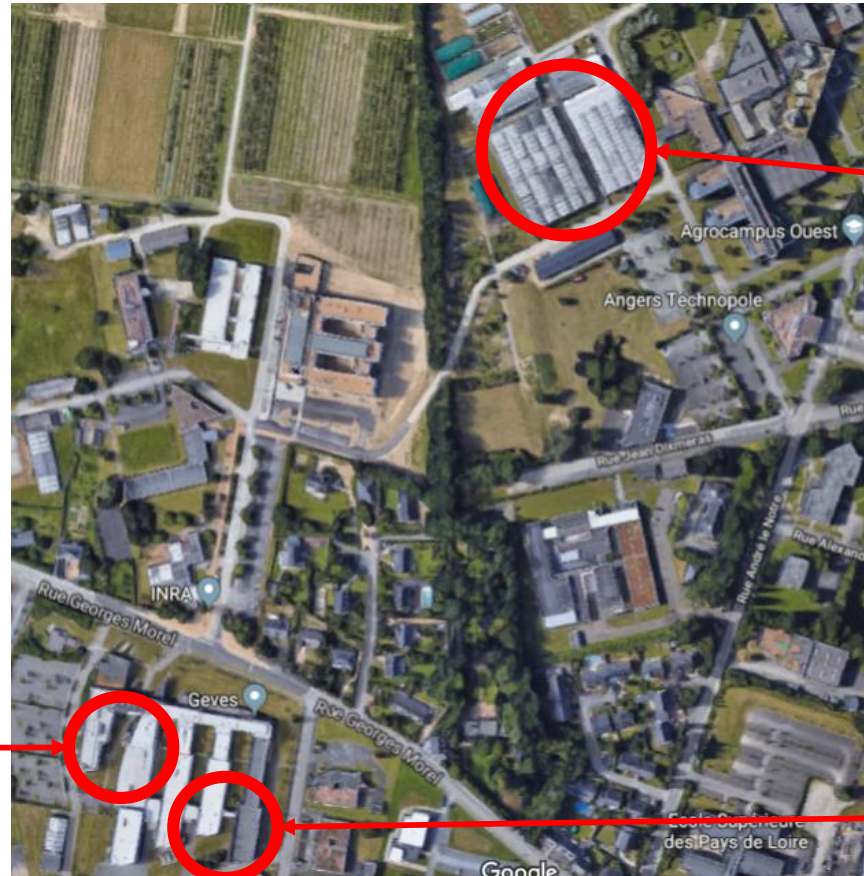
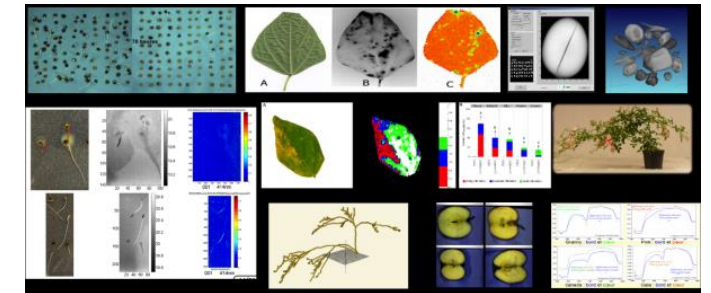


