

The response of weed and crop species to shading: Measurement and prediction from traits



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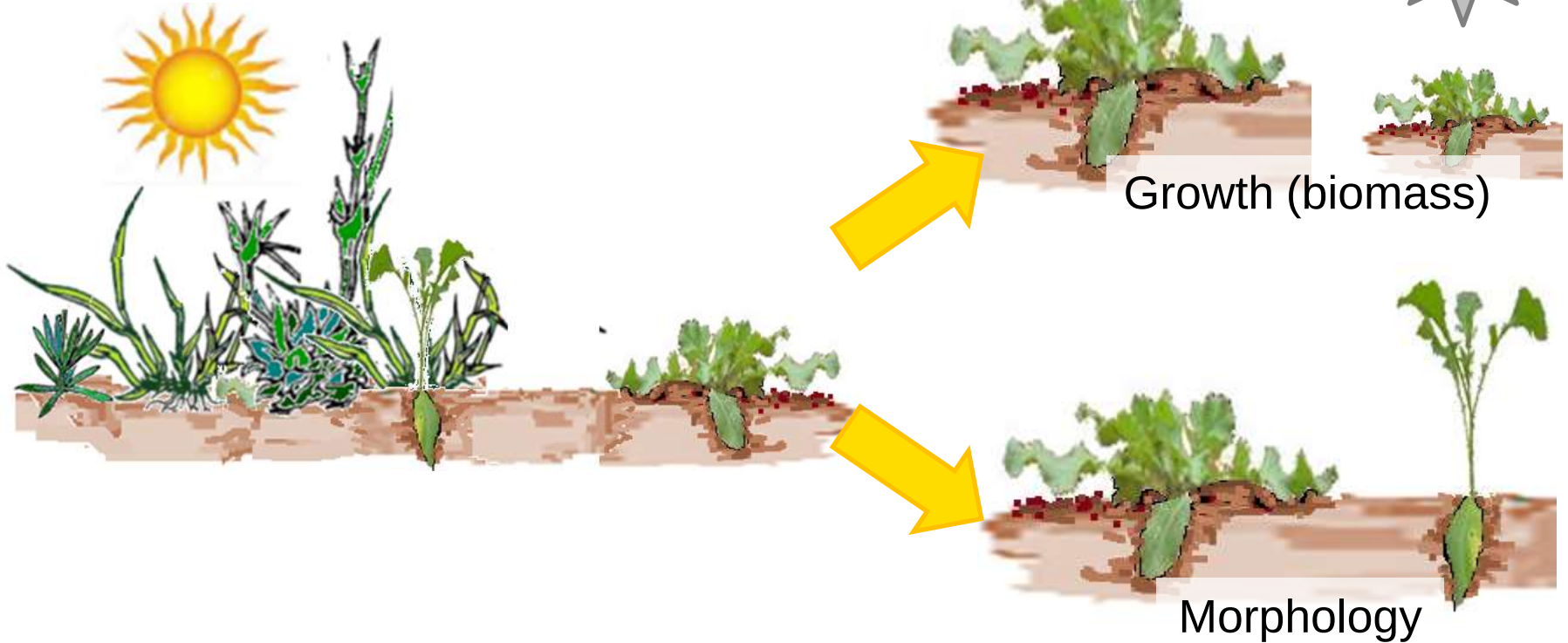
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Context & objectives

Light availability varies
in crop:weed canopy



Context & objectives

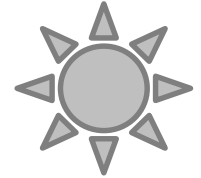
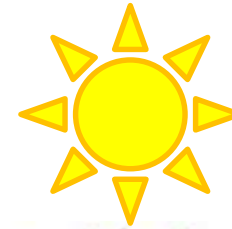
Integrated weed management
→ Crop choice = lever

Which crop traits drive weed control?

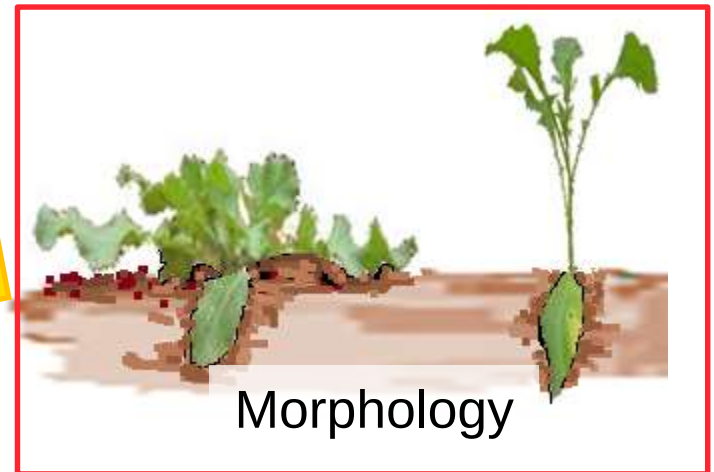
Which crop traits reduce yield loss due to weeds?



