European Scientific Conference

June 02 and 03, 2022 – Towards Pesticide Free Agriculture

Co-production of knowledge, tools and solutions for agroecological weed management

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Production

Damage

Biodiversity

Reservoir for crop auxiliaries

Production

Damage

Biodiversity

Reservoir for crop auxiliaries

?

Replace 1 simple & efficient technique by combinations of partially efficient & interacting techniques

Production

Damage

Biodiversity

Reservoir for crop auxiliaries

?

Replace **1 simple** & **efficient** technique
by **combinations** of **partially** efficient & **interacting** techniques

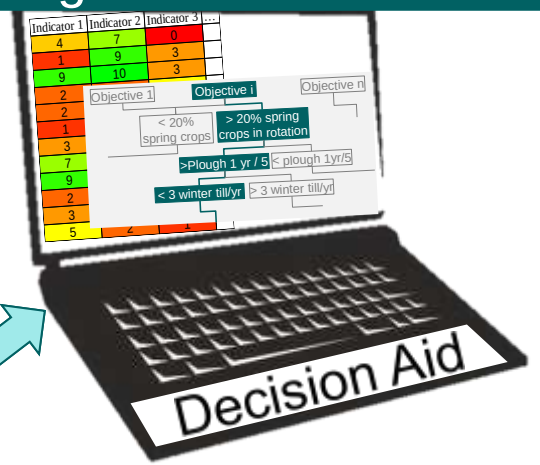
Innovations identified by research are rarely adopted by farmers

Synthesise knowledge

Analyse processes

What is missing?

Organise decision rules



How to take decisions?

Design cropping systems

Synthesise knowledge

Model and code

Run virtual experiments

Organise decision rules

Model and code

Determine generic decision rules

Determine structure, input & output formats

Test prototypes

Test & apply methodology

Determine local decision rules

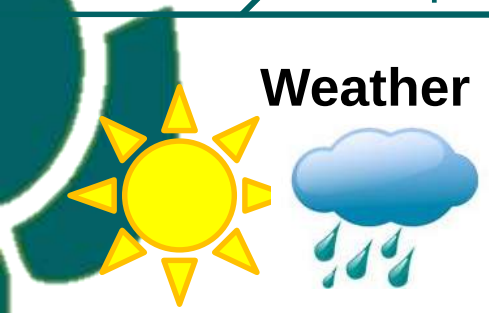
Conduct experiments

Conduct experiments

Analyse processes

Develop methodology

Design cropping systems

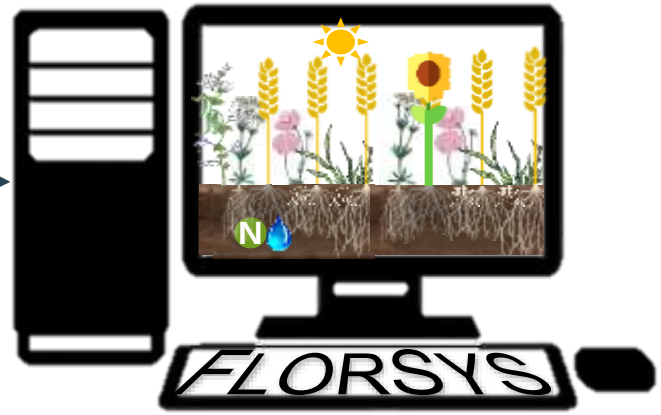


Weather

33 crop species

32 weed species

Cropping system



Soil characteristics

Biophysical processes
Daily time-step – multiannual
3D individual-based - multispecies

Detailed inputs →

Colbach et al (2014) Eur J Agron, Colbach et al (2021) Field Crops Research, Gardarin et al (2012) Ecol Modelling, Mézière et al (2015) Ecological Indicators, Munier-Jolain et al (2013) Ecol Modelling, Pointurier et al (2021) Ecol Modelling

