



Environmental control in the cultivation of everbearing strawberries in Finland

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Agronomist, developing knowledge for best practice cultivation of Flevo Berry varieties

- open field
- substrate cultivation tunnels and greenhouses
- propagation
- vertical farming

Independent adviser greenhouse strawberries USA, Canada, Armenia, Turkmenistan and Kenya

Volunteer work in strawberries in Rwanda, Nepal and Colombia

Climate management in tunnels or greenhouses is inextricably linked to:

- The condition of the plants
 - Plant load
 - Canopy width
 - Healthiness of the canopy
 - The fertilizing and irrigation accuracy
 - Eventually pests & diseases fighting the crop
 - Maintenance on the plants



Climate management in tunnels is never an easy challenge

You have to deal with:

- Limited temperature control
- Light deficiency or excess
- The natural daylength limits
- Foggy circumstances outside
- Certain varieties have easily issues
- Uneven or inferior plant quality



Climate in high greenhouses, more stable



Uneven gutters, the lower gutter 30% less yield



For greenhouses I made an RTR table to find out the best temperature

RTR = Radiation Temperature Ratio

Temperature = average 24 hours temperature

In tunnels it's more difficult to manage the temperature, however the direction should preferably be the same

To manage the temperature in the tunnels, a good crop management can support a good climate

RTR strategy choice 24-hours temperatures

Plant phase	Narrow* green canopy	Wide* green canopy	Narrow aged canopy	Wide aged canopy
No plantload/few flowers	12 + 6 Max 21 °C	12 + 6 Max 21 °C	12 + 3 Max 16.5 °C	12 + 3 Max 16.5 °C
Flowering to first fruit development	12 + 3 Max 16.5 °C	12 + 4.5 Max 18.75 °C	12 + 2 Max 15 °C	12 + 3 Max 16.5 °C
Developing fruits < 2 fruits/leaf	12 + 3 Max 16.5 °C	12 + 4.5 Max 18.75 °C	12 + 2 Max 15 °C	12 + 3 Max 16.5 °C
Developing fruits > 2 fruits/leaf	12 + 2 Max 15 °C	12 + 3 Max 16.5 °C	12 + 1.5 Max 14.25 °C	12 + 2 Max 15 °C
High plantload, from ripening fruit	12 + 2 Max 15 °C	12 + 3 Max 16.5 °C	12 + 1.5 Max 14.25 °C	12 + 2 Max 15 °C

*narrow = 20 - 40 cm

*wide = 40 - 60 cm

RTR Table

Mol PAR	6°C/10 mol PAR (12+6)	4.5°C/10 mol PAR (12+4.5)	3°C/10 mol PAR (12+3)	2°C/10 mol PAR (12+2)	1.5°C/10 mol PAR (12+1.5)
1	12.0 °C	12.0 °C	12.0 °C	12.0 °C	12.0 °C
2	12.6	12.45	12.3	12.2	12.15
3	13.2	12.9	12.6	12.4	12.3
4	13.8	13.35	12.9	12.6	12.45
5	14.4	13.8	13.2	12.8	12.6
6	15.0	14.25	13.5	13.0	12.75
7	15.6	14.7	13.8	13.2	12.9
8	16.2	15.15	14.1	13.4	13.05
9	16.8	15.6	14.4	13.6	13.2
10	17.4	16.05	14.7	13.8	13.35
11	18.0	16.5	15.0	14.0	13.5
12	18.6	16.95	15.3	14.2	13.65
13	19.2	17.4	15.6	14.4	13.8
14	19.8	17.85	15.9	14.6	13.95
15	20.4	18.3	16.2	14.8	14.1
16	21.0	18.75	16.5	15.0	14.25

More than 16 mol PAR: recommended temperature same as 16 mol level.



