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# Contribution of cereal-legume intercropping to agroecological weed management

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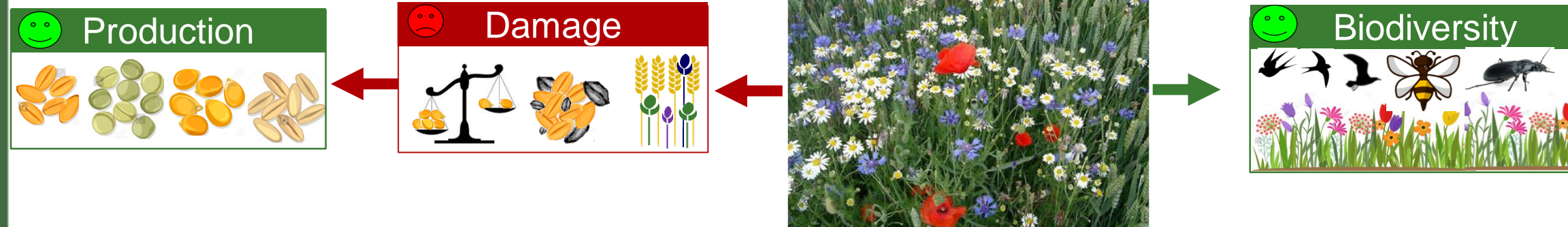
<sup>2</sup> Université de Toulouse, INRAE, ENSFEA, UMR AGIR, F-31326, Castanet-Tolosan, France

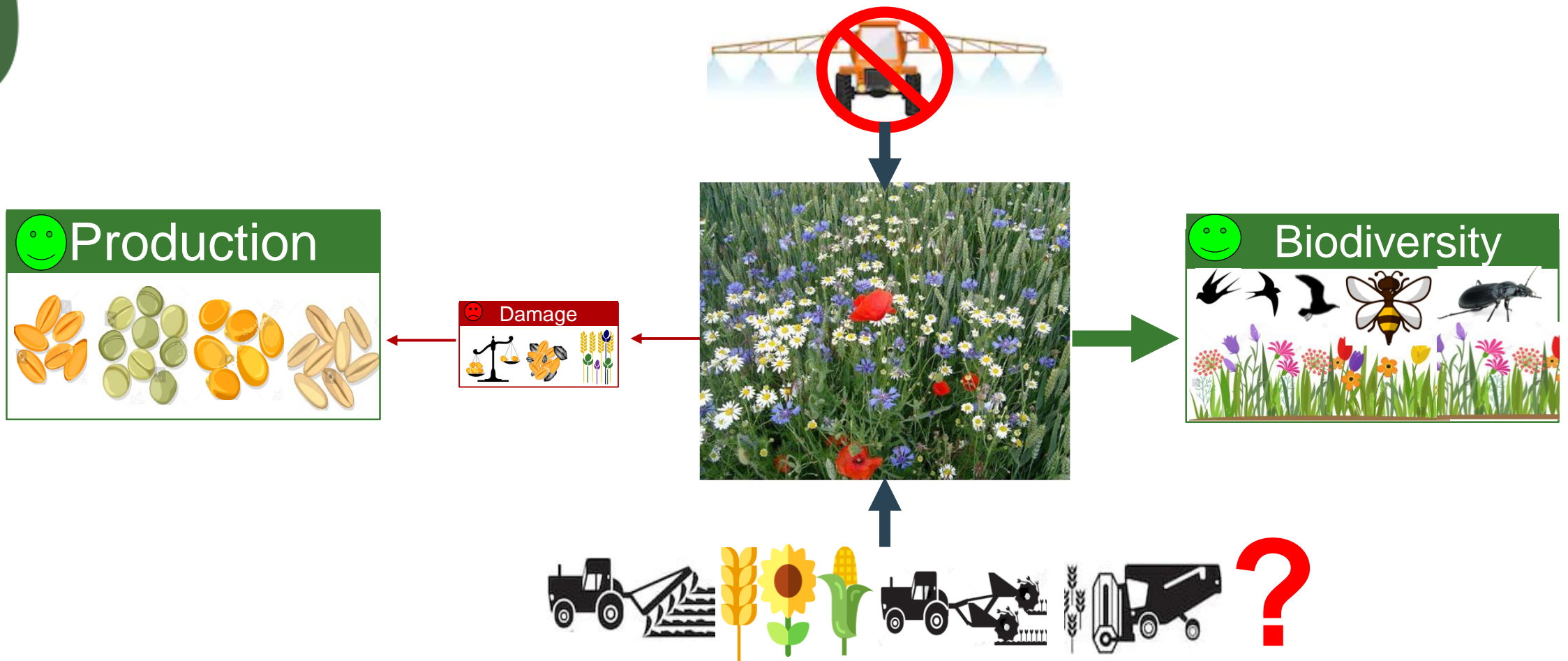
<sup>3</sup> Université de Toulouse, INRAE, UMR AGIR, F-31326, Castanet-Tolosan, France

