Climax Conseils Training

Managing Crop Balance

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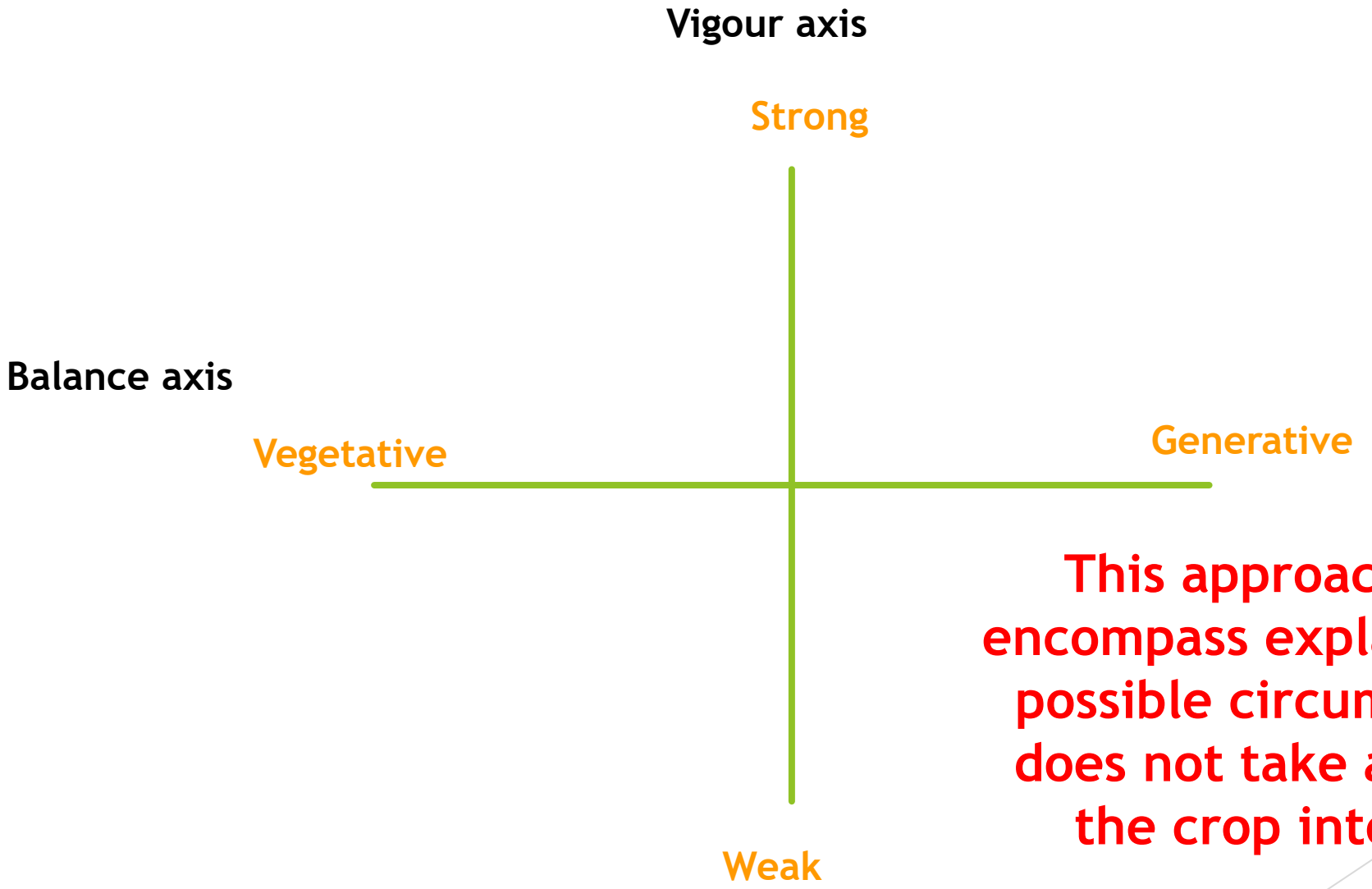
Vigour vs. balance

- Vigour
  - First priority
  - Based on the balance between sources (photosynthesis) and sinks (growth).
- Balance
  - Second priority
  - Based on the distribution of sugars (photosynthesis) between the different organs (sink strength) for an equal vigour

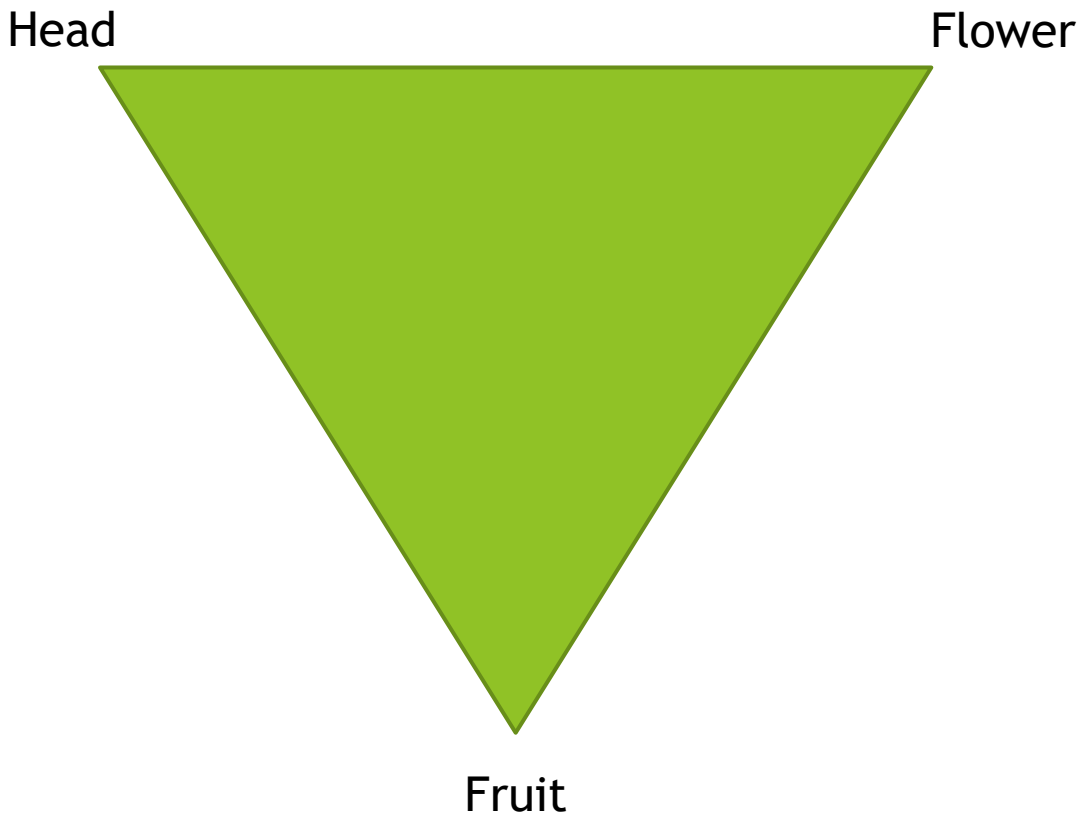
Vigour vs. balance: Two-axis approach



This approach does not encompass explanations of all possible circumstances and does not take all aspects of the crop into account.

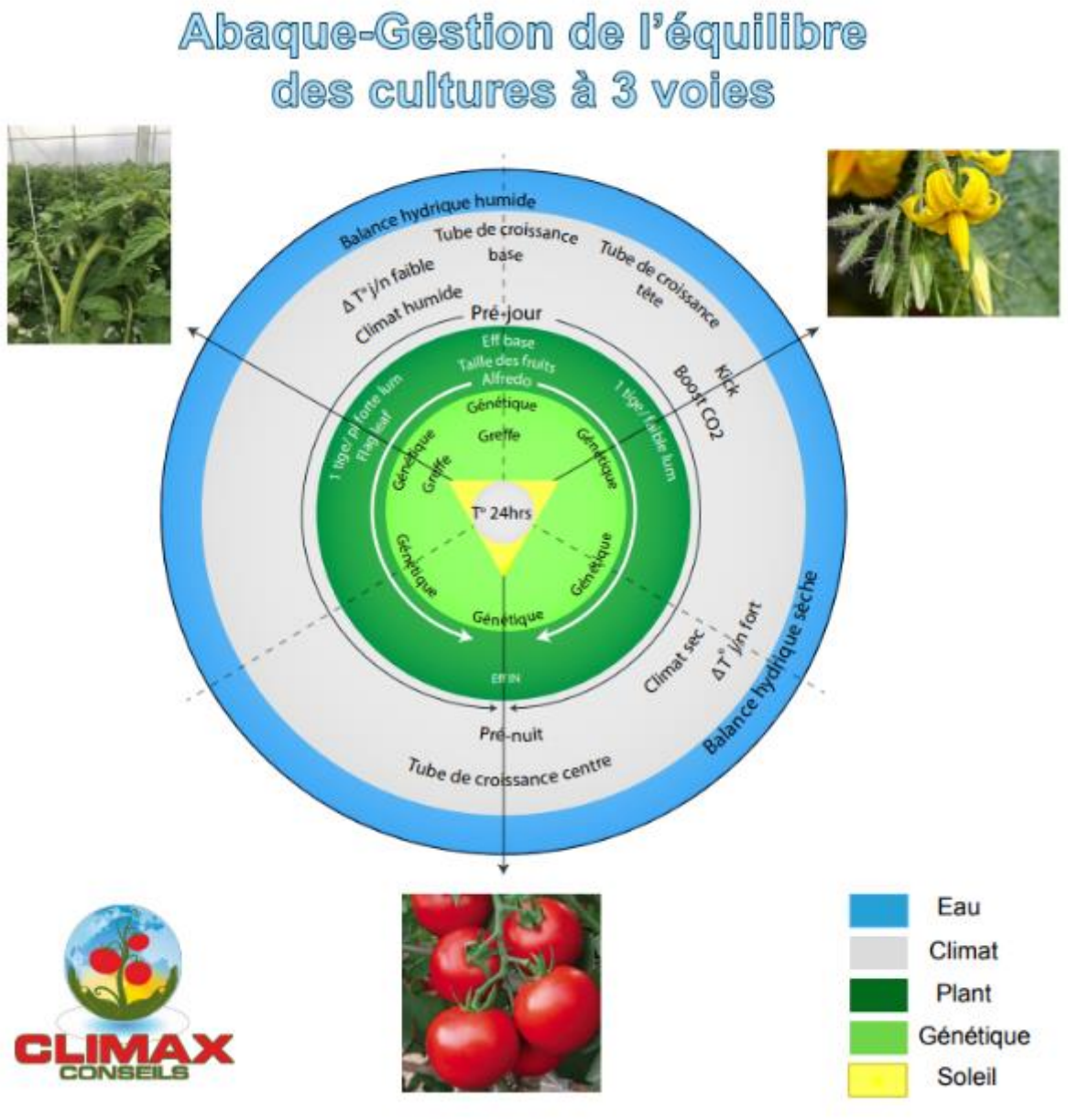
Vigour vs. balance: Detailed approach (three zones)

Sugar distribution zones



Vigour vs. balance: Your toolbox

Three-Channel Crop Balance Management Graph



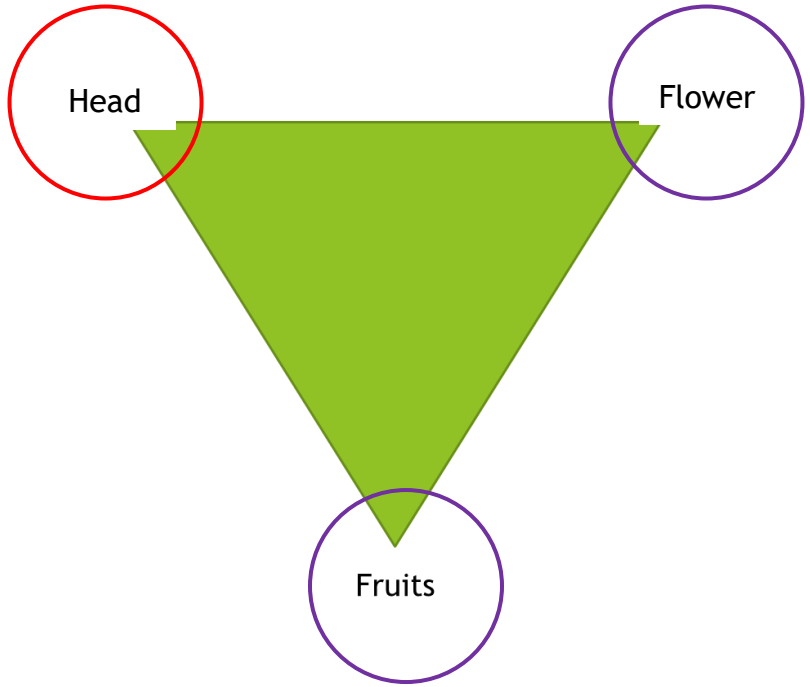
Reading your plants

Reading your plants

You must learn to read to succeed!

Distribution of assimilates in fruit vegetables (e.g. tomatoes)

Reading your plants



Répartition des assimilats entre parties végétative et reproductive

Situation normale		Trop reproductive	Trop végétative
Feuilles	Partie végétative 30 %	Partie végétative 20 %	Partie végétative 40 %
Tige			
Racines			
Fruits	Partie reproductive 70 %	Partie Reproductive 80 %	Partie Reproductive 60 %

- Vegetative zone
- Generative zones

Distribution of assimilates in fruit vegetables

Reading your plants

GENERAL INDICATORS OF BALANCE

Organ	Too vegetative	Too generative	
Young stem	Too strong Very purple Many suckers	Too thin Few suckers	Head
Leaf	Short with a strong stem Long, stretched out horizontally and pale Large leaflets	 Short (Christmas tree)	
Cluster	Upright, straight, long and thin	Short, 45° from stem, conical shape and curved at the tip (nice cluster)	Flower
Flower	Pale yellow, particularly in the morning (should be egg yolk yellow) Flowering more than 10 cm from the head Irregular sequence of flowering	 Flowering less than 10 cm from the head	
Fruit	Slow fruit grow Distortion and irregular size	Fast fruit growth Even growth and regular size	Fruit

Reading your plants

Reading your plants

Tom'Pousse data collection method

- **Plant data collected weekly**
- **Helps you track your plants' progress and quickly react to any changes in their development**
- **Helps you keep track of the factors you cannot see by simply looking: growth speed, flowering, fruit set, time between fruit set and harvest, etc.**

Tom'Pousse data: Tomatoes

Reading your plants

Week _____ Density _____ Density sucker #1 _____

Variety _____ Density sucker #2 _____

		Plants					
		1	2	3	4	5	mean
Growth	cm						
Leaf lenght	cm						
Leaf width	cm						
1st flower open height	cm						
Stem diameter	mm						
Number of leaves							
No Flowering cluster							
No setting cluster							
Cluster lenght	cm						
No harvest cluster							

Beef tomato target
25 è 35 cm
45 cm
45 cm
10 cm
10 mm cherry/12 mm beef
LAI
Minimum flowering speed of 0,8 cluster/week
< 5 cm

			Cluster number										
Main stem	1												
	2												
	3												
	4												
	5												
Moyenne													
sem. préc.													
différence													

mean

fruits/main stem

fruits/sucker #1

fruits/sucker #2

fruits/ m2

Fruits set /m2

Tom'Pousse data: Peppers

Reading your plants

Week: _____ **Variety:** _____ **Row:** _____

Measure		Growth	Number of flowers/stem	Stem diameter	No apex node	N° flowering node	N° fruit setting node	N° harvesting node	N° Forming flower node	Number flower A-B-C
	1									
	2									
	3									
	4									
	5									

	Fruits set / plant	Fruits set /m2	Fruits/plant	Fruits/m2
Tot				

Planting density:

3,12 pl/m2

Head density:

6,23 pl/m2

 # de fruits per node

# Plants	# nœud													
1														
2														
3														
4														
5														
Mean (/5)														
Mean. prev. week														
# f. set/plant														

Distribution of assimilates in fruit vegetables: Establish your language

Reading your plants

Percentage of energy used by the different distribution zones

80% = little energy

100% = balanced

120% = a lot of energy

Example: 80 – 100 – 120 → 80% head – 100% flower – 120% fruit

Reading tomato plants

Reading your plants

1

Head:

Flower:

Fruit:

Reading tomato plants

Reading your plants

2

Head:

Flower:

Fruit:

Reading tomato plants

Reading your plants

3

Head:

Flower:

Fruit:

Reading tomato plants

Reading your plants

4

Head:

Flower:

Fruit:

Reading tomato plants

Reading your plants

5

Head:

Flower:

Fruit:

Reading tomato plants

Reading your plants

6

Head:

Flower:

Fruit:

Reading tomato plants

Reading your plants

7

Head:

Flower:

Fruit:

Reading pepper plants

Reading your plants

1

Head:

Flower:

Fruit:

Reading pepper plants

Reading your plants

2

Head:

Flower:

Fruit:

Reading pepper plants

Reading your plants

3

Head:

Flower:

Fruit:

Reading pepper plants

4

Reading your plants

Head:

Flower:

Fruit:

Reading pepper plants

Reading your plants

5

Head:

Flower:

Fruit:

Reading pepper plants

Reading your plants

6

Head:

Flower:

Fruit:

Reading cucumber plants

Reading your plants

2

Head:

Flower:

Fruit:

Reading cucumber plants

Reading your plants

3

Head:

Flower:

Fruit:

Reading cucumber plants

Reading your plants

4

Head:

Flower:

Fruit:

Reading cucumber plants

Reading your plants

5

Head:

Flower:

Fruit:

Reading cucumber plants

Reading your plants

6

Head:

Flower:

Fruit:

Reading cucumber plants

Reading your plants

7

Head:

Flower:

Fruit:

Reading cucumber plants

Reading your plants

8

Head:

Flower:

Fruit:

Reading cucumber plants

Reading your plants

9

Reading cucumber plants

Reading your plants

10

Head:

Flower:

Fruit:

Tomatoes: Visual description and plant reading

Reading your plants

	80%	100%	120%
Head	**Stem diameter lower than 10mm at 20 cm from the head**	**Setem diameter between 10 and 12 mm**	**Stem diameter higher than 12 mm**
	Small leaf	**Leaf: width 75% of the length**	**Broad leaves**
	Thin sucker on no developpement	**Big leaflet**	**Strong sucker as big as the main stem**
	Stem thin and stretch	Leaves with bubble	Suckers started from the leaves
		Lightly curled leaves	Striated, flat or split stem
			Flat head
Flower and fruit setting	**Flower stalk thin and straight**	**Rolling cluster with wide base**	**Very wide rolling cluster, short**
	Bad flowering sequence or abortion	**Fast fruit setting**	**Very fast fruit setting**
	Flowering lower than 10 cm from the head	**Flowering at 10 cm from the head**	**Flowering closed than 10 cm from the head**
	Flower shape like a pear	**Oblong flower of 1 cm**	**Oblong flower of 1,5 cm**
	Pale flower and king flower at the first rank	Fleurs d'un beau jaune vif	Impossibilité de mettre un support de grappe
	Low flower number	Good flower number	Too much flower number
	Cluster upward 70o from the horizontal	**Cluster outgoing at 45o**	**Cluster outgoing at less than 45o**
			More than one king flower per cluster
Fruit	**Fruit swelling slowly**	**Fruit swelling on the target**	**Fruit swelling too fast**
	Pale fruit	One to two cluster with the right harvest size	**Dark green fruit**
	Bad swelling sequence on the cluster		**Too big**
			Fruit too much exposed to sun
			Too much cluster with the right fruit size

Peppers: Visual description and plant reading

Reading your plants

	80%	100%	120%
Head	Stem diameter thin (< 6-7 mm)	stem diameter close to 6-7 mm	Stem diameter strong (> 6-7 cm)
	Sucker weak or absent	Sucker a little bit smaller than stem	Sucker as strong as head
	Slow growing (< 8 cm/week)	Growing to 8-10 cm/week	Growing faster than 10 cm/week
	Small leaves on the head	Good leave area	Leafy head
	Nearly no purple color	Purple color at each node	A lot of purple in the head
Flower and fruit setting	Thin flower upward	Strong flower curled	Too strong curled flower
	Flowering late (under the 3rd node)	Flowering between the 2nd and 3rd node	Floraison au 1er nœud voir en tête
	Abortion	Fruit setting of 2 to 3 nodes flush	Fruit setting of more than 3 nodes flush
	1 inch fruit fall		
Fruit	Low fruit load	Good fruit load and distribution	Too much fruit
	Flat fruit	Good fruit size, shape and thick flesh	Heavy fruit and difformed

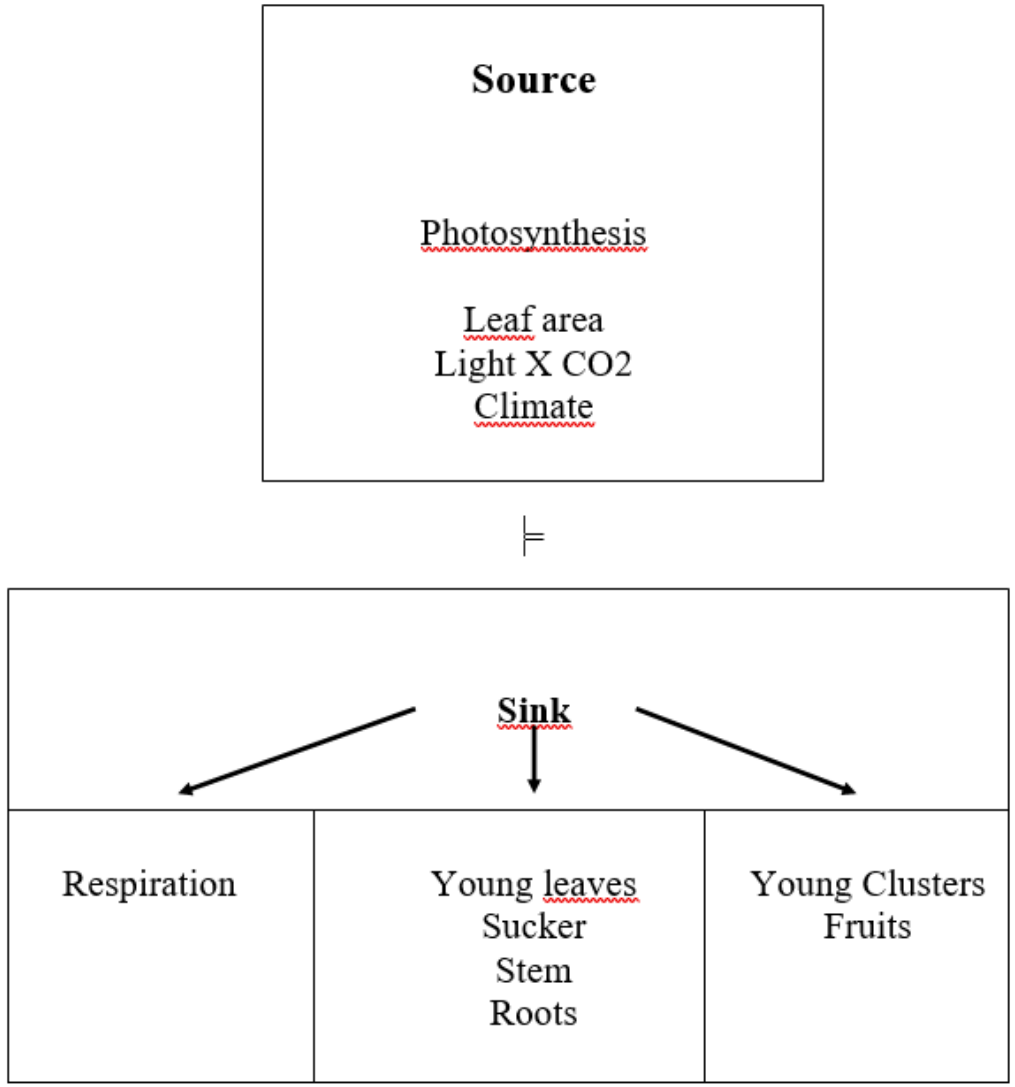
Cucumbers: Visual description and plant reading

Reading your plants

Organ		Critère	80%	100%	120%
Head	Main stem	Stem diameter at 20 cm from the apex	Less than 8 mm	9-10 mm	More than 11 mm
		Arrow	Inside the leaves	out of 20-30 cm	Out more than de 30cm
		Tendril and sucker	poor development	Regular at each node	Very strong
		Leaf diameteer	less than 25 cm	25-30 cm	more than 30 cm
		Leaf orientation	Horizonal	45°	Vertical
	Sucker	Diameter	Less than 6mm	6-7 mm	more than 8mm
Flower		Color	Pale yellow	Yellow post-it	Dark yellow
		Flowering height	Lower than 45 cm	45 cm	higher than 45 cm
		Fruit setting	Abortion	No abortion	High fruit setting
		Nb flower/node	no flower	1-2 flowers per node	More than 2 flower per node
		Nb flower open	0 or 2 flowers open per plant	Always one flower open each morning	Always one flower open each morning
		Ratio stem/fruit	1	1/2	1/3
Fruit		Number	Low fruit load	1-2 fruit/plant ready to harvest	More than 2 fruit /plant ready to harvest
		Shape	Short, pointed, curled	Straight and well balance (width and length)	Too long

Vigour: Source-sink balance

- First priority
- Balance between supply and demand



Determine the supply

- See Crop Planning chapter
  - Respect the climate potential (greenhouse type)
    - Light x CO_2
      - Role of the time of year

Generating source (photosynthesis): Leaf area

Vegetative-generative balance

- Crop management
  - Number of leaves
    - Leaf area index (LAI)
      - Leaf area m^2/ground area m_2
    - Measuring

A)

- Cut off mature leaves and use them to calculate the number of leaves required to cover 1 m^2 of ground area.

  = number of leaves/m^2 of leaves

- LAI = (number of leaves/plant * density)/(number of leaves/m^2 of leaves)

B)

- Take the following formula (source: Infos Serre, CTIFL, Bulletin nº 1, February 2017)
- Leaf #1 is the leaf found just under the first developing bunch.

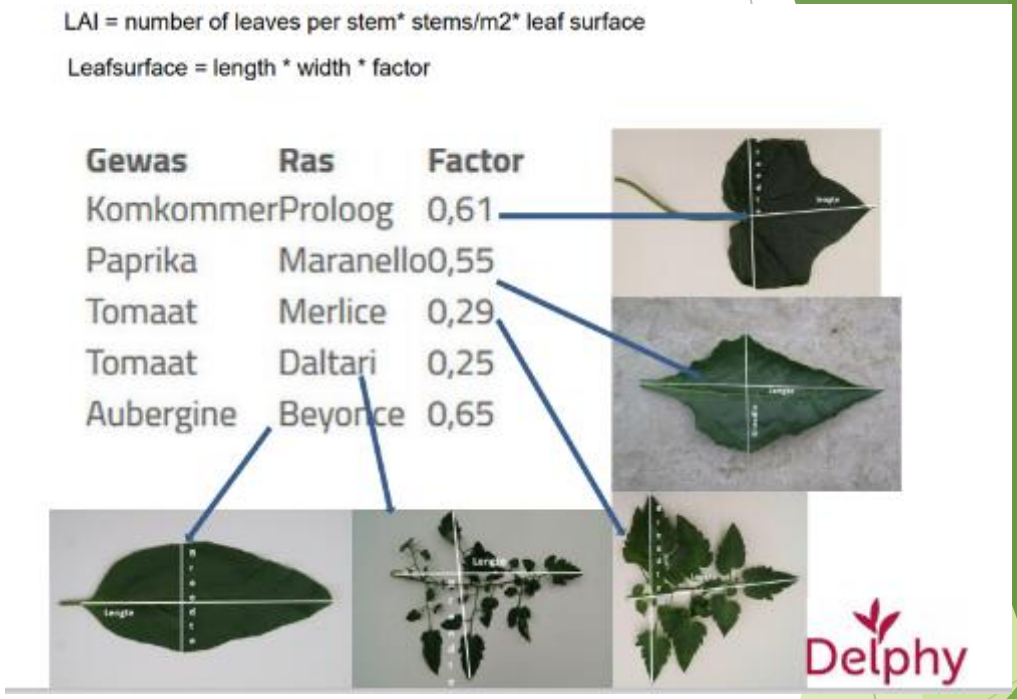
$$LAI_{estimé} = \left[\frac{\text{longueur feuille n°9} \times \text{largeur feuille n°9} \times 0{,}33 \times \text{densité} \times \text{nombre de feuilles}}{10\,000}\right] - 0{,}25$$

Generating source (photosynthesis): Leaf area

Vegetative-generative balance

- Crop management
  - Number of leaves
    - LAI: Leaf area index
      - = Leaf area m^2/ground area m^2
    - Measuring

C) Delphy

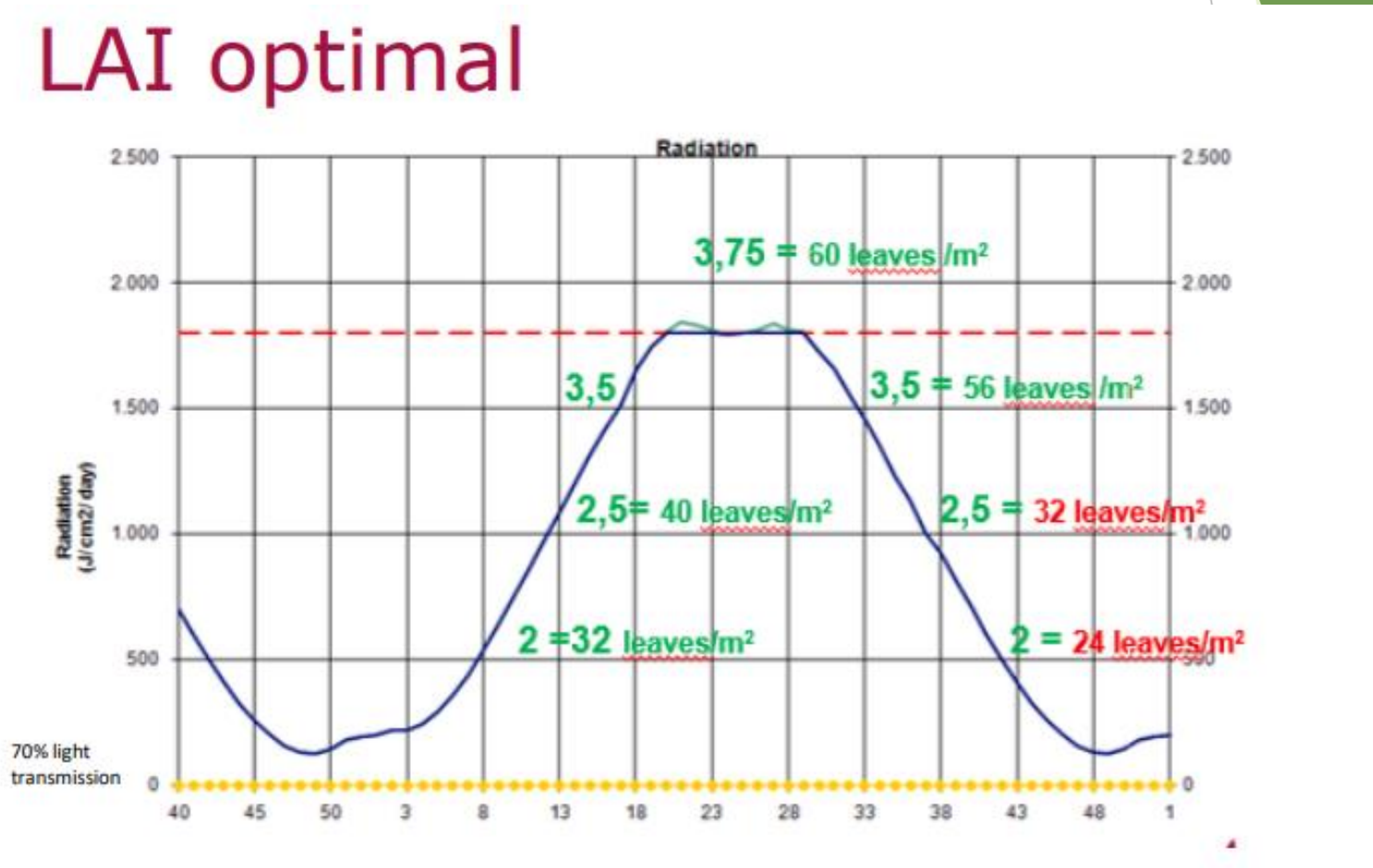


LAI = number of leaves/stem * number of stems/m^2 * (length * width * factor)

Generating source (photosynthesis): Leaf area

Vegetative-generative balance

- Crop management
  - Number of leaves in a greenhouse with a rating of 0.5



Generating source (photosynthesis): Leaf area

- Crop management
  - Number of leaves in a greenhouse with a rating of 2

Light interception of the lower leaf based on LAI at 18°C (joules/cm2/week)

		Light sum per week (joules/cm2/week)									
LAI	% lum	10000	9000	8000	7000	6000	5000	4000	3000	2000	1000
3	0,89	82	74	66	57	49	41	33	25	16	8
2,9	0,89	88	80	71	62	53	44	35	27	18	9
2,8	0,88	95	86	76	67	57	48	38	29	19	10
2,7	0,87	103	93	82	72	62	51	41	31	21	10
2,6	0,86	111	100	89	78	66	55	44	33	22	11
2,5	0,85	119	107	96	84	72	60	48	36	24	12
2,4	0,83	129	116	103	90	77	64	51	39	26	13
2,3	0,82	139	125	111	97	83	69	56	42	28	14
2,2	0,81	150	135	120	105	90	75	60	45	30	15
2,1	0,79	161	145	129	113	97	81	64	48	32	16
2	0,78	174	156	139	122	104	87	70	52	35	17
1,9	0,76	187	169	150	131	112	94	75	56	37	19
1,8	0,74	202	182	162	141	121	101	81	61	40	20
1,7	0,72	218	196	174	152	131	109	87	65	44	22
1,6	0,70	235	211	188	164	141	117	94	70	47	23
1,5	0,68	253	228	202	177	152	126	101	76	51	25
1,4	0,65	273	245	218	191	164	136	109	82	55	27
1,3	0,62	294	264	235	206	176	147	118	88	59	29
1,2	0,59	317	285	253	222	190	158	127	95	63	32
1,1	0,56	341	307	273	239	205	171	137	102	68	34
1	0,53	368	331	294	258	221	184	147	110	74	37
0,9	0,49	397	357	317	278	238	198	159	119	79	40
0,8	0,45	427	385	342	299	256	214	171	128	85	43
0,7	0,41	461	415	369	323	276	230	184	138	92	46
0,6	0,36	497	447	397	348	298	248	199	149	99	50
0,5	0,31	535	482	428	375	321	268	214	161	107	54
0,4	0,26	577	519	462	404	346	288	231	173	115	58
0,3	0,20	622	560	498	435	373	311	249	187	124	62
0,2	0,14	670	603	536	469	402	335	268	201	134	67
0,1	0,07	723	650	578	506	434	361	289	217	145	72

Vegetative-generative balance

The grey boxes represent the minimum number of joules required per leaf to reach 24-hour mitochondrial respiration at 18 °C.
Adding leaves beyond the indicated level will prevent the leaves' energy requirement from being met.