Effect of shading



Growth (biomass)



Morphology

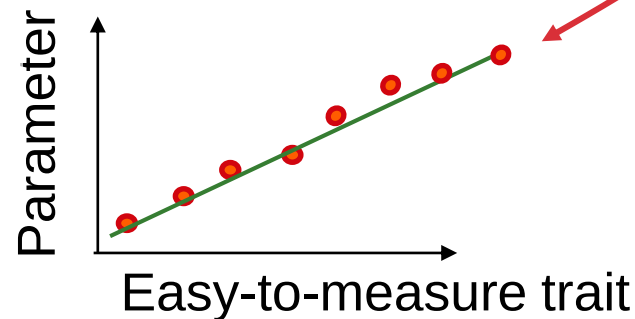
Which weed traits drive yield loss?

The different steps

1. **Measure** the **parameters** that drive light competition in contrasting crop and weed species



2. Estimate the parameters from easily measured traits with **functional relationships**

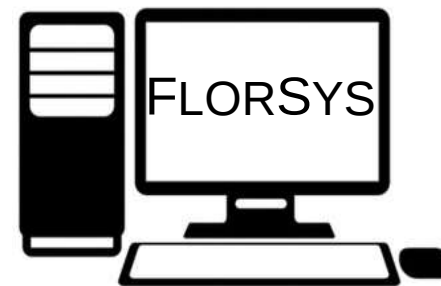


3. Run **virtual experiments**

Which crop traits drive weed control?

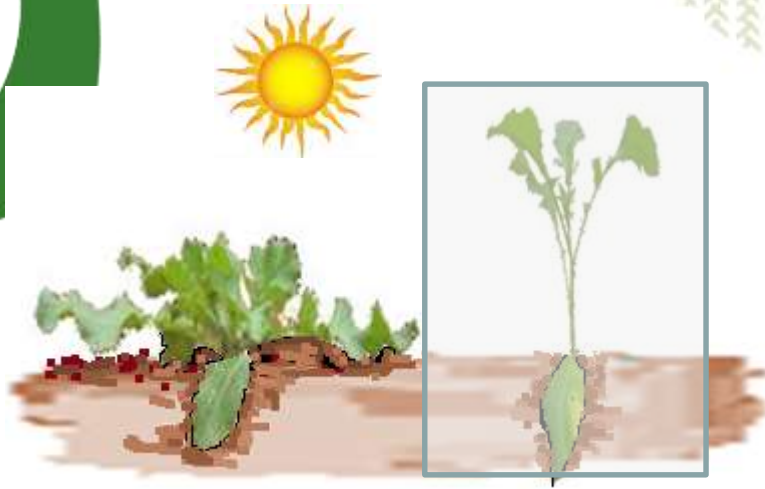
Which crop traits reduce yield loss to weeds?

Which weed traits drive yield loss?



Colbach N, Moreau D, Dugué F, Gardarin A, Strbik F, Munier-Jolain N (submitted) The response of weed and crop species to shading. 1. How to predict their morphology and plasticity from species traits and ecological indexes? Eur J Agron

1. Garden plot experiments



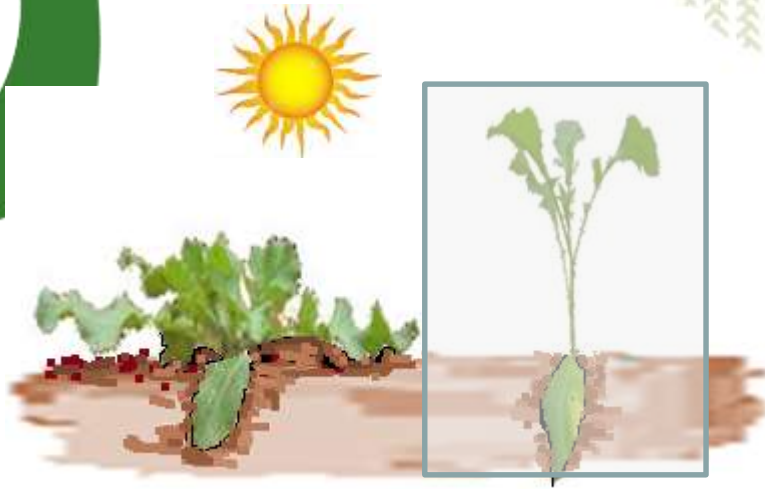
16 families

33 weed species

26 crop species (10 cash, 16 cover)

(3 wheat varieties, 3 pea varieties, 2 field bean varieties)

