



irc 2023 SYDNEY

16th INTERNATIONAL RAPESEED CONGRESS
24 - 27 September 2023

GLOBAL CROP - GOLDEN OPPORTUNITIES

Colzette: A 3D model to identify architectural traits to promote vigour

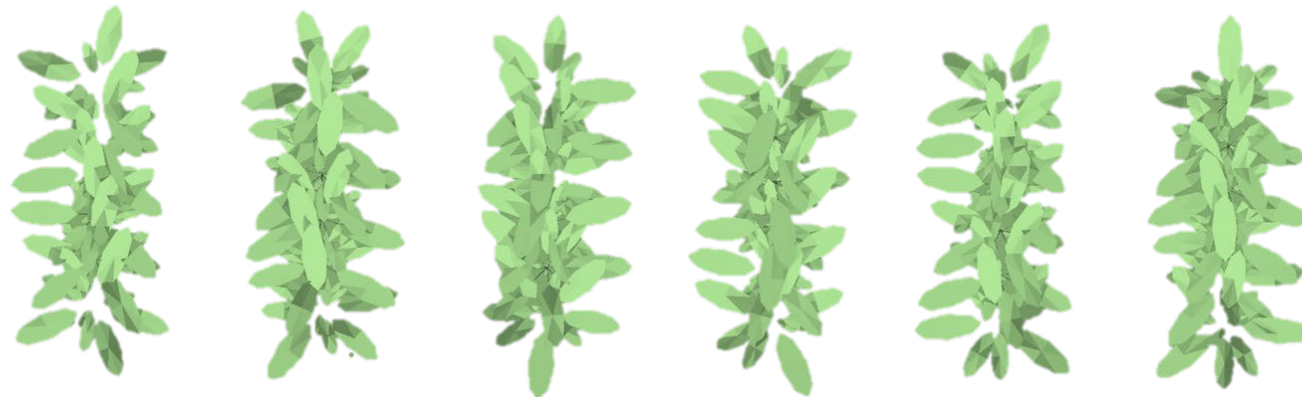
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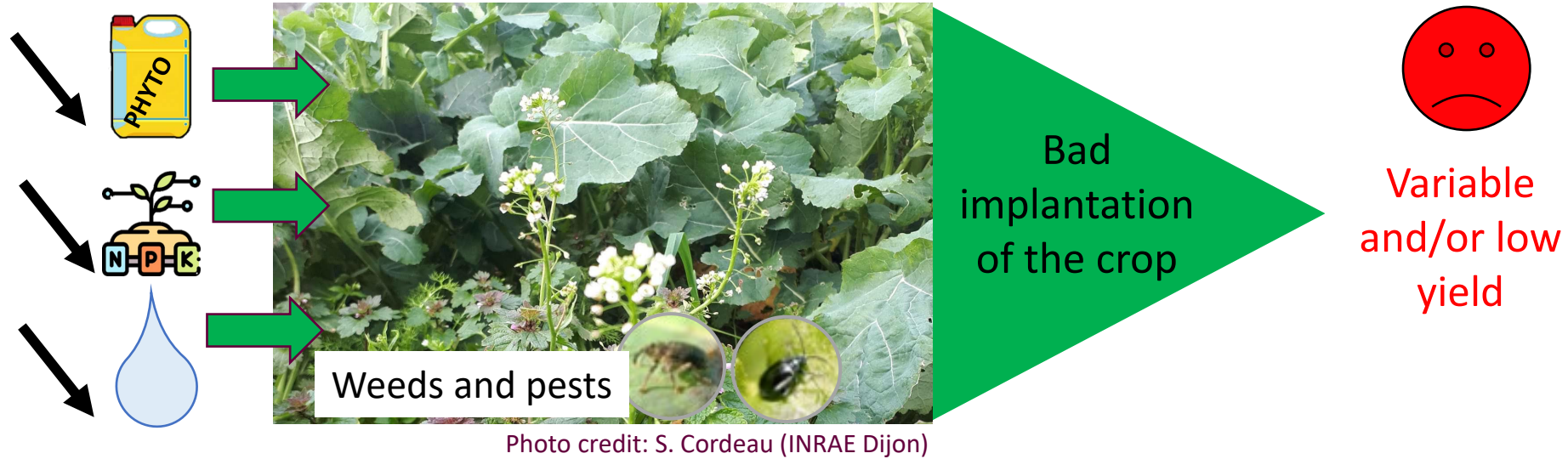
For correspondence: laurene.perthame@agroparistech.fr