Generating source (photosynthesis): Leaf area

Vegetative-generative balance

- **Crop management**
  - **Number of leaves**
    - **The required LAI varies depending on light reception**
    - **In summer, aim for an LAI of around 3.0 to 3.75, depending on the type of greenhouse.**
    - **Aim lower if the fruit load is very low (supply adjustment)**
    - **Reduce LAI progressively as the light decreases**
    - **Essential for maintaining optimal humidity levels in the canopy**

Generating long-term sinks (demand)

- See Crop Planning chapter
  - Respect the climate potential (greenhouse type)
    - Light x CO_2
      - Density
      - Fruit load

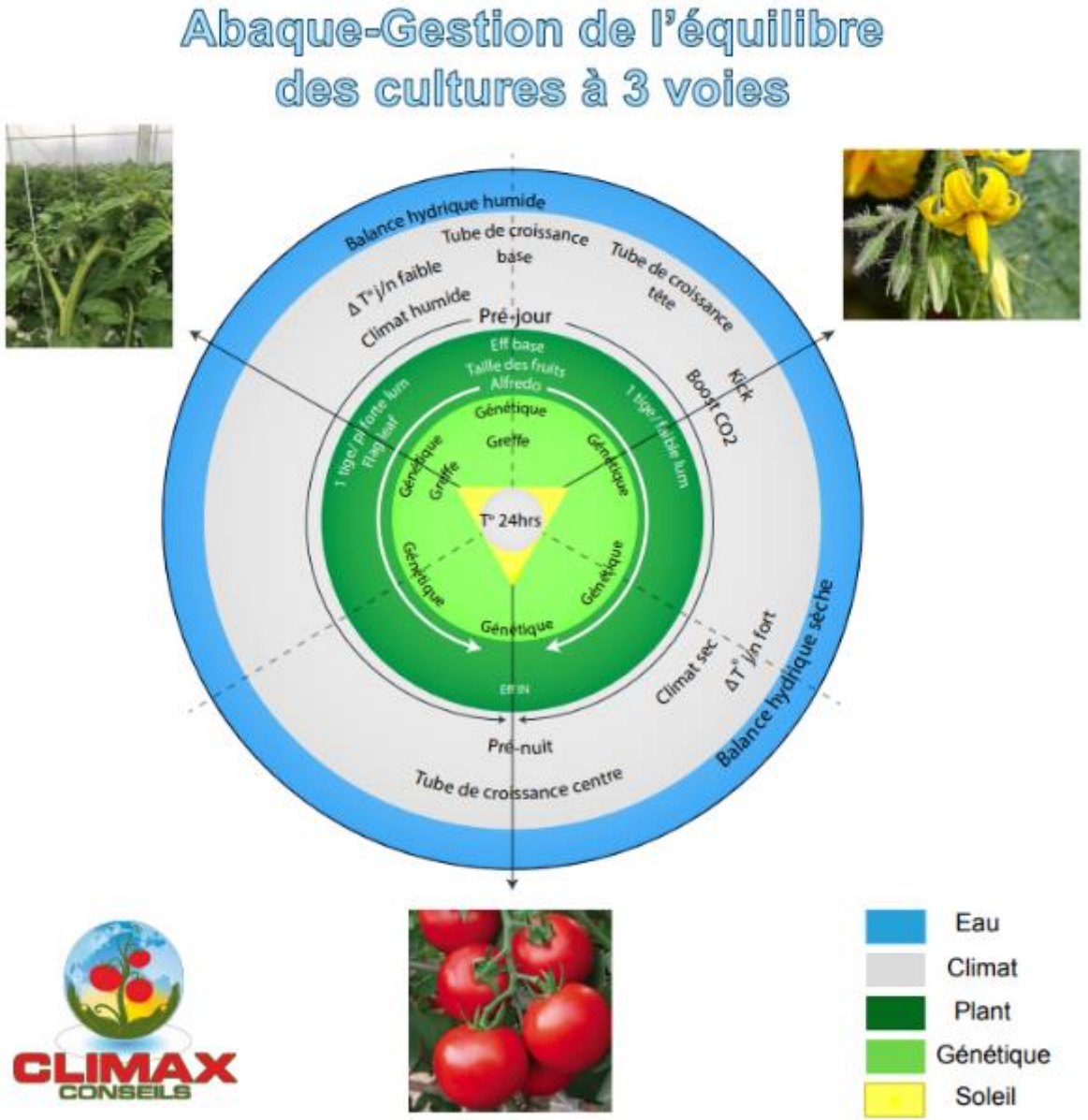
Managing short-term sinks (demand)

- Basics of crop management:

- **24-hour temperature**
- Light quality
- Crop balance: Three-Channel Crop Balance Management Graph
  - Genetic balance
  - Water balance
  - Climate balance
  - Vegetative-generative balance

Vigour vs. balance: Your toolbox

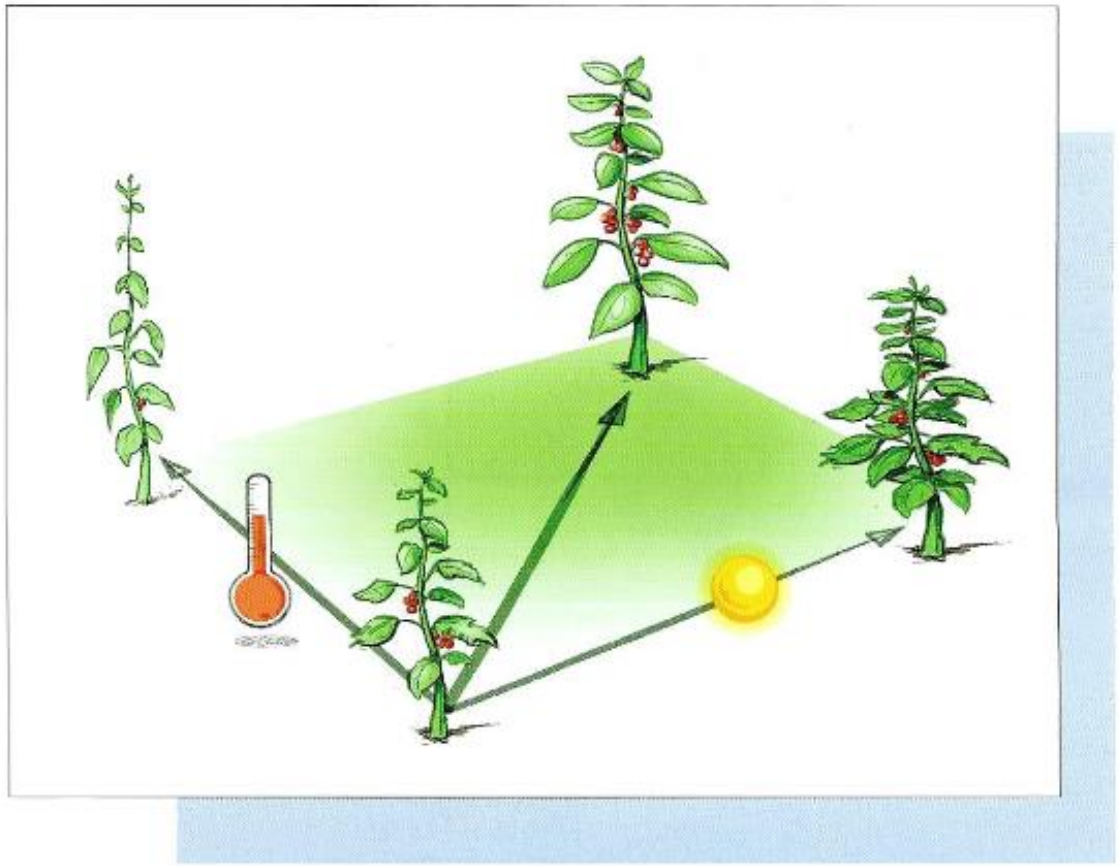
Three-Channel Crop Balance Management Graph



Relationship between temperature and light in terms of vigour and balance

24-hour temperature

Figure 3.6.9-1 Plant balance as a result of the Ratio Temperature to Radiation (RTR)



Temperature management according to light reception

24-hour temperature

- Goal:
  - Establish a good balance between temperature and light on a daily basis.

Figure 6.8.2-3 Scatterplot of daily RTR Ratio Temperature to Radiation

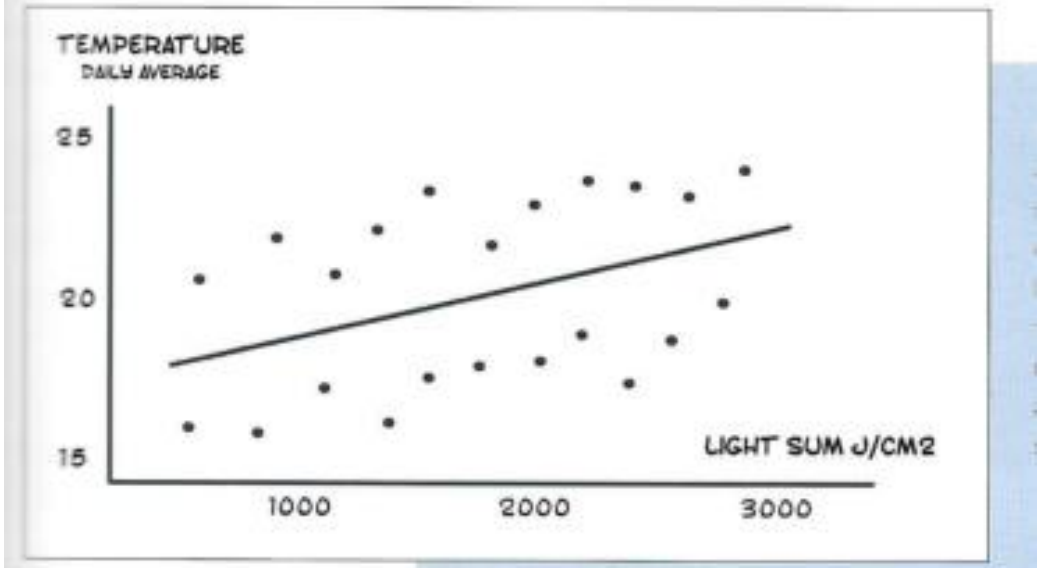
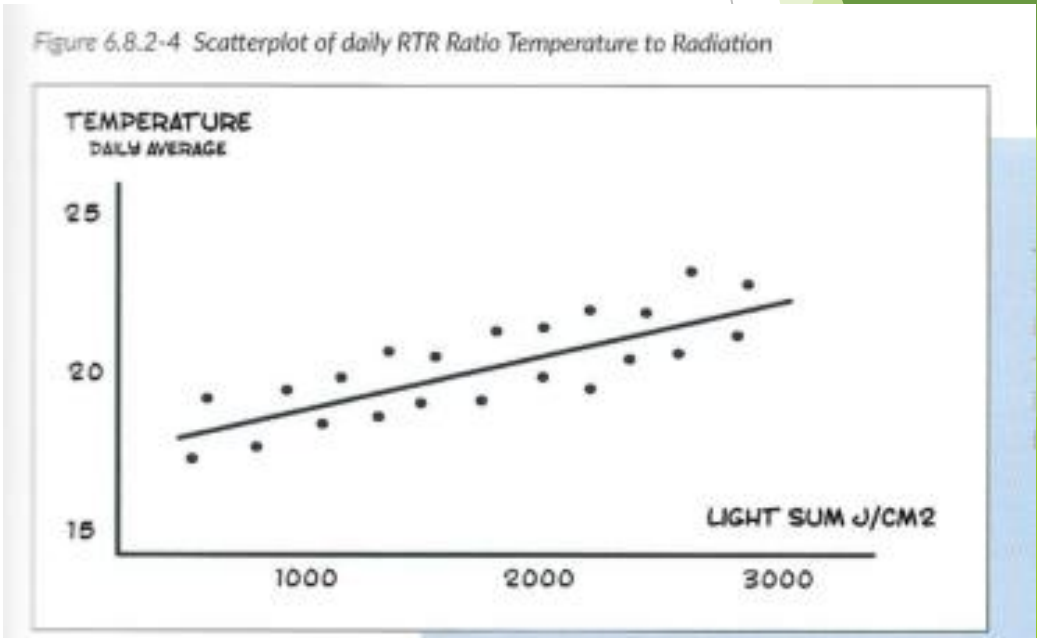


Figure 6.8.2-4 Scatterplot of daily RTR Ratio Temperature to Radiation



Temperature management according to light reception

24-hour temperature

- First element of short-term management (navigating).
- Temperature-light relationship is the most powerful tool.
- It can help you reach maximum production and quality.
- It is the only tool that allows you to act preventatively. Other balance strategies are more reactive.
- It allows you to cultivate strong plants that will be more resistant to diseases and insects.

Temperature management according to light reception

Impact of 1°C on the growth rate of the crops			
	Tomato	Cucumber	Pepper
Vegetative growth	7%	6%	35%
Fruit growth	13%	8%	

Plants are like athletes, or any other living being. The more effort you ask of them, the more nourishment they need. Therefore, you must balance the Energy budget.

Unbalanced budget = obesity or anorexia, even for plants.

Temperature management according to light reception

24-hour temperature

- Excel calculator

Light requirement /week								
							1200	
Fruits(g)	Joules/fr	Delay FS-H	Joules/week/fr	Light Veg	Density	Growth rate	Veg/cl	LUE
200	700	8	88	2520	2,8	0,75	1200	5

Temperature management according to light reception

24-hour temperature

- **Excel calculator**

Light requirement /week								
							1200	
Fruits(g)	Joules/fr	Delay FS-H	Joules/week/fr	Light Veg	Density	Growth rate	Veg/cl	LUE
200	700	8	88	2520	2,8	0,75	1200	5

Fruits(g)	200	Fruit weight for beef tomato (dry weight = 5%)
Joules/fr	700	Light required to fill the fruit
Delay FS-H	8	Time (weeks) between fruitt setting and harvest
Joules/week/fr	88	Light required to fill one fruit for one week (Joules/fr divided by Delay FS-H)
Light Veg	2520	Light requirement to grow the stems for one cluster at 18°C : = Veg/cl X Growth rate 18 X density
Density	2,8	number of head/m2
Speed18	0,75	Growth rate at 18°C based on the cultivar type
Veg/Cl	1200	Light requirement to grow one cluster/stem
LUE	5	Overall light required to grow 1 g of fruit (LUM X CO2)

Temperature management according to light reception

24-hour temperature

- Excel calculator

Light requirement /week									
							1200		
Fruits(g)	Joules/fr	Delay FS-H	Joules/week/fr	Light Veg	Density	Growth rate	Veg/cl	LUE	
200	700	8	88	2520	2,8	0,75	1200	5	

			Light requirement/week for each T24hrs							
Growth rate (Cluster/week)			0,75	0,82	0,89	0,96	1,03	1,1	1,17	1,24
Fruit		T° (°C)	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
Fruit/m2	Light 18C	Veg18C	0,75	0,82	0,89	0,96	1,03	1,1	1,17	1,24
1	88	2520	2608	2795	2983	3171	3359	3546	3734	3922
2	175	2520	2695	2894	3093	3292	3492	3691	3890	4089
3	263	2520	2783	2993	3204	3414	3625	3835	4046	4256
4	350	2520	2870	3092	3314	3536	3758	3980	4201	4423
5	438	2520	2958	3191	3424	3657	3891	4124	4357	4590
10	875	2520	3395	3685	3975	4265	4556	4846	5136	5426
15	1313	2520	3833	4180	4527	4874	5221	5568	5915	6262
20	1750	2520	4270	4674	5078	5482	5886	6290	6693	7097
25	2188	2520	4708	5168	5629	6090	6551	7011	7472	7933
30	2625	2520	5145	5663	6180	6698	7216	7733	8251	8769
40	3500	2520	6020	6651	7283	7914	8546	9177	9808	10440
50	4375	2520	6895	7640	8385	9130	9876	10621	11366	12111

Temperature management according to light reception

24-hour temperature

- Measuring or assessing the light received
  - Pyranometer/light meter/PAR sensor
  - Weather forecast
  - Type of greenhouse (light x CO2)
  - Greenhouse orientation and time of year
  - Leaf area
- Assess crop needs
  - Fruit load
  - Fruit size
  - Plant density

Temperature management according to light reception

24-hour temperature

- What are the crops' upper and lower limits?
  - What are the crops' upper and lower limits?
    - Releases the sugars that have accumulated in the leaves to ensure optimal photosynthesis the next day
    - Reduces cell elongation (sugar in the leaves and root pressure)
    - Ensures plant growth
    - Maximizes dehumidification (int vs. ext delta AH)
  - What are the consequences of not heating?
    - Short leaves and sugar obstructions
    - Poor fruit quality and morning dew
    - Edema and guttation

Temperature management according to light reception

24-hour temperature

- **What are the crops' lower limits for preventing accumulation (short leaves)**

Minimum T24hrs required to unload leaf sugar related to daylight sum

Daylight sum	Temperature minimumT24hrs
J/cm2/day	(°C)
1400	18
1800	19,4
2200	20,9
2600	22,3
2800	23,0

