Crop Nutrition

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Nutrient requirements of crops

Greenhouses are not fields.

- Nitrogen requirements: 135 kg/ha in the field vs 1800 kg/ha in the greenhouse
- Yield:
  - Annual: Field: 30-50 t/ha, greenhouse 600-700 t/ha; 20 t/ha in summer
    - Greenhouses produce in 2.5 weeks what fields produce over an entire season.
      - Field: Bicycle = you adjust to the current visual
      - Greenhouse: Formula 1 = need to speed up before entering the race track,and adjust afterwards
  - Duration of harvest: field: 6 weeks, greenhouse: 44 weeks
    - In the field: recommendations are made for the entire season.
    - In the greenhouse: the basic recommendation (spreadsheet) is used to enter the race track; then the indications on the road are followed and adjustments are made.

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Nutrient requirements of crops

Greenhouses are not fields: Oxide vs elements

- Field agrologists think in terms of oxide: N-P2O5-K2O-MgO.
- Greenhouse agrologists think in terms of elements: N-P-K-Mg.
- 20-20-20 = 20-8.8-16.6

Ox form	Atomic weight		Nutrient + oxyde			
	Atom	A.W	O	Nutrient	Total	% Atom/tot
	O	16,0				
P2O5	P	31,0	80,0	61,9	141,9	0,44
K2O	K	39,0	16,0	78,0	94,0	0,83
MgO	Mg	24,3	16,0	24,3	40,3	0,60

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Nutrient requirements of crops

Greenhouses are not fields: impact of lack of rainfall or snow melt

- You're going to live with your mistakes.
  - No rain for leaching
    - Water quality is important
      - Sodium: soil destructuration, toxicity
      - Nutrients: Ca, Mg
      - Alkalinity: Fertilizers + alkalinity = high pH
        - Blocking of minerals (especially minor ones)
        - Precipitation of P-Ca (can be an environmental benefit)
      - No acidification from leaching and rain
  - No snow melt

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Nutrient requirements of crops (basis for yields)

Table 4.5
Tomato plant nutrient requirements.

Yield expectation (kg/m²)	N g/m²	P g/m²	K g/m²	Mg g/m²
10	32	4	52	5
25	70	10	114	12
40	92	16	148	20

* adapted from various sources, see Appendix B. Leaf nutrient content given in Appendix C.

Table.4.23
Cucumber plant nutrient requirements.

Yield expectation (kg/m²)	N (g/m²)	P (g/m²)	K (g/m²)	Mg (g/m²)
15	25	6	44	7
25	38	10	65	13
40	56	16	88	20

Source: adapted from various sources, see Appendix B. Leaf nutrient contents are given in Appendix C.

Koller et al. 2016

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Nutrient requirements of crops

Table 4.1
Pepper plant nutrient requirements

Yield expectation (kg/m²)	N g/m²	P g/m²	K g/m²	Mg g/m²
10	36	5	43	4
25	59	8	70	7
40	81	11	97	9

* adapted from various sources, see Appendix B. Leaf nutrient contents are given in Appendix C.

Table.4.39
Lettuce plant nutrient requirements.

Yield expectation (kg/m²)	N (g/m²)	P (g/m²)	K (g/m²)	Mg (g/m²)
2.5	5	1	8	0.8
4	8	1.6	13	1.2
6	12	2.4	19	1.8

Source: adapted from various sources, see Appendix B. Leaf nutrient contents are given in Appendix C.

Koller et al. 2016

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Nutrient requirements of crops (period base = Light sum)

Hydroponic tomatoes planted in mid-December and end of harvest in late November

Weekly estimate of fertilizer uptake by a greenhouse tomato crop

Greenhouse area (m2)	10000	Number of beds	1								
Weekly calendar	g/bed					mg/bed					
Week	N	P	K	Ca	Mg	Fe	Cu	Mn	Zn	Mo	B
1 to 4	21252,000	5023,200	34003,200	12320,000	4533,760	70560,000	2268,000	31920,000	20160,000	4200,000	13440,000
5 to 8	27284,954	6449,171	43655,926	15817,364	5820,790	90590,360	2911,833	40981,353	25882,960	5392,283	17255,307
9 to 12	37480,202	8858,957	59968,323	21727,653	7995,776	124440,196	3999,863	56294,374	35554,342	7407,155	23702,894
13 to 16	42513,028	10048,534	68020,845	24645,234	9069,446	141149,974	4536,963	63853,560	40328,564	8401,784	26885,709
17 to 20	47313,506	11183,192	75701,609	27428,119	10093,548	157088,320	5049,267	71063,764	44882,377	9350,495	29921,585
21 to 24	48446,388	11450,964	77514,221	28084,863	10335,229	160849,667	5170,168	72765,326	45957,048	9574,385	30638,032
25 to 28	49037,667	11590,721	78460,268	28427,633	10461,369	162812,808	5233,269	73653,413	46517,945	9691,239	31011,964
29 to 32	45454,846	10743,873	72727,753	26350,635	9697,034	150917,274	4850,912	68272,100	43119,221	8983,171	28746,148
33 to 36	50684,071	11979,871	81094,513	29382,070	10812,602	168279,128	5408,972	76126,272	48079,751	10016,615	32053,167
37 to 40	37269,712	8809,205	59631,538	21605,630	7950,872	123741,335	3977,400	55978,223	35354,667	7365,556	23569,778
41 to 44	23121,704	5465,130	36994,726	13403,886	4932,630	76767,712	2467,534	34728,251	21933,632	4569,507	14622,421
Tot kg/bed	1719	406	2751	997	367						

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Nutrient requirements of crops

Let's simplify our lives; Let's talk ratio (nutrient balance) = stage; this will be easier: Hydroponics

Usual nutrient ratio used at the dripper of hydroponic crop

	Crop stage	K/N	K/Ca	K/Mg		
extra Ca veget stage	Seedling	1,3	1,2	6,1	T	Tomato
Standard	TF3-F5	1,5	1,7	6,5	F	Flowering stage
Extra K	TF6-H2	1,8	2,3	8,4	H	Harvest stage
Standard	TH3-End	1,5	1,7	6,5	C	Cucumber
Extra Ca - Mg	Ccig-End	1,3	1,6	8,0	cig	Cigar size (4 in.)
Extra Ca + Ca - Mg	Ccig-End + P	1,3	1,2	8,0	P	Pepper
Extra Ca + Ca	Ccig-Fin + P + E	1,3	1,2	6,2	E	Eggplant
	Leafy veg (NFT)	1,2	1,3	4,5		

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Nutrient requirements of crops

Let's talk ratio (nutrient balance) = stage; this will be easier: Organic farming

Nutrient adjustement by crop : Color indicate recette modification requirements

eek from plant	Tomato			Cucumber and snap beans			Pepper			Eggplant		
	% growth[a]	Stage	K/N	% growth[a]	Stage	K/N	% growth[a]	Stage	K/N	% growth[a]	Stage	K/N
1	30	F1	1,3				10	Veg	1,3	10	Veg	1,3
2	45	F1,6	1,3				15	Veg	1,3	20	Veg	1,3
3	60	F2,3	1,3				20	Fr1	1,3	30	Fr1	1,3
4	70	F3	1,3	10	Veg	1,3	30	Fr2	1,3	40	Fr2	1,3
5	80	F4	1,5	30	Veg	1,3	40	Fr ≥ 1po	1,3	50	Fr3	1,3
6	90	F5	1,5	70	Cigar	1,5	50	Gros	1,3	60	Rec	1,3
7	100	F6	1,6	100	Réc	1,5	60	Gros	1,3	70	Rec	1,3
8	100	F7	1,6				70	Gros	1,3	80	Rec	1,3
9	100	Rec	1,6				75	Gros	1,3	90	Rec	1,3
10			1,6				80	Gros	1,3	100	Rec	1,3
11			1,6				85	Gros	1,3			
12			1,6				90	Réc	1,3			
13			1,6				95	Réc	1,3			
14			1,6				100	Réc	1,3			

a- 100% = 6 feet height plant

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Nutrient requirements of crops

Let's talk ratio = stage vs light X CO_2; Not as easy but!!!:

- If you plant
  - In January?
  - In May?
- Varies from single to double
- But we have tools

Weekly calendar	g/bed	
Week	N	P
1 to 4	21252,000	5023,200
5 to 8	27284,954	6449,171
9 to 12	37480,202	8858,957
13 to 16	42513,028	10048,534
17 to 20	47313,506	11183,192
21 to 24	48446,388	11450,964
25 to 28	49037,667	11590,721
29 to 32	45454,846	10743,873
33 to 36	50684,071	11979,871
37 to 40	37269,712	8809,205
41 to 44	23121,704	5465,130

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Nutrient requirements of crops

Let's talk ratio = stage vs light X CO_2; Not as easy but!!!: Hydroponic production

- No need to panic
  - You water approximately
    - January: 1.7 L x 3.5 mS/cm = 5.95 ECL
    - May: 5 L x 2.5 mS/cm = 12.5 ECL
  - More than double = OK
  - And if your plants are young (% growth), give less water, so less fertilizer. That's fine.

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Recipes: Water quality

- **Here are a few important points to remember for determining water quality:**
  - Soluble salt content (salinity)
  - Sodium absorption ratio (SAR)
  - Concentration of certain major elements and compounds
  - Presence of toxic amounts of certain trace elements
  - Alkalinity
  - Presence of phytotoxic elements (pesticides and herbicides). Accurately identify sources…
  - Presence of suspended particles

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Recipes: Water quality

- **Poor quality water may lower yields because:**
  - Excess salinity
  - Nutrient imbalance
  - Toxicity of certain elements
  - Clogging of irrigation system
  - Inactivation of certain pesticides

Analyse d'eau	Spec min	Spec max	301405 Échantillon 19/11/20
Alcalinité (ppm)	0	50	↑ 343.56
Chlorure (ppm)	0	50	↑ 611.72
pH	-	-	7.65
Conductivité électrique (mmhos/cm)	0	1	↑ 2.91
Nitrate (N-NO3) (ppm)	0	5	< 0.6
Ammonium (N-NH4) (ppm)	0	5	0.4
Phosphore (ppm)	0	5	< 0.21
Potassium (ppm)	0	5	↑ 7.7
Calcium (ppm)	0	120	↑ 158.1
Magnésium (ppm)	0	25	↑ 33.2
Sulfate (ppm)	0	100	↑ 212.7
Bore (ppm)	-	-	0.23
Cuivre (ppm)	0	0.2	< 0.03
Fer (ppm)	0	0.5	< 0.05
Manganèse (ppm)	0	1	0.07
Molybdène (ppm)	0	0.05	< 0.02
Zinc (ppm)	0	0.5	↑ 3.95
Aluminium (ppm)	0	0.2	0.01
Sodium (ppm)	0	30	↑ 426.9
RAS	-	-	8.05

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Hydroponic recipes: desired solutions

