Contribution of cereal-legume intercropping agroecological weed management

Thomas Forestier, Laurent Bedoussac, Catherine Bonnet, Didier Raffaillac, Etienne-Pascal Journet, Eric Justes, Nathalie Colbach

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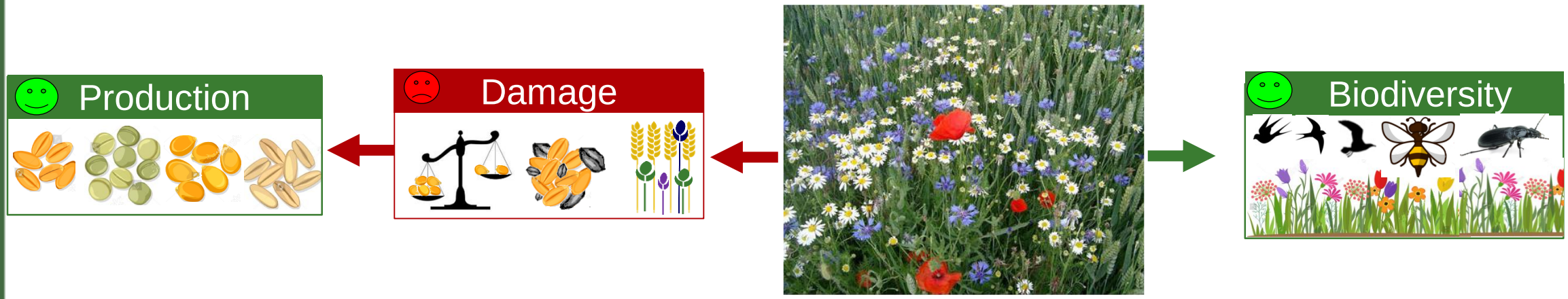
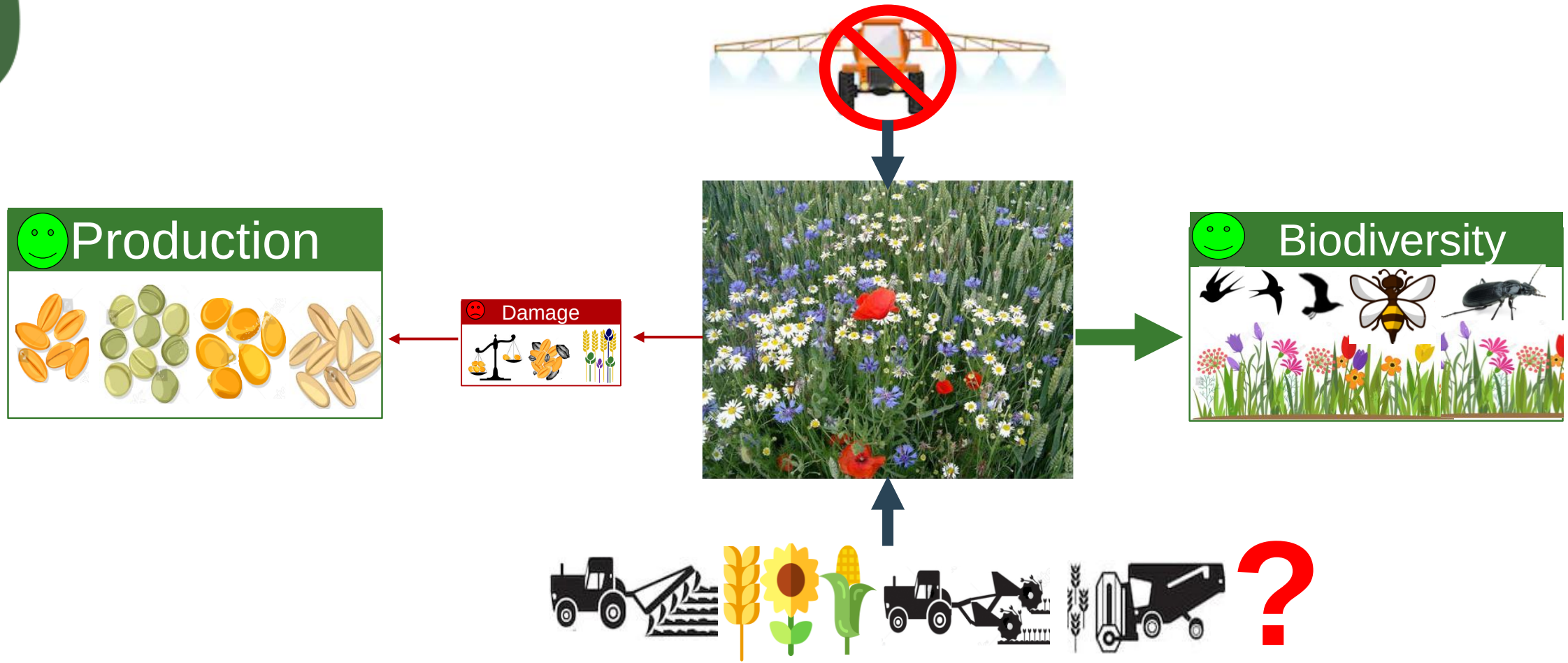
ReMIX
Species mixtures for redesigning European cropping systems