Source: Climax Conseils

Temperature management according to light reception

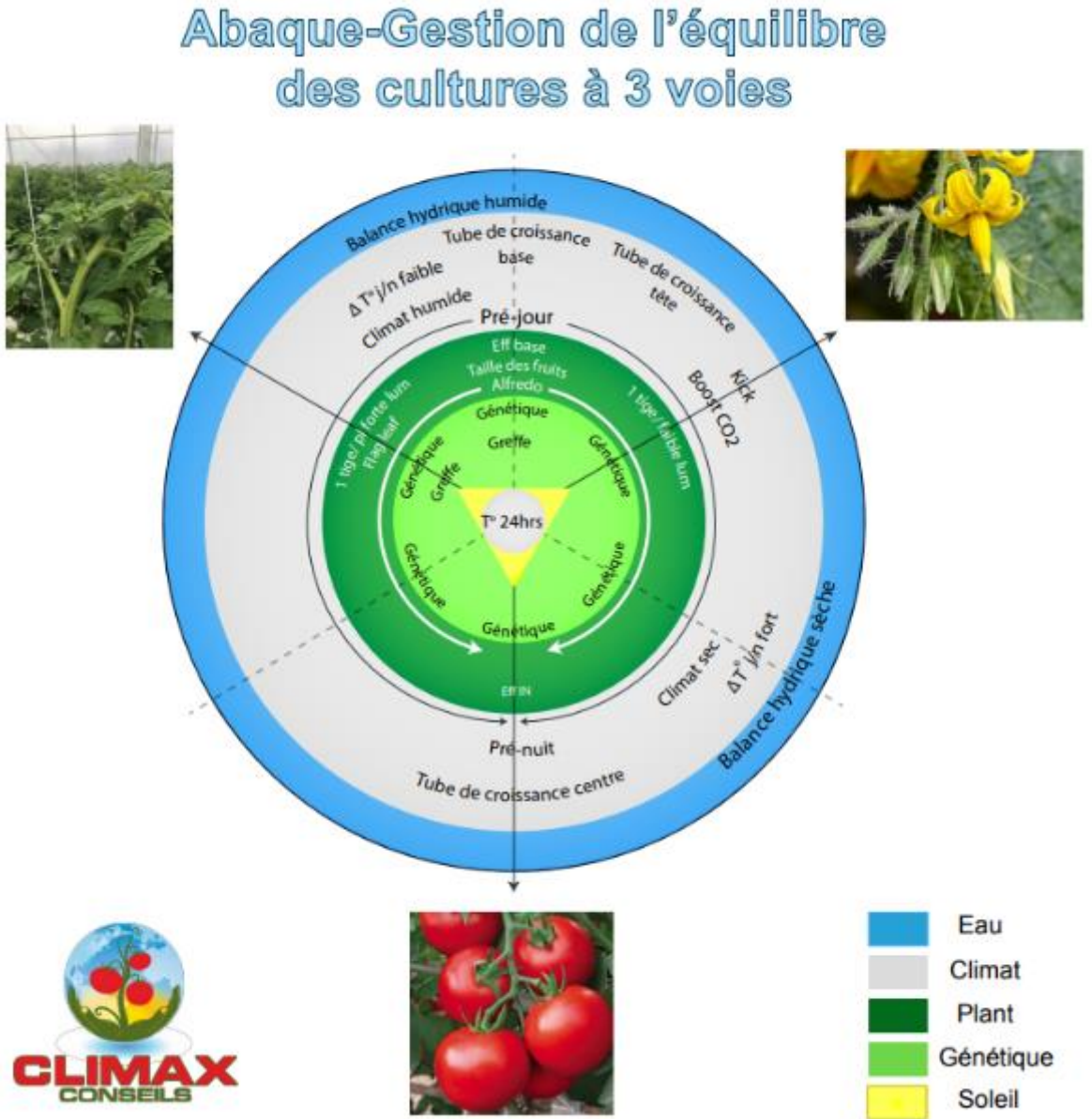
24-hour temperature

- **Conclusion**
  - Too warm makes balance impossible
    - Forget the other strategies; they simply will not work or they will damage your plants.
  - Keeping the crops a little too cold makes for a strong balance (120%-120%-120%).

THE REST IS FINE-TUNING

Vigour vs. balance: Your toolbox

Three-Channel Crop Balance Management Graph



Physiological aspects of crop balance

- Basics of crop management:

- 24-hour temperature
- **Light quality**
- Crop balance: Three-Channel Crop Balance Management Graph
  - Genetic balance
  - Water balance
  - Climate balance
  - Vegetative-generative balance

Physiological impact of light

Physiological concepts: Light quality and how plants react

- Light quality is the foundation of many physiological responses in plants.
- Though we may not realize it, many of the actions we take are as a result of the plants' reaction to this factor.

Physiological impact of light

Role of cell elongation in vegetative-generative balance

- Cell elongation is a key mechanism for increasing a plant's vegetative growth.
  - Longer and straighter leaves (searching for light)
  - Longer internodes (searching for light)
  - Elongated and straight clusters (searching for light)
  - Fragile tissues and higher susceptibility to disease
- How do cells become elongated?
  - **Imagine filling up a balloon with water after you have taken the time to apply a hardening paste to the rubber.**
    - The faster the water enters, the more the balloon will grow before the paste hardens.
    - The faster the paste hardens, the smaller the balloon will remain.

Physiological impact of light

Role of cell elongation in vegetative-generative balance

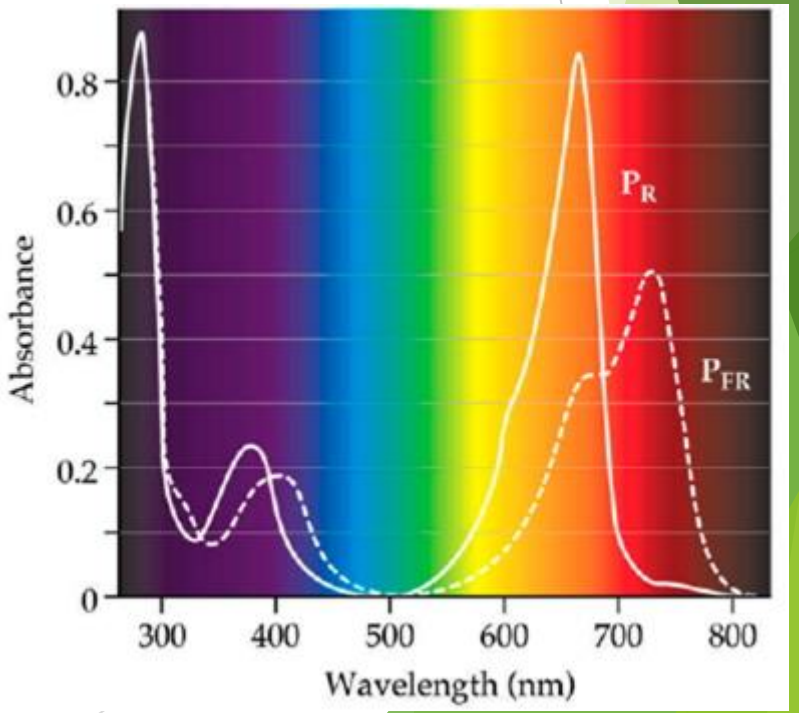
- What makes the balloon fill up (rapid water entry)?
  - Root pressure (higher soil temperature, low salinity, high water content in soil, low transpiration or cold heads)
  - Sugar or K-ion concentration in cells (osmotic effect)
    - Impact on phosphorus and nitrate levels?

Role of cell elongation in vegetative-generative balance

Physiological impact of light

What determines how fast the paste hardens? Phytochrome hormones (pigment)

- Shade avoidance: Etiolation
  - Far-red (FR) light = etiolation
  - 700–750 nm
  - Beginning and end of the day
  - Heavily reflected in the crop canopy
- Red (R) light = accessible light = no competition for light
  - 620–680 nm



Effect of phytochromes

Physiological impact of light

Pr vs. Pfr phytochromes

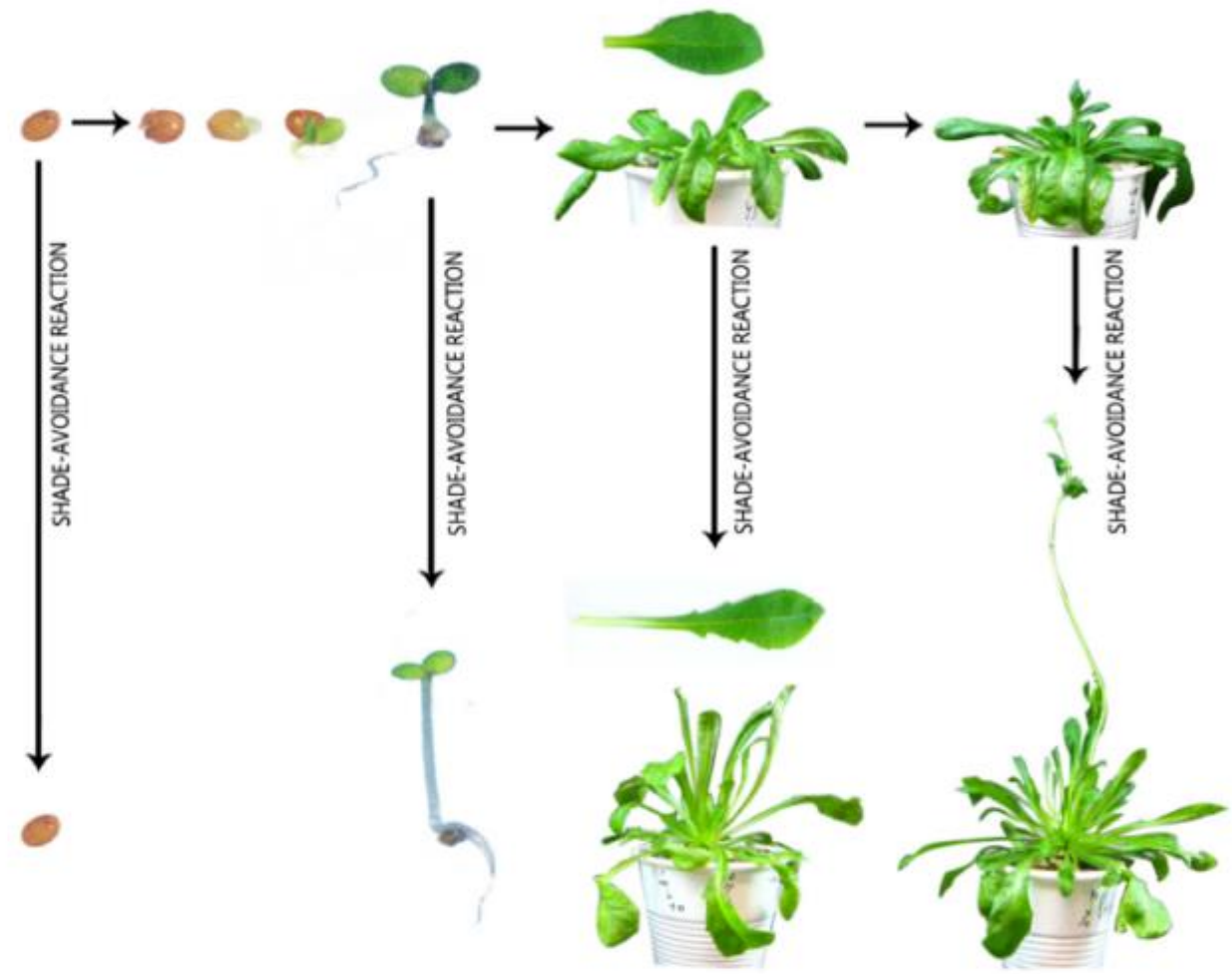


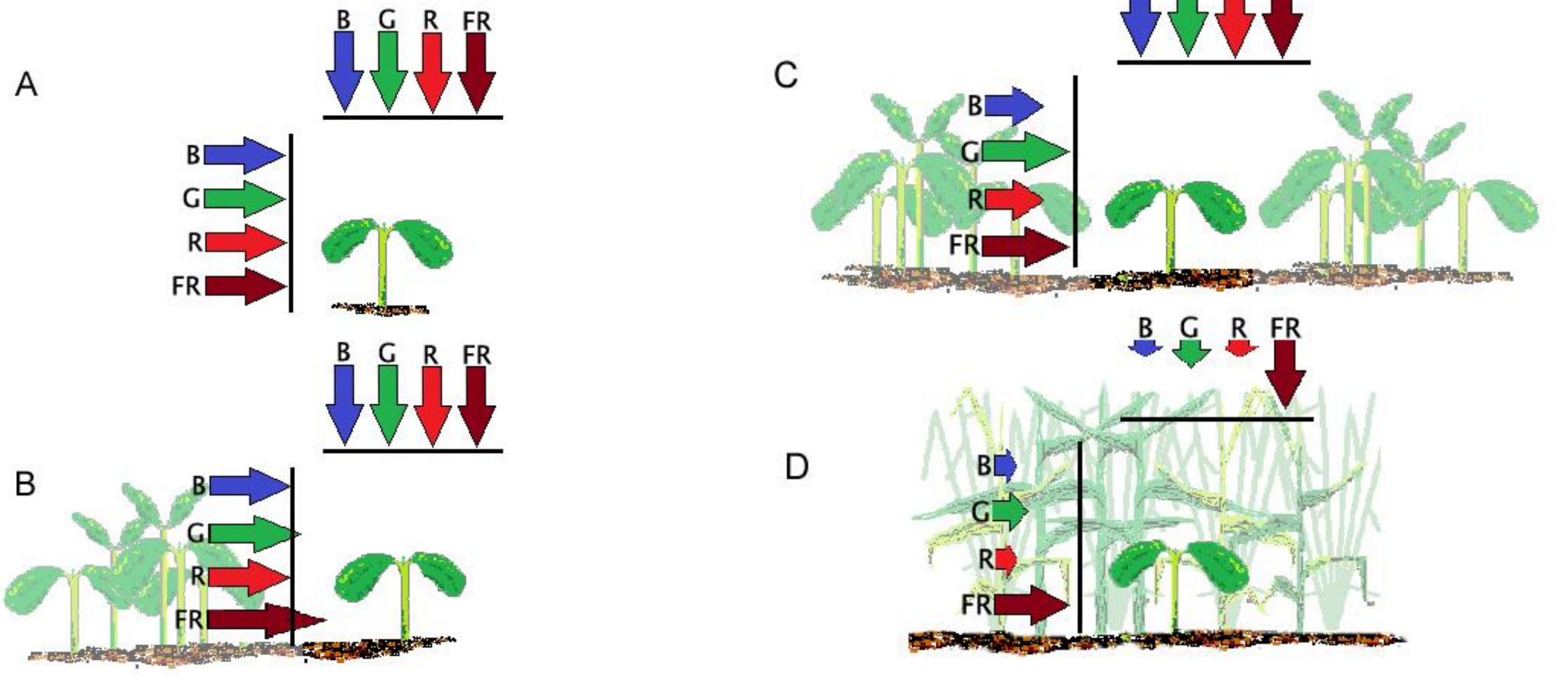
Figure 1. Shade light signals cause shade-avoidance responses throughout the life cycle of plants of *Arabidopsis thaliana*.

The upper set of pictures shows the progression of Arabidopsis plants under open conditions. Shade light causes alternative growth and developmental patterns including the repression of seed germination, the promotion of hypocotyl growth, the promotion of petiole growth and more erect leaves and early flowering.