To achevez 50ppm after nutrient injection

	Crop stage	N	P	K	Ca	Mg	S	Fe	Cl	Alcalinity
extra Ca veget stage	Seedling	231, 0	62, 0	292, 0	240, 0	48, 0	0, 0	1, 00	20, 0	80, 0
Standard	TF3-F5	241, 0	46, 5	370, 5	216, 0	57, 0	0, 0	1, 00	0, 0	80, 0
Extra K	TF6-H2	240, 0	46, 5	437, 0	191, 0	52, 0	0, 0	1, 00	0, 0	80, 0
Standard	TH3-End	240, 0	46, 5	370, 0	216, 0	57, 0	0, 0	1, 00	0, 0	80, 0
Extra Ca - Mg	Ccig-End	240, 0	39, 0	312, 0	200, 0	39, 0	0, 0	1, 00	0, 0	80, 0
Extra Ca + Ca - Mg	Ccig-End + P	240, 0	39, 0	312, 0	260, 0	39, 0	0, 0	1, 00	0, 0	80, 0
Extra Ca + Ca	Ccig-Fin + P + E	240, 0	39, 0	312, 0	260, 0	50, 0	0, 0	1, 00	0, 0	80, 0
	Leafy veg (NFT)	145, 0	35, 0	180, 0	140, 0	40, 0	0, 0	3, 00	0, 0	80, 0

	Crop stage	Cu	Mn	Zn	Mo	B
extra Ca veget stage	Seedling	0, 05	0, 55	0, 33	0, 05	0, 32
Standard	TF3-F5	0, 05	0, 55	0, 33	0, 05	0, 32
Extra K	TF6-H2	0, 05	0, 55	0, 33	0, 05	0, 32
Standard	TH3-End	0, 05	0, 55	0, 33	0, 05	0, 32
Extra Ca - Mg	Ccig-End	0, 05	0, 55	0, 33	0, 05	0, 32
Extra Ca + Ca - Mg	Ccig-End + P	0, 05	0, 55	0, 33	0, 05	0, 32
Extra Ca + Ca	Ccig-Fin + P + E	0, 05	0, 55	0, 33	0, 05	0, 32
	Leafy veg (NFT)	0, 03	1, 50	0, 20	0, 05	0, 30

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Hydroponic recipes: major elements used

Nutrient source usually used in greenhouse vegetable crops

Macroelement + iron

Fertilizer	N-NO3	N-NH4	P	K	Ca	Mg	Fe	S-SO4	Cl
Calcium nitrate	14,5	1			19				
Potassium nitrate	13,8			38,2					
Fe-EDTA							13,2		
Fe-DTPA-7							7		
Fe-DTPA-11							11		
KH2PO4 (Mono-potassium Phosphate)			22,7	28,3					
K2SO4 (potassium sulfate)				41,7				55,5	
MgSO4 (Epsom salt)						9,9		13	

Less used fertilizer

Fertilizer	N-NO3	N-NH4	P	K	Ca	Mg	Fe	S-SO4	Cl
Ammonium nitrate	17	17							
Magnesium nitrate	11					9,6			
PureCal	13				18				
Calcium chloride					29,9				53
Calcium chelat (10%) Ca-EDTA					10				
PeKacide (0-60-20)			26,2	16,6					
potassium chloride				49,8					45
potassium bicarbonate				38?					
potassium silicate				10,37					
Fe-EDDHA Q-FE-6							6		

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Hydroponic recipes: minor elements used

		%
Iron	Fe-EDTA 13.2%	13,2
	Fe-DTPA 11%	11,0
	Fe-DTPA 7%	7,0
	Fe-EDDHA Q-FE-6	6,0
Copper	Sulfate	25,0
	Chelate	14,0
Manganese	Sulfate	29,5
	Chelate	13,0
Zinc	Sulfate	35,0
	Chelate	14,0
boron	Borax	15,0
	Acid	17,5
	Solubore	20,0

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Hydroponic recipes: Calculation tool

Solution A and B

								CEest
meq	0, 8		7, 5	12, 0	4, 0	24, 3		2, 43
PA	18, 0		39, 0	20, 0	12, 0			

PPM	N	P	K	Ca	Mg	S	Fe	Cl	CE drip	calinit
Desired solution	231, 0	62, 0	292, 0	240, 0	48, 0	0, 0	1, 00	0, 0	1, 5	80, 0
Water analysis effec	3, 9	0, 0	4, 2	63, 9	1, 9			40, 5		103, 0
Chlorine source			0, 0	0, 0						
Chlorine effect			0, 0	0, 0				0, 0		
Acid source	0, 0	1, 0								23, 0
Nitric acid	0, 0									
Phosphoric acid		21, 9								
Nutrient to add	227, 1	40, 1	287, 8	176, 1	46, 1		1, 00			
Calcium nitrate	143, 7			176, 1						
Chelated iron :							1, 00			
Monopotas. Phos. :		40, 1	50, 0							
Nutrient to add	83, 4	0, 0	237, 7	0, 0	46, 1		0, 00			
Potassium nitrate	83, 4		232, 6							
Nutrient to add	0, 0		5, 2							
Ammonium nitrate	0, 0									
Potassium sulfate			5, 2			2, 2				
Mg nitrate	0, 0				0, 0					
Mg Sulf./oxyde :					46, 1	60, 8				
Nutrient concentrati	231, 0	62, 0	292, 0	240, 0	48, 0	63, 0	1, 00			
% d' ammonium :	4, 01				SO4	189, 1				

Solution C

PPM	Cu	Mn	Zn	Mo	B
Desired solution	0, 05	0, 55	0, 33	0, 05	0, 32
Water analysis effec	0, 00	0, 00	0, 00	0, 00	0, 05
Nutrient to add	0, 05	0, 55	0, 33	0, 05	0, 27
Copper :	0, 05				
Manganese:		0, 55			
Zinc:			0, 33		
Molybdene:				0, 05	
Boron					0, 27
Nutrient to add	0, 00	0, 00	0, 00	0, 00	0, 00
Nutrient concentrati	0, 05	0, 55	0, 33	0, 05	0, 32

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Hydroponic recipes: sample recipe 100 litres concentrated 200 X = 20,000 L of nutrient solution

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Cucumber cigar size to the end

Solution A	Liters:	100					# de gramme	kg	Lbs
	Concentr:	200							
Calcium nitrate	Nitrate:	14, 5	%	Calcium	19, 0	%	16903, 3 g.	16, 90	#####
	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	%	7242, 4 g.	7, 24	#####
Fe- DTPA 11%	Fer:	11, 0	%				181, 8 g.	0, 18	0, 40
Ammonium nitrate	Nitrate:	17, 0	%	Ammonium	17, 0	%	412, 7 g.	0, 41	0, 91

Solution B	Liters:	100					# de gramme	kg	Lbs
	Concentr:	200							
Potassium nitrate	Nitrate:	13, 8	%	Potassium	38, 3	%	7242, 4 g.	7, 24	#####
Monopotassium Phosphate	Phosphore:	22, 7	%	Potassium	28, 3	%	2244, 9 g.	2, 24	4, 94
Potassium sulfate	Sulfate:	18, 0	%	Potassium	41, 7	%	0, 0 g.	0, 00	0, 00
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	%	7675, 0 g.	7, 68	#####
Introduce	2, 0	Litres de solution C							

Micronutrients

Solution C	Liters	10	# de gramme
	Concentr:	10000	
Sulfate Copper		25, 0	20, 0 g.
Sulfate Manganese:		29, 5	186, 4 g.
Sulfate Zinc:		35, 0	94, 3 g.
Sodium Molybdate:		46, 0	10, 9 g.
Acid Boron		17, 5	165, 7 g.

Solution D	Liters in	0, 00	Nitric Acid 67%	21, 0
	Litters in	0, 68	Phosphoric acid 75%	39, 7

Only for information if you use Acid concentrated tank

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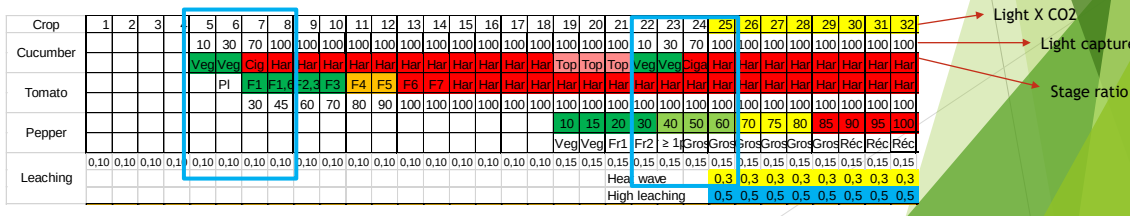
Organic recipes: Identification of recipe changes

Let's talk ratio = stage vs light X CO_2; Not as easy but!!!: Organic farming

- Each 4-week run (light X CO2) requires a different dosage.
- Each colour change (stage X % growth) requires a new recipe (change in ratios).
- Leaching losses must be taken into account.



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Organic recipes: Calculation of requirements by stage of growth and time of year

	Weekly calendar	g/bed				
	Week	N	P	K	Ca	Mg
	Weeks					
Tomato requirements	9 à 12	37480,202	8858,957	59968,323	21727,653	7995,776
Correction K/N				1,300		
Correct standard analysis		1,000	0,500	0,000	1,000	1,100
Correct Leach		1,100	1,100	1,100	1,100	1,100
Correct %growth		0,600	0,600	0,600	0,600	0,600
Basis recommendation		24737	2923	0	14340	5805
Others contributions						
Final recommendation	9 à 12	24737	2923	0	14340	5805

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Organic recipes: Choice of fertilizers

Fertilizer		Nutrient content										
		N	P	K	Ca	Mg	Fe	Cu	Mn	Zn	Mo	B
Choix (1)	Source											
K	Potassium sulfate 0-0-50			42%								
Mg	Magnésium Sulfate					9,9%						
N	Feather meal 13-0-0	13,0%	0,0%	0,0%	0,5%							
P	Actisol 5-3-2	5,0%	1,3%	1,7%	7,0%	0,5%	0,0%					
	earthworm manure	0,6%	0,1%	0,3%	1,9%	0,1%						
	Actisol 4-4-2	4,0%	1,8%	1,7%	7,0%	0,5%						
	Alfalfa meal	3%	0,16	2,40%	1,9	0,23						
	BioSol	1,2%	0,3%	0,5%	1,0%	0,0%						
	Sul-Po-Mag 0-0-22			18%		11%						
	Blood meal 12-0-0	12%										
	Actisol 4-6-8	4,0%	2,6%	6,6%	6,0%							
	BioFert Rapidegro 0-0-5			4,15%								
	Nature Nectar 5-0-0	5%										
	Alfalfa green	3,0%	0,2%	2,8%	1,9%	0,3%	0,1%	0,001%	0,006%	0,003%	0,006%	0,003%
	Eco+ 5-4-3	5%	2%	2%								
	Manure	1,0%	0,4%	0,8%	0,5%							
	Basalte 0-0-4			3,4%	3,0%	3,0%						

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Organic recipes: Making the recipe

Tomato : Fertilizer recommendation (g/bed/week)

bed area (m^2) 10000

Fertilizer	Plant to F3	F4-F5	F6-Harv	Heat wave	Mid-sept
Actisol 5-3-2	221473,9	847978,6	1995243,8	658563,7	998322,6
Feather meal 13-0-0	0,0	0,0	-338837,3	312525,5	44895,0
Magnésium Sulfate	47450,1	161267,5	139341,5	141095,4	69719,7
Potassium sulfate 0-0-50	-8859,0	51664,6	349787,1	257248,8	94410,4

