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# Ferme verticale:

## Une révolution agricole grâce aux lampes LED

Dr Céline C.S. Nicole

11 Mars 2021

innovation ✨ you



**CCI FRANCE PAYS-BAS**  
FRANSE KAMER VAN KOOPHANDEL



# Signify est le leader mondial de l'éclairage

Nos produits, systèmes et services d'éclairage à haute efficacité énergétique permettent à nos clients de bénéficier d'une qualité d'éclairage de haute qualité, tout en augmentant leur sécurité et leur confort quotidiens.

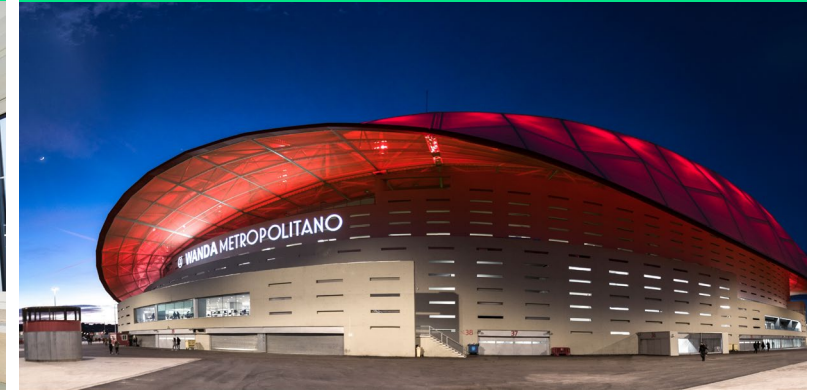
## Light sources



## Luminaires



## Systems and Services



**No. 1**

Connected, LED,  
Conventional

**€6.2bn**

sales in 2019,  
~ 75% professional

**38,000**

people in 74 countries

**No. 1**

Industry Leader  
Dow Jones Sustainability  
Index

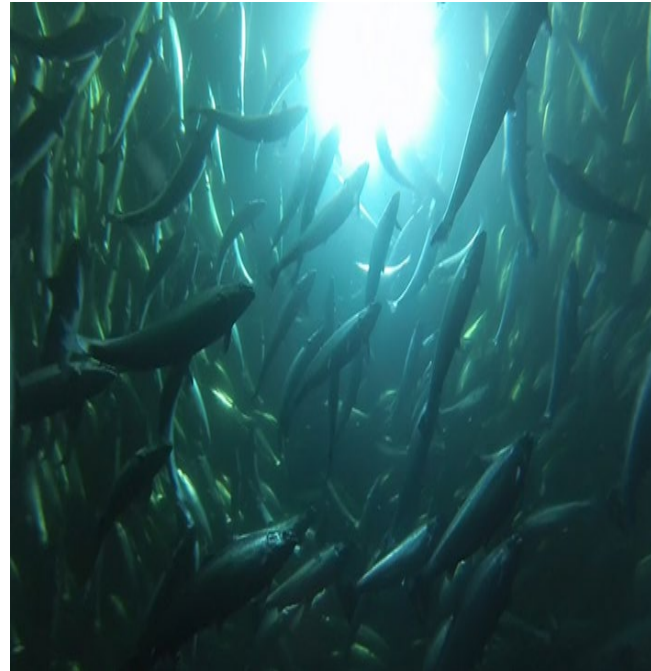
# Eclairage pour toute l'agriculture

De « recettes lumineuses » destinées à accroître la qualité et le rendement de la production agricole



## Horticultural Lighting

Cultures maraîchère, fruitière, florale



## Aquaculture LED

Aquaculture en mer ou piscine



## Once animal

Aviculture et élevage porcin

# Eclairage pour l'aviculture

## Performance Enhancing



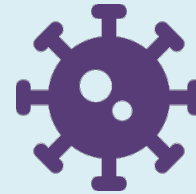
- AgriShift® and AquaShift®
- Layer, Broiler, Turkey, Swine and Aquiculture
- Animal specific solutions that:
  - ✓ Enhance productivity
  - ✓ Promote animal welfare
  - ✓ Improve feed conversion
  - ✓ Reduce stress
  - ✓ Decrease diseases and infections

## Reproduction



- HatchShift® and Breeder Lighting
- Layer, Broiler, Turkey and Swine
- Solutions that:
  - ✓ Enhance hatchability
  - ✓ Decrease post hatch myopathies
  - ✓ Increase postnatal muscle mass
  - ✓ Allow sex determination

## Bio Security



- BioShift® and BioShift® High Speed Bacterial Disinfection
- Eggs and general material
- Direct and indirect photo-induced disinfection solution that inactivates and/or kills a wide range of harmful microorganisms (virus, bacteria, fungus and parasites)



Research conducted at Texas A&M University and Stephen F. Austin University by Gregory Archer and Joey Bray (unpublished) showed that adding **Junglite Green™** over feed and water lines resulted in:

Facteur de conversion 1.7, poids + 4.4%

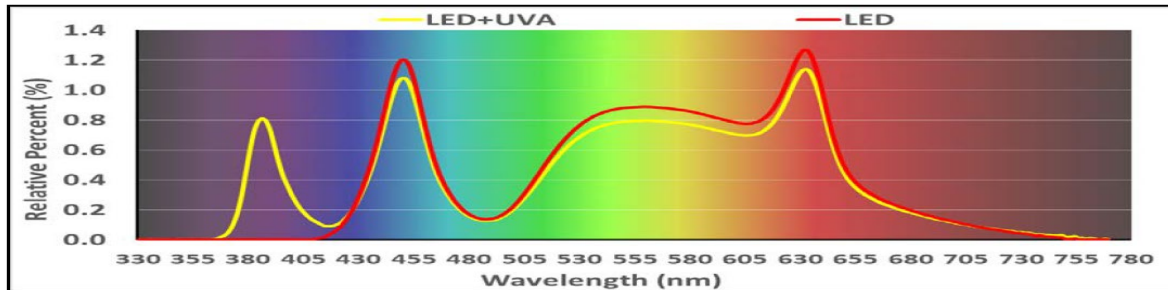
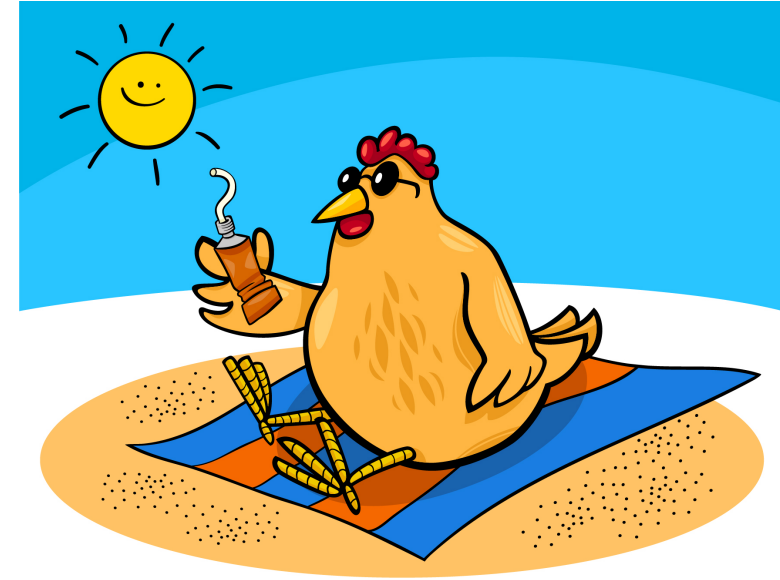
Age, d	WL	RL	GL
0	94.27 ± 2.33 <sup>a</sup>	97.75 ± 2.93 <sup>a</sup>	91.24 ± 2.71 <sup>a</sup>
21	892.80 ± 18.13 <sup>b</sup>	682.53 ± 17.38 <sup>c</sup>	1,051.17 ± 30.23 <sup>a</sup>
49	2,188.04 ± 48.68 <sup>c</sup>	2,176.66 ± 45.00 <sup>c</sup>	2,409.73 ± 48.59 <sup>b</sup>

<sup>a-c</sup>Values not marked with the same letters differ significantly ( $P < 0.05$ ).

Cao, J. *etal* . The Journal of Applied Poultry Research 17, 2008.

Once animal

# Eclairage pour l'aviculture : UV-A



Pullets spent 75% of time under UV-A, ate and drank more

Research conducted at Iowa State University by Kai Liu and Hongwei Xin

- Reduced stress biomarkers:
  - 3X less corticosterone
  - 2X lower H:L ratio
  - lower body asymmetry

- Reduced fear responses
  - Lower tonic immobility times
  - Fewer inversion wing flaps

# Eclairage pour l'aquaculture



## Marine-Based Aquaculture

Under water LED lights  
Powerline control system  
LightRecipes™



## Land-Based Aquaculture

Tank LED lights  
Under water LED lights  
Pathway LED lights  
DALI control system  
LightRecipes™



## Future Aquaculture

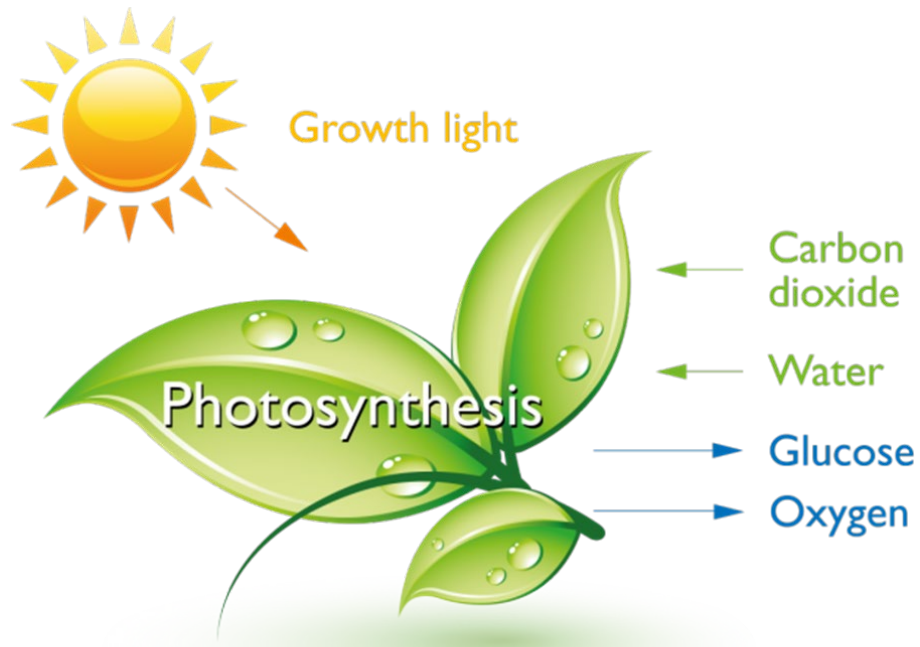
Universities  
Research Institutes

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Algae  
Seaweed  
Other species

- Optimal fish light spectrum (better visibility of feed, maturation prevention, better feed conversion ratio)
- Optimal lighting distribution (Homogenous light distribution, lice control)
- Optimal light control (easy interface, easy to adjust light recipe, dimming to control fish depth)

