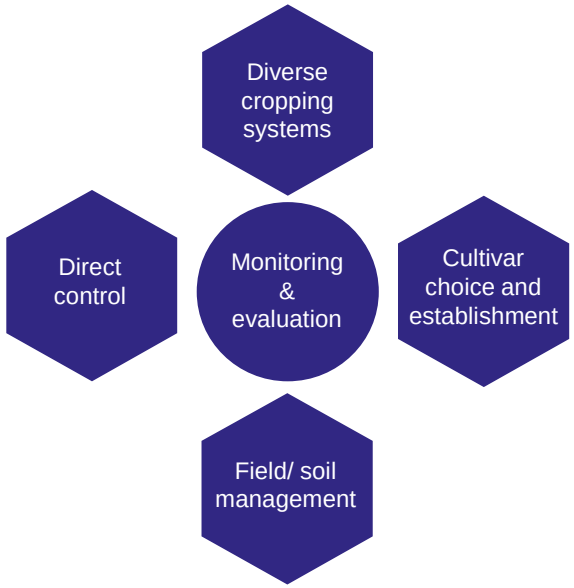
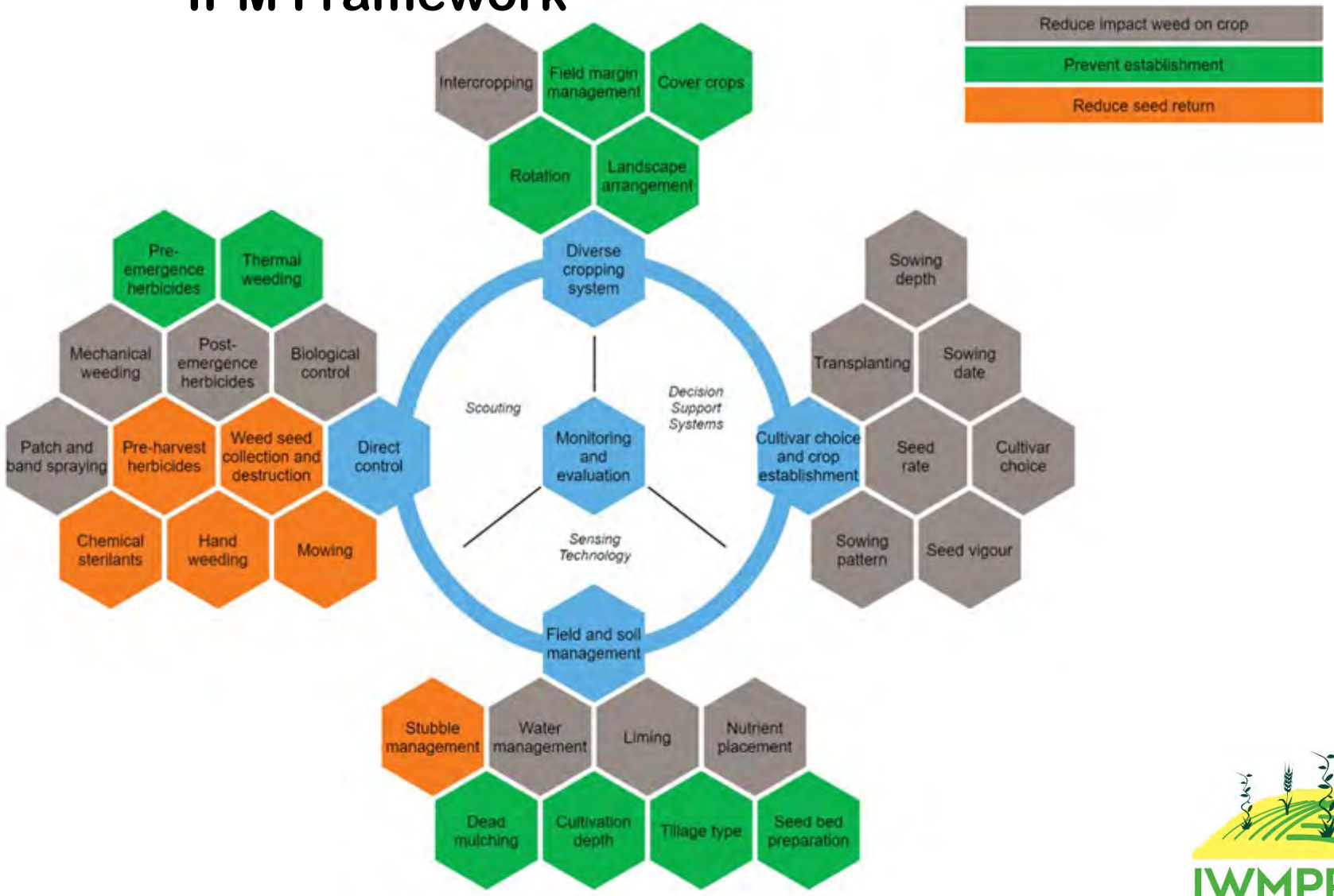
Prevent the establishment of weeds

Reduce the impact of weeds on the crop

Reduce seed return



IPM Framework



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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727321


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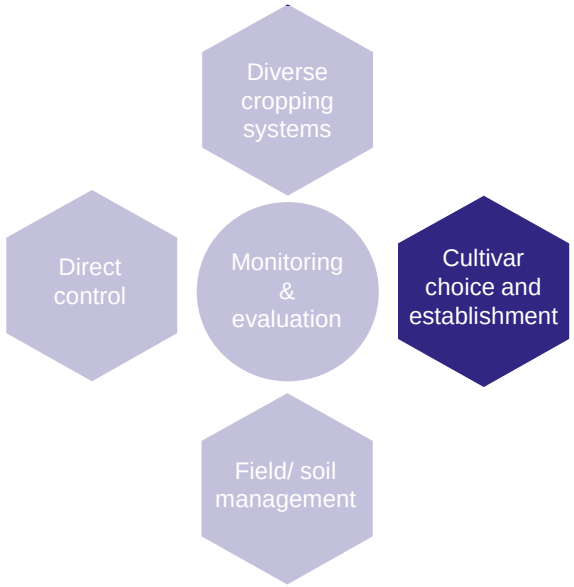

Sowing date
Delayed sowing

Ludovic Bonin, ARVALIS-Institut du Végétal

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ARVALIS Institut du végétal

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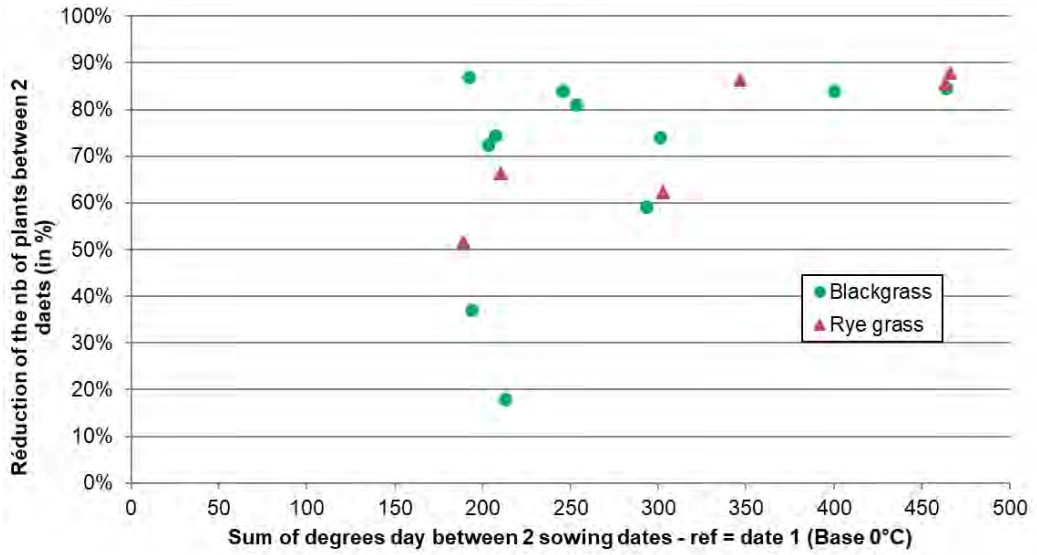
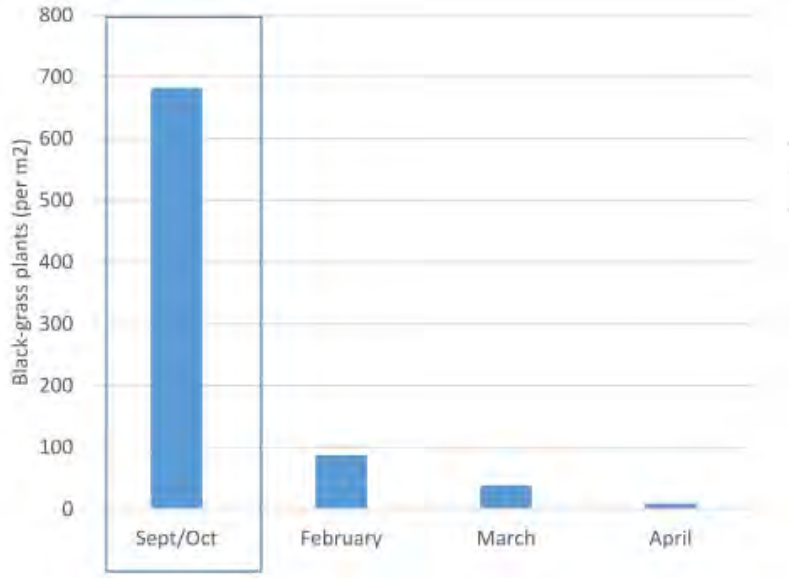
Delayed sowing: a tool for grassweeds management



Effect of difference in sowing date (in sum of degrees) on grassweed reduction (in %) – IWMPRAISE France



Effect of sowing date (e.g. change in crop rotation) on blackgrass emergence – IWMPRAISE UK

Average efficacy compared to date 1 "control " (economic return in €/ha)	Reference: Early sowing	Intermediate sowing	Late sowing
Control	0 % (595€)	51 % (922€)	59 % (917€)
« Light » herbicide program (-10 to -20%)	75% (1074€)	96% (1275€)	97% (1170€)
Reference	87% (1068€)	99% (1186€)	99.8% (1008€)

Synthesis of 5 trials (FR) comparing sowing dates

- This IWM strategy was nearly used in every trials in IWMPRAISE (alone or combined)
- Delayed sowing is a useful tool for grassweed management in cereals,
- Decrease up to 90% of blackgrass or ryegrass densities, with 3 weeks delay,
- Allows to keep an economic otpimum while limiting the use of herbicides

Implementation

Benefits	Barriers	Farmers' opinions (from open field days)
• Decrease of grassweeds densities in autumn (especially in fields with high densities/resistant populations to herbicides), • Real reduction (herbicides) opportunities with combined methods (e.g. delayed sowing + soil tillage), • Marginal cost of the technique (no specific machinery or skill) • In problematic fields (blackgrass/ryegrass), it allows the potential yield to be « protected » (less competition of weeds).	• depends on the weather conditions, which can sometimes be difficult in autumn • Decrease yield potential (≈0.4 t/ha for 10 days delay (⇔ to optimal sowing date in FR)), • Competition in autumn, with other works.	• Farmers are very interested but seemed to be reluctant to risk (weather conditions and soil structure), • Those who already delayed sowing dates have difficulty to control large grassweed populations (resistant, high densities)

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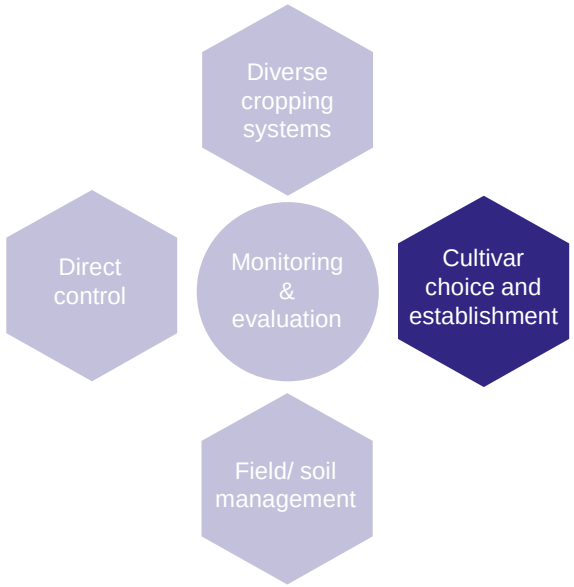

Wider rows as supportive tactics for mechanical weeding in cereals

Bo Melander, Aarhus University

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Wider rows for mechanical weed control

- Flat hoe shares developed for early treatments in cereals
- Inter-row spacing of 15-20 cm is possible
- Increasing the seed rate to Improve intra-row weed suppression

More information in:
McCollough, M. R. and B. Melander (2022). "Improving upon the interrow hoed cereal system: the effects of crop density and row spacing on intrarow weeds and crop parameters in spring barley." Weed Science: 1-12.

Implementation

- Implementable in practise
- Seeding equipment that can handle wider rows and increased seed rates may be needed
- Complete suppression not possible
- Increasing employment in organic cereals

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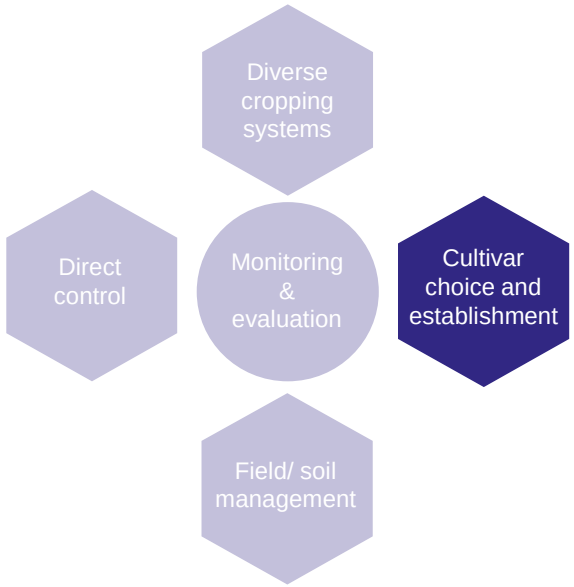

Cultivar selection

Mette Sønderskov, Aarhus University

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Photo from ARVALIS Culturales (L. Bonin)