Introduction

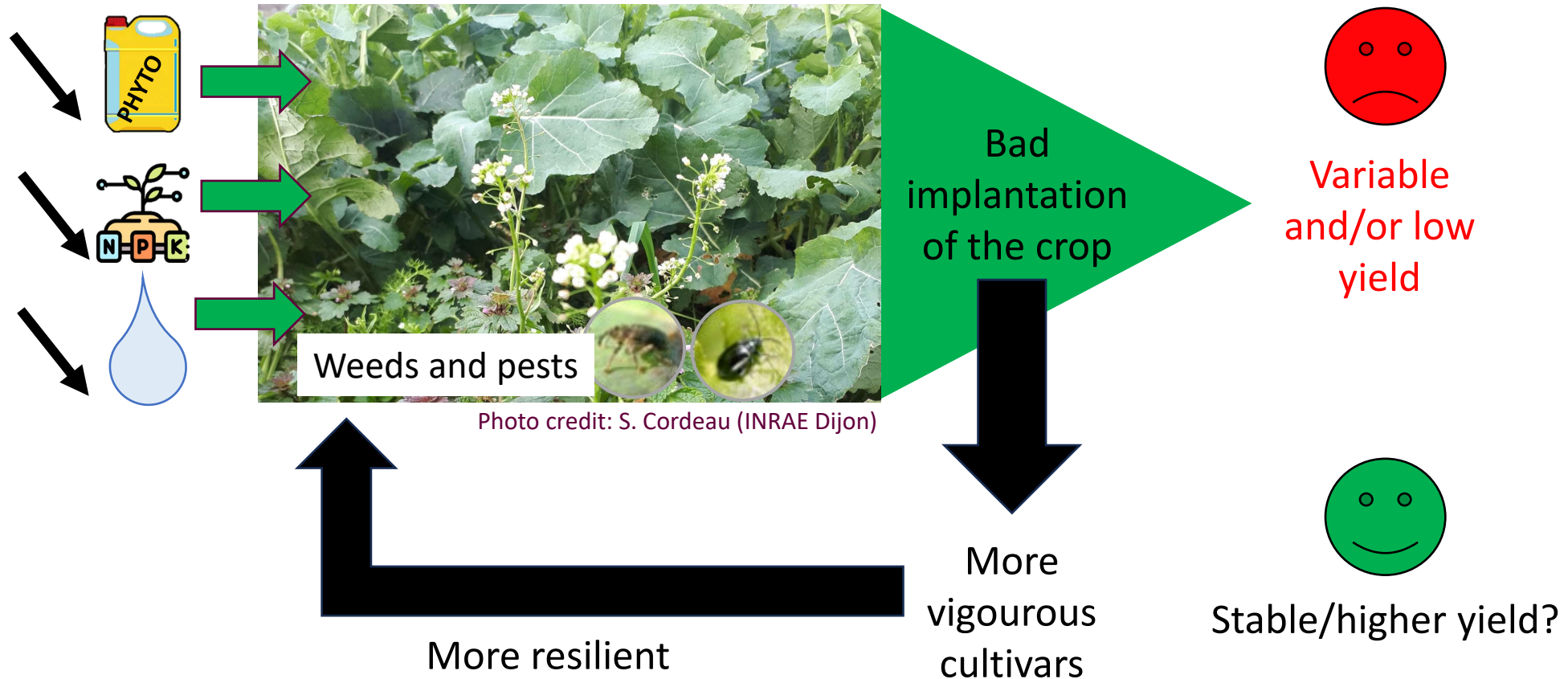
WOSR: a tricky crop management





Introduction

Vigourous cultivars might improve crop management





Introduction

Identify vigorous cultivars by improving light capture



More vigorous cultivars =
Aboveground architectural structure

Autumnal vigour at canopy closure

Efficient light capture

Efficient carbon production

OBJECTIVE: Influence of architectural traits and sowing pattern on light capture efficiency to improve management and breeding of vigorous WOSR cultivars

Method

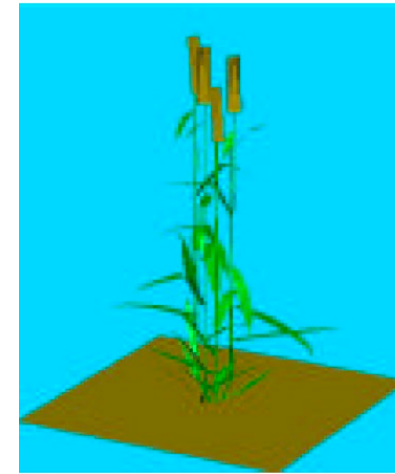
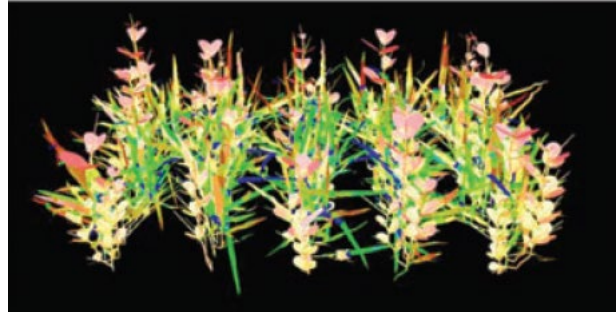
Construction of the Colzette architectural model

Structural 3D model of WOSR rosette

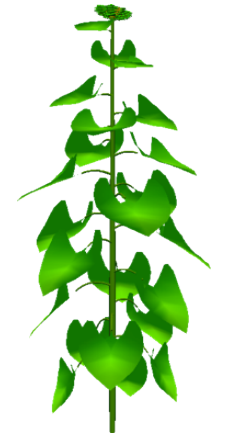
Plant-environment interface

Environmental spatial heterogeneity

Test quickly several scenarios (i.e. phenotypes, management techniques)



ADEL-Wheat
Fournier et al. 2003



SUNFLO
Casadebaig et al. 2010

Light partitioning wheat-pea mixture
Barillot et al. 2014

Modelling approach inspired by existing models for other crops: no existing 3D model with light capture for early rosette!

Jullien et al. 2010
Groer et al. 2007



Method

Construction of the Colzette architectural model

Input variable

Parameter

Output variable

(1) User set **total leaf area**

(2) Number leaves = **phyllochron** + **degree.days**



Pradal et al. 2008

Geometric= Multiscale Tree Graph
formalism (MTG)
3D architecture = PlantGL graphic library.