F3 = flowering of the 3td cluster
Har = Harvest
Heat wave = day > 30°C

Cucumber and snap beans : Fertilizer recommendation (g/bed/week)

bed area (m^2) 10000

Fertilizer	Pl-Cigar	Cigar-Har	Har summer	Har Heat wave	Mid-sept
Actisol 5-3-2	232983,1731	465966,346	504898,847	635408,6539	499161,303
Feather meal 13-0-0	0	0	239602,885	301537,1245	236880,098
Magnésium Sulfate	44308,43935	88616,8787	96021,0115	120841,1982	94929,8528
Potassium sulfate 0-0-50	47741,9013	113041,104	122485,933	154146,9594	121094,034

Pl-Cigar = Plantation to 4 in. Fruit
Har = harvest

Pepper and eggplant : Fertilizer recommendation (g/bed/week)

bed area (m^2) 10000

Fertilizer	Pl-Fr2	Fr 1in.to 4 F	Harvest	Heat wave	Mid-sept
Actisol 5-3-2	116491,5865	249405,475	378674,135	610447,3084	499161,303
Feather meal 13-0-0	55281,80616	118356,918	179702,164	289691,5629	236880,098
Magnésium Sulfate	22154,21967	47431,6116	72015,7586	116094,0817	94929,8528
Potassium sulfate 0-0-50	23870,95065	51107,0882	77596,2614	125090,2147	102285,969

Fr2 = 2 fruit set
Fr 1 in. to 4F = First fruit 1 in. to plant height of 4 foot

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Organic recipe: After head pinching

- Planning the end of fertilization
  - Stop adding fertilizers
    - Saline effect
    - Financial loss
  - Preparing for the next season
    - Winter crop
    - Next year's planting

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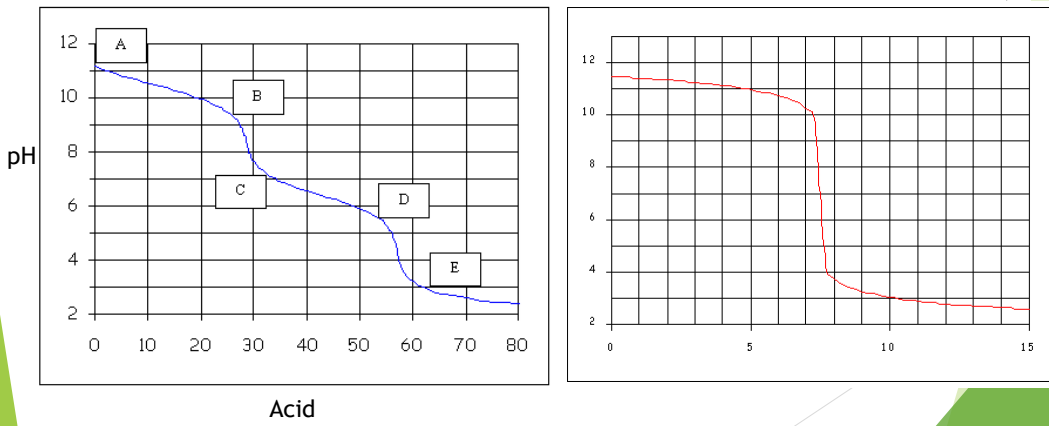
Soil application techniques

- Dry fertilizer
  - One side of bed per week under polyethylene
  - Constant humectation (drip-tape position)
    - Plastic sheeting protects from drying out
    - Proper fertilizer positioning
    - Irrigation strategy must allow for regular moistening (problem in late fall and winter)
- Soluble fertilizer
  - In irrigation: Must take into account water requirements or daily addition

24

pH

- Alkalinity = buffer effect (opposite of the buffer pH (lime index))



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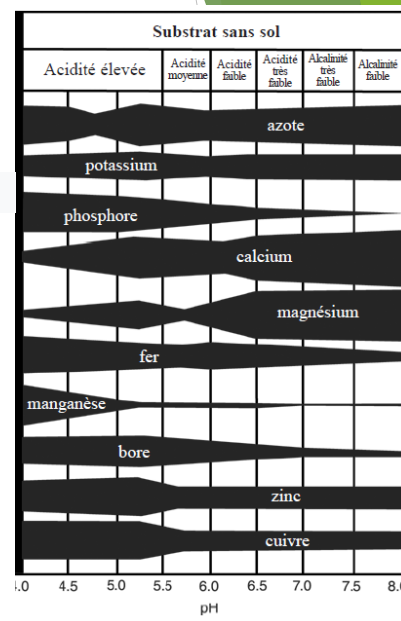
pH in hydroponics

Main problems caused by pH imbalance*

pH too low (< 5.5)	pH too high (> 6.5)
Risk of poisoning :	Risk of deficiency :
Iron	Fer
Iron	Manganèse
Manganese	Zinc
Zinc	Cuivre
Copper	Bore
Risk of deficiency :	
Calcium	
Magnésium	
Risk of leach :	
Phosphates (PO_4^{---}) (in substrate)	

*Source : Les techniques de cultures en multicellules. 1999. IQDHO . *in* Acides, engrais et mystères…, Liette Lambert, 2000.



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pH in hydroponics

- **pH of 4.5 or lower**:
  - Rootlet burn
  - Degradation of rock wool structure
  - In practice, avoid pH < 5 at dripper and in substrate
- **pH of 6.2 and higher**:
  - Precipitation of Ca and/or Mg with P ⇒ Calcium and/or magnesium phosphate
    - Decreased availability
    - Clogging of irrigation system
  - EDTA chelated iron (Fe 13%) may break down and no longer be available to the plant.
    - Use Fe DTPA when there is a risk. Some growers move to DTPA for all the time.

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pH in hydroponics

- In true hydroponic culture (NFT), low-volume substrates and inert substrates (rock wool):
  - The impact of the water's alkalinity becomes much more important, as does adjusting the pH of the irrigation water.
  - It is better always to maintain a certain buffer by aiming for 50 ppm of $CaCO_3$ (80 ppm before the addition of fertilizers) to prevent a rapid decrease in pH and better substrate uniformity (acid zones).
  - The plant has the **greatest** ability to modify pH, not the acid you add.

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pH in hydroponics

- Feed solution: pH of 5.5 to 6.0
  - Prevent the risk of clogging
- Another way to acidify:
  - Add ammonium: 10% max in spring and 6% in summer
- NB: Standard calcium nitrate already contains 1% ammonium while PureCal does not.

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pH in hydroponics

Table 1: Neutralisation of the alkalinity of the water with acids and ppm needed in 100 ml of acid

ACID			CONCEN-TRATION	[2]Quantity to neutralise 100 ppm $CaCO_3$ in 1000 liters			PPM needed in 100 ml of acid
			%	grams	ml	brings	
NITRIC	(HNO_3)		67	187	131	28 ppm	21 ppm of N
PHOSPHORIC	(H_3PO_4)		85	223	131	58 ppm P	44 ppm of P
SULFURIC	(H_2SO_4)		35	280	221	32 ppm S	43 ppm SO_4
			93	105	57	32 ppm S	168 ppm SO_4
CITRIC	($C_6H_8O_7$)	ANHYDROUS[1]	100	192	-		
		LIQUID	50	384	310		

Notes:

1 Solid Product

2 All the data in the table concerning concentrations and quantities to neutralise 100 PPM of CaCO3 are provided by Mr. Claude Gélinas P.Ag.

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pH in hydroponics

TWO RULES TO REMEMBER

- RULE NO. 1:
  - ALWAYS ADD THE **ACID TO THE WATER = WELL DONE!**
  - NEVER THE OTHER WAY AROUND...IT MIGHT EXPLODE!!!
  - WATER IN **ACID = SUICIDE!**
- RULE NO. 2: INJECT THE ACID BEFORE THE FERTILIZER, THAT'S **RIGHT**!
  - TO PREVENT THE FORMATION OF PRECIPITATES

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pH in hydroponics

- pH as a physiological indicator
  - When pH rises or acid consumption increases (in NFT), that's a sign the plant is having a vegetative reaction. Rebalance the plant.
  - When pH decreases,
    - this may indicate a reproductive reaction of the plant
    - it may be a case of root mortality (asphyxia, irrigation accident, too much drying, etc.).
      - Correct watering and rebalance the plant.

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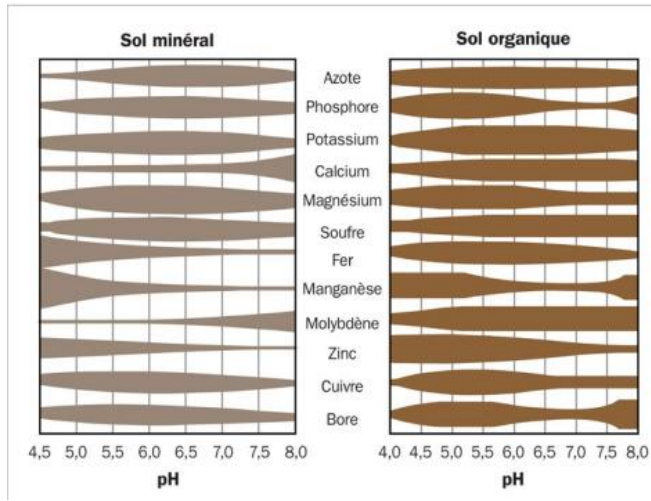
Soil pH



Availability of nutrients based on soil pH (OMAFRA)

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Soil pH

- In soil, CEC (cation exchange capacity) has
  - some ability to adsorb
  - the capacity to hold onto elements
  - the ability to resist variations in pH.
  - If irrigation water has a high pH and high alkalinity
    - Minor impact on soil pH in the short term, especially if volume is high.
    - This will buffer the water's alkalinity (basic effect) against the soil's buffer pH (acidic effect).
    - If no action is taken (choice of fertilizers, etc.), the soil pH will increase over the years.

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Soil pH

For those who need to lower the pH of their soil

- Labs use a soil titration procedure with hydrochloric acid.
  - Goal: To calculate with some degree of precision the amount of sulfur to add to the substrate to lower the pH to the desired level.
- Reaction directly related to microbial activity.
- Lowering soil pH does not happen quickly.
- Microbes responsible for lowering pH:
  - must digest the sulfur
  - ⇒ excrete sulfuric acid
  - ⇒ lower the pH of the substrate
- However, this technique is considered a short-term measure.
- Wet the surface of the soil before applying (sulfur dust).

The amount of elemental sulphur required to lower pH (kg sulphur per ha)

Soil texture	For each 1.0 pH unit	For each 0.1 pH unit
Sand	350	35
Sandy loam	750	75
Loam	1,100	110

For example lowering a pH of 6.0 to 5.0 in a loam soil would require 1,100 kg elemental sulphur per ha.

OMAFRA 2013

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Salinity (electrical conductivity = EC)

Salinity:

- Creates a competition-for-water effect between the substrate and the roots (sea water effect)
- Salinity too high = hydric stress
- Salinity too low: plant will explode at the weakest point (even in a heat wave):
  - Cracking of fruit
  - Bursting of fruit vessels (uneven ripening)
- 1 mS/cm = 35 cm water column or 3.5 kPa
  - Don't underestimate salinity effect

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Salinity = Osmotic pressure
Hydroponics vs soil

- **Hydroponics**
  - Matrix pressure:
    - Day: -1kPa
    - Night: -4.5 kPa
  - Osmotic pressure
    - Electrical conductivity (EC)
      - 1 mS/cm = -33.3 kPa
      - Tomatoes in summer =
        - Night: 4.5 mS/cm = -150 kPa
        - Day: 2.5 mS/cm = -83 kPa
          - Increases quickly
          - Adaptation by plant

The osmotic effect dominates.