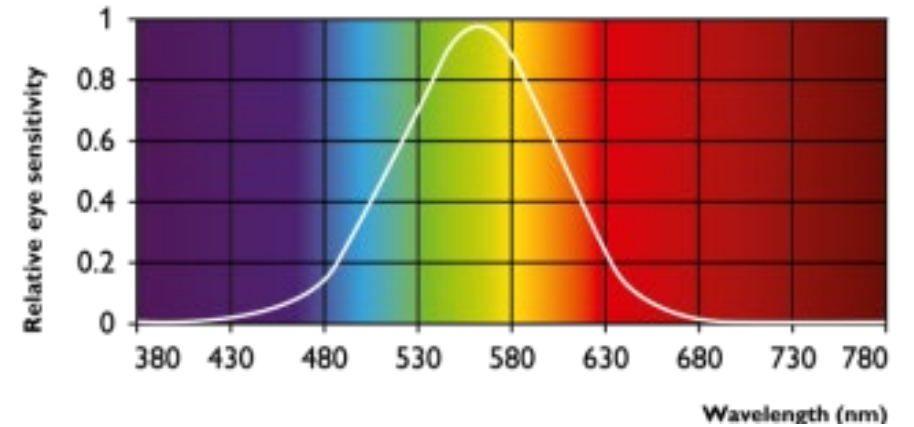
# Plante - Lumière



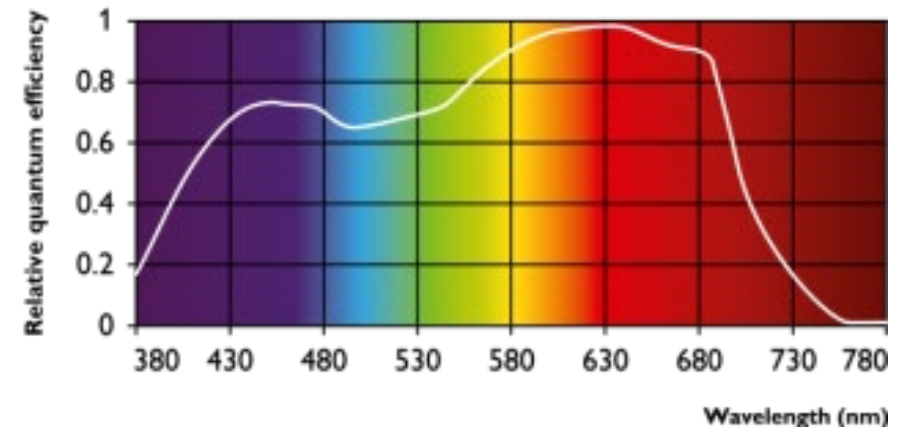
1. **Sa croissance** : Photosynthèse
2. **La transmission de signaux** : Développement de la plante, l'enracinement, floraison, morphologie, la couleur

Ces deux facteurs interviennent simultanément et interagissent entre eux.

## Human eye



## Green plants



# Eclairage pour l'horticulture

## Vegetables & Fruit



Tomato  
Cucumber  
Lettuce  
Strawberry  
Pepper

## Floriculture



Rose  
Chrysanthemum  
Gerbera  
Alstroemeria  
Phalaenopsis  
Potted plants  
Annuals &  
Perennials

## Vertical Farming



Food processors  
Converting growers  
Branded producers  
Idealists

## Bio Based Compounds



MMJ  
Compounds

Licensed  
markets  
only -  
Specific way  
of working



# La lumière sur l'évolution de la culture maraîchère en un siècle

Daylight



## Value of natural and supplemental light sources



Flexibility and reliability



Quality management



Pesticide free produce



Location independency



Yield potential

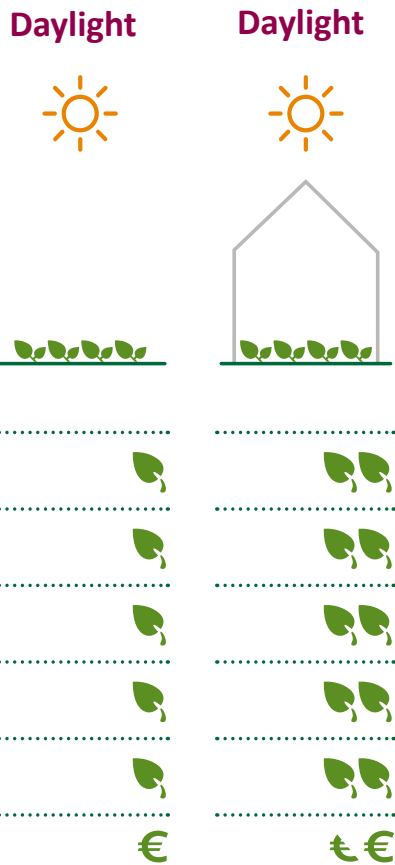


Investment



# La lumière sur l'évolution de la culture maraîchère en un siècle

## Value of natural and supplemental light sources





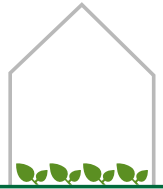
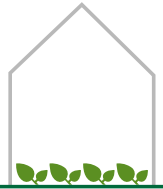
























# La lumière sur l'évolution de la culture maraîchère en un siècle

	Daylight	Daylight	HPS lighting + daylight
<b>Value of natural and supplemental light sources</b>			
Flexibility and reliability	1 leaf	2 leaves	3 leaves
Quality management	1 leaf	2 leaves	3 leaves
Pesticide free produce	1 leaf	2 leaves	3 leaves
Location independency	1 leaf	2 leaves	3 leaves
Yield potential	1 leaf	2 leaves	3 leaves
Investment	€	€€	€€€



# La lumière sur l'évolution de la culture maraîchère en un siècle

Value of natural and supplemental light sources	Daylight	Daylight	HPS lighting + daylight	LED toplighting + daylight
				
				
Flexibility and reliability				
Quality management				
Pesticide free produce				
Location independency				
Yield potential				
Investment	€	€€	€€€	€€€€