Method

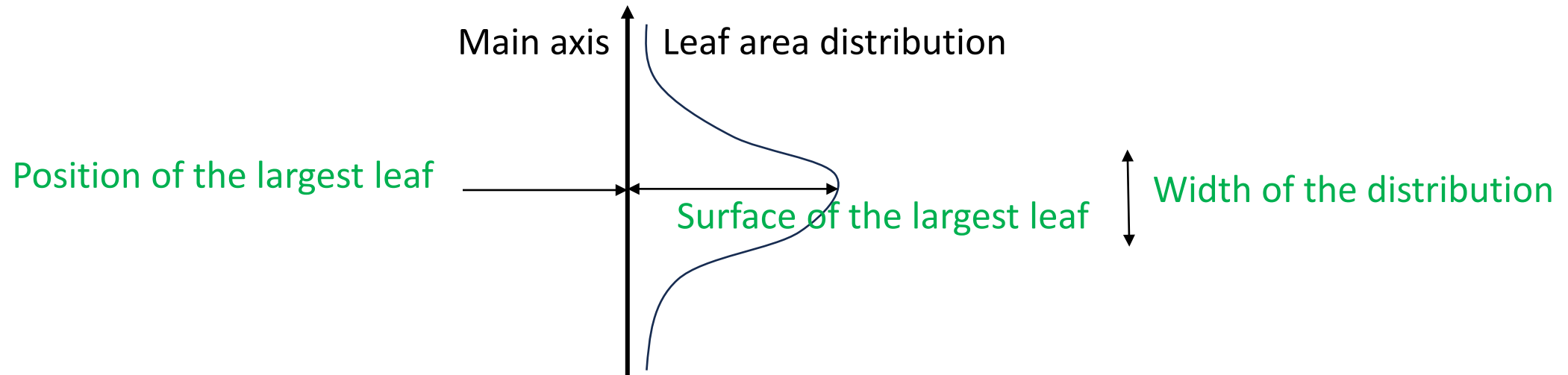
Construction of the Colzette architectural model

Input variable

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Output variable

- (1) User set total leaf area
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- (3) Total leaf area is distributed along main axis (bell-shaped function)





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- (5) 3D leaf geometry = allometric ratio **leaf length/width**



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Construction of the Colzette architectural model

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- (5) 3D leaf geometry = allometric ratio **leaf length/width**
- (6) **Light captured at leaf scale** = ray tracing model Caribu

Chelle et al. 2004



Method Simulation Plan

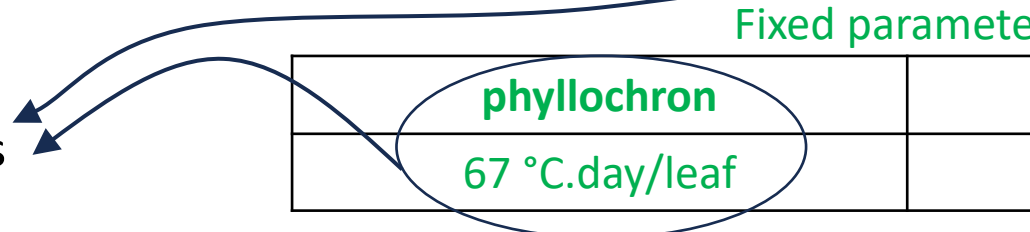
Input variable

Total leaf area	degree.days
300 cm ²	950 °C.day

Fixed parameters

phyllochron	phyllotaxy angle
67 °C.day/leaf	137,5°

14 leaves





Method Simulation Plan

Input variable


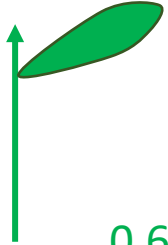
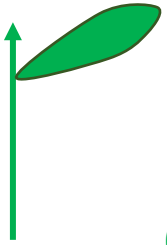
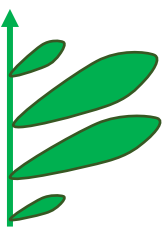
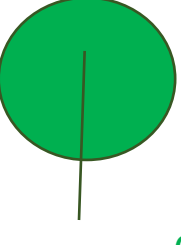
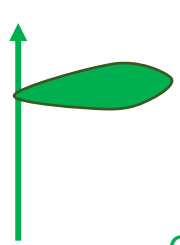



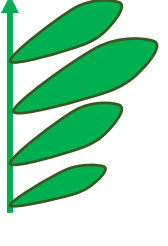
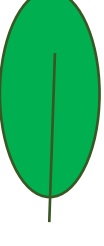
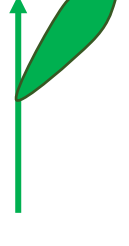
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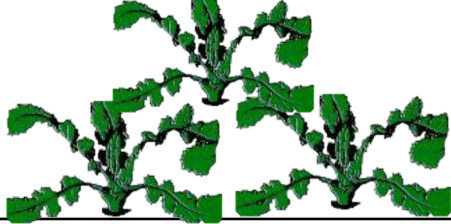


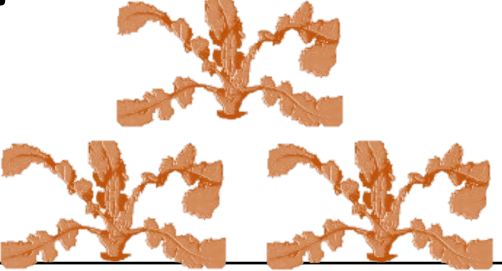
14 leaves

Parameters for 2 contrasting phenotypes

	Position of largest leaf on main axis	Surface of the largest leaf	width of the distribution	Width to Length leaf coefficient	Petiole angle to main axis
Experimental data from plants in Isolated conditions 1 pl/m ² 	 0.66	 0.12	 0.24	 0.83	 60
High density stand 36 pl/m ² 	 0.57	 0.17	 0.28	 0.37	 30



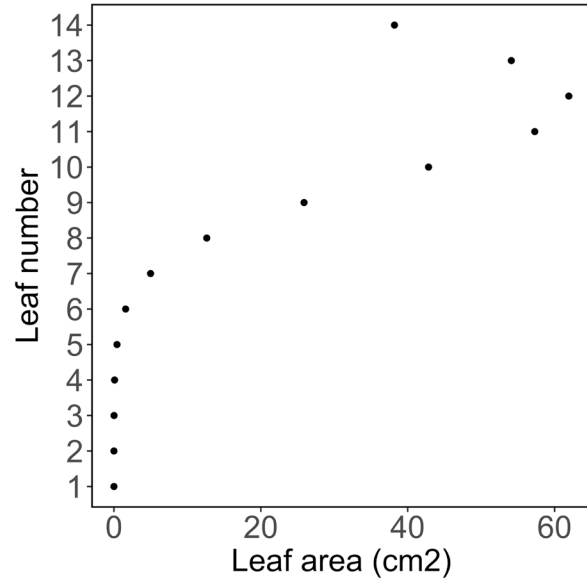
Method Simulation Plan

<i>Light captured at leaf scale</i> Phenotype	Sowing pattern	Isolated plant (1pl/m²)	High density stand (36pl/m²)	
			Row	Homogeneous
Isolated phenotype				
High density phenotype				

