



HAL
open science

Contribution of cereal-legume intercropping agroecological weed management

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

► To cite this version:

Thomas Forestier, Laurent Bedoussac, Catherine Bonnet, Didier Raffailac, Etienne-Pascal Journet, et al.. Contribution of cereal-legume intercropping agroecological weed management. 16. European society for agronomy congress, Sep 2020, Séville, Spain. 20p. hal-02960079

HAL Id: hal-02960079

<https://hal.inrae.fr/hal-02960079v1>

Submitted on 7 Oct 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Contribution of cereal-legume intercropping to agroecological weed management

Thomas Forestier¹, Laurent Bedoussac², Catherine Bonnet³, Didier Raffailac³, Etienne-Pascal Journet^{3,4}, Eric Justes^{3,5}, **Nathalie Colbach¹**

¹ Agroécologie, AgroSup Dijon, INRAE, Univ. Bourgogne, Dijon, France - Nathalie.Colbach@inrae.fr

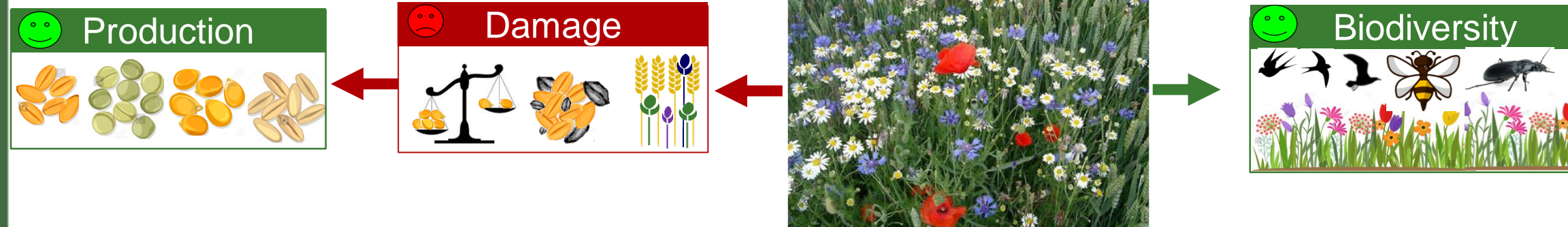
² Université de Toulouse, INRAE, ENSFEA, UMR AGIR, F-31326, Castanet-Tolosan, France

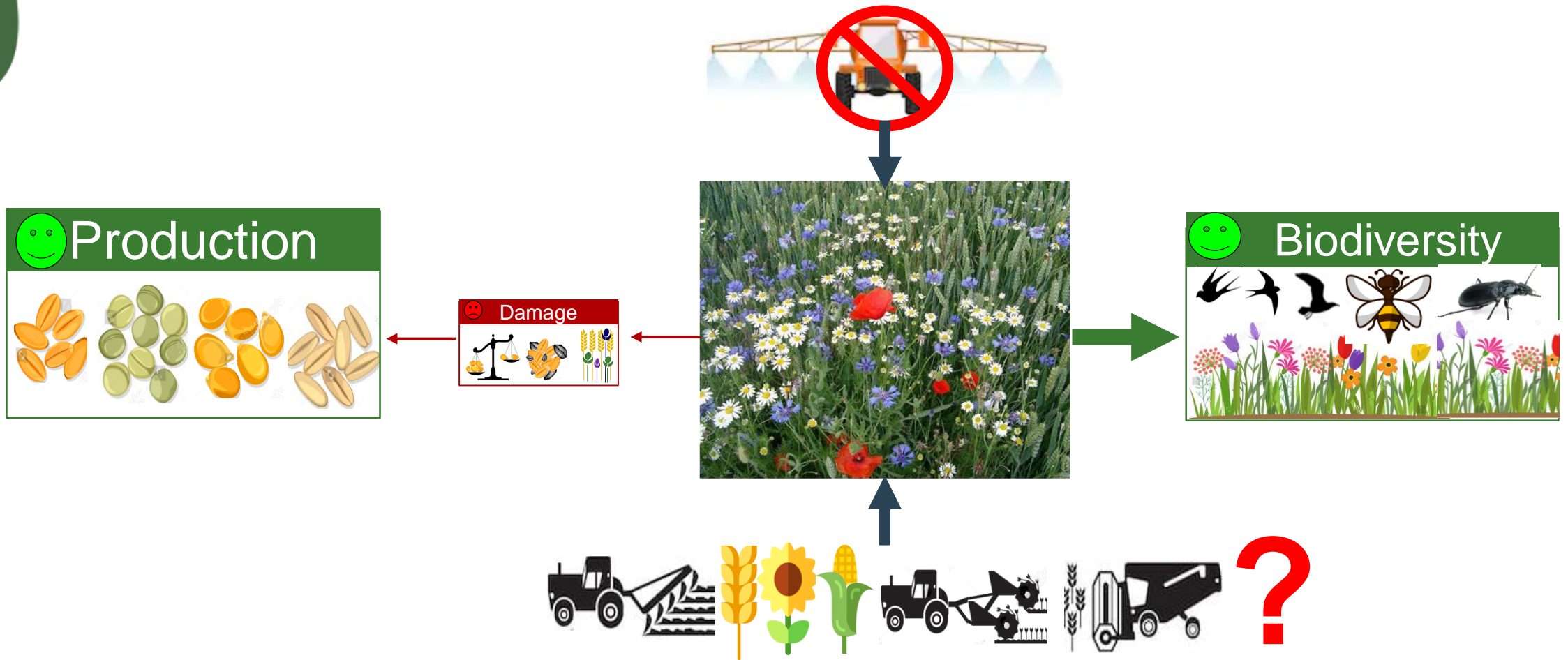
³ Université de Toulouse, INRAE, UMR AGIR, F-31326, Castanet-Tolosan, France

