressure ventilation
  - Jet fan system
  - Exhaust ventilation with louvers
    - Avoid combining this type with roll-up vents!

Exhaust fan

Louvers



Jet fan system

According to type of greenhouse chosen

Ventilation

- According to your needs:
  - Summer heatwave ventilation (3 $m^3/m^2/min$)
    - Roof
    - Roll-up
      - + Wind limitations (positive-pressure)
    - Exhaust fans
  - Well-distributed winter daytime ventilation (November 15 to April 1) (0.3 $m^3/m^2/min$)
    - Roof
      - Snowstorm?
    - Positive-pressure or jet fan
  - Winter nighttime ventilation (November 15 to April 1) (0.05 $m^3/m^2/min$)
    - Roof
    - Positive-pressure or jet fan

Roof vents

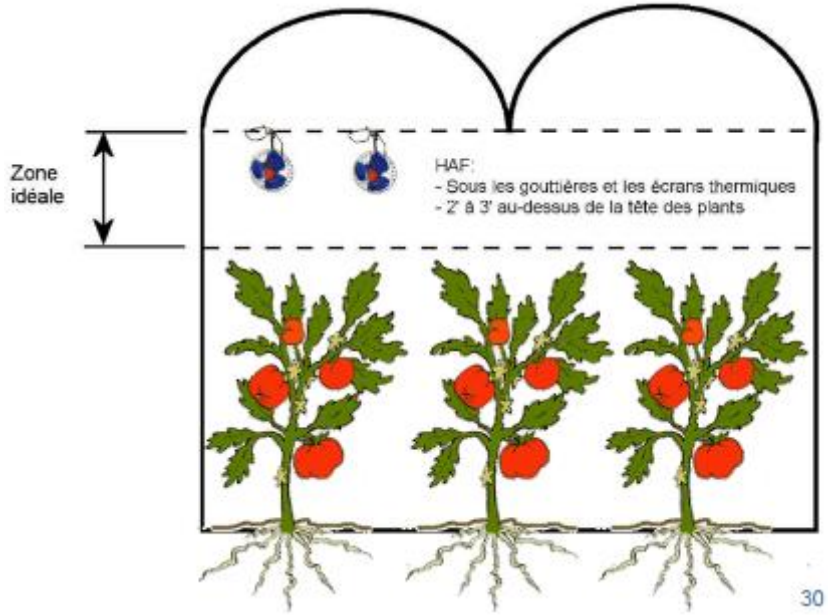
Roll-up vents

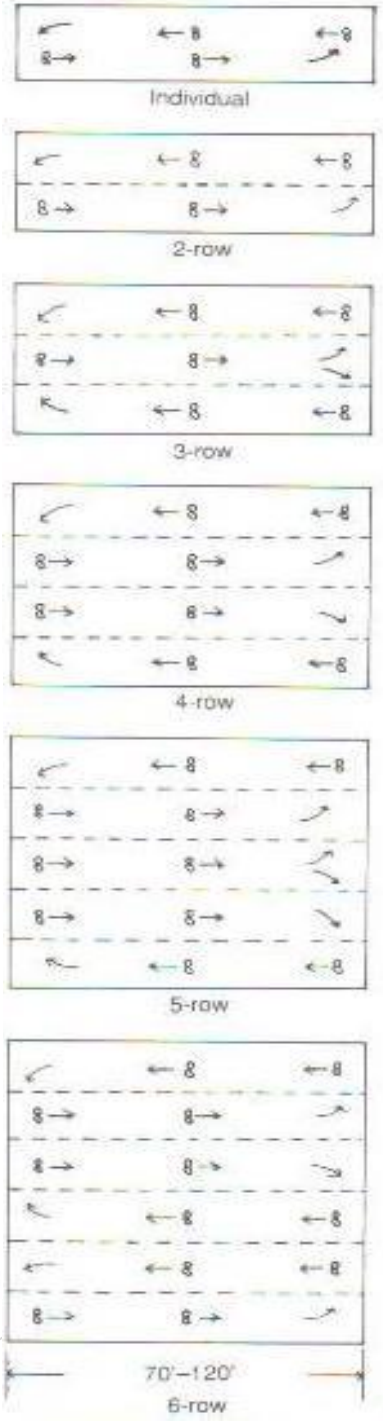
Recirculating ventilation

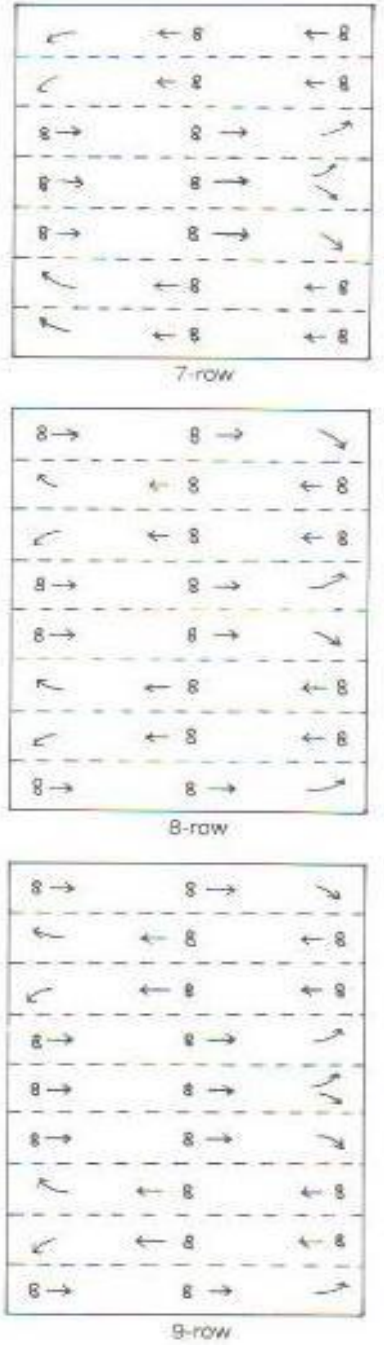
Horizontal air flow (HAF)

- Climate homogeneity
- Needs
  - ~4 CFM per sq. ft. of greenhouse floor
  - + 50% for lettuce, and must be angled towards the crop

HAF







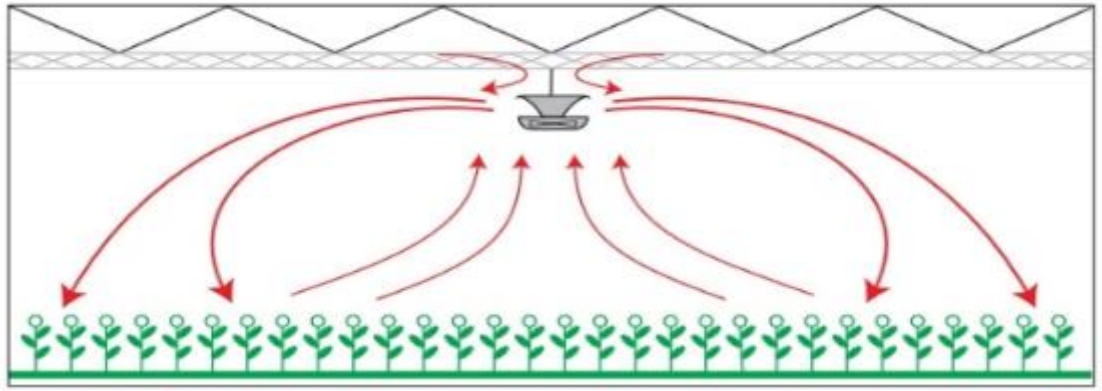
Ventilation

Recirculating vents

Vertical Air Flow (VAF)

V-Flo

Eliturbo



Structure: Thermal screen

Double-layer thermal screen

Obscura 9950 FR W

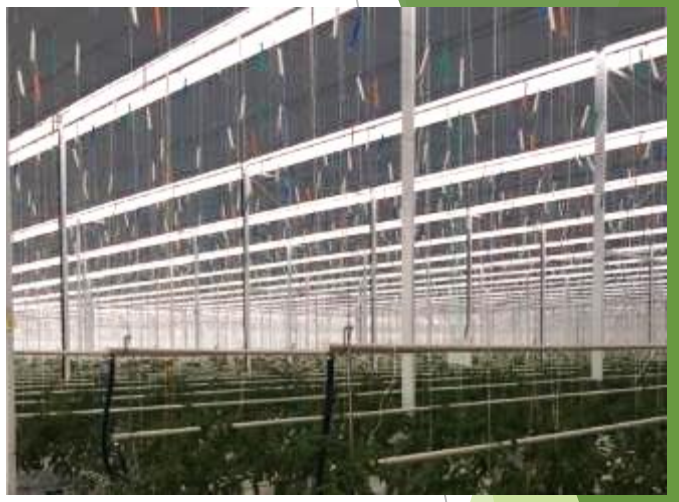
Luxous 1547 D FR

Loss reduction
Thermal screens

- Made of plastic or aluminium strips
- Reduce energy consumption by 20–30%

Types:

1. **Thermal screens**
   - Insulate roof and/or walls overnight
   - Provide shade during intense heat
2. **Transparent (day) screens**
   - Act as thermal layer
   - Provide a high level of light transmission
   - Less condensation on the glass (climate less dry for young pepper and cucumber crop)
3. **Blackout screens**
   - Work for plants that require less light
   - Prevent light pollution



Thermal screens on roof

Double-layer screens on roof

Loss reduction
Thermal screens

Approximate cost	Single-layer screens	Double-layer screens
Material only	$15–$20/m^2	$30–$35/m^2
With installation	± $30/m^2	± $40/m^2
R-value (insulation factor)	2.3	2.8

Loss reduction
Thermal screens

Energy requirement	With screens	Without screens	% of savings
Average consumption (12 months)	± 650 kWh/m²	± 850 kWh/m²	± 25-35 %
Average consumption (8 months)	± 230 kWh/m²	± 300 kWh/m²	± 15-25 %

	% of reduction due to use of screens
Energy required (12 months)	↓ 25-35%*
Energy required (8 months)	↓ 15-25%

*50% reduction in energy consumption with the use of double-layer screens

Heating

Propane or natural gas – forced air

Air heater

Furnace

Source: Gobeil Dion & Associés

Heating

Biomass

Boiler (hot water)

Source: Gobeil Dion & Associés

Heating

Biomass

Furnace (forced air)

Source: Gobeil Dion & Associés

Heating

Biomass — wood chips (for year-round large structures)

Boiler house

Wood chip storage

Source: Gobeil Dion & Associés

Heating

Biomass — wood pellets (for small structures and/or nine-month production seasons)

Wood pellet storage

Source: Gobeil Dion & Associés

Heating and distribution

Hot water

forced air

Source: Gobeil Dion & Associés

Heat distribution

Hot water

✓ Advantages:

- Vertical and horizontal temperature homogeneity
- Climate stability
- Compatibility with crops in gutters
- Rails running between rows of crops

✗ Disadvantages:

- High installation cost
  - Welding, design by engineer, etc.
- Long installation time

Pipes on the ground

Pipes around perimeter

Heat distribution

Hot water

- **Possible heating zones**
  - Floor rails
  - Perimeter
  - Gutter (for melting snow — snow pipe)
  - Crop canopy (grow pipe)
  - Underground (organic cultivation)

Heat distribution

Hot water — thermal energy storage tank

- With hot water system
- Required for CO_2 recovery

✓ Advantages:

- Security (thermal energy storage)
- Heating system optimization (modulation)
- CO_2 recovery
- Increased equipment lifespan
  - Reduced boiler on-off cycling.

✗ Disadvantages:

- High investment cost
- Large space requirement
- Additional inspections
- Experts needed for installation

250,000-L thermal energy storage tank

Heat distribution
Forced air

- The basics:
  - One per row
  - Located behind the shoot turning

Heat distribution
Forced air

- Off-centered

CO_2 supplementation

Natural

- Ventilation (crucial without injection)
- Organic matter breakdown

CO_2 supplementation

Flue gas

Not CSA approved, but…

CO_2 supplementation
Flue gas

Necessary components:

- Generator
- Condensing or high-efficiency boiler
  - The condenser cools the gas, allowing for its introduction into the greenhouse
  - Heat is stored in a thermal energy storage tank during the day
    - CO_2 is needed during the day (for photosynthesis)
    - Heat is needed mainly overnight

CO_2 supplementation
Liquid CO_2

- Components:
  - Tank
  - Vaporizer
  - Valve manifold
- For large-scale greenhouses
- Used with the following heating systems:
  - Biomass
  - Electric
  - When the propane or natural gas condensing boiler is not sufficient
- Tank rented monthly

Liquid CO_2 tank

Vaporizer

CO_2 supplementation
Distribution in the greenhouse

- Distribution tube types
  - Hose
  - Rigid pipe
- Designated rate of supplementation (6–30g/m^2/hr)
- Maintain pressure in the network of tubes
  - Separation of the rate of supplementation and the distribution volume.

CO_2 distribution via hose

CO_2 distribution via rigid pipe

Photosynthesis lighting

HPS

- Energy efficiency: 1.6 µmol/J
- Affordable price
- Source of heat
  - Heat produced by thermal energy accounts for 30% of electric energy consumption.
  - Recuperation of up to 50% of heat with thermal screens

LED (many hobbyists)

- Energy efficiency: 3 µmol/J
- Consumes less energy (20–30% less)
- Production optimization:
- Variable lighting spectrum
- Adjustment needed
- Expensive but fast-growing technology ▫ lower prices to come
- Wide variety of products

Cucumber misting

- Spider mite control
  - Reduces pest activity
  - Supports predatory mite activity (especially *Phytoseiulus persimilis*)
- Typically, low pressure