PATHOLED : light sources and plant pathology test outcomes

LED technology and plant phenotyping



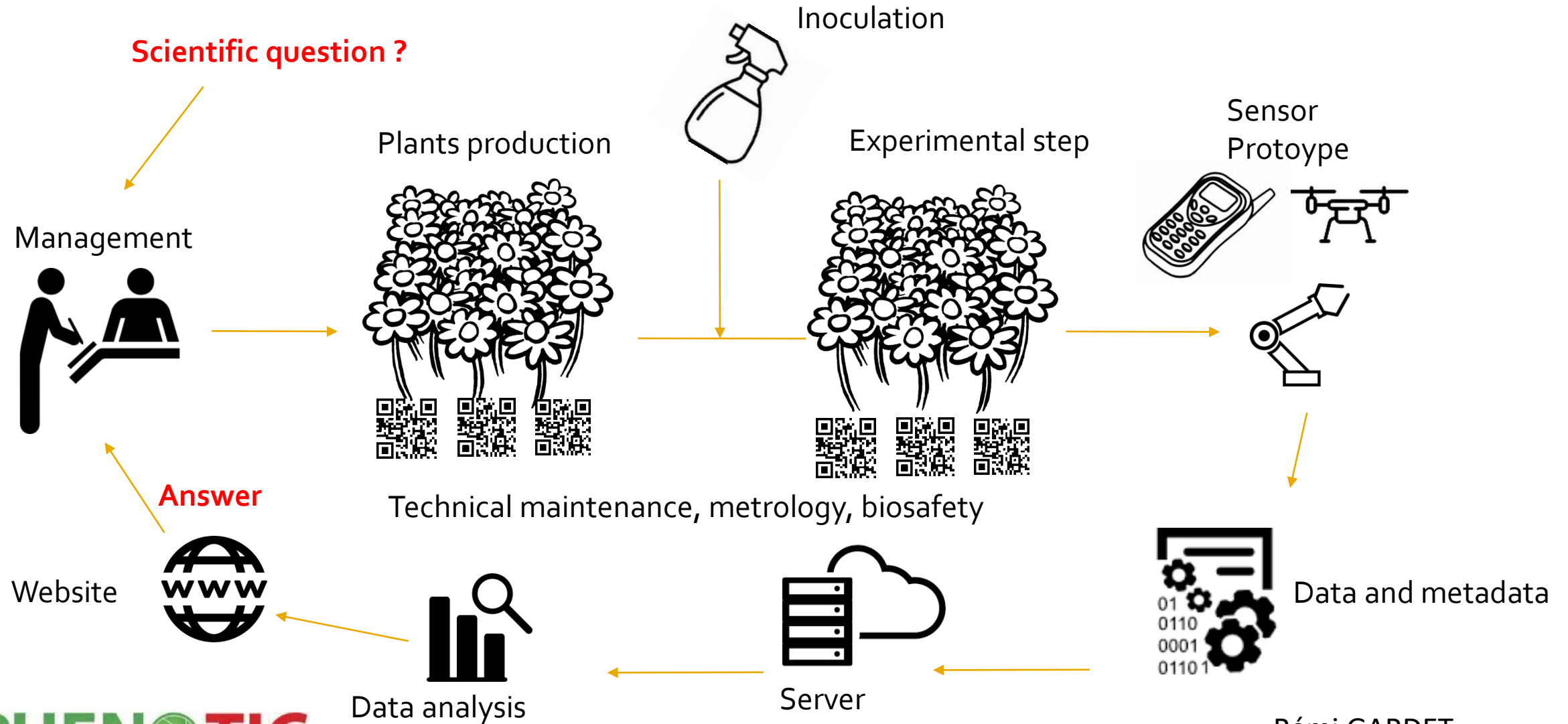
Facilities of PHENOTIC for plants in AGROCAMPUS OUEST and INRA



