Are no-till herbicide-free systems possible? A simulation study

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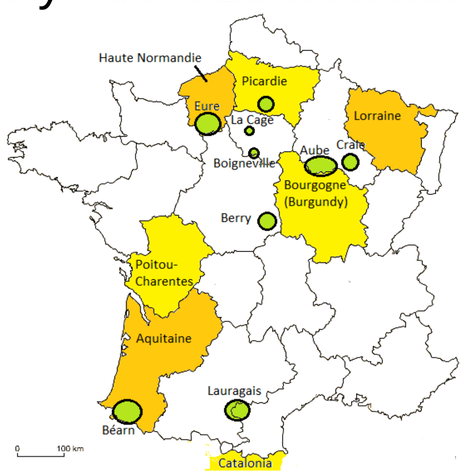
Questions What happens if tillage is deleted? How to reduce tillage, herbicides & weeds?

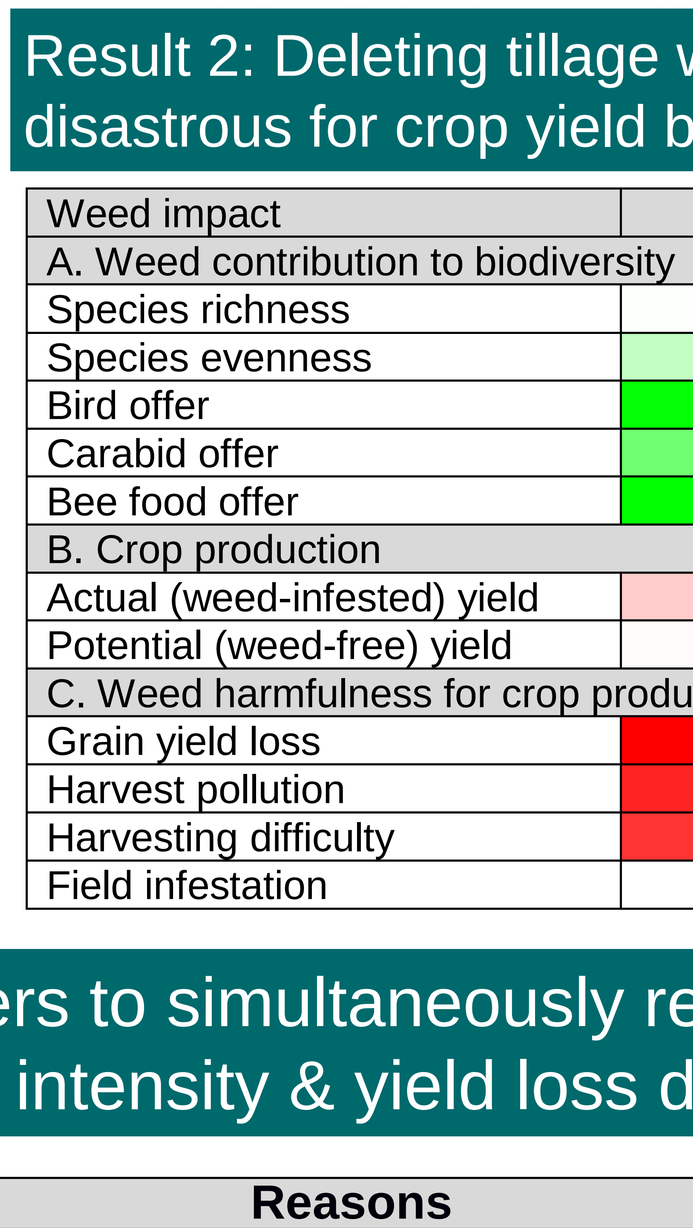
Material & Methods: Experiment farmers' practices with a mechanistic simulation model

395 **recorded** cropping systems
(surveys, statistics,advisors ...)
Same 395 **without tillage**
Same 395 **without herbicides**
30 years x 10 weather series

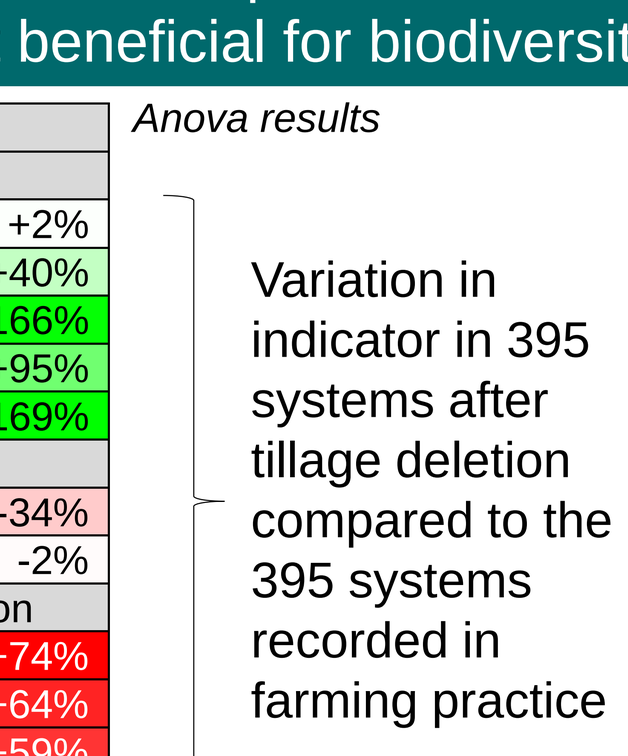


Daily time-step
30 weed species

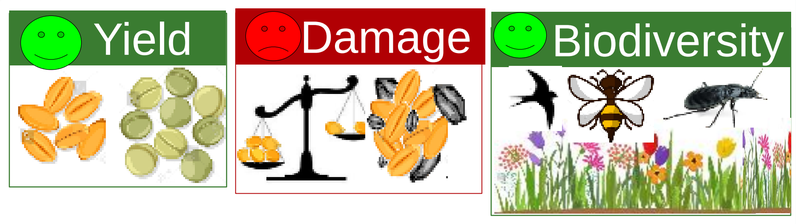
(Colbach et al, 2014, 2021)