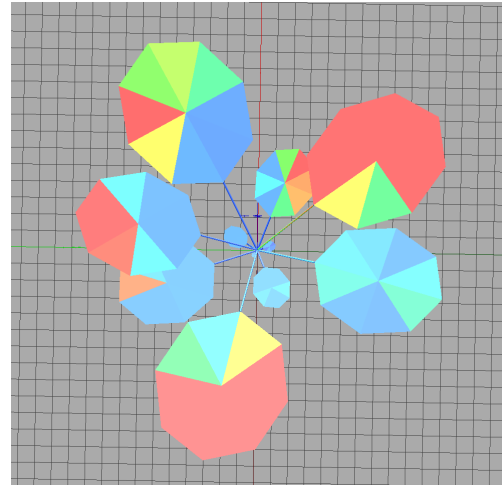


Simulation Results

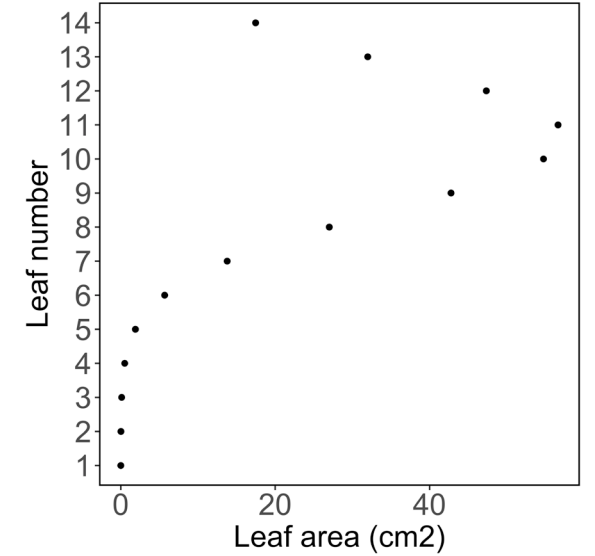
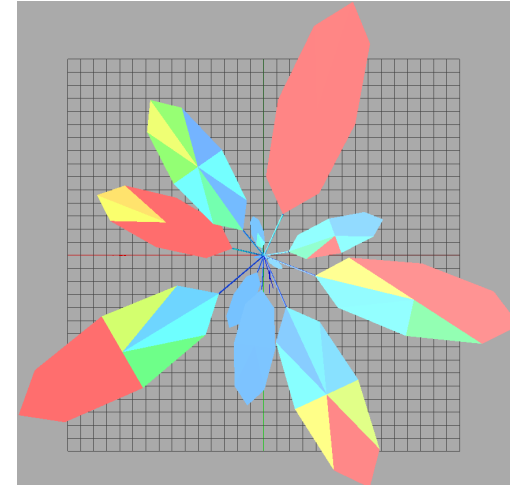
Light captured in condition of isolated plant for the 2 phenotypes (1 plant/m²)



Isolated phenotype



High density phenotype



Total light captured: 313

Total light captured: 408



-23% of light captured with the isolated phenotype compared to high density phenotype