Weather

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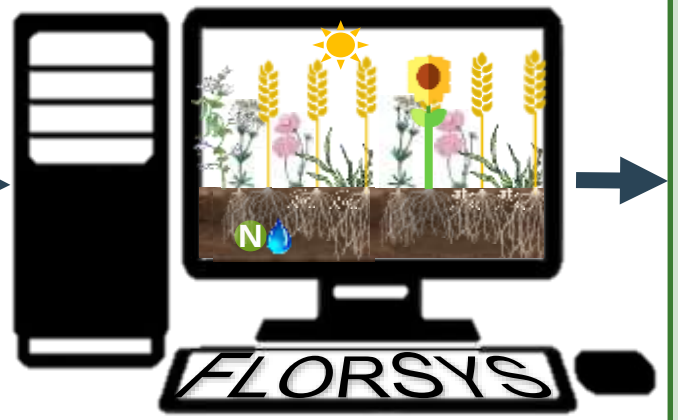
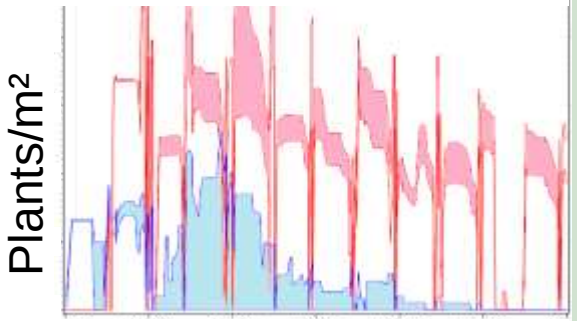


For each state variable



For each plant & day

Height
Width
Location
Depth
Width

Biomass
Leaf area
Biomass
Root length

Understand

Crop production

Weed harmfulness

Biodiversity

Indicator 1	Indicator 2	Indicator 3	…
0	0	1	
3	5	4	
0	3	1	
10	9	10	
7	8	4	
2	2	5	
4	10	9	
7	5	1	
2	2	1	
10	0	1	
7	2	2	
8	8	3	

Compare

Detailed inputs → Biophysical processes
Daily time-step – multiannual
3D individual-based - multispecies → Daily 3D outputs → Indicators

Colbach et al (2014) Eur J Agron, Colbach et al (2021) Field Crops Research, Gardarin et al (2012) Ecol Modelling,
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- Climate change → Quantify competition of weed and crop species for water
  - Which morphological traits are affected by water stress?
  - Does the effect depend on plant species?

A high throughput phenotyping platform

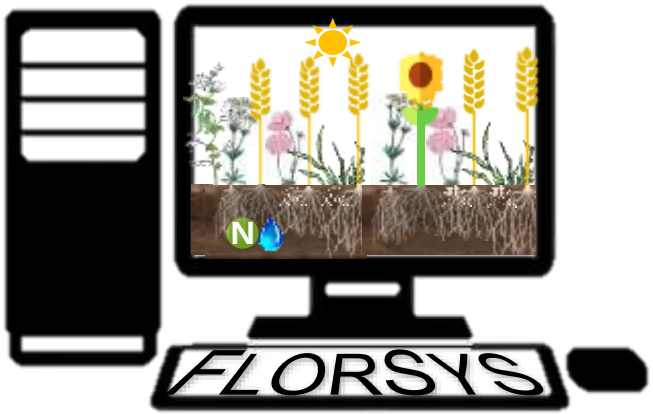
7 water regimes

7 contrasting crop & weed species

2 crops – 5 weeds
3 monocots – 4 dicots
1 summer – 5 winter annuals

Wheat
Oilseed rape
Abuthilon theophrasti
Alopecurus myosuroides
Avena fatua
Geranium dissectum
Tripleurospermum inodorum