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Developing fruits > 2 fruits/leaf	12 + 2 Max 15 °C	12 + 3 Max 16.5 °C	12 + 1.5 Max 14.25 °C	12 + 2 Max 15 °C
High plantload, from ripening fruit	12 + 2 Max 15 °C	12 + 3 Max 16.5 °C	12 + 1.5 Max 14.25 °C	12 + 2 Max 15 °C

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Explanation

12 = basic 24 hours temperature in °C

+3 = for each PAR light, 0.3°C higher

PAR = Photosynthetically Active
Radiation

mol PAR measured inside tunnel

Joules measured outside tunnel

1 mol PAR inside = approx. 70 Joules
outside
(if light transmission tunnel = 65%)

Joules measured outside : 70) =
mol PAR inside

RTR Table

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3	13.2	12.9	12.6	12.4	12.3
4	13.8	13.35	12.9	12.6	12.45
5	14.4	13.8	13.2	12.8	12.6
6	15.0	14.25	13.5	13.0	12.75
7	15.6	14.7	13.8	13.2	12.9
8	16.2	15.15	14.1	13.4	13.05
9	16.8	15.6	14.4	13.6	13.2
10	17.4	16.05	14.7	13.8	13.35
11	18.0	16.5	15.0	14.0	13.5
12	18.6	16.95	15.3	14.2	13.65
13	19.2	17.4	15.6	14.4	13.8
14	19.8	17.85	15.9	14.6	13.95
15	20.4	18.3	16.2	14.8	14.1
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Choose the right strategy in the previous table.

Check the desired 24 hours temperature based on plant condition and DLI

DLI (Daily Light Integral) = total amount of PAR light in 1 day

More than 16 mol PAR: recommended temperature same as 16 mol level.

Plant temperature

Besides the air temperature in the tunnel, also the plant temperature needs attention

The temperature of the leaves can become too high when plants close the stomata.

Reasons:

- The film on the tunnel is not diffuse
- Water stress (less uptake compared to evaporation)
- Very low Relatively Humidity (< 40%) or high Humidity Deficit (>12)
 - A healthy green crop can cool itself easily. Check the leaves manually.
 - If young leaves feel cool compared to old leaves, the stomata are open.



Manually check of temperature

- **When young fully opened leaves feel cooler compared to old leaves:**
 - Plants are active
 - Stomata are open
 - Plants consume CO₂
 - Photosynthesis is going on
 - Evaporation pulls up the water and nutrients from the roots
 - Plant and air temperature are okay



When stomata close during day light...

- Temperature of leaves increases
- CO₂ uptake stops
- No transpiration through stomata anymore
- Water and nutrient uptake significantly reduced (in particular Ca)
 - Catnose fruits
 - Dry truss stems and black dried fruits
- Quickly aging of leaf area (life span of a leaf reduced)
- Small fruits and bad flavour
- No growth



Quickly closing stomata

- When temperature drops quickly on the end of day
- When RH increases quickly on the end of the day
- When sunny weather quickly exchanges to cloudy or rainy weather

This issues can appear:

- Tipburn
- Cracked fruit necks
- Cracked petioles
- Damaged just set fruits



Managing the climate in a tunnel is not always to do in an optimal way

You can do the maximum to support a good climate and with that a good crop, when:

- Leaf canopy is wide and healthy
 - Avoid aging
- Irrigation and fertilizing strategy are right
 - Avoid over- and under irrigation and fertilizing
- Number of fruits is balanced with the number of leaves
 - Stimulate new growth
 - Avoid too much leaf cutting