# La lumière sur l'évolution de la culture maraîchère en un siècle

## Value of natural and supplemental light sources

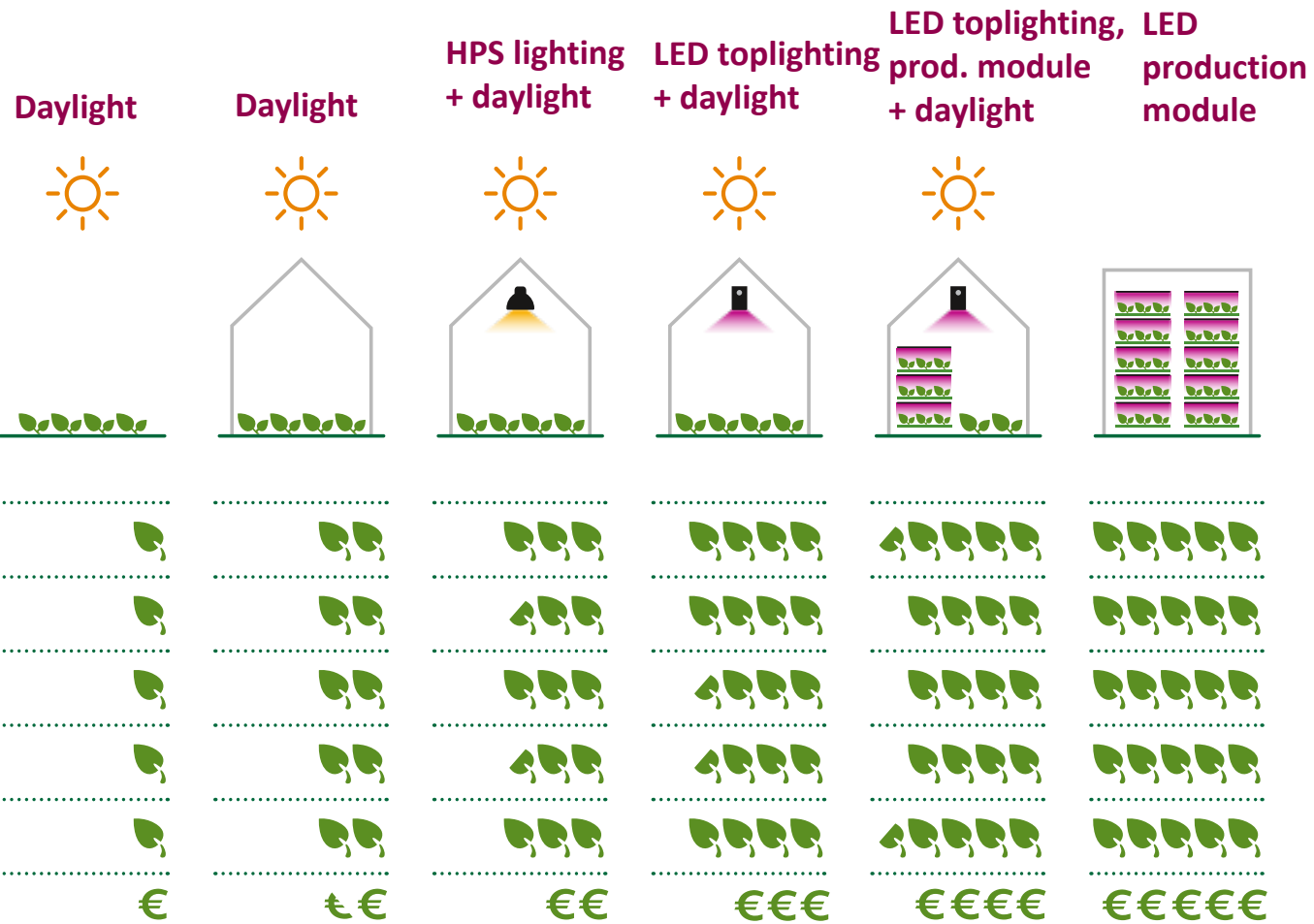
	Daylight	Daylight	HPS lighting + daylight	LED toplighting + daylight	LED toplighting, prod. module + daylight
Flexibility and reliability	1 leaf	2 leaves	3 leaves	4 leaves	5 leaves
Quality management	1 leaf	2 leaves	3 leaves	4 leaves	5 leaves
Pesticide free produce	1 leaf	2 leaves	3 leaves	4 leaves	5 leaves
Location independency	1 leaf	2 leaves	3 leaves	4 leaves	5 leaves
Yield potential	1 leaf	2 leaves	3 leaves	4 leaves	5 leaves
Investment	€	€€	€€€	€€€€	€€€€€





# La lumière sur l'évolution de la culture maraichère en un siècle

## Value of natural and supplemental light sources



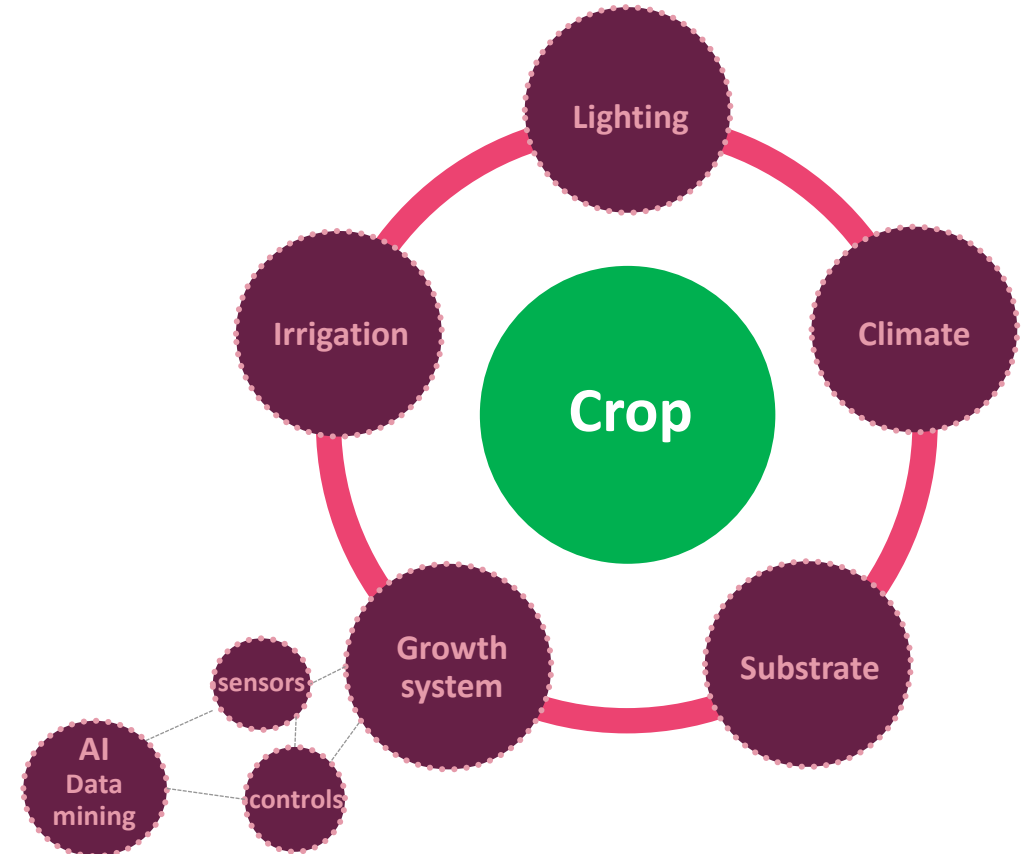


# Recette de production en ferme verticale

Pourquoi et comment optimiser les fermes verticales

## **growth recipe** →

A knowledge-based instruction on how to use the right settings for climate and lighting conditions for a specific crop.