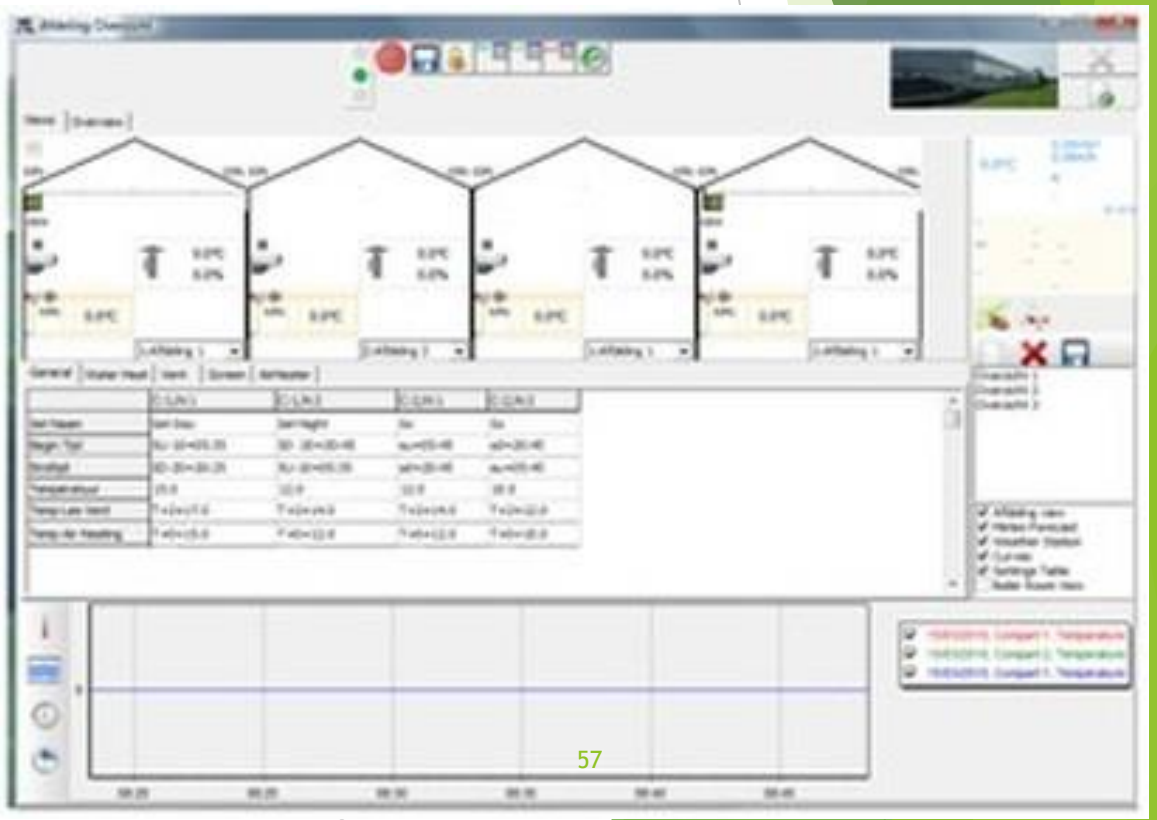
Source: Gobeil Dion et Associés

Climate Control

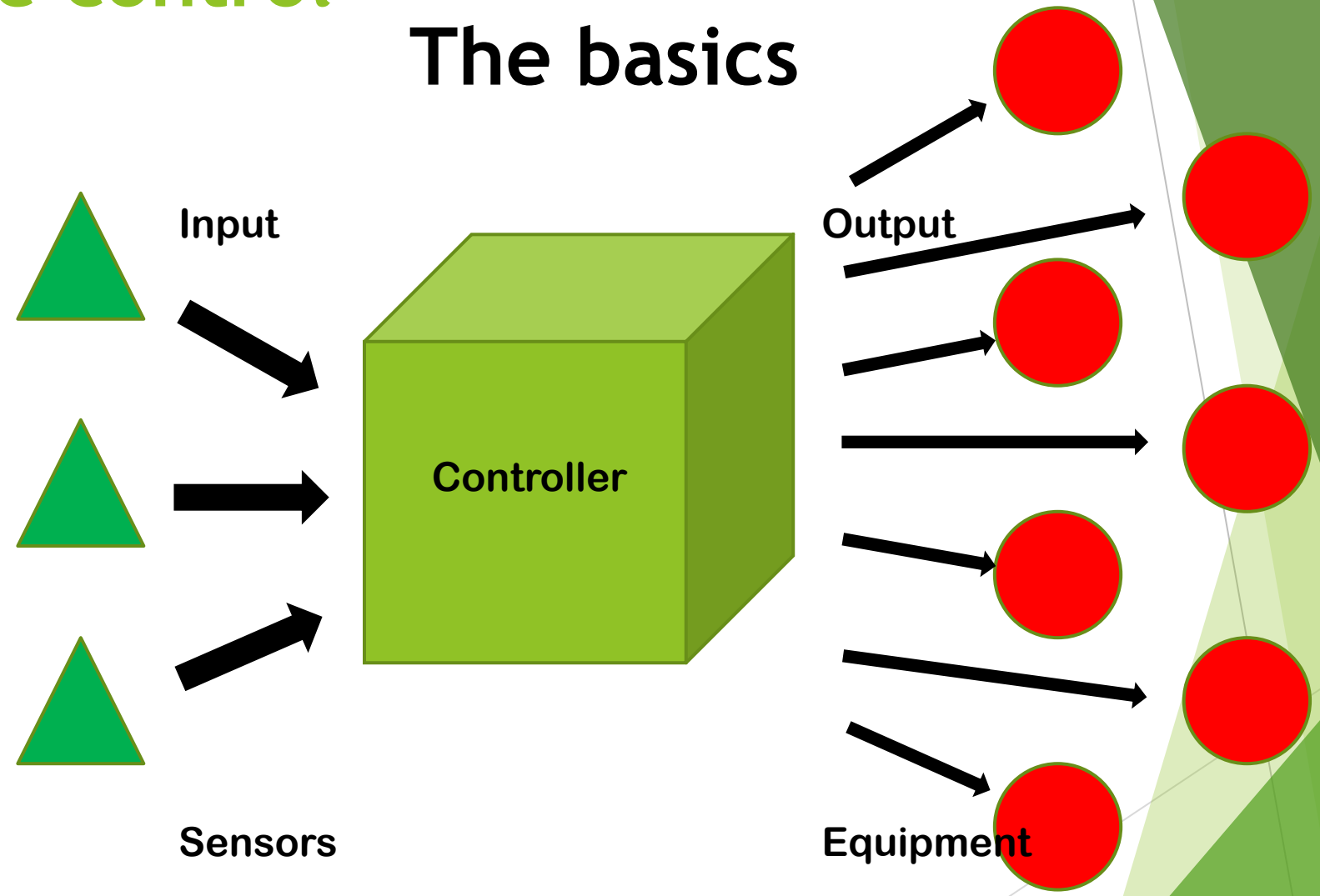
Climate Control

WHAT CAN YOU CONTROL?

- TEMPERATURE
  - HEATING
  - VENTILATION
  - THERMAL SCREEN
- MOISTURE
  - MISTING
- LIGHTING
- CO_2
- IRRIGATION



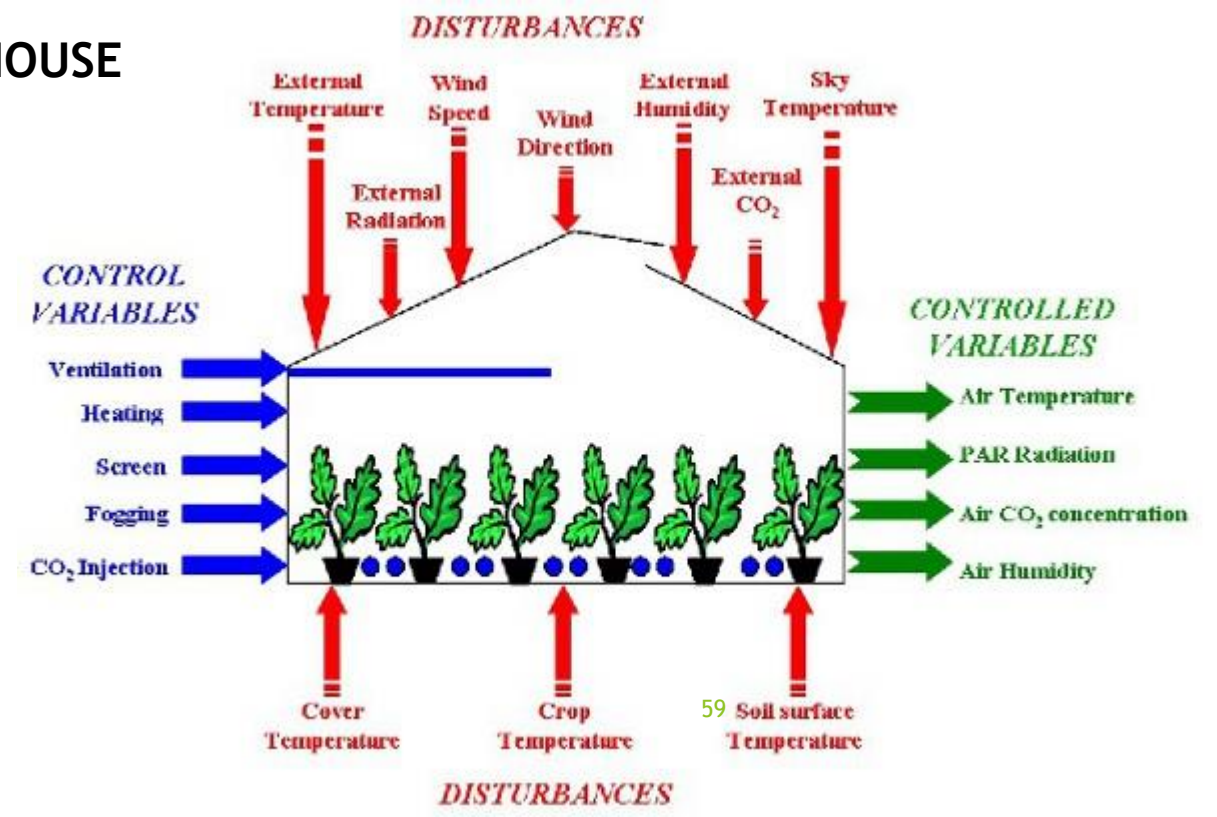
Climate control



Climate control

WHAT DOES A CLIMATE CONTROLLER DO?

- INPUT (INFORMATION)
- WEATHER:
  - TEMPERATURE OUTSIDE GREENHOUSE
  - LIGHT INTENSITY
  - WIND DIRECTION
  - WIND SPEED
  - RAIN
  - RELATIVE HUMIDITY



Weather station

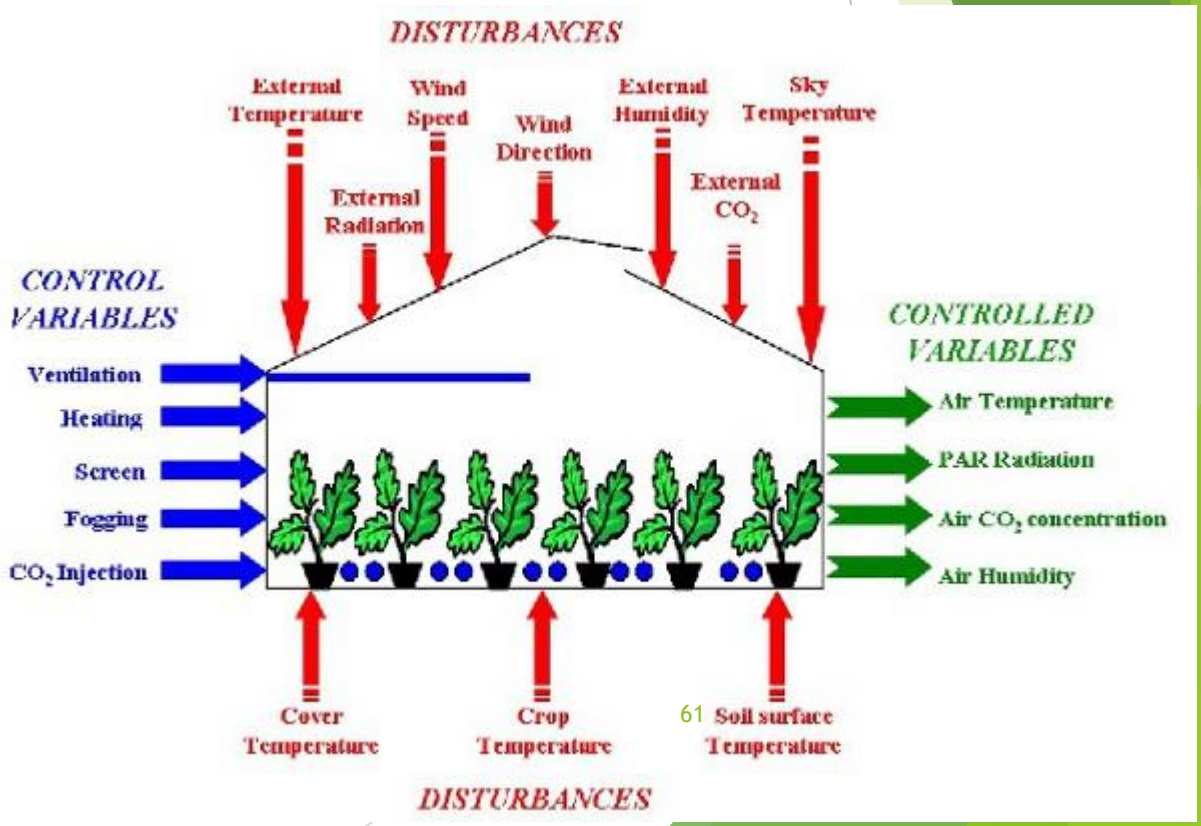
- **Weather station**
  - Outdoor temperature
  - Outdoor humidity
  - Pyranometer
  - Wind speed and direction
  - Rain and snow detection

Weather station

Climate Control

WHAT DOES A CLIMATE CONTROLLER DO??

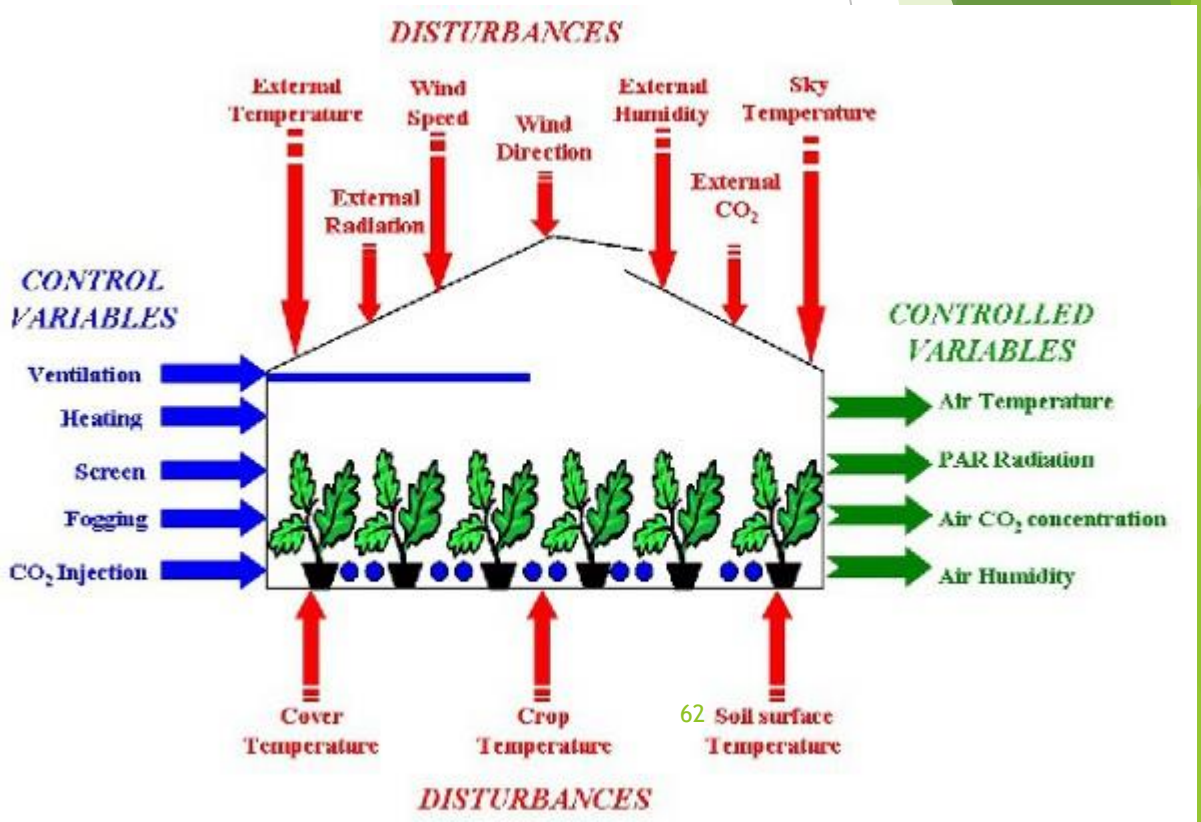
- INPUT (INFORMATION)
  - TEMPERATURE INSIDE GREENHOUSE
  - RH OR VPD
  - GROUND TEMPERATURE
  - CO2
  - EC
  - pH
  - WATER FLOW
  - TENSION



Climate Control

WHAT DOES A CLIMATE CONTROLLER DO?

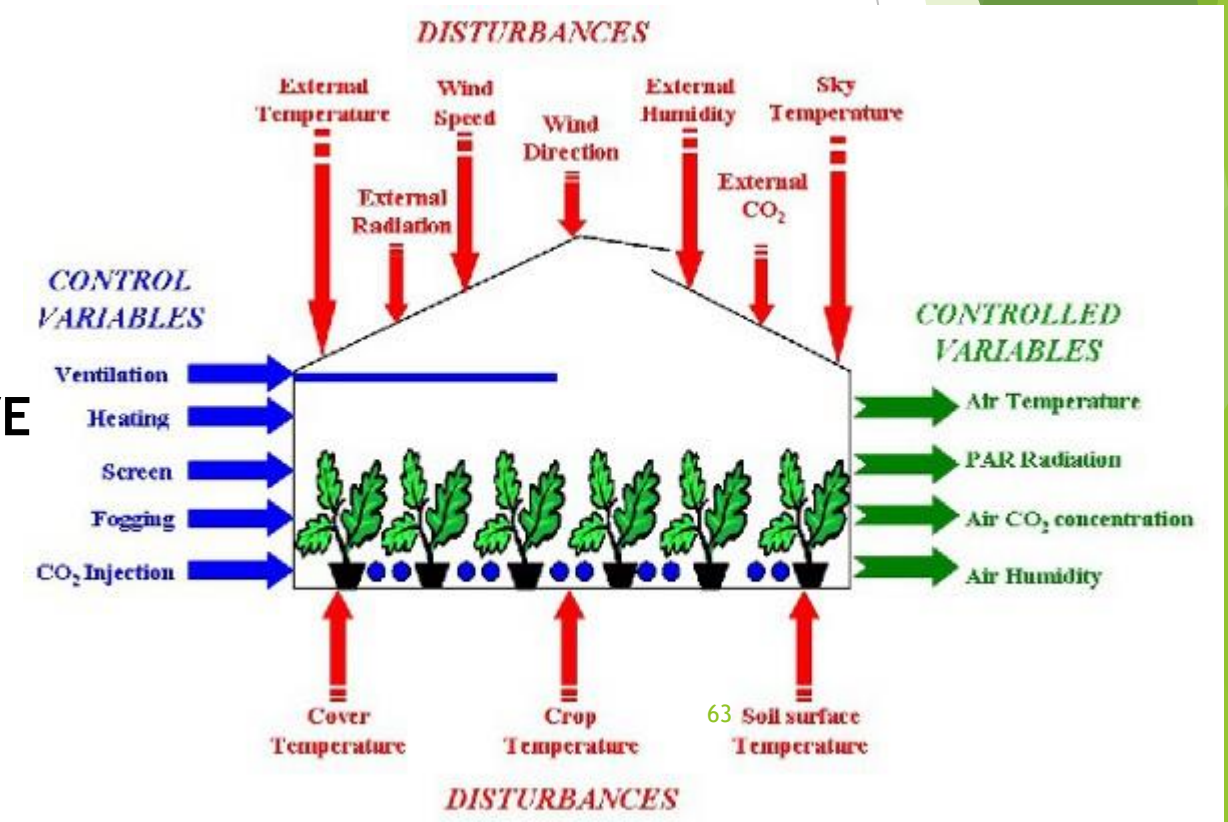
- OUTPUT
  - HEATING
  - FURNACES
  - PUMP
  - HAF VENTILATORS
  - POSITIVE PRESSURE VENTILATION
  - EXHAUST FAN VENTILATION
  - MOTORIZED ROOFS
  - ROLL-UP VENTS
  - MISTING VALVES AND PUMPS



Climate control

WHAT DOES A CLIMATE CONTROLLER DO?