Effect of phytochromes

Physiological impact of light

Pr vs. Pfr phytochromes



Role of cell elongation in vegetative-generative balance

Physiological impact of light

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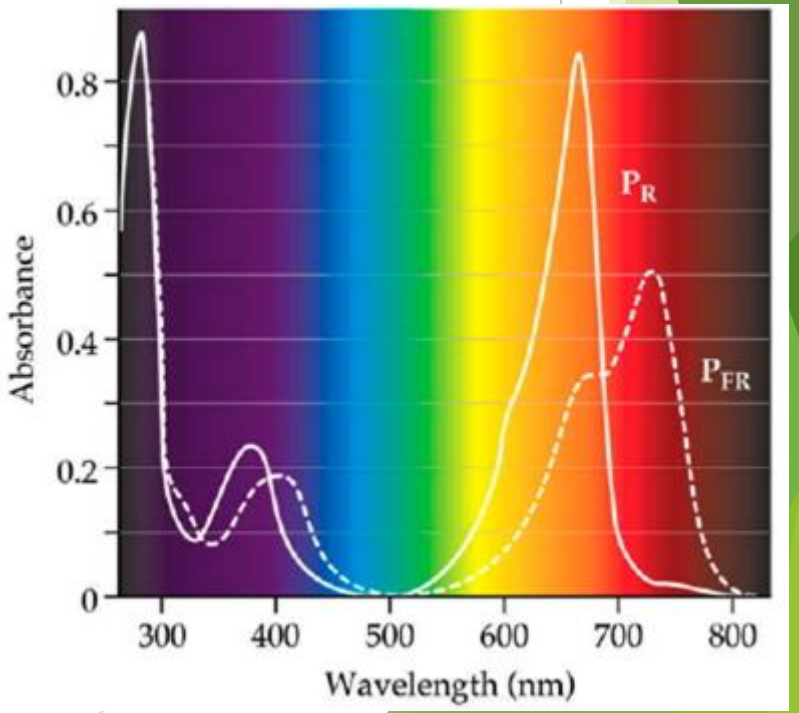


Physiological impact of light

Role of cell elongation in vegetative-generative balance

- How to avoid etiolation:
  - Prevention of extensive water intake at the beginning and end of the day
    - Fresher and/or dryer substrates at the beginning and end of the day
    - Higher salinity at the beginning and end of the day
    - Start deshumidification before sunrise and keeping air dry at the end of the day
    - Emptying the cells of sugars at night
    - Preventing excess phosphorus and nitrates
  - Prevention of slowed cell wall hardening
    - Preventing plants from touching each other
    - Keeping clusters in the sun (short leaves or Alfredo) and ensuring plants flower high enough
    - Ensuring plants are spaced far enough apart
    - Avoiding cell multiplication during periods of insufficient light
      - Negative DIF (morning dip)
      - Slow transition between night and day temperatures

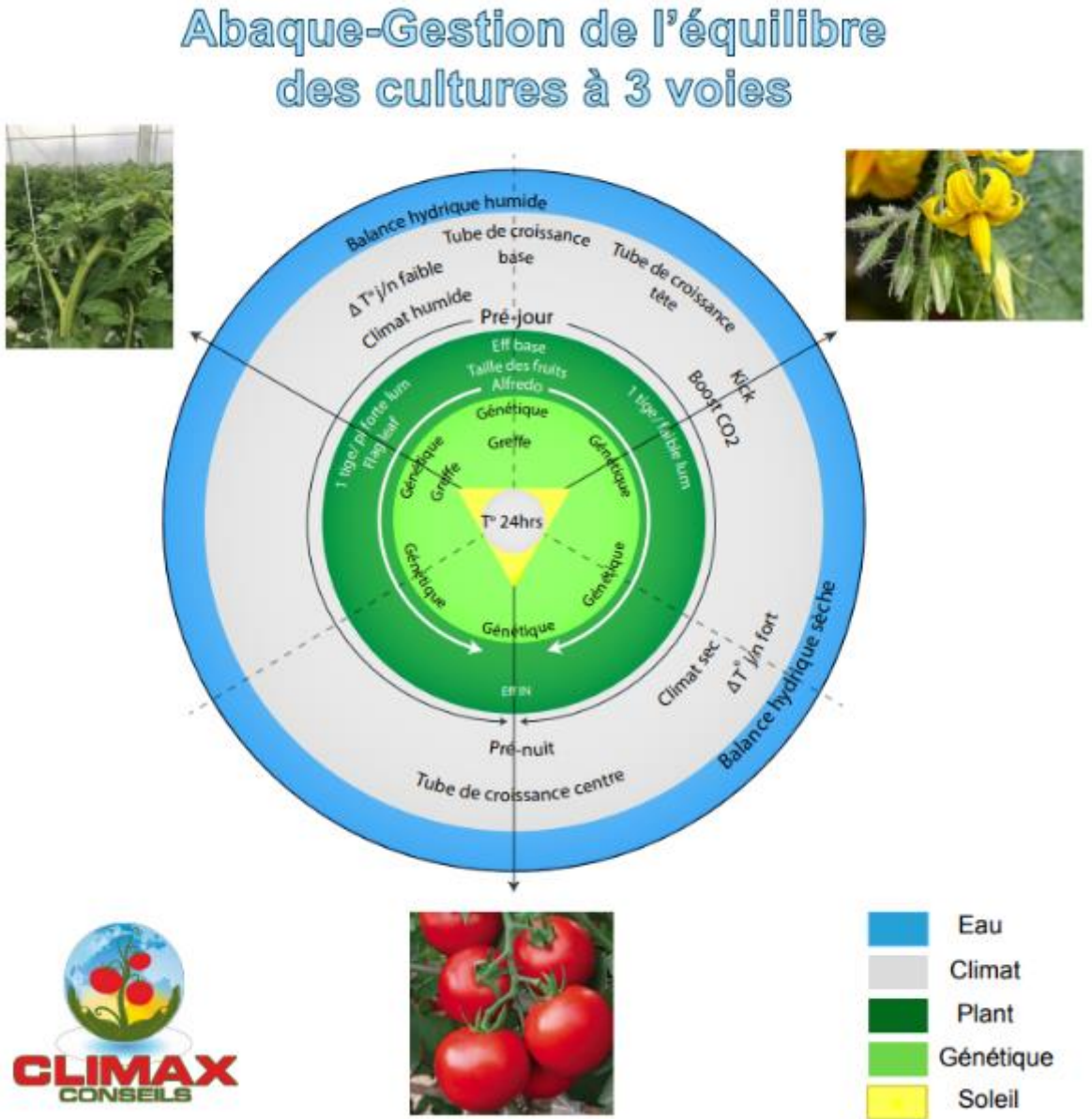
Physiological aspects of balancing crops

- Basics of crop management:

- 24-hour temperature
- Physiological impact of light
- Balancing crops: Three-Channel Crop Balance Management Graph
  - Genetic balance
  - Water balance
  - Climate balance
  - Vegetative-generative balance

Vigour vs. balance: Detailed approach

Three-Channel Crop Balance Management Graph



Physiological aspects of balancing crops

- Basics of crop management:

- 24-hour temperature
- Physiological impact of light
- Crop balance: Three-Channel Crop Balance Management Graph
  - **Genetic balance**
  - Water balance
  - Climate balance
  - Vegetative-generative balance

Genetic balance

Genetic balance

- You must respect the crops' genetic traits.
  - Some varieties will naturally favor one particular distribution zone.
  - It is important to anticipate this and adjust your focus to the plant's weak points.

Genetic balance

Genetic balance

- Beefsteak tomatoes example:
  - Kivu: Naturally generative and will save clusters at all costs, to the detriment of the head. Watch the head.
  - Caiman: Grows large fruit to the detriment of the head and clusters. Watch the head and clusters.
  - Frederik: Always grows highly vigorous vegetation (stem and leaves) to the detriment of the clusters and fruit size. Watch the clusters and fruit size.

Genetic balance

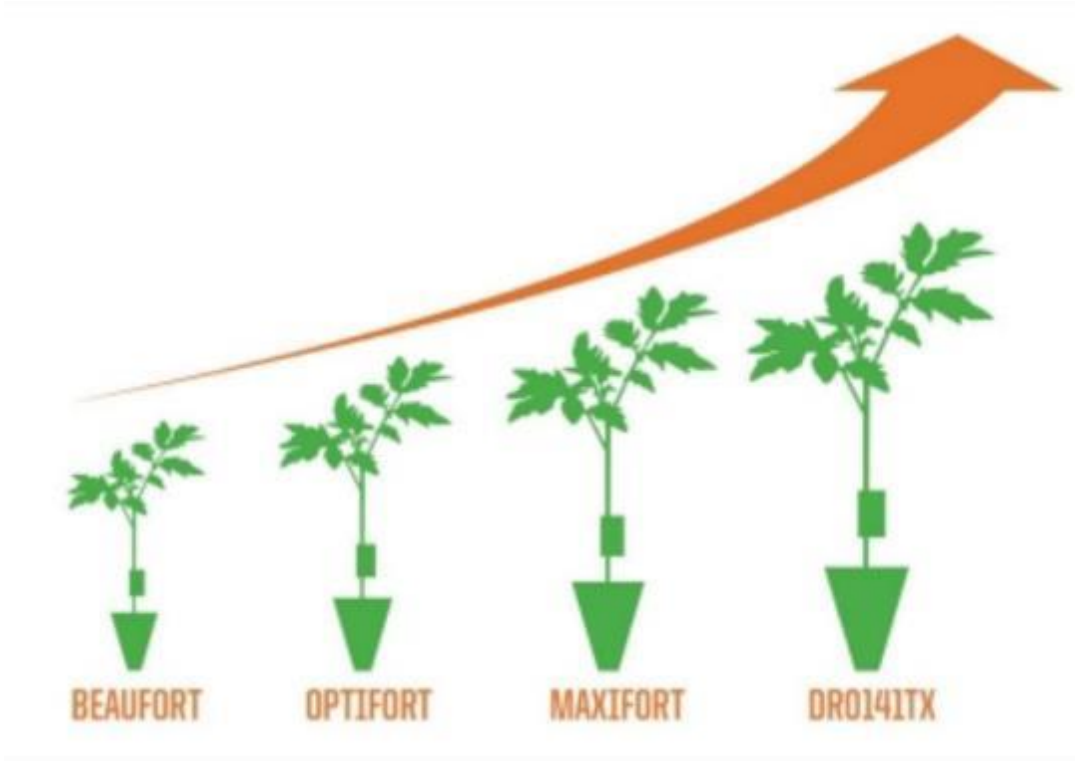
Genetic balance

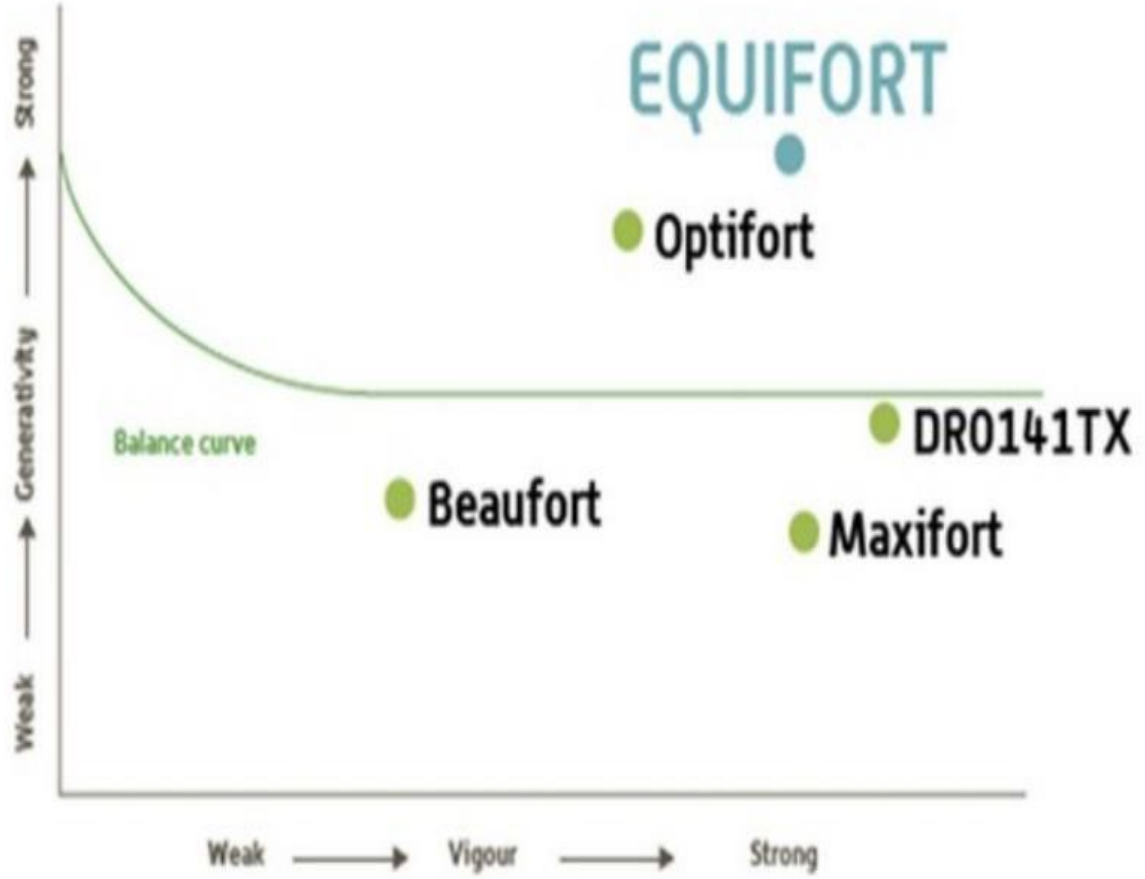
- **Grafting:**
  - **Grafting will**
    - **increase resistance to root diseases;**
    - **enable the growth of a strong root system to withstand a long growing season; and**
    - **help make the head and clusters more vigorous.**

Genetic balance

Genetic balance

- Grafting





Genetic balance

Genetic balance

Strategies' impact on crops

Actions		Head	Flower	Fruit
Genetic balance	Variety	+ / - / 0	+ / - / 0	+ / - / 0
	Grafting	+	+	0

Physiological aspects of crop balance

- Basics of crop management:

- 24-hour temperature
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- Balancing crops: Three-Channel Crop Balance Management Graph
  - Genetic balance
  - Water balance
  - Climate balance
  - Vegetative-generative balance

Strategies for balancing plants

Water balance

- **Irrigation**
  - Irrigation management is a very powerful tool in balancing plants.
  - It influences the plants' vegetative aspect as well as fruit quality.
  - However, you must make sure not to inhibit growth by keeping plants too dry (closed stomata = decreased photosynthesis).

Strategies for balancing plants

Water balance

- **Irrigation**
  - What is the effect of
    - cycle frequency vs. substrate type?
    - the relationship with received light?
    - the number of cycles?
    - salinity?
    - the bag’s drainage or tension?

Water balance

Phytochromes and turgidity

Physiological impact

- Affects the swelling of cells before they are hardened (Pr-Pfr interaction)

Tools

- Water balance
  - Important in the morning and at night (darkening the color of the heads)
    - Irrigation management (watering and draining)
    - Activating the crop in the morning (increasing HD)
    - Kick in the late afternoon

Strategies for balancing plants

Water balance

CLIMAX CONSEILS
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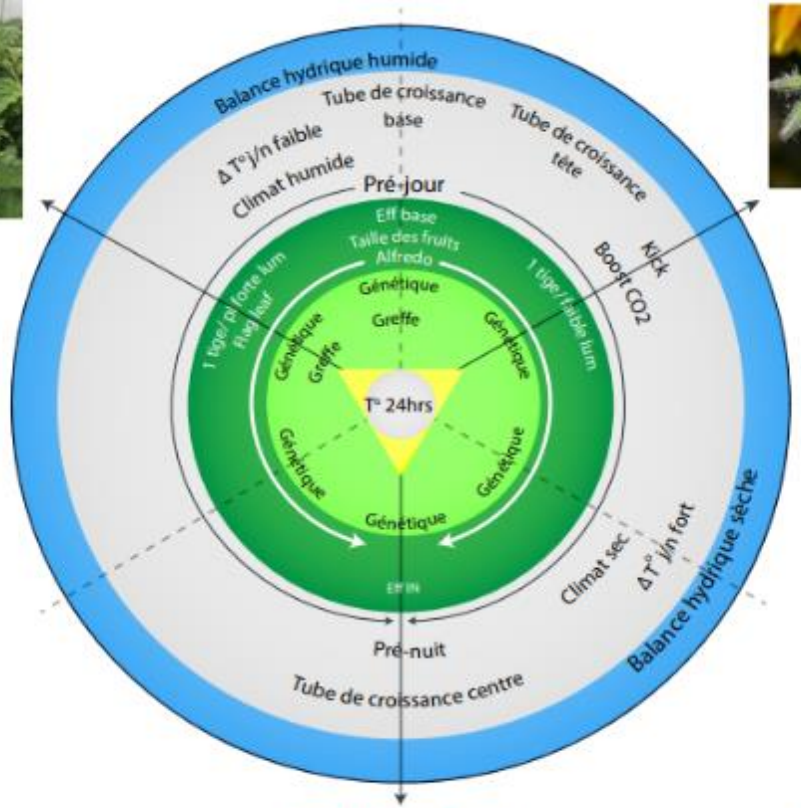
Vegetative/generative balance management

Water management

Management tool	Vegetative	Generative
Electrical conductivity (EC)	↓	↑
Water content of the soil (substrate)	↑	↓
watering frequency	↑	↓
Water volume	↓	↑
Beginning and ending of watering	⟷	↔
Night dryness	↕	↕
Root temperature	↑	↓
Nutrients (K, SO4, Cl et Na)	↓	↑
Nutrients (NO3)	↑	↓

Water balance

Water balance



Eau
Climat
Plant
Génétique
Soleil

Strategies' impact on crops

Actions		Head	Flower	Fruit
Water balance	Wet	+	-	-
	Dry	-	+	+

0	No impact
-	Negative impact
+	Positive impact

Physiological aspects of balancing crops

- Basics of crop management:

- 24-hour temperature
- Physiological impact of light
- Balancing crops: Three-Channel Crop Balance Management Graph
  - Genetic balance
  - Water balance
  - **Climate balance**
  - Vegetative-generative balance

Climate balance

Strategies for balancing plants

- Climate
  - For any given 24-hour temperature, there is a multitude of possible climate scenarios.
    - Day-night differential
    - Transition speed (ramping)
    - Transition time
    - Humidity, CO_2, ventilation, pipe temperature

Climate balance

Some physiological concepts

Phytochromes and temperature

Physiological impact

- Cold temperatures reduce cell multiplication during periods of shade avoidance

Tools

- Morning dip
  - Watch out for water stress (poor tension in the plant)