Key morphological traits from FLORSYS model



Souche-Suchovsky (2021) M2 thesis, Moreau et al (in revision) Weed Res

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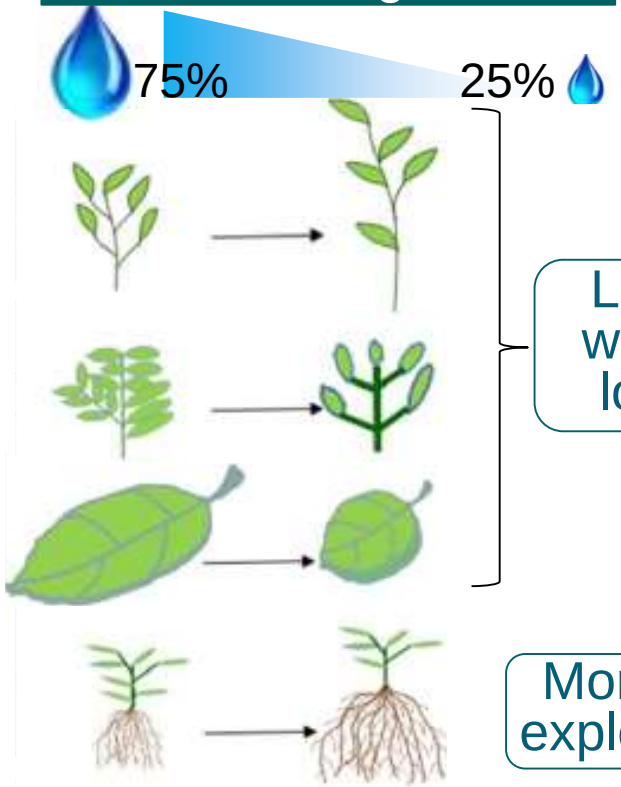
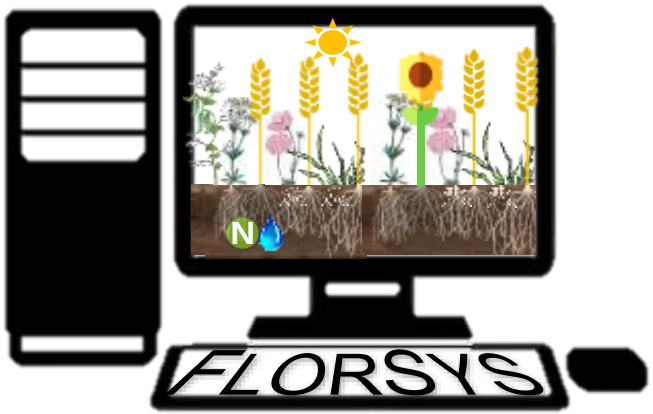
7 water regimes



No systematic ≠
- Weeds vs crops
- Mono vs dicots
- Sampling dates

Next step = introduce into FLORSYS model

Key morphological traits from FLORSYS model



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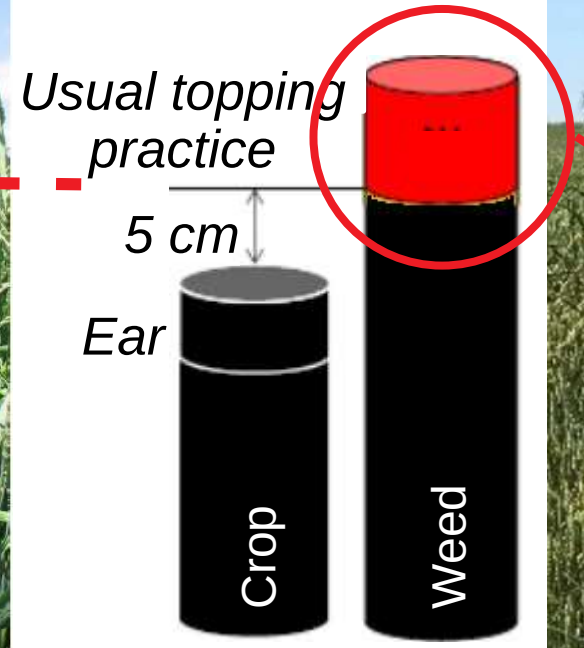
- Crop "topping" → limit weed seed return to soil seed bank ("protect" future crops)

Alopecurus myosuroides



Crops:
- Winter wheat (N=9)
- Spring barley / spring pea (N=2)

Number of seeds
Viability/germinability

Cordeau et al (2022)