⁴ Université de Toulouse, INRAE, CNRS, LIPM, F-31326, Castanet-Tolosan, France

⁵ CIRAD, Persyst Department, F-34398, Montpellier, France

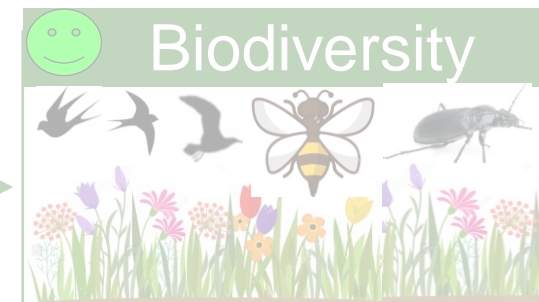
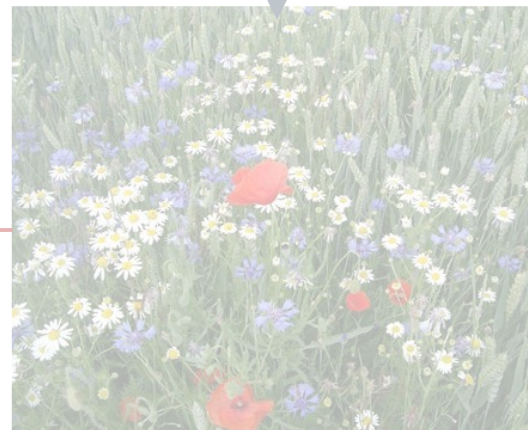
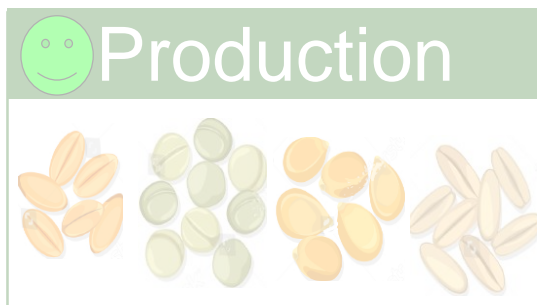








Many factors + long-term = complex system
→ need models!



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



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






Production type: Food Feed Fodder Services for cash crop

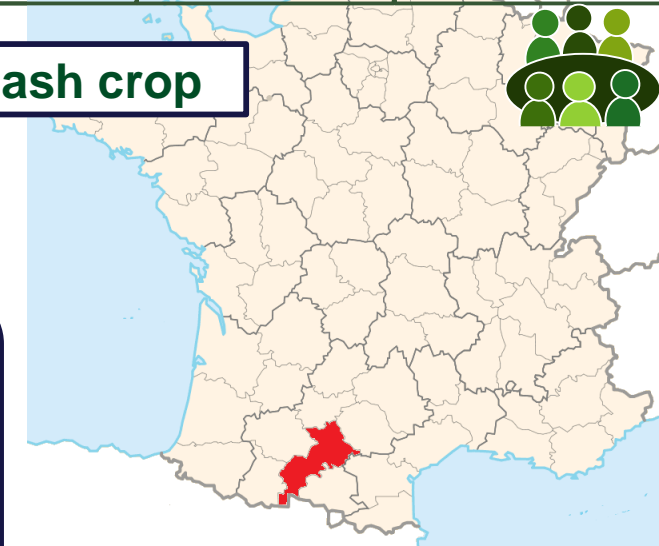
Wheat + Faba bean *Triticum aestivum* + *Vicia Faba*