- **Soil**
  - Exterior: Matrix pressure
    - -10kPa

    Tension dominates.
  - Greenhouse
    - Matrix pressure
      - Day: -1.5 to -6 kPa (field capacity)
      - Night: -3.5 to -6.5 kPa
    - Osmotic pressure
      - EC (SSE)
        - Tomatoes: 2.5 mS/cm = -83 kPa
          - Adaptation by plant
          - Fertility to be maintained
    - Osmotic + matrix effect dominates.

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Salinity (EC)

Electrical conductivity (EC, mS/cm)) to maintain in mature hydroponic crops related to seasons

Season	Tomato		Cucumber		Pepper		Lettuce
	Dripper	Bag	Dripper	Bag	Dripper	Bag	Water
Winter	3,2-3,5	5,0-5,5	2,5-2,8	3,0-3,5	2,8-3,2	3,5-4,0	2
Spring	2,8-3,0	4,5-5,0	2,2-2,5	2,5-3,0	2,5-2,8	3,0-3,5	1,7
Summer	2,4-2,6	4,0-4,5	1,8-2,2	2,0-2,5	2,2-2,5	2,5-3,0	1,2
Fall	2,8-3,0	4,5-5,0	2,2-2,5	2,5-3,0	2,5-2,8	3,0-3,5	1,7

The bag EC is the goal, the dripper EC is the tool

In soil, keep 1,0mS/cm lower with a minimum de 2,0mS/cm to ensure fertility (0,75mS/cm for lettuce)

To increase flavor, keep higher EC

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Salinity (EC)

- Role of leaching
  - Uniformity of electrical conductivity (time and space)
  - Uniformity of water content (space)
  - More leaching
    - Closer to the EC at the dripper
  - Less leaching
    - Moving away from the EC at the dripper
      - It is wrong to believe that a decrease in leaching will automatically result in an increase in EC.
      - In hydroponics, leaching of less than 30% will lead to uniformity problems.
        - Even with NFT, there has to be a minimum amount of leaching.

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Equipment

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Equipment: Fertilization station

- Hydroponics: 3 tanks = A-B-Acid
- Organic: 1 tank
  - Potassium sulfate
  - Magnesium sulfate
  - Minor elements: To complement the lack of compost supply (50% of hydroponic dose)

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Equipment: Positioning of irrigation system

- 4 drip tapes per bed with manual valves
- 2 on each side
  - In some cases 3+1
- Feeding
  - Centre = half row
  - Start = full row

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Equipment: Positioning of soil cover

- Must fully cover solid fertilizers

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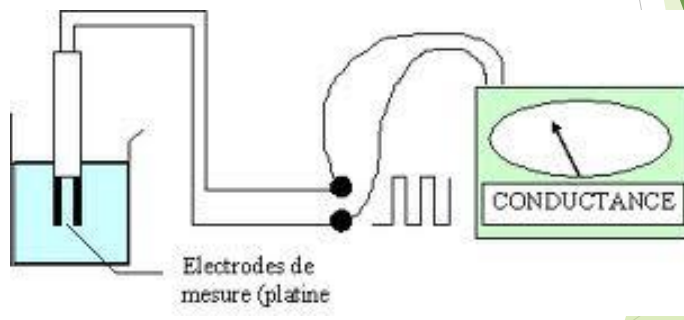
Equipment: salinity meter (EC)



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Equipment: salinity meter (EC)

- Salinity meter and calibration solution
  - With temperature compensation
  - Low EC (organic)
    - 0-3999 µS
  - High EC (hydroponic tomatoes)
    - 0-20 mS

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Equipment: salinity meter (EC)

<u>Calibration</u>:

- Calibrate your EC meter periodically using the appropriate calibration solution:
  - 5000 µS/cm or 5.0 mS/cm
  - The solution must be as close to the measured medium as possible.

<u>Maintenance</u>:

- Clean with a cotton swab
- Watch out for T° disturbance in T°-compensated devices…

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Equipment: pH metre

- Mandatory in hydroponics
- pH meter and calibration solutions

- 7.0 pH solution
- 4.0 pH solution

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Equipment: pH meter

Calibration:

- Calibrate your pH meter periodically using the appropriate calibration solutions:
  - 7.0 buffer pH
  - 4.0 buffer pH

Maintenance:

- Sensitive device, be careful not to let sensor dry out.
- Use storage solutions.
- Clean sensor with a cotton swab.

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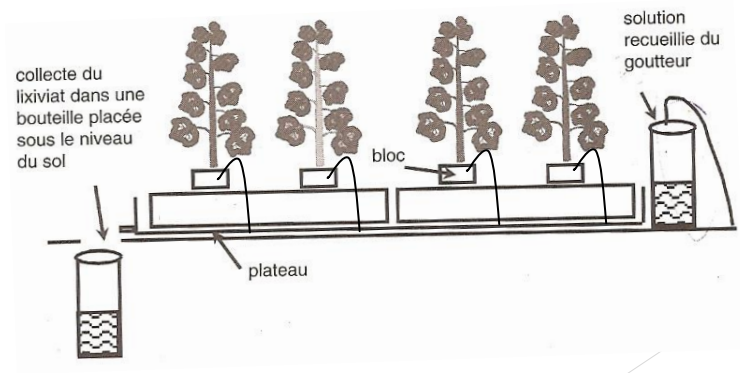
Equipment: Monitoring the water gift and leachate

- Hydroponics
  - Control dripper – (leaching of bag/no drippers in bag) X no drippers/m^2 = Consumption



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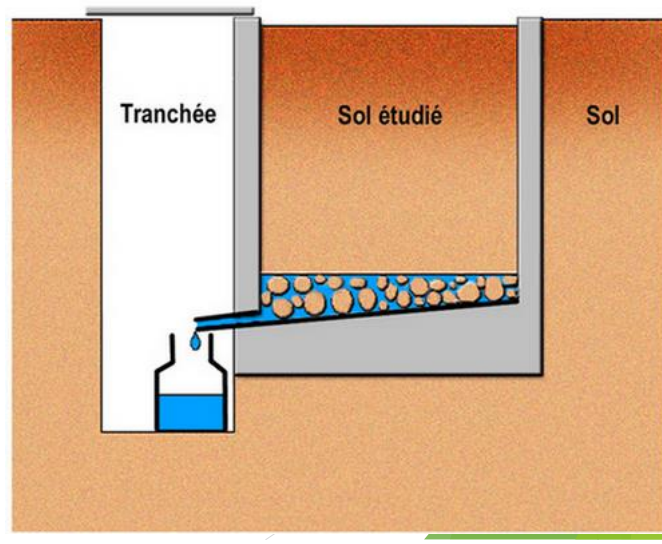
Equipment: Monitoring the water gift and leachate

- **Lysimeter in soil**



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Equipment: Measurement of water content

- TDR sensor
  - Soil or substrate
  - Volumetric water content
  - Uses the polarity of the water, which reacts to the magnetic field

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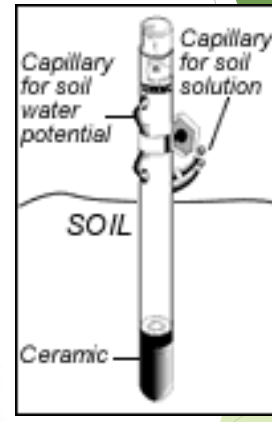
Equipment: Measurement of water content

- Tensiometer
  - Measures matrix pressure at point of contact



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Follow-up tools: irrigation follow-up log

Water management follow up log

Site _____

Date		Dripper			Leachate			Bag		% Leach	Uptake	Sun
		Water	EC	pH	Eau	EC	pH	EC	pH		mL/pl	
	M											
	T											
	W											
	T											
	F											
	S											
	S											
	Total											
	M											
	T											
	W											
	T											
	F											
	S											
	S											
	Total											

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Follow-up tools – Soil analysis: Sampling

- Sampling method (Dorais 2021)
  - Remove top inch of soil (fertilized zone), and take samples with an auger 2.5 cm (1 inch) in diameter.
  - Collect soil cores in a clean bucket, mix soil gently and thoroughly, and place in a clearly marked container or plastic bag.
  - Never allow a soil sample to be exposed to very hot temperatures or to dry out.
  - The depth of the zone to be sampled should be 20 cm.
  - The distance between the zone to be sampled and the crop row should be 10 cm (V system).
  - The number of cores per sample should be around 10.

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Follow-up tools – Standard soil analysis

- Before start of season
- Makes it possible to adjust soil richness

Soil Test Values and Ratings

Organic Matter (%)*	pH*	Phosphate P_2O_5 (ppm)*	Potassium K_2O (ppm)*	Calcium Ca (ppm)*	Magnesium Mg (ppm)*	Boron B (ppm)*	Copper Cu (ppm)*	Salt (mS/cm)
5.5	6.9	387 H+	143 H	1917 H+	205 H+	1.4	2.6	
11.9	7.4	1272 H+	577 H+	5887 H+	513 H+	1.2	1.6	
9.8	7.4	966 H+	554 H+	3844 H+	404 H+	1.0	1.7	
6.9	5.4	106 M+	119 M+	1004 M+	86 M	0.3	0.5	
11.0	6.2	203 H+	148 H	1599 H	194 H+	0.7	45.0	

Zinc Zn (ppm)*	Sulfur S (ppm)*	Manganese Mn (ppm)*	Iron Fe (ppm)*	Sodium Na (ppm)*	Aluminum Al (ppm)*	Lime Index*	Nitrogen N (%)	Nitrate-N NO_3-N (ppm)
7.0	22	37	159	29	886	7.0		
11.8	543	73	131	385	<100	7.4		
10.3	208	56	170	200	157	7.4		
38.4	22	46	155	14	1131	6.0		
25.8	21	15	163	44	1218	6.5		

% P/Al	Ratio Ca/Mg	Man	Sod	CEC (Meq/100g)	Base Saturation % K	% Mg	% Ca	% H	% Na	Total % Base Saturation
19.07	9:1	0	0	14	2.2	12.5	69.9	14.5	0.9	84.6
555.46	11:1	0	0	37	3.4	11.7	80.4	- 0.1	4.6	95.5
268.68	10:1	0	0	25	4.8	13.7	78.0	0.0	3.5	96.5
4.09	12:1	0	0	18	1.4	4.0	27.8	66.6	0.3	33.2
7.28	8:1	0	0	16	2.0	10.0	49.6	37.5	1.2	61.6

Calcul CEC et % saturation en base							
		kg/ha					
	pH tampon	Ca	Mg	K	CEC		P (kg/ha)
Calcul CEC/100g	7,4	11774	1026	961,666667	32,0990232		1110,91703
% Saturation	3%	82%	12%	3,4%			
Objectif (kg/ha)		9707	1078,53	1122			300
À corriger (kg/ha)			52,53	160,00			-810,92

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Follow-up tools- Soil analysis via SSE (SME) assessment

- Measuring the balance of the root environment
- Monthly in hydroponics
- Monthly or mid-season in soil