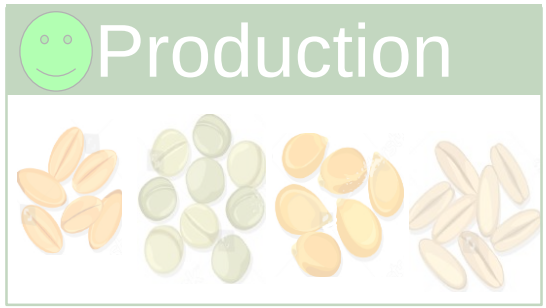
ESA 2020

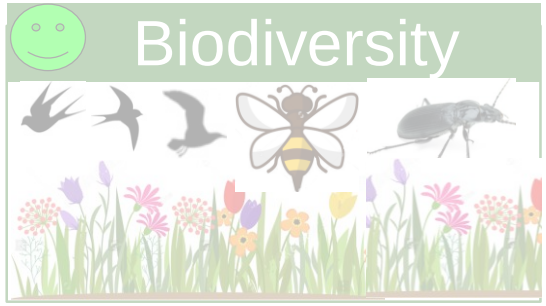
XVI European Society for Agronomy Congress 1 to 3 September, 2020 - Sevilla - Spain


Production
Damage
Biodiversity


Production
Damage
Biodiversity
?

Many factors + long-term = complex system
→ need models!





?

Objective Evaluate weed (dys)services in cropping systems with intercropping combining expertise & simulations

Step 1 Design management scenarios for intercropping
→ Participatory workshops with farmers & researchers

Step 2 Upscale from management plants to cropping systems
Translate rules into list of operations
→ Data from cropping system trials + expertise

Step 3 Virtual experiments with a mechanistic simulation model
→ Multicriteria long-term evaluation of weed (dys)services

Step 4 Diagnostic on simulation output
→ Identify technical drivers of cropping-system performance

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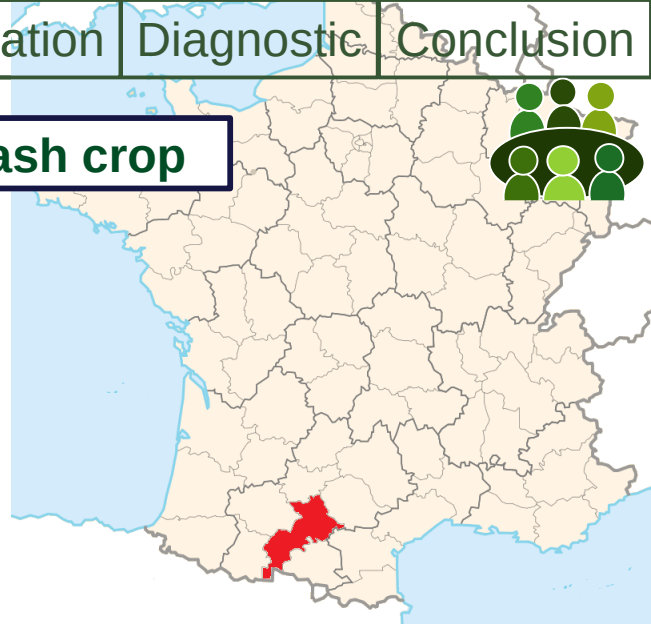
Production type: ☑ Food ☑ Feed ☐ Fodder ☐ Services for cash crop

Wheat + Faba bean *Triticum aestivum + Vicia Faba*



Objective
- High-quality wheat
- Provide nitrogen to wheat
- Control diseases.
- Harvest even if bad weather

Haute-Garonne, France
- Organic agriculture
- Soil type "boulbènes"
- Previous crop = wheat
- 15 ha