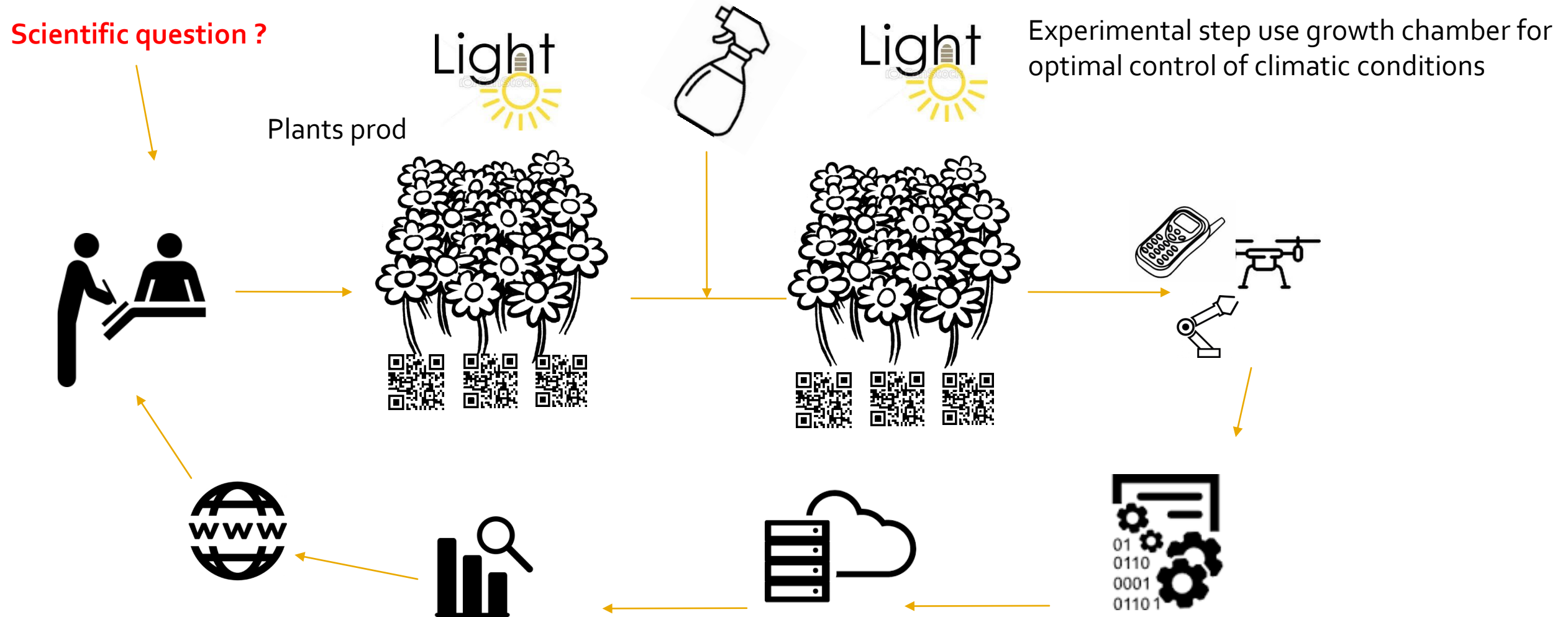
Workshop PATHOLED

Facilities of PHENOTIC for seeds in GEVES

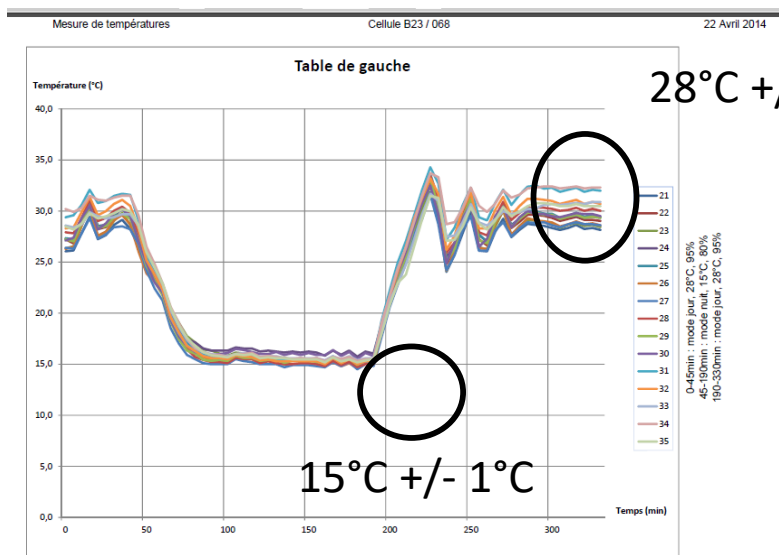
Phenotyping track (David Rousseau, dec, 2017)



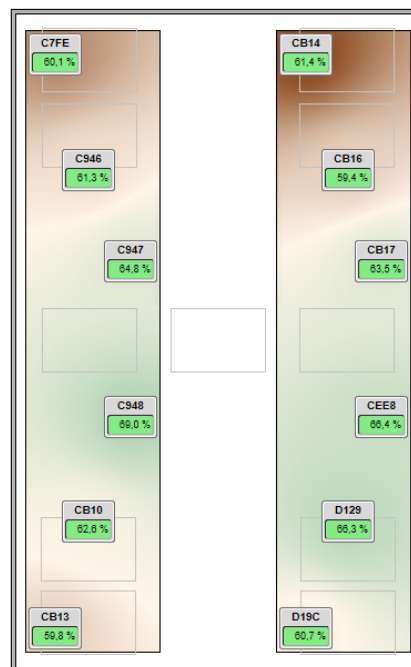
Phenotyping track and lighting



Spatial characterization in growth chamber (for large plant of 10cm to 80cm)



Charaterization of temperature with 15 points /3,5m², Rémi Gardet, 2014



Charaterization of humidity with 2 x 6 points /3,5m², Rémi Gardet, 2017

Growth chamber for large plant
Rémi Gardet, 2019



For temperature and humidity the characterizations of spatial heterogeneity show little differences

Spatial characterization in growth chamber

125cm from
the spot

Surface de la table		Longueur de la table (en centimètre) où le point de mesure a été pris															
Largeur	12	327	328	338	361	370	378	342	318	322	347	359	365	352	323	320	
	41	446	476	502	570	625	641	624	594	612	664	654	638	570	512	472	
	70	359	384	399	422	444	437	421	395	396	403	410	397	368	344	328	
		12	37	62	87	112	137	162	187	212	237	262	287	312	337	362	
22cm de la table		Longueur de la table (en centimètre) où le point de mesure a été pris															
Largeur	12	338	348	355	363	358	343	326	304	312	327	338	360	355	339	321	
	41	475	516	531	587	654	686	718	692	706	719	714	691	644	584	546	
	70	355	394	416	431	439	428	412	393	372	266	393	380	368	346	328	
		12	37	62	87	112	137	162	187	212	237	262	287	312	337	362	
43cm de la table		Longueur de la table (en centimètre) où le point de mesure a été pris															
Largeur	12	319	352	376	361	322	302	286	288	287	291	293	326	333	311	291	
	41	505	611	650	668	669	714	835	893	886	809	763	717	796	779	672	
	70	350	389	421	423	425	408	397	403	401	359	369	363	381	372	339	
		12	37	62	87	112	137	162	187	212	237	262	287	312	337	362	
79,5cm de la table		Longueur de la table (en centimètre) où le point de mesure a été pris															
Largeur	12	205	296	360	330	237	184	222	296	310	247	182	218	298	320	232	
	41	455	744	1143	864	443	312	965	1654	1855	994	332	658	1018	1372	832	
	70	257	399	490	460	320	252	324	430	439	342	240	294	395	419	308	
		12	37	62	87	112	137	162	187	212	237	262	287	312	337	362	