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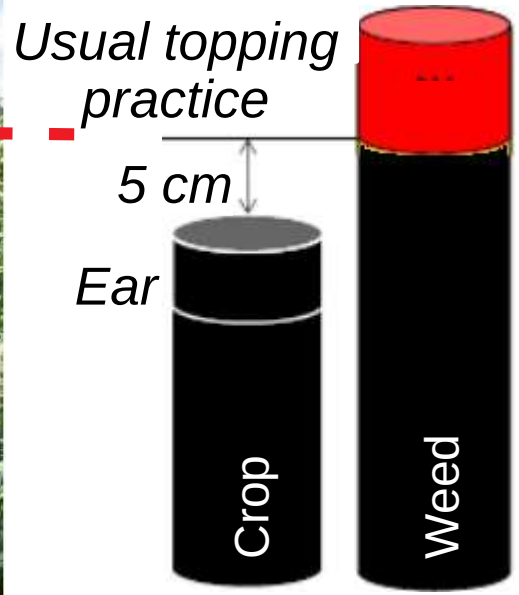
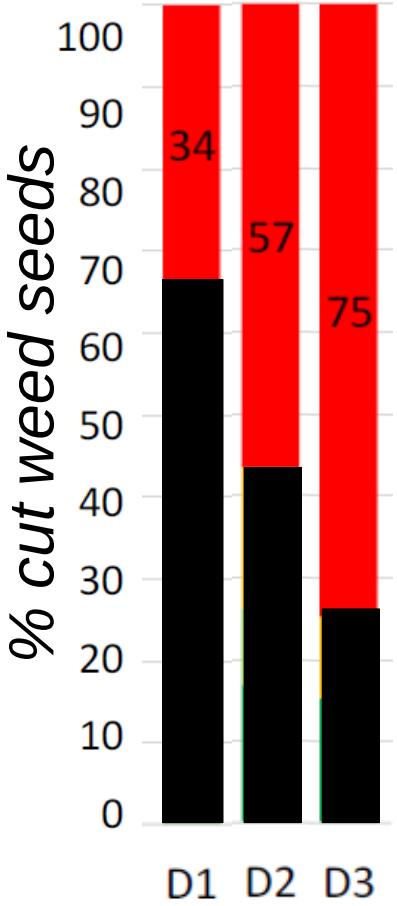
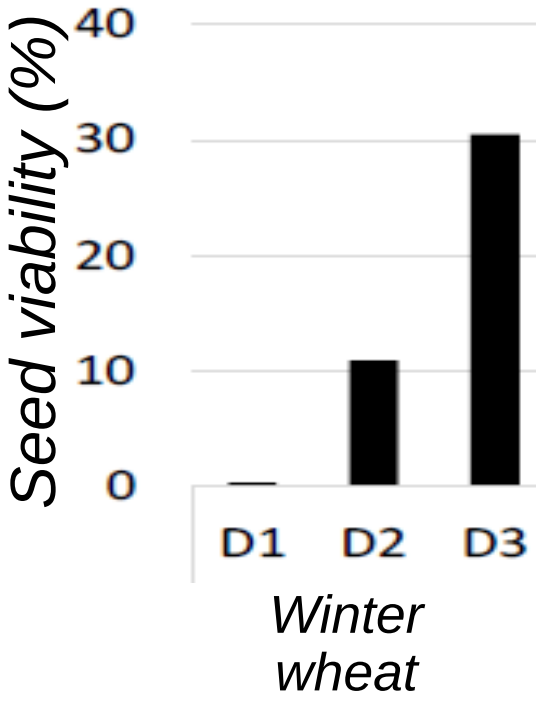


