Landsharing vs landsparing: how to reconcile crop production and biodiversity ? A simulation study focusing on weed impacts

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PROGRAMME

LANDSHARING *VS* LANDSPARING: HOW TO RECONCILE CROP PRODUCTION AND BIODIVERSITY? A SIMULATION STUDY FOCUSING ON WEED IMPACTS

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Introduction

Weeds are harmful for crop production but essential for biodiversity. They are affected by cultural practices, their seeds survive for years in the soil and disperse among fields. Here, the weed dynamics model FLORSYS (Colbach *et al.*, 2014) was used to analyse whether weed-related biodiversity and crop production can be reconciled in each field or whether separate fields should be used to maximise either biodiversity or production.

Materials and Methods

FLORSYS is a virtual field cluster on which cropping systems can be tested, including seed dispersal (Thomson *et al.*, 2011). It predicts indicators of weed impact on biodiversity and production. Here, a cluster of four fields was simulated with pedo-climatic conditions from South-Western France. First, a medium-production system with a soybean/maize/wheat/maize rotation, superficial tillage, glyphosate in maize and conventional herbicides in other crops was tested with four annual crop-patterns (Fig. 1.A). Then, five combinations of a high-production system with a high-biodiversity system were simulated (Table 1.B). All systems were chosen based on previous single-field simulations (Bürger *et al.*, 2016). Each scenario was simulated over 28 years and repeated 10 times with randomly chosen weather series from South-Western France.

Results and Discussion

The more crops are grown each year, the less weed impact varies between years (see example in Fig. 1.B) but the stronger it is in average, with more biodiversity and weed harmfulness, and less crop production (Table 1.A). Effects are larger than in single-field simulations (Bürger *et al.*, 2015) because seed dispersal from weed-favourable crops (here wheat) in year N to neighbour fields grown with favourable crops in year N+1, thus avoiding depressive effects of unfavourable crops (here maize) following favourable crops.
The more fields are grown with the high-production system, the higher the production in the cluster and the lower both biodiversity and harmfulness. Even when growing only 25% of high-biodiversity system, biodiversity is higher than for the medium-production system. And even when growing only 25% of high-production system, production is higher and harmfulness lower than for the medium system.

Conclusions

With the seed dispersal functions and small field cluster used here, landsparing was more effective than landsharing to reconcile crop production and biodiversity.

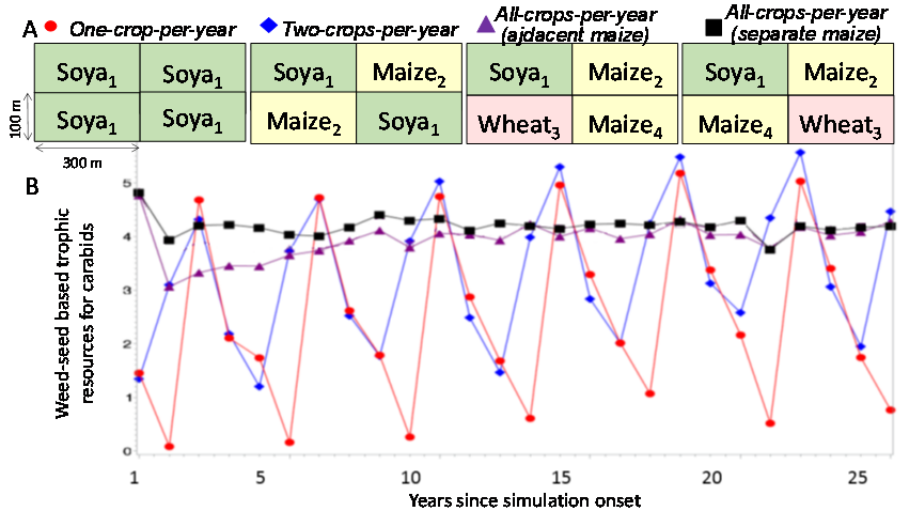

Figure 1. Effect of annual crop patterns on weed impact. A. Crop patterns of a soybean/maize/wheat/maize rotation at 1st year. B. Weed-seed based food offer for carabids in the field cluster (mean over 10 repetitions).