Management plan

Sowing ☐ simultaneous ☑ delayed
19 Nov

Harvest ☑ simultaneous ☐ delayed
June

1. Tillage
Plough, Stubble breaking
Rotary harrow + Spring tine if clods

2. Sowing
Combined seed drill:
Faba bean @ 4 cm (90 kg/ha)
Cereal seed drill:
Wheat @ 2-3 cm (200 kg/ha)

3. Weeding
Harrow just after sowing if possible
2-3 x "écroûteuse"

4. Harvest
Conventional combine harvester

5. Seed sorting
Farm or cooperative

Year	Control
1	Barley
2	Camelina
3	
	Maize
4	Wheat
5	Buckwheat
6	
	Soya

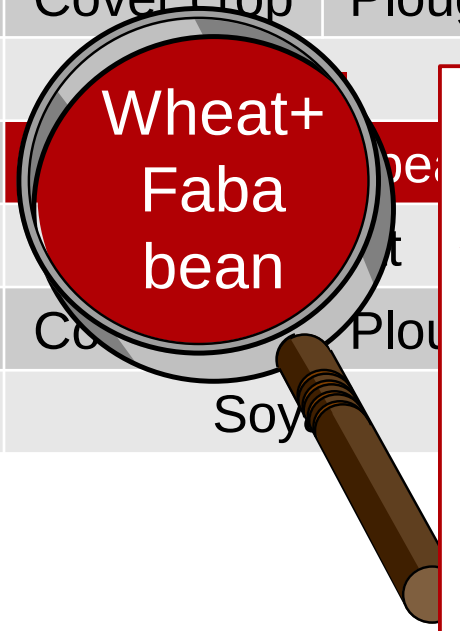
Source: cropping-system trial at INRAE Toulouse

Year	Control	I1WheatBean	I1BarleyPea	I2
1	Barley	Barley	Barley+Pea	Barley+pea
2	Camelina	Camelina	Camelina	Camelina
3	Cover crop / Plough	Cover crop / Plough	Cover crop / Plough	Cover crop / Plough
	Maize	Maize	Maize	Maize
4	Wheat	Wheat+Faba bean	Wheat	Wheat+Faba bean
5	Buckwheat	Buckwheat	Buckwheat	Buckwheat
6	Cover crop / Plough	Cover crop / Plough	Cover crop / Plough	Cover crop / Plough
	Soya	Soya	Soya	Soya

Source: cropping-system trial at INRAE Toulouse

Source: management plans based on decision rules designed with farmers

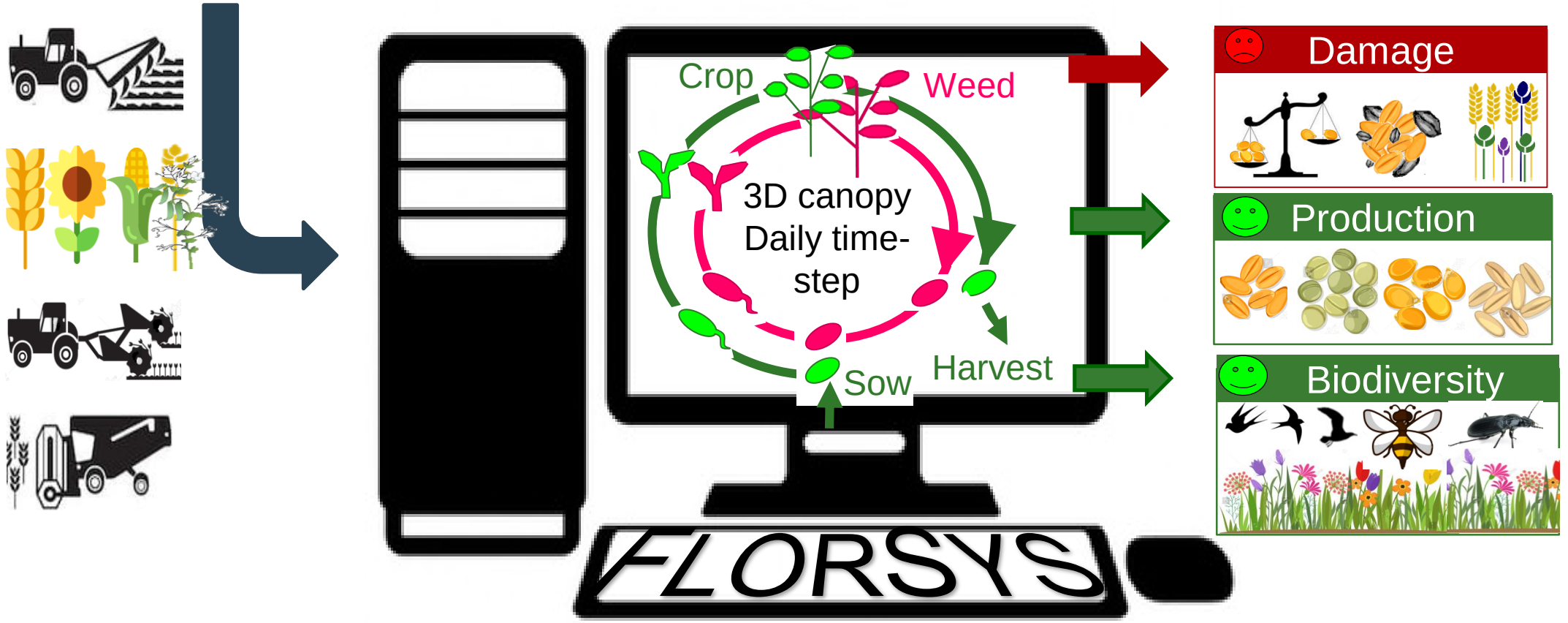
Year	Control		I1WheatBean		I1BarleyPea		I2	
1	Barley		Barley		Barley+Pea		Barley+pea	
2	Camelina		Camelina		Camelina		Camelina	
3	Cover crop	Plough	Cover crop	Plough	Cover crop	Plough	Cover crop	Plough
	Maize							
4	Wheat							
5	Buckwheat							
6	Cover crop	Plough						
	Soya							