- OUTPUT
  - GROUND HEATING
  - IRRIGATION PUMP
  - VALVES
  - ACID PUMP
  - STOCK SOLUTION PUMP
  - CO_2 SUPPLEMENTATION VALVE
  - ETC.



Climate control: From simple to complex

Climate management

- Basic:
- **Thermostat**
- **Timer**

Control systems

Low-end climate management

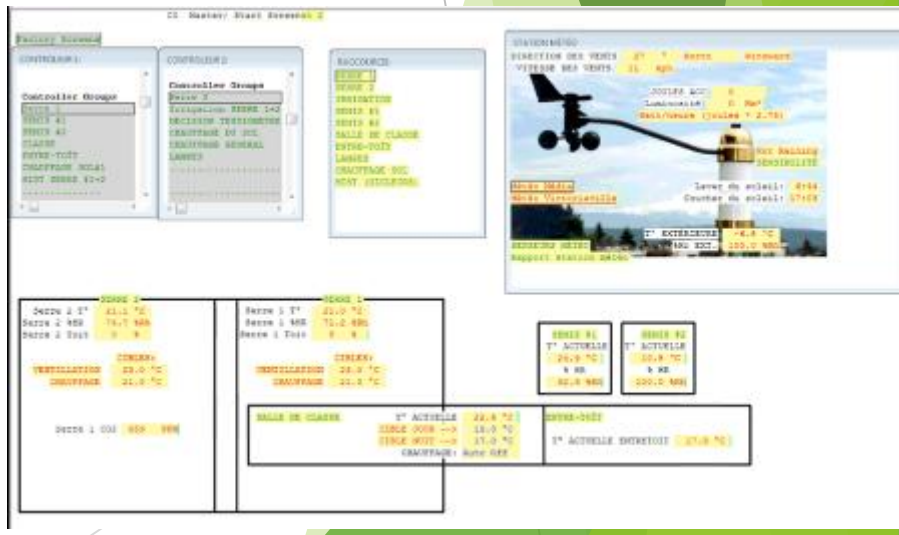
- **Main suppliers:**
  - **Link4 Corporation (iGrow 800 or 400)**
  - Orisha
  - Otomate (Arduino)
  - Maximus
- Characteristics:
  - Data collection
  - Possible graphic display
  - Remote access

Source: Climax Conseils

Control systems

Mid-range climate management

- Suppliers
  - Damatex
  - Argus
  - Priva (Priva Compass)
  - Hoogendoorn (ISII and ISII compact)
- Characteristics
  - Advanced management model
  - Highly effective graphic displays, in general
  - Many functions
  - Strong technical knowledge needed (agronomy, engineering, automation)



Control systems

Top-end climate management

- **Suppliers**
  - **Hoogendoorn (IIVO)**
  - **Ridder**
  - **Priva (Priva Connext)**
  - European companies
- Highly intelligent, powerful design
- Constraints management
  - System capacity
  - Energy supply

Climate control

Essential components

- Backup
- Alarms
  - Bells
  - Telephone
- Remote access
  - LogMeIn
  - TeamViewer
  - VPN

Electronics will be electronics

Control systems

Communication

- Sensaphone
- AcuRite

AcuLink Internet Bridge: Remote Monitoring Online & Mobile App 09150

Source: Climax Conseils

Growing medium

Types of cultivation environments

- **Hydroponic**
  - With substrates
    - On the ground, or in insulation or gutters
    - In bags, pots or grow beds
      - Coconut fiber
      - Rockwool
      - Peat mix

Rockwool (grow bag)

Many variations available
Six different products available through Grodan

https://www.grodan.com/learning/ng2-0-technology/

Coconut fibre

Jiffy Preforma

Growing medium

Types of cultivation environments

- **Hydroponic**
  - Without substrates
    - NFT in gutters or channels
    - Crops in floating trays
    - Aeroponics

Growing medium

Several types of cultivation envionments

- **Organic**
  - In the earth
  - In containers
  - Organic mix in grow beds

Growing medium

Different climate needs for different root zones

- **Hydroponic or organic**
  - Heating the root zone
    - Ground (organic)
    - NFT channels and grow beds
  - Insulation
  - Heating or tempering of irrigation water
  - White poly pipe (summer planting)
  - Ground cover (moisture conservation)
  - Drainage
  - Styrofoam under grow bags (hydroponics)

Irrigation

Available water source

Artesian well

- Watch out for salt content (water from the ocean) and mineral concentration

Surface well

- Heightened risk of contaminants

Pond, lake or river

- Very high risk of contaminants

City water

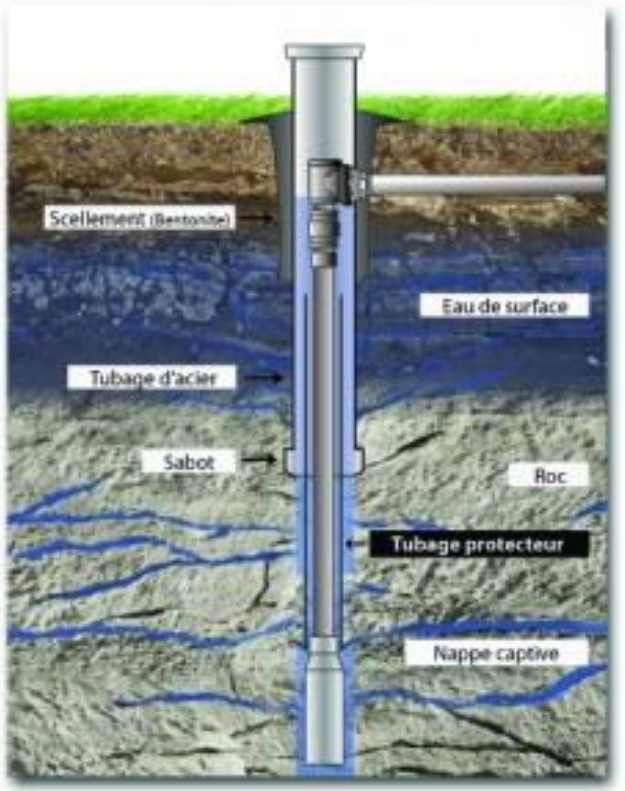
- Good for humans, not good for plants, but risk of contaminants is low

Rainwater

- For air purification and greenhouse cleaning. Chance of acid rain. Not always clean.

Recirculated water

- Must be filtered and disinfected, and nutrients must be readjusted



Artesian well

Water is never as clean as it seems. Always test it!

Irrigation

- **Water supply systems**
  - Daily needs
    - Hydroponic: 10 L/m^2/d
    - Organic: 6 L/m^2/d
  - Peak-hour needs
    - Hydroponic: 1.5 L/m^2/h
    - Organic: 0.75 L/m^2/h

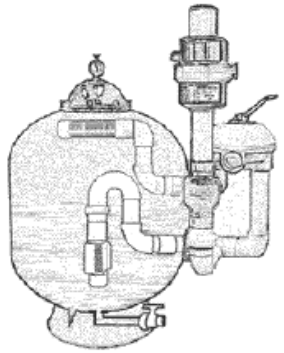
Irrigation and fertilization

System elements

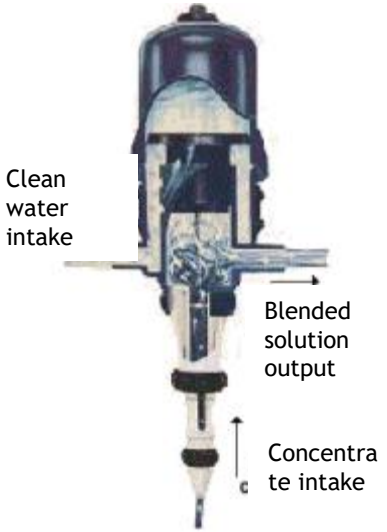
- Fertilization station
  - Fertilizer tanks
- 24-hour supply
- Water heater
- Filters
- Injector
- Sensors

Fertilizing station

Water heater



Filter



Injector

Water tank

Irrigation

24-hour supply

According to size and water needs

Irrigation

Water heater

- Tank capacity
- Flue gas evacuation

Energy sources

- Electric
- Oil
- Natural gas or propane
- Biomass

- **Plate heat exchanger**

- **Water tempered to the room's temperature**

Irrigation

Filters

Material to be remove	Mesh	Microns
Leaves	30	500
Gravel	10	1600
Coarse sand	70	200
Fine sand	600	25
Algae	2000	7,5
Silt	3000	5

Filter 3"

3" Screen Cartridge

Fertilization

- Hydroponic
  - Stock solution example

Institut de technologie agro-alimentaire de Saint-Hyacinthe

Par Jacques Thériault agr. Climax Conseils

Tomato F6-H2

Solution A	Liters:	4500							
	Concentr:	200				# de gramme		kg	Lbs
Calcium nitrate	Nitrate:	14,5	%	Calcium	19,0	%	717754,5 g.	717,75	1579,06
	Ammonium	1,0	%					0,00	0,00
Calcium chloride	Chlorure	53,0	%	Calcium	29,9	%	0,0	0,00	0,00
Potassium nitrate	Nitrate:	13,8	%	Potassium	38,2	%	373032,7 g.	373,03	820,67
Fe-DTPA 11%	Fer:	11,0	%				8181,8 g.	8,18	18,00
Ammonium nitrate	Nitrate:	17,0	%	Ammonium	17,0	%	0,0 g.	0,00	0,00

Solution B	Liters:	4500							
	Concentr:	200				# de gramme		kg	Lbs
Potassium nitrate	Nitrate:	13,8	%	Potassium	38,3	%	373032,7 g.	373,03	820,67
Monopotassium Phosphate	Phosphore:	22,7	%	Potassium	28,3	%	130681,3 g.	130,68	287,50
Potassium sulfate	Sulfate:	18,0	%	Potassium	41,7	%	163146,3 g.	163,15	358,92
Potassium chloride	Chlorure	45,0	%	Potassium	49,8	%	0,0	0,00	0,00
Magnesium nitrate	Nitrate:	11,0	%	Magnesium	9,9	%	0,0 g.	0,00	0,00
Sulf. or oxy. Magnésium	sulfate:	13,0	%	Magnesium	9,9	%	464141,8 g.	464,14	1021,11
Introduce	90,2	Litres de solution C							

Micronutrients

Solution C	Liters	90		
	Concentr:	10000		# de gramme
Sulfate Copper		25,0		180,0 g.
Sulfate Manganese:		29,5		1678,0 g.
Sulfate Zinc:		35,0		848,6 g.
Sodium Molybdate:		46,0		97,8 g.
Acid Boron		17,5		1491,1 g.

Solution D	Liters in A	0,00	Nitric Acid 67%	21,0
	Litters in	30,64	Phosphoric acid 75%	39,7

Irrigation and fertilization

Fertlizer tanks

A, B, acid, utility; or a single tank for organic

Fertilization

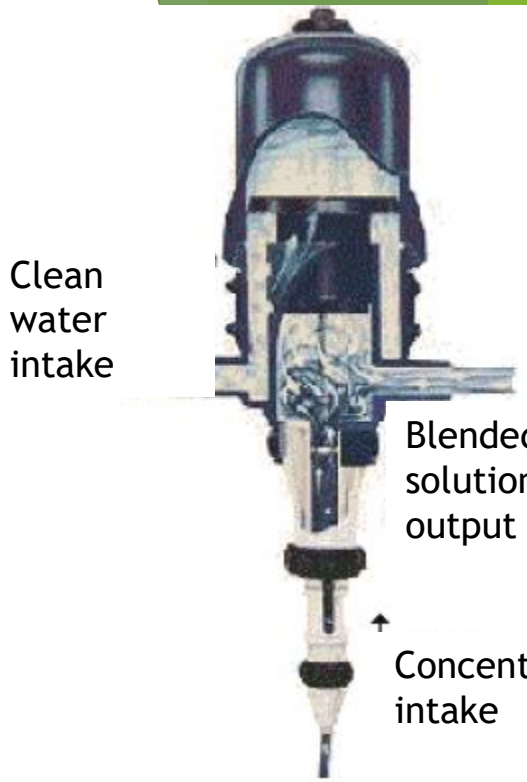
Organic

- **Manure used for greenhouse vegetables**
  - Basic fertilizer
  - Soluble nutrients (K, Mg)
  - Micronutrients
  - Manures (organic)
  - Compost (organic)
  - Microfauna (organic)

Irrigation and fertilization

Injector

- Proportioner
- Pumps

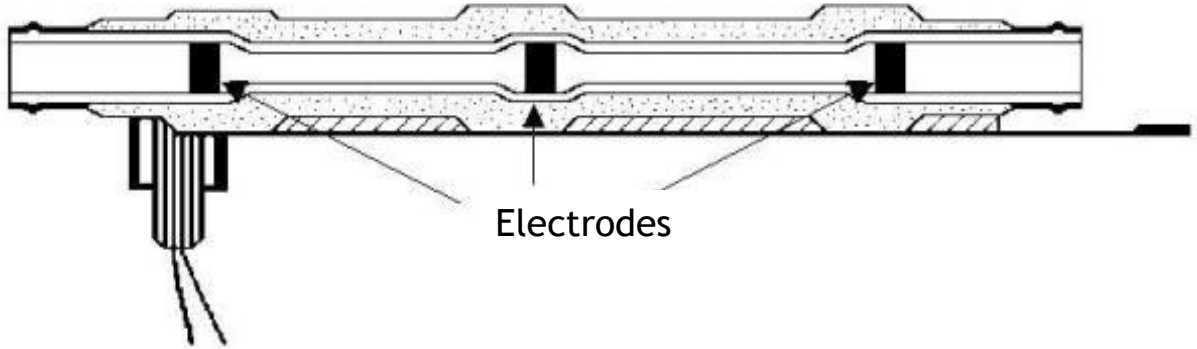


Irrigation and fertilization

Sensors

Automated system security

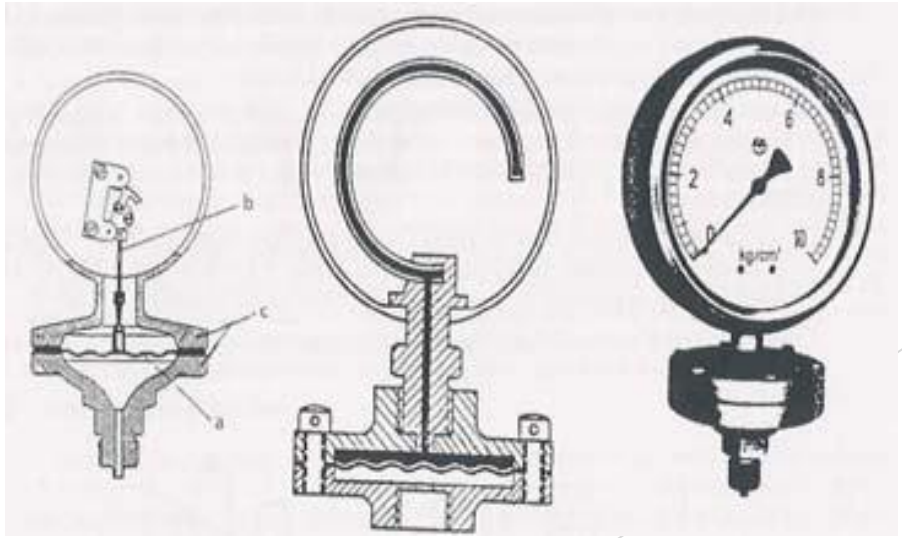
- Double EC sensors
- Double pH sensors



Irrigation and fertilization

Distribution within greenhouses

- Electric valves
- Manometer
- Pressure regulator
- Emitters



Irrigation and fertilization
Distribution within greenhouses

Spaghetti emitter

Emitters:

- Compensating
- Non-compensating
- Sustainable from season to season
- Flow rate of 2-4 L/h, verify scheduling and substrate needs

Uniformity

- Minimal difference between emitters

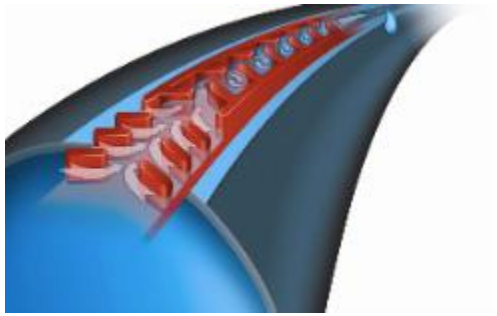
Difference between emitters
=
Difference for plants
=
Difference in yield

Irrigation and fertilization

Distribution within greenhouses

Drip tape:

- Slope
- Tape thickness
- Uniformity
- Number of lines (4 lines per row)



Drip tape

Flow Rates

Available in 4, 5, 6, 8, 10, 12 & 15 mil Tape

Part Number	Outlet Spacing (in.)	Individual Emitter Flow Rate (gph)		Q-100 (gpm/100 ft.)		Filtration Requirement
		@ 8 psi	@ 10 psi	@ 8 psi	@ 10 psi	Mesh
0.07 Emitter		**gph/Emitter**		**gpm/100 ft.**		200
EAXxx0817	8	.07	.08	.17	.20	
EAXxx1608	16	.07	.08	.08	.10	
0.09 Emitter		**gph/Emitter**		**gpm/100 ft.**		200
EAXxx0822	8	.09	.10	.22	.25	
0.13 Emitter		**gph/Emitter**		**gpm/100 ft.**		**140** NEW
EAXxx0467	4	.13	.15	.67	.75	
EAXxx0834	8	.13	.15	.34	.37	
EAXxx1222	12	.13	.15	.22	.25	
EAXxx1617	16	.13	.15	.17	.19	
EAXxx2411	24	.13	.15	.11	.12	
0.15 Emitter		**gph/Emitter**		**gpm/100 ft.**		**140** NEW
EAXxx0650	6	.15	.17	.50	.56	
EAXxx1225	12	.15	.17	.25	.28	
0.20 Emitter		**gph/Emitter**		**gpm/100 ft.**		**140** NEW
EAXxx04100	4	.20	.23	1.00	1.12	
EAXxx0667	6	.20	.23	.67	.75	
EAXxx0850	8	.20	.23	.50	.56	
EAXxx1234	12	.20	.23	.34	.38	
EAXxx1625	16	.20	.23	.25	.28	
EAXxx2417	24	.20	.23	.17	.19	
0.27 Emitter		**gph/Emitter**		**gpm/100 ft.**		**140** NEW
EAXxx04134	4	.27	.30	1.34	1.50	
EAXxx0867	8	.27	.30	.67	.75	
EAXxx1245	12	.27	.30	.45	.50	
EAXxx1634	16	.27	.30	.34	.38	
EAXxx2422	24	.27	.30	.22	.25	
0.34 Emitter		**gph/Emitter**		**gpm/100 ft.**		**140** NEW
EAXxx0884	8	.34	.37	.84	.94	
EAXxx1256	12	.34	.37	.56	.62	
EAXxx1642	16	.34	.37	.42	.47	
EAXxx2428	24	.34	.37	.28	.31	

NOTE: X – denotes the diameter. 5 for 5/8", 7 for 7/8" and 11 for 1-3/8". xx – denotes mil thickness.

Irrigation and fertilization General diagram with recirculation (large-scale project)

Irrigation and fertilization

Controller

- **Function:**
  - Time (low-end)
  - Radiation (high-end)
  - Tensiometer (mid-range)
- **Testing (high-end only)**
  - EC
  - pH
  - Flow Rate
  - Temperature
- **Cost: $150-$5,000**
- **Could be a feature on the climate controller**

Part 2: Equipment by Greenhouse Type

Points of comparison for installations

- Coverings
- Thermal screens
- Management
- Heating:
  - Fuel
  - Generation
  - Distribution
- Ventilation
- CO_2
- Controllers
- Irrigation and fertilization

Coverings

Installation type	Glass	Plastic	Polycarbonate	Other
Individual greenhouse		X		X
Gutter-connected greenhouse	?	X	X	X
Greenhouse complex	X	X		
Large complex	X	X		

Adapted from Climax Conseils

Thermal Screens

Installation type	Single-layer	Double-layer
Individual greenhouse		
Gutter-connected greenhouse	X	
Greenhouse complex	X	
Large complex		X

Adapted from Climax Conseils

Type of cultivation

Installation type	Conventional	Organic
Individual greenhouse	X	X
Gutter-connected greenhouse	X	X
Greenhouse complex	X	?
Large complex	X	

Adapted from Climax Conseils

Heating with fuel

Installation type	Propane	Natural gas	Electricity	Biomass	Oil	Other
Individual greenhouse	X	X	X		X	
Gutter-connected greenhouse	X	X	X	x	X	Geothermal
Greenhouse complex	?	X		X		Geothermal – thermal discharges
Large complex		X		X		Biomethanization

Adapted from Climax Conseils

Heat distribution

Installation type	Forced air	Hot water
Individual greenhouse	X	
Gutter-connected greenhouse	X	X
Greenhouse complex		X
Large complex		X

Adapted from Climax Conseils

Heat generation

Installation type	Central	Individual
Individual greenhouse		X
Gutter-connected greenhouse	X	X
Greenhouse complex	X	
Large complex	X	

Adapted from Climax Conseils

Heat ventilation

Installation type	Roof	Roll-up and positive-pressure	Exhaust fan
Individual greenhouse	X	X	X
Gutter-connected greenhouse	X		X
Greenhouse complex	X		
Large complex	X		

Adapted from Climax Conseils

Winter daytime ventilation

Installation type	Roof	Positive-pressure	Jet fan
Individual greenhouse		X	X
Gutter-connected greenhouse	X	X	
Greenhouse complex	X		
Large complex	X		

Adapted from Climax Conseils

Cool nighttime ventilation

Installation type	Roof	Positive-pressure	Jet fan
Individual greenhouse		X	X
Gutter-connected greenhouse	X	X	
Greenhouse complex	X		
Large complex	X		

Adapted from Climax Conseils

CO_2 source

Installation type	Liquid	Combustion	Natural
Individual greenhouse		X	X
Gutter-connected greenhouse	X	X	
Greenhouse complex	X	X	
Large complex	X	X	

Adapted from Climax Conseils

Climate controller

Installation type	Basic	Low-end	Weather station	Mid-range	Top-end
Individual greenhouse	X	X			
Gutter-connected greenhouse		X	X	X	
Greenhouse complex			X	X	
Large complex			X		X

Adapted from Climax Conseils

Irrigation and fertilization

Installation type	Water tank	Water heater	Controller		
			Low-end	Mid-range	Top-end
Individual greenhouse	x	x	x	x	
Gutter-connected greenhouse	X	X		X	X
Greenhouse complex	X	X			X
Large complex	X	X			X

Adapted from Climax Conseils

Irrigation and fertilization

Installation type	Hanging gutters	Recirculation	Injector	
			Proportioner	Dosing pumps
Individual greenhouse			x	
Gutter-connected greenhouse	X		X	X
Greenhouse complex	X	X		X
Large complex	X	X		X

Adapted from Climax Conseils

Greenhouse Installation

Dany Boudreault, T.P.
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Climax Conseils

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Agenda

- Placement
  - Transplants
  - Crop supports
  - Rows of leafy greens in cold frame greenhouses
- Chemical and physical soil treatment
- Placement
  - Irrigation system
  - Ground cover
  - Stem holders
  - Heat tubes
  - Crop canopies

Transplant placement

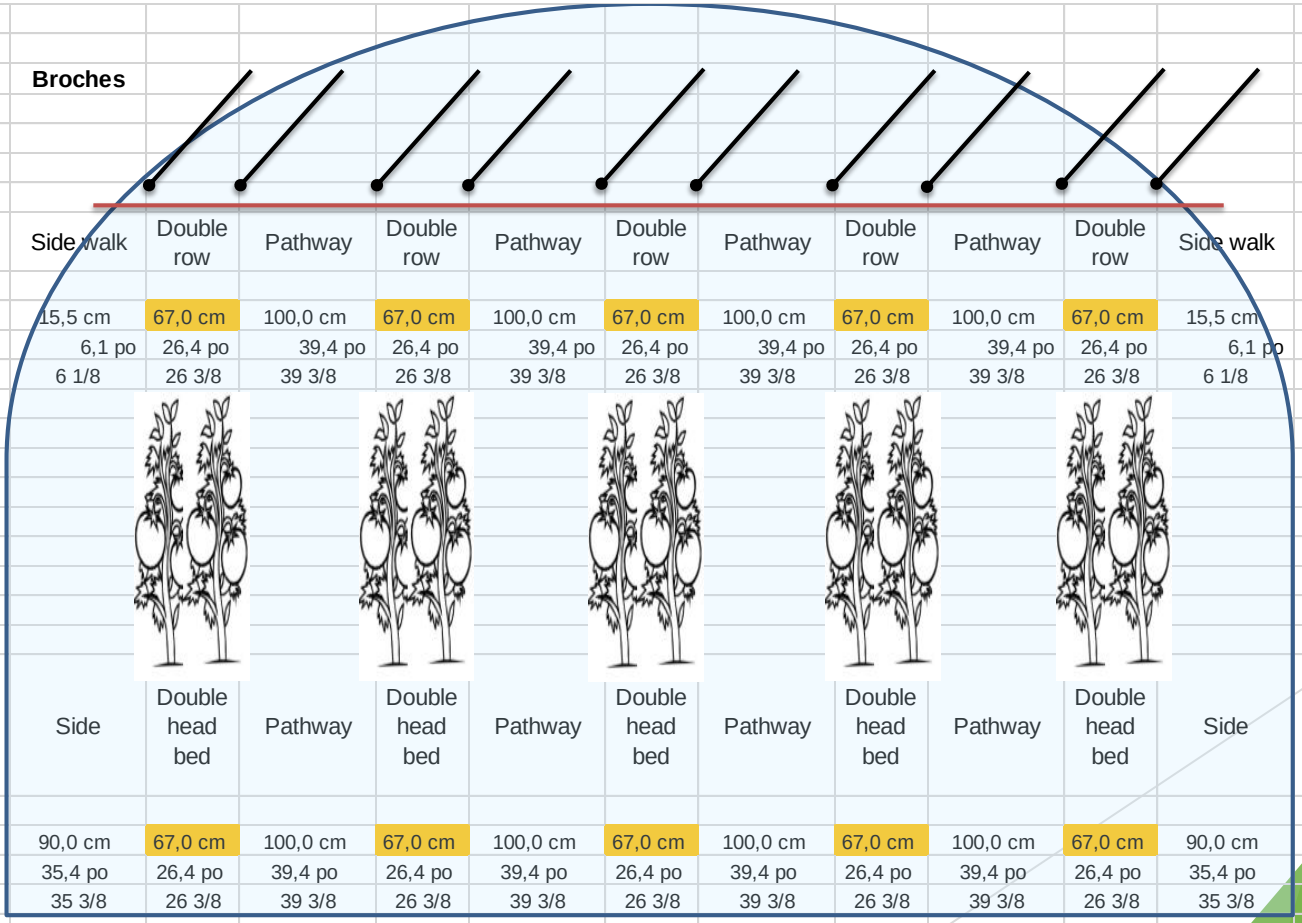
- Double row placement
- 1.6-m rule
- Individual greenhouse:
  - All possibilities
- Gutter-connected greenhouse:
  - 1.6-m rule works well

Crop support placement

- Purpose
  - Supporting the plants
  - Wire supports
    - Tomatoes: 9-gauge
    - Cucumbers: 11-gauge
    - Hooks grab/secure to the wire
  - Fixing wires to posts/walls
    - Keep some slack

Crop support placement

- 60-100-60



25,1 pieds

= 766,0 cm

301,6 po

58,4 po

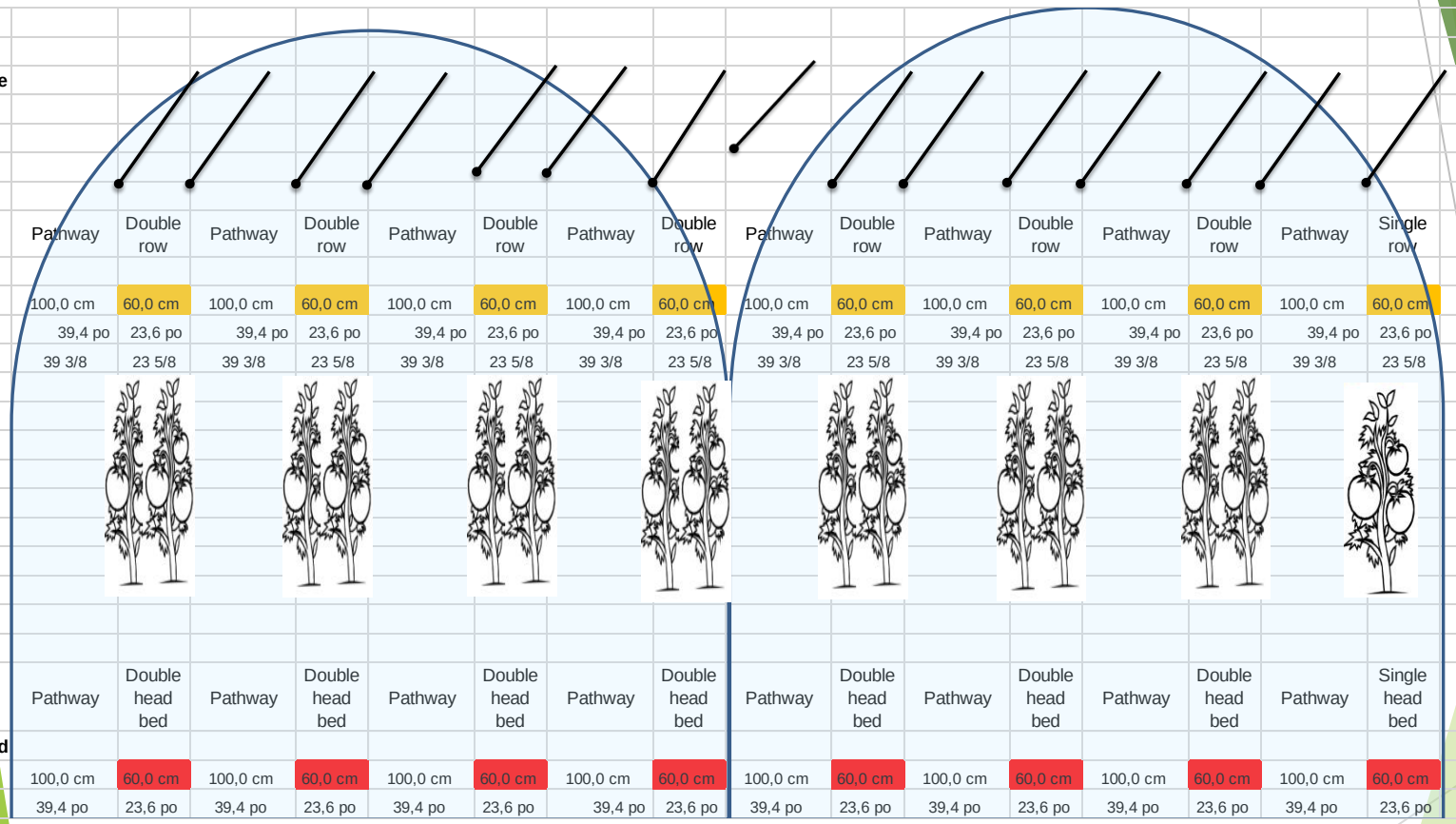
30,0 pieds

= 915,0 cm

360,2 po

(915,0)

Gutter-connected greenhouse (two arches)