<sup>4</sup> Université de Toulouse, INRAE, CNRS, LIPM, F-31326, Castanet-Tolosan, France

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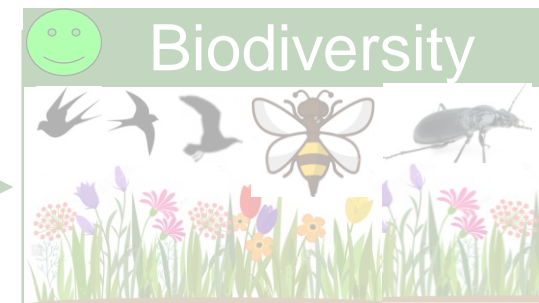
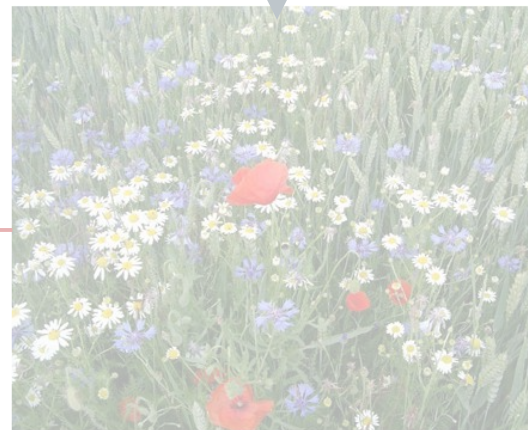
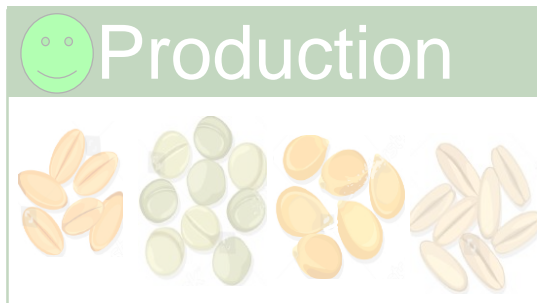








Many factors + long-term = complex system  
→ need models!



**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

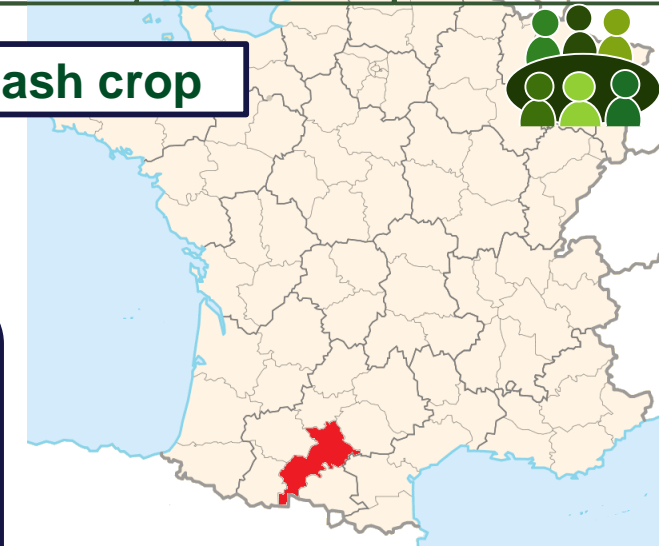
Wheat + Faba bean *Triticum aestivum* + *Vicia Faba*