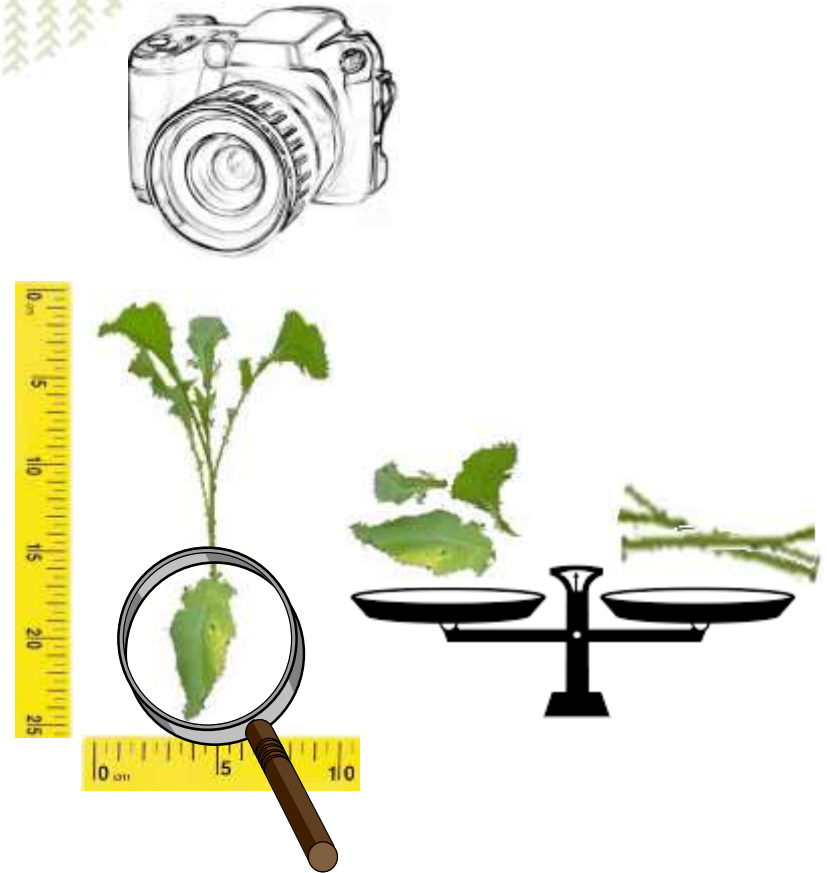
1. Garden plot experiments



Measurements

- Plant height and width
- Leaf area
- Leaf biomass
- Above-ground biomass
- Leaf area profile