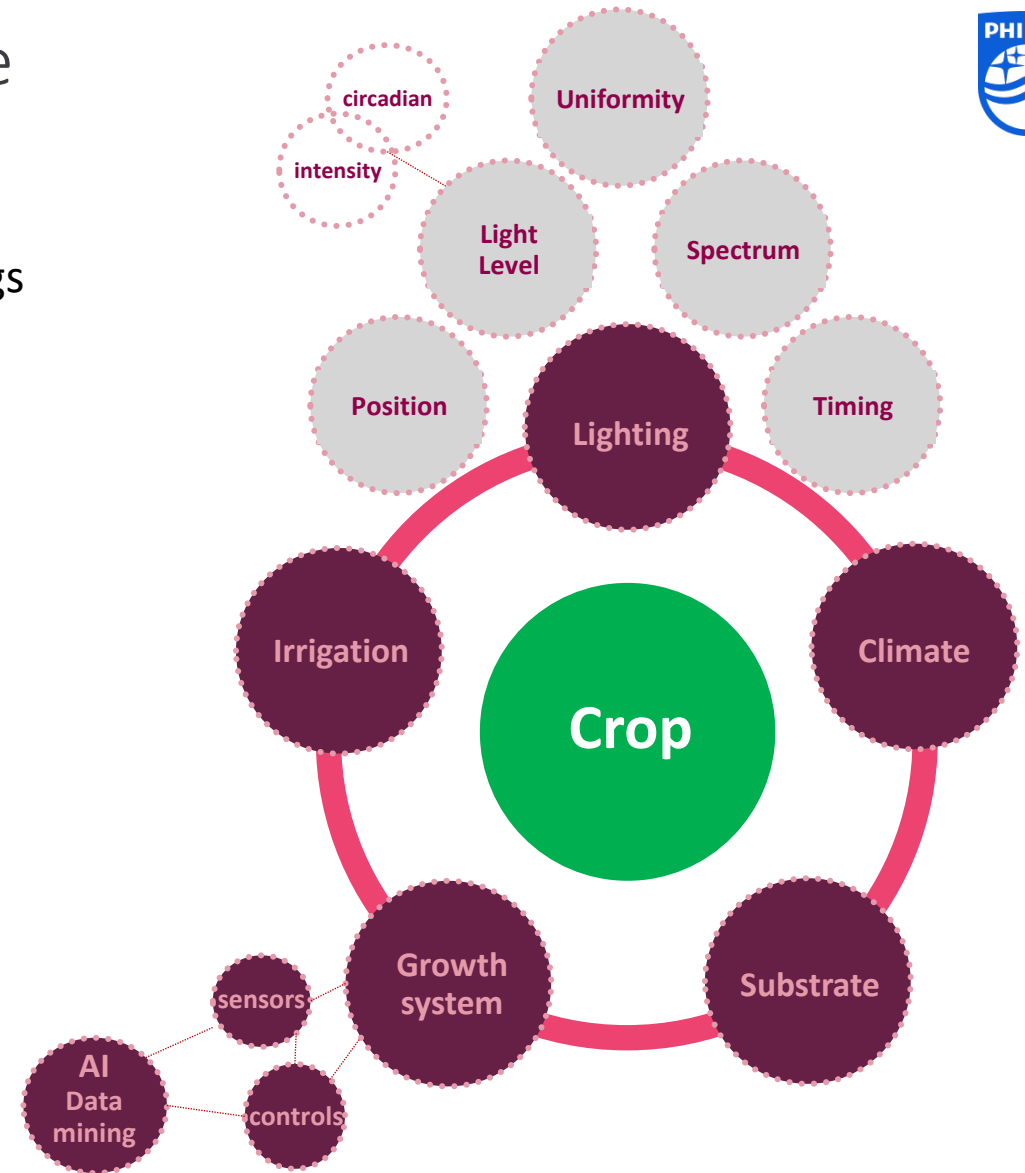


# Recette de production en ferme verticale

Pourquoi et comment optimiser les fermes verticales

## **growth recipe** →

A knowledge-based instruction on how to use the right settings for climate and lighting conditions for a specific crop.



# Notre démarche en recherche et nos partenaires pour les recettes



- Formulation scientifiques d'hypothèses
- Projets de recherche Universitaires
- Echange avec les producteurs (essais)
- Echange avec les semenciers
- Echange avec les spécialistes du climat et substrat





## Les contrôles de qualité par la lumière

- ✓ La couleur
- ✓ La durée de conservation
- ✓ La vitamine C, K etc..
- ✓ Le goût
- ✓ Le nitrate
- ✓ La texture

# La couleur

**Lollo rosso**



**Red Salanova**



**Red Oak**



# La couleur : les anthocyanes



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Feuille de chêne  
*cv. Rouxai*