Some physiological concepts

Climate balance

Thermal impacts

Physiological impacts

- Warm zones strongly attract sugars

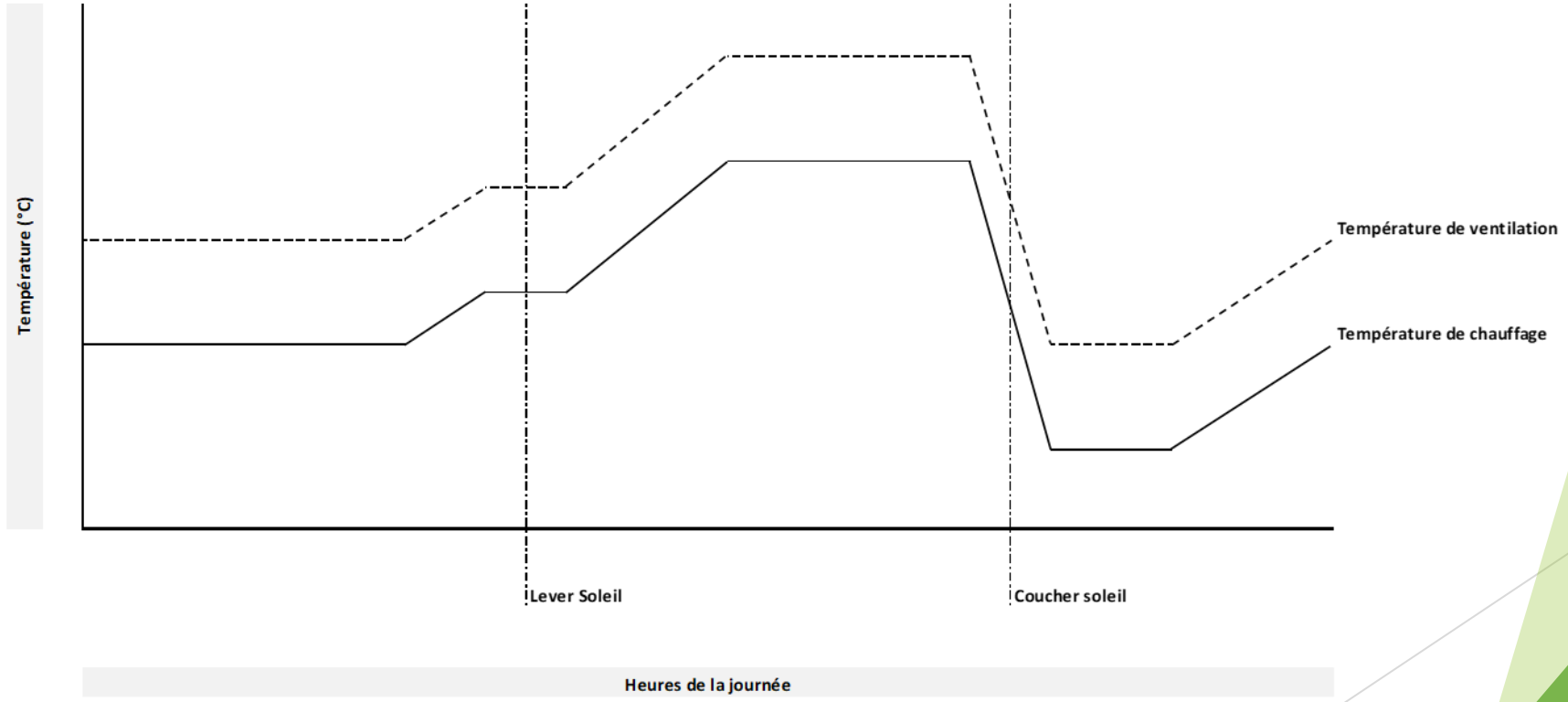
Tools

- Root heating
- Grow pipes
- Basic heating
- Water balance
- Pruning (warms the fruit)
- Flag leaf (cools the fruit)
- Day-night differential = longer internodes = plant is more open = warms the fruit
- Pre-night drop: fruit warmer than the rest of the plant

Climate balance

Strategies for balancing plants

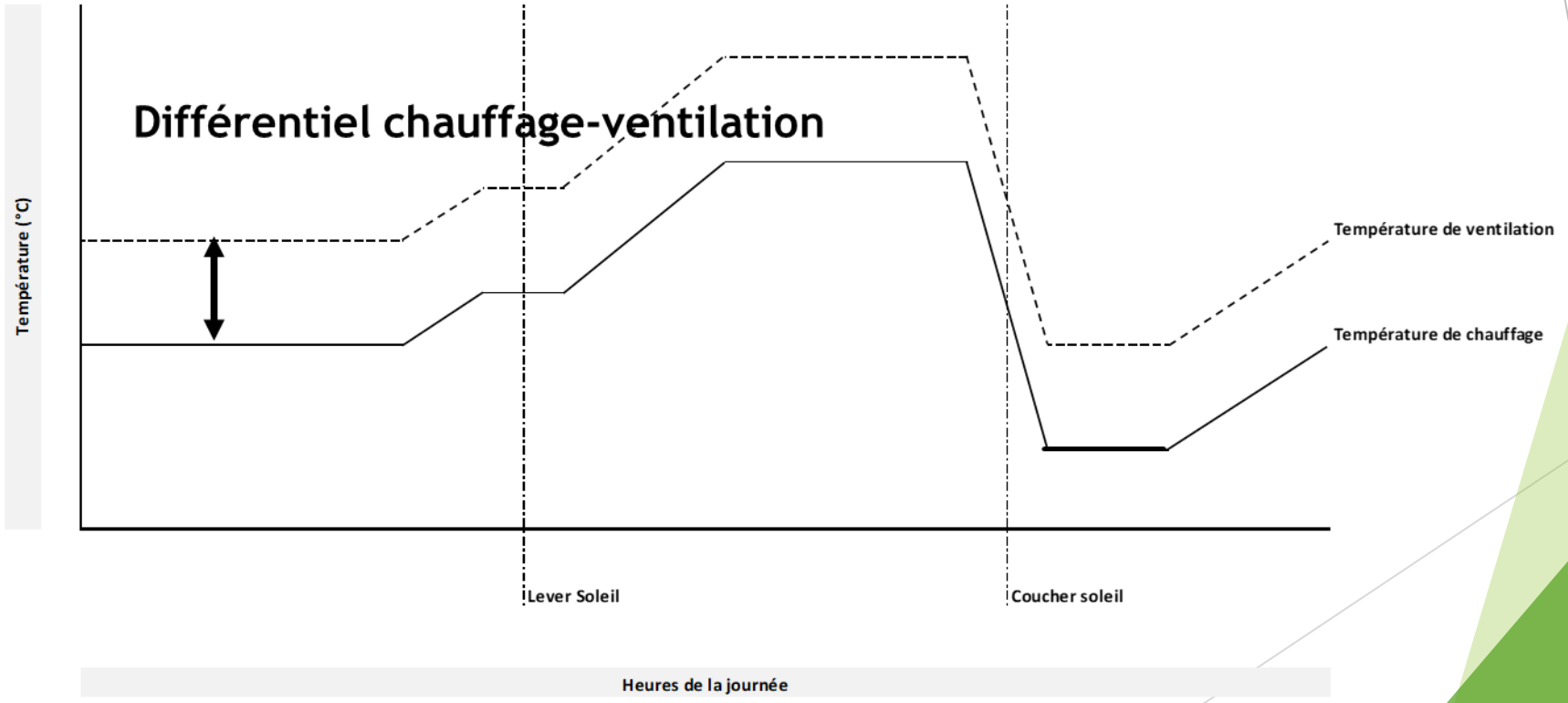
- **Basics of climate management**



Climate balance

Strategies for balancing plants

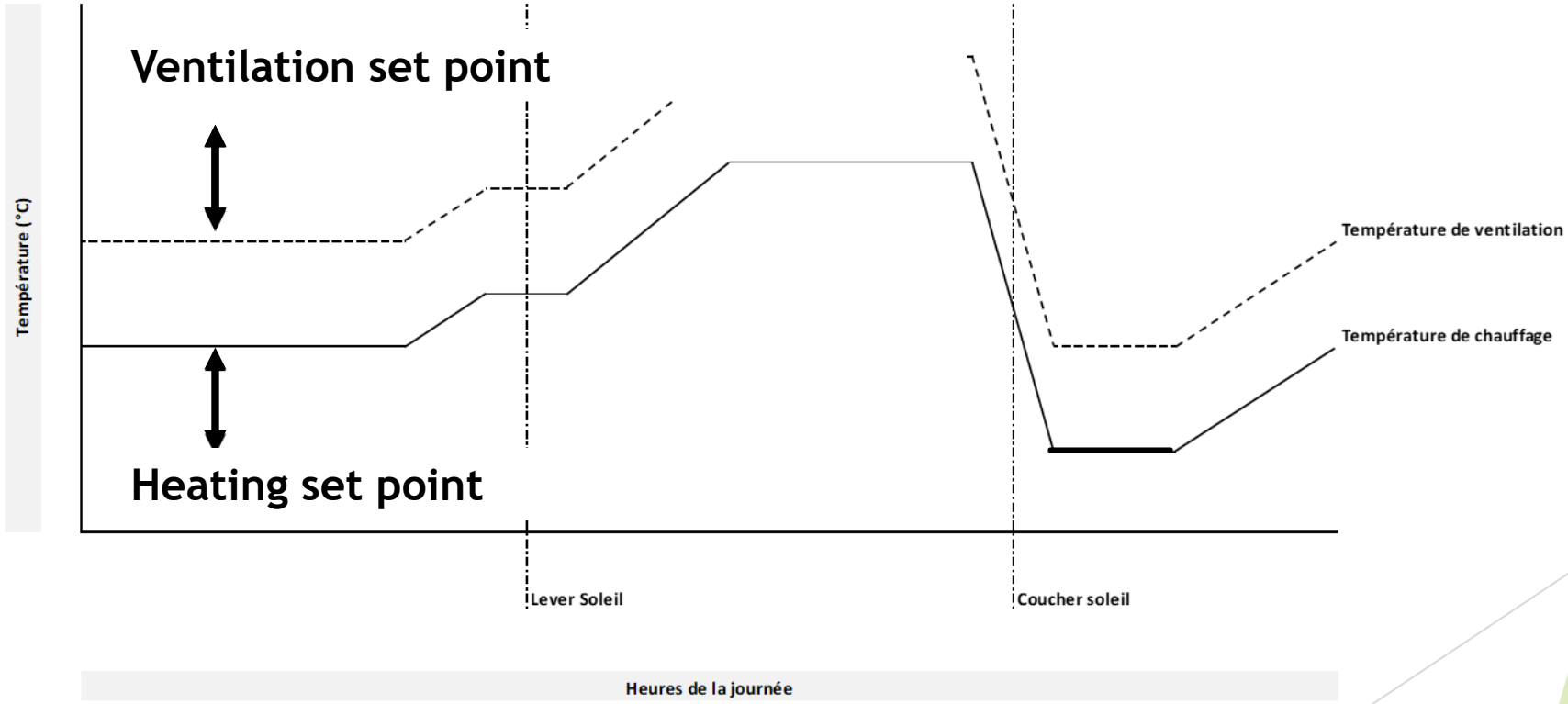
- **Basics of climate management**



Climate balance

Strategies for balancing plants

- **Basics of climate management**



Climate balance

Strategies for balancing plants

- Basics of climate management
  - Heating set point:
    - If the greenhouse temperature drops below the heating set point
      - activate the heating system
  - Ventilation set point:
    - If the greenhouse temperature rises above the ventilation set point
      - open the roof vents

Climate balance

Strategies for balancing plants

- Basics of climate management
  - Many influences can interfere:
    - Heating set point
      - Sun radiation (W/m^2)
      - Daily light accumulation (J/cm^2)
      - RH or HD: Increase the set point if more humid
    - Ventilation set point
      - Sun radiation (W/m^2)
      - Daily light accumulation (J/cm^2)
      - RH or HD: increase the set point if dryer

Strategies for balancing plants

Climate balance

Vegetative/generative balance management

Climate management

Management tool	Vegetative	Generative
24 hr temperature		
Relative humidity		
Humidity deficit (HD) (g/m3)		
Air changeover		
Day/night difference		
Speed of change		
Pipe temperature		
CO2		

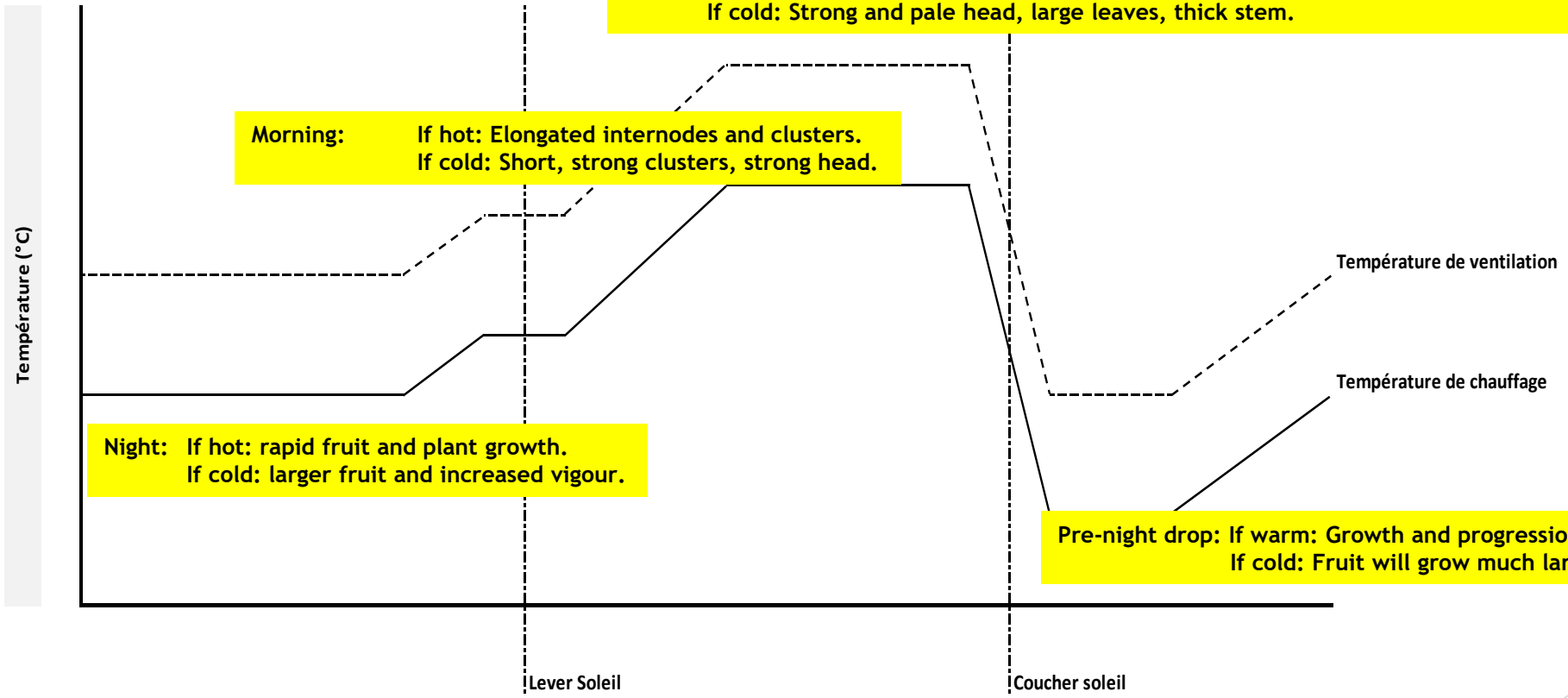
Note: In the short term, raising the 24-hour temperature will increase generative growth. However, in the long term, it will cause an increase in vegetative growth. The plant will favor vegetative growth to the detriment of its clusters, especially under insufficient light. In addition, in tomatoes, the fruit will set too soon.

Strategies for balancing plants

Climate balance

Day: If hot: Fast growth and maximum photosynthesis. Flowers will open. Thin head and stem, short leaves.
If cold: Strong and pale head, large leaves, thick stem.

Morning: If hot: Elongated internodes and clusters.
If cold: Short, strong clusters, strong head.



Night: If hot: rapid fruit and plant growth.
If cold: larger fruit and increased vigour.

Pre-night drop: If warm: Growth and progression of the plant as a whole.
If cold: Fruit will grow much larger. Weakening of head.

Climate balance

Strategies for balancing plants

- Basics of climate management
  - Heating-ventilation differential
    - Inactive control zone: Climatic no-man's land
    - Can be very narrow for active system management
      - To actively dehumidify
      - To maintain a precise temperature
      - To create crop stress
    - Can be very large for passive system management
      - To conserve moisture within the greenhouse
      - To avoid crop stress

Strategies for balancing plants

Climate balance

- Climate potential in relation to exterior temperature
  - Difficulty to heat or insufficient heat
    - Not possible to adjust it to the crop's needs depending on the light
    - Reduce the LAI (photosynthesis) if impossible to heat
  - Difficulty managing humidity (elevated exterior AH)
    - Dehumidification boost
      - Botrytis: 1 x @ 12 hours
      - Leaf mould: 1 x @ 4 hours
  - Extreme heat conditions (Heat wave)
    - Impossible to control. Save what you can.
    - Ensure the plants are activated and transpiring (water availability)

Climate balance

Strategies for balancing plants

- **To quantify the balance, you must build a daily profile.**
  - **Day-night differential**
  - **Pre-night drop, morning dip, kick, transition speed**
  - **Verify the vertical temperature profile**

Strategies for balancing plants

Climate balance

- Climate management
  - What is the 24-hour temperature's impact?
  - What is the day-night differential's impact?
  - What is the pre-night drop's impact?
  - What is the kick's impact?
  - What is the morning dip's impact?
  - What is humidity's impact?
  - What is ventilation's impact?

Climate balance

Strategies for balancing plants

- Climate management
  - Any stress or rapid changes in climate send a signal to the plants for generative growth.

Climate balance

Strategies for balancing plants

- **Climate management**
  - **What is the 24-hour temperature's impact?**
    - **Increasing the 24-hour temperature generally causes increased generative growth, if there is enough energy available for it. If not, the increase is in vegetative growth.**

Strategies for balancing plants

Climate balance

- **Day-night differential**

  - **Day-night differential:**

    0 °C = vegetative

    2–3 °C = balanced

    4–6 °C = generative

  - A day-night differential lengthens the internodes.
  - May be necessary to reduce energy costs or offset the impact of a hot day.