Analyses	Résultats		Unités	Date de l'analyse	Méthode de référence
	Base sèche	Telle quelle			
*Sodium		10.3	ppm	2019/06/17	MA 08
*Calcium		169	ppm	2019/06/17	MA 08
*Magnésium		53.2	ppm	2019/06/17	MA 08
*Potassium		160	ppm	2019/06/17	MA 08
*Cuivre		292	ppb	2019/06/17	MA 08
*Fer		1950	ppb	2019/06/17	MA 08
*Manganèse		388	ppb	2019/06/17	MA 08
*Zinc		193	ppb	2019/06/17	MA 08
Chlorures		9.11	ppm	2019/06/18	MA 97
pH		5.87		2019/06/17	
Alcalinité		11.3	ppm	2019/06/18	MA 98
Conductivité		163	mS/m	2019/06/18	
*Dureté		642	ppm	2019/06/17	Calculé
Nitrates		605	ppm	2019/06/18	MA 90
*Phospates		5.00	ppm	2019/07/04	MA 35
*Solides Dissous Totaux		1200	ppm	2019/06/19	MA 34
*Sulfates		353	ppm	2019/06/19	MA 33

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Follow-up tools – SSE (SME) soil analysis: objectives in soil

	SSE en sol biologique (ppm)		
	MAPAQ	G. Breton*	R. Robitaille
pH	6-6,4	5,5-6,8	
CE	1,5-2,24	3-4,5	2,5-4,5
N-NO3	80-139	140-320	140-340
P	3,5-4,5	4,0-15	4,0-18,0
K	110-179	280-420	300-600
Mg	60-99	120-180	>120
Ca	140-219	220-330	200-700
Éléments mineurs			
B	0,05-0,5	0,05-0,5	
Cu	0,001-0,5	0,001-0,5	0,1-0,5
Fe	0,3-3	0,3-3	
Mn	0,2-3	0,05-3	
Zn	0,3-3	0,3-3	

Tirée de Robitaille (Biobulle no 13)

* Sol riche en matière organique

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Follow-up tools – SSE soil analysis: Objectives in hydroponics

- The objective is not change the recipe, but the bag.
- Adjust concentrations according to EC.

	ppm			
	Standard	Extra Ca	Extra K	Bag
EC	2,6	2,7	2,6	3,8
NH4mmole	16,8	16,8	16,8	7
K	370,5	331,5	436,8	312
Ca	216	236	191	400
Mg	57,6	69,6	51,6	108
NO3	224	238	224	322
SO4	422,4	422,4	422,4	648
P	46,5	46,5	46,5	31
Fe ppm	0,84	0,84	0,84	1,4
Mn	0,55	0,55	0,55	0,3
Zn	0,33	0,33	0,33	0,46
B	0,32	0,32	0,32	0,54
Cu	0,05	0,05	0,05	0
Mo	0,05	0,05	0,05	0,05

Source : Alain Vée 2002

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Follow-up tools – EC (in-house) Soil Analysis

- Soil EC method 1:2
  (Sonneveld and Voogt, 2009) X 2
- Field saturated soil

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

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Follow-up tools – EC analysis in hydroponics

- **100-mL syringe (rock wool) or filter system (compost)**
- **Compression of substrate (peat, coconut fibre)**
- **Always in a leaching substrate**

60

Objective: Foliar analyses

- More to confirm a problem than to detect

	Tomato			Cucumber		
Macro (%MS)	Obj	min	Max	Obj	min	Max
N	5,25	5	5,5	6	5,75	6,25
P	0,6	0,5	0,8	1	0,85	1,25
K	4	3,75	5,25	4	3,75	5,25
Mg	0,45	0,4	0,5	0,45	0,5	0,55
Ca	1,5	1,5	4	1,5	1,4	2
S	1,76	0,96	4	1,5	1,4	2
Micro (ppm)						
B	75	33	99	75	30	108
Cu	13	10	16	12,7	1,9	19
Fe	245	100	390	234	95	300
Mn	264	55	385	320	50	600
Mo	5,8	0,96	9,6	3,07	0,96	5,76
Zn	45	19	84	137	58	96

From Robitaille (Biobulle no 13)

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CROP PROTECTION

1

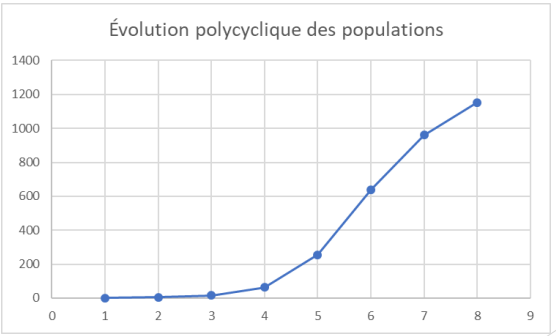
Overall objective

- In greenhouse production, prepare for a WAR against pests and diseases.

2

Greenhouse environment

- A perfect environment for proliferation
  - Exponential polycyclic growth



White Fly

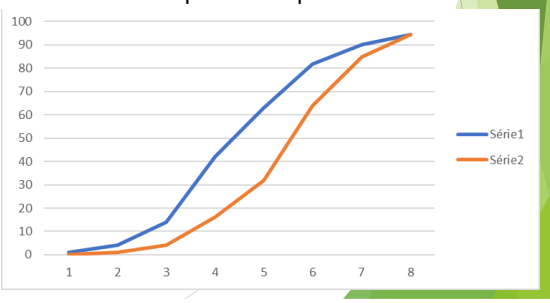
Génération	Population
1	1
2	400
3	160000
4	64000000
5	2,56E+10
6	1,024E+13
7	4,096E+15
8	1,6384E+18

3

Strategy for application within the greenhouse

- Change from exponential polycyclic growth to arithmetic growth that is stable within the environment and suitable for production
  - Control the spread of pests and diseases

Population equilibrium



4

Crop protection

Good planning

- Know your enemies

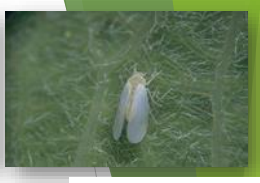
Preference of main pest and diseases met on crop under diversification

Pests	Tomato	Cucumber	Pepper	Eggplant	Snap beans	Lettuce
White fly	x					
Aphids		x	x	x		x
Two spotted spider mites		x		x	x	
Russet mites	x					
Western flower thrips		x		x	x	
Oignon thrips	x					x
Striped Cucumber beetle		x				
Diseases						
Grey mold	x		x	x		
Gummy stem blight		x				
Powdery mildew	x	x				
Mildew		x				x
Pythium		x				

5

Crop protection

In greenhouse production,



while tomatoes, cucumbers, peppers and lettuce grow…

so do insects and diseases that thrive in the greenhouse.

6

Crop protection

Insects

- A whole army

Whiteflies

Thrips

Frankliniella occidentalis

Lygus bug

7

Crop protection

Insects

- A whole army

Caterpillars

Squash bugs

Striped cucumber beetles

8

Crop protection

Insects

- A whole army

Carmine mites

Spider mites

Melon aphids

9

Crop protection

Insect damage

Tomato russet mite infestation

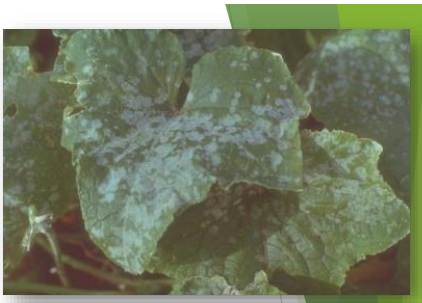
Cucumber plant damaged by thrips

Sooty mould on tomato plant

10

Crop protection

Diseases



Powdery mildew

Fusarium oxysporum (For)

Grey mold

11

Crop protection

Diseases

Pythium

Leaf mold

Gummy stem blight (source: OMAFRA)

Powdery mildew

12

1. Bacterial canker

➢**Symptoms:**

13

1. Tomato brown rugose fruit virus (ToBRFV)
Biology of the pathogen

➢Main symptoms in tomatoes:

Photos: Sébastien Couture, Agr., Climax Conseils

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Crop protection

Good planning

- Hygiene

- Keep growing crops clean
  - Essential
- Clean the greenhouse
  - Crop residues
  - Weeds
- Take preventative measures
  - Add hydrated lime to the soil
  - Use insect screens
  - Install a misting system to increase humidity
- Keep crops clean at all times

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Crop protection

Good planning

- Hygiene

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Crop protection

Good planning

- Hygiene (example)

Self-analysis grid
Tomato brown rugose fruit virus

1. Preventive measures

A. Hygiene
Your work environment and work clothing are clean and/or disinfected, and hand washing and disinfection and/or glove wearing is part of your routine.

B. Seeds and transplants
Seeds are purchased from a GSPP-accredited seed company and have not been repackaged.
Seeds have been disinfected.
Transplants come from a provider that follows strict hygiene practices.
Hygiene measures are taken when grafting and pinching.
Plants are not watered by soaking.
Plants are tended in batches.

C. Crops
A disinfection schedule for work tools and equipment is established and followed.
The crop soil and substrates are new and placed in a clean area.
Plants are free of guttation, condensation and drips.
Employees are trained to detect rugose.
Aisles allow workers to pass through with minimal plant contact.

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Crop protection

Good planning

- Work techniques
  - When: In good weather
  - Pruning is done properly

Tomato leaves pruned with a knife. Note where that the side shoot base was removed.

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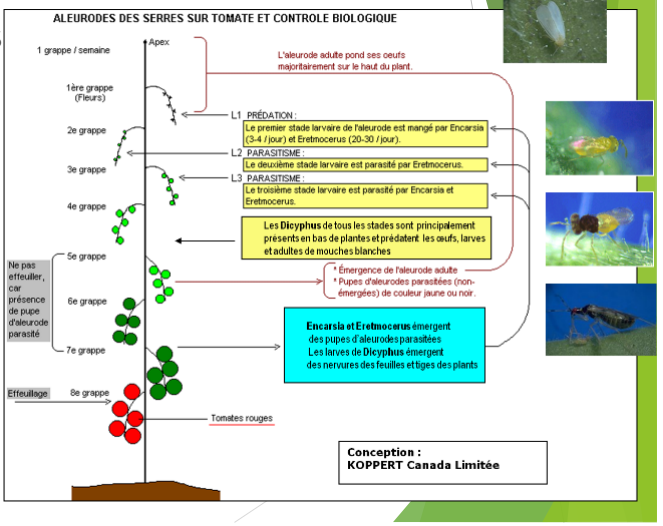
Crop protection

Good planning

- Know the enemy's life cycle
  - Insects
    - Where to look



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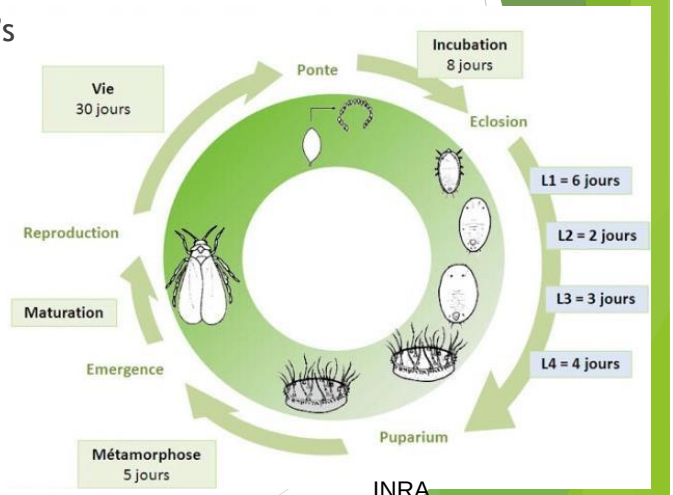
Crop protection

Good planning

- Know the enemy's life cycle
  - Insects
    - When to look
    - Anticipate



INRA

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Crop protection

Good planning

- Know the enemy's life cycle
  - Fungal diseases
    - Anticipate

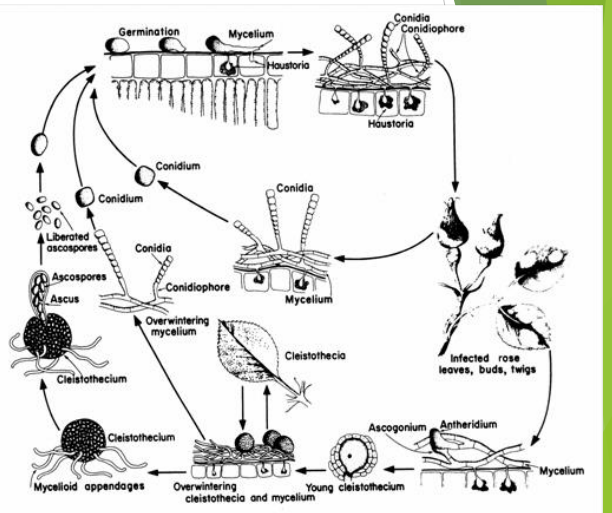

FIGURE 11-40 Disease cycle of powdery mildew of roses caused by *Sphaerotheca pannosa* f. sp. *rosae*.