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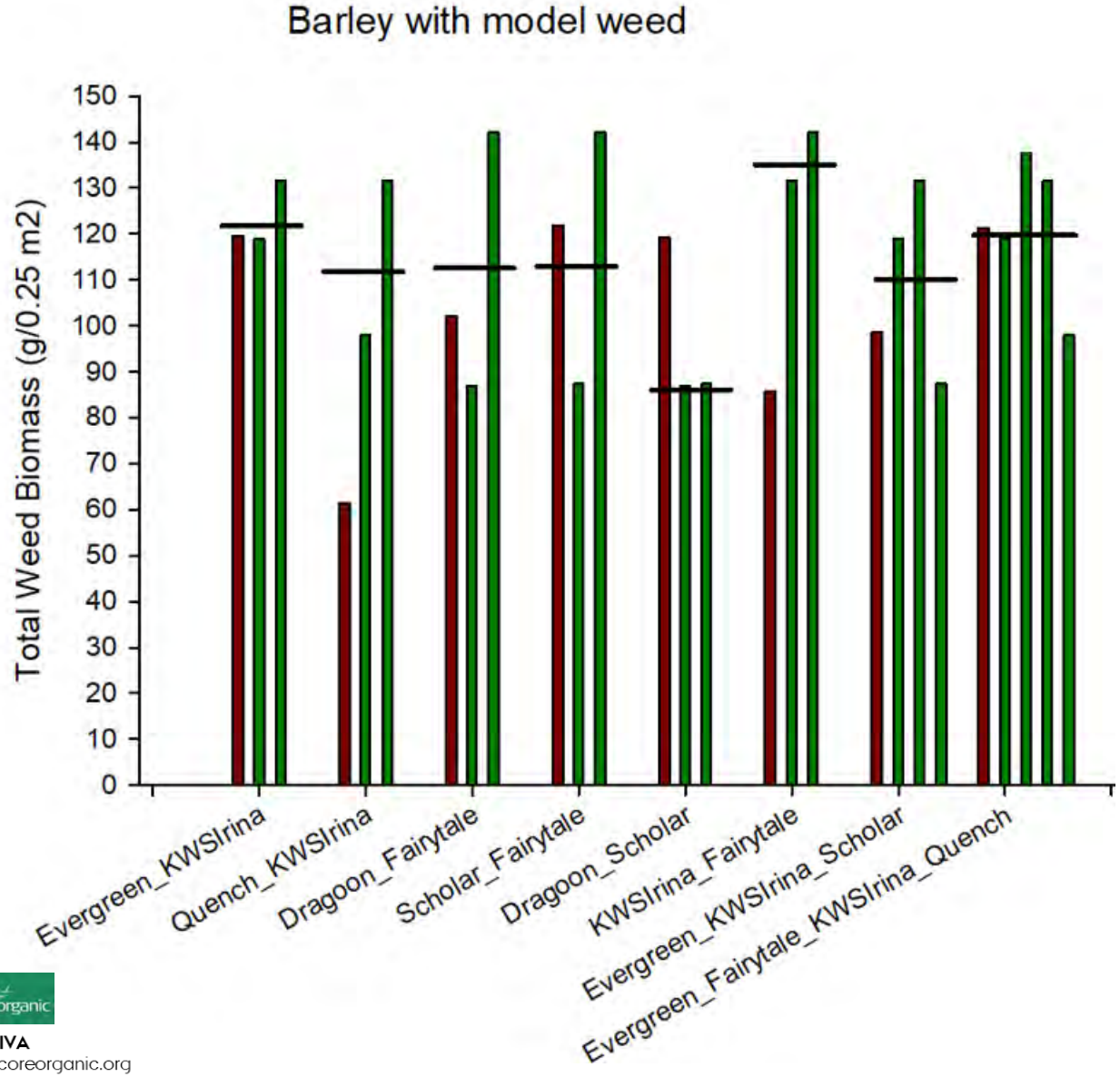
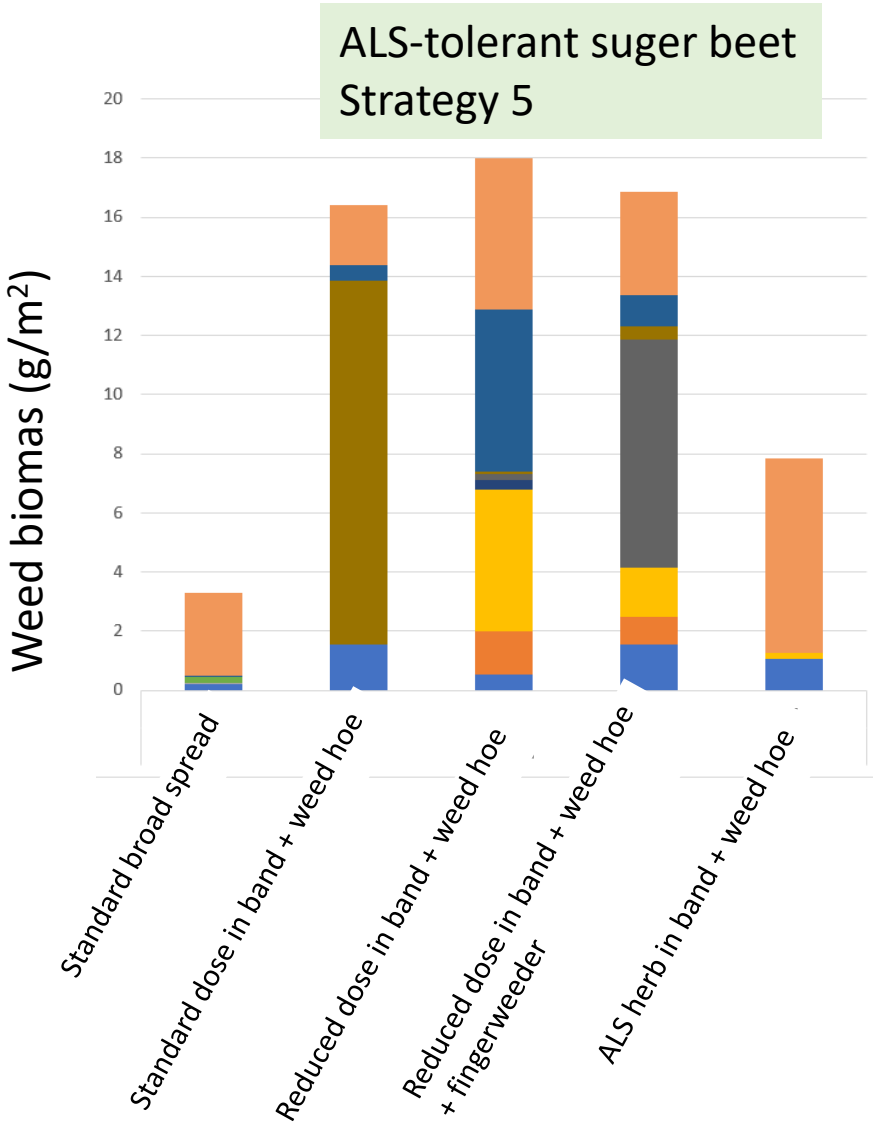
Cultivar selection for increased weed control?





Implementation

- ALS-tolerant crops: readily implementable when on market
  -drawback: resistance risk

- Cultivar mixtures: implementable when there is knowledge of cultivar characteristics

  -drawback: small variation among modern cultivars
  -much experimental work to have the knowledge of which cultivars to mix
  -small influence on weed growth compared to other tactics

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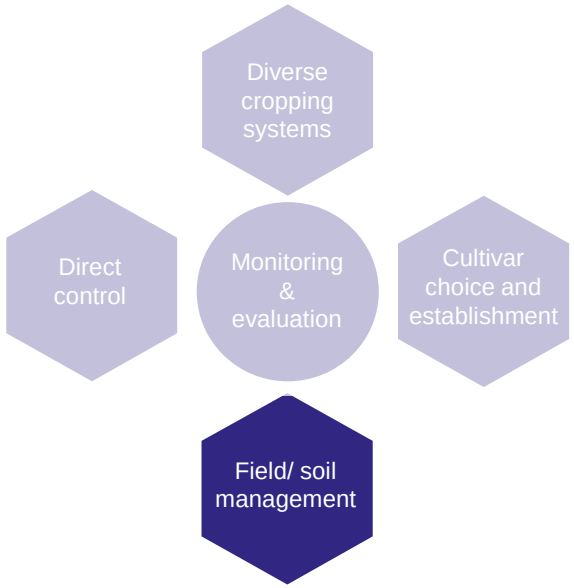

Soil tillage type/depth

Bruno Chauvel, INRAE

IWMPRAISE

INRAE
la science pour la vie, l'humain, la terre

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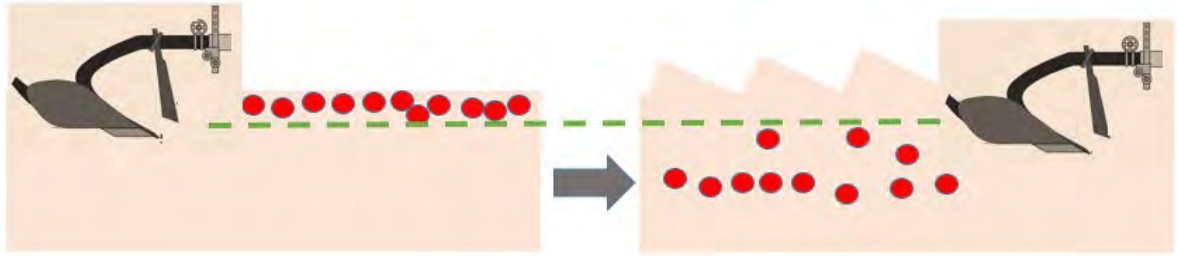
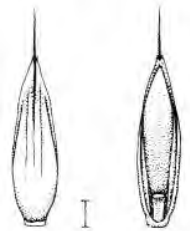
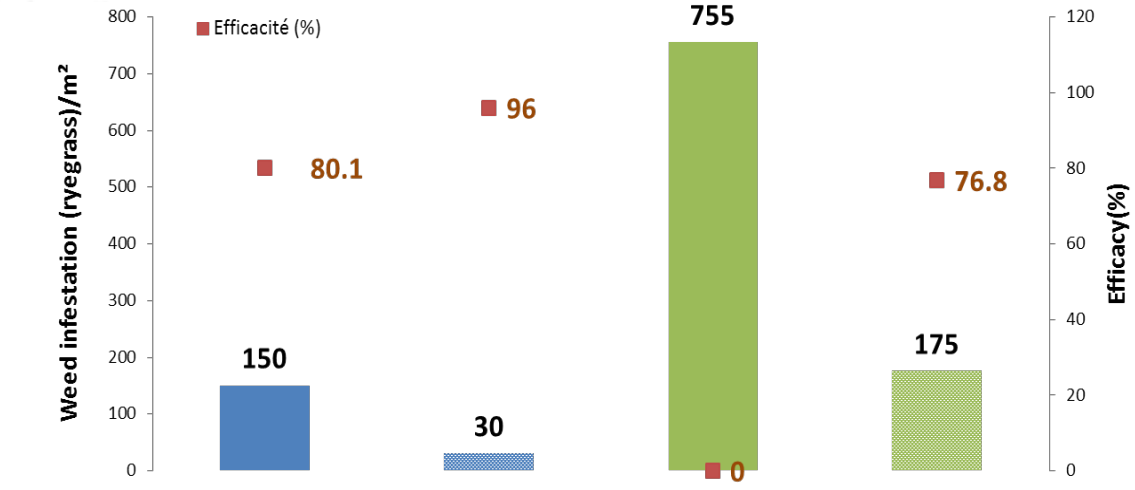
Aim: to place the weed seeds deep enough so that they cannot emerge

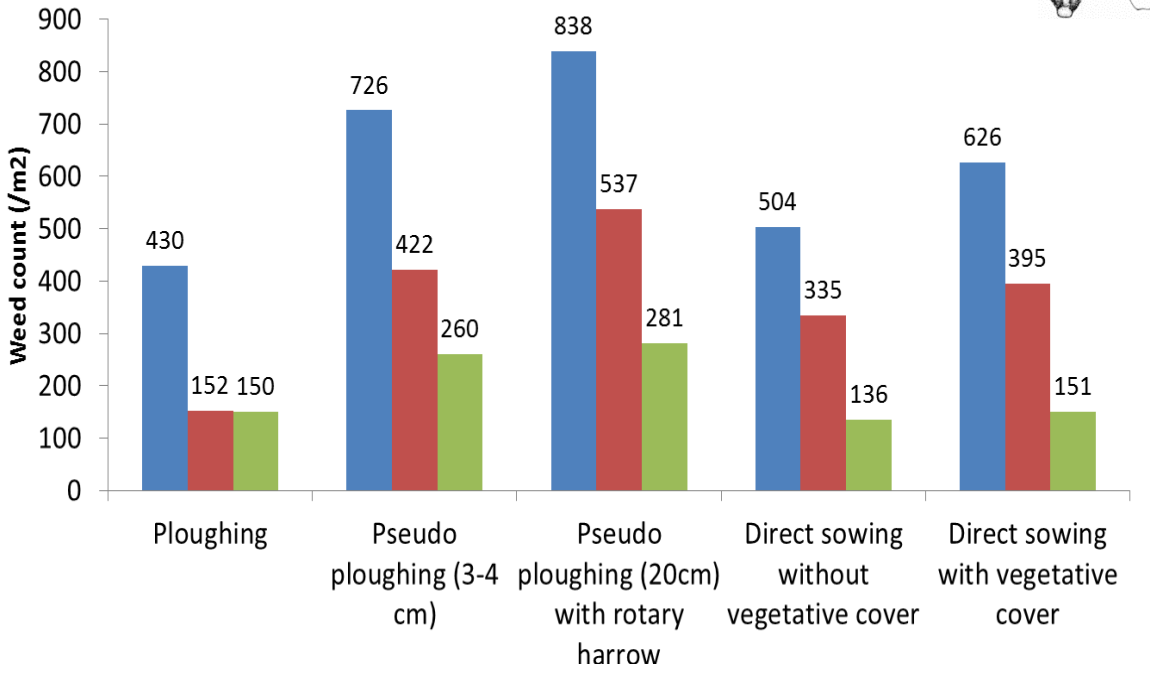






Soil tillage	ploughing	ploughing	No till	No till
Sowing date	12/10	Delayed (30/10)	12/10	Delayed (30/10)

Difference between *Lolium* sp. density in ploughed and no-till practice with two sowing dates. Weed density on the left y-axis and control efficacy on the right y-axis in red (INVIVO ©)



Counts of *Alopecurus myosuroides* depending on sowing date and tillage practice (trial of Vallangoujard, APCA ©).

The effectiveness of ploughing varies according to the biology of the weed species annual, perennial /// broadleaves, grassweed.

Implementation

Deep soil tillage with inversion is a cultivation practice that has both a role in soil structuring and in seed bank management

- Its effectiveness can be reduced or increased depending on other cultivation practices (stale seed bed, delayed sowing date, straw management) and weather conditions.

- Burying the seeds by soil tillage is a preventive practice on soil seed bank that can be considered as one of the pillars of integrated weed management in the absence of synthetic herbicides.

IWMPraise - Booklet, 2020

- These tillage practices can be questioned for :
  - their negative effects on soil biodiversity (mycorrhiza, earthworms)
  - the degradation of organic matter
  - the cost of their implementation (working time, energy costs)

➔ In a rotation that is as diversified as possible, a good knowledge of the biology of weed seeds is required to optimize the effects of deep soil tillage

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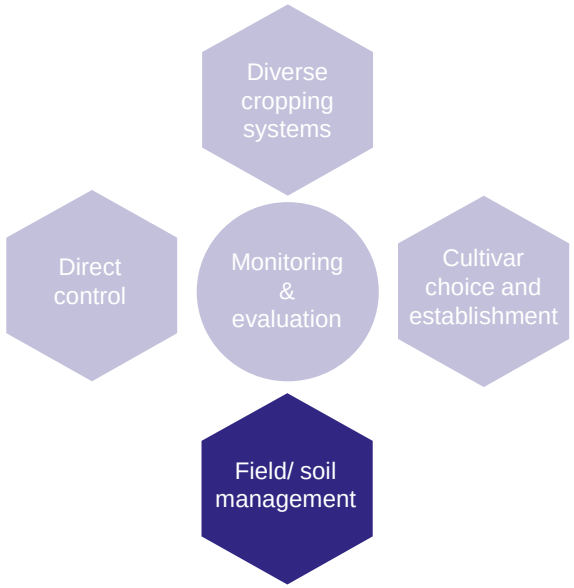


Grain sorghum planted into dead mulch (Italy): WP 2

Christian Frasconi, Daniele Antichi, CiRAA

IWMPRAISE

C.i.R.A.A. Università di Pisa Centro di Ricerche Agro-Ambientali *Enrico Avanzi*

dal 1850 Dondi® insieme per la terra

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727321

Grain sorghum planted into dead mulch and evaluation of Dondi CUT-ROLLER RT300® for mechanical termination of cover crops

Main characteristic of CUT-ROLLER RT 300	
Working width	275 cm
Roller diameter	86 cm
Number of blades	15
Blades height	18 cm
Weight	1900 kg (2600 kg*)
* Roller filled with water	