5 stages

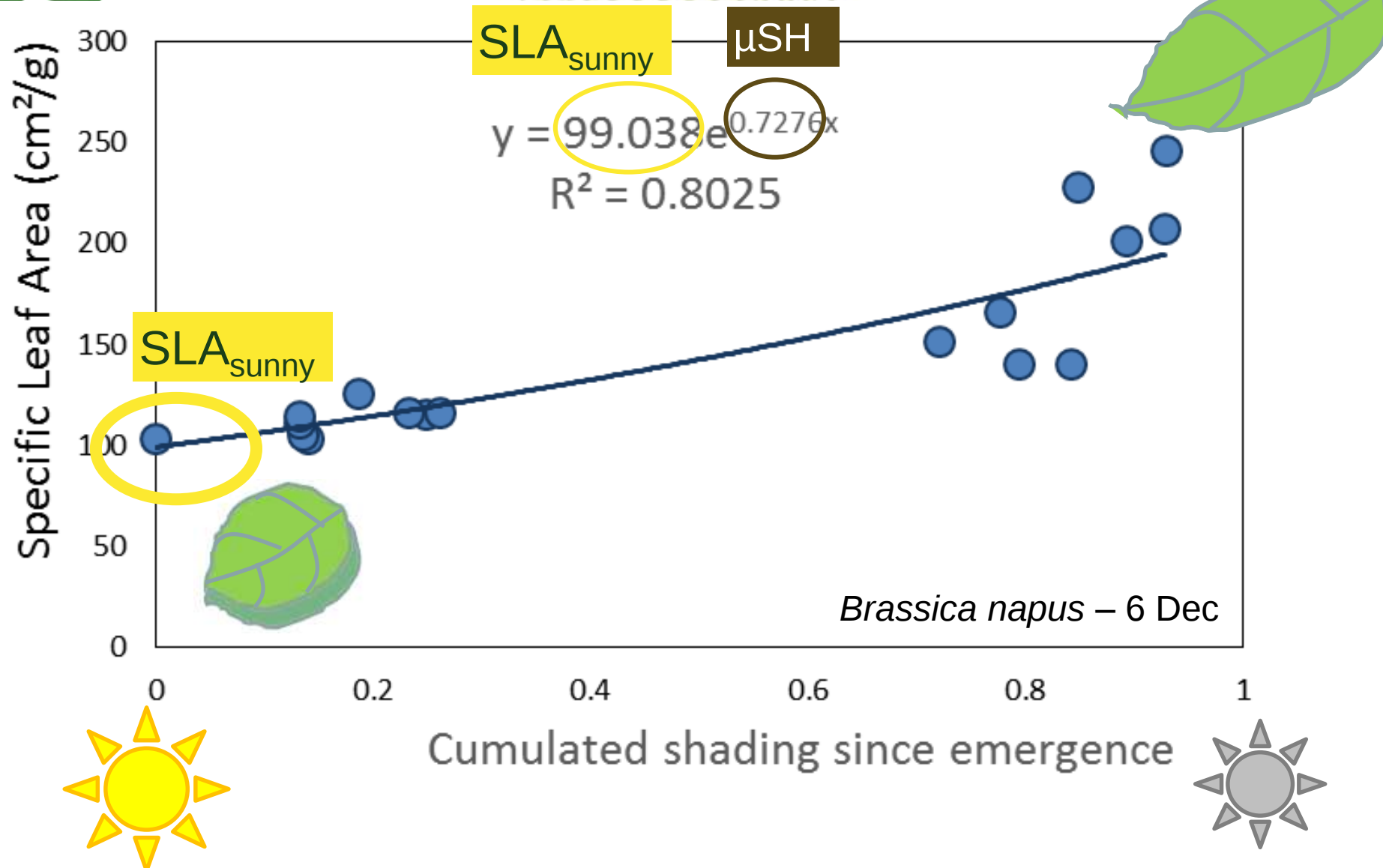


ading. 1. How

Colbach N, Moreau D, Dugué F, Gardarin A, Strbik F, Munier-Jolain N (submitted) T to predict their morphology and plasticity from species traits and ecological indexes?

Introduction – Material & methods – **Experiments** – Functional relationships – Simulations – Conclusion

Concept for shading response parameter



Colbach N, Collard A, Guyot SHM, Mézière D, Munier-Jolain NM (2014). Eur J Agron 53:74-89.

Munier-Jolain NM, Collard A, Busset H, Guyot SHM, Colbach N (2014) Field Crops Research 155:90-98.

Results: Shading reponse strategies



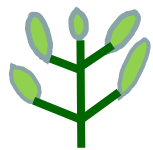
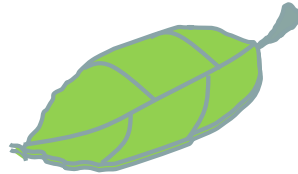
Initial leaf area
RGR

Grow fast to occupy space



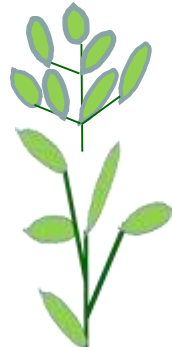
SLA
 μ_{SLA}

Increase light interception area
with thinner larger leaves



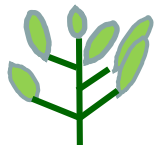
LBR
 μ_{LBR}

Increase light interception area by
increasing leaf biomass to the detriment
of stem biomass



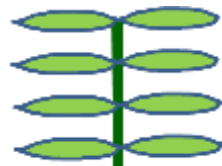
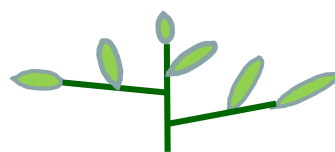
HM
 b_{HM}
 μ_{HM}