Balance in plant energy can be disrupted

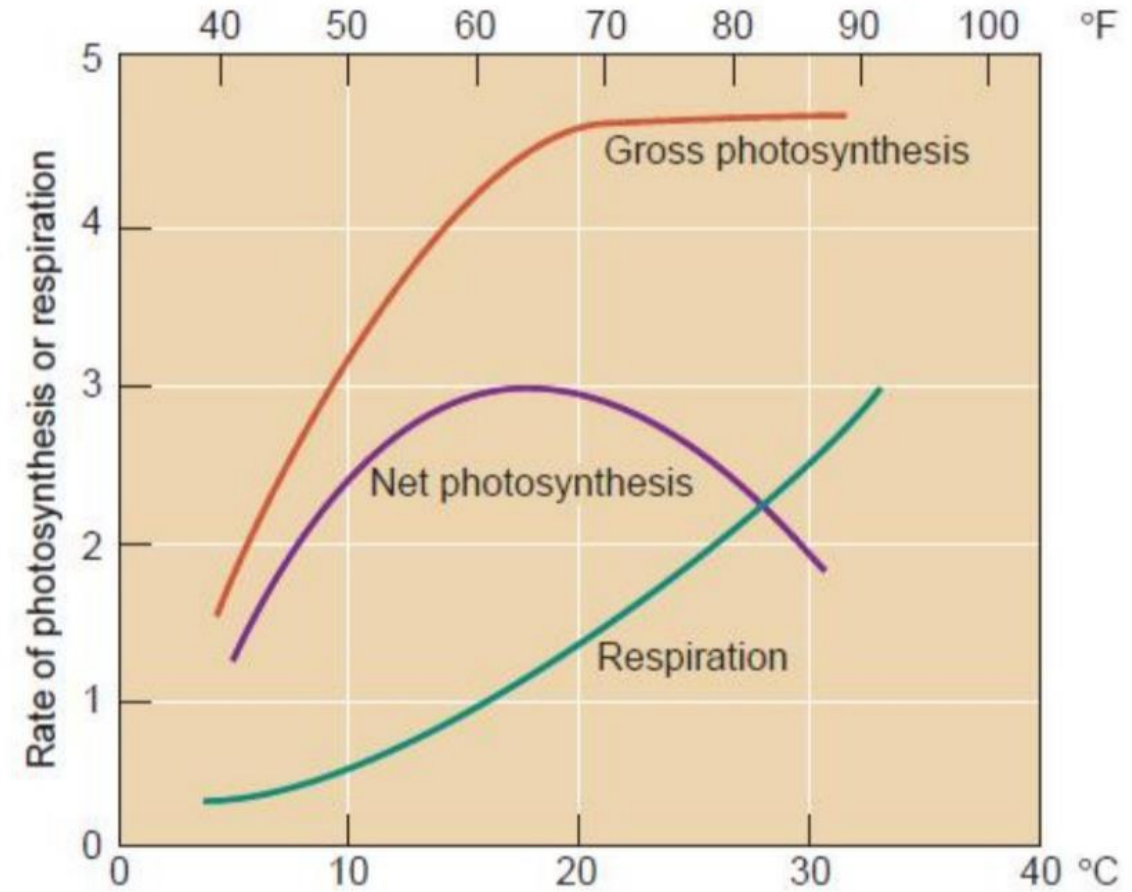
- When flower- and fruit development compared to leaf area are very high
- Reason:
 - Oversupply of initiated trusses during long day length or variety characteristics
- Symptoms:
 - Quickly aging crop
 - Flower abortion or half abortion
 - Insufficient flower quality
 - Insufficient vegetative growth



Avoid a premature tired or aging crop

Reasons of aging:

- Life span of a leaf is limited
- A low or even negative net-photosynthesis
- EC-sum too high, accumulating nutrients in substrate
- Removing leaves too late or too early
- Mildew, spider mite and other pests and diseases



Life span of a leaf is limited

- Depending of leaf temperature approx. 50 -75 days
- The higher the temperature, the shorter the life span
- More stress means shorter life span
- High plant load : shorter life span

New leaves should appear at minimal the same speed as leaves age

- Stimulate new leaf growth and elongate leaf life span
 - Moderate temperature (RTR table)
 - Active climate (ventilation)
 - Accurate fertilizing and irrigation schedule



Reasons of a low or negative net photosynthesis

- Number of fruits compared to leaves is high
 - Optimal 2 developing fruits for 1 adult green leaf
- Leaf canopy width is limited
- Too late leaf cutting. A worn-out leaf canopy
- Too high air temperature over a relatively long period (also night)
- Closed stomata, no CO₂ uptake
 - Water stress / wrong irrigation
 - Too high RH
 - Too low RH
 - Too high plant temperature