Two types of blade tested

L1 chisel edge blades

L2 rectangular edge blades

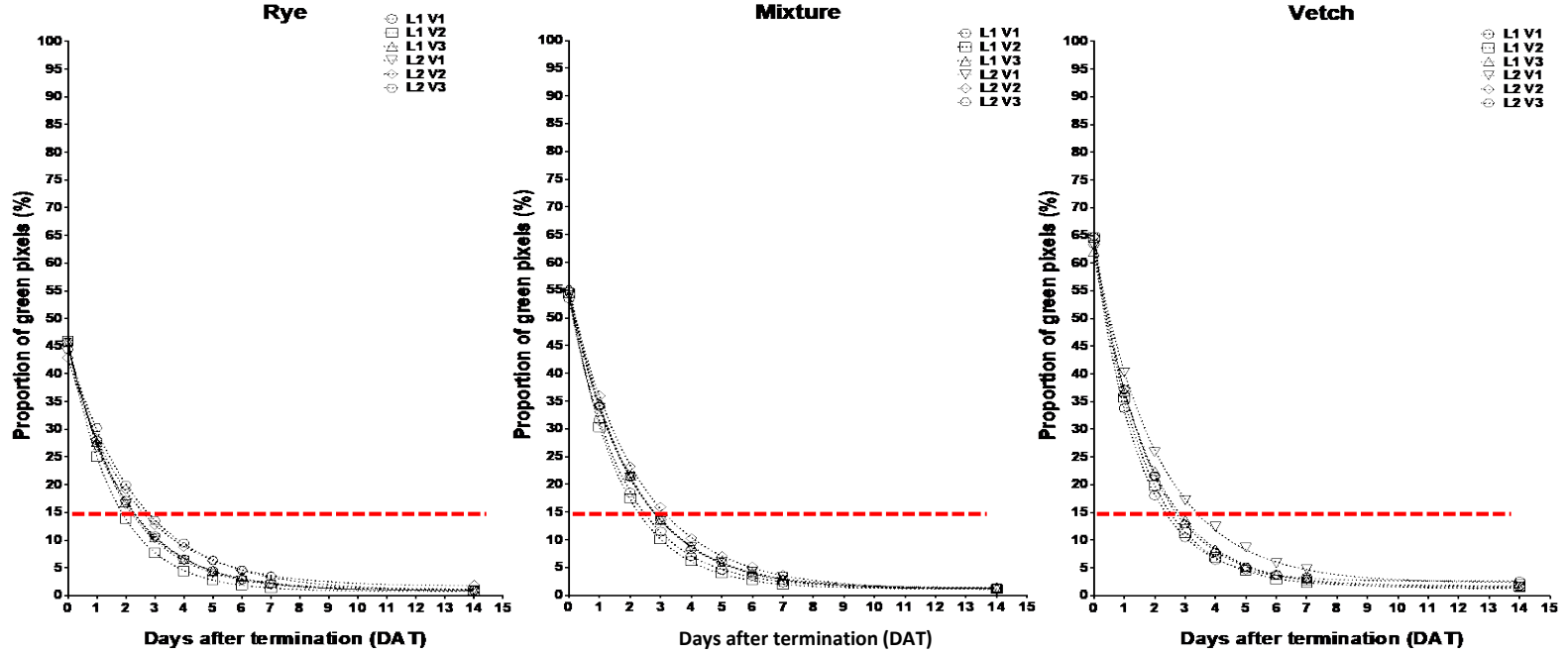
Three working speeds tested V1 (5 km/h) V2 (10 km/h) V3 (15 km/h)

Three cover crops tested rye, vetch, mixture (rye+vetch)

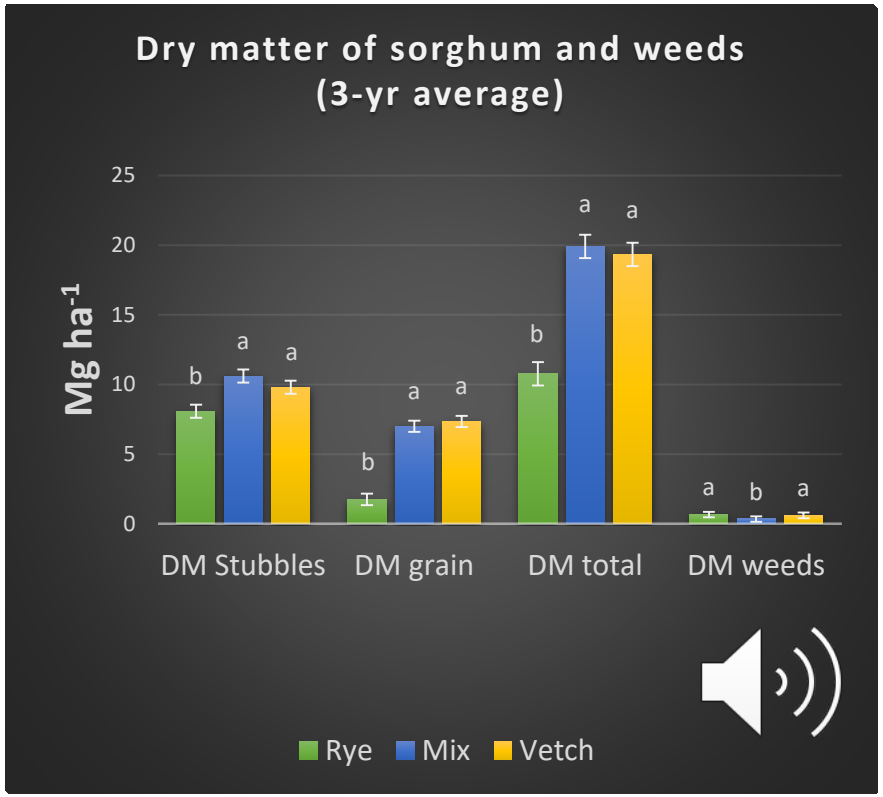
Data of green cover, obtained by digital image analysis, were analysed with non linear regression adopting a one phase decay model: $y = (y_0 - y_\infty) \cdot e^{-kx} + y_\infty$

$y = green\ cover\ [\%]$ $y_0 = green\ cover\ at\ 0\ DAT [\%]$ $y_\infty = y\ value\ at\ infinite\ [\%]$

$k = rate\ costant\ [day^{-1}]$ $x = time\ after\ treatment\ [day]$



Sorghum planted into different dead mulches



Implementation

- Cover crops used as dead mulch could be a good preventive technique to manage weeds in conservation agriculture systems. Modern technologies for precision agriculture, such as artificial vision weed detection and herbicide site-specific VRA application systems, could synergically contribute to control weed after crop emergence.

- Cover crop establishment costs could represent a barrier for their wider application among farmers. Further research and efforts should aim to reduce cover crop establishment costs. Using combined cultivator implemented with a compact pneumatic broadcast seeder could allow to perform shallow soil tillage and cover crop establishment with a single passage, thus reducing labour and operational costs.

- Modern no-till planters seem to perform satisfactorily cash crop establishment into the dead mulch. However in certain cases (clayey soils, wet soils in plastic conditions), some issues could raise jeopardizing the efficacy of the cash crop planter. Strip tillage equipment and tractor's RTK-GNSS assisted guidance systems could contribute to overcome these problem.

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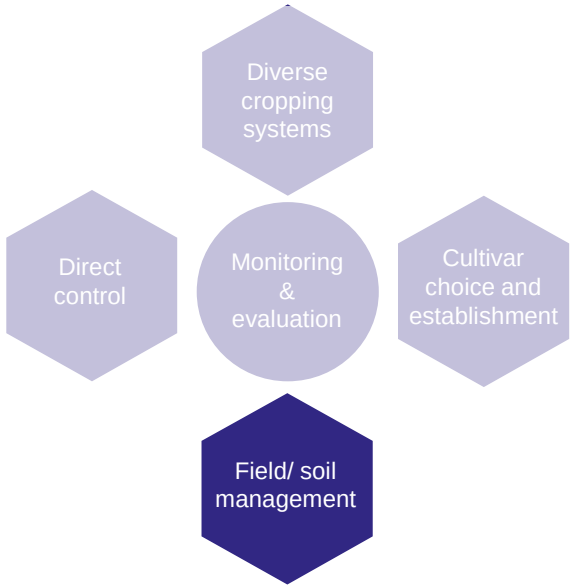

Seed bed preparation Alternatives for glyphosate

Ludovic Bonin, ARVALIS-Institut du Végétal

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ARVALIS Institut du végétal

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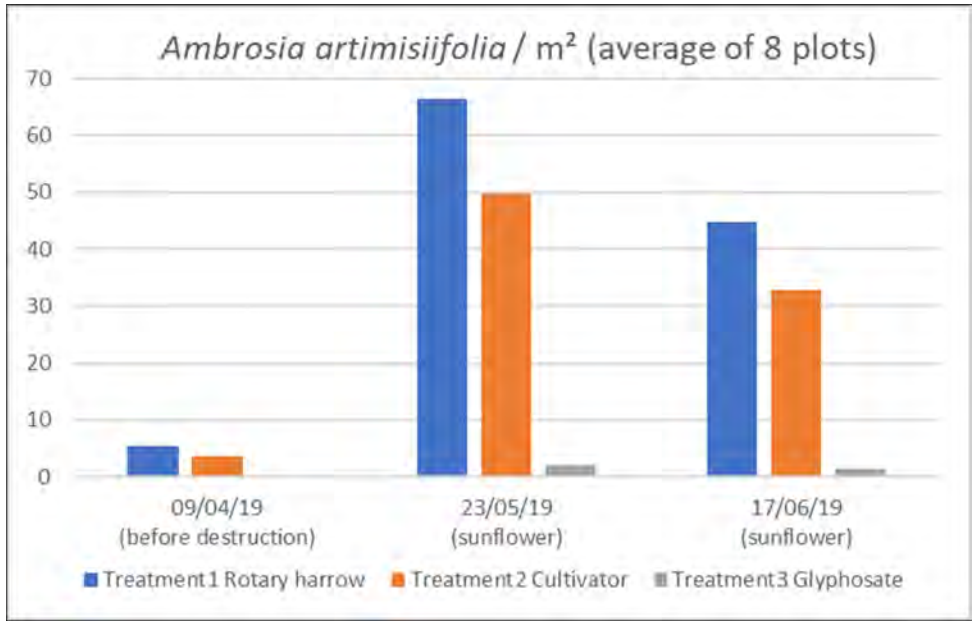
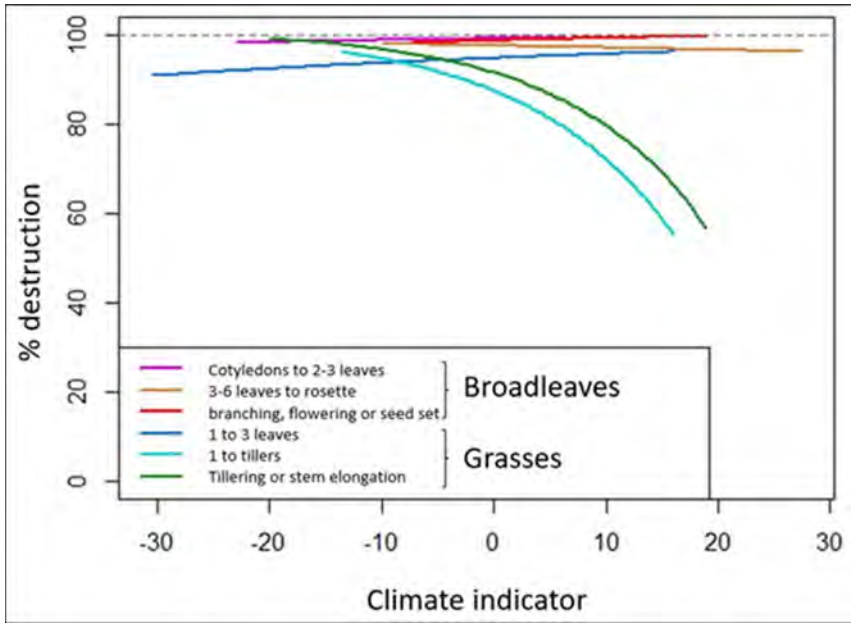
Alternatives for glyphosate: mainly soil tillage



Ragweed germination in 2019 trial in sunflower – IWMPRAISE France Terres Inovia

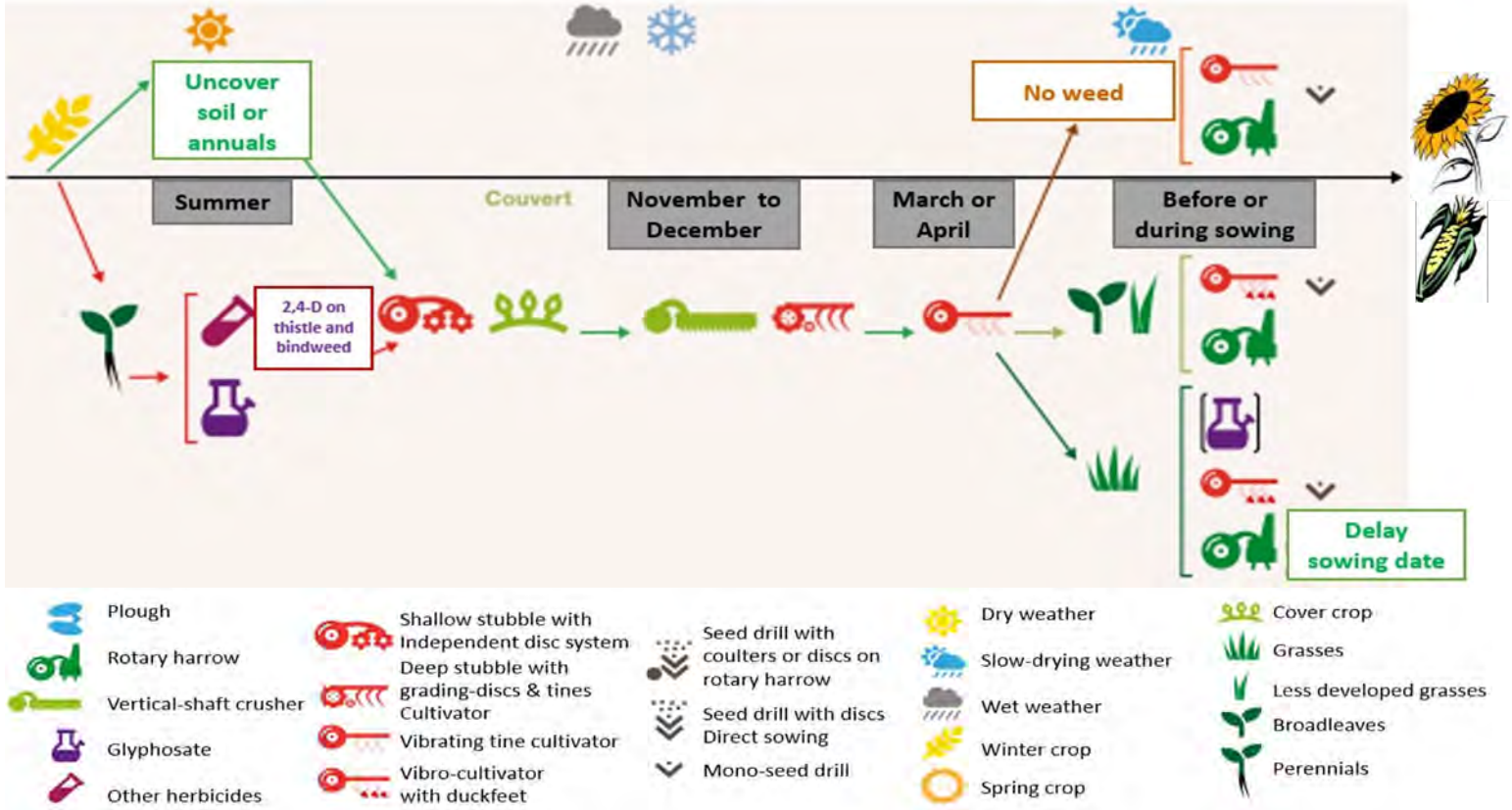


Weed destruction (%) among type of weeds and climate indicator (P-ETP) (compilation of 30 trials IWMPRAISE and other trials)

- Alternatives for glyphosate were studied in 20 trials in IWMPRAISE, before autumn seeded crops or spring crops. These alternatives were mainly based on soil tillage (type of tool, passage date, depth, etc…)
- Tillage is efficient to destroy young seedlings of ragweed. Nevertheless, tillage can stimulate more regrowth of weeds. Indeed, rotary harrow seems to stimulate more germination than a tine cultivator.
- The efficacies of the different strategies were assessed with an indicator called “climatic indicator” which represents the difference between rain and potential evapotranspiration => For grass species, the efficiency of destruction is lower when the climate is wet, especially from tillering stage ; For broadleaved weeds species, the quality of the destruction seems independent of the climate and the stages of the weeds

Implementation

- Destruction is more efficient when the elements of the equipment (tines or discs) have a good coverage,
- Glyphosate without any tillage avoid new germinations of weeds but is not enough to correctly prepare the soil for sowing, especially for spring crops (e.g. sunflower).
- Tillage can induce excessive drying of the seedbed and impact the potential yield. It also accentuates soil erosion.
- Time and fuel consuming are higher without glyphosate (from +4 to + 55 min/ha; and from 0 to 16 l/ha).