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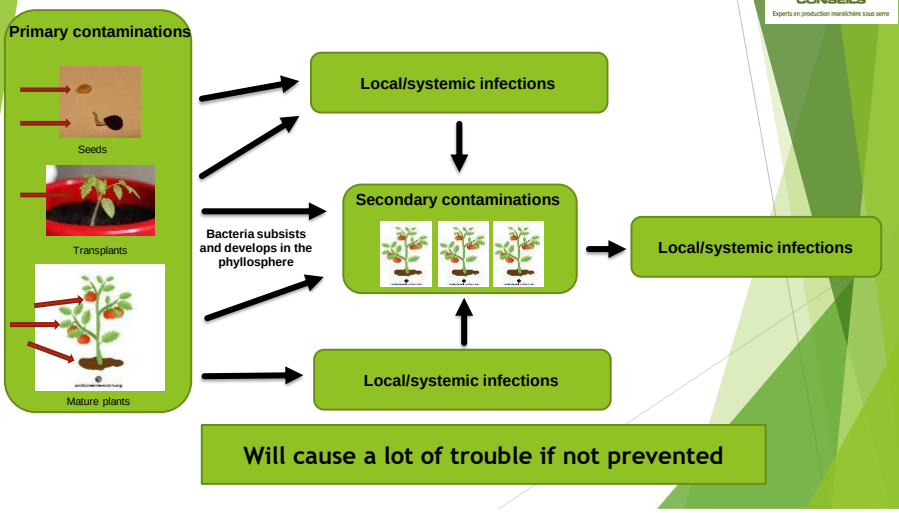
1. Bacterial disease: Bacterial canker
Biology of the pathogen

➢ **Contamination and infection, in a nutshell:**



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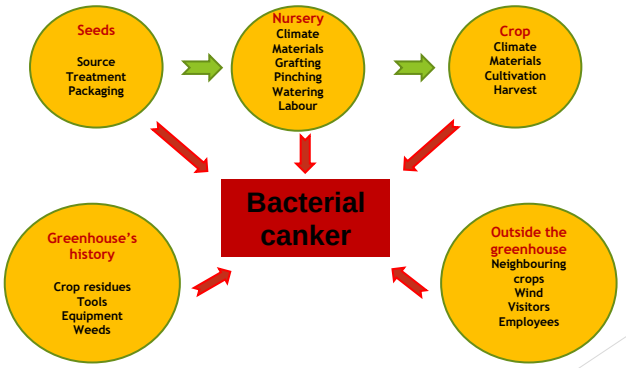
2. Le chancre bactérien: Preventing its introduction

- **Possible sources of infection:**



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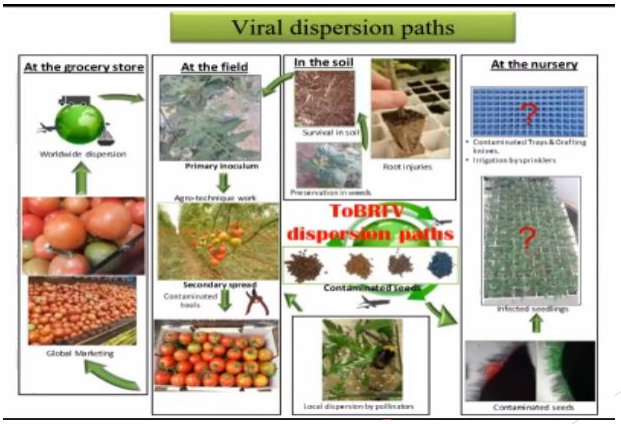
1. Viral disease: ToBRFV Biology of the pathogen



Dr. Aviv Dombrovsky, Canadian Greenhouse Conference, 2021

Will cause a lot of trouble if not prevented

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Crop protection

Good planning

- Hygiene (example)

D. The greenhouse's history
Absence of weeds and residues from previous crops.
Equipment, structure and materials have been cleaned and disinfected.

E. The greenhouse's external environment
Harvest crates did not come from grocery stores or other producers.
Greenhouse's periphery is clean and free of crop debris and weeds.
Water source is free of viruses.
Host plants are known and are not on the farm.

F. Greenhouse access
No unauthorized visitors are allowed in.
Producer has protective gear that all visitors must wear.
All employees and visitors wash and disinfect their hands upon entering.
Shoe washing station, shoe covers or new shoes can be found at the entrance.
Employees start their day in the greenhouse.
No food is eaten inside the greenhouse.

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Barriers

- Genetics
- Seed treatments
- Insect screens

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Crop protection

Good planning

- Genetics: Resistant cultivars

- Cultivar options:
  - Hybrid varieties
  - Example: Tricia
  - **Resistances:**
  - HR: ToMV/Ff: 1-5/Fol: 0, 1/For/Sl
  - Concerns:
    - Leaf mould on Macarena
    - Powdery mildew on Komett

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Crop protection

Good planning

- Resistant cultivar options

15. *Lycopersicon esculentum* (*Solanum lycopersicum*) (Tomato)

Scientific name	English common name	French common name	Code
Viruses:			
Beet curly top virus	Curly top		BCTV
Cucumber mosaic virus	Cucumber mosaic	Mosaique du concombre	CMV
Pepino mosaic virus	Pepino mosaic virus		PepMV
Tobacco mosaic virus	Tobacco mosaic		TMV
Tomato apex necrotic virus	Tomato apex necrotic virus		ToANV
Tomato mosaic virus	Tomato mosaic	Mosaique de la tomate	ToMV
Tomato torrado virus	Tomato torrado virus		ToTV
Tomato spotted wilt virus	Tomato spotted wilt	Maladie bronzée de la tomate	TSWV
Tomato yellow leaf curl virus	Tomato yellow leaf curl	Maladie des feuilles jaunes en cuillère de la tomate	TYLCV
Bacteria:			
Clavibacter michiganensis subsp. *michiganensis*	Bacterial canker	Chancre bactérien	Cmm
Pseudomonas corrugata	Pith necrosis	Moelle noire	Pc
Pseudomonas syringae pv. *tomato*	Bacterial speck	Moucheture bactérienne	Pst
Ralstonia solanacearum	Bacterial wilt	Flétrissement bactérien des solanées	Rs
Xanthomonas campestris pv. *vesicatoria* (now *Xanthomonas axonopodis* pv. *vesicatoria*)	Bacterial spot	Gale bactérienne	Xcv (now Xav)
Fungi:			
Alternaria alternata f. sp. *lycopersici*	Alternaria stem canker	Alternariose	Aal
Alternaria solani	Early blight		As
Fulvia fulva (ex *Cladosporium fulvum*)	Leaf mold	Cladosporiose	Ff (ex Cf)
Fusarium oxysporum f. sp. *lycopersici*	Fusarium wilt	Fusariose vasculaire	Fol
Fusarium oxysporum f. sp. *radicis-lycopersici*	Fusarium crown and root rot	Pourriture des racines	For
Leveillula taurica (anamorph: *Oidiopsis sicula*)	Powdery mildew	Oïdium	Lt
Oidium neolycopersici (ex *Oidium lycopersicum*)	Powdery mildew	Oïdium	On (ex Ol)
Phytophthora infestans	Late blight	Mildiou aerien	Pi
Phytophthora parasitica	Buckeye fruit and root rot	Mildiou terrestre, chancre du collet	Pp
Pyrenochaeta lycopersici	Corky root rot	Maladie des racines liégeuses	Pl
Stemphylium botryosum f. sp. *lycopersici*	Gray leaf spot	Stemphyliose	Sbl
Stemphylium lycopersici	Gray leaf spot	Stemphyliose	Sl
Stemphylium solani	Gray leaf spot	Stemphyliose	Ss
Verticillium albo-atrum	Verticillium wilt	Verticilliose	Va
Verticillium dahliae	Verticillium wilt	Verticilliose	Vd
Nematodes:			
Meloidogyne arenaria	Root-knot	Nématodes à galles (galles racinaires)	Ma
Meloidogyne incognita	Root-knot	Nématodes à galles (galles racinaires)	Mi
Meloidogyne javanica	Root-knot	Nématodes à galles (galles racinaires)	Mj

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Crop protection

Good planning

- Genetics: Grafting

Plants to graft:

- Productive and/or flavourful varieties
- Varieties susceptible to soil-borne diseases

X

Rootstocks:

- Maxifort
- Optifort
- Multifort
- Estamino
- Fortamino
- Emperador

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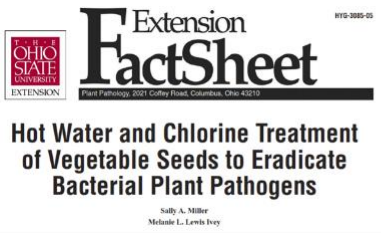
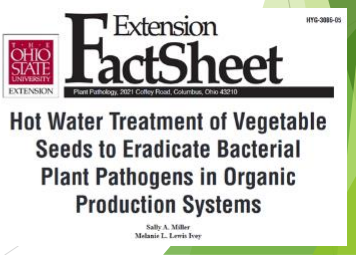
Crop protection

Good planning

- Seed treatments for non-pregerminated seeds: Bacterial canker and ToBRFV
  - Very important for organic crops





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Crop protection

Good planning

- Insect screens

Positive impact on the following:

- Pollination
- Beneficial insects
- Moths
- Butterflies (caterpillars)
- Physical barrier for flying insects:
  - Lygus bug
  - Striped cucumber beetles

Impact on ventilation:

- Expected effect on the ventilation system, possibly rendering it insufficient.
- Greenhouse size x 25%/air porosity = size of roll-up required.

Do not forget

- Air-lock entrance
- Vent pipe opening
- Etc.