"Toppable" amount can ↗ with time



BUT Viability ↗ with time



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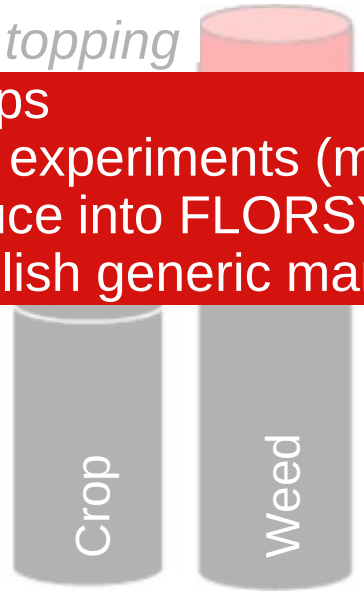
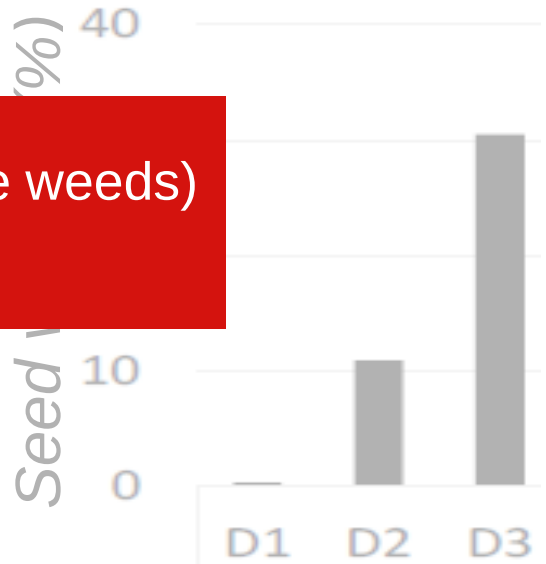
Usual topping



"Toppable" amount can ↗ with time

Northern France

BUT Viability ↗ with time

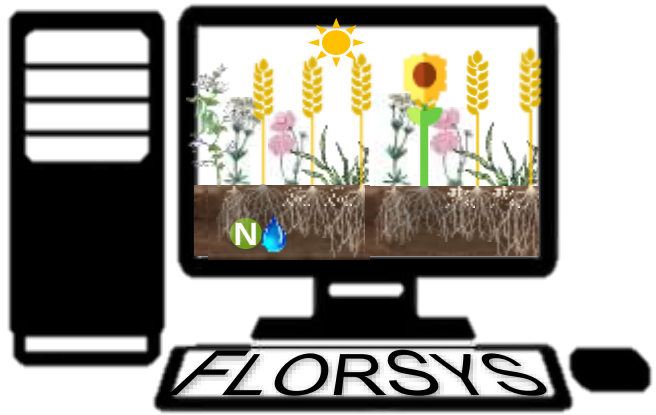


Winter wheat

Next steps
= repeat experiments (more years, more crops, more weeds)
= introduce into FLORSYS model
→ Establish generic management rules

Cordeau et al (2022)

- Use FLORSYS to run virtual experiments and answer contrasting questions



Optimize techniques for weed management → decision rules

Crop sowing dates
Colbach et al 2005 Weed Res

Dates and tools for false seed bed operations
Labreuche et al 2020 Innov Agron, Boquet et al in prep

Identify indicators for field measurements

Weed indicators of crop yield loss due to weeds
Colbach & Cordeau 2018 Eur J Agron

Crop ideotypes for weed management

Identify species traits that drive competitveness
Colbach et al 2019 Field Crops Res

Identify pea ideotypes
Colbach et al 2022 Frontiers Plant Sci

Identify wheat ideotypes
Lebreton et al in prep

Multi-criteria evaluation of weed impacts in cropping systems

Systems with herbicide-tolerant varieties
Bürger et al 2013 Agric Syst

Hundreds of farmers' systems from many regions to identify sustainable how-herbicide systems
Colbach & Cordeau 2018 Eur J Agron, 2022 Frontiers Agron