Table 1. Weed-related biodiversity, crop production and weed harmfulness indicators in the field cluster (means over time and fields). Means followed by the same letter are not significantly different at *P*=0.05 (least significant difference test after analyses of variance depending on scenario, year & repetition)

	Weed-related biodiversity								*Crop*		*Weed harmfulness*							
Scenario[$]	*Species richness*		*Bird food*		*Carabid food*		*Bee food*		*(energy) production*		*Yield loss*		*Harvest pollution*		*Harvesting problem*		*Field infestation*	
A. Annual crop pattern in region (crops per year) entirely grown with soybean/maize/wheat/maize																		
One	11.2	G	3.6	H	2.5	I	0.7	F	68344	D	23	E	1.2	F	1.6	G	1.1	F
Two	12.0	E	4.2	G	3.4	H	0.9	E	60184	E	34	C	1.6	E	1.9	F	1.6	D
All (adjacent maize)	12.9	DC	4.1	G	3.9	G	1.1	D	55511	F	40	B	1.9	DC	2.3	DE	2.0	B
All (separate maize)	12.9	D	4.3	F	4.2	E	1.1	D	51920	G	44	A	2.0	C	2.4	C	2.2	A
B. Percentage fields with *high-production*[&] vs. *high-biodiversity*[#] cropping systems[%] in region																		
0% - 100%	15.7	A	9.6	A	8.7	A	2.8	A	59257	E	41	B	2.8	A	3.2	A	1.8	C
25% - 75%	14.9	B	8.9	B	7.5	B	2.2	B	70045	D	30	D	2.4	B	2.8	B	1.4	E
50% - 50%	13.7	C	8.0	C	6.1	C	1.6	C	80603	C	20	F	1.9	D	2.2	E	0.9	G
75% - 25%	11.7	F	7.1	D	4.4	D	0.9	E	90257	B	10	G	1.2	F	1.4	H	0.4	H
100% - 0%	8.4	H	5.4	E	0.6	J	0.2	G	100452	A	0	H	0.0	G	0.0	I	0.0	I
Partial R^2	0.33		0.78		0.87		0.66		0.43		0.38		0.45		0.44		0.31	

[$]Always significant at p=0.0001.[&] Twice tilled [#]No till. [%] rotation is glyphosate-tolerant maize monoculture with one glyphosate in crop.

Acknowledgements

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Landsharing vs. landsapring: how to reconcile crop production and biodiversity? A simulation study focusing on weed impacts

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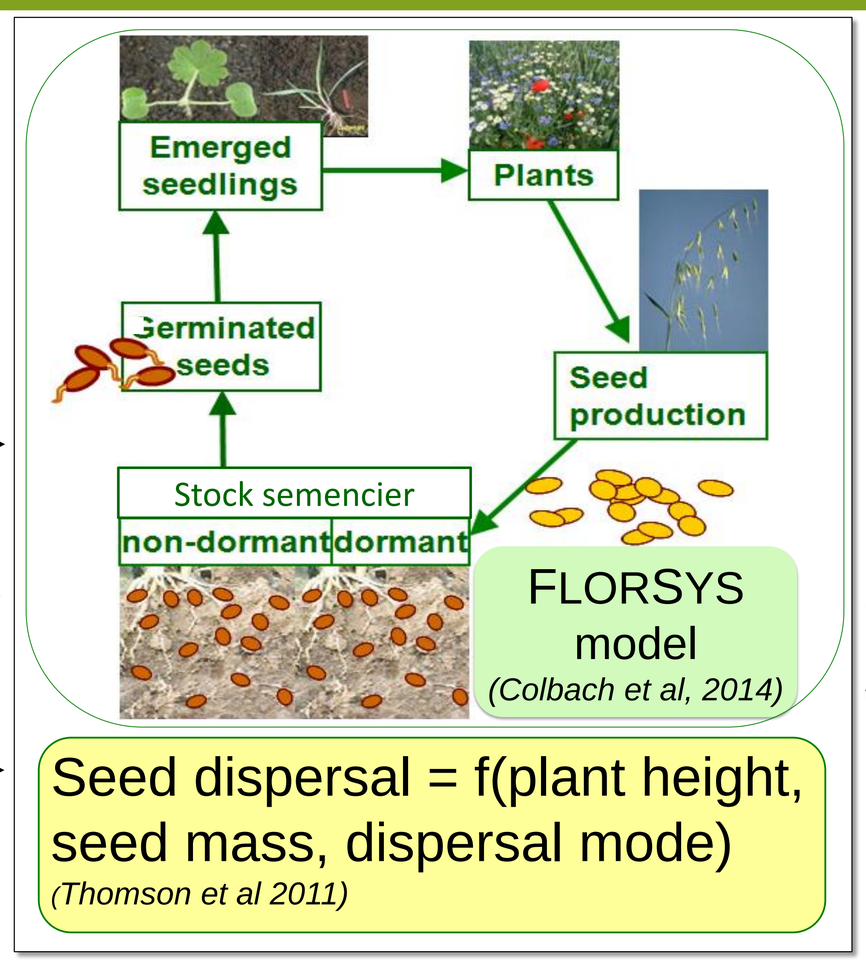
Weeds are harmful for agricultural production but essential for biodiversity. Species composition and abundance depend on cropping systems, but also on weed seed dispersal between fields.