Total

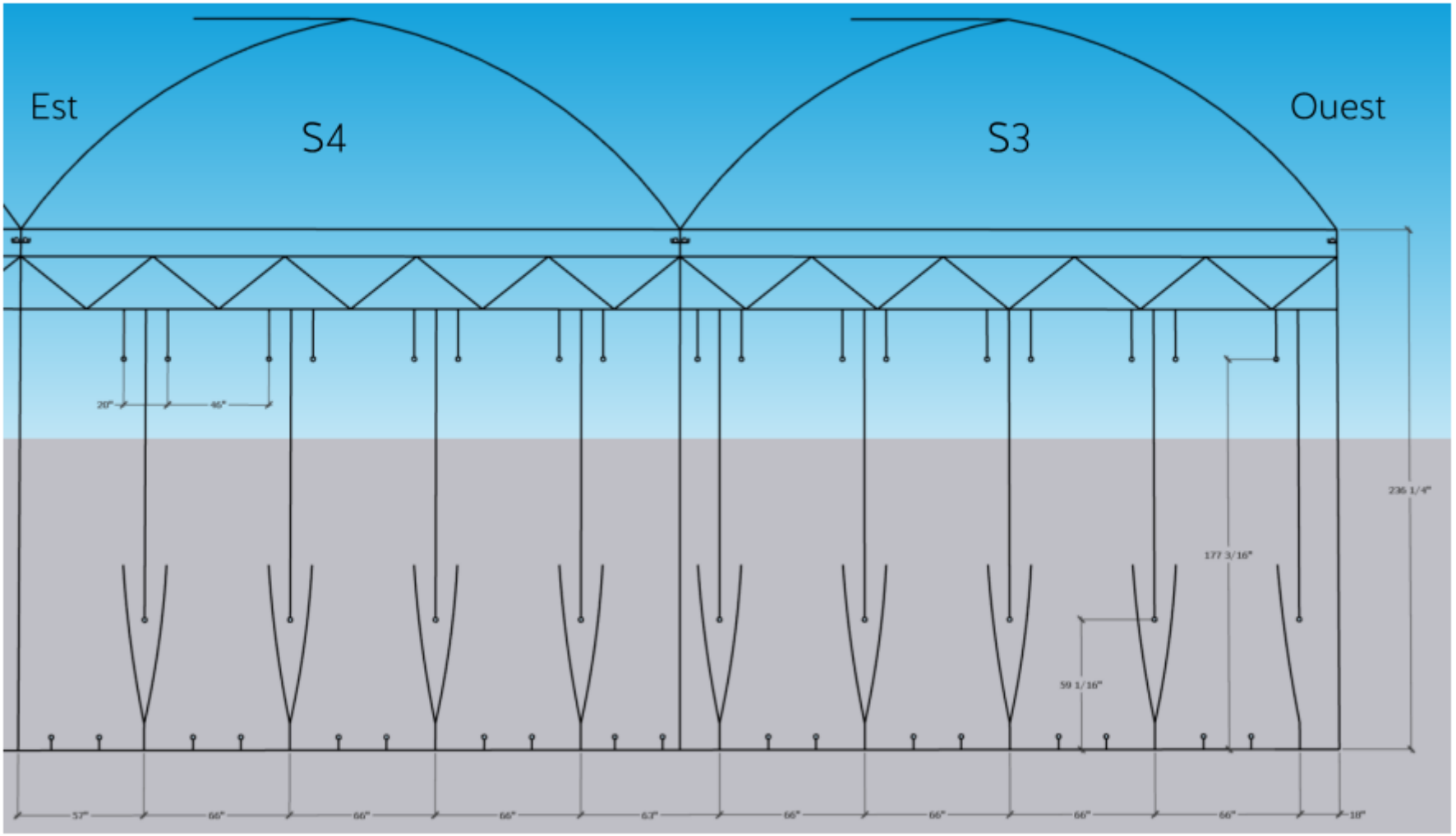
1 280,0 cm

42,0 **Feet**

1 280,0 cm

42,0 **Feet**

Gutter-connected greenhouse with roll-up separators (for diversification)



Gutter-connected greenhouse of undefined length

Leafy greens in cold frame greenhouses

- General rule
  - Rows spaced 4 ft. apart from centre to centre
    - 12-in. aisles
  - Border rows
    - 2 ft.
    - Easily accessible
- Mix of vegetables and fruits
  - High wire (layering) Double rows
    - 8 ft. from centre to centre
  - Single rows of no layering crop
    - 4 ft. from centre to centre

Soil preparation (chemical)

- Standard analysis: medium-term mineral availability
  - When: before the start or at the end of the season
  - Why: allows you to correct soil fertility as well as organic matter and pH levels.
  - Sampling method
    - Use an auger (2.5-cm (1-in.) diameter)
      - From the bed, randomly collect 10 core samples of soil from a depth of 20 cm.
      - Put the samples in a clean bucket, mix the soil gently, and place it in a clearly labelled container or plastic bag.
      - Send it to a specialized lab
    - Never expose soil samples to extreme heat or let them dry out.

Example of a standard analysis

Résultats d'analyses						
Numéro			[redacted]			
Identification champ						
Culture prévue						
AEL-I-SOL-006		pH	6.9 R	6.9 R	6.3 B	
AEL-I-SOL-007		pH tampon	7.0 B	7.0 B	6.3 M	
AEL-I-SOL-005		Mat. Org. %	9.5 TR	13.2 TR	5.9 R	
AEL-I-SOL-003+AEL-I-EQP-028	kg/ha	P	724 TR	1 003 TR	361 TR	
		K	1 419 TR	4 558 TR	393 R	
		Ca	7 986 TR	9 576 TR	2 870 M	
		Mg	767 TR	1 080 TR	157 B	
	ppm	Al	799 MB	687 M	1 197 B	
	ISP	P/Al*	40.5 I	65.1 I	13.5 I	
	ppm	Mn	24.4 TR	27.5 TR	27.8 TR	
		Cu	2.93 TR	3.56 TR	1.71 TR	
		Zn	26.79 TR	32.12 TR	4.84 B	
		B	1.34 MB	1.89 B	0.44 P	
		S				
		Fe	121	122	260	
%		N total	0.35	0.43	0.21	
		C / N	14.7	16.7	14.9	
ppm		$N\text{-}NH_4$	11.0	12.0	11.0	
ppm		$N\text{-}NO_3$	25.00	87.00	11.00	

TP=Très pauvre, P=Pauvre, M=Moyen, MB=Moyen bon, B=Bon, R =Riche, TR=Très riche

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Example of adjustments made as the result of a standard analysis

		kg/ha					
	pH tampon	Ca	Mg	K	CEC		P (kg/ha)
Calcul CEC/100g	7,1	10460	833	1284	31,5169528		995
% Saturation	11%	74%	10%	5%			
Objectif (kg/ha)		9531	1058,97	1101			300
À corriger (kg/ha)			225,97	-182,67			-695,00

Aim for 5-10% organic matter

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Soil preparation (physical)

Broadfork for hard soil

BCS tractor for looser soil
Use to incorporate amendments and fertilizers before the crop installation

Soil preparation (physical and chemical)

- Depth:
  - 30 cm max (roots need 20 cm, except in sand)
  - Pay attention to soil heating

Soil preparation (physical and chemical)

- Flat or raised beds? For drainage.

Soil preparation (physical and chemical)

- SSE soil analysis
  - Measures what is available in the soil solution (root zone)
  - EC too high, excess sulfate or sodium
    - Leaching

Soil preparation (physical and chemical) Example SSE analysis

Water analysis	Spec min	Spec max		
Alkalinity (ppm)	0	50	↑ 103.20	30.75
Chloride (ppm)	0	50	24.88	31.40
pH	-	-	7.69	5.94
Soluble Salts (mmhos/cm)	0	1	0.29	↑ 1.37
Nitrate Nitrogen (N-NO3) (ppm)	0	5	2.4	↑ 106.5
Ammonium Nitrogen (N-NH4) (ppm)	0	5	< 0.2	< 0.2
Phosphorus (ppm)	0	5	< 0.21	↑ 42.0
Potassium (ppm)	0	5	2.6	↑ 228.4
Calcium (ppm)	0	120	39.4	77.2
Magnesium (ppm)	0	25	1.2	23.8
Sulfate (ppm)	0	100	5.3	↑ 104.2
Boron (ppm)	-	-	0.03	0.28
Copper (ppm)	0	0.2	< 0.03	↑ 0.21
Iron (ppm)	0	0.5	< 0.05	↑ 2.41
Manganese (ppm)	0	1	< 0.03	0.58
Molybdenum (ppm)	0	0.05	< 0.02	↑ 0.09
Zinc (ppm)	0	0.5	< 0.03	0.33
Aluminum (ppm)	0	0.2	< 0.01	< 0.01
Sodium (ppm)	0	30	13.3	18.7
SAR	-	-	0.57	0.48

mmhos = mS

House EC reading: 1:2 analysis (Sonneveld and Voogt, 2009)

Stir the sample well, and then let it sit for 30 minutes.

Stir it again, and then let it sit for another 5 minutes.

Dip the top end (1/3 length) of the EC meter into the supernatant to take the reading.

Reading x 1.8 = root EC

Picture 4.1 Preparation of the specific 1:2 volume extract. Sufficient field-moist soil is added to two parts of water so that the volume is increased with one part

While crops are growing, do not take from the top 1 cm of soil (fertilizer application zone)

Purpose of taking EC reading at the outset

- Greens seedlings: 0.25–0.5 mS/cm
  - Emergence problems
- Transplanted greens: 0.75–1.25 mS/cm
  - Water stress
- Cucumbers: 1–1.5 mS/cm
  - Water stress and Pythium
- Peppers and eggplants: 1.5–2.5 mS/cm
  - Water stress
- Tomatoes: 2.5–3.5 mS/cm
  - Water stress

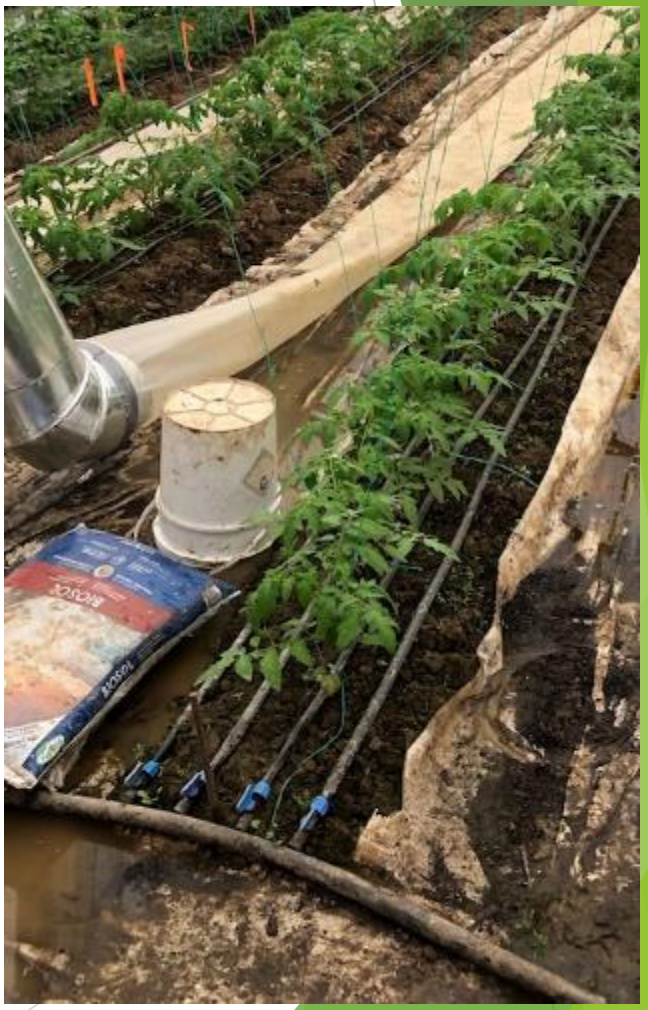
Soil preparation (physical and chemical)

- Ground temperature:
  - Tomatoes: 18 °C
    - Potassium deficiency
  - Cucumbers: 20 °C
    - Silicon < risk of Pythium

- If planting at the end of April or later, soil heating is usually not necessary.
- Clear mulch:
  - Good for temperature
  - Not good for weeds

Irrigation system placement

- Four drip tapes with manual valves per bed
- Two on each side
  - Sometimes three on one side and one on the other
- Supply
  - Centre: 2 x half row
  - End: 1 x full row



Irrigation system placement

- Four drip tapes per bed
  - If they are too far apart…

Ground cover placement

- White over black
  - Fabric vs. plastic
  - Width
- Anchoring pins (U staples)

Ground cover placement

- Purpose
  - Avoid soil moisture evaporation
  - Avoid growth of weeds
  - Avoid thrip pupation
  - Promote amendment mineralization

Ground cover placement

Ground cover placement

Stem holder placement

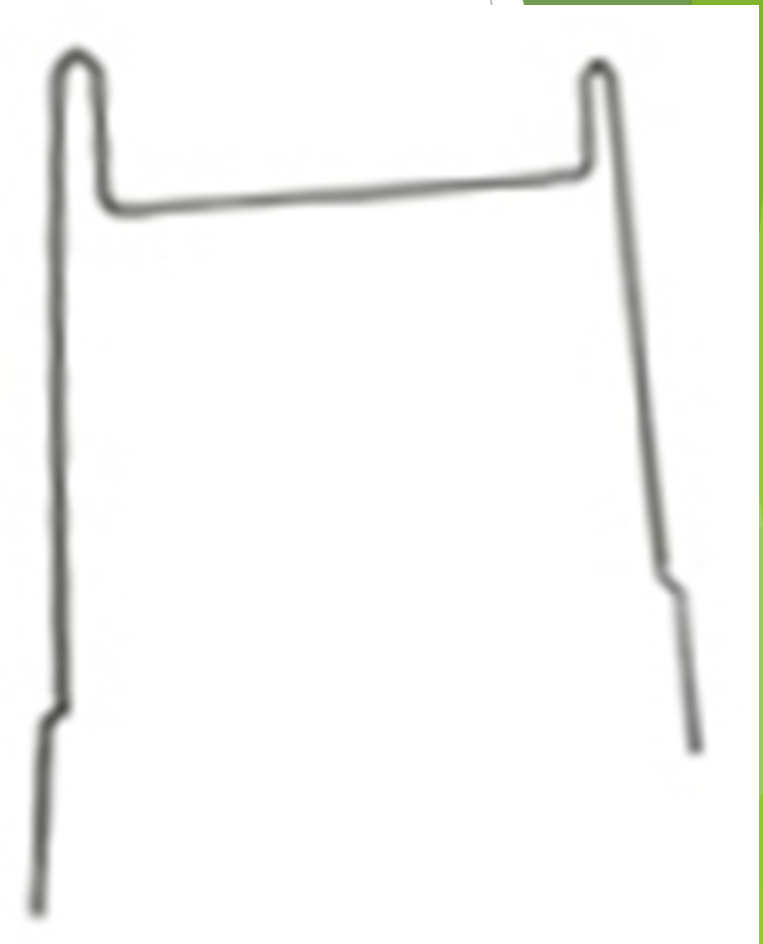
- 4 ft. apart
- Larger than wires

Stem holder placement

- Different types
  - 13” x 24”
  - Beefsteak
  - Double row

Stem holder placement

- Different types
  - 13” x 16”
  - Beefsteak
  - Single row



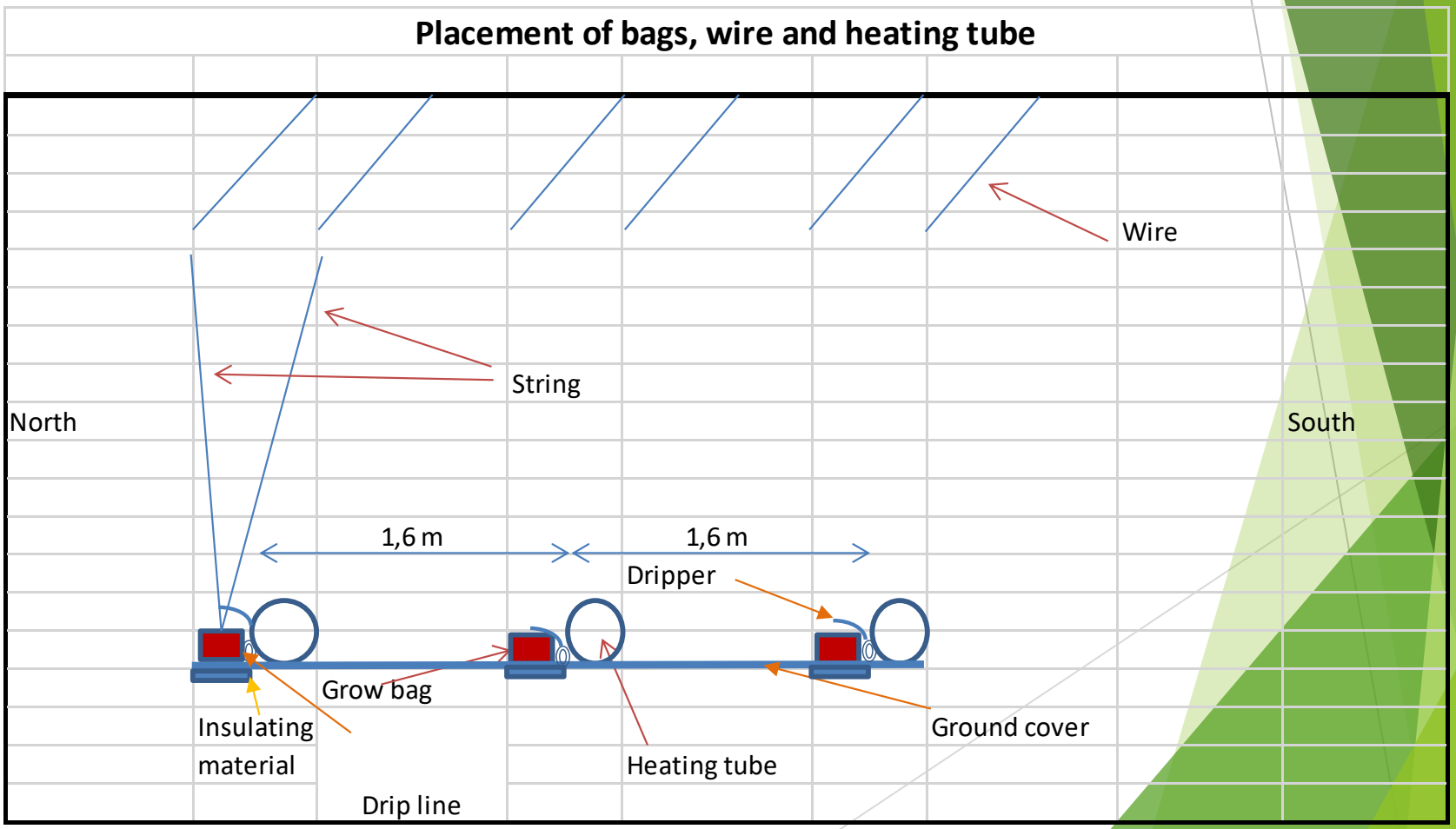
Stem holder placement

- Different Types
  - 16” x 24”
  - Cherry
  - Double row

Heat tube placement

- The basics:
  - One per row
  - Drop back to the shoots turning
  - Encourages V-shaped canopy