Benefits	Barriers	Farmers' opinions (from open field days)
• Less use of glyphosate, reduction of water pollution, etc… • Effective on glyphosate resistant weeds, • Seedbed preparation	• If soil tillage is used : time & fuel consuming, • Soil erosion, • Excessive drying of seedbed (e.g. for spring crops) => poor émergence	• Glyphosate is widely used but wisely (not every year, not everywhere), lots of farmers no longer use it, • Essential for farmers in conservation agriculture

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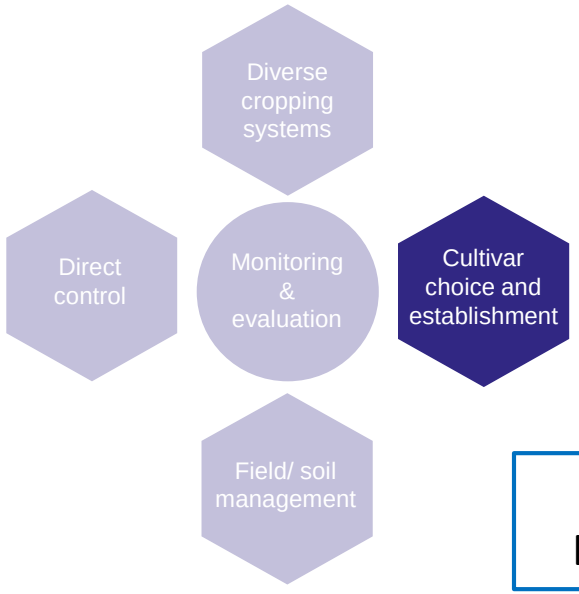
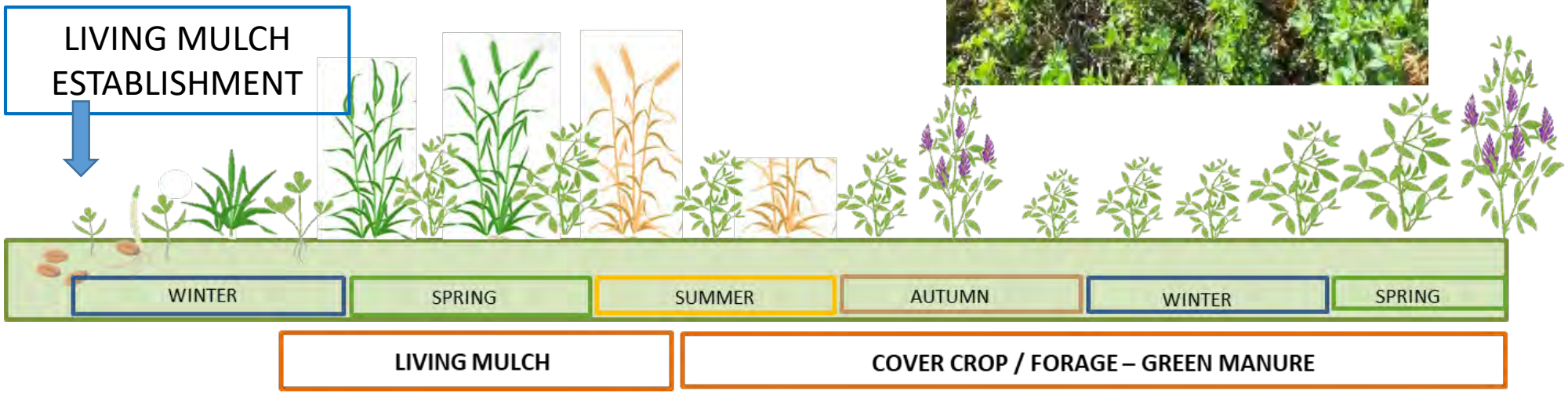
Field and soil management – Stubble management

Camilla Moonen & Federico Leoni, Scuola Superiore Sant'Anna

IWMPRAISE

Sant'Anna
Scuola Universitaria Superiore Pisa





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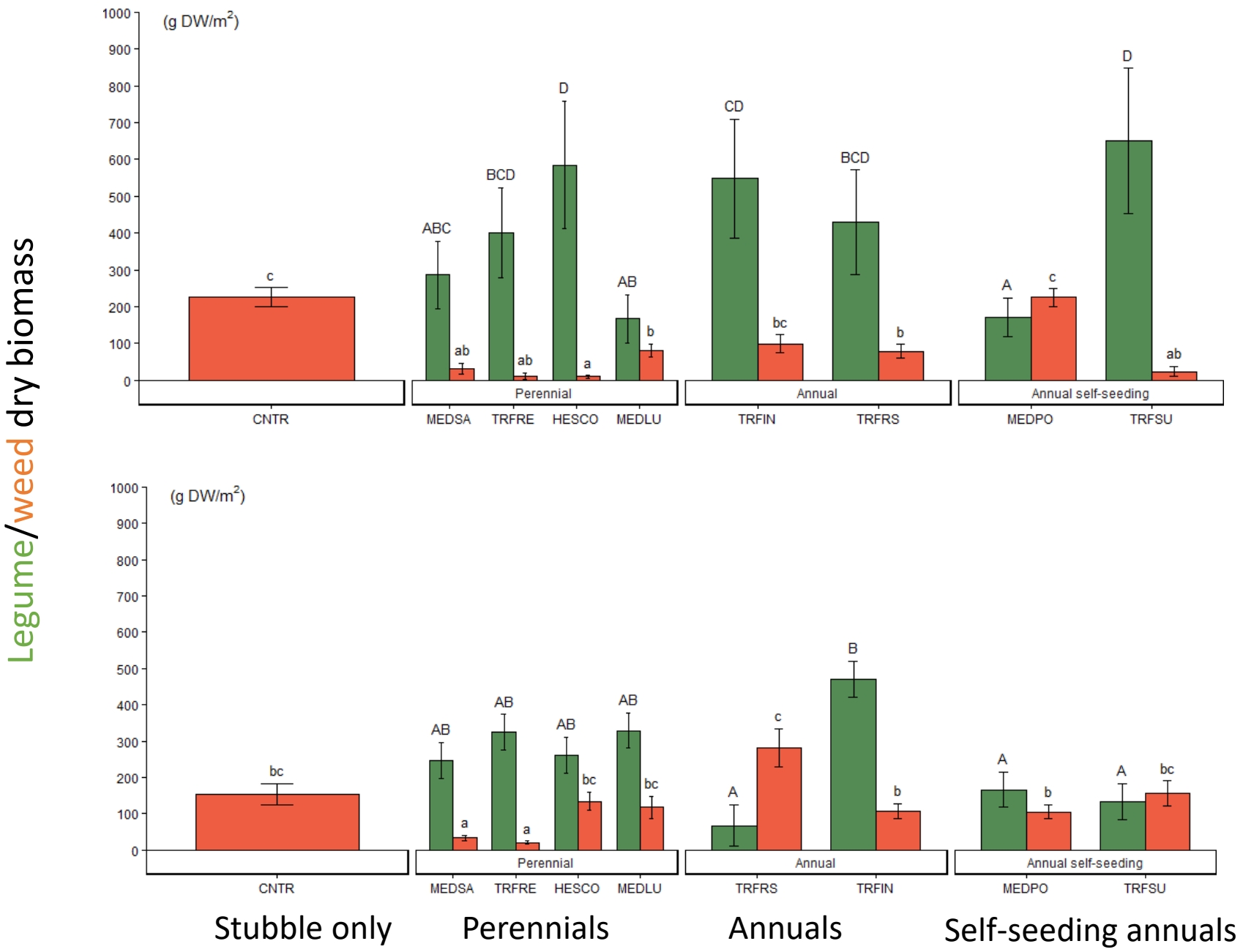

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Weed dry biomass (red) and legume dry biomass (green) in low-input (top) and integrated (bottom) durum wheat stubble in spring (Two locations in Italy).

(Re-)growth capacity depends on legume species and management intensity.

Weed control best with perennial legumes

Implementation

- **Annual legumes**: In favourable years annual legumes may regrow from their seeds but this is unusual. Their dead biomass is not suitable to suppress weeds in the intercrop period, especially when the wheat crop was competitive and reduced their biomass in the intercrop period.
- **Self-seeding legumes**: their regrowth capacity depends on the soil and weather conditions. Interesting option if the right legume for the local situation is selected.
- **Perennial legumes**: they have a good regrowth capacity under high and low management intensity and in different environmental conditions. Weed control is reliable. They can be used as green manure or for haymaking for several years. Highest management flexibility.

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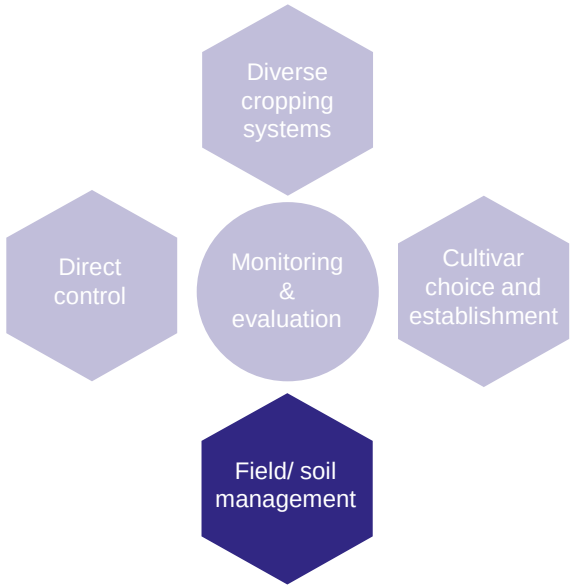
Reduce the impact of weeds on the crop

Reduce seed return



Stubble management,

Mette Sønderskov & Peter Kryger Jensen, AU

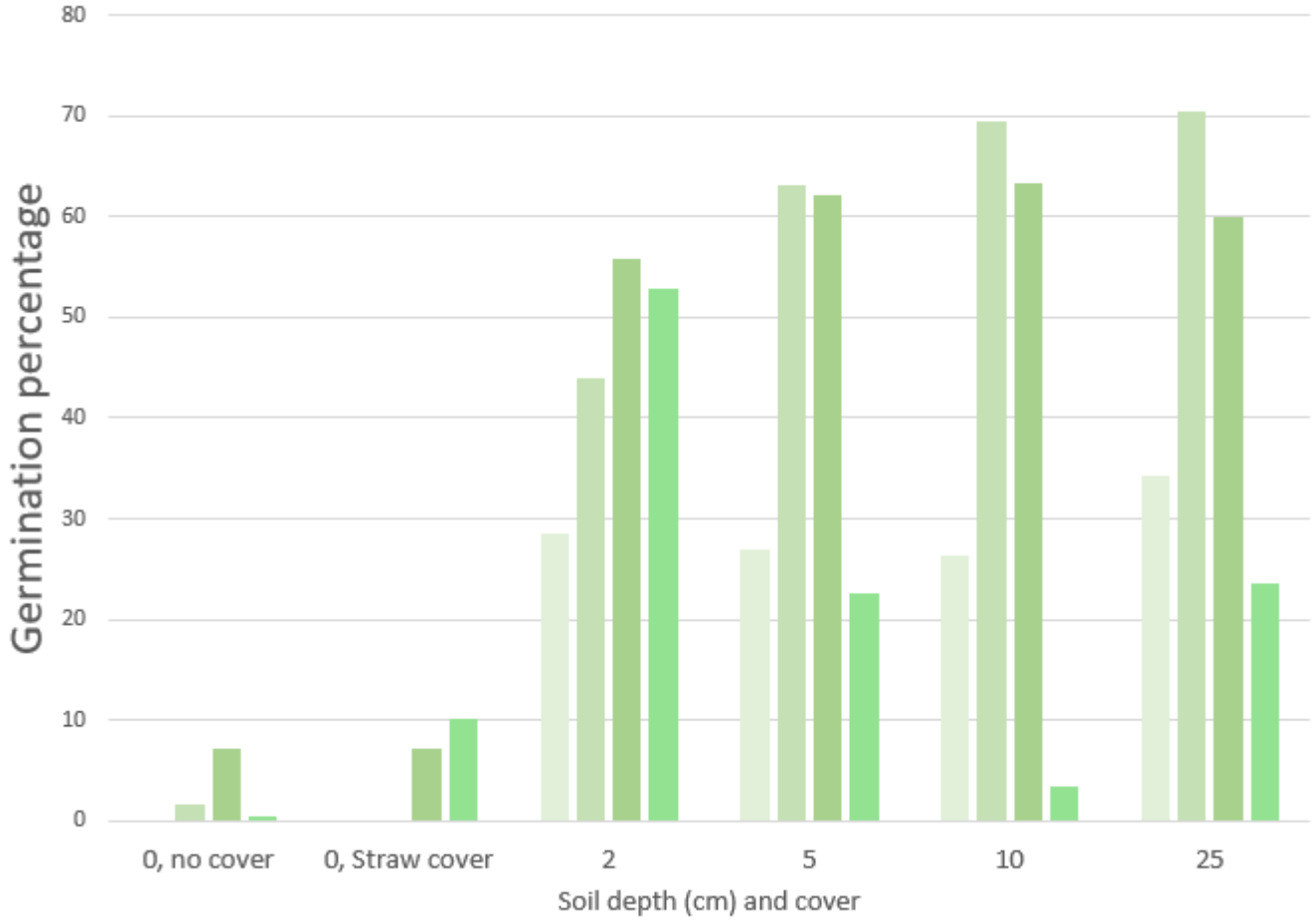
IWMPRAISE

AARHUS UNIVERSITY

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727321

Survival of *Alopecurus myosuroides* seeds buried 1 year at different soil depths

Jensen (2009) *Weed Research 49, p. 592-601*



Survival of *two grass weed species after different post harvest treatments*

Jensen (2010) Grass and forage science 65, 85-91

Estimated germination (%) kept at soil surface or buried at 2 cm fra Aug.-Sep (same year)

	Year			
	2004	2005	2004	2005
Soil depth and cover	*Poa pratensis*		*Lolium perenne*	
0 cm, no cover	9·5[b]	0·0[a]	6·3[c]	0·9
0 cm, chopped straw	0·9[a]	0·7[a]	3·4[b]	0·4
2 cm	11·9[b]	15·1[b]	0·2[a]	0·0

Statistically significant differences between treatments within a column ($P < 0·05$) are indicated by different letters.