45cm from
the spot

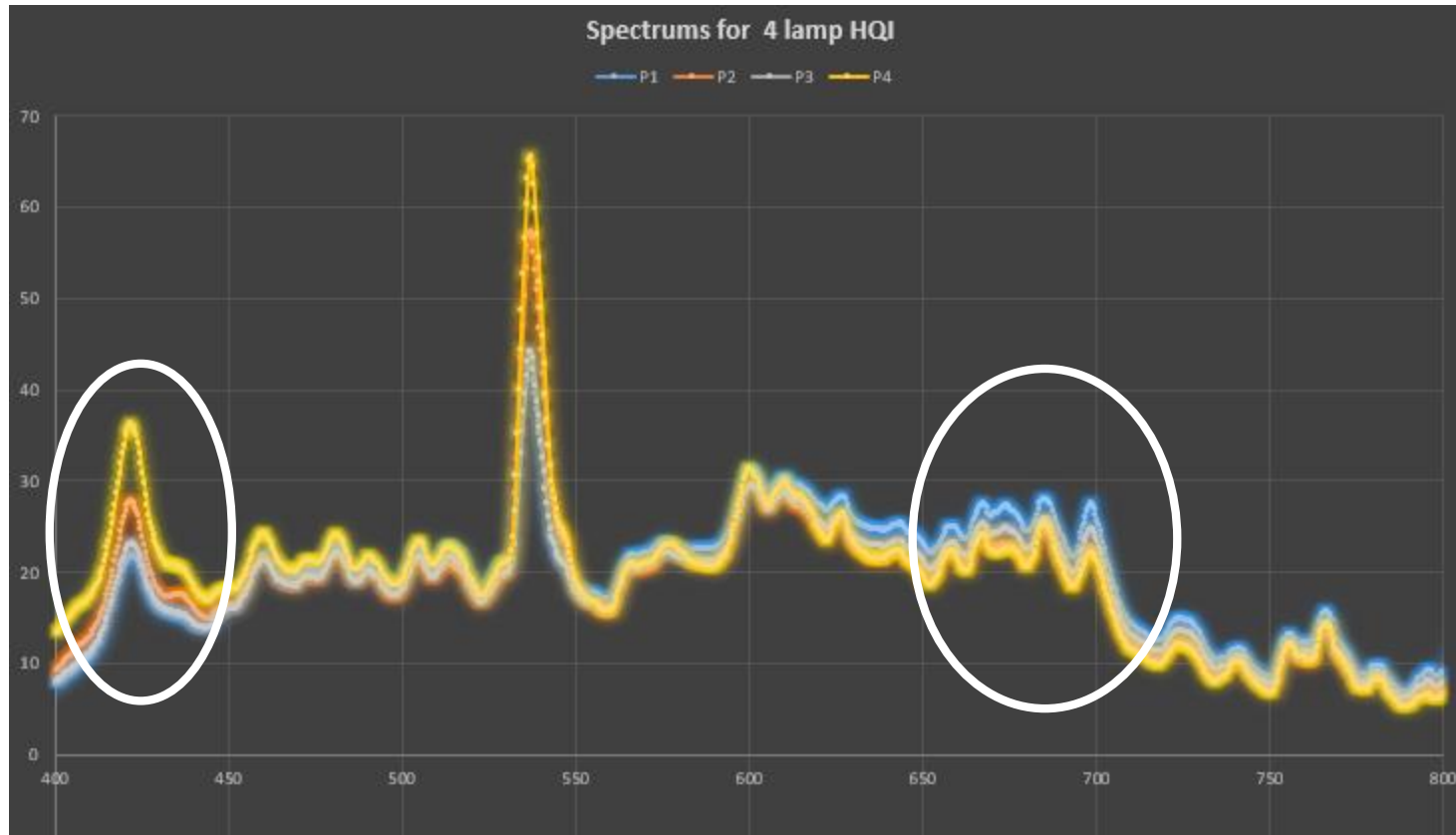
Charaterization of light with 45 points /3,5m², Rémi Gardet, 2014