Question Can weed-related biodiversity and crop production be reconciled in each field or should separate fields be used to maximise either biodiversity or production?

Material and methods Simulations with a virtual-field model

Input variables

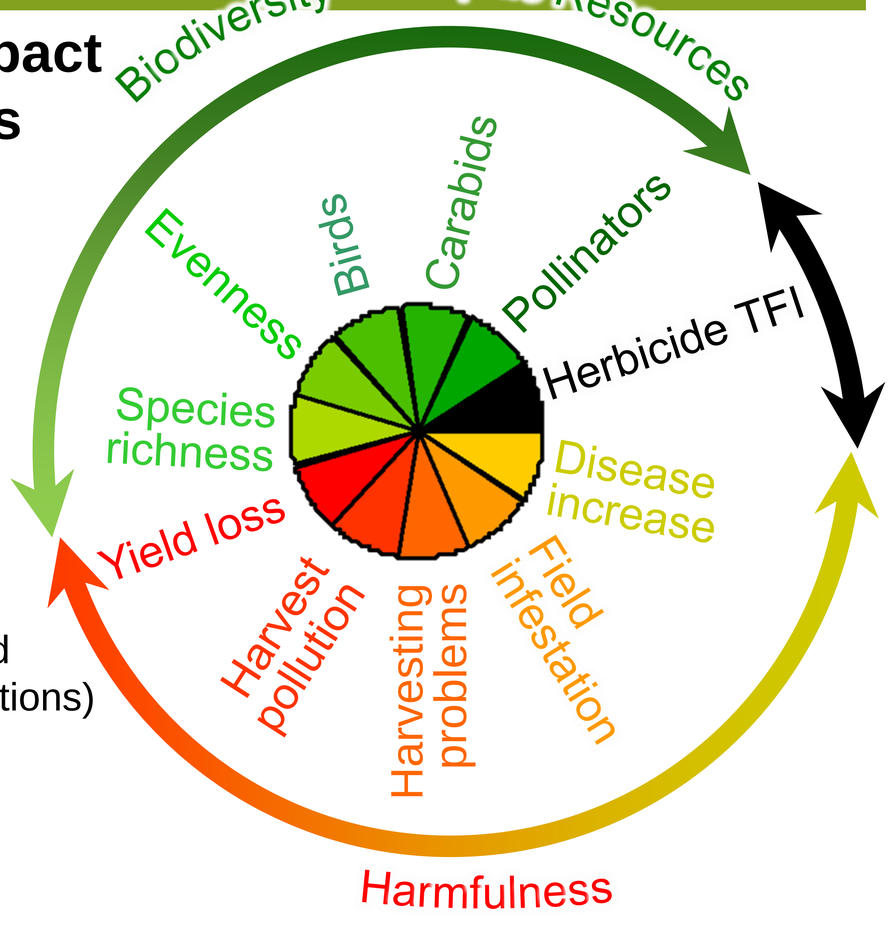
- 9 landscape systems (annual crop pattern x cropping system)
- 1 pedo-climate (Aquitaine)
- Initial weed community (25 species)
- Field cluster (4 fields)