Longevity of seeds of four annual grass and two dicotyledon weed species as related to placement in the soil and straw disposal technique

P K JENSEN
Faculty of Agricultural Sciences, Department of Integrated Pest Management, University of Aarhus, Slagelse, Denmark

Longevity of seeds of *Poa pratensis* and *Lolium perenne* as affected by simulated soil tillage practices and its implications for contamination of herbage seed crops

P. K. Jensen
Department of Integrated Pest Management, Faculty of Agricultural Sciences, Aarhus University, Slagelse, Denmark

Implementation

- Readily implementable and requires no special equipment
- Most effective for annual grass weed seeds according to Jensen 2009, 2010

- Leave the seeds at the soil surface for at least 1 month
- If any treatment before a month – not deeper than 1 cm – very light tine harrowing

- Can interfere with cover crop management

- Seed bank management relates to soil tillage type and frequency
  -important to consider the most common and troublesome weed species

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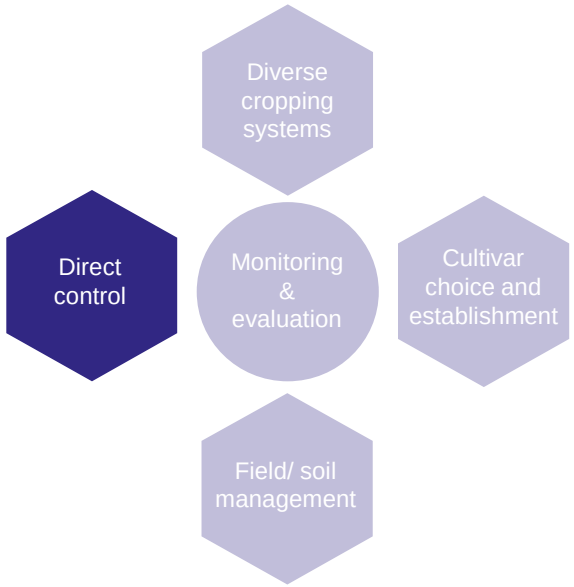
Seed bed preparation

Prevent the establishment of weeds

Reduce the impact of weeds on the crop

Reduce seed return



Mechanical weeding in vineyards,

Dr Flora O'Brien, NIAB

Presented by J.L. Gonzalez-Andujar, IAS-CSIC

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727321

Mechanical weeding

The treatments

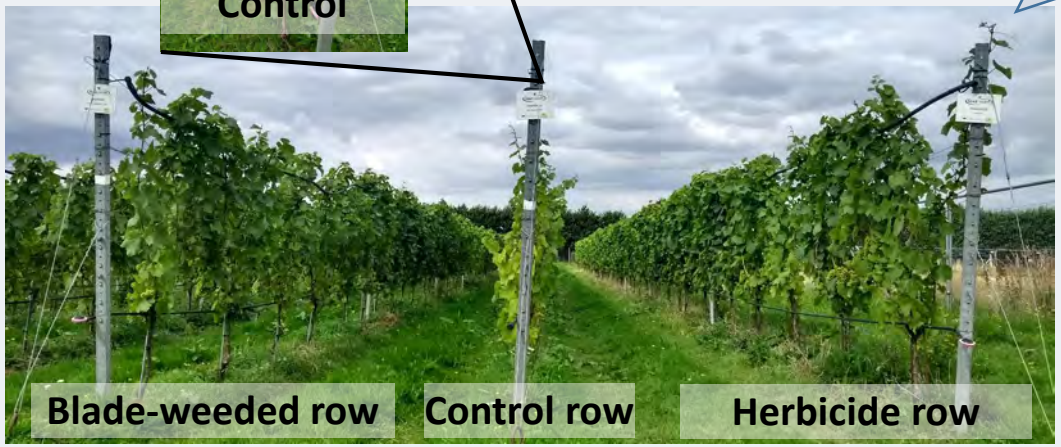
- Control (strimming only)
- Herbicide (grower standard)
- Blade (mechanical)
- Disk (mechanical)

Blade (Radius SL+, Clemens)

Disk (Finger disk & finger weeder, Clemens)

Control

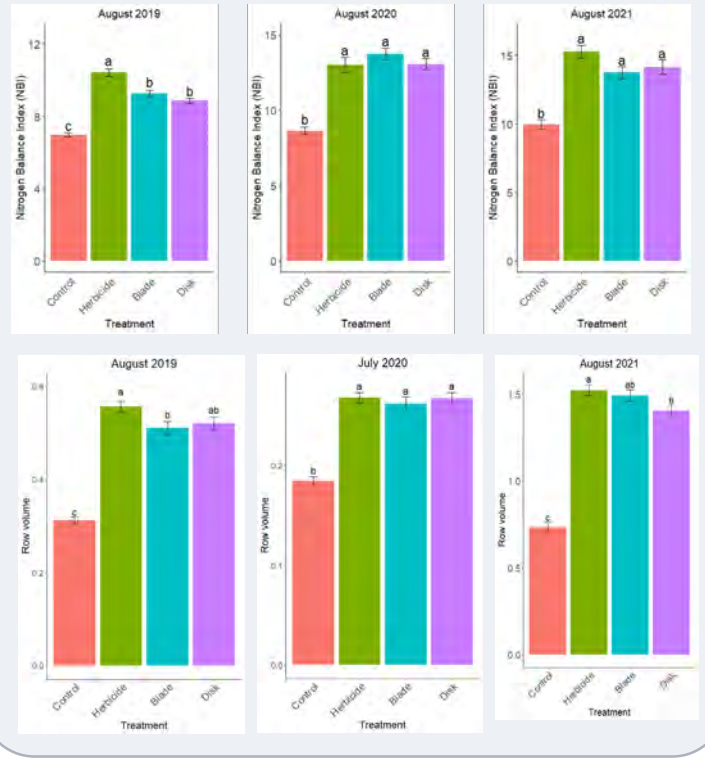
Control vines were visibly **chlorotic and less vigorous**, as reflected by the in field measurements



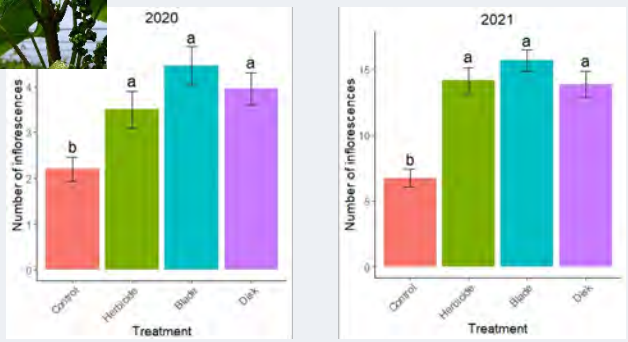
Blade-weeded row **Control row** **Herbicide row**

Reduction in weed abundance occurred in Blade and herbicide treated vine rows in both years:

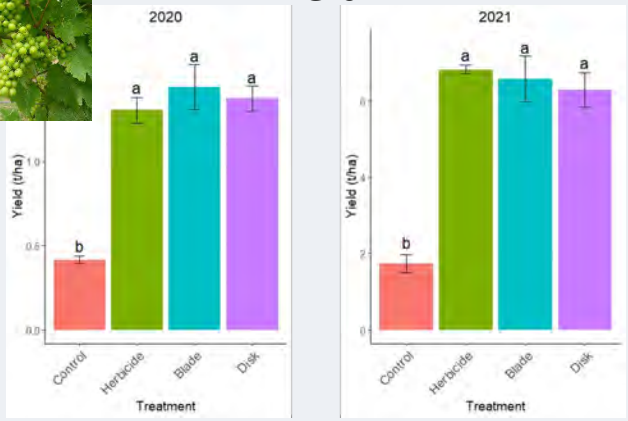
Survey date		Control	Herbicide	Blade	Disk
2020	January	297	307	357	328
	August	420.5	321	68	200
	November	589.8	134.5	280	371
2021	April	570	466.5	523	416.5
	August	300	528	417.5	415
	November	589.5	264	498	532.5



Inflorescence counts



Yield



Vines in the no treatment control had significantly fewer inflorescences and **>3x lower yields** than mechanically and herbicide weeded vines.

Implementation

Barriers to the use of mechanical weeding include:

- ***soil type and weather conditions***
- ***labour & fuel costs***

Benefits of mechanical weeding:

- Achieves a level of weed control that is comparable to that of herbicides, while maintaining the same level of vine vigour, yield and quality.
- Removes the need for chemical (herbicide) applications.
- Additional benefits may include:
  - reduced frost risk
  - lower humidity and therefore lower disease pressure.

Utilising a combined approach of different mechanical weeders (e.g. blade and disk) may yield the best results.

NIAB

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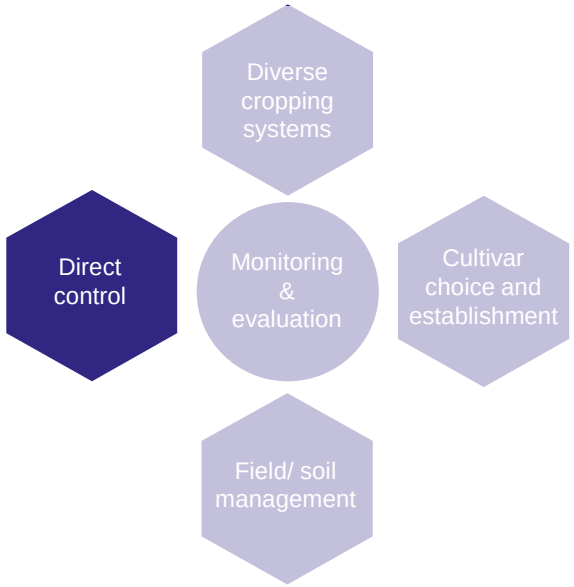


Thermal weeding
Automated physical intra-row weed control

Bo Melander, Aarhus University

IWMPRAISE

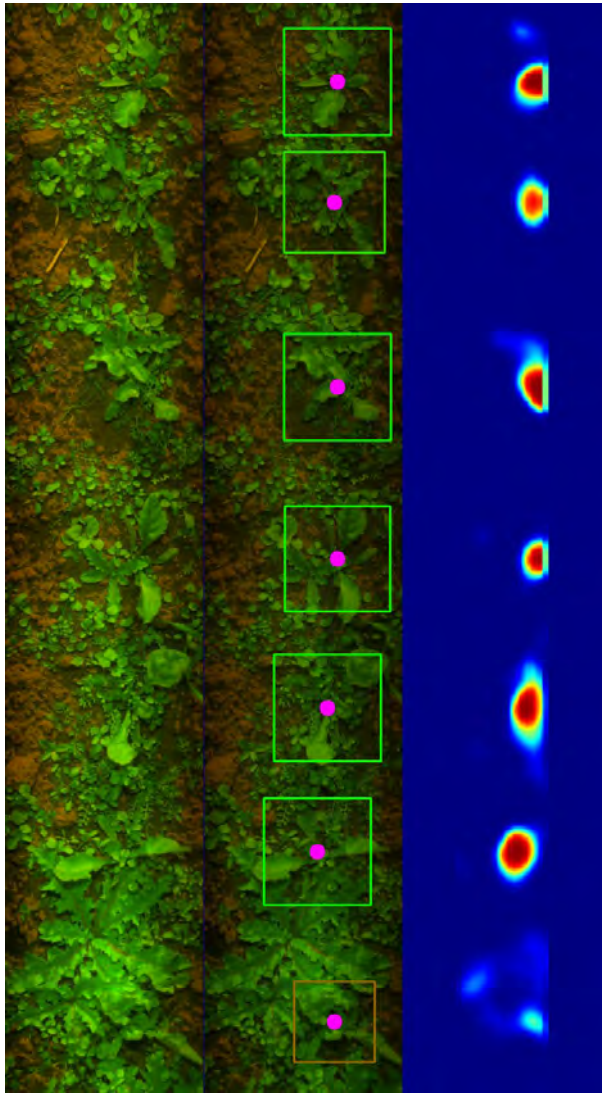
AARHUS UNIVERSITY

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727321

Automated intra-row weed control in sugar beets

IWMPRAISE

- Significant improvements of the software for detecting fodder beet plants based on AI- and ML-technologies
- Intra-row weeding possible in close proximity to beet plants – 1 cm distance for mechanical blades
- > 60 % intra-row weed control achieved



Implementation

- Equipped with hoe blades for inter-row cultivation, automated intra-row weeders provide a complete non-chemical solution
- Great potential for expanding the technology to many other direct-sown row crops
- Weed plants growing in close proximity to crop plants remain a challenge – supplementary tactics may be needed
- Two machines (Robovator) are operating in commercial sugar beet fields in 2022. GPS-based machines are also being employed in commercial settings

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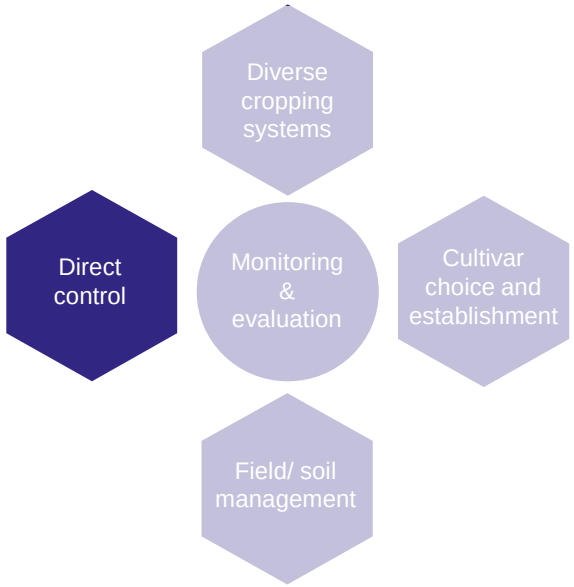

Herbicides pre/post

Ludovic Bonin, ARVALIS-Institut du Végétal
John Cussans & William Smith, NIAB

IWMPRAISE

ARVALIS Institut du végétal

NIAB

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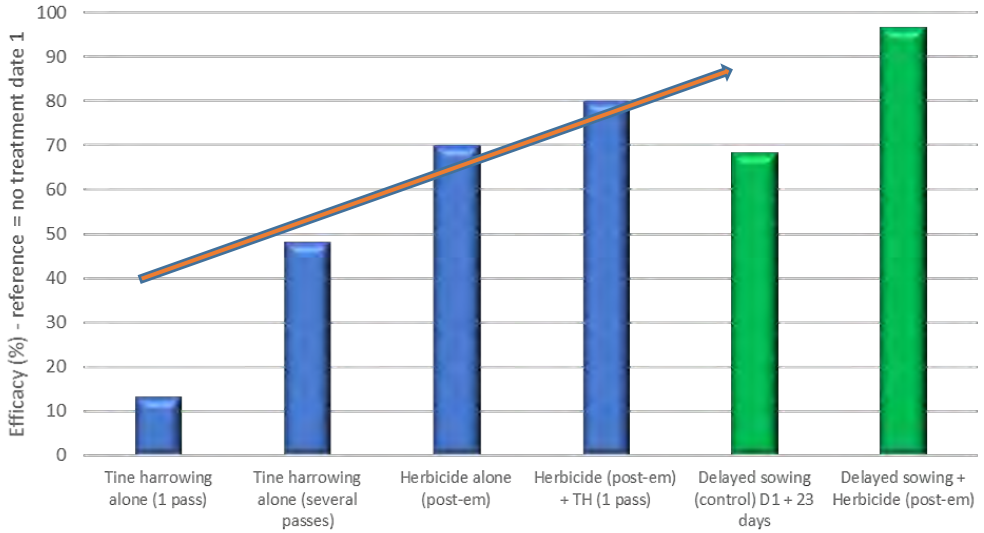
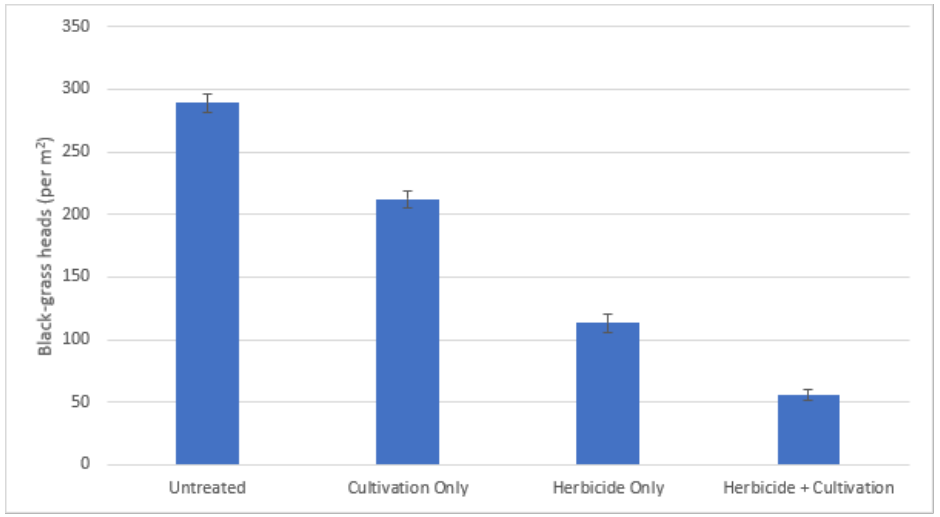
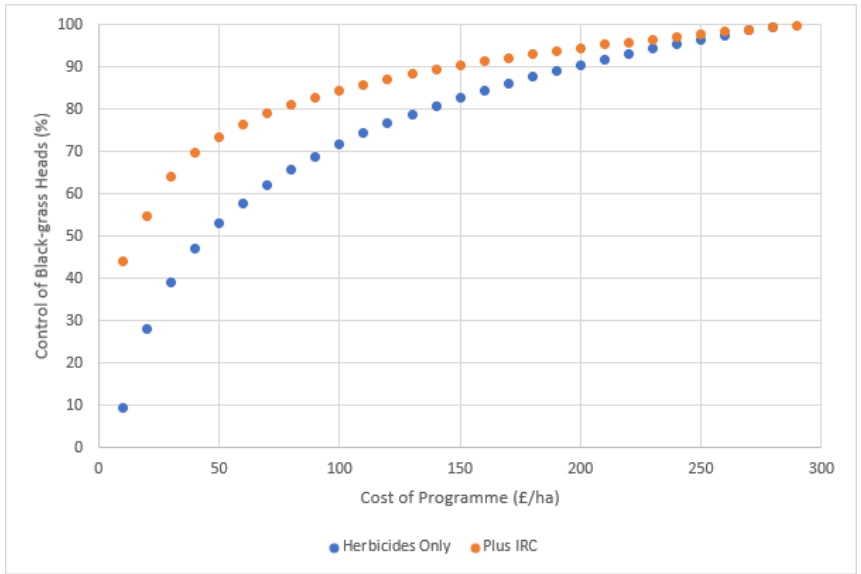
Herbicides pre/post :



Efficacy (%), against blackgrass, of strategies combining herbicides and/or tine harrowing / delayed sowing – Lunery (18) 2021



Effect of inter-row cultivation (Garford machinery) on blackgrass heads in wheat – UK 2019.