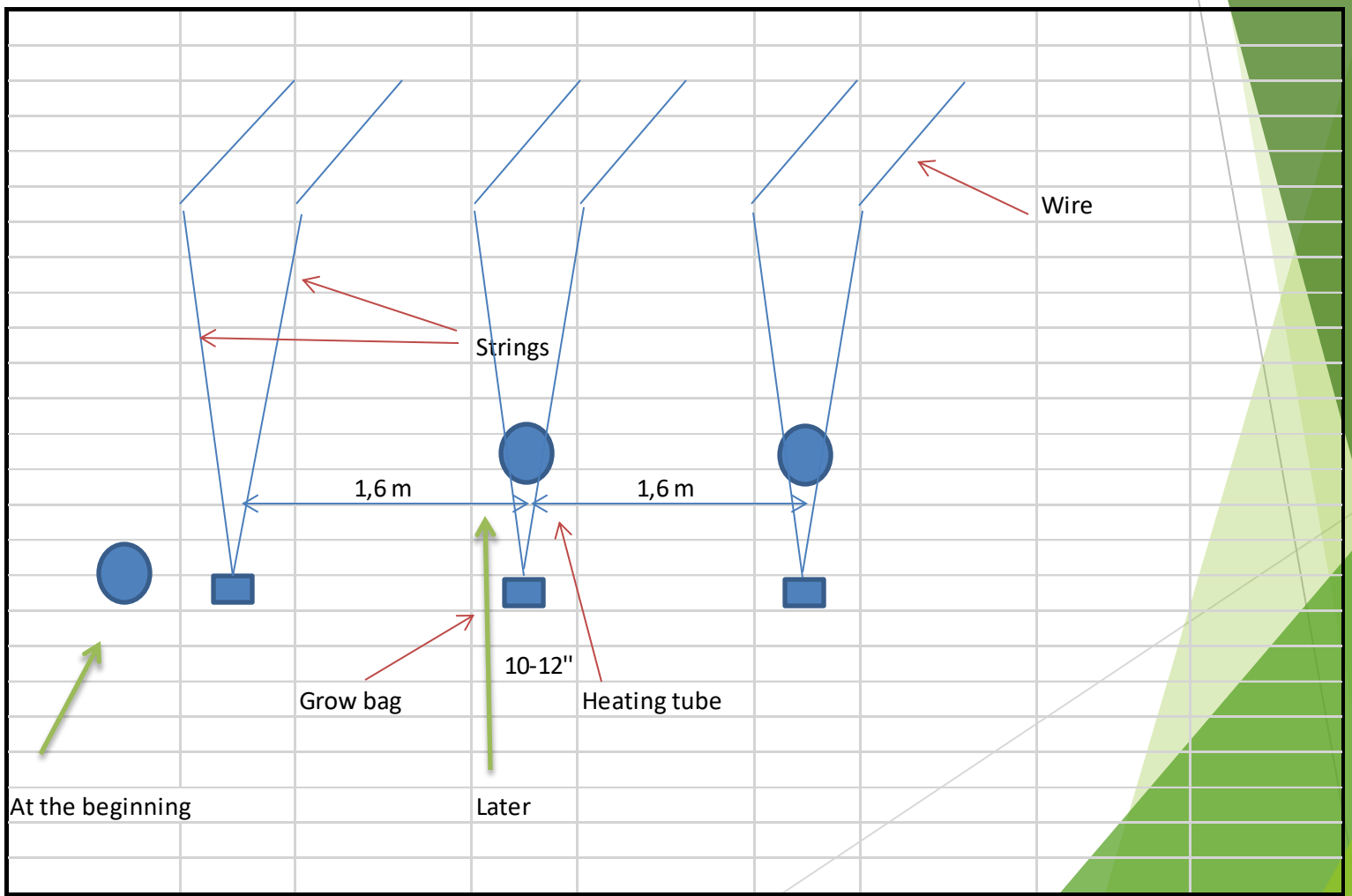
Placement of heat tubes with use of stem holders (off-centered)



Heat tube placement

- Off-centered

Placement of heat tubes without use of stem holders (centered)



Canopy placement

- Lighting
  - Hung on ropes over wire supports
    - Prevention of competition between canopies
    - U-shape of the double-head base

Crop Planning

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Program

- How to select a greenhouse vegetable cultivar
- Transplant management planning
- Crop load planning
  - Why?
  - Structure and CO_2 effect
  - Planting density
  - Managing fruit load from planting to the hottest period of the summer
  - End-of-season management

How to select a greenhouse vegetable cultivar

- Characteristics sought:
  - Market
  - Taste
  - Yield
- Disease resistance
- Seed merchants
- Hybrid/non-hybrid

How to select a greenhouse vegetable cultivar

Resistance

ISF disease resistance

ISF: International Seed Federation

How to select a greenhouse vegetable cultivar

Resistance

THE FOLLOWING SEPARATORS WILL BE USED:

- / (slash) - to separate pest codes
- : (colon) - to separate the species code from the strain/race/pathotype code. The colon is followed by a space
- , (comma) - to separate strain/race codes. The comma is followed by a space
- - (hyphen) - to indicate an uninterrupted series of strain/race numbers
- . (dot) - to separate numbers defining a compound strain/race name

How to select a greenhouse vegetable cultivar

Seed merchants

- Some large groups
  - Bayer/De Ruiter
  - Enza Zaden
  - Gautier
  - Rijk Zwaan
  - Sakata
  - Syngenta

How to select a greenhouse vegetable cultivar

Seed merchants

- Values/Beliefs
- GSPP: Good Seed and Plant Practices
- Biosecurity
  - Packaging and repackaging

How to select a greenhouse vegetable cultivar

Hybrids

- F1
- Selection
- ⃠ OGM

How to select a greenhouse vegetable cultivar

- Main soil-borne diseases:
  - PL Corky root (tomato)
    - No resistance = rootstock
  - FOL: Fusarium wilt (tomato)
  - FOR: Fusarium root rot (tomato and cucumber)
    - Resistance not always present = rootstock
  - Va *Verticillium albo-atrum*
  - Vd *Verticilium dahliae*
- Nematodes…

Organic

- Main soil-borne diseases:
  - PL Corky root

Organic

- Main soil-borne diseases:
  - FOL Fusarium wilt

Organic

- **Main soil-borne diseases:**
  - **FORL Fusarium crown and root rot**

Organic

- Main soil-borne diseases:
  - Va *Verticillium albo-atrum*

Organic

- Main soil-borne diseases:
  - Vd *Verticillium dahliae*

Organic

- Main soil-borne diseases
  - Nematodes…
    - *Ma* *Meloidogyne arenaria*
    - *Mi* *Meloidogyne incognita*
    - *Mj* *Meloidogyne javanica*

How to select a greenhouse vegetable cultivar

Basic package for greenhouse tomatoes

- **ToMV:0-2, Ff:A-E, Fol:1,2, For**
  - Tomato Mosaic Virus race 0 to 2
  - *Passalora fulva* (Pf) race A to E (12 races in all) (formerly *Fulvia fulva* (Ff)) and Leaf Mold (LM), *Cladosporium fulvum* (Cf)
  - *Fusarium oxysporum* f.sp. *lycopersici* (race 1 and 2)
  - *Fusarium oxysporum* f.sp. *radicis-lycopersici*

How to select a greenhouse vegetable cultivar

Basic package for tomato rootstock

- **ToMV:0-2/Fol:0,1/For/Pl/Va:0/Vd:0 Ma/Mi/Mj**
  - Pl = *Pyrenochaeta lycopersici* corky root
  - Vd = *Verticillium dahliae* (race 0) there are 2 races
  - *Verticillium albo-atrum* (race 0)
  - Ma/Mi/Mj = Me*loidogyne arenaria*, *incognita* and *javanica*

How to select a greenhouse vegetable cultivar

Cucumber

Table 2. English cucumbers

Seed merchant	Cultivar	Size (cm)	Growing season				Resistance/tolerance *		Crop type		Comments
			W	Sp.	Su	F	powdery mildew	Cca**	vining	bush	
De Ruiter	Camaro	34-40	X			X	I	X	x		Very popular in winter
	Denali	32-36			X	X	H		X		Trial only, promising
	Eldora	32-38		X	X		H	X	X	x	Trial only, promising
	Dominica	32-36		X	X	X	I	X	X		Very popular in the spring, summer, and fall
	Logica	34-42		X	X	X	H	X	X		Very long fruit, very productive
	Discover	32-40		X	X	X	H	X	X		The most tolerant of powdery mildew, but with 15-20% lower yield than average
	Annica	32-38	X	X	X	X	H	?		X	For bush cucumbers only
syngenta	Bomber	31-36			X		I	X	X	X	Rapid and vigorous, trial only
	Monroe	32-36		X		X	I	X	X		Trial only
	Mountie	32-38	X	X	X	X	I	X	X	X	Low light tolerant, trial only

How to select a greenhouse vegetable cultivar

Pepper

Table 1. Two squares of peppers

Seed merchant	Cultivar	Size (g)	Colour	Seedling growth*			Comments
				moderate	average	rapid	
De Ruiter	Morraine	200	red		X		
	Fantasy	210-250	red			X	
	Orange Glory	180-200	orange			X	Reference for fruit quality
	Derby	200-220	yellow			X	
	Striker	210	yellow	X			Reference for fruit quality but average taste

Transplant production schedule

- Depending on crop
- Time of year
- Harvest start date
- Various techniques:
  - Grafting
  - Pinching

Time and space management

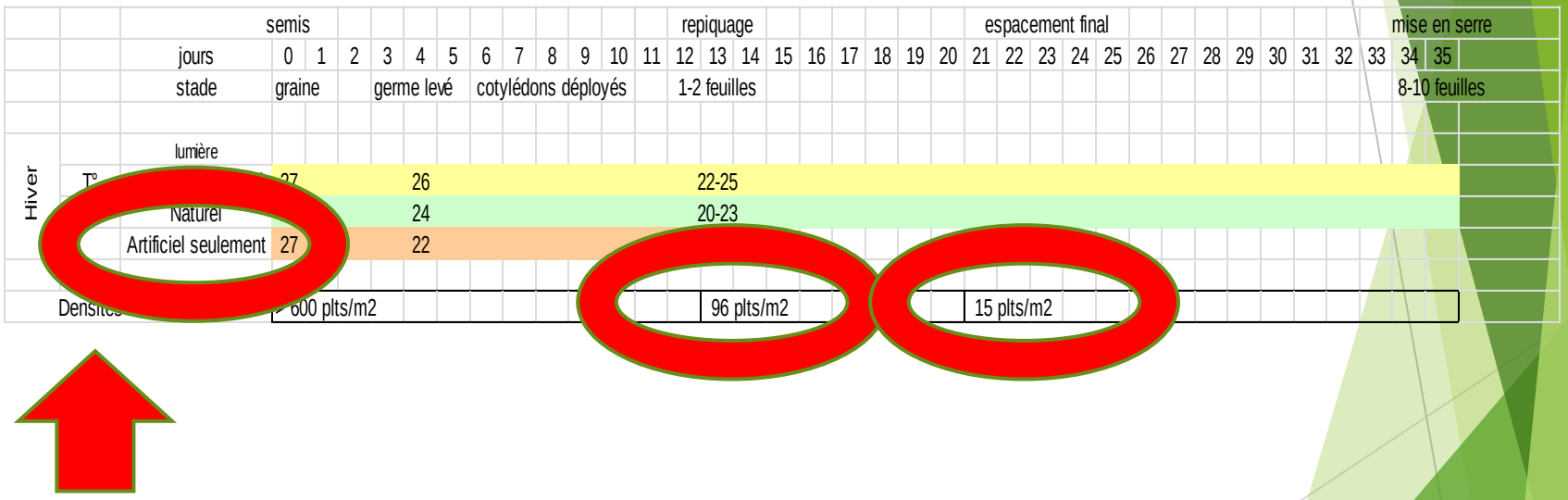
- Schedule in terms of the types of plants to develop:
  - Tomatoes – 35 days
  - Grafted tomatoes
  - Cucumbers
  - Peppers
  - Eggplants

Time and space management

- The basics:
  - Plants do not touch one another
  - Plants double their leaf area every four days
- Take into consideration:
  - Usually, you space once.