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Nicole CCS *et al*, 2016

Pre-harvest coloration treatment



9

6

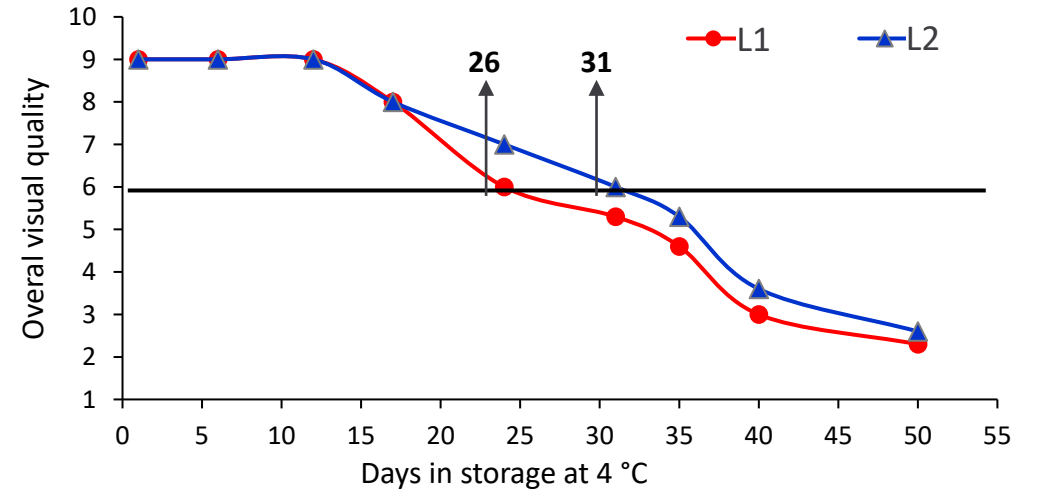
1

Durée de conservation :  
OVQ

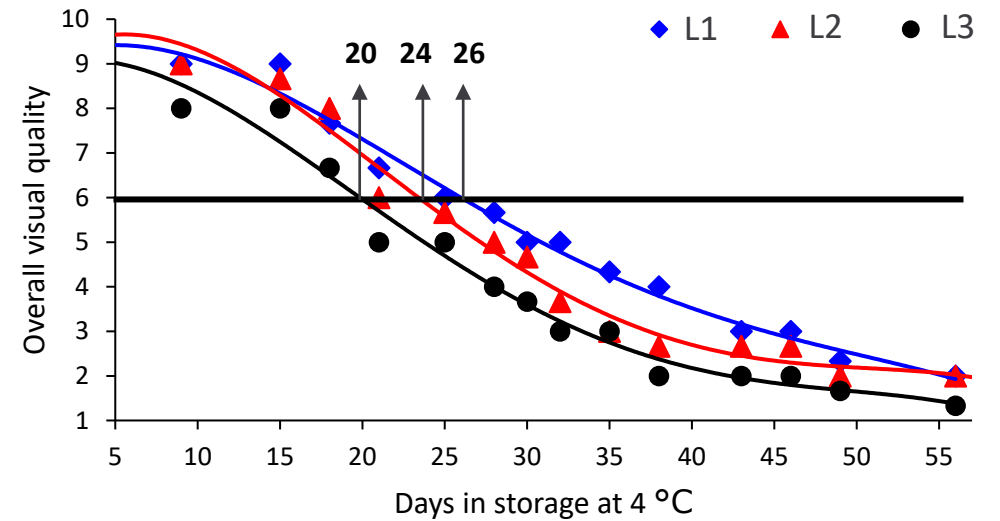
# Contrôle de la durée de conservation



Pousses d'épinards



Roquette sauvage



# Les valeurs nutritives

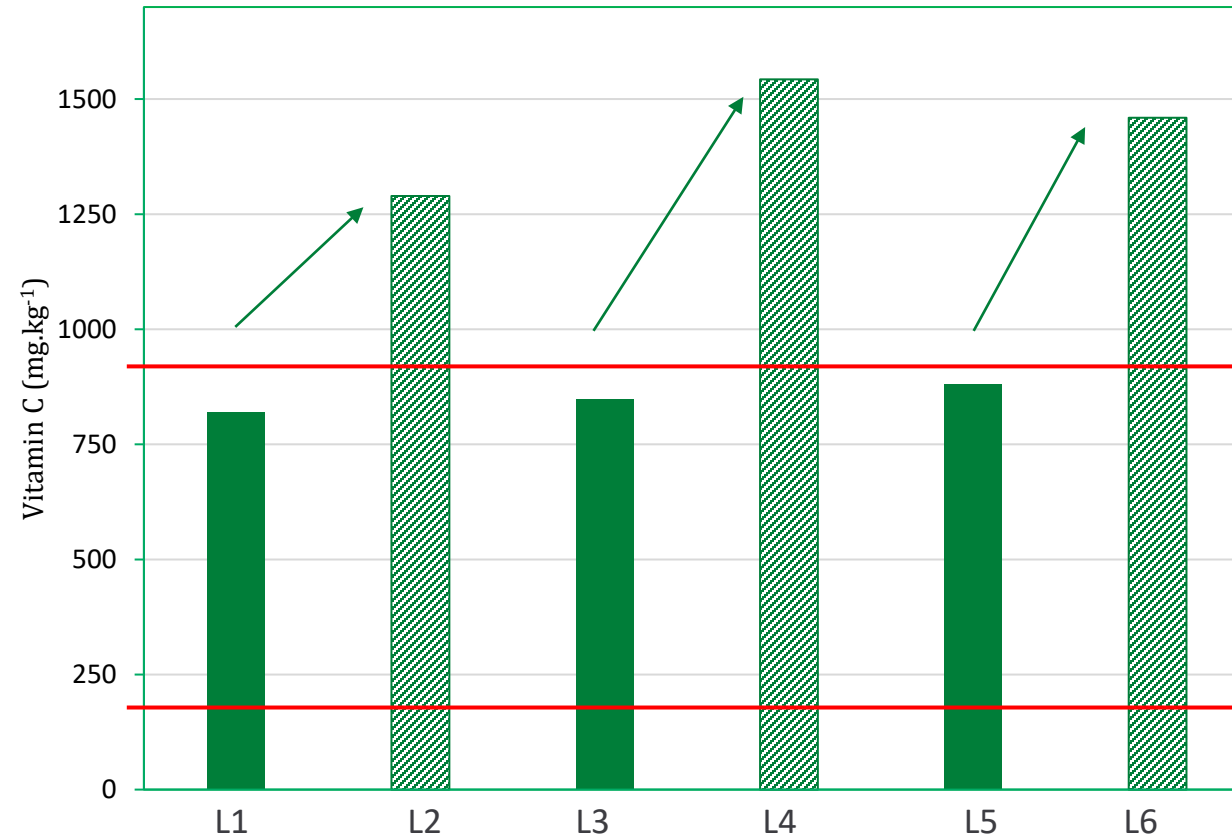




# Contrôle de la vitamine C dans la roquette sauvage

## Optimize...

- by increasing vitamin C with pre harvest light treatment
- **Vitamin C** is a powerful antioxidant. It protects your body from the damage of free radicals, toxic chemicals and pollutants.
- Eating 50g of rocket salad provides the dietary recommendation (RDA) of 75mg in vitamin C.