- Combination of non chemical methods and herbicides can achieve very interesting levels of control of grassweeds,
- Cost-effectiveness of grassweed herbicides isn't constant. It becomes much more expensive to get the last few % control,
- There is a real economic as well as IWM case for adoption, to combine mechanical weed control approaches with effective herbicides.

Implementation

Benefits	Barriers	Farmers' opinions (from open field days)
• Less use of herbicides, reduction of water pollution, etc… • Management of resistant populations.	• Efficacy is variable and make its adoption difficult (reliability), • Cultivation depends on weather/soil conditions, • Labour demand & conflict with other farm operations • Even if GPS are available, working time are higher (⇔ herbicide application) • To maximise the effect of mechanical weed control, weed densities must be reduced beforehand (delayed sowing, ploughing, etc…)	• the technique is of interest to farmers, but the reliability of implementation (time/cost/effectiveness) is an issue.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Prevent the establishment of weeds

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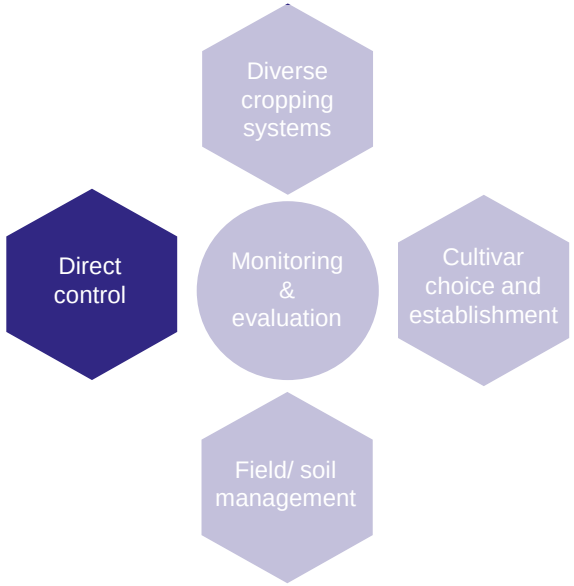


Band spraying & mechanical weeding in wide row crops

Donato Loddo, National Research Council of Italy

IWMPRAISE

Consiglio Nazionale delle Ricerche

PSP

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727321

Maize - Italy

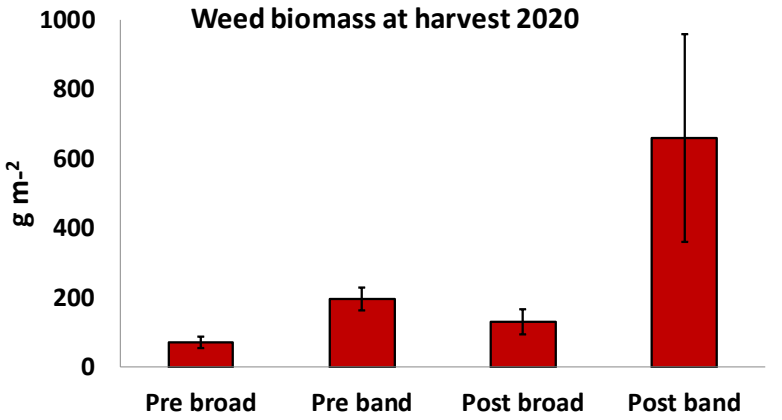
Pre-emergence band application by sowing machine

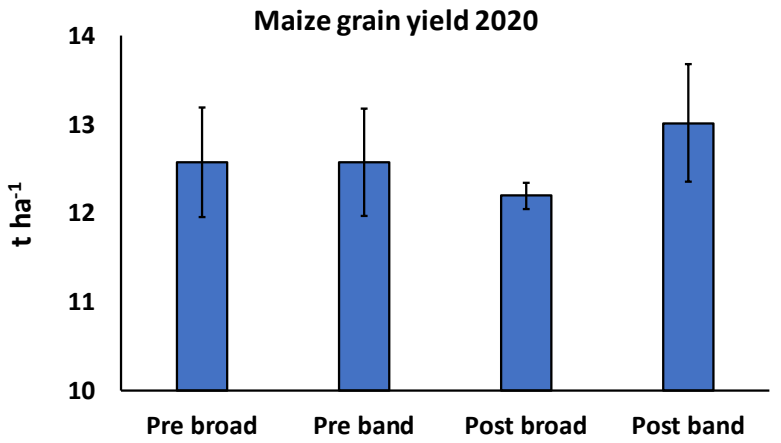
Pre-emergence broadcast by boom sprayer

Post-emergence band application by hoeing machine

Post-emergence broadcast by boom sprayer

Sprayed band 25 cm
Herbicide reduction 66%
Camera-guided hoeing

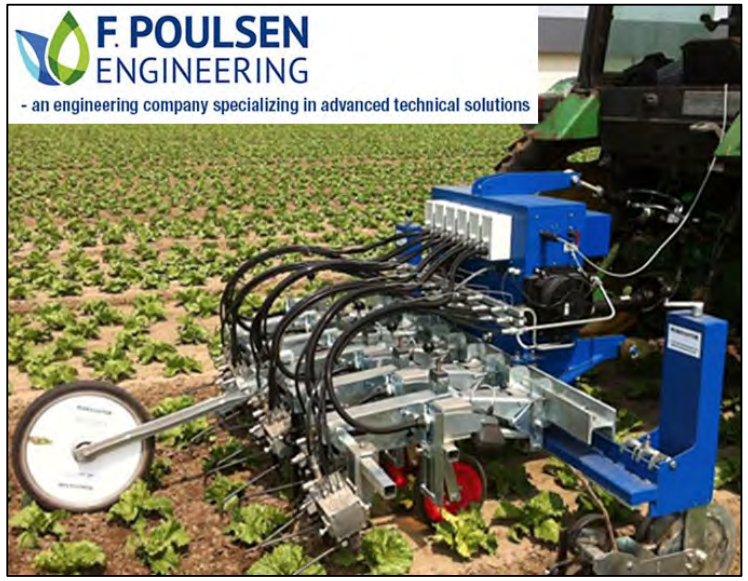




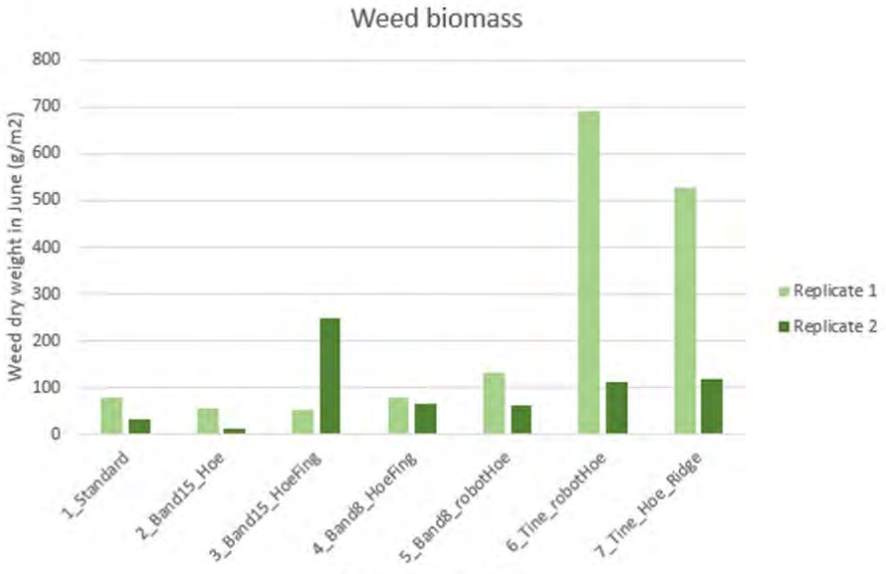
Sugar beet - Denmark

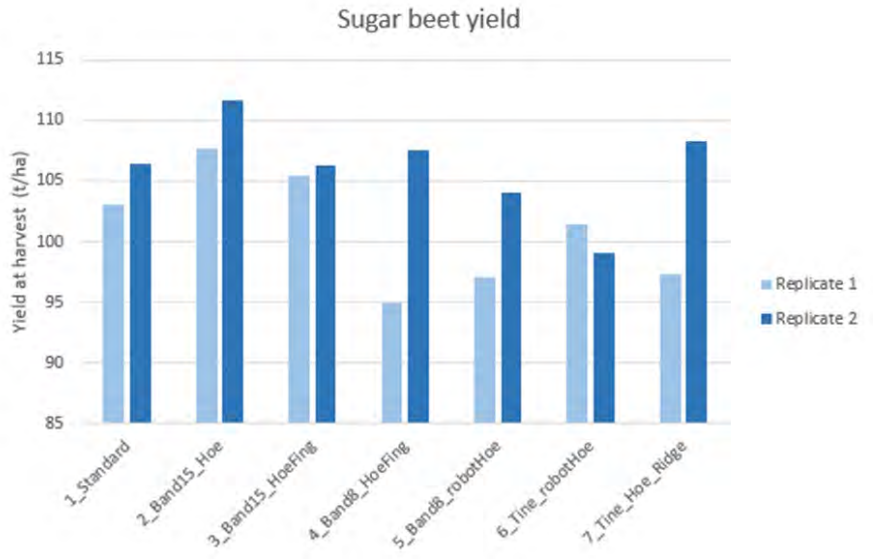
Four strategies were tested in 2020 combining post-emergence band-spraying with weed hoeing.
Sprayed band width 8-15 cm
Herbicide reduction 80-65%

Strategies without herbicide application with different combinations of tine harrow, weed hoeing, finger weeder and ridging were also included.



Robovator
An automated camera guided weeder was also tested.





Implementation

Opportunities

Despite the **higher weed biomass** observed in plots with band spraying, **similar or higher crop yields** were obtained in comparison with broadcast spraying plots.

Band spraying can be performed with **different machineries** (seeder, hoeing machine, boom sprayer) and at **different moments**.

Recent technological advances (GPS/RTK, auto-steering systems, sensor guided machineries) have strongly improved accuracy and efficiency of both band spraying and mechanical control.

Band spraying combined with inter-row hoeing can be a feasible (periodic?) alternative to broadcast spraying, enabling to reduce herbicide doses substantially (reduction > 66%).

Barriers

High accuracy is required, better to adopt "**smart**" mechanical weed control tools.

Control efficacy strongly affected by **weather conditions**, preparing a **back-up alternative tactic** is recommended.

Controlling perennials is challenging, further tactics (e.g. **mapping and patch spraying**) are necessary to reduce herbicide doses in this case.

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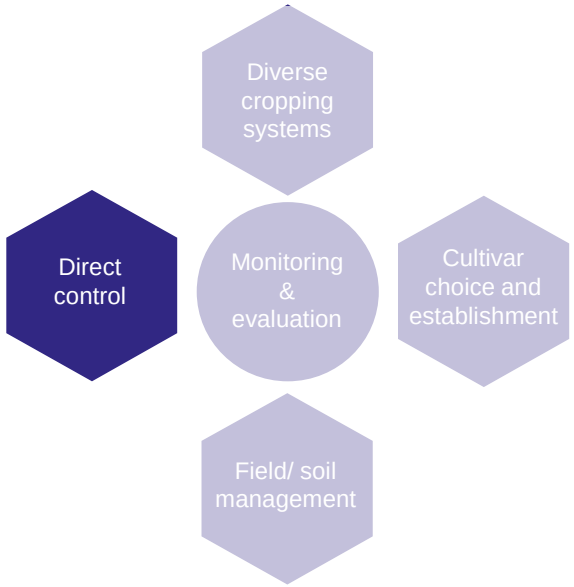
Prevent the establishment of weeds

Reduce the impact of weeds on the crop

Reduce seed return



Band spraying & mechanical weeding in narrow row crops

Mette Sønderskov, Aarhus University

IWMPRAISE

AARHUS UNIVERSITY

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727321

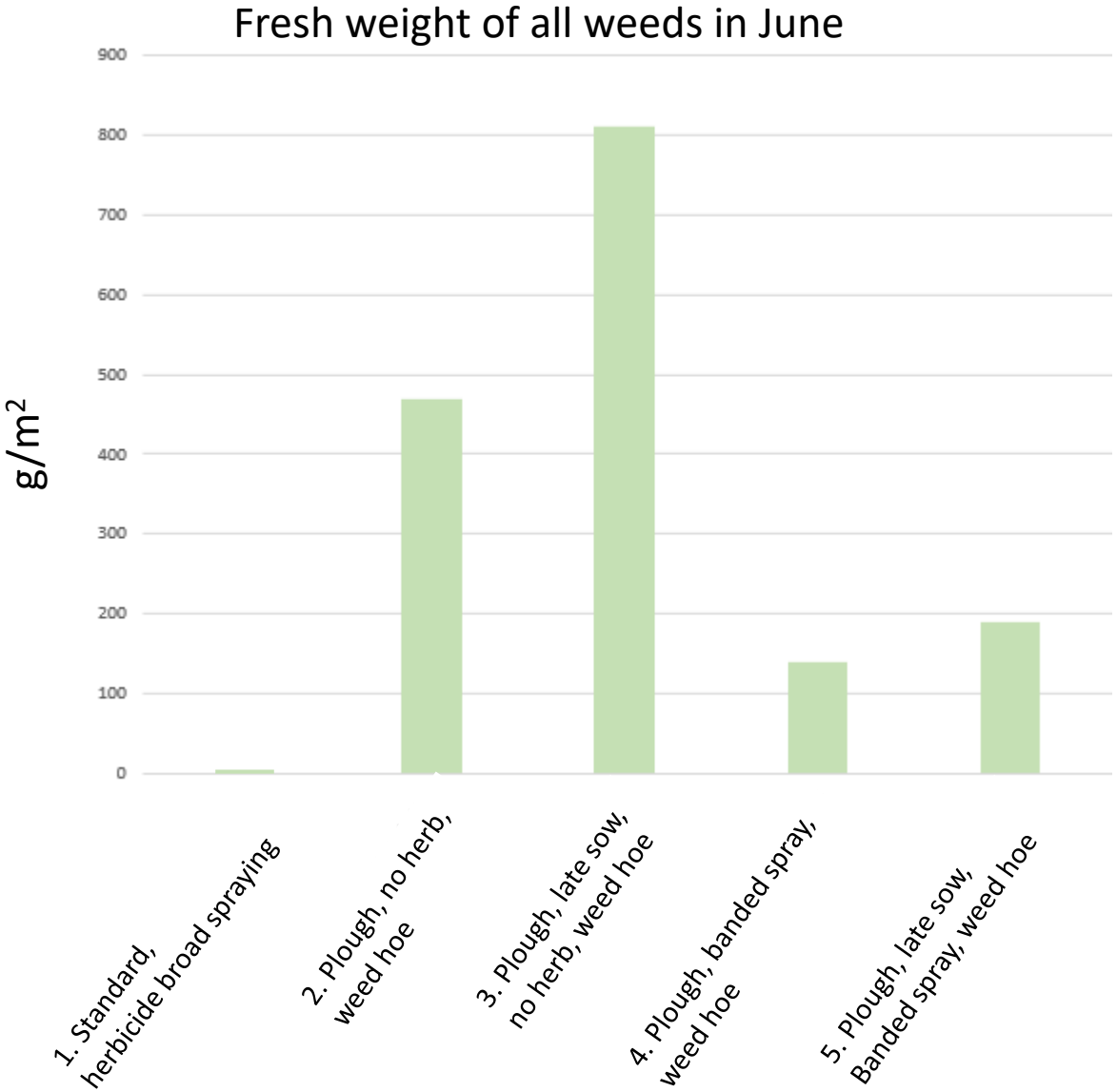
Demonstration trial in wheat (Denmark)