Detailed list of operations

3 Nov Residue shredding
4 Nov Disks (7 cm deep)
5 Nov Rotary harrow (5 cm)
19 Nov Rotary harrow (5 cm)
19 Nov **Wheat** sowing
(140 seeds/m², 3 cm deep, interrow 16 cm)
19 Nov **Faba bean** sowing
(18 seeds/m², 3 cm deep, interrow 50 cm)
...

→ 2 control cropping systems (without intercropping)
→ 10 systems with ≥ 1 intercropping



Colbach et al (2006, 2010, 2014) Eur J Agron, Colbach et al (2007) Ecol Mod; Colbach et al. (2014) Soil Till Res; Colbach et al. (2014)^ Weed Res; Colbach et al (2017, 2020) Ecol Indic; Gardarin et al. (2012) Ecol Mod; Munier-Jolain et al (2013) Ecol Mod; (2014); Munier-Jolain et al (2013) Field Crops Res; Mézière et al (2015) Ecol Indic

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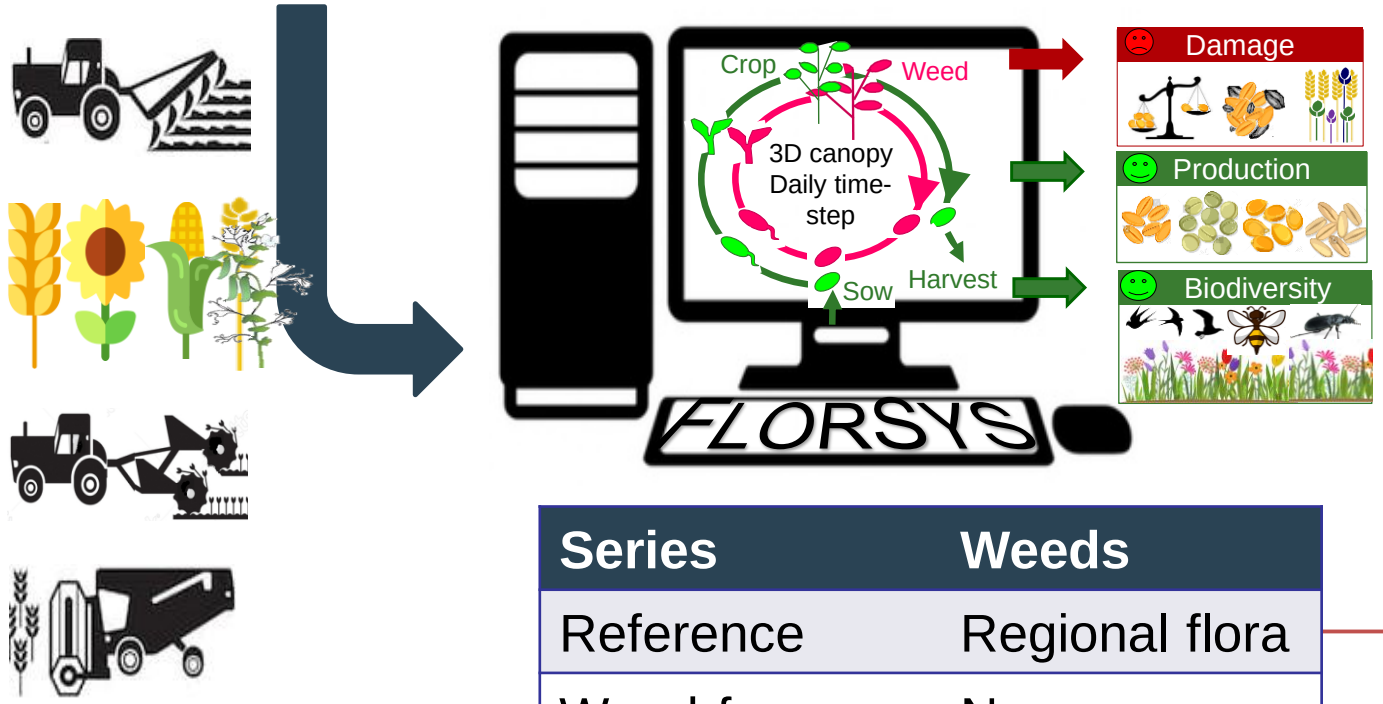