Reach light by increasing plant height



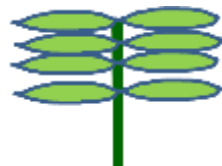
WM
 b_{WM}
 μ_{WM}

Avoid shade cast by neighbour by
growing laterally

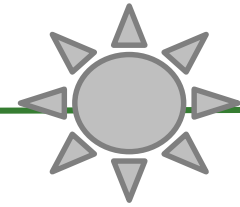


RLH
 b_{RLH}
 μ_{RLH}

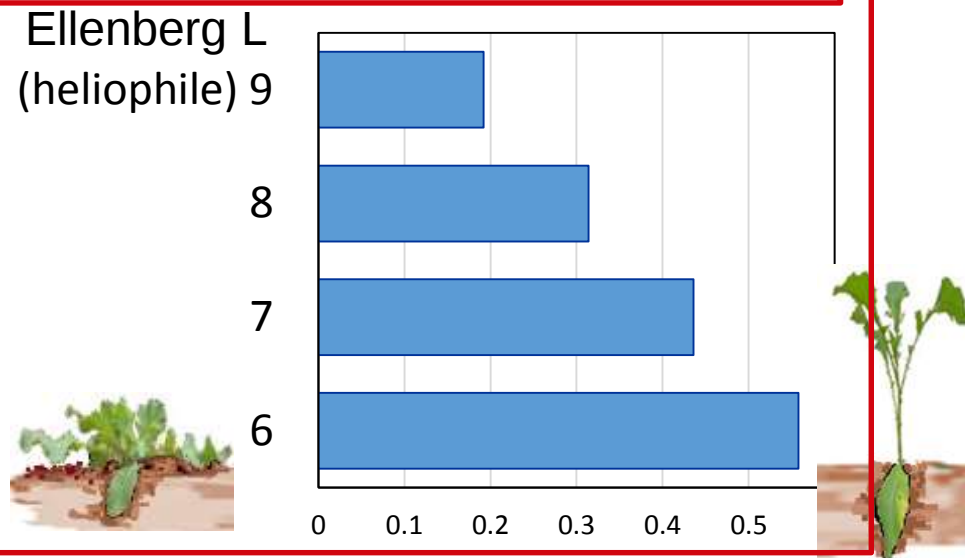
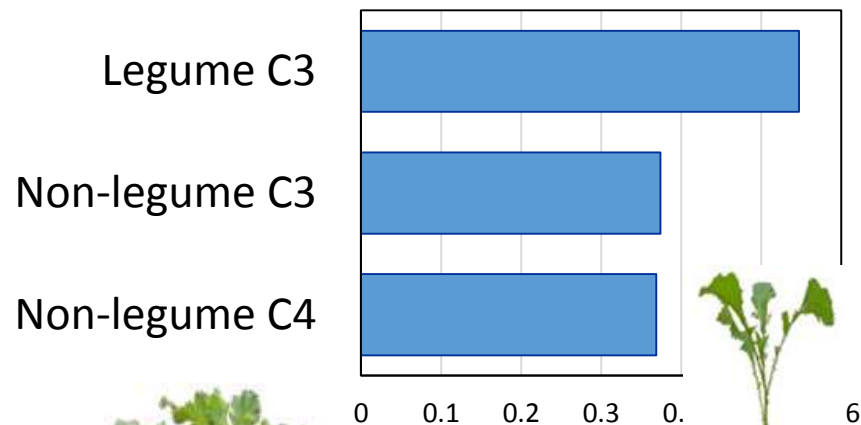
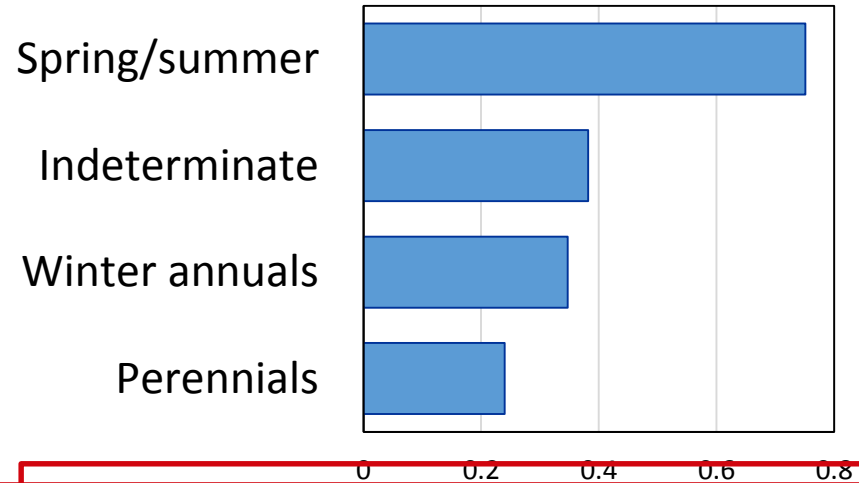
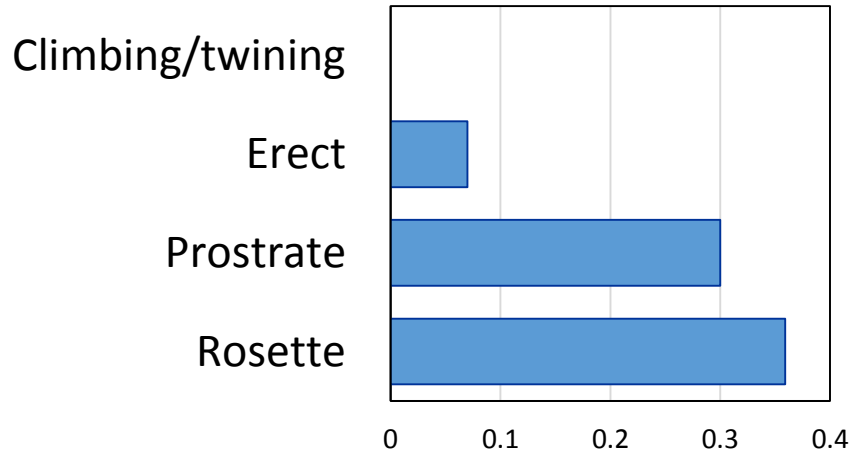
Reach light by moving leaf area
toward the top



2. Functional relationships



Etiolating ability μ_{HM}



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3. Virtual experiments

Identify farmers' practices

272 cropping systems

7 regions

Surveys, Biovigilance, advisors, design...