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	
5	Wheat		Wheat		Wheat		Wheat	
6	Buckwheat		Buckwheat		Buckwheat		Buckwheat	
7	Cover crop	Plough	Cover crop	Plough	Cover crop	Plough	Cover crop	Plough
8	Soya		Soya		Soya		Soya	

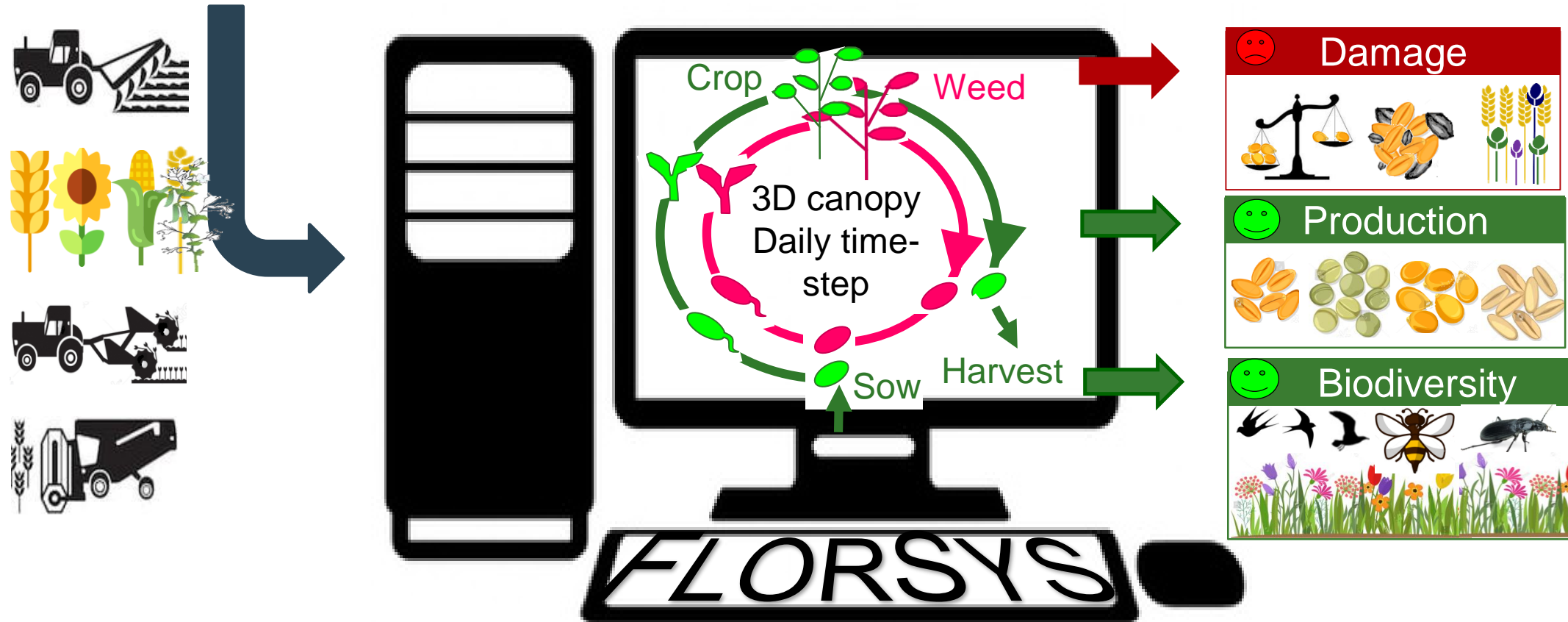


**Wheat+
Faba
bean**

Detailed list of operations

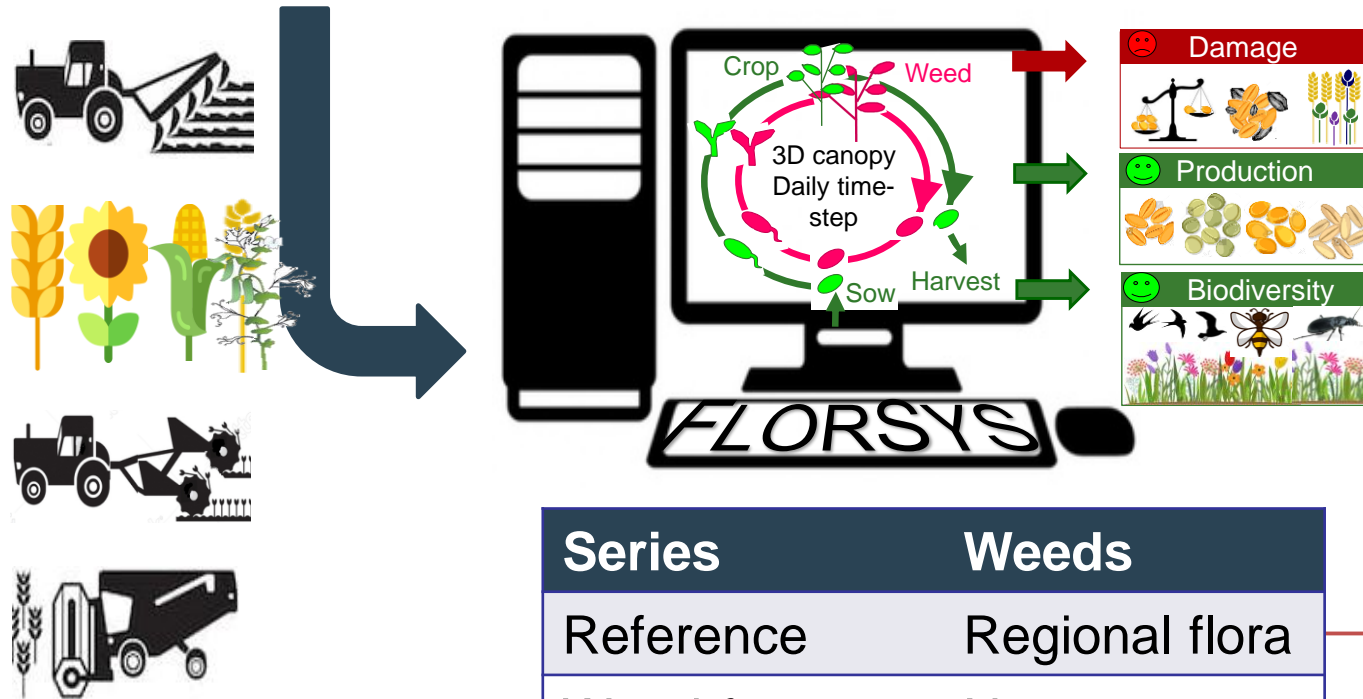
- 3 Nov Residue shredding
- 4 Nov Disks (7 cm deep)
- 5 Nov Rotary harrow (5 cm)
- 19 Nov Rotary harrow (5 cm)
- 19 Nov **Wheat** sowing
(140 seeds/m², 3 cm deep, interrow 16 cm)
- 19 Nov **Faba bean** sowing
(18 seeds/m², 3 cm deep, interrow 50 cm)
- ...

- 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

- 2 control cropping systems (without intercropping)
- 10 systems with ≥ 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