Growth chamber with 9 lamps :
6 HQI + 3 NaT, Rémi Gardet 2014

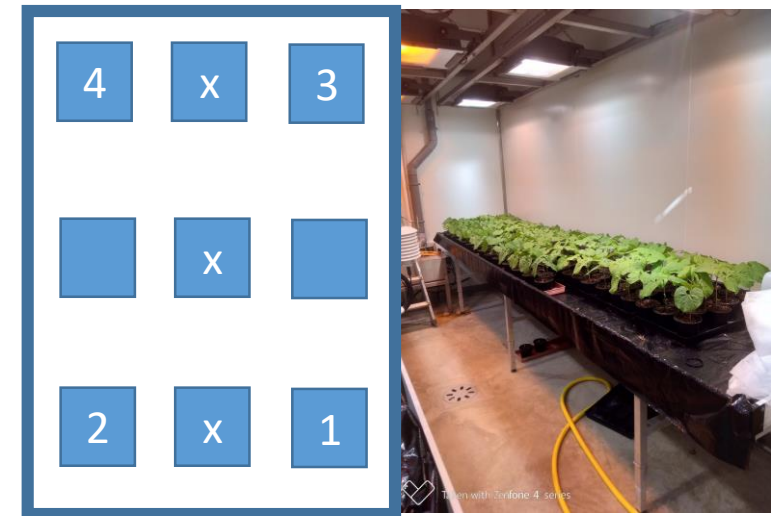
For ligthing, the characterization of spatial heterogenity shows the important differents, more than 100%.
With traditional techniques, it is difficult to have intensity and homogeneity to large distance between ligth and plants

Spectral variation in the time with traditional lighting



Spectral variation in the time to HQI spot (more than 6000h, Rémi Gardet 2018)

4 lamps HQI (with more than 6000h using) of the growth chamber reference show variation for spectral ratios



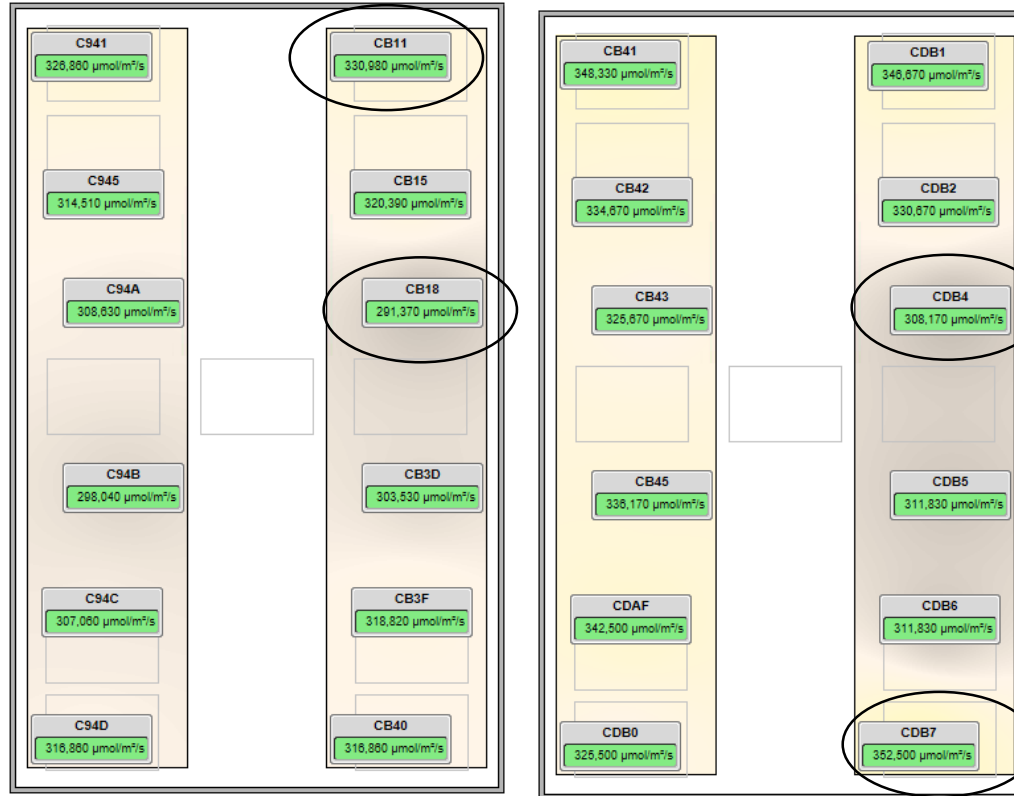
The growth chamber reference
Rémi Gardet 2018

The limites of traditional lighting / LED lighting as a solution

PHENOTIC exemple

Traditional lighting for growth chamber with large plant	Problem for the phenotyping	The advantage of LED lighting for growth chamber with large plant
Spatial heterogeneity	Experimental design on 6m ² (100-200 plants)	New design to lamp
Quality of spectrum	Repetability of tests Desease expression	Spectrum to choose
Fixed intensity	Adpatation to many patho-system	Variable intensity
Thermal heating	Infared System without inertia	Thermal heating less
Double power consumption	Expensive test	Cheaper test