Oct. 24th 2019

Strategy 1 Strategy 2 Strategy 3 Strategy 4 Strategy 5

Apr. 25th 2020

Late sowing Late sowing



Implementation

- Supported by wider row establishment and increased sowing density to have high crop competitiveness, while leaving space for weed hoeing

- Demand for spraying equipment to make a narrow band on the crop row, incl. proper nozzles and suitable boom technic

- High precision to keep the band on the narrow crop row and steer the weed how between rows

- Reducing the reliance on herbicides and lowering the applied dose on field level

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Seed bed preparation

Proof of concept for weed seed collection at harvest

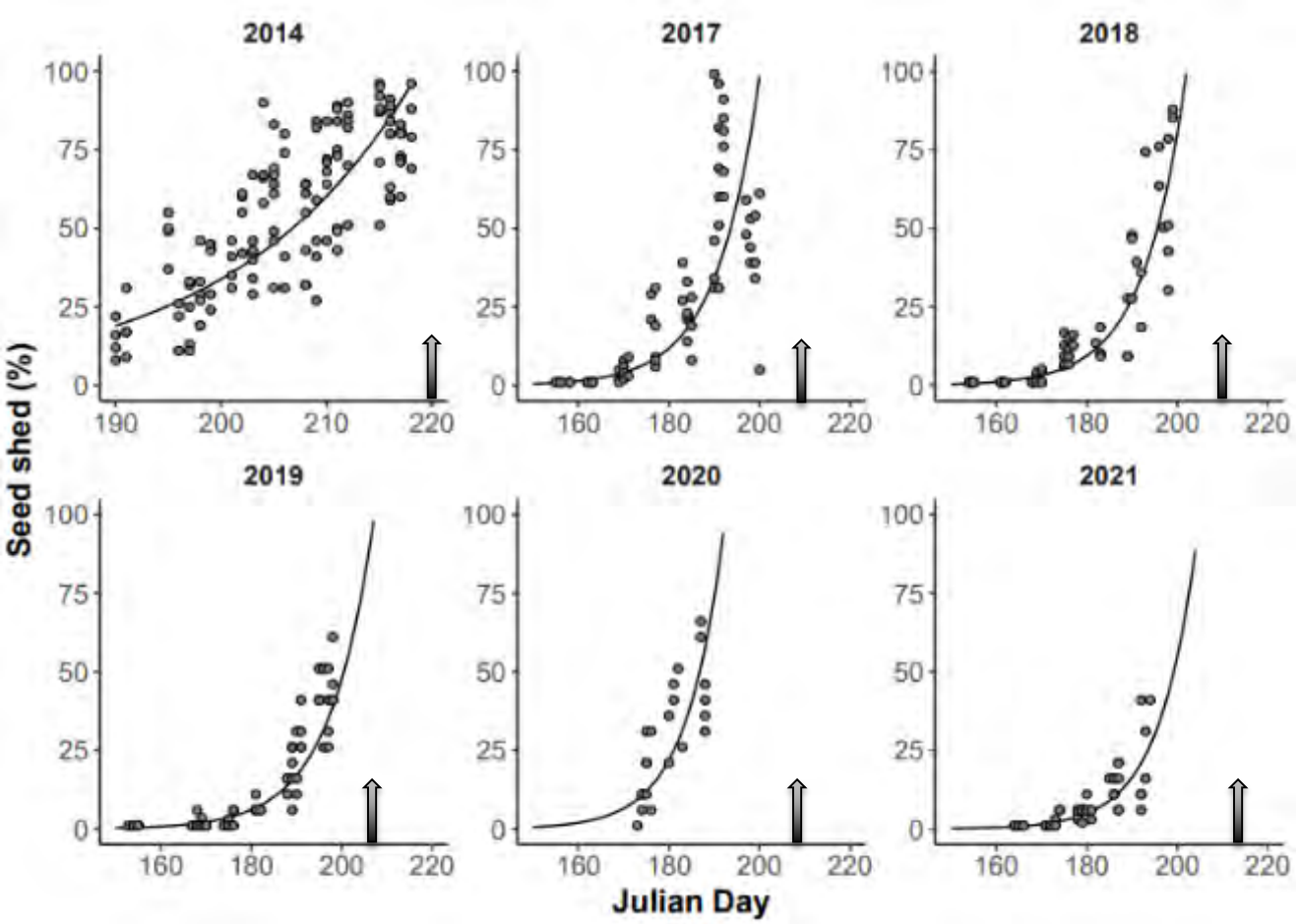
Richard Hull, Rothamsted Research, UK
Donato Loddo, CNR, Italy

Reduce seed return

Direct control

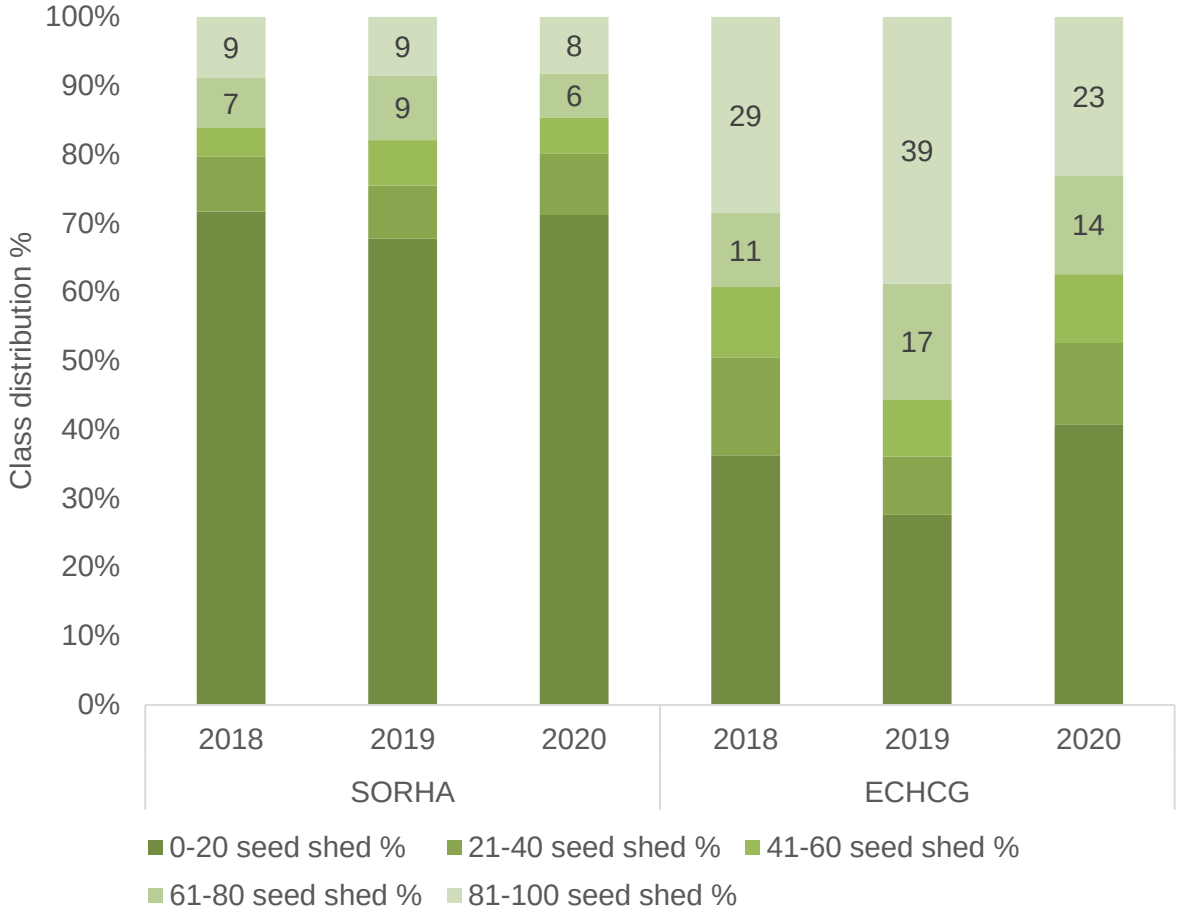
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727321

Alopecurus myosuroides seed shedding data, UK



Approx. harvest date

Sorghum halepense and *Echinochloa crus-galli seed shed at harvest, Italy*



Implementation

- Limited scope for HWSC options for *Alopecurus myosuroides* in winter wheat fields in the UK and Italy, but weed surfing / cutting off heads in June could be an alternative.
- Brome species would be better target for HWSC at harvest time in the UK.
- Both *Lolium multiflorum* and *Sorghum halepense* are excellent candidates for the implementation of HWSC tactics in Italian winter wheat and soya bean crops respectively.

- HWSC could be a very successful tactic to reduce seed return, but is species specific.
- HWSC could be used in combination with weed surfing, especially in mixed weed scenarios.

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Top cutter for weeds growing taller than the crop
Video was shown here.


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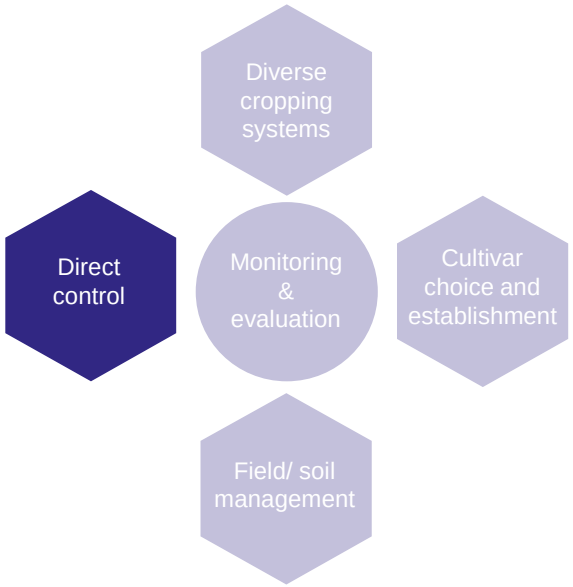
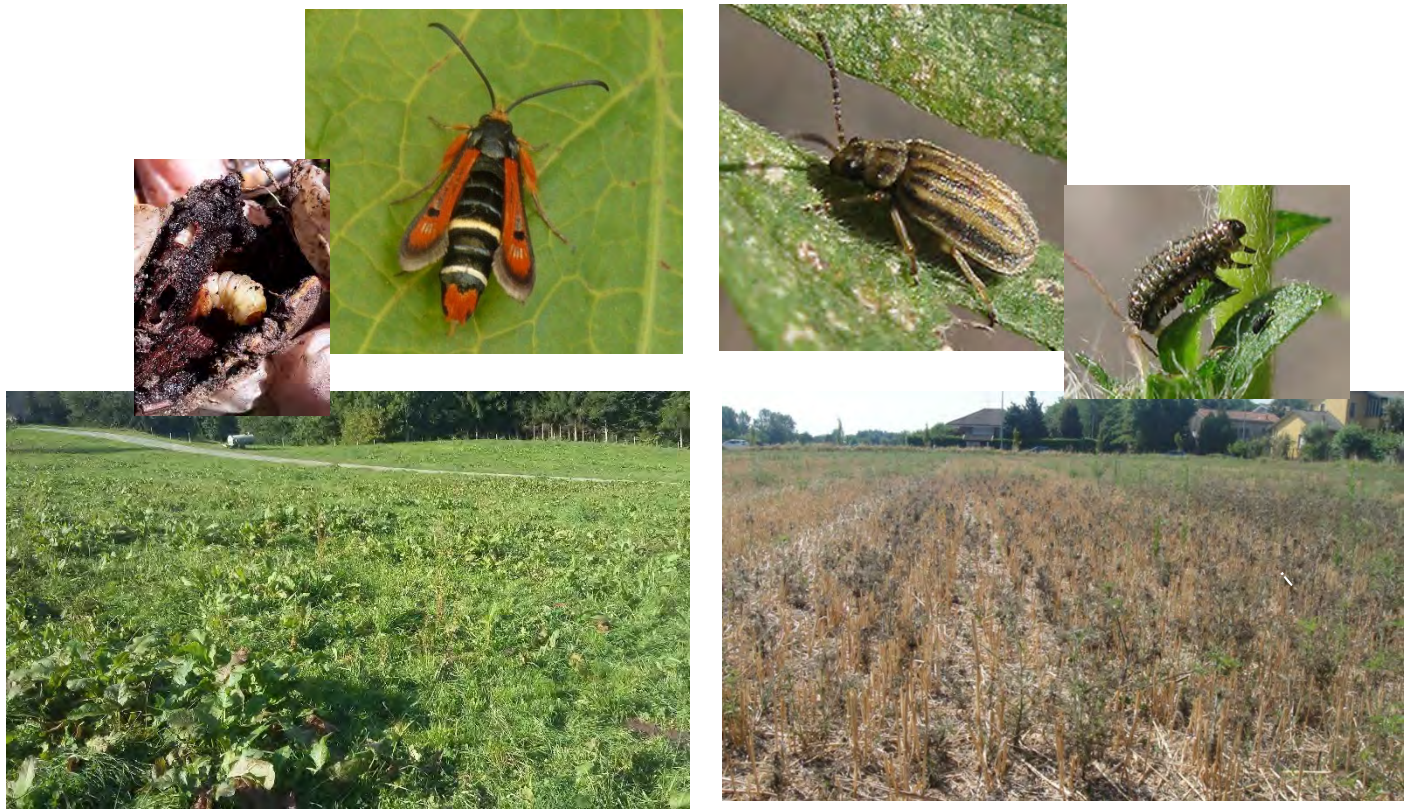
Biological control of weeds

Urs Schaffner
Agroscope Reckenholz and CABI Switzerland





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Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of Economic Affairs, Education and Research EAER

Agroscope

CABI

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UNIVERSITÄT FREIBURG

Kmetijski inštitut Slovenije

With Julie Klötzli, Matthias Suter, Heinz Müller-Schärer, Robert Leskovšek and Andreas Lüscher

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727321

Approaches of biological control of weeds

Importation biological control

Release of a non-native natural enemy

Target: invasive non-native plant

Example: Biological control of *Ambrosia*

Augmentative biological control

Multiple applications of a natural enemy

Target: native weed

Example: Biological control of *Rumex*

Implementation of biological control of Rumex

Tactics and potential benefits

- Develop commercial biological control product against *Rumex*
- Particularly relevant in organic farming, but also in integrated farming
- Does not disturb sward, keeps germination of *Rumex* seeds low

Challenges

- So far, efficiency only in warmer regions in Europe
- Large plants only moderately affected
- Costs