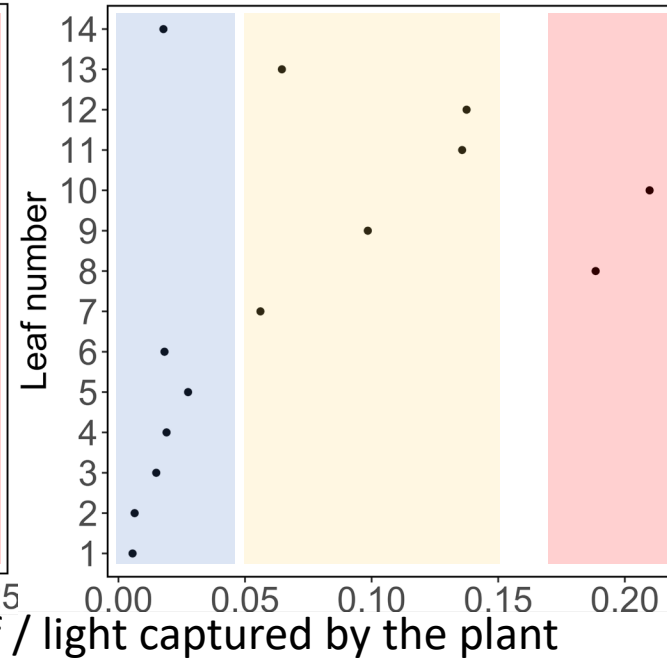
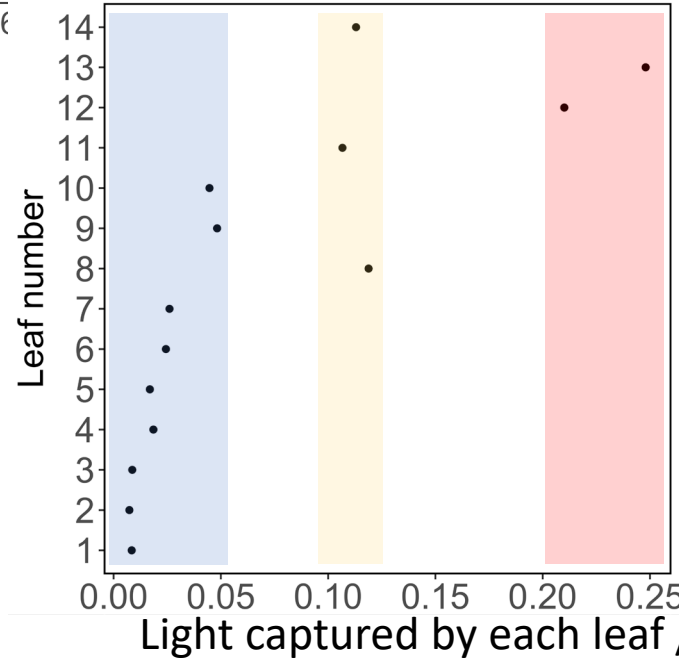
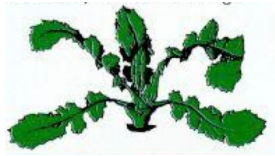
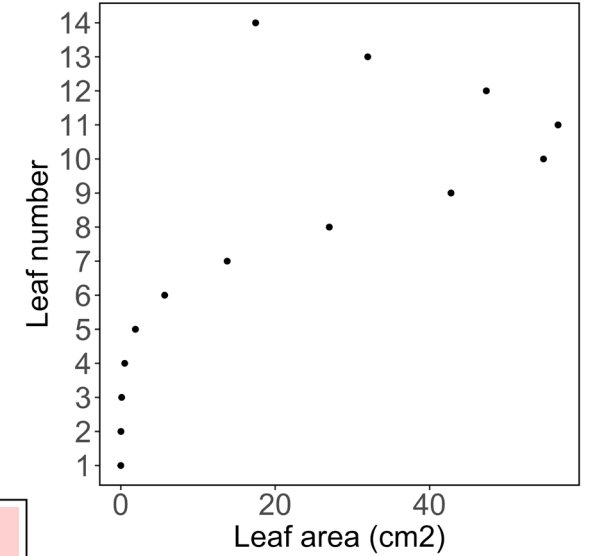
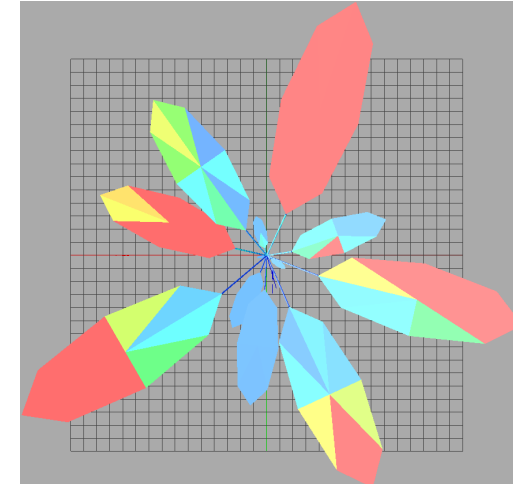
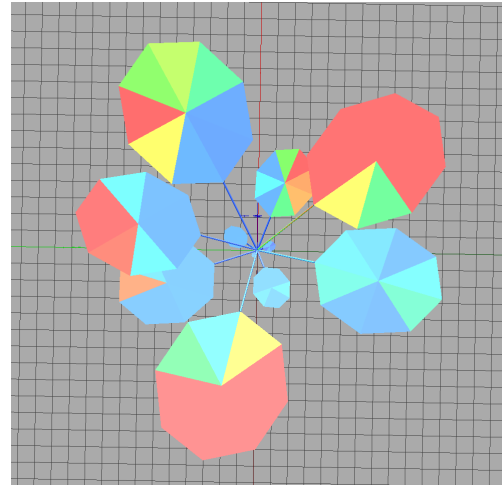
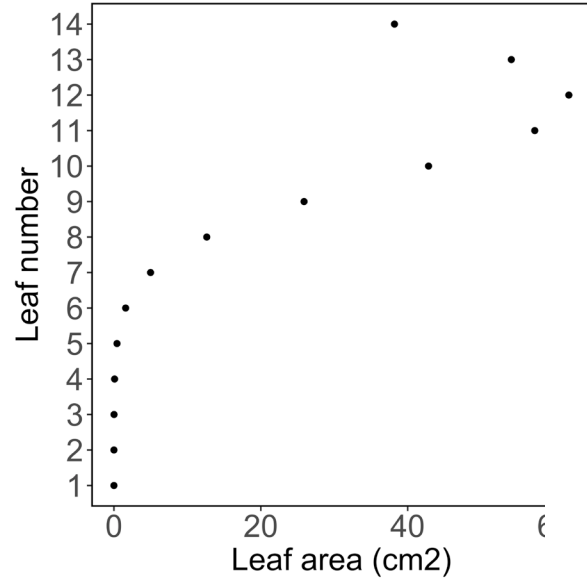


Simulation Results

Light captured in condition of isolated plant for the 2 phenotypes (1 plant/m²)

Isolated phenotype

High density phenotype

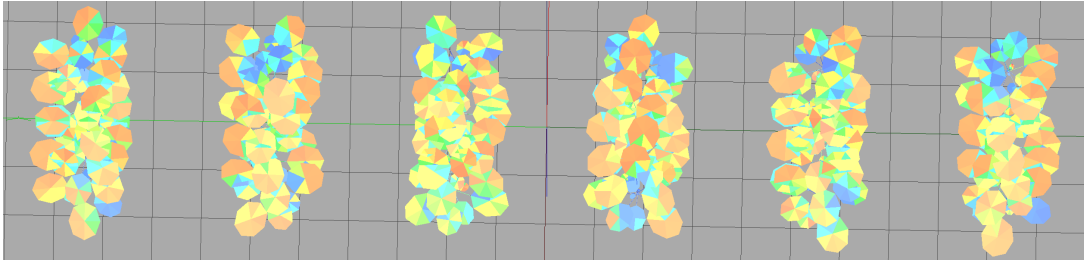




Simulation Results

Light captured in condition of dense stand for the 2 phenotypes (36 plants/m² in rows)