### 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  
19 Nov  delayed

Harvest  simultaneous  
June  delayed

**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
4	Maize		Maize		Maize		Maize	
4	Wheat		Wheat		Wheat		Wheat	
5	Buckwheat		Buckwheat		Buckwheat		Buckwheat	
6	Cover crop	Plough	Cover crop	Plough	Cover crop	Plough	Cover crop	Plough
	Soya		Soya		Soya		Soya	

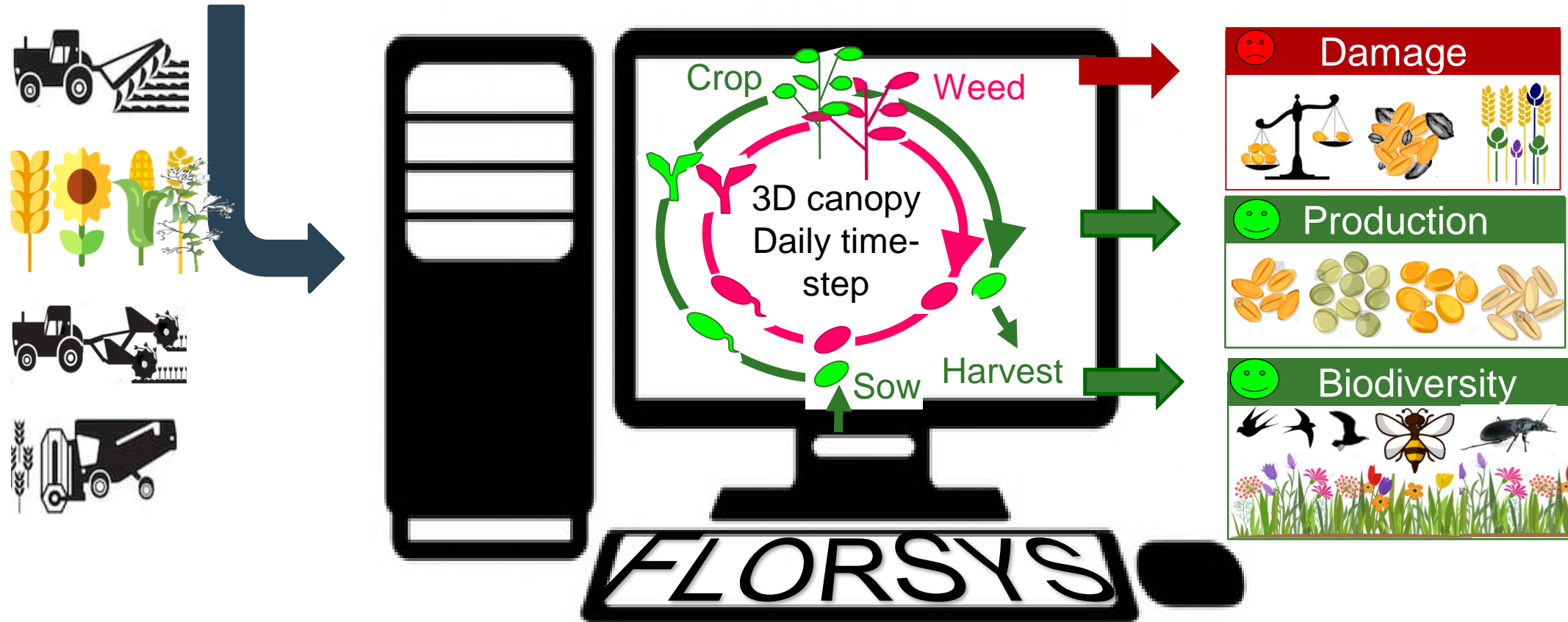


**Wheat+  
Faba  
bean**

**Detailed list of operations**

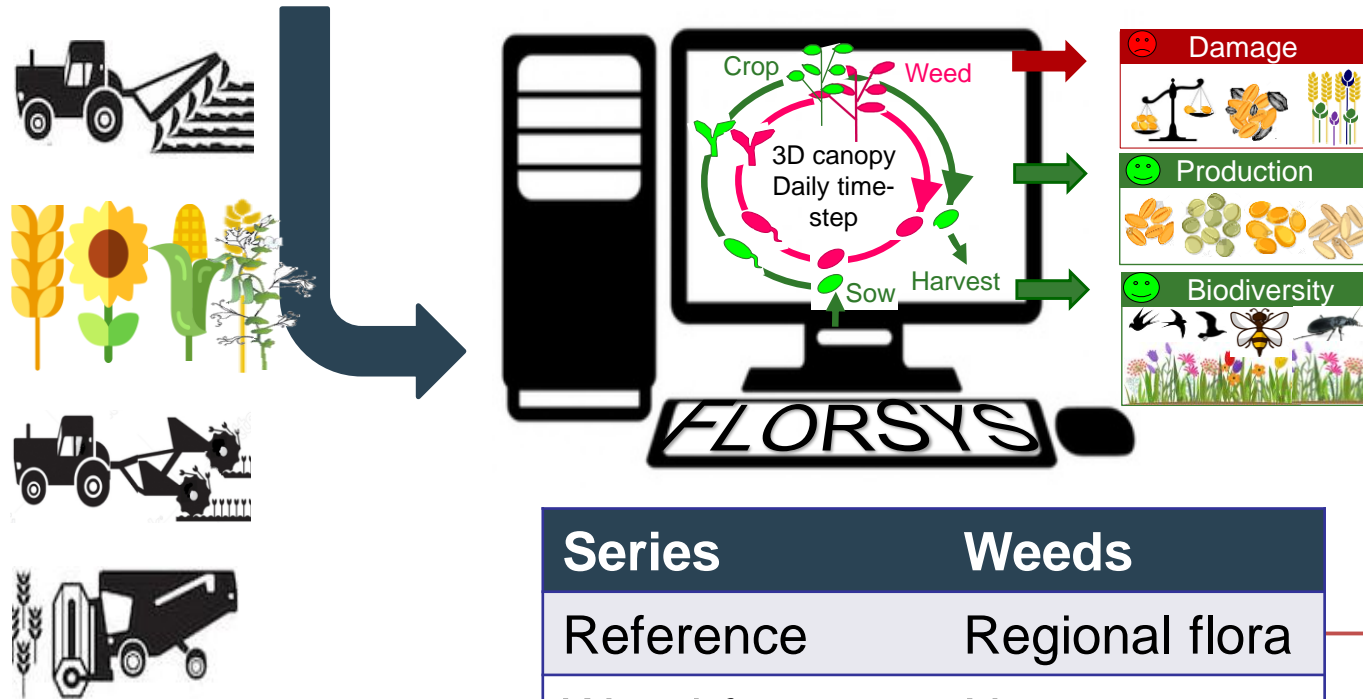
- 3 Nov Residue shredding
- 4 Nov Disks (7 cm deep)
- 5 Nov Rotary harrow (5 cm)
- 19 Nov Rotary harrow (5 cm)
- 19 Nov **Wheat** sowing  
(140 seeds/m<sup>2</sup>, 3 cm deep, interrow 16 cm)
- 19 Nov **Faba bean** sowing  
(18 seeds/m<sup>2</sup>, 3 cm deep, interrow 50 cm)
- ...

- 2 control cropping systems (without intercropping)
- 10 systems with  $\geq 1$  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)<sup>^</sup> 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

- 2 control cropping systems (without intercropping)
- 10 systems with  $\geq 1$  intercropping



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 (%)
		Richness	Richness	Richness	Richness	Yield	Yield	
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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 (%)
		Value	Letter	Value	Letter	Value	Letter	Value
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Fallow management



Preliminary results