Cropping-system trials →extrapolate
Colbach et al 2021 Field Crops Res

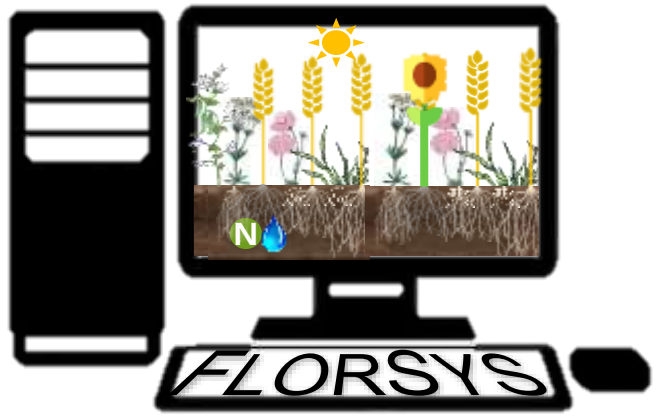
Support cropping-system design

Assess systems designed by advisors and participatory workshops
Cavan et al 2020 Innov Agron, Queyrel et al submitted Agric Syst

Combine FLORSYS with optimization algorithms
Perthame et al in revision
Zheng 2022 M2 thesis

Simulate thousands of recorded & virtual systems to feed DSS
Colas 2018 PhD thesis, Boquet et al in prep

- Use FLORSYS to run virtual experiments and answer contrasting questions



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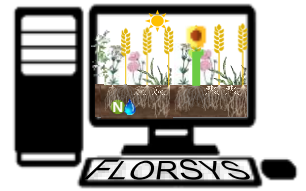
Pea ideotype for weed control in herbicide-free spring pea

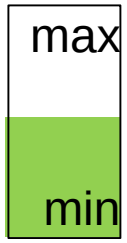
Colbach et al 2022 Frontiers Plant Sci



17 pea varieties
in 3600 cropping systems
x 10 weather repetitions
x 30 years

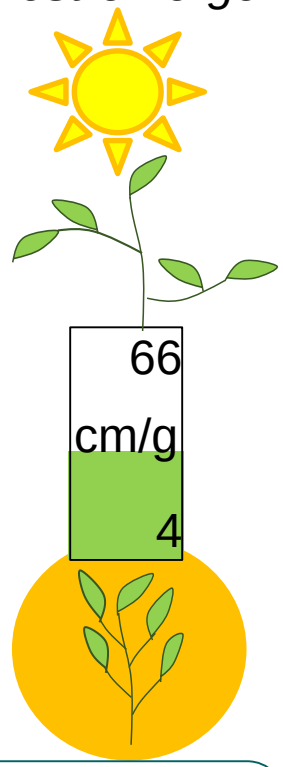
Range of variation for all pea varieties

Range for ideotype



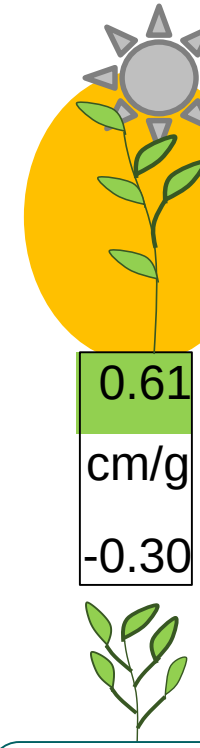
Characteristics if early pea sowing & frequent tillage in rotation