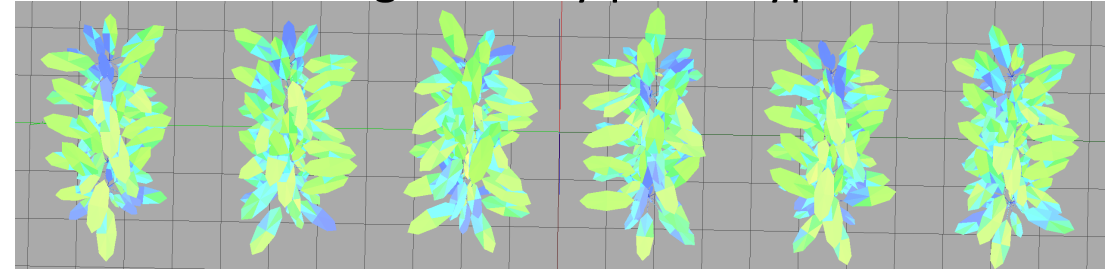
Isolated phenotype



Total light absorbed: 12158



High density phenotype



Total light absorbed: 14767

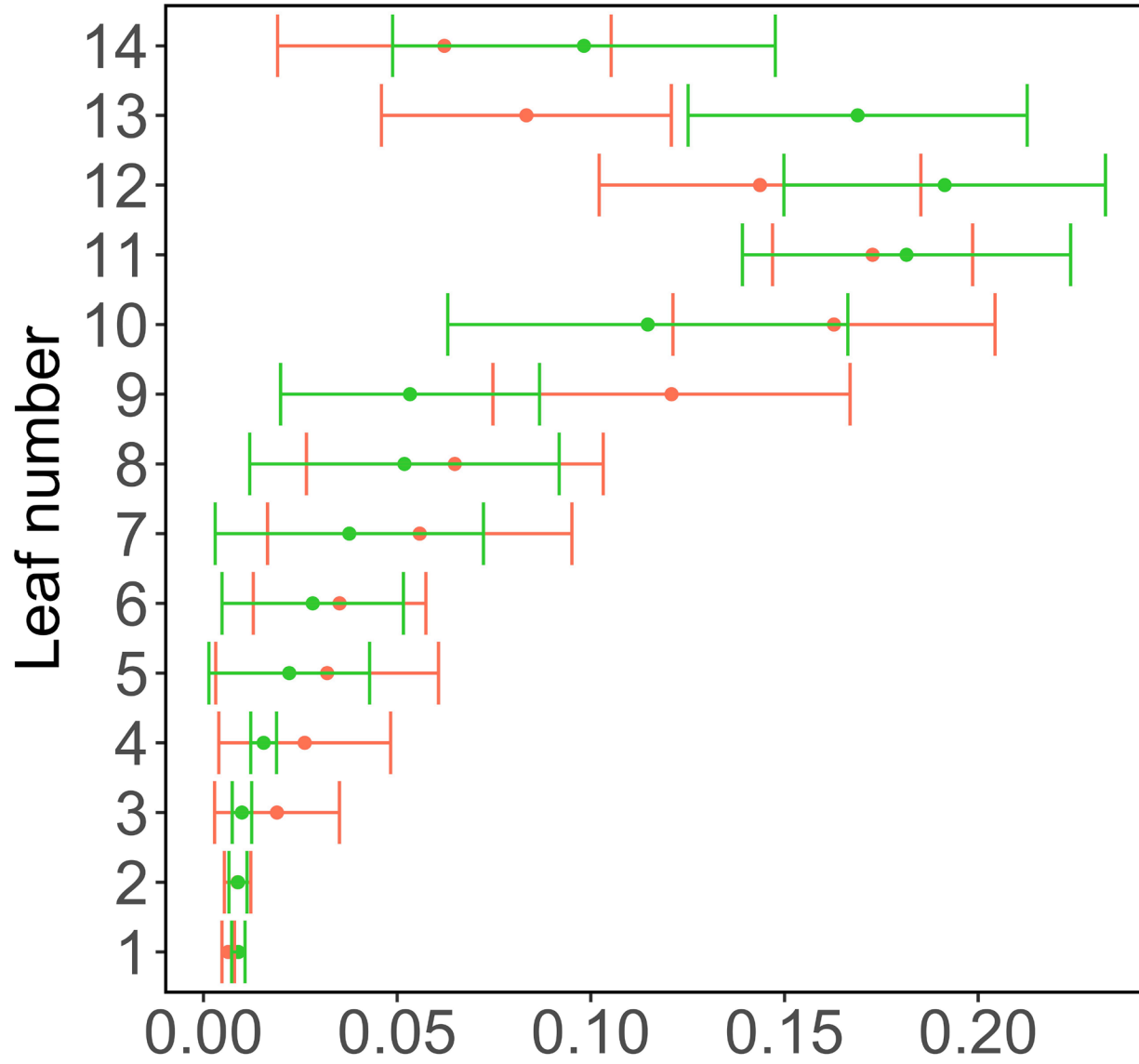


-18% of light captured with the isolated phenotype compared to high density phenotype



Simulation Results

Light captured in condition of dense stand for the 2 phenotypes (36 plants/m² in rows)



Isolated phenotype



High density phenotype



Mean light captured by each leaf / mean light captured by the plant and standard deviation