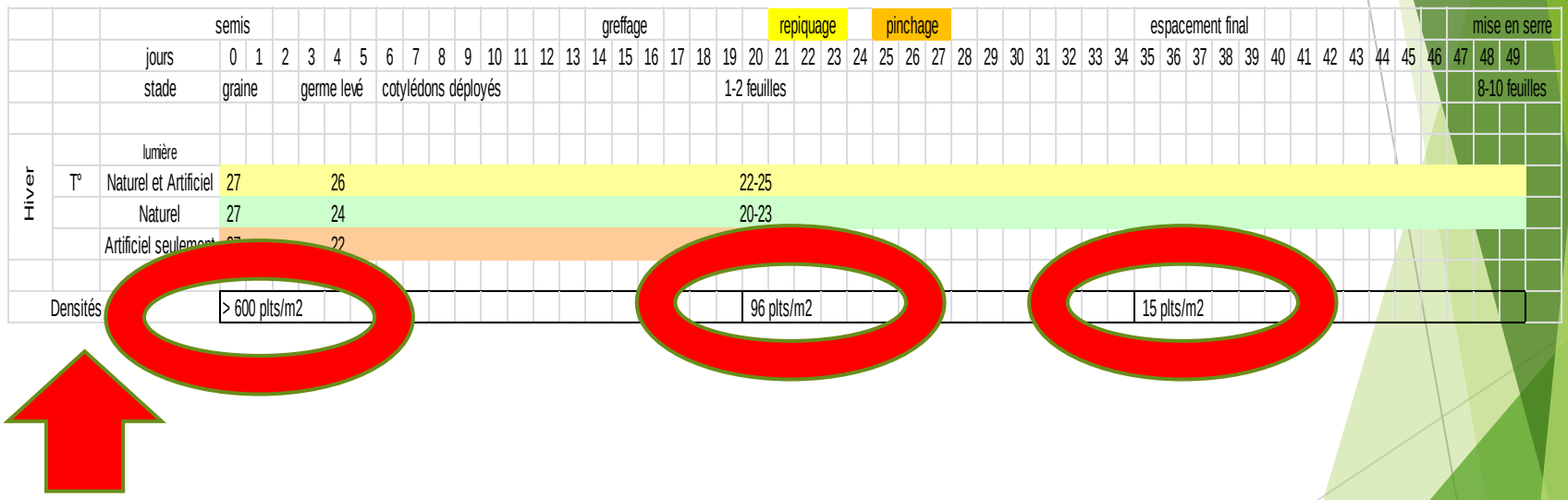
Time and space management

- Non-grafted tomatoes



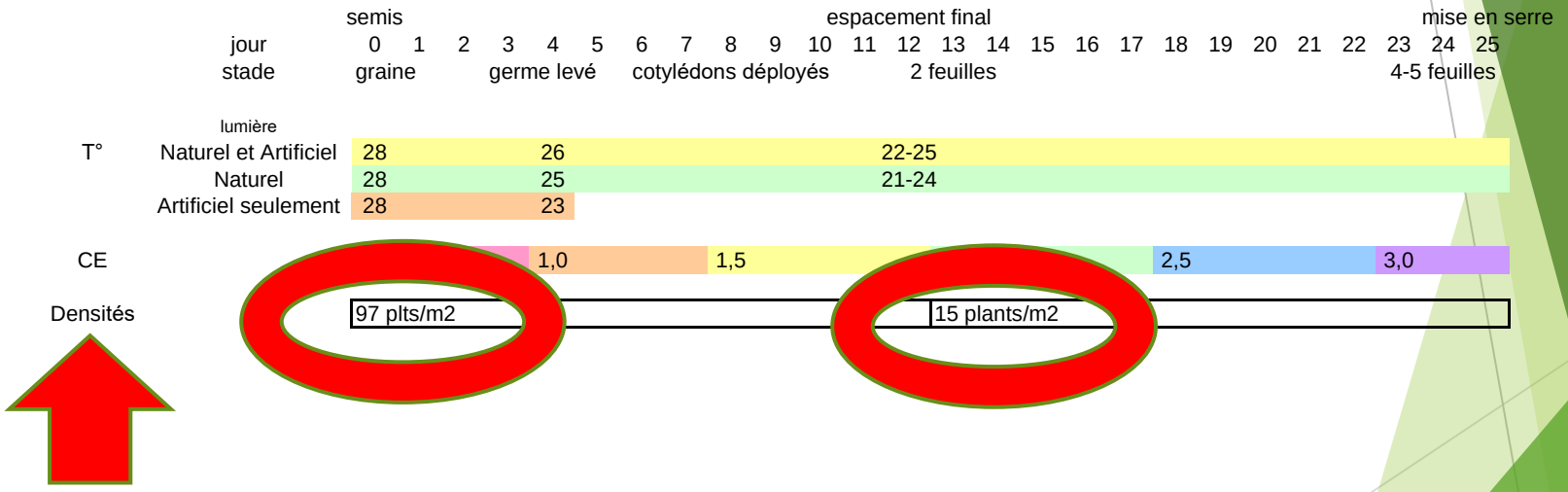
Time and space management

- Grafted/pinched tomatoes



Time and space management

- Cucumbers



Time and space management

- Peppers

Transplant preparation - Peppers

Stage	Pre-emergence	Post-emergence	Transplanting	Spacing	Placement in greenhouse and planting
Day	1	5	17-18	30	42-53
Stage		Germinated seedlings	First true leaf	As soon as leaves touch	Start of Y (node 0) at a clearly visible Y
Seedling density/m^2	1,000	1,000	100	20	****2.7 – 3.5
Temperature	25-26°C	25°C day – 24°C night	23-25°C day and 21°C night	21-23°C day - 20°C night	*****21-23°C day - °C night

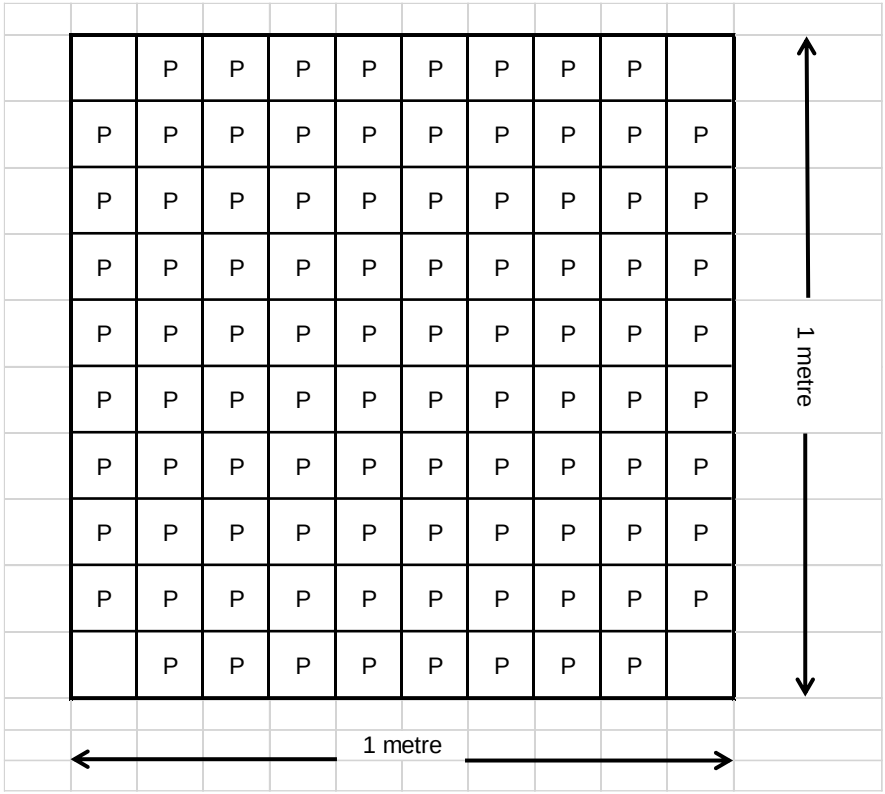
Time and space management

Eggplants

Transplant preparation - Eggplants

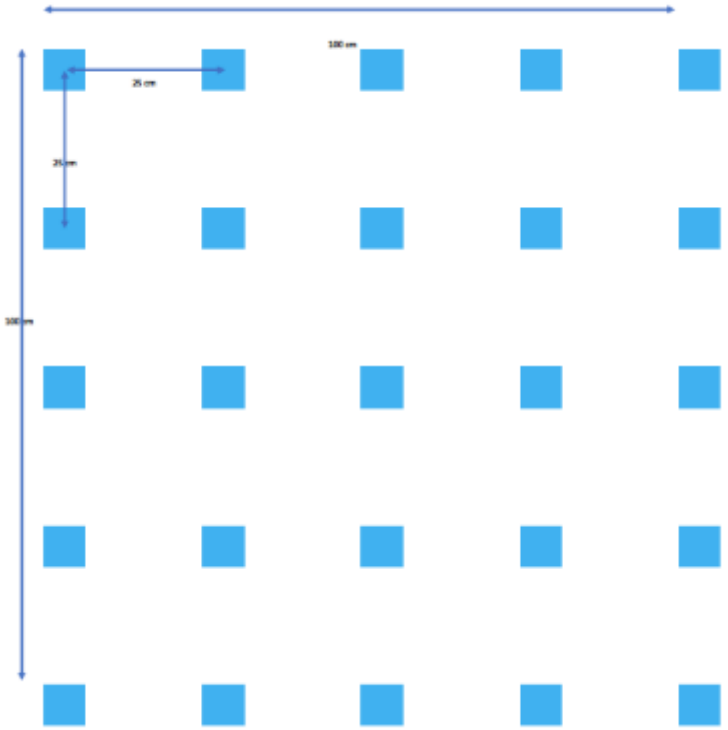
Stage	Pre-emergence	Post-emergence	Transplanting	Spacing			Placement in greenhouse and planting
Day	1	5	Non-grafted: 15 days 22 days	Grafted	Non-grafted: 25-27 days 32.35 days	Grafted	42-53
Stage		Seedlings germinated	First true leaf	As soon as leaves touch			Size: 25 to 30 cm
Temperature	26-27°C	22°C day, night (little variation)	20-23°C day, night (little variation)	20-23°C day, night (little variation)			Winter: 18-19°C Spring: 22-23°C Little variation-day-night at first
RH (DH)	100%	55-65%	55-65%	65-75%			60-80% (3-7 g/m3)
CO^2		500-700 ppm	500-700 ppm	500-700 ppm			500-700 ppm
Artificial light (PAR)		35 W/m2 PAR Building (175 umol/m2/s) or 17 W/m^2 in greenhouse	35 W/m2 PAR Building (175 umol/m^2/s) or 17 W/m^2 in greenhouse	35 W/m2 PAR Building (175 umol/m2/s) or 17 W/m2 in greenhouse			
Need: DLI (mol/m2/day)		10	10	10			

Time and space management

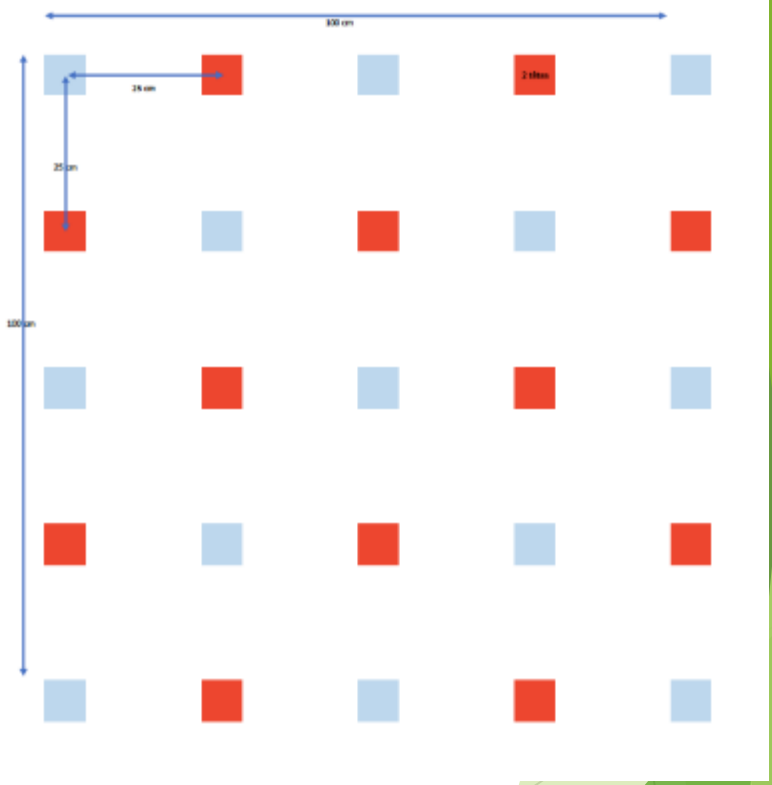


96 plants/m^2
Or
100 cm^2/pl (10cmX10cm)

Time and space management



16 plants/m^2
Or
625 cm^2/pl (25 cm X 25 cm)



8 feet/m^2
Or
625 cm^2/pl (25 cm X 25 cm)

Time and space management

Time and space management

Time and space management

Time and space management

- Plant with one head

Time and space management

- Plant with two heads

Time and space management

- Great root system!

Fruit load planning - Density

- Why:
  - A plant is a living thing
    - Can increase in weight
    - Can decrease in weight
      - Distress or burnout

RESPECTING THE PLANT'S PRODUCTION CAPACITY IS THE BEST WAY FOR SUCCESS

Fruit load planning

Excessive fruit load

Aborted

Fruit load planning

Excessive fruit load

Aborted

Fruit load planning

Excessive fruit load

Aborted

Fruit load planning

Low fruit load after excessive fruit load

Russetting

Fruit load planning

Excessive fruit load

Short fruit

- English cucumber:
  - 280 mm (11 inches)
  - CFIA length requirements

Fruit load planning

Excessive fruit load

Pointed fruit

Fruit load planning

Excessive fruit load

Root loss and disease

Fruit load planning

Excessive fruit load

Burn out and yellow stem

Fruit load planning

Excessive fruit load

Burn out and Erwinia

Fruit load planning

- Step 1: Choice of densities
  - First criterion:
    - Your type of greenhouse
    - With or without CO_2

$$CO_2 + H_2O \rightarrow CH_2O + O_2$$

(carbon dioxide) (water) (sugar) (oxygen)

- Quantity and quality of leaves
- Light
- CO_2
- H_2O

Structure and CO_2

- Type 1: Greenhouse with high light level with CO_2 injection
- Type 2: Greenhouse with high light level without CO_2 injection or moderate light level with CO_2 injection.
- Type 3: Greenhouse with moderate light level without CO_2.
- Type 4: Greenhouse with low light level without CO_2.

Types of greenhouses

- Type 1 and 2: Greenhouse with high light level
  - Arches spaced 5 feet or more apart
  - Less structure in the roof (W) (the most common) or reflective structures (white)
  - Quality plastic
    - antidrip
    - transparent (not yellow)
  - Pre-2015 glass

- With CO_2 injection: type 1 greenhouses; can become type 2 in the summer without CO_2 injection
- Now there are type 0.5 greenhouses
  - New glass greenhouses with CO2
  - Polyethylene: Luxuriante (Hol-Ser) and Luminosa (Harnois) with CO_2

Types of greenhouses

- Type 3: Greenhouse with moderate light level without CO_2.
  - Fairly significant encumbrance of roof
    - Poor polyethylene
    - Arches close together (4 feet or less)
    - W and trusses
    - Thermal screens too wide when not in use
    - People take the roof for a technical corridor (dirty tubes, electrical wires, rusty heating tubes, etc.)
- With CO_2 : Type 2 greenhouse

Types of greenhouses

- Type 4: Low light level without CO_2
  - Wooden greenhouse
  - Very crowded polyethylene greenhouse
    - Institutional or demonstration greenhouses

What type of greenhouse do you have?

0.5-1.0-1.5-2-2.5-2.7-2.9-3-3.1-3.3-3.5-3.7-4

Beefsteak tomato yield potential

- Type 0.5 : 72kg = 100%
- Type 1.0 : 60 kg = 83%
- Type 2. 0 : 52 kg = 72%
- Type 3.0 : 45kg = 62.5%
- Type 4: 40 kg = 55%

- Do these figures make you angry?!! Me too.

Beefsteak tomato yield potential

- Type 0. : 72kg = 100%: Winter production greenhouse under lights
- Type 1.0: 60 kg = 83%: Low greenhouse (3-season), tall greenhouse (4-season)
- Type 2.0: 52 kg = 72% : 3-season greenhouse
- Type 3.0: 45kg = 62.5%: Training or 2-season greenhouse
- Type 4.0: 40 kg = 55%: Training greenhouse

The structure is your best investment

and makes the other activities profitable (heating, labour, etc.)

Crop load planning

- Choice of tomato densities: heads/m^2

Type of greenhouse	Tomato			
	Beefsteak			Cherry
	Medium	Large	Very Large	
	190-210g	220-250g	>270g	
1	3.2	2.8	2.5	3.8
2	2.8	2.4	2.2	3.3
3	2.4	2.1	1.9	2.9
4	2.1	1.8	1.7	2.5

Crop load planning

- Choice of cucumber densities: heads/m^2

Type of greenhouse	Cucumber			
	English		Lebanese	
	High wire	Umbrella	High wire	Umbrella
1	2.5	1.8	3.5	2.5
2	2.2	1.6	3.0	2.2
3	1.9	1.4	2.6	1.9
4	1.7	1.2	2.3	1.7

Crop load planning

- Choice of densities of peppers: heads/m^2

Type of greenhouse	Peppers	
	Blocky	Conical
1	6.5	8.5
2	5.6	7.3
3	4.9	6.4
4	4.3	5.6