Post-emergence

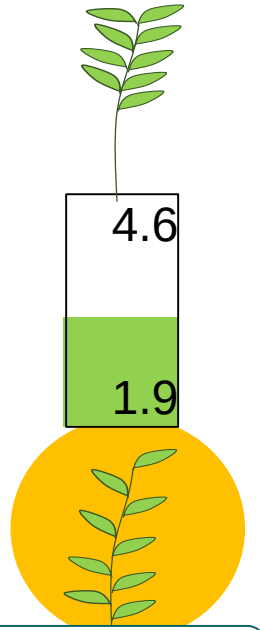


Less damage due to mechanical weeding

Vegetative

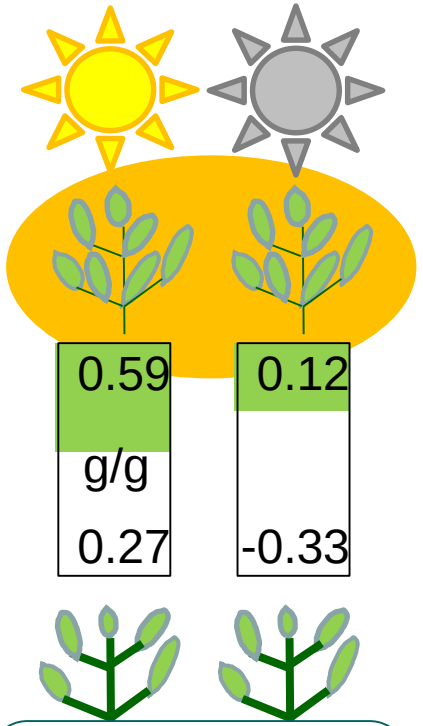


More shade avoidance



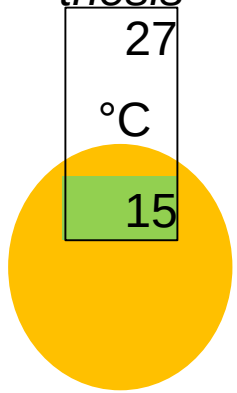
More light interception

Reproduction



More light interception and weed shading until full maturity

Threshold for max photosyn-thesis



More biomass accumulation in early plant life

Use FLORSYS to run virtual experiments and answer contrasting questions

Optimize techniques for weed management → decision rules

Crop so… … seed bed operations

Colbach et … Boquet et al in prep

Identify i…

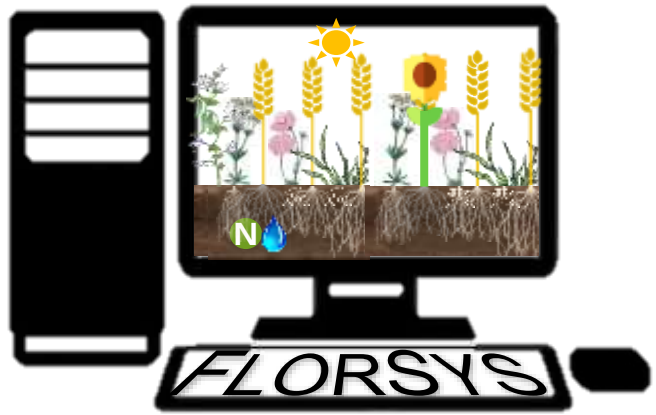
Weed indicat… …ods

Colbach & Cordeau …

AGRO-TRANSFERT RESSOURCES ET TERRITOIRES

OdERA 2

http://www.odera-systemes.org/



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Multi-cri… …cts in cr…

Systems … …farmers' … …many regions tolerant … …stainable… … systems

Bürger et al … …u 2018 Eur… …Agron

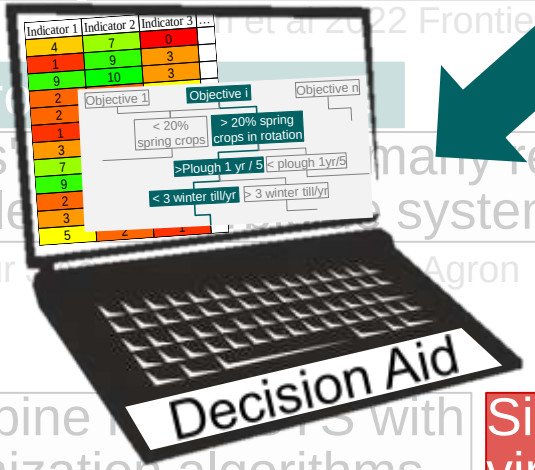
Cropping-system trials →extrapolate

Colbach et al 2021 Field Crops Res

DeciFlorSys

UN OUTIL POUR ACCOMPAGNER LES AGRICULTEURS DANS LA TRANSITION AGROÉCOLOGIQUE

available soon



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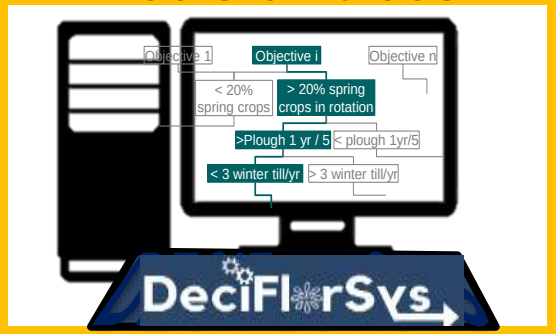
AIMS