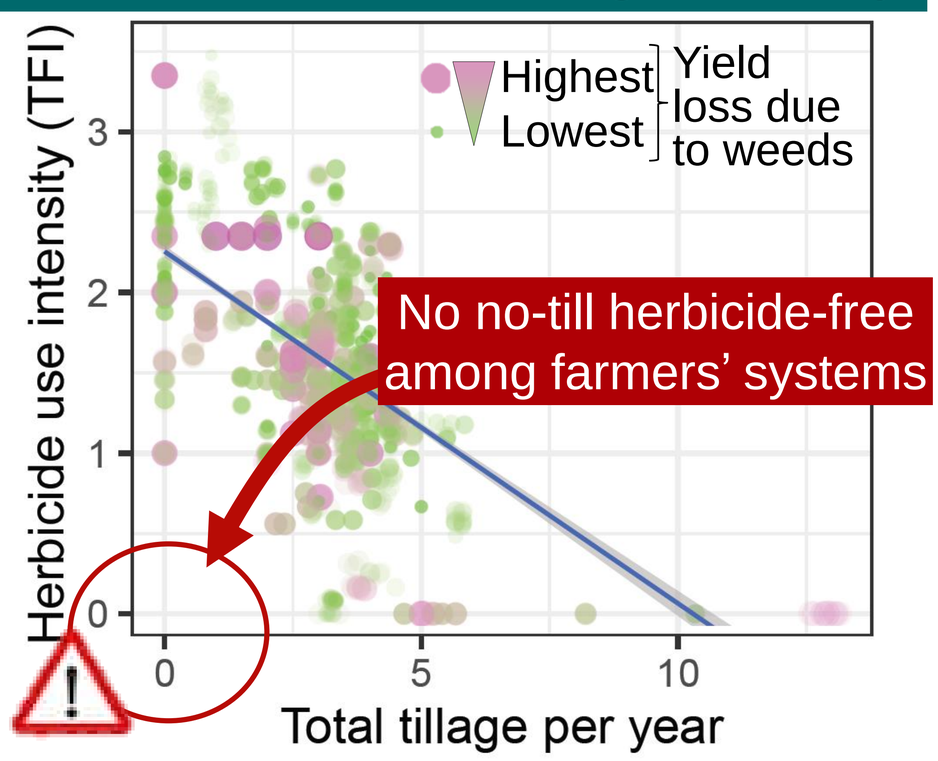
3D daily output, over 30 years



Annual weed-impact indicators



Result1: In recorded systems, herbicide use ↘ with tillage intensity



Result 2: Deleting tillage without compensation = disastrous for crop yield but beneficial for biodiversity

Weed impact	
A. Weed contribution to biodiversity	
Species richness	+2%
Species evenness	+40%
Bird offer	+166%
Carabid offer	+95%
Bee food offer	+169%
B. Crop production	
Actual (weed-infested) yield	-34%
Potential (weed-free) yield	-2%
C. Weed harmfulness for crop production	
Grain yield loss	+74%
Harvest pollution	+64%
Harvesting difficulty	+59%
Field infestation	0%

Anova results

Variation in indicator in 395 systems after tillage deletion compared to the 395 systems recorded in farming practice

Result 3 The key levers to simultaneously reduce herbicide use & tillage intensity & yield loss due to weeds

Key levers	Reasons	Risks
Many crop species & varieties in rotation. Alternate winter & spring crops	Alternates conditions favouring different weed species. Diversifies crop management techniques	Little advice on minor crops. Complex systems
Sow early (particularly wheat & maize)	Better crop emergence	More weed emergence in crops
Early crop harvest	Leaves less time for weeds to reproduce in crop	Incomplete crop maturity
Permanent crop cover (fallow cover crops, double crops, multiannual crops)	Permanent competition for weeds. More frequent weed-habitat disturbance if cover crops or double crops)	Water stress for summer crops
Frequent spring / summer crops	More weed seed germination during fallow → fewer remaining weed seeds to emerge in cash crops. Short crop cycle → less time for weed reproduction in crop	Water stress during end of crop cycle
Frequent rolling during fallow	↗ soil-weed seed contact → more weed seed germination during fallow → fewer remaining weed seeds to emerge in cash crops	
Increase mechanically weeded field area	Non-chemical weed destruction in cash crops	Difficult if mulch. Crop damage. Can trigger weed emergence in cash crops
Sow with narrow interrows	↘ empty space where weeds can grow	Mechanical weeding = difficult
Do not irrigate or irrigate late after sowing	↘ weed emergence	↘ crop emergence & growth
Frequent shredding during fallow	Non-chemical weed destruction during fallow	
Late topping (particularly in wheat)	↘ weed seed production & soil seed bank replenishment	Can damage crop

Results from Classification and regression trees on 3 x 395 cropping systems x 10 weather series

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Colbach N et al (2014). Weed Research 54, 541–555
Colbach N et al (2021) Field Crops Res 261, 108006
Colbach & Cordeau (2022) Frontiers Agron 4, 823069