Intensity and homogeneity with led ligth



100% white 4000K

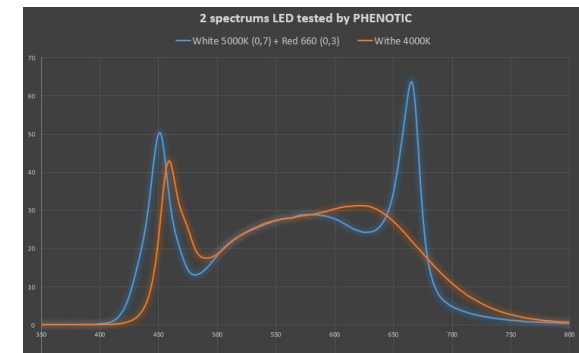
70% white 5000K
30% red 660nm

Charaterization to
2 rooms with 11
lamps 250W

300 $\mu\text{mol/m}^2/\text{s}$ at
120 cm

+/- 10%

Rémi Gardet, 2017



Rémi GARDET
May 14, 2019

slide 8

Spectrum to choose to specific applications

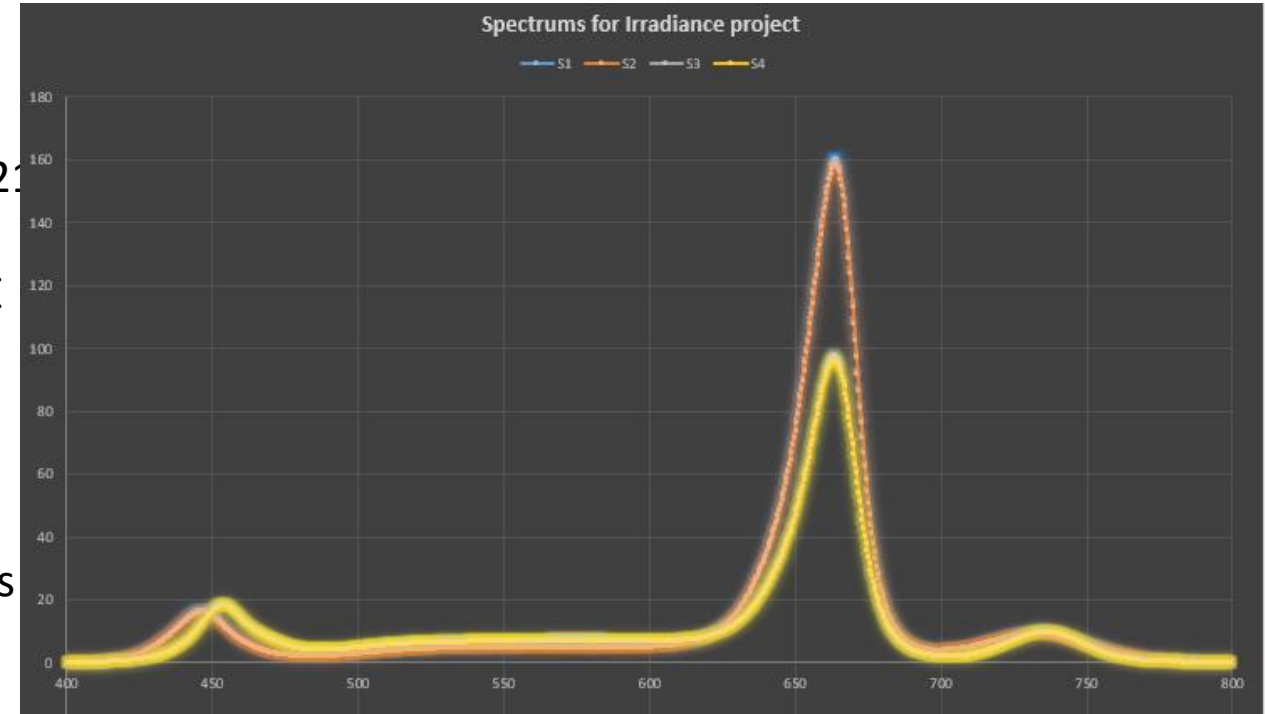
Irradiance project exemple



Irradiance project 2019-2021
by Laurent Crespel and
Philippe Morel, IRHS, ArchE
team