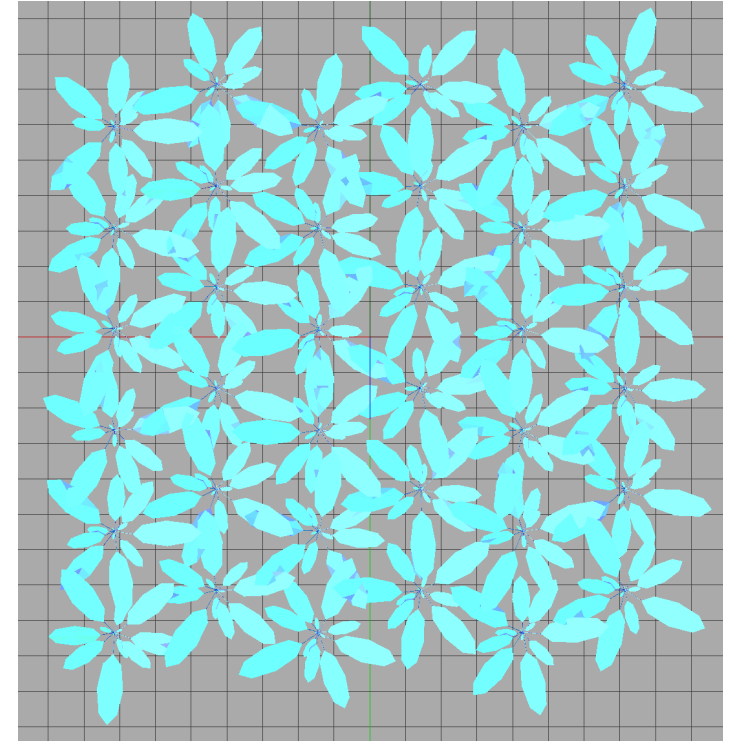
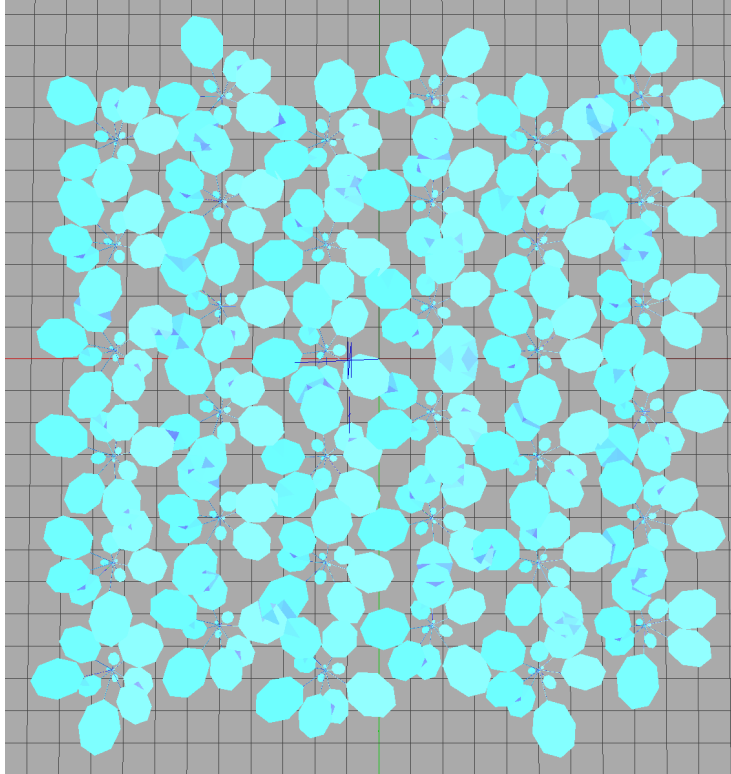


Simulation Results

Light captured in condition of dense stand for the 2 phenotypes (36 plants/m² homogeneous)