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3. Virtual experiments

Identify farmers' practices

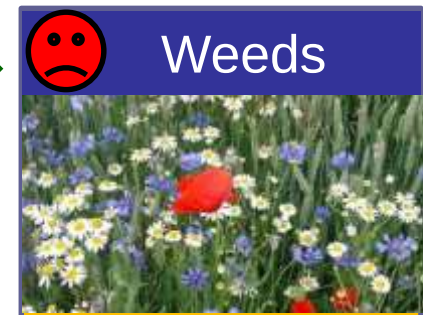
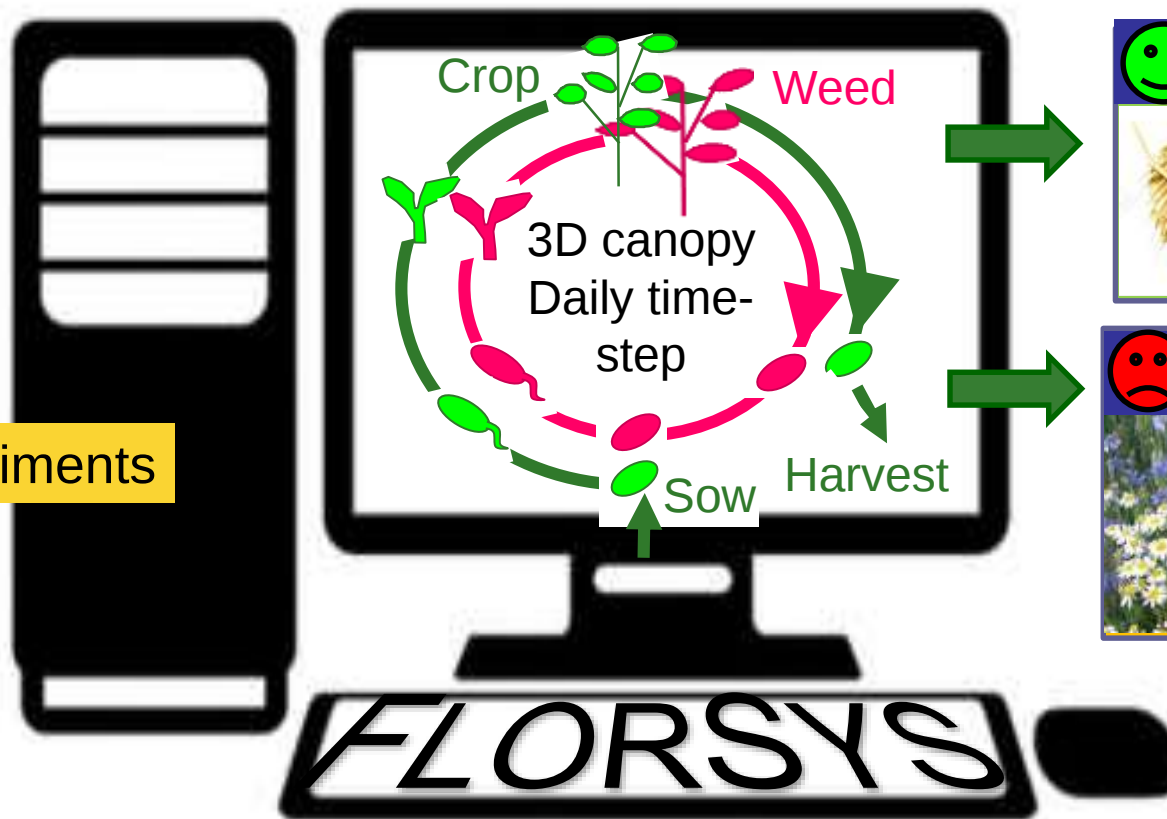
272 cropping systems

7 regions

Surveys, Biovigilance, advisors, design...



Virtual experiments



Colbach et al (2006, 2010, 2014) Eur J Agron, Colbach et al (2007) Ecol Mod; Colbach et al. (2014) Soil Till Res; Weed Res; Colbach et al (2017) Ecol Indic; Gardarin et al. (2012) Ecol Mod; Munier-Jolain et al (2013) Ecol Mod, (2014) Field Crops Res; Mézière et al 2015 Ecol Indi