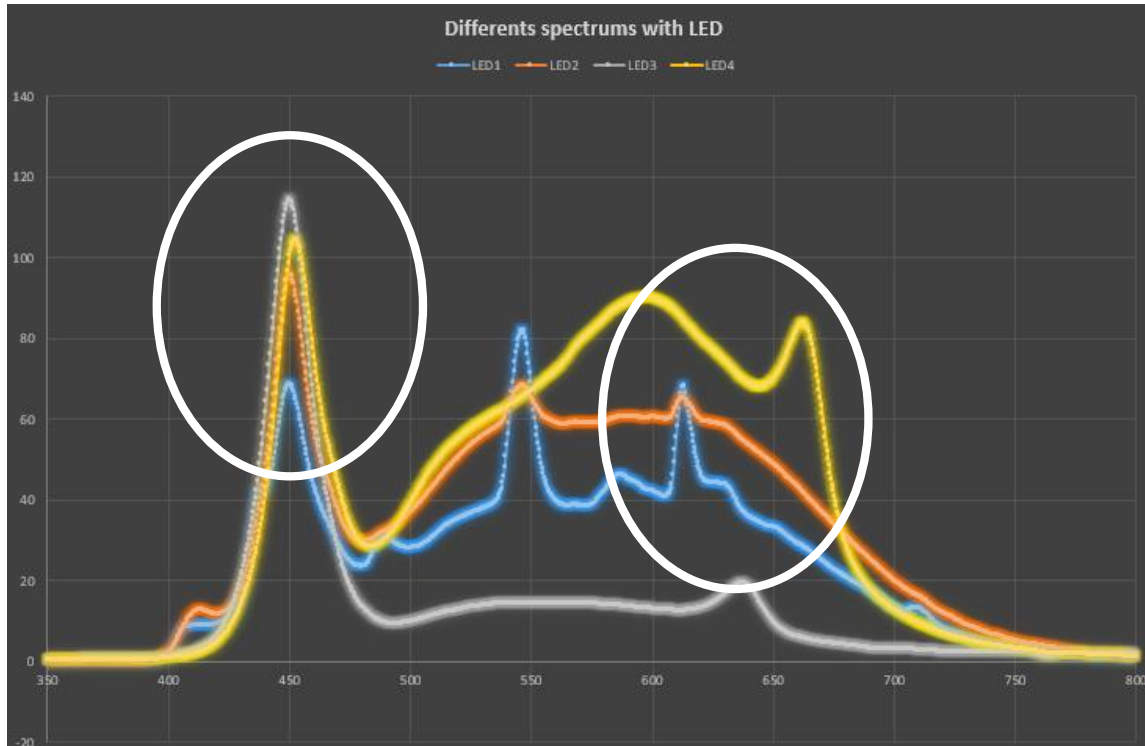
Use LED lighting to branch
out young plants with
specific spectrum and ratios
between bleu 440, red 660
and far red 730

Growth chamber for Irradiance
project with LED tube in the
facilities of PHENOTIC, Rémi Gardet 2019