USDA database for kiwi



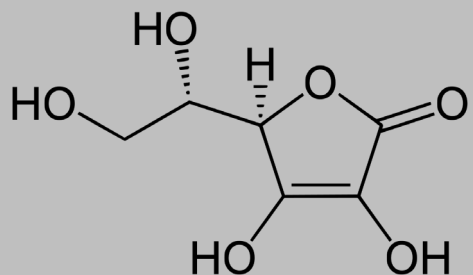
USDA database

Vitamin K ~ 4mg/kg (USDA ~ 2)  
Beta carotene ~ 25 mg/kg (USDA = 15)  
Xanthophyll ~ 50 mg/kg (USDA =40)



C.C.S. Nicole, J. Mooren, A.T. Pereira Terra, D. H. Larsen, E.J. Woltering, L. F. M. Marcelis, J. Verdonk, R. Schouten, F. Troost. Acta Hort. 1256, 481-488 (2019)

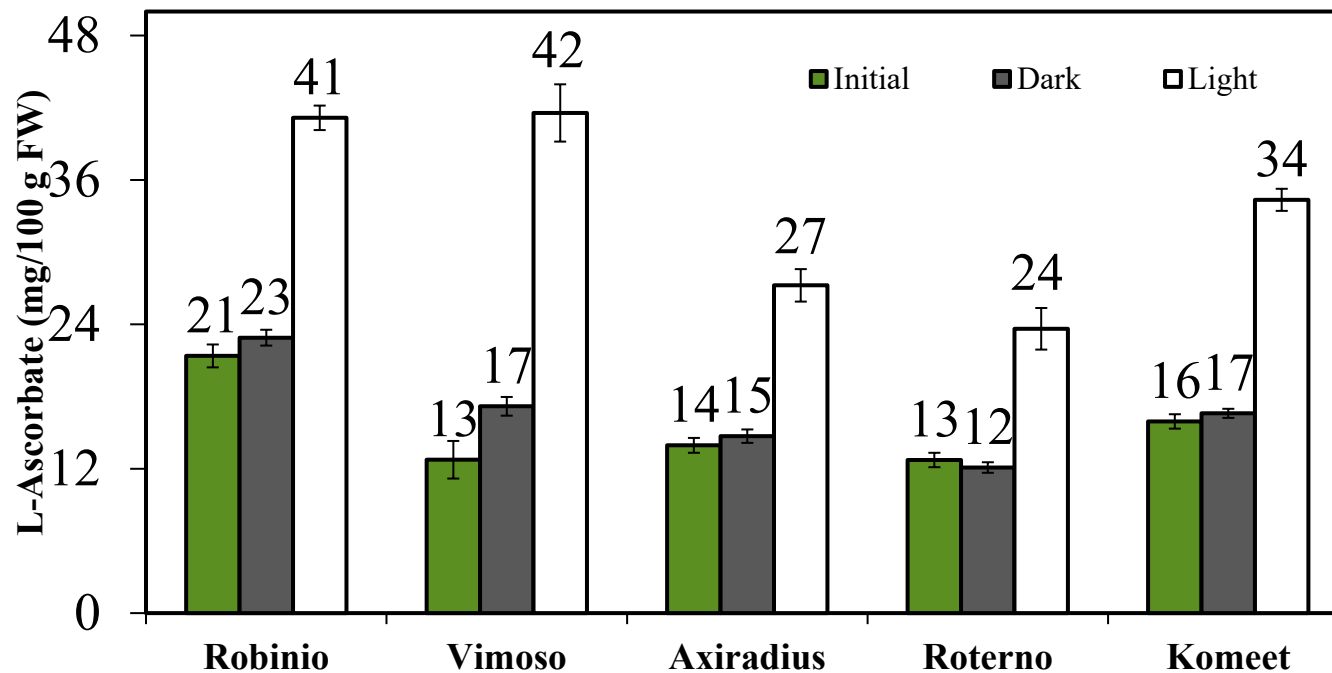
# Contrôle de la vitamine C dans la tomate



Light is a regulator of vitamin C in plant and fruits



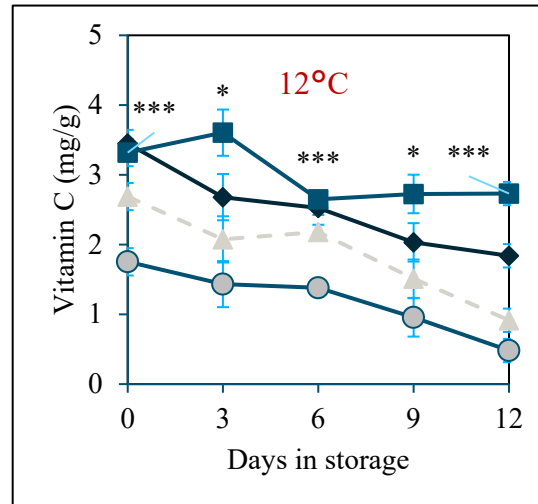
Ntagkas, *etal*, Plants (2019) and Metabolites (2020), 10, 266