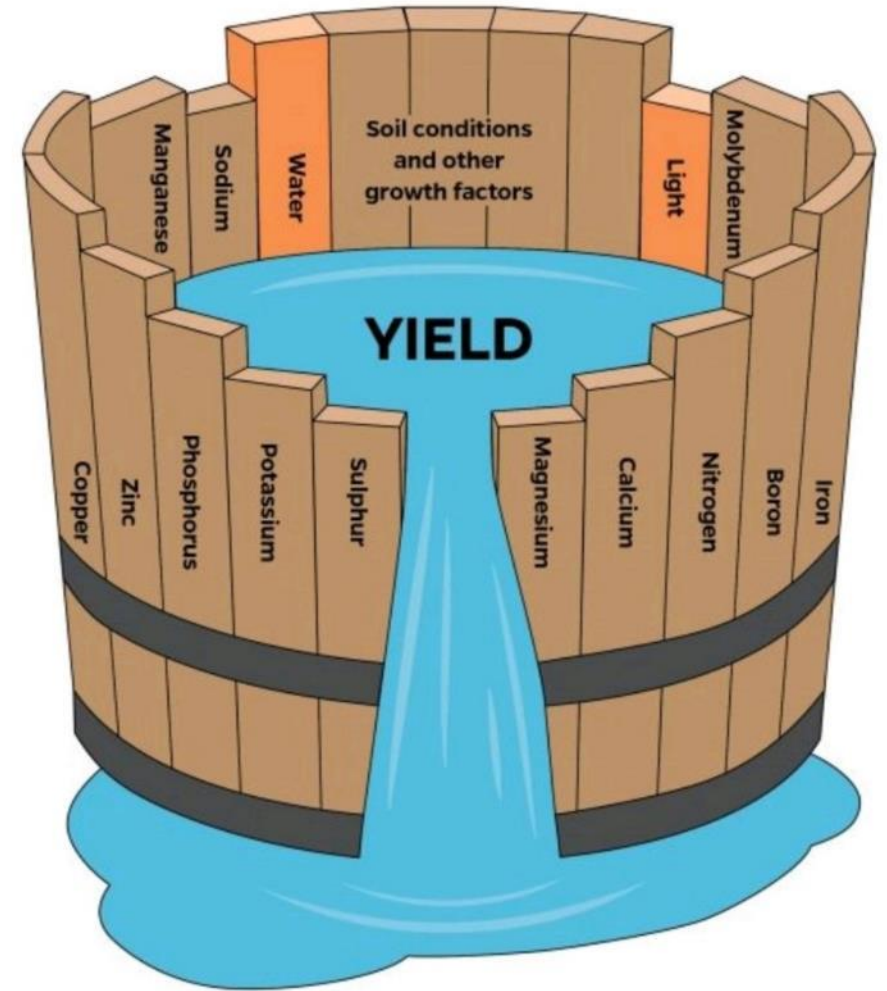
Consequences of a low or negative net photosynthesis

- Growth stop
- Flower abortion (also in rhizome)
- Susceptible to diseases
- Insufficient flower quality
- Insufficient flavour (low brix)
- Small fruits



Effect of fertilizing on quickly aging plants

- Too high EC-sum limits water uptake (water stress)
- Accumulating nutrients in leaves (in particular B + Mn)
- Na in substrate + high EC in substrate limits Ca uptake
- Insufficient K during high flush, makes leaves empty
- Disbalance in total nutrient demand of the plants
- Periodically too dry substrate limits nutrient uptake
- Too wet substrate causes dying root tips : Ca uptake limited



Continuously some NH_4 in the schedule or a shot of NH_4 in time can help to keep the plants growing

Influence leaf management on aging plants

- **Too late removal of worn-out leaves :**
 - new leaves intercept less light
- **Too early leaf removal :**
 - Even partly green leaves contribute to photosynthesis
 - You remove also nutrients
 - During aging, nutrients move to the rhizome and young plant parts
- **With a very dense crop, partly aged leaf removal is no issue**



Avoid rigorous leaf cutting

- Quickly removing of photosynthesis capacity
- Abrupt decreasing of evaporation
- You remove the nutrient warehouse of the plant
- Still running root pressure damages the plant cells
- Tipburn and other cracked plant parts
- Flower abortion
- Less flavour / less brix

Better:

- Remove only 1 leaf per plant, for example every 10 days



Influence of pests and diseases on aging of the crop

All are eating and drinking sugars, nutrients, plant sap, chlorophyll from the plants.

They make plants tired

- Powdery mildew
- Neopestalotiopsis
- Colletotrichum
- Phytophthora
- Aphids
- Spider mite
- Tarsonemid mite



Avoiding tipburn

Usually happens after suddenly high root pressure

- Rootpressure is stimulated by
 - Evaporation leaves through the stomata (strong pull action, with active plants)
 - Osmotic pull (is low pull) shows up as guttation if stomata are closed because of very high RH. Gives no tipburn risk



Suddenly damaging high root pressure happens when:

- After rigorous leaf cutting on the end of a flush
- Irrigation too late on the day, with low plant load
 - If temperature is cooling down on the end of the day, the root pump is still running
 - 3-4 hours before seriously decreasing temperature last irrigation is usually okay
 - With cloudy weather, even 5-6 hours before decreasing temperature give the last irrigation
- Weak plant cells caused by low calcium makes it worse
 - (inactive plants, too dry during high radiation, too high EC, too wet substrate - dying root-tips)