3. Virtual experiments

Identify farmers' practices

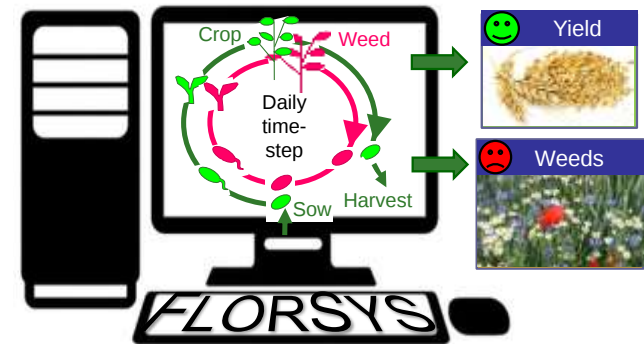
272 cropping systems

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Virtual experiments



Scenario	Herbicide	Weeds
Reference	Farmers' practices	Regional flora
Weed-free	Farmers' practices	None

Yield loss due to crop:weed competition for light

Simulation plan (30 years x 10 weather repetitions)

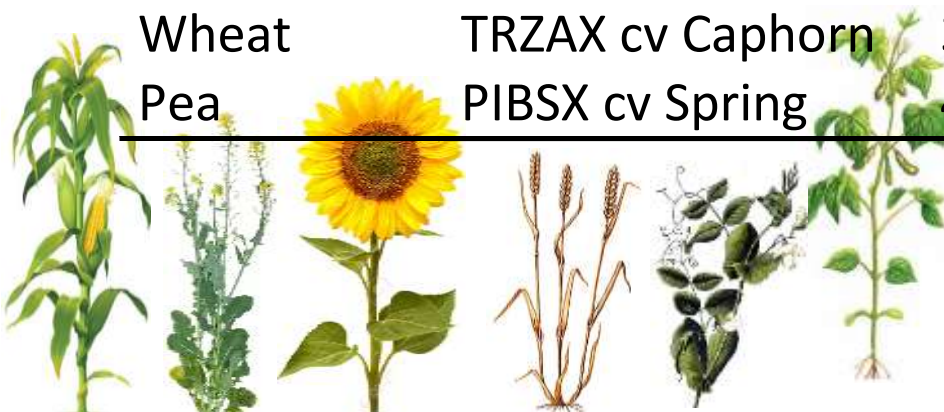
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The crops with the lowest yield loss

Yield loss due to crop:weed competition for light

Crop species		N	Variation in Yield loss (100t/t)	
Maize	ZEAMX	17342	-31.4	a
Oilseed rape	BRSNN	10452	-26.8	b
Sunflower	HELAN	3127	-1.7	d
Wheat	TRZAX cv Cézanne	18187	0.4	e
Triticale	TTLSS	655	0.5	e
Wheat	TRZAX cv Orvantis	3939	0.9	e
Soybean	GLXMA	689	4.3	f
Pea	PIBSX cv Enduro	446	7.7	fgh
Wheat	TRZAX cv Caphorn	3028	11	h
Pea	PIBSX cv Spring	4340	26.9	i

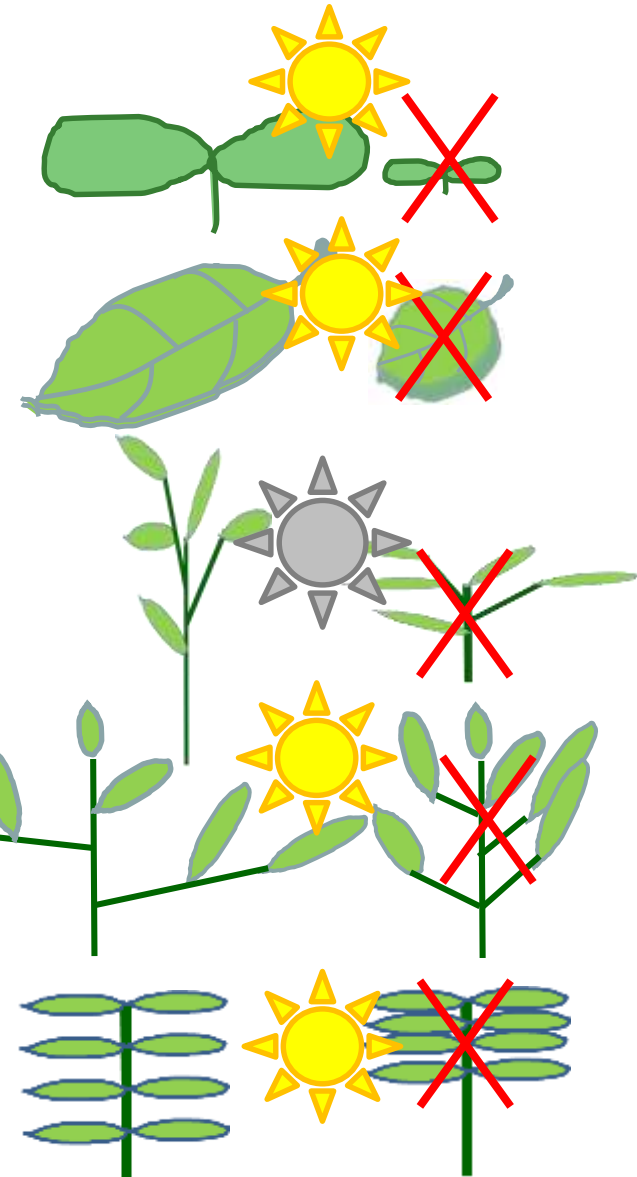
(average of all cropping systems, regions, days & weather repetitions)