Reference

Analysis

Design

Decision trees



Evaluation

Cropping system	Trophic resources for		Damage to crop production			Herbicide use intensity
	Carabids	Bees	Yield loss	Harvest pollution	Field infestation	
Reference (OSRape/Wheat/Wheat/*Barley*)	4.65	1.59	45.8	2.82	1.51	1.71
Prototype A	4.6	1.59	31.8	2.37	1.02	0.57
Prototype B	5.11	1.66	25.5	2.09	0.87	0.56

Queyrel et al submitted Agric Syst

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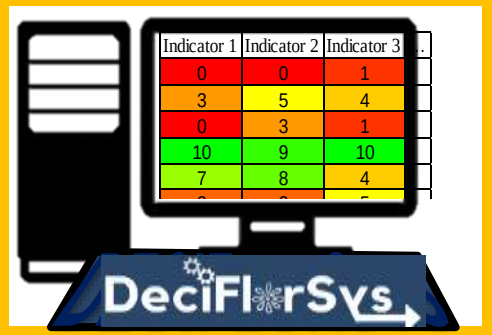
Calculator



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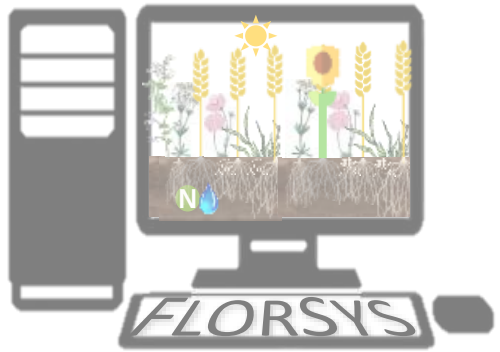
Prototype B	5.11	1.66	25.5	2.09	0.87	0.56
B1 = B + mechanical weeding	4.82	1.6	23.7	2.03	0.84	0.56
B2 = B + mech weeding instead of herbicides	5.01	1.67	24.2	2.11	0.99	0
B3 = B2 + lentil instead of lucerne	5.07	1.74	40.6	2.68	1.28	0

Queyrel et al submitted Agric Sy

Conclusion

A generic model to synthesize and transfer knowledge to stakeholders



- Essential to juggle with the many techniques, objectives, conditions
  → determine flexible rules adapted to local conditions
- All models are false but some are useful
  → continuously check model outputs and conclusions vs field observations

Ensure that research results are applicable in fields

- Implicate stakeholders in research
  → participatory science
- Go beyond multicriteria weed evaluation
  → multicriteria cropping-system evaluation of all aspects of sustainability
  → need and connect several evaluation tools
- Train future farmers, advisors (and not only scientists)

Thank you for your attention

Bürger et al (2013) Simulation study of the impact of changed cropping practices in conventional and GM maize on weeds and associated biodiversity. Agric Syst 137, 51-63

Cavan et al (2020) Comparaison de méthodes de conception de systèmes de culture innovants pour la gestion durable des adventices. Innov Agron 81:189-200, https://doi.org/10.15454/gas3-1w19

Colas F. (2018) Co-développement d'un modèle d'aide à la décision pour la gestion intégrée de la flore adventice. Métamodélisation et analyse de sensibilité d'un modèle mécaniste complexe (FLORSYS) des effets des systèmes de culture sur les services et disservices écosystémiques de la flore adventice. *PhD Thesis, Univ. Bourgogne Franche-Comté, Dijon, France. 334 p.*

Colbach et al (2005) How to model the effects of farming practices on weed emergence. Weed Research 45, 2-17

Colbach et al (2014) Assessing innovative sowing patterns for integrated weed management with a 3D crop:weed competition model. Eur J Agron 53, 74-89, http://dx.doi.org/10.1016/j.eja.2013.09.019

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