Avoiding dry truss stems and flowers

- Reasons similar to tipburn
- Can look like bacterial disease Erwinia (with drops on the truss)
- Happens after low calcium transport during several days, followed by high root pressure.
 - Periodically not active crop
 - Water stress (low RH + insufficient irrigation = stomata closed = less calcium transport)
- Low Ca in cells + periodically high root pressure = exploding weak cells
 - Dried stems and flowers
 - Misshapen fruits



Recommended EC- levels and irrigation strategy

- Strive to an EC-sum of 2.50 (= drip EC + drain EC)
- If EC-sum is increasing:
 - For example from 11.00 – 15.00 irrigate with lower EC (however not < 1.00 EC)
 - Create most drain between 11.00 – 15.00
 - Before 11.00 and after 15.00 irrigate with normal EC (1.2-1.4)
 - If EC-sum is back on desired level, irrigate whole day with normal EC.
- Irrigate on dry-out 5-7% or on radiation, to avoid insufficient or excessive irrigation
- Adjust fertilizing schedule based on frequent water- and plantsap analysis

Mineraal		Huidig niveau	Optimum			
Suikers	%	3,4	3,5 - 6,9	1		
	%	5,5		2		
pH		5,3	5,5 - 6,3	1		
		5,3		2		
EC	mS/cm	11,2	10,2 - 13,7	1		
	mS/cm	10,6		2		
K - Kalium	ppm	5080	4000 - 5750	1		
	ppm	4074		2		
Ca - Calcium	ppm	883	600 - 1500	1		
	ppm	4861		2		
K / Ca		5,75		1		
		0,84		2		
Mg - Magnesium	ppm	478	750 - 1000	1		
	ppm	1615		2		
Na - Natrium	ppm	31	10 - 50	1		
	ppm	44		2		
NH4 - Ammonium	ppm	35	40 - 90	1		
	ppm	52		2		
NO3 - Nitraat	ppm	456		1		
	ppm	652		2		
N uit Nitraat	ppm	103		1		
	ppm	147		2		
N - Stikstof totaal	ppm	455		1		
	ppm	823		2		
Cl - Chloride	ppm	850	710 - 2140	1		
	ppm	1515		2		
S - Zwavel	ppm	217	50 - 200	1		
	ppm	238		2		
P - Fosfaat	ppm	963	500 - 1000	1		
	ppm	932		2		
Si - Silicium	ppm	1,9	5,0 - 10,0	1		
	ppm	5,0		2		
Fe - IJzer	ppm	0,38	0,95 - 2,40	1		
	ppm	1,97		2		
Mn - Mangaan	ppm	35,31	10,00 - 40,00	1		
	ppm	110,50		2		
Zn - Zink	ppm	5,21	1,55 - 2,95	1		
	ppm	16,80		2		
B - Borium	ppm	1,62	1,50 - 4,00	1		
	ppm	14,11		2		
Cu - Koper	ppm	0,14	0,15 - 0,30	1		
	ppm	0,24		2		
Mo - Molybdeen	ppm	0,05	0,05 - 0,10	1		
	ppm	0,06		2		
Al - Aluminium	ppm	<0,50		1		
	ppm	1,08		2		

Raadpleeg uw adviseur voor een passend bemestingsadvies.
 Omdat HouwCrisControl geen invloed heeft en/of geen controle uitdient op de mineralisatie, aanvaardt HouwCrisControl geen enkele aansprakelijkheid over schade die voortvloeit uit de door HouwCrisControl geleverde analysesresultaten of adviezen.



Avoiding too high relative humidity

- **Pollen don't detach from the flower and cannot pollinate the pistils**
 - Risky if RH is $> 80\%$ during the day
 - If RH $> 80\%$ for 3-4 days, flowers are not fertile anymore
 - White petals fall off = flower not fertile anymore
- **Tunnels closed too much**
 - Often happens when trying to create extra earliness
- **Ventilation above gutters recommended**



Flowers under a dense leaf canopy

- Pollinators cannot reach the flowers
- RH under the leaves is usually higher
 - Pollen don't detach easily from the flower
 - More misshapen fruits
- Fruits are sensitive to:
 - botrytis
 - mucor
 - rhizopus
 - mildew
 - suzukii
 - duponchelia



Another consequence of high temperature

Development from flower initiation to fruit goes very quickly

- Growing degree hours run fast
- Plants must work hard
- Are roots able to supply water and nutrients quickly enough?
- Is photosynthesis productive enough to follow the speed of growing degree hours?
- During the long days in Finland, is there more photosynthesis during a day and less waste during the night, compared to Netherlands?