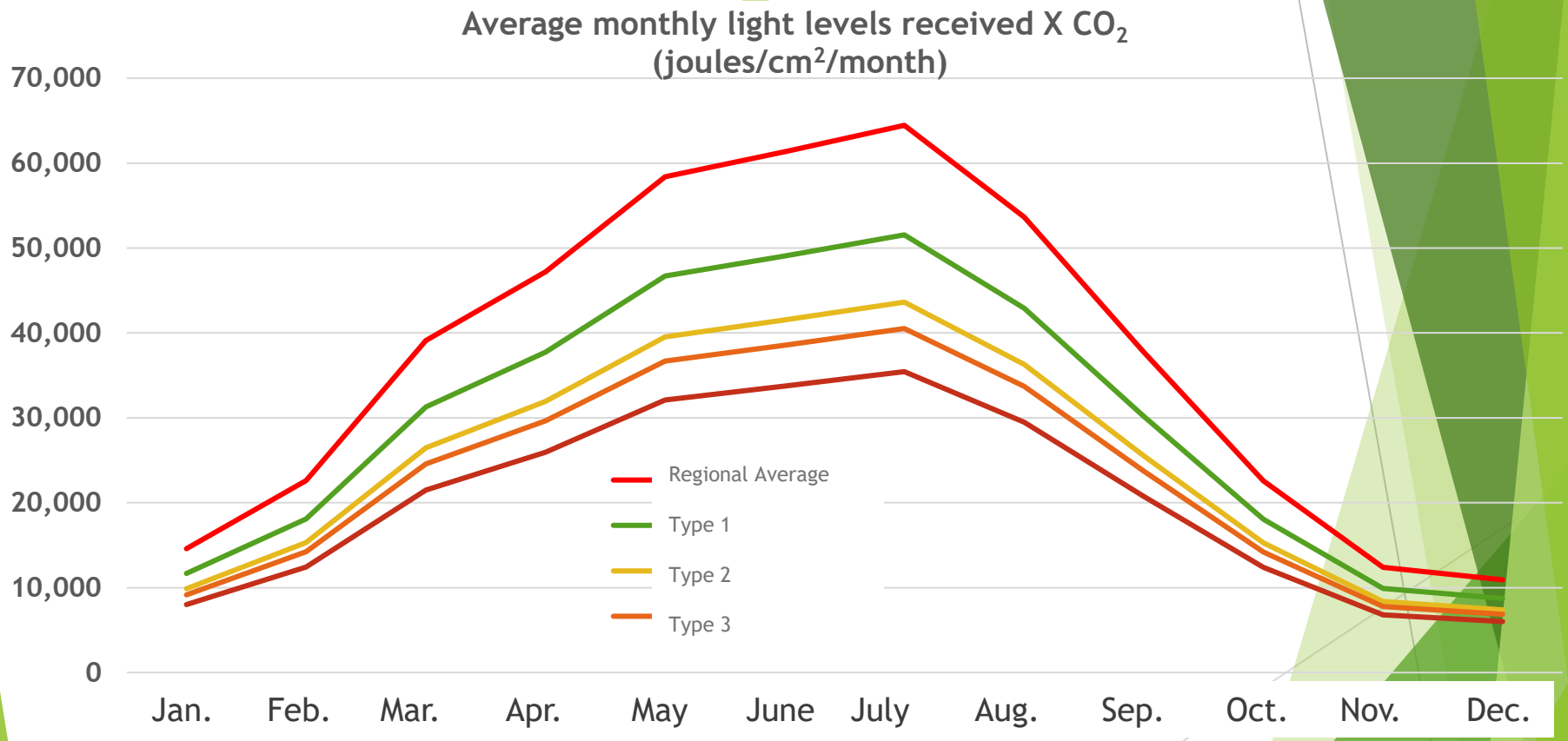
Crop load planning

- Choice of eggplant densities:
- Size (g) X heads/m^2

Type of greenhouse	Eggplant
	g/stratum
1	2,770
2	2402.9
3	2085.8
4	1835.5

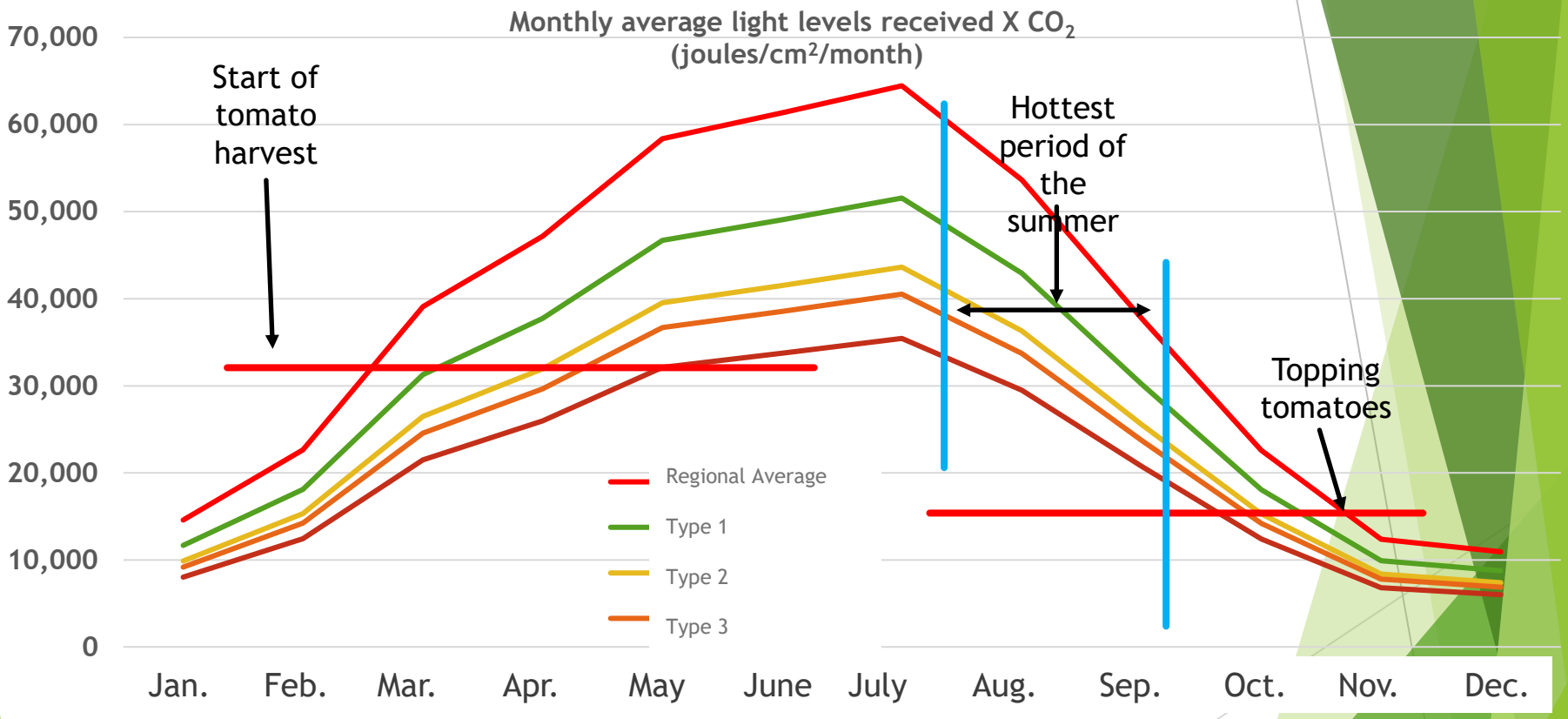
Fruit load planning

Structure and CO_2



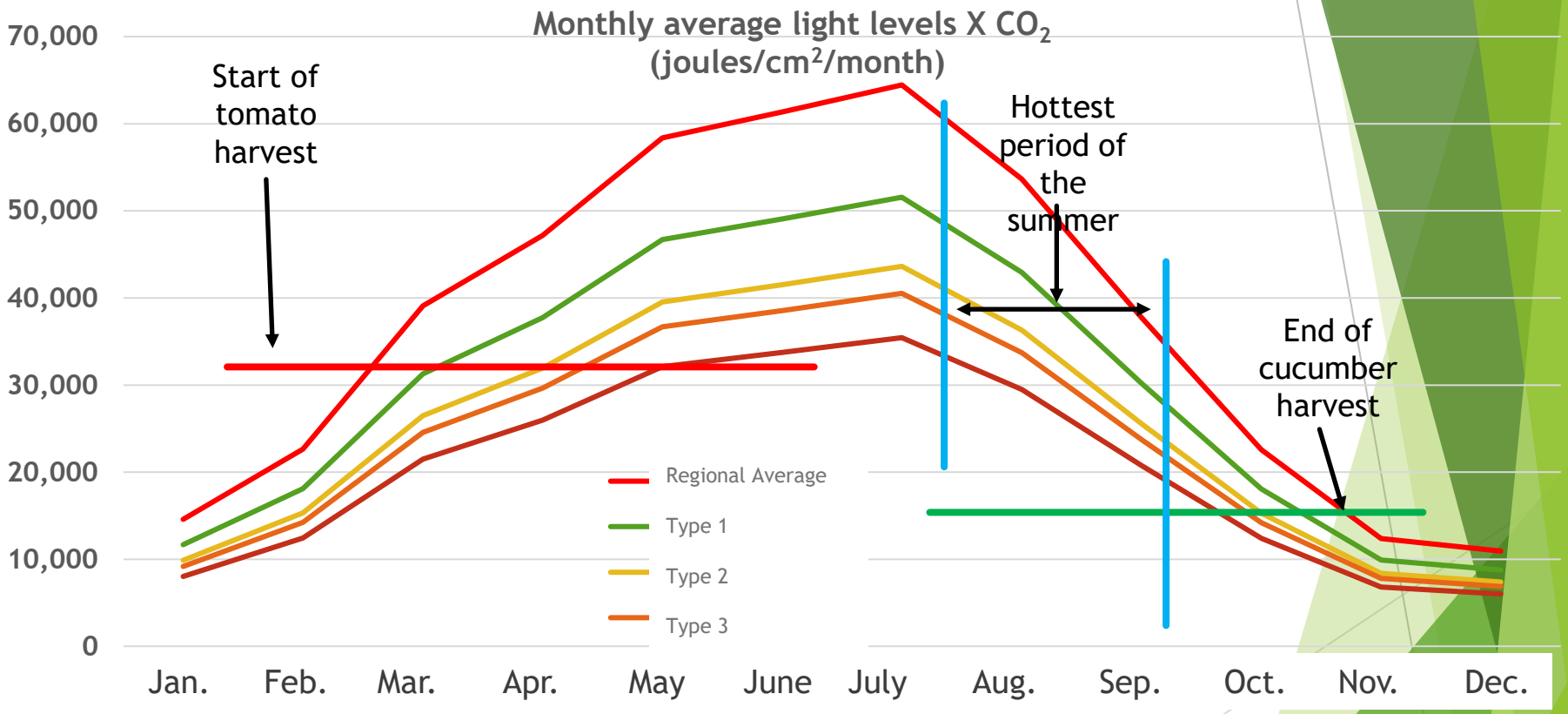
Fruit load planning

Tomato



Fruit load planning

Cucumber



Fruit load planning

Crop load management:
From planting to the hottest period of the summer

Reach climate potential without ever exceeding it.

Fruit load planning

Tomato

- When to trim to 3 fruits/cluster. Mid-May in general.

Month	Fruit crop load Tomatoes					Density Tomatoes			
	T1	T2	T3	T4		T1	T2	T3	T4
	Fr/m²	Fr/m²	Fr/m²	Fr/m²		Pl/m²	Pl/m²	Pl/m²	Pl/m²
January	13	2				2.0			
February	35	18	3			2.0	2.8	2.4	
March	55	44	22	7		2.6	2.7	2.4	2.1
April	65	61	46	28		3,2	2.7	2.4	2.1
May	80	65	62	54		3,2	2,7	2,4	2,1
June	70	59	50	45		3,2	2.7	2.4	2.1
July	65	55	45	40		3,2	2.7	2.4	2.1

Fruit load planning

Cucumber (Umbrella system)

Month	Fruit crop load Cucumbers					Density Cucumbers			
	C1	C2	C3	C4		C1	C2	C3	C4
	Fr/m²	Fr/m²	Fr/m²	Fr/m²		Pl/m²	Pl/m²	Pl/m²	Pl/m²
January	1.00					1.5			
February	3.50	1.90	0.66			1.5	1.5	1.5	
March	5.50	4.50	4.00	2.90		1.5	1.5	1.5	1.5
April	6.00	5.90	5.50	4.50		1.5	1.5	1.5	1.5
May	8.00	6.60	6.20	5.20		1.5	1,5	1,5	1,5
June	8,50	7,00	6,75	5,50		1,5	1.5	1.5	1.5
July	7.00	6.40	6.12	5.25		1.5	1.5	1.5	1.5
August	6.75	5.30	4.90	4.00		1.5	1.5	1.5	1.5
September	4.90	3.75	3.25	2.75		1.5	1.5	1.5	1.5
October	3.50	1.88	1.70	1.50		1.5	1.5	1.5	1.5
November	2.00					1.5			
December									

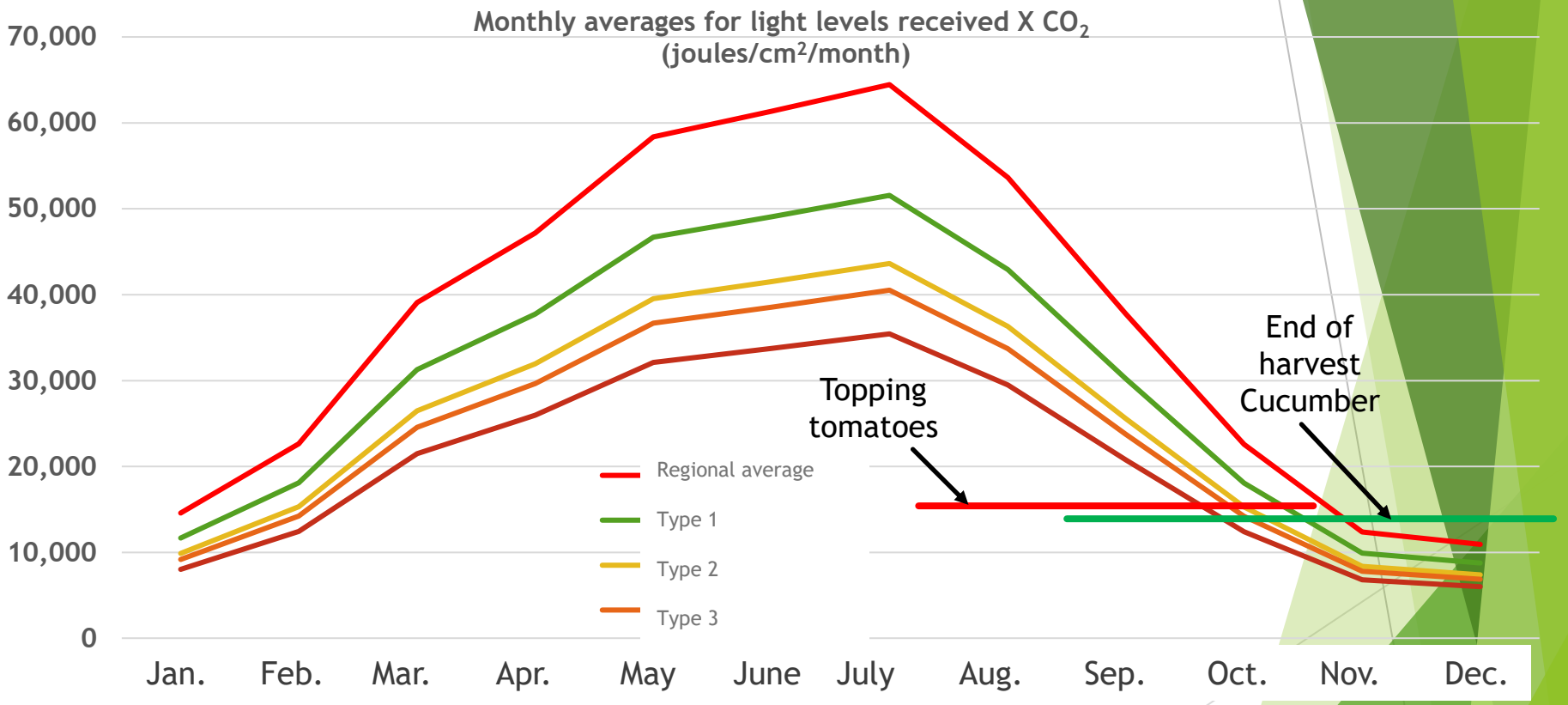
Fruit load planning

Fruit load management: End of season

Tomatoes

Fruit load planning

Radiation limits - end of season



Fruit load planning

Topping date

Date	Time between topping and harvest	Date	Max. yield
End of harvest 1	Weeks	Topping	kg/m^2
2021-12-29	12	2021-10-06	11
2021-12-22	12	2021-09-29	12
2021-12-15	11.5	2021-09-25	13
2021-12-08	11	2021-09-22	13
2021-12-01	11	2021-09-15	13
2021-11-24	10.5	2021-09-11	13
2021-11-17	10	2021-09-08	13
2021-11-10	10	2021-09-01	13
2021-11-03	9.5	2021-08-28	13
2021-10-27	9	2021-08-25	13
2021-10-20	9	2021-08-18	13
2021-10-13	8.5	2021-08-14	13
2021-10-06	8.5	2021-08-07	13

Fruit load management

Fruit crop load

Month	Fruit crop load Tomatoes					Density Tomatoes			
	T1	T2	T3	T4		T1	T2	T3	T4
	Fr/m^2	Fr/m^2	Fr/m^2	Fr/m^2		Pl/m^2	Pl/m^2	Pl/m^2	Pl/m^2
July	65	55	45	40		3,2	2.7	2.4	2.1
August	65	55	45	40		2.6	2.7	2.4	2.1
September	60	51	35	30		2.6	2.7	0.0	0.0
October	50	32	26	9		2,6	0.0	0.0	0.0
November	30	12	5			0.0	0.0	0.0	
December	10					0.0			

Fruit load planning

Crop load management:
End of season

Cucumbers

Fruit load management

Fruit crop load

Month	Fruit crop load Cucumbers					Density Cucumbers			
	C1	C2	C3	C4		C1	C2	C3	C4
	Fr/m²	Fr/m²	Fr/m²	Fr/m²		Pl/m²	Pl/m²	Pl/m²	Pl/m²
July	7.00	6.40	6.12	5.25		1.5	1.5	1.5	1.5
August	6.75	5.30	4.90	4.00		1.5	1.5	1.5	1.5
September	4.90	3.75	3.25	2.75		1.5	1.5	1.5	1.5
October	3.50	1.88	1.70	1.50		1.5	1.5	1.5	1.5
November	2.00					1,5			
December									

Thank you!

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