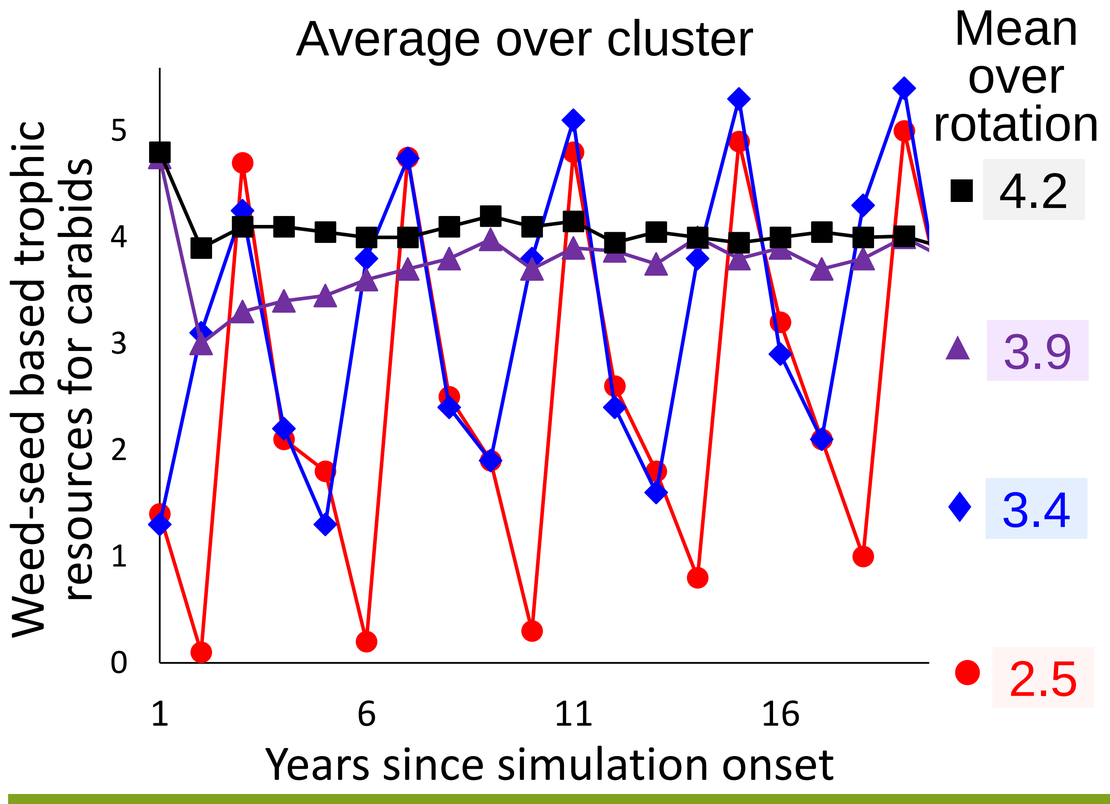
Simulation

(28 years, 10 randomized weather repetitions)

Weed-impact indicators



Result 1 Cropping system pattern can increase and smooth weed impact over time

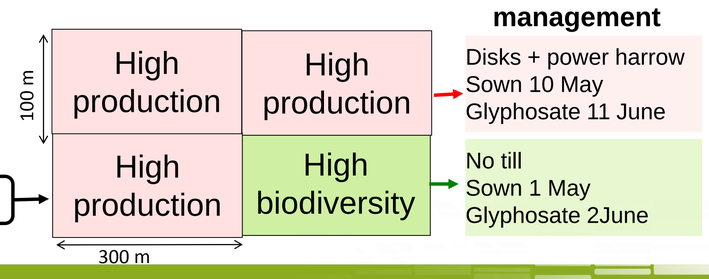


Four 3-ha fields grown with Soya/Maize/Wheat/Maize

Year N		Year N+1		Year N+2		YearN+3		
Soya	Maize	Maize	Soya	Wheat	Maize	Maize	Wheat	All crops per year (separate maize)
Maize	Wheat	Wheat	Maize	Maize	Soya	Soya	Maize	
Soya	Maize	Maize	Soya	Wheat	Maize	Maize	Wheat	All crops per year (adjacent maize)
Wheat	Maize	Maize	Wheat	Soya	Maize	Maize	Soya	
Soya	Maize	Maize	Wheat	Wheat	Maize	Maize	Soya	2 crops per year
Maize	Soya	Wheat	Maize	Maize	Wheat	Soya	Maize	
Soya	Soya	Maize	Maize	Wheat	Wheat	Maize	Maize	1 crop per year
Soya	Soya	Maize	Maize	Wheat	Wheat	Maize	Maize	

Result 2 Landsparing was best to reconcile crop production and biodiversity

Means over cluster and rotation	Weed-related biodiversity: Species richness	Bird food	Carabid food	Bee food	Crop production (MJ/ha)	Weed harmfulness: Yield loss	Harvest pollution	Harvesting problem	Field infestation
A. Landsharing: annual crop pattern in region grown with soybean/maize/wheat/maize									
One crop/year ●	11.2g	3.6h	2.5i	0.7f	68344d	23e	1.2f	1.6g	1.1f
Two crops/year ♦	12.0e	4.2g	3.4h	0.9e	60184e	34c	1.6e	1.9f	1.6d
All (adjacent maize) ▲	12.9dc	4.1g	3.9g	1.1d	55511f	40b	1.9dc	2.3de	2.0b
All (separate maize) ■	12.9d	4.3f	4.2e	1.1d	51920g	44a	2.0c	2.4c	2.2a
B. Landsparing: % fields with high-production vs. high-biodiversity strategies in region									
0% - 100%	15.7a	9.6a	8.7a	2.8a	59257e	41b	2.8a	3.2a	1.8c
25% - 75%	14.9b	8.9b	7.5b	2.2b	70045d	30d	2.4b	2.8b	1.4e
50% - 50%	13.7c	8.0c	6.1c	1.6c	80603c	20f	1.9d	2.2e	0.9g
75% - 25%	11.7f	7.1d	4.4d	0.9e	90257b	10g	1.2f	1.4h	0.4h
100% - 0%	8.4h	5.4e	0.6j	0.2g	100452a	0h	0.0g	0.0i	0.0i



Perspective Conclusions cannot be extrapolated. New simulations are needed for each case.

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