Speed of increasing gdh influenced by temperature

With frozen plants from the cold store (gdh topflower in plant approx. 12.500):

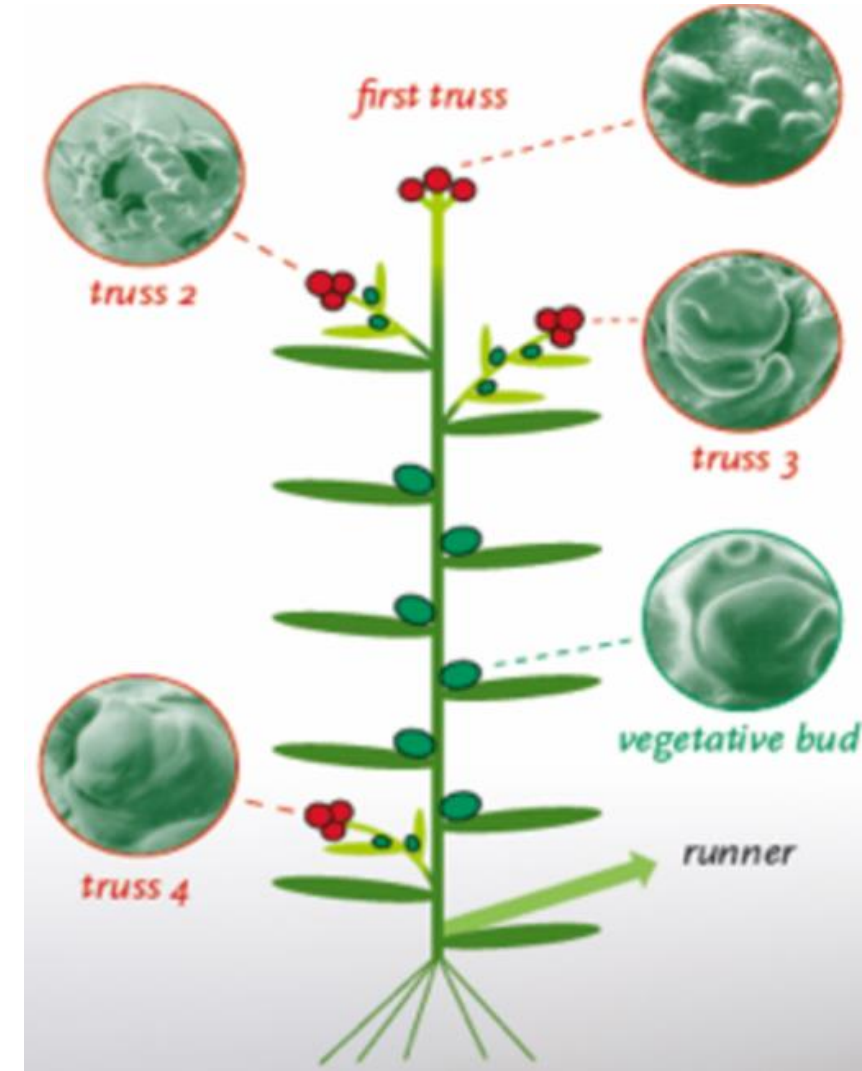
Time from planting to first flush:

- Average 24 hours temperature 13°C --- 75 days
- Average 24 hours temperature 15°C --- 60 days
- Average 24 hours temperature 17°C --- 50 days

Second flush starts 27.500 gdh after start new flower initiation

Time from start initiation until harvest:

- Average 24 hours temperature 13°C --- 135 days
- Average 24 hours temperature 15°C --- 110 days
- Average 24 hours temperature 17°C --- 92 days
- Average 24 hours temperature 20°C --- 74 days



Kiitos huomiostasi ja mielenkiinnostasi

Cultivation manuals & Variety information available for:



All everbearing varieties

- Hademar
- Florice
- Favori
- Furore
- Bravura
- Florentina

June bearing varieties:

- Sonsation
- Flair
- Dahli
- Faith
- Falco
- Magnus

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