Spectrum for Irradiance project with LED tube, Rémi Gardet 2019

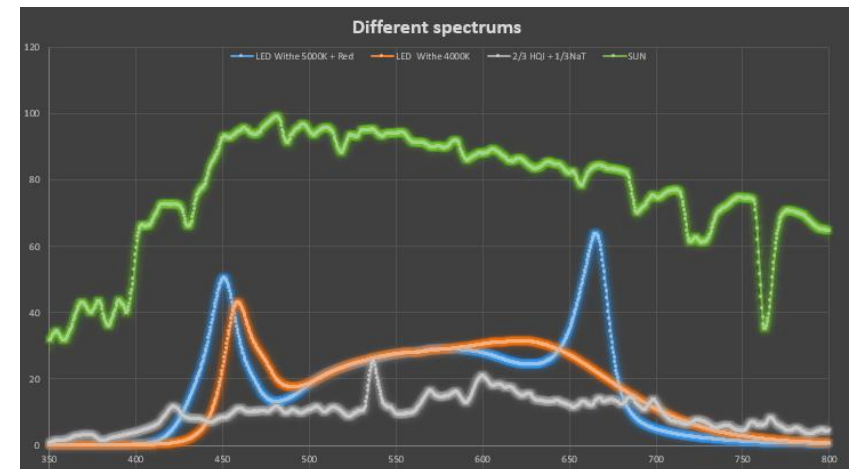
Different spectrum tested



Rémi Gardet 2018-2019

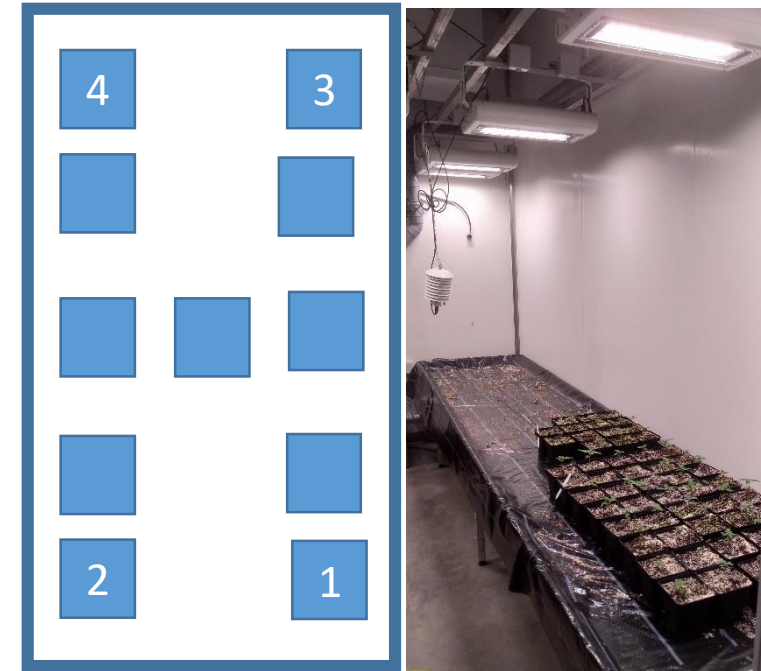
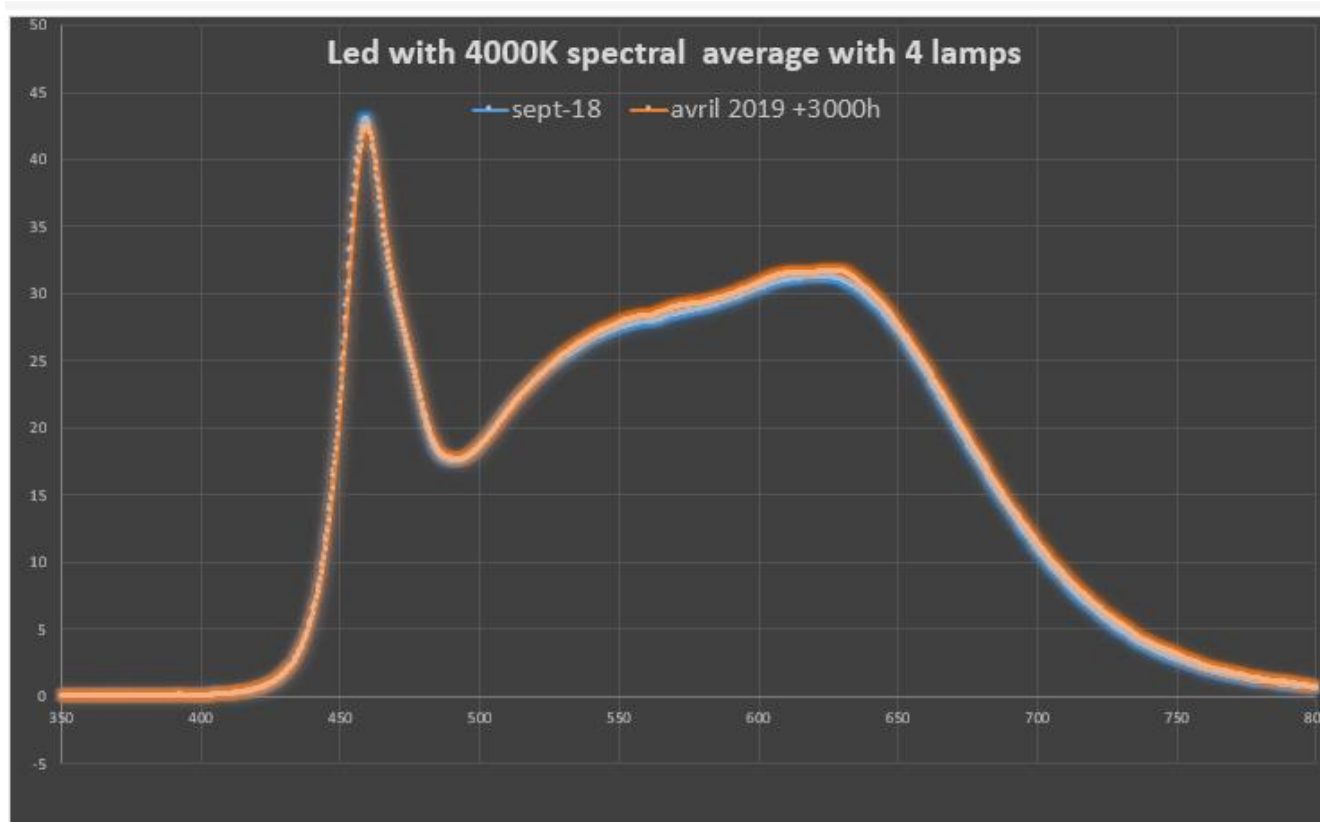
To adapt lighting LED for plant, the manufacturers compensate for blue peak of classic LED by red peak

To compare the sun spectrum



Rémi Gardet 2018-2019

Spectrum quality of lighting LED in the time



The growth chamber with LED lighting, Rémi Gardet 2019

LED lighting as a solution / PHENOTIC exemple

Ligth and phenotyping	The advantage of LED lighting for growth chamber with large plant	Evolution
Spatial heterogenity	Ok 300 $\mu\text{mol}/\text{m}^2/\text{s}$ +/-10% to 120cm	Adapted distance between LED ligthing and plants with mobil table or mobil roof
Spectrum quality	Limits Repetability of tests Fix spectrum to choose	<u>For good deseases expression, we install multi-spectra LED ligthing I (4 and 6 channels).</u>
Variable intensity	Ok, 0-100% Low intensity to Venturia.i and Appel tree for exemple	Variable intensity to multi-spectral solution
Thermal heating less	Ok Operated no cooling unit	Growth chamber with more large operating range (8°C to 28°C) Best regulation of hygrometry
Cheaper test	-25% Electric power (2,75Kw against 3,6Kw to same intensity)	Remain expensive