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Crop protection

Good planning

- Insect screens

CARACTÉRISTIQUES

Caractéristiques	ProtekNet 17 gr	ProtekNet 25 gr	ProtekNet 56 gr	ProtekNet 55 gr	ProtekNet 60 gr	ProtekNet 70 gr	ProtekNet 108 gr
Grandeur de maille	0.85 mm X 0.85 mm 0.0335" X 0.0335"	0.35 mm X 0.35 mm 0.0138" X 0.0138"	0.25 mm X 0.73 mm 0.0098" X 0.0287"	5 mm X 3 mm 0.19" X 0.12"	1.2 mm X 1.9 mm 0.05" X 0.07"	0.85mm X 1.4 mm 0.0335" X 0.0551"	0.43mm X 0.43 mm 0.02" X 0.02"
Matériau	Polyamide	Polyamide	Polypropylène	Polyéthylène Haute Densité	Polyéthylène	Polyéthylène	Polyéthylène Haute Densité
Poids	17 gr / m² 0.056 oz / pi²	25 gr / m² 0.082 oz / pi²	56 gr / m² 0.184 oz / pi²	55 gr / m² 0.18 oz / pi²	60 gr / m² 0.197 oz / pi²	70 gr / m² 0.230 oz / pi²	108 gr / m² 0.355 oz / pi²
Traité U.V.	Oui	Oui	Oui	Oui	Oui	Oui	Oui
Porosité	≈ 75%	≈ 62%	≈ 70%	≈ 95%	≈ 80%	≈ 75%	≈ 70%
Luminosité	≈ 93%	≈ 90%	≈ 91%	≈ 93%	≈ 93%	≈ 90%	≈ 90%
Couleur	Transparent	Transparent	Transparent	Blanc	Transparent	Transparent	Transparent
Durée de vie min.	1 - 2 ans	2 - 3 ans	5 ans	10 ans	5 ans	5 ans	5 ans
Largeurs **	2.20 m 7.2'	2.10 m - 3.10 m 4.20 m - 6.30 m 8.4 m 6.9' - 10' 14' - 21' 28'	1.60 m - 2.10 m 4.20 m 5.2' - 6.9' 14'	0.75 m - 1.2 m 5.5 m 2.46' - 3.93' 18'	2.1m-4.2m 6.3m-8.4m 6.8' - 13.7' 20.6'-27.5'	2.1m-4.2m 6.3m-8.4m 6.8' - 13.7' 20.6'-27.5'	2m - 4m 6.5' - 13' 4m-8m 19.7'-26.2'
Longueurs **	100 m 328'	50 m - 100 m - 250 m 164' - 328' - 820'	100 m - 200 m 328' - 656'	100 m - 300 m - 500 m 328' - 984' - 1 640' m	100 m -153 m 100 m 328'-502' 328'	100 m -153 m 100 m 328'-502' 328'	50 m - 100 m - 250 m 164' - 328' - 820'
Insectes	ProtekNet 17 gr	ProtekNet 25 gr	ProtekNet 56 gr	ProtekNet 55 gr	ProtekNet 60 gr	ProtekNet 70 gr	ProtekNet 108 gr
Altises		X	X				X
Cécidomyie		X					X
Chrysomèles	X	X	X		X	X	X
Coccinelles	X	X	X	X	X	X	X
Drosophile à ailes tachetées	X	X	X			X	X
Guêpes	X	X	X	X	X	X	X

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Crop protection

- Climate control
  - Problems related to moisture
    - Grey mold
    - Powdery mildew
    - Downy mildew
    - Gummy stem blight
    - Leaf mould
  - Problems related to dryness
    - Mite infestations
    - Powdery mildew

- Humidity
- Condensation /dripping
- Cold
- Uniformity

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Crop protection

Climate control

- Humidity

- Too humid:
  - Botrytis blight
  - Powdery mildew

- Too dry:
  - Spider mites
  - Powdery mildew

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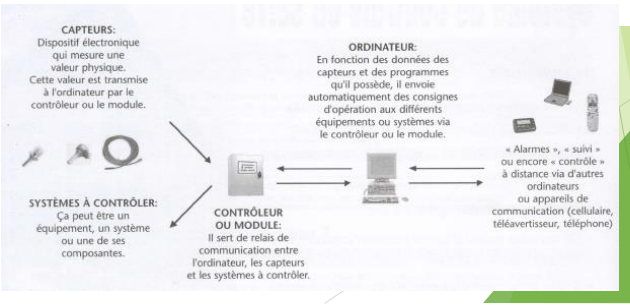
Crop protection

Climate control

- Control the climate
  - If too humid, dehumidify
  - Heat and ventilate



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Crop protection

Climate control

- Misting: Mite infestation
  - If too dry

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Crop protection

Climate control

- Water cycle
  - Condensation
  - Evaporation
  - Drainage

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Crop protection

Climate control

- Dripping

- Can be prevented by using an anti-condensation film.
- Leads to healthier plants.
- Also leads to
  - better light transmission; and
  - energy savings.

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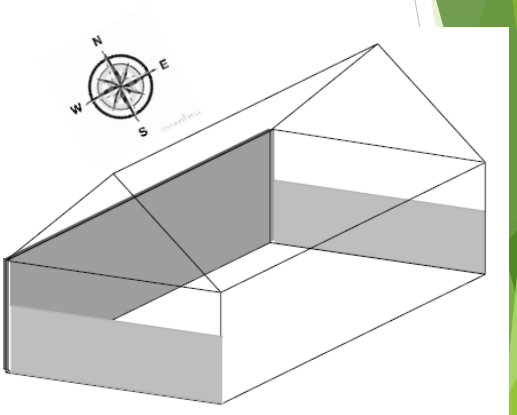
Crop protection

Climate control

- Insulation
- Prevent cold zones



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Crop protection

Climate control

- Uniformity

Insects and diseases often stem from cold zones.

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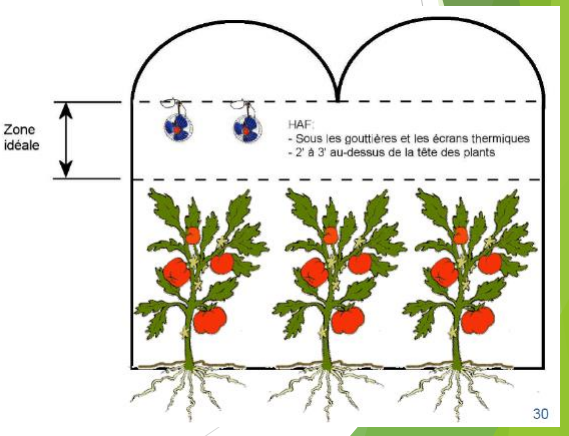
Crop protection

Climate control

- Uniformity

HAF



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Crop protection

Good planning:

- Prevention
  - When preparing/ordering plants
  - Biological control programs can be started during the plants' propagation in a nursery or a propagator.

- RootShield (fungi)
  - Soil-borne diseases
- Hypoaspis miles (mites)
  - Insects/thrips
- Encarsia formosa (wasps)
  - Insects/whiteflies

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Crop protection

Good planning

- Use of biological control agents

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Crop protection

Good planning

- Use of biological control agents
  - Agent types:
    - Parasitoid
    - Predator

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Crop protection

Good planning

- Use of biological control agents
  - Agent types:
    - Parasitoid
    - Predator

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Crop protection

Good planning

- Use of biological control agents
  - Strategies

Tétranyques à deux points – individus/m²

Auxiliaires	Préventif	Curatif	Foyer d'infestation
Amblyseius andersoni	3-6	6-20	100 et +
Amblyseius andersoni -Sachets	0,5 aux 4 semaines	1 aux 4 semaines	
Neoseiulus californicus	3-6	6-20	100 et +
Neoseiulus californicus -Sachets	0,5 aux 4 semaines	1 aux 4 semaines	
Amblyseius fallacis	3-6	6-20	100 et +
Phytoseiulus persimilis	3-6	6-20	50 et +
Feltiella acarisuga	0,05-0,1	0,25-1	5-10 et +
Stethorus punctillum	1	5	100

Consulter votre conseiller pour choisir le meilleur auxiliaire pour les autres espèces d'acariens ravageurs. (Tétranyques de Lewis, Tarsonèmes, Acariose bronzé, etc.)

- **Preventative**
  - Control insects before detecting them due to problems.
- **Inundation**
  - Strategy involving large quantities → easy application.
- **Curative**
  - Treatment with bioinsecticide to reestablish or help with biological control.
- **Starting biological control as early as possible**
- **Regular <u>OBSERVATION</u> and knowledge of problems**

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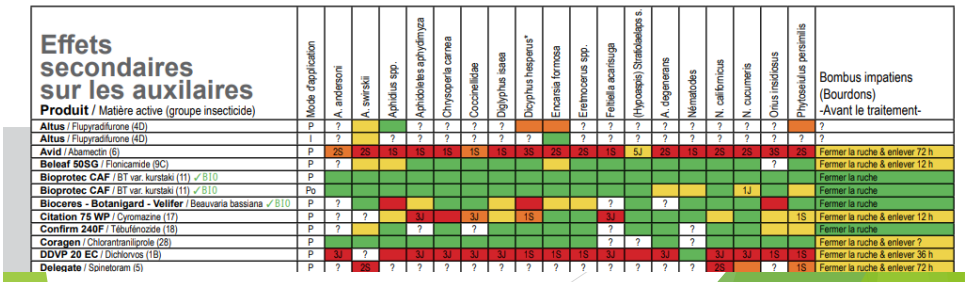
Crop protection

Good planning

- Use of biological control agents
  - Strategies

- **You are working with living organisms**
  - Verify compatibility with pesticides
    - https://www.plantproducts.com/fr/images/Tableaux_lutte_integree_2019.pdf (French only)



Effets secondaires sur les auxiliaires **Produit** / Matière active (groupe insecticide)	Mode d'application	A. andersoni	A. swirskii	Aphidius spp.	Aphidoletes aphydimyza	Chrysoperla carnea	Coccinellidae	Diglyphus isaea	Dicyphus hesperus*	Encarsia formosa	Eretmocerus spp.	Feltiella acarisuga	(Hypoaspis) Stratiolaelaps s.	A. degenerans	Nématodes	N. californicus	N. cucumeris	Orius insidiosus	Phytoseiulus persimilis	Bombus impatiens (Bourdons) -Avant le traitement-
Altus / Flupyradifurone (4D)	P	?			?	?	?	?			?	?	?	?	?	?	?	?		?
Altus / Flupyradifurone (4D)	I	?		?	?	?	?	?	?		?	?	?	?	?	?	?	?	?	?
Avid / Abamectin (6)	P	2S	2S	1S	1S	1S	1S	1S	3S	2S	2S	1S	5J	2S	1S	2S	2S	3S	2S	Fermer la ruche & enlever 72 h
Beleaf 50SG / Flonicamide (9C)	P	?																?		Fermer la ruche & enlever 12 h
Bioprotec CAF / BT var. kurstaki (11) ✓BIO	P																			Fermer la ruche
Bioprotec CAF / BT var. kurstaki (11) ✓BIO	Po																1J			Fermer la ruche
Biocères - Botanigard - Velifer / Beauvaria bassiana ✓BIO	P	?										?		?						Fermer la ruche
Citation 75 WP / Cyromazine (17)	P	?	?		3J		3J		1S			3J							1S	Fermer la ruche & enlever 12 h
Confirm 240F / Tébufénozide (18)	P	?			?		?					?			?					Fermer la ruche
Coragen / Chlorantraniliprole (28)	P											?	?		?					Fermer la ruche & enlever ?
DDVP 20 EC / Dichlorvos (1B)	P	3J	?		3J	3J	3J	3J	1S	1S	1S	3J		3J		3J	3J	1S	1S	Fermer la ruche & enlever 36 h
Delegate / Spinetoram (5)	P	?	2S	?	?	?	?	?	?	?	?	?	?	?	?	2S		?	1S	Fermer la ruche & enlever 72 h

Crop protection

Good planning

- Use of biological control agents
  - Strategies

- **You are working with living organisms**
  - Verify compatibility with pesticides
    - https://www.biobestgroup.com/en/side-effec manual

biobest®
SUSTAINABLE CROP MANAGEMENT

		acetamiprid		azadirachtin	captan
		s	i	s	s
Amblyseius cucumeris	Nymph/adult	3	1	1	1
	Persistance	5 Days	-	-	-

Phytosanitary treatments

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Crop protection

Equipment

- The essentials:
  - Pesticide applicator certificate
  - Sprayers
    - Pump
    - Manual
  - Mask
  - Protective clothing

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Crop protection

Equipment

- To make your life easier
  - Cold fogger
  - PulsFOG
  - Boom sprayer
  - Turbo ULV fogger
  - Kasko helmet

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Crop protection

Elements of control: pesticides or biopesticides

- Properly target applications

Pesticides…

- Fungicide to control fungal diseases (fungi)
- Insecticides to control insects
- Acaricides to control mites
- Algaecides to control algae
- Rodenticide to control rodents
- **Do not use herbicide in a greenhouse!!!**

Each product must be used at a specific stage of the pest's or disease's development.