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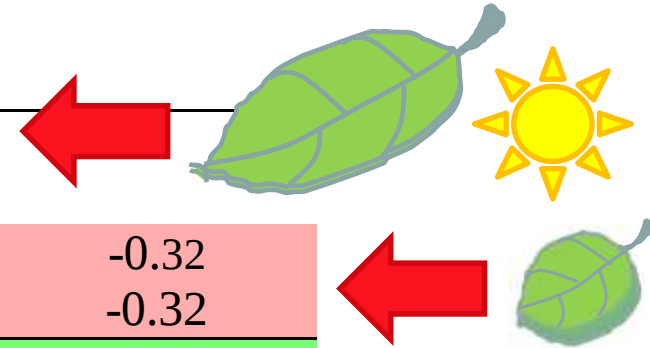
The crop traits that reduce yield loss

Crop species parameters		Stage (BBCH)	Yield loss
RGR	Relative growth rate	0	-0.33
LA0	Leaf area at emergence	0	-0.33
SLA0	Specific leaf area	1-3	-0.35
		5-7	
		8	
		9-10	
LBR0	Leaf biomass ratio	0-4	
HM0	Specific plant height	0-6	
b_HM	HM of light vs heavy plants	8-10	
HM_mu	Specific plant height	2-4	-0.32
		5-8	
WM0	Specific plant width	4-10	-0.36
b_WM	WM of light vs heavy plants	7-8	-0.32
WM_mu	Specific plant width	1	-0.34
RLH0	Median leaf height	4-5	
b_RLH	Unevenness of leaf distribution	5-6	0.32
		8-10	
RLH_mu	Median leaf height	0-3	
		9-10	



The crop traits that increase potential yield

Crop species parameters		Stage (BBCH)	Yield loss	Potential yield (MJ/ha)
RGR	Relative growth rate	0	-0.33	
LA0	Leaf area at emergence	0	-0.33	
SLA0	Specific leaf area	1-3	-0.35	
Trade-off between traits that - Reduce weed infestation - Increase yield potential				-0.32
				-0.32
				0.56
LBR0				
HM0	Specific plant height	0-3		
b_HM	HM of light vs heavy plants	8-10		+0.35
HM_mu	Specific plant height	2-4	-0.32	
		5-8		0.42
WM0	Specific plant width	4-10	-0.36	
b_WM	WM of light vs heavy plants	7-8	-0.32	
WM_mu	Specific plant width	1	-0.34	
RLH0	Median leaf height	4-5		-0.38
b_RLH	Unevenness of leaf distribution	5-6	0.32	
		8-10		0.48
		0-3		-0.45
RLH_mu	Median leaf height	9-10		-0.37



Conclusion

Traits and processes that drive competition for light

- Competition: occupy space early and fast rather than disturb or avoid neighbours
- Trade-off between competition and potential production



Practical implications

- Ecologists: traits of successful weed species
- Farmers: rules for choosing crops in rotation
- Seed breeders: guidelines for improving varieties



Limits

- Model limited to crop:weed competition for light (*but see Moreau*)



Perspectives

- Crop mixtures
 - Crop ideotypes
- that reconcile weed control and potential production



Thank you for your attention

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Colbach N, Busset H, Roger-Estrade J, Caneill J (2014) Predictive modelling of weed seed movement in response to superficial tillage tools. Soil Tillage Res 138:1-8

Colbach N, Collard A, Guyot SHM, Mézière D, Munier-Jolain NM (2014) Assessing innovative sowing patterns for integrated weed management with a 3D crop:weed competition model. Eur J Agron 53:74-89.

doi:<http://dx.doi.org/10.1016/j.eja.2013.09.019>

Gardarin A, Dürr C, Colbach N (2012) Modeling the dynamics and emergence of a multispecies weed seed bank with species traits. Ecol Modelling 240:123-138. doi:<http://dx.doi.org/10.1016/j.ecolmodel.2012.05.004>

Munier-Jolain NM, Collard A, Busset H, Guyot SHM, Colbach N (2014) Modelling the morphological plasticity of weeds in multi-specific canopies. Field Crops Research 155:90-98. doi:<http://dx.doi.org/10.1016/j.fcr.2013.09.018>

Munier-Jolain NM, Guyot SHM, Colbach N (2013) A 3D model for light interception in heterogeneous crop:weed canopies. Model structure and evaluation. Ecol Modelling 250:101-110.

doi:<http://dx.doi.org/10.1016/j.ecolmodel.2012.10.023>