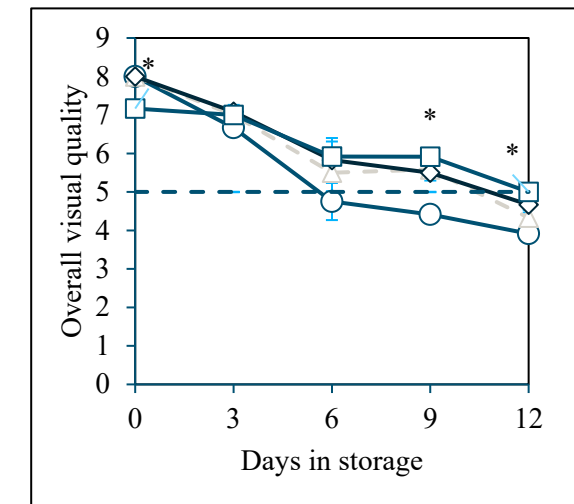
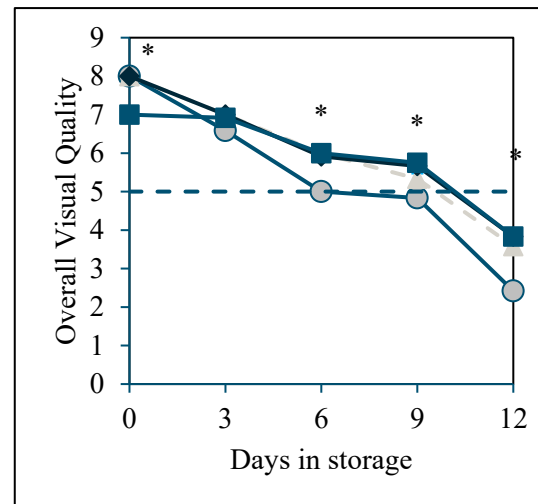
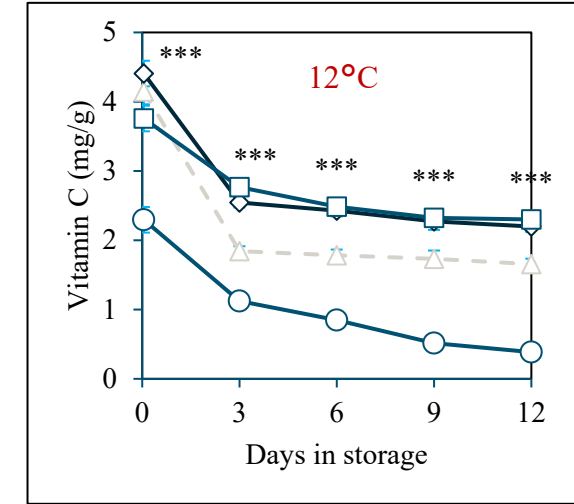
# Contrôle de la vitamine C dans le basilique



cv. Emily



cv. Dolly



Dorthe H. Larsen, Ernst J. Woltering, Celine C. S. Nicole and Leo F. M. Marcelis\*. (2020) Front. Plant Sci. 11:597906.

# Contrôle du goût

Espèce sauvage

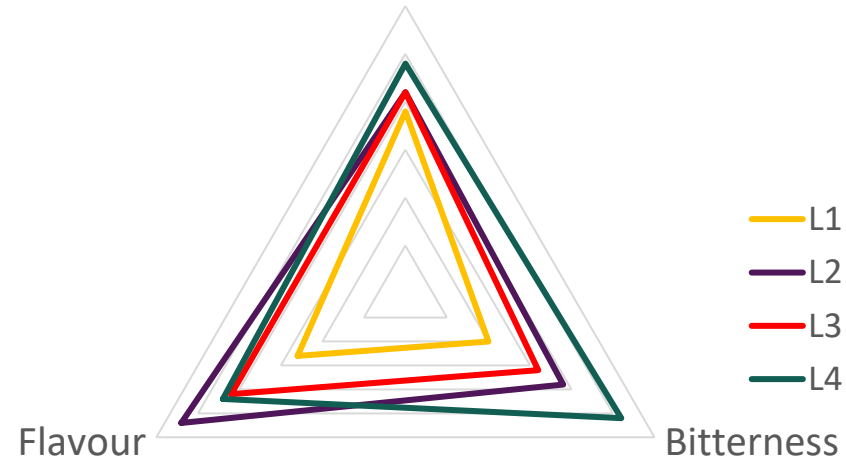


Espèce cultivée



Sweetness

Nicole CCS et al, 2017



# Contrôle de la texture

Croissance 2 semaines à intensité medium suivie d'1 semaine à intensité variable



Le niveau d'éclairage juste avant la récolte détermine la qualité du produit plutôt que la qualité d'éclairage ultérieure

# Les bénéfices de la ferme verticale



## Improve Reliability

- Controlled production cycle > increase predictability
- No pressure from disease or climate
- Grow free of pesticides



## Optimize Quality

- LED light recipes improve plant quality and uniformity (rooting, color, flavor)
- LED light treatments maximize nutrient content (vitamin C, nitrate, potassium)



## Increase Yield

- Highest yield/m<sup>2</sup>
- Shorter production cycles, year round
- Less waste in value chain, longer shelf life



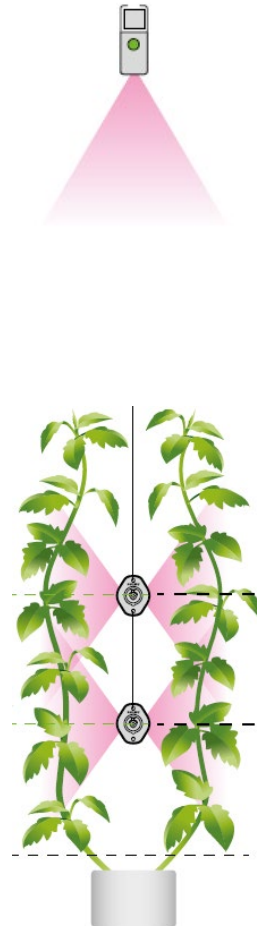
## Increase Water Efficiency

- Minimize water usage

# Le Jardin de Rabelais



LED Top and interlighting:  
Augmentation du gout et de la production



# Le groupe Cheminant



- Lieu: Carquefou / Nantes
- Culture: Cucumber and tomato (total 12ha)
- Surface: Cucumber (1,7 ha)
- Intensité total: 200  $\mu\text{mol}/\text{m}^2/\text{s}$ 
  - o 135  $\mu\text{mol}/\text{m}^2/\text{s}$  Toplight
  - o 67  $\mu\text{mol}/\text{m}^2/\text{s}$  Interlight
  - o Production en hiver: ca 2,5  $\text{kg}/\text{m}^2/\text{wk}$



GrowWise Strawberry research cell

# QUESTIONS ?