Series	Weeds
Reference	Regional flora
Weed-free	None

→ Effect of **weeds**

Simulation plan (30 years x 10 weather repetitions)

Intercropping strategy
Control
I1WheatBean
I1BarleyPea
I2
Low inputs
Very low inputs

Intercropping strategy	Fallow management	Wild plant species richness		Trophic resources Farmland birds		Potential energy yield (MJ/ha)		Yield loss (%)	
Control	plough	20.8	D	5.02	DE	120828	A C	61	
	cover crop	20.9	D	6.04	E	134263	B D	63	
I1WheatBean	plough	17.5	C	4.06	BC	121754	A C	59	
	cover crop	20.3	D	5.81	DE	122293	A C	62	
I1BarleyPea	plough	20.9	D	5.82	DE	124828	A C	62	
	cover crop	21.9	D	6.06	E	144263	B D	63	
I2	plough	17.6	C	4.81	CD	122185	A C	60	
	cover crop	21.3	D	5.83	DE	138014	CD	62	
Low inputs	plough	15.5	A	2.81	A	115506	AB	53	
	cover crop	16.5	BC	3.8	AB	115937	A	57	
Very low inputs	plough	16.5	AB	3.82	AB	116044	AB	58	
	cover crop	16.6	BC	3.82	AB	118580	AB	58	

Preliminary results

Intercropping strategy	Fallow management	Wild plant species richness		Trophic resources Farmland birds		Potential energy yield (MJ/ha)		Yield loss (%)
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Trade-off

Preliminary results

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No systematic ↘ or ↗ due to intercropping

Preliminary results

Analyse Indicator = f(crop, cropping techniques, weather …)

Crop	Yield loss (%)	
Faba bean	36.0	A
Wheat-Faba bean	11.0	B
Wheat	10.0	B

Switching from legume to cereal-legume
→ Yield loss divided by more than 3

Analyse Indicator = f(crop, cropping techniques, weather …)

Crop	Yield loss (%)	
Faba bean	36.0	A
Wheat-Faba bean	11.0	B
Wheat	10.0	B

Switching from legume to cereal-legume
→ Yield loss divided by more than 3

Crop	Yield loss (%)	
Pea	51.0	A
Barley-Pea	20.0	B
Barley	16.0	C

Switching from legume to cereal-legume
→ Yield loss divided by more than 2

Switching from cereal to cereal-legume
→ Maintains yield without fewer N fertilizer (not shown)

Management effects: Cancel or amplify intercropping effects

Virtual experiments → evaluation + diagnostic of intercropping

→ *Multi-criteria evaluation of weed impacts difficult to measure in fields*

→ *Long-term effects = essential for weed impacts*

Need to include nitrogen + water competition

See Moreau et al – Session 2.1 – 2 Sept

Intercropping ↘ weed harmfulness & need for fertilizer

→ *Yield loss in intercropping < legume crops (though no herbicides)*

→ *Potential yield in intercropping = cereals (though no fertilizer)*

→ *Need to fine-tune management + adapt to production context*

→ *Trade-offs → need to let stakeholders choose = f(their objectives)*

No unique solution → need flexible rules + models to establish them

Thank you for your attention

Cropping system	Fallow management	Wild plant species richness		Trophic resources Farmland birds		Potential energy yield (MJ/ha)		Yield loss (%)	
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Fallow management

Preliminary results