Strategies for balancing plants

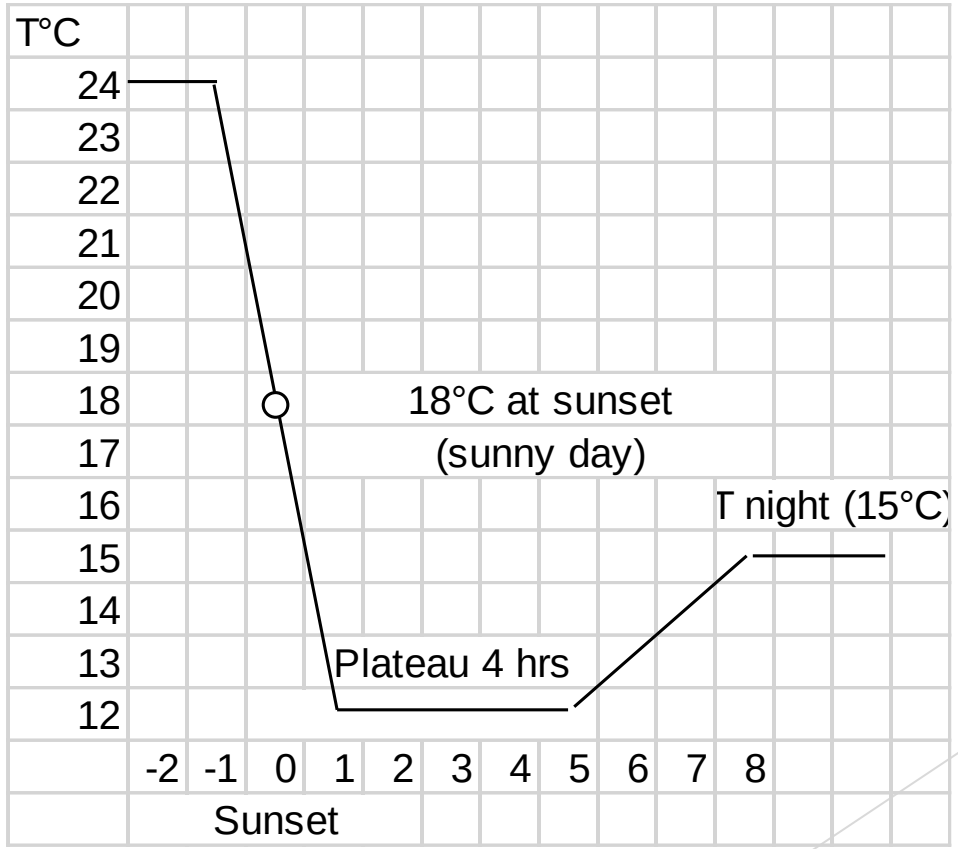
Climate balance

- **Building the profile: Pre-night drop**
  - **Warm organs develop faster and attract photoassimilates (sink effect)**
    - Large tomatoes and English cucumbers
      - Rapid decrease at end of day
        - Red: 3–6 °C, 3–4 °C/h
        - Pink: 6–12 °C, 6–12 °C/h
      - Temperature maintained for at least 3 h
      - Little to no impact on small tomatoes
    - Keep an eye on the humidity levels
      - Force ventilation

Climate balance

Strategies for balancing plants

- **Building the profile: Pre-night drop**



Strategies for balancing plants

Climate balance

- **Building the profile: Pre-night drop**
  - It is important to adjust the 24-hour temperature according to the crops' needs before planning a pre-night drop.
  - If it is necessary, the plant should have head strength and energy for the pre-night drop to be successful.
    - Lower the 24-hour temperature according to the new desired size.
    - The plant's basic needs must be met before the pre-night drop is implemented.
  - What constitutes a pre-night drop is the speed at which the temperature drops, not the low temperature.
  - Be sure to respect the 24-hour temperature.
  - Do not drop the temperature too early in the afternoon.
    - Implement the drop no earlier than 1 h before sunset (risk of root pressure and stunted growth).
    - Can be done after sunset.

Strategies for balancing plants

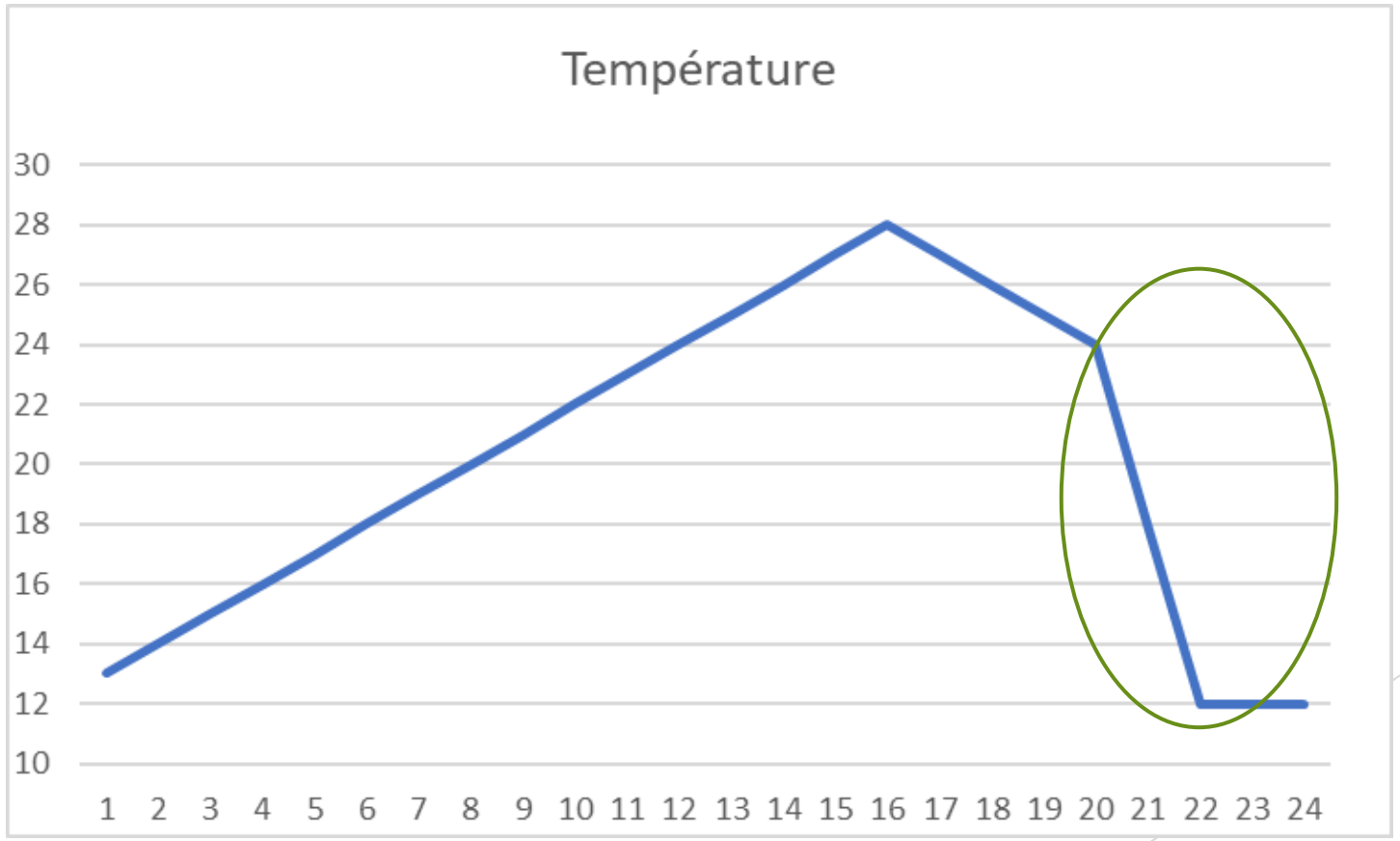
Climate balance

- **Building the profile: Pre-night drop**
  - Pay attention to the fruit:
    - A lot of sugar is sent to the fruit very quickly
    - If the cluster is weak, it is better to move the sugar out of the cluster quickly than to try to grow larger fruit
    - Different fruit quality problems can arise:
      - Dark green fruit
      - Blotchy/uneven ripening
      - Russetting
      - Cracking

Climate balance

Strategies for balancing plants

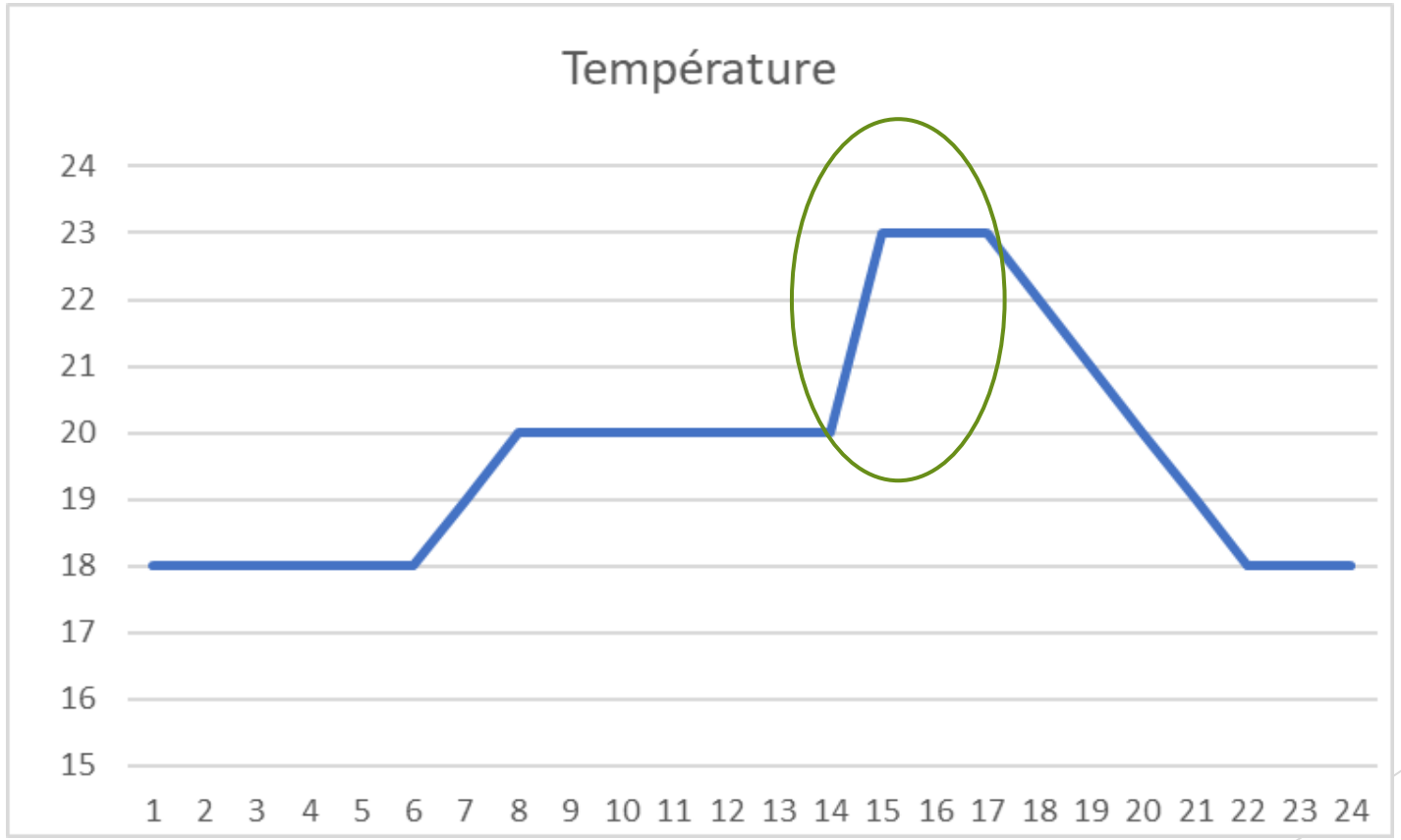
- **Building the profile: Pre-night drop (aggressive)**



Strategies for balancing plants

Climate balance

- **Building the profile: Kick (bumblebee boost)**



Strategies for balancing plants

Climate balance

- **Building the profile: Kick (bumblebee boost)**
  - Strengthen flower clusters

    Rapid increase in transpiration in the middle of the afternoon

    3 °C for 3 h if sunny

    2 °C for 5 h if overcast
  - Must heat and ventilate
  - The climate must be active (not damp). Otherwise, there is risk of edema and poor pollen quality.

Strategies for balancing plants

Climate balance

- **Building the profile: Morning dip**
  - **Temperature dip of 1-2 °C in the morning, at sunrise.**
  - **Lasts 1 h.**
  - **Temperature is slowly raised back to morning temperature.**
  - **The goal is to reduce the impact of FR light on cell elongation.**
    - **Shorter, curved clusters and denser head.**
  - **Do not do this more than 3-4 consecutive days.**
  - **Keep the plants' morning activation in mind (plant stay cold).**

Root temperature

Climate balance

- Root temperature has a significant impact on the following:
  - Water absorption increases if warmer
    - Calcium transport
    - Root pressure
    - Better stomatal opening and transpiration
  - Warm = strong root growth and growth of absorbent hairs
    - Be careful of lack of oxygen or sugar (weak zone for sugar attraction)

Root temperature

Climate balance

- **Cold temperature:**
  - **Roots' capacity for absorption decreases rapidly below 20 °C**
  - **Decrease in sink demand**
    - **Decrease in root development**
    - **Decrease in osmosis**
    - **Decrease in exudation**
  - **In the morning, water absorption does not meet transpiration needs**
  - **Risk of root diseases (competition between roots and fungi)**

Root temperature

Climate balance

- **High temperature:**
  - **Risk of too much root pressure if no transpiration**
    - **Guttation**
    - **Edema**
    - **Micro cracking = russeting**
    - **Botchy/uneven ripening**

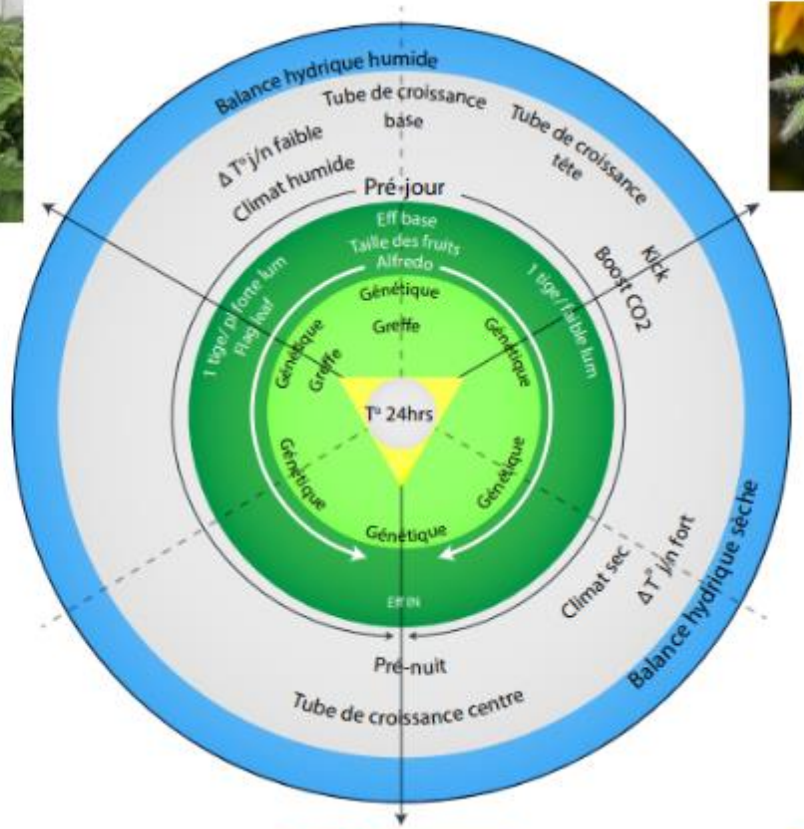
Root temperature

Climate balance

- For tomatoes:
  - Aim for min18 °C
- For cucumbers and pepper:
  - Aim for min 20 °C

Climate balance

Climate balance



Strategies' impact on crops

Actions			Head	Flower	Fruit
Climate balance	Temperature	Cooling	+	+	+
	Humidity	Humid	+	-	-
		Dry	-	+	+
	CO_2	Boost	0	+	0
	Grow pipes	Low	+	+	-
		Middle	-	-	+
		High	+	+	-
	Changes	Steady climate	+	+	-
		Day-night differential	-	+	+
		Kick	0	+	0
		Morning dip	+	+	-
		Pre-night drop	-	-	+

Physiological aspects of balancing crops

- Basics of crop management:

- 24-hour temperature
- Physiological impact of light
- Balancing crops: Three-Channel Crop Balance Management Graph
  - Genetic balance
  - Water balance
  - Climate balance
  - **Vegetative-generative balance**

Organ competition: An important aspect of vegetative balance

Vegetative-generative balance

Physiological effects

- Favoring one organ to the detriment of another

Tools

- Thermal effect
- Cluster size
- Alfredo (competition at head = IN later on (thermal))
- Rootstock: favors roots
- Double head: favors roots/head

Strategies for balancing plants

Vegetative-generative balance

- Crop management
  - Pruning strategies
    - Number
    - Location
  - Fruit load
  - Plant density

Strategies for balancing plants

Vegetative-generative balance

- Crop management
  - Pruning location:
    - Pruning at the head (Alfredo)
    - Pruning the middle of the plant (in)
    - Pruning at the base (bottom)
    - Addition of flag leaf
  - What is the impact of each of these strategies?