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Crop protection

Elements of control: pesticides or biopesticides

- PHI
- Re-entry interval
- Permit

Preharvest interval (PHI)

- It is very important to respect the PHI
- The PHI will vary from one product to another
- Insecticide vs. fungicide

Re-entry interval

(or restricted-entry interval (REI))

- Period of time required between pesticide application and the workers' return to the site.
- Prevents skin exposure and, to a lesser degree, respiratory exposure.

Permit/certificate

- Pesticide applicator certificate is required
- The Department of Environment and Local Government

Pesticide Applicator Certificate (gnb.ca)

Pest Management Regulatory Agency (PMRA)

Certifiers

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Crop protection

Elements of control: pesticides or biopesticides

- Diseases

TABLEAU 1 – FONGICIDES ET BIOFONGICIDES HOMOLOLOGUÉS EN 2020
DANS LA FRAISE, LES FINES HERBES ET LES PRINCIPAUX LÉGUMES CULTIVÉS EN SERRE

Nom commercial	Matière active	Cultures								Délai avant récolte (jour)	Délai de réentrée[5] (heures)	Groupe de résistance[1]	Indices de risque[2]		Type de traitement[3] (préventif / curatif)	Mode d'action dans la plante[4]	Mode Application	Doses (Se référer à l'étiquette pour plus de détails)	Intervalle entre les applications et nombre max. permis	Coûts 2020 $/1 000 Litres sauf indication contraire	LMR USA (ppm)
		Tomate	Concombre	Poivron	Aubergine	Laitue	Fraise	Basilic	Fines herbes				IRS	IRE							
ACTINOVATE SP	*Streptomyces lydicus* souche WYEC	3, 11	3, 11	3, 11	11	11	3, 4			0	1	BM02	5	1	Prév.	C	FA	C : 425g/ 475-800 L/ha F, P : 425g/1 000L/ha T : 425g/100g/100 L /ha Traitement semence (voir étiquette)	7-14 jours	115-231 $/ha	-
AGRIPHAGE-CMM BIO	Bactériophage de *Clavibacter michiganensis*	8a								0	Après séchage	S. O.	5	1	Prév. + Cur.	--	F	T : 12 à 40 ml/100 m²	3-4 jours	En 0,95L : 0,77-2,56 $ / 100 m² En 10L : 0,42-1,4 $ /100 m²	-

https://www.agrireseau.net/documents/Document_103276.pdf (French only)

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Crop protection

Elements of control: pesticides or biopesticides

- Insects

TABLEAU : INSECTICIDES, BIO-INSECTICIDES ET ACARICIDES HOMOLOGUÉS EN 2020 DANS LA FRAISE, LES FINES HERBES ET LES PRINCIPAUX LÉGUMES PRODUITS EN SERRE

Nom commercial	Matière active	Cultures							Délai avant récolte (jours)	Délai de réentrée (heures)	Groupe de résistance	Indices de risque		Mode d'action dans la plante	Mode d'action sur l'insecte	Stade de développement de l'insecte touché	Mode d'application	Dose	Intervalle entre les applications et nombre max. permis	Coût 2020 $/1 000 L sauf indication contraire	LMR
		Tomate	Concombre	Poivron	Aubergine	Laitue	Fraise	Fines herbes				IRS	IRE								
ALTUS	Flupyradifurone	1, 10, 18	1, 10, 18	1, 10, 18		1, 10, 18			T-C-L (11); P (3)	12	4D	18	77	P (SL, SA)	Ing	Tous	F D (voir étiquette)	500-1 000 mℓ/ha (min. 500 L d'eau/ha) 7,5-20 mℓ/100 m2 (selon l'insecte ciblé)	7 jours (T, C, L) 10 jours (P) (max. 2L de produit/hectare de culture)	62-124 $/ha 0,9-2,5 $/100 m2	ND	L(80), C(0,4), T(1,5), P(1,5)
AMBUSH 50 EC	Perméthrine	1	1						T-C (1)	24	3A	174	2	C	C, Ing	Adulte et larve	F	200 mℓ	–	ND	T(2), A(0,5), L(20), P(0,5)

https://www.agrireseau.net/documents/Document_103282.pdf (French only)

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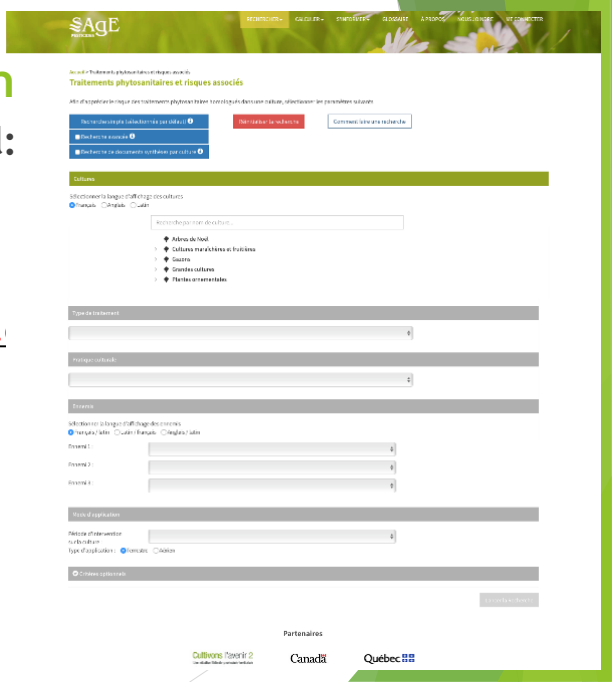
Crop protection

Elements of control: pesticides or biopesticides

www.sagepesticides.qc.
(French only)



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Other ressources (English)

- http://www.omafra.gov.on.ca/english/crops/pub835/p835order.htm

  Check the following websites for information on compatibility of pesticides with biocontrols:
  https://www.biobestgroup.com/en/side-effect-manual
  https://www.koppert.ca/en/products/side-effects/.

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Crop protection

Good planning

- Use of biopesticides to control diseases
  - Biopesticide types
    - Biofungicides

- **RootShield**
- **Trianum**
- **Rhapsody ASO**
- **CEASE**
- **PRESTOP**
- **Mycostop**
- **Etc.**

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Crop protection

Good planning

- Method combinations

Combining biological control methods

- Predators
- Parasitoids
- Pesticide or biopesticide treatment
- Misting
- Traps
- Netting
- Host plants and banker plants



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Pollination


Koppert Hive

Browning of the stamen

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Pollination

- Crops
- Cost

Required for the following:

- Tomatoes
- Eggplants
- Garden cucumbers

(if non-parthenocarpic)

- Melons
- Strawberries and raspberries

Agri-Réseau

Agri-Réseau

Cost per m^2

- 0.75–$1.00/$m^2$
- > cost of hand pollination
- Better production

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Pollination

- Hive types

Type A:

- Pollination of 1000–1500 m^2
- Lasts 10–14 weeks
- Contains 75–100 worker bees
- Includes only a queen and the worker bees

Type B:

- Pollination of 500–1000 m^2
- Lasts 6–8 weeks
- Contains 75–100 worker bees
- May include queens, males and queen cells

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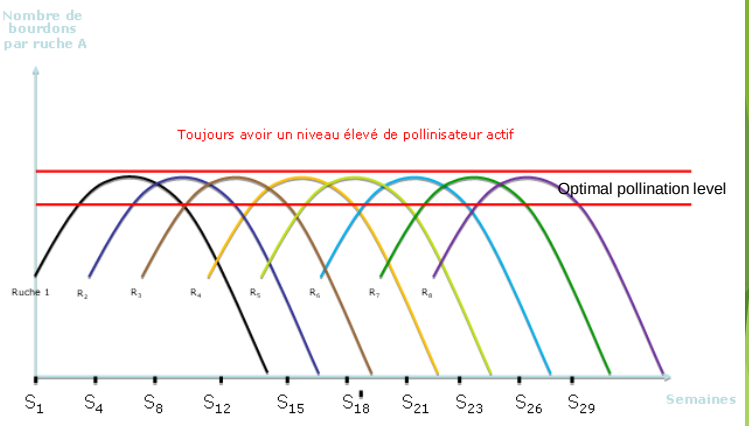
Pollination

- Schedule



Exemple pour 3000 m² → Entrer une ruche A toute les 3-4 semaines

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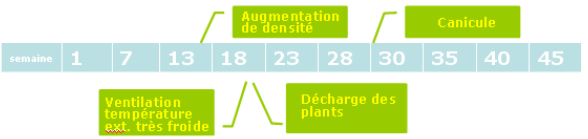
Pollination

- Schedule

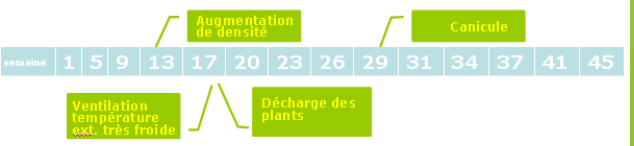
Exemple pour 1000 m2

→ Entrez une **ruche B** toute les ±5-6 semaines



Exemple pour 3000 m2

→ Entrez une **ruche A** toute les ±3-4 semaines



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Pollination

- Before
  - Create a hive introduction plan at the beginning of the season.
  - Use bee-friendly polyethylene.
  - Introduce pollinators on time (the week of or one week before the start of pollination).
  - Introduce pollinators on a regular basis to avoid dips in pollination.

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Pollination

- During
  - Check markings two times per week so you can quickly react if necessary.
  - Introduce more hives when
    - you increase plant density;
    - the exterior temperature is < 5 °C — if you ventilate using roof openings;
    - you remove plants; or
    - you experience a heatwave.
  - Find a balance between the number of bees and the quality of the pollen.
  - Use hive entrance reducers in artificial lighting.

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Merci

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