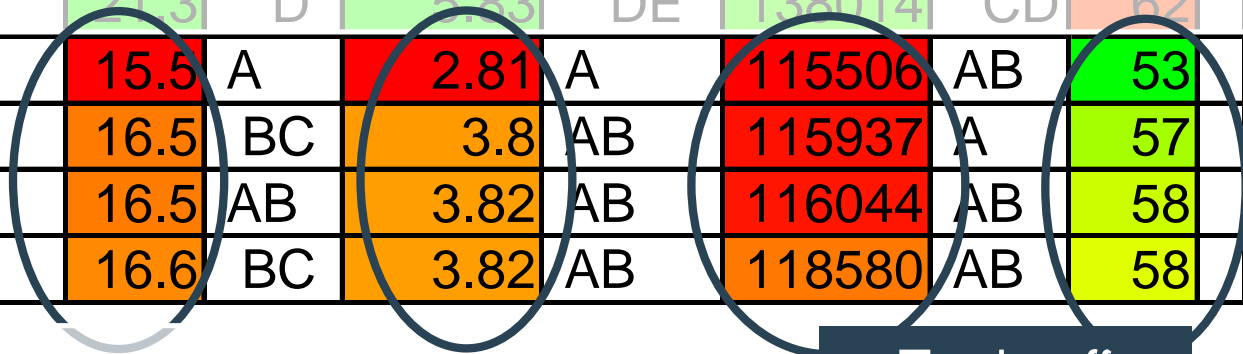
Intercropping strategy	Fallow management	Wild plant species richness		Trophic resources Farmland birds		Potential energy yield (MJ/ha)		Yield loss (%)
		Value	Letter	Value	Letter	Value	Letter	
Control	plough	20.8	D	5.02	DE	120828	A C	61
	cover crop	20.9	D	6.04	E	134263	B D	63
I1WheatBean	plough	17.5	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	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



Trade-off



Preliminary results



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



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
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	20.2	D	4.2	DE	124828	A C	62
	cover crop	21.6	D	5.6	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

Fallow management



Preliminary results