LAI: If tomato plant has too much foliage

- Tomato plant:
  - Pruning the base (keep 2 m of canopy)
  - Pruning Alfredo
  - Pruning the middle of the plant (IN)

Large leaves on a plant can stop its fruit from being warmed by the sun to increase fruit size.

LAI: If foliage is too dense

- Tomato:
  - Pruning at the base (keep 2 m of canopy)
    - The canopy can be cut back if the crop is young (low fruit load) under bright lighting
      - Depletion deleafing
        - Split stem: Very strong
        - Excessive vigor: Mild; but consider the future
        - Late start or early finish
  - Tomato ripening (the last 2 and 3 clusters of beefsteak and cherry respectively)
  - Instruction to worker is not the goal

Split stem

Excessive vigor

Pruning Alfredo

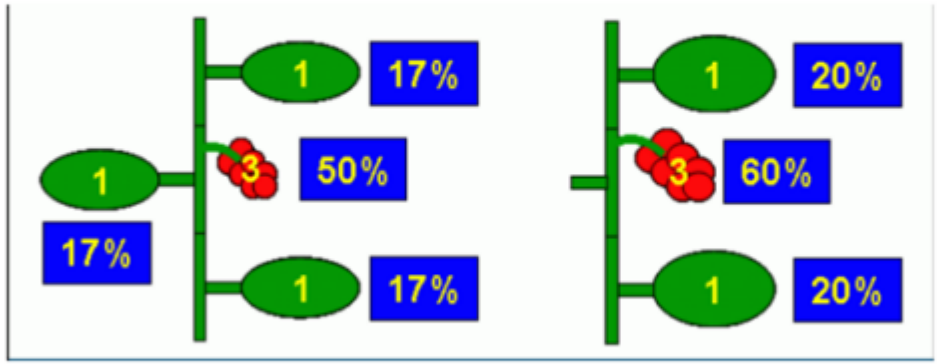
Technique: Pinch young leaves within the head

- Makes the cluster and adjacent leaves more vigorous
- Reduces cluster etiolation
- Opens up the foliage (light and aeration)
- Improves warming of the growing fruit and clusters
- Reduces parasol effect
- Adjusted LAI at high density or in strong vegetative cultivar
- Reduced working time as compare to bottom deleafing

Delphy

3 / (3+1+1+1) = 0,5

3 / (3+1+1) = 0,6



Source: WUR

Delphy

Pruning Alfredo

- Cherry:
  - Adjusting the LAI
  - Opening up the foliage
  - Improving cluster vigour
  - Low impact on fruit size
- Beefsteak:
  - Ensuring good size and cluster vigor in plants with strong vegetative vigor
  - Maintaining the LAI and open canopy profile
  - Don’t do it with low vigor
- Prevent cluster etiolation in plants with heads spaced apart by fewer than 14” on the wire or in young plants with large leaves.
- Remove leaves that block the sun (parasol)
- Correct the seasonal LAI

IN pruning

- Remove mature leaves from overcrowded foliage
  - Aerate and promote increased size (sun) (done above the clusters you want to grow).
  - Remove leaves that have clumped together (reduction) to ensure air circulates between the macroclimate and microclimate.
  - Use strictly as a corrective measure
  - Correct the seasonal LAI
  - Stop the big brother to shade the little brother (top of the plant)
  - Balance the light between north and south (winter, spring)

If foliage is too sparse (short leaves)

- Short leaves: Plant's adaptation for balancing its energy needs with its growth requirements
  - The most powerful corrective measure: Increasing the density
  - Preventing fruit loads from being extremely low
  - Reducing CO_2

Short leaves

If foliage is too sparse (short leaves)

- Short leaves (twisted leaves): Accumulation of sugar in leaves
  - Rebalance the distribution
    - LAI too high
    - Too much luminosity
    - Insufficient fruit load
    - Too cold
    - Too much CO_2

Twisted leaves

If foliage is too sparse Decrease in vigour

- Flag leaf
  - Keep leaves that grow on suckers
  - Try to cool it down so the head is not affected
  - Consider your pruning method (knife)

Strategies for balancing plants

Vegetative-generative balance

- **Crop management**
  - **Foliage location**

High (Alfredo)

- Remove the smallest leaf possible from under the cluster at the head.
- More direct light (less FR). Change of light spectrum for the cluster.
- More energy for the cluster (a leaf that has less growing to do).
- Short, curved and strong cluster.
- Flowering higher on the head
- Fast and constant fruit set.
- Note the effect these leaves have on the fruit's lifespan (8 weeks) and on the LAI.

Middle (IN)

- Remove leaves from the middle of the plant.
- Remove the leaves that block the light or are in a damp clump.
- More light for developing fruits.
- Aeration in the middle of the plant: Reduced risk of disease.
- Increase fruit temperature (sink effect)
- Favour fruit size and development speed.

Low (Bottom)

- Prune the bottom of the plant.
- More light on mature fruits.
- Increased fruit temperature and accelerated ripening.
- Fruits' exposure to radiant heat from pipes or tubes.
- Enables decrease in fruit load.

Strategies for balancing plants

Vegetative-generative balance

- **Crop management**
  - **Foliage location**

Addition of a flag leaf

- Let a sucker grow at the head, then pinch it off after one leaf grows
- Reduces direct light on the cluster (change in light spectrum)
- Creates shade for the head and stimulates head and stem development
- Done in cold weather to proactively create leaves before periods of high heat
- Enables a fast recovery from loss of leaves due to disease
- Leads to lower flowering
- Will negatively affect fruit size
- Note the effect this leaf has on the fruit's lifespan (8 weeks) and on the LAI.

Strategies for balancing plants

Vegetative-generative balance

- **Crop management**
  - **Fruit load:**
    - The bigger the fruit load, the lower the leaf-fruit ratio.
    - An increased fruit load sends the plant a signal for generative growth
    - Be careful:
      - Increased fruit load must be balanced with light reception.
      - Load = number of fruit x fruit size.
      - Any increase in load on the head due to reduced pruning and vice versa will impact the plant's balance by 8 weeks.
      - An increase in load must correspond to the annual light response curve
        - The higher the load, the lower the required temperature for equal luminosity.
      - Maintaining the necessary 24-hour temperature must also be taken into account for increased fruit load.
        - E.g. the 24-hour temperature in July could be 22-23 °C without an opportunity to cool down!

Strategies for balancing plants

Vegetative-generative balance

- **Crop management**
  - **Crop density:**
    - Increased plant density sends a signal for vegetative growth.
      - The presence of other plants modifies the spectrum of received light according to leaf length.
      - Less light is received by the leaves, which increases the leaf area for the same temperature.
    - Adequate plant density enables the absorption of all available light.
    - The optimal LAI must be respected to all densities.
    - An increase in the number of plants requires an increase in light energy to ensure vegetative growth.
    - Crop density must correspond to the annual light response curve.
    - Density and fruit load are closely related:

$$\text{Number of fruits/m}^2 = \text{number of plants/m}^2 \times \text{number of fruits/plant}$$

Strategies for balancing plants

Vegetative-generative balance

- Crop management
  - Short leaf problem:
    - Reduction in plant's vegetative growth to adjust energy supply to the plant's needs.
    - It is closely related to the 24-hour temperature, fruit load and plant density.
    - Must be distinguished from an irrigation or fertilization problem.
    - To fix the problem:
      - Verify the crop's needs by using the lighting vs. temperature spreadsheet.
      - Adjust the 24-hour temperature according to source-sink balance (ideally the nighttime temperature)
      - Prune the bottom leaves of the plant and adjust the number of leaves to the number of fruits, if necessary.
        - If seriously affected, prune 1/3 of the leaves from the bottom.

Strategies for balancing plants (except pepper)

Vegetative-generative balance

CLIMAX CONSEILS
Experts en production maraîchère sous serre

Vegetative/generative balance management

Crop management

Management tool	Vegetative	Generative
Fruits/m2	↓	↑
Leaf number (LAI)	↑	↓
Head density	↑	↓
Tristing of the plant	↓	↑
In deleafing	No	Yes
Alfredo deleafing	No	Yes
Layering	No	Yes

Strategies for balancing plants (Pepper)

Vegetative-generative balance

CLIMAX CONSEILS
Experts en production maraîchère sous serre

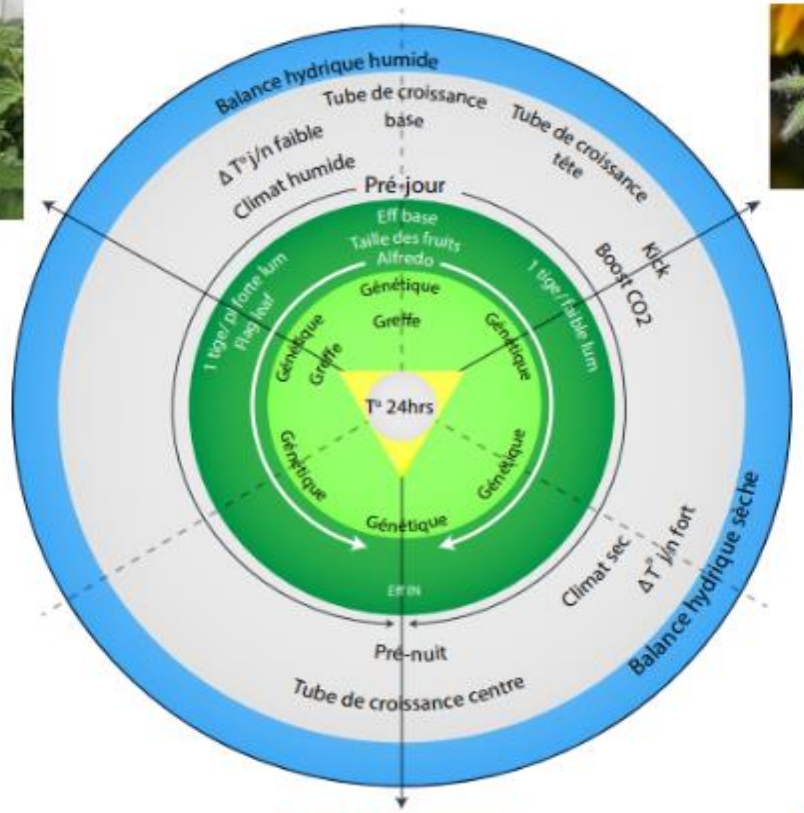
Vegetative/generative balance management

Pepper management

Management tool	Vegetative	Generative
Fruits/plant	↓	↑
Consecutive fruits on the stem	↓	↑
Empty nodes between 2 flush	↑	↓
Nb of node before the first fork	↑	↓
Sucker lenght	↑	↓
Sucker pruning height	↓	↑
Plant twisting	No	Yes
Layering	No	Yes

Vegetative-generative balance

Vegetative-generative balance



Strategies' impact on crops

Actions			Head	Flower	Fruit
Vegetative-generative balance	Fruit	-1	+	+	+
		0	0	0	0
	Leaves	Flag leaf	+	0	-
		-3 at base	+	+	-
		Bracts	-	+	+
		IN	-	-	+

Strategies for balancing plants

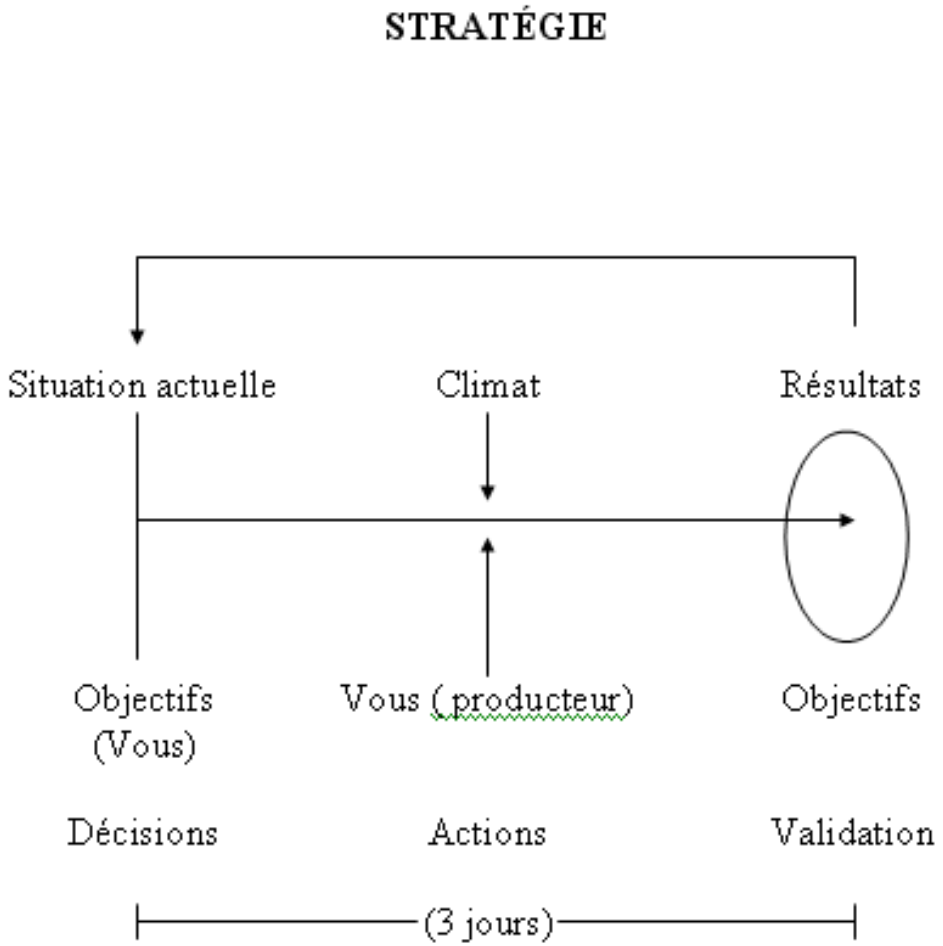
Strategies' impact on crops

Actions			Head	Flower	Fruit
Genetic balance		Variety	+ / - / 0	+ / - / 0	+ / - / 0
		Grafting	+	+	0
Climate balance	Temperature	Cooling	+	+	+
	Humidity	Humid	+	-	-
		Dry	-	+	+
	CO_2	Boost	0	+	0
	Grow pipe	Low	+	+	-
		Middle	-	-	+
		High	+	+	-
	Changes	Steady climate	+	+	-
		Day-night differential	-	+	+
		Kick	0	+	0
		Morning dip	+	+	-
		Pre-night drop	-	-	+
Vegetative-generative balance	Fruit	-1	+	+	+
		0	0	0	0
	Leaves	Flag leaf	+	0	-
		-3 at base	+	+	-
		Bracts	-	+	+
		IN	-	-	+
Water balance		Humid	+	-	-
		Dry	-	+	+

0	No impact
-	Negative impact
+	Positive impact

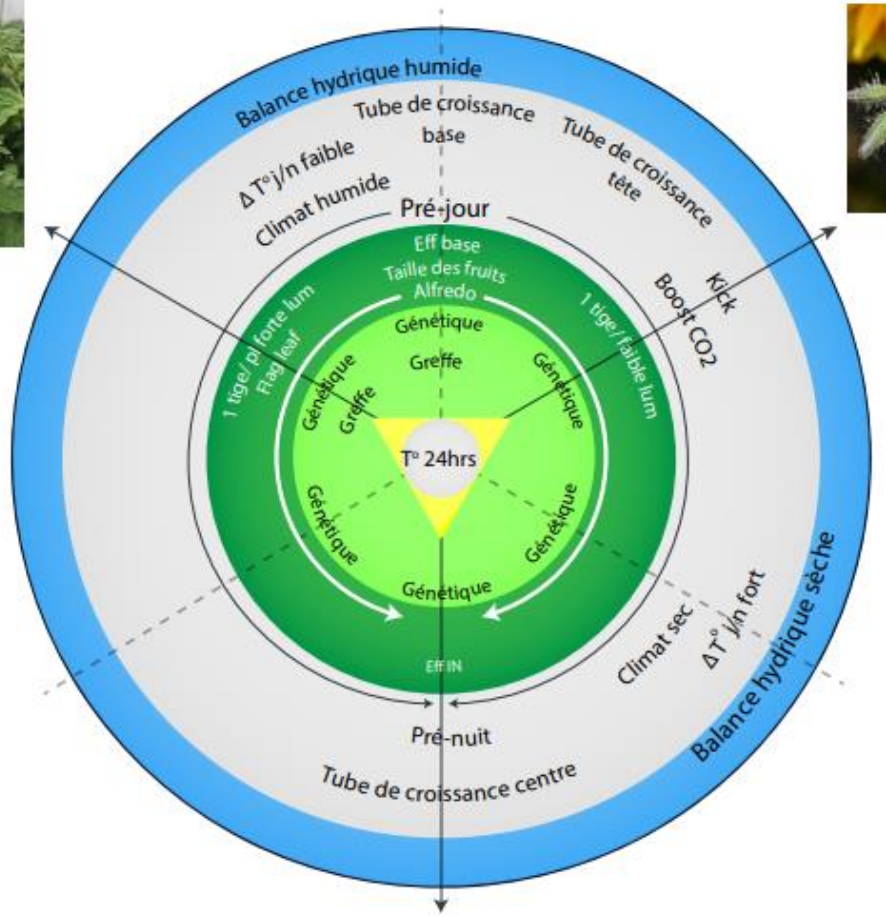
Strategies for balancing plants

- **Strategy:**



Thank you

Abaque-Gestion de l'équilibre des cultures à 3 voies



Eau
Climat
Plant
Génétique
Soleil