Isolated phenotype

High density phenotype



Total light absorbed: 32104

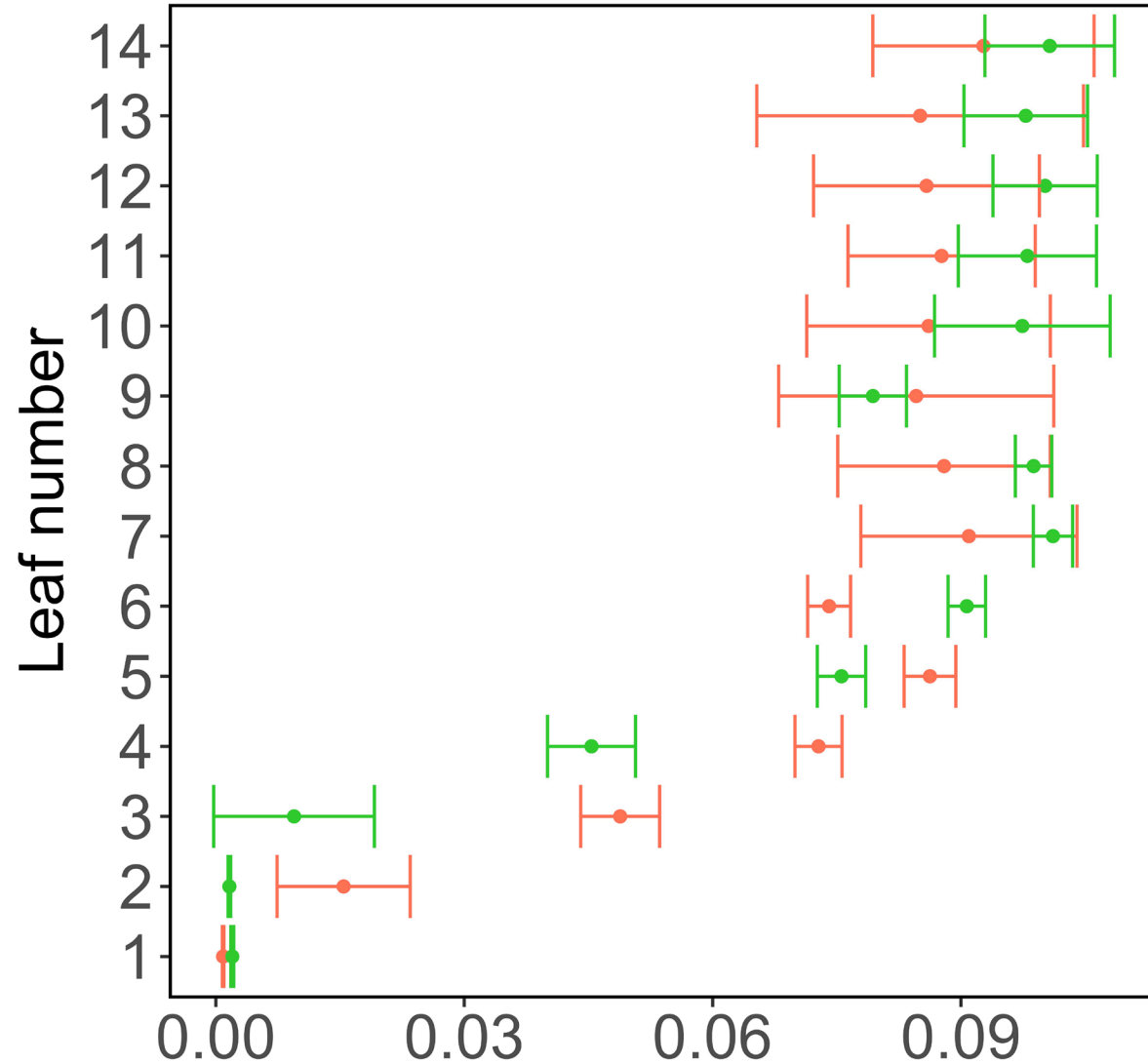
Total light absorbed: 33897

-5% of light captured with the isolated phenotype compared to high density phenotype

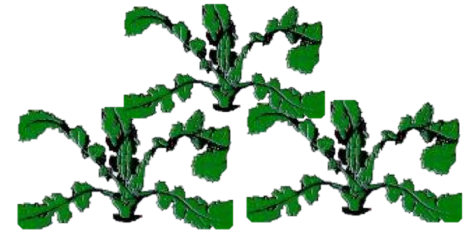


Simulation Results

Light captured in condition of dense stand for the 2 phenotypes (36 plants/m² homogeneous)



Isolated phenotype



High density phenotype

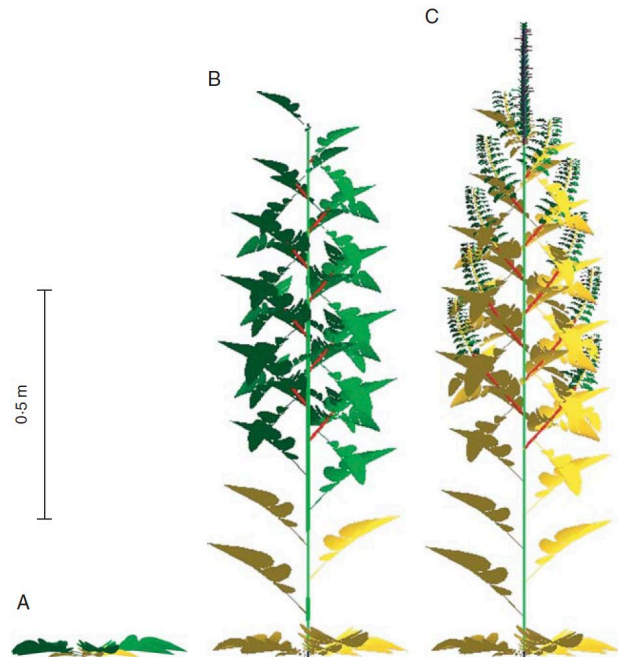


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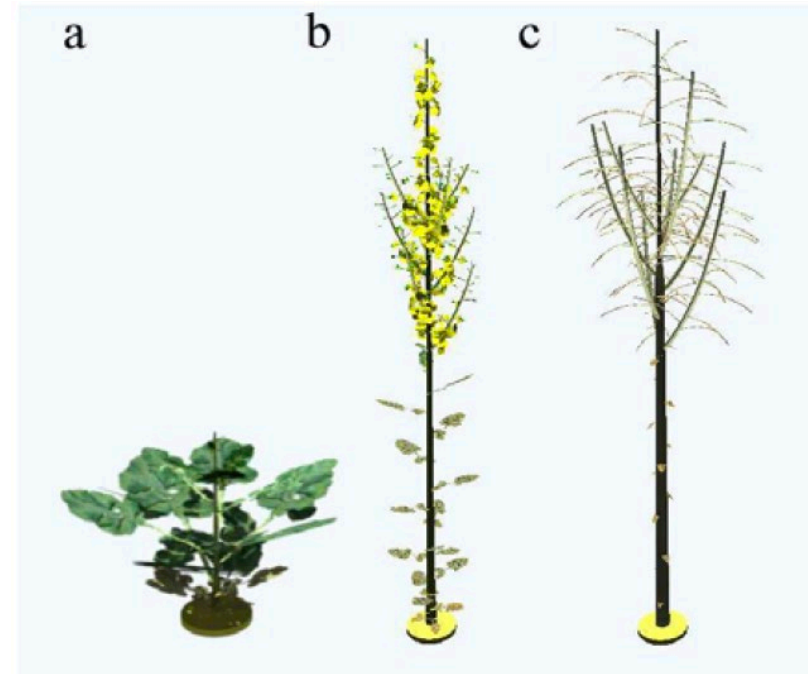
Discussion and conclusion

- First structural model with light capture for WOSR at autumnal stage → develop the model through the entire crop cycle



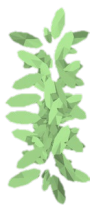
RGLD
Jullien et al. 2010

2D model



Groer et al. 2007

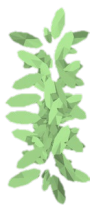
Later stages
No ray-tracing



Discussion and conclusion

- First structural model with light capture for WOSR at autumnal stage → develop the model through the entire crop cycle
- Tested two architecture phenotypes regarding their light capture to identify vigorous plants in different sowing pattern
 - High density phenotype was more efficient to capture light in all sowing pattern
 - High interaction between sowing pattern and light capture efficiency Weiner et al 2001

Necessity to add C metabolism (photosynthesis) in the model to conclude about vigour



Discussion and conclusion

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Necessity to add C metabolism (photosynthesis) in the model to conclude about vigour

- Useful tool for breeding and management of phenotypes regarding light capture efficiency.
In this study: architecture and sowing pattern
In the future: cultivar mixtures



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