Slovenia

- High establishment rate in warmer regions
- Within 3 years, 90% mortality of *Rumex* plants with 1-2 rosettes

Dead plants

Root decay

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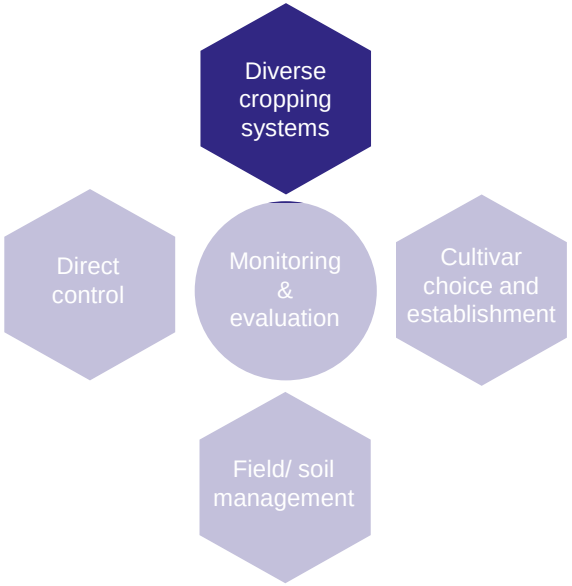
Seed bed preparation

Prevent the establishment of weeds

Reduce the impact of weeds on the crop

Reduce seed return



Cover cropping in olive orchards

J.L. Gonzalez-Andujar, IAS-CSIC

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727321

Highlights

		Richness		Abundance		Diversity (Shannon index)	
		INTER	INTRA	INTER	INTRA	INTER	INTRA
Year 1	TL	5 b[1]	5 b	24 a	25 b	0.97 b	0.95 b
	GCC	12 a	12 a	23 a	50 a	1.91 a	1.59 a
Year 2	TL	3 b	2 b	24 a	13 b	0.49 b	0.32 a
	GCC	6 a	7 a	24 a	286 a	1.05 a	0.69 a
Year 3	TL	4 a	3 b	4 a	5 b	0.97 a	0.66 a
	GCC	4 a	5 a	19 a	103 a	0.64 a	0.59 a

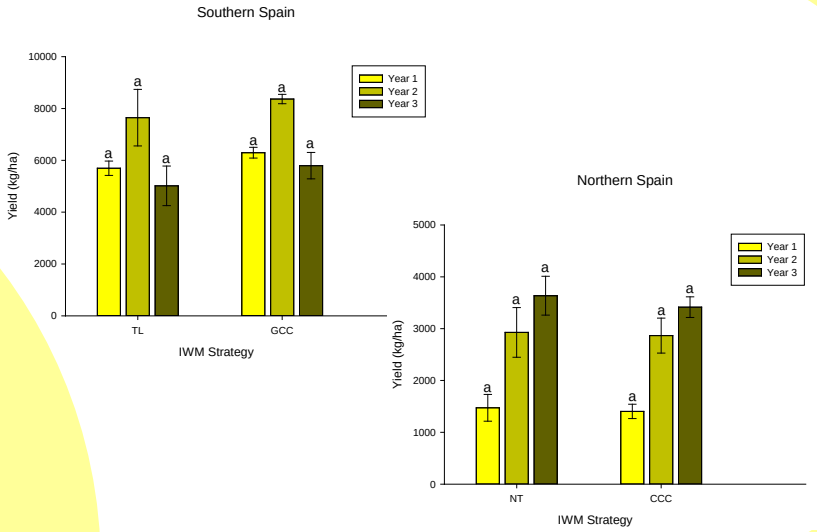
[1] Significant differences between IWM strategies (Tukey test, $P < 0.05$)

TL: Tillage

GCC: Grass cover crops in the inter-rows and pruning wood residues in the intra-rows

More abundant and diverse flora with cover crops than tillage in southern Spain

Olive yield was not affected by the IWM strategy



- Higher **organic N content**, **OM** and **K**:

		N (%)		OM (%)		K (%)	
		INTER	INTRA	INTER	INTRA	INTER	INTRA
Year 1	TL	0.08 b[1]	0.08 b	1.13 b	1.28 b	361 b	366 a
	GCC	0.11 a	0.09 a	1.79 a	1.50 a	433 a	396 a
Year 2	TL	0.08 b	0.10 a	1.03 a	1.18 a	429 a	431 a
	GCC	0.10 a	0.11 a	1.22 a	1.28 a	428 a	428 a
Year 3	TL	0.08 b	0.08 a	0.99 b	1.04 a	377 b	382 a
	GCC	0.12 a	0.10 a	2.03 a	1.38 a	443 a	433 a

[1] Significant differences between IWM strategies (Tukey test, $P < 0.05$)

TL: Tillage

GCC: Grass cover crops in the inter-rows and pruning wood residues in the intra-rows

Soil fertility improvement using soil cover methods in southern Spain

Olive fruit quality parameters without differences between IWM strategies

- Similar **fruit oil content**, which is taken into account in the calculation of the payment to the grower
- Similar **fruit moisture**
- Similar **fat content**, which is vital to determine fruit ripening
- Similar **acidity values**, key parameter that provides a reference of the oil quality

Implementation

- **BENEFITS OVER MECHANICAL/CHEMICAL WEED CONTROL:**
  - **Soil protection**: *promote soil moisture conservation and prevent erosion*
  - **Soil fertility improvement** (OM and N)
  - Help to maintain **beneficial flora** at an affordable and manageable threshold
  - **Reduce herbicide use**, the appearance of resistant weeds and phytosanitary contamination hazards
  - **Reduce tillage operations** and fuel consumption and pollution
  - **More environmentally sustainable farms**: *use of local resources (living cover crops and pruning wood residues generated on the farm)*

- **BARRIERS:**
  - **Elderly farmers** (>55 years old): *lack of interest in innovating and introducing new approaches*
  - **Importance of the correct selection of species**: adapted to local environmental conditions and farmer targets
  - Require **careful management** and **continuous monitoring:**
    - *Spontaneous cover crops: it is vital a proper weed seedbank of the selected weed species*
    - *Cultivated cover crops: the costs of seeds and sowing hinder their installation*
    - *Sowing date, mowing date and killing methods are key factors*

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Prevent the establishment of weeds

Reduce the impact of weeds on the crop

Reduce seed return

Crop diversification – cover crops in arable system

Camilla Moonen & Federico Leoni, Scuola Superiore Sant'Anna

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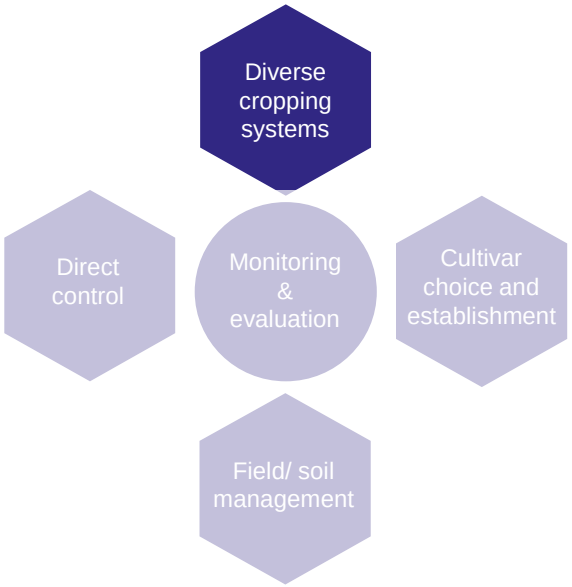
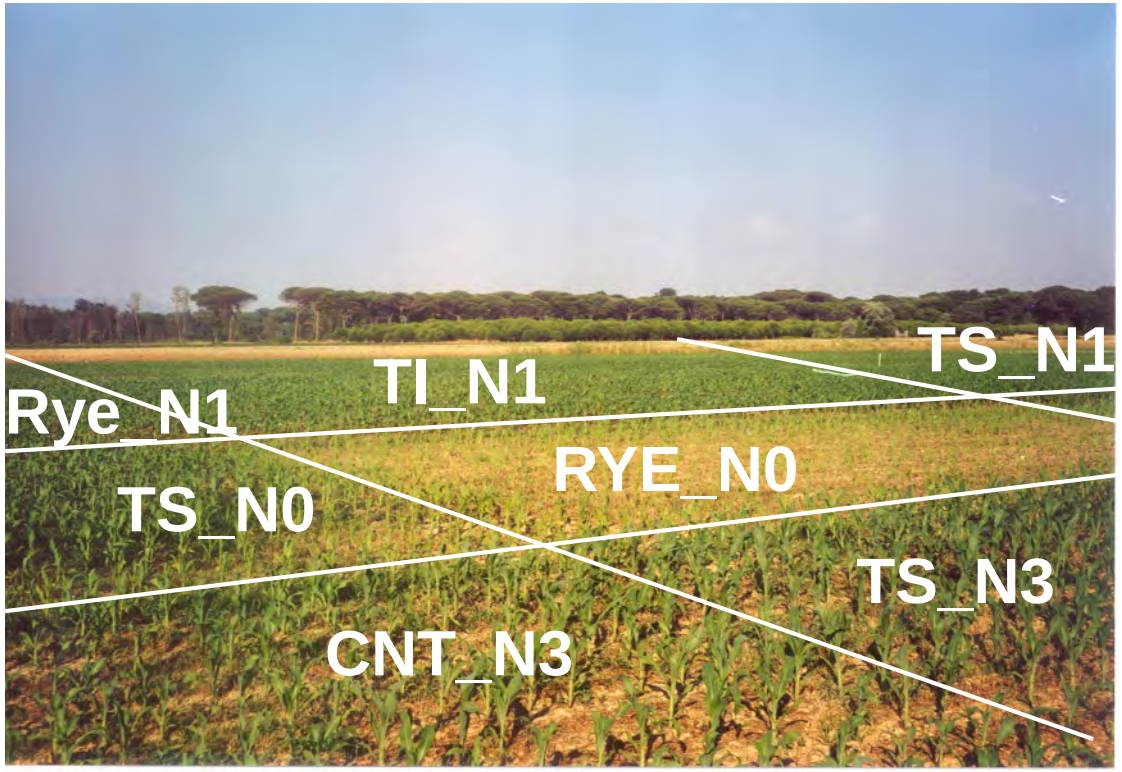
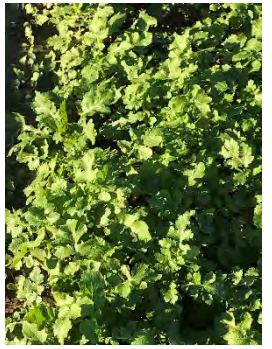
Sant'Anna
Scuola Universitaria Superiore Pisa







Cover crop species choice is extremely important and depends on:

1) Local climate and soil conditions;
2) Desired ecosystem services from the cover crop.

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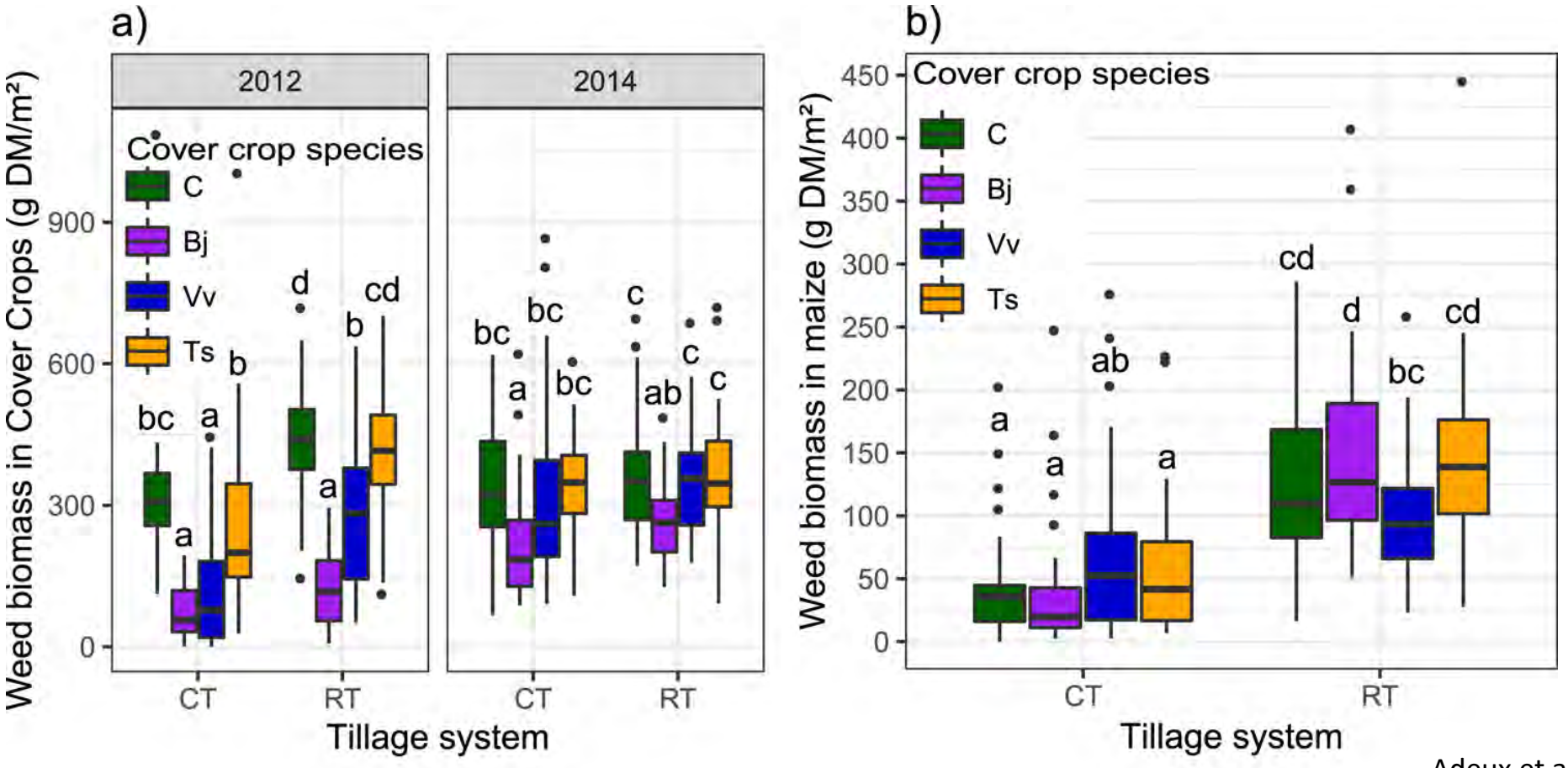
- Cover crops exert the greatest effect during their growth cycle.
- Weed suppression capacity is species-dependent.
- *B. juncea* and *V. villosa* are more effective than T. *subterranneum* in the local context due to reduced establishment.
- Hardly any effect in following crop.
- Tillage system does not affect weed biomass in cover crop phase but higher weed biomass in following crop.



Weed dry biomass in the cover crop (a) and in the following maize crop (b)

Control
Brassica juncea
Vicia villosa
Trifolium subterraneum

Adeux et al., 2020. doi: 10.1016/j.eja.2020.126221.

Implementation – some examples

Vicia villosa Roth.

Preferred conditions:

- Autumn sowing
- Germinates at low temperatures
- Adapts well to hot and dry weather
- Resistant to acidic or alkaline soils.
- Prefers light soils

Ecosystem services:

- Weed control increases with biomass
- Soil fertility improvement

Secale cereale L.

Preferred conditions

- Autumn sowing
- Suitable for acidic, sandy, lean soils;
- Resistant to cold;
- Lower thermal requirements than wheat and other cereals

Ecosystem services:

- Allelopathic capacity positive for weed control but could negatively affect the crop.
- Negative effect on C/N ratio so N-fertilisation is needed

Brassica juncea L. Czern.

Preferred conditions:

- Early autumn sowing
- Well-drained soils
- Low cold resistance

Ecosystem services:

- Prevent erosion
- Suppress weeds and soil-borne diseases
- Alleviate soil compaction
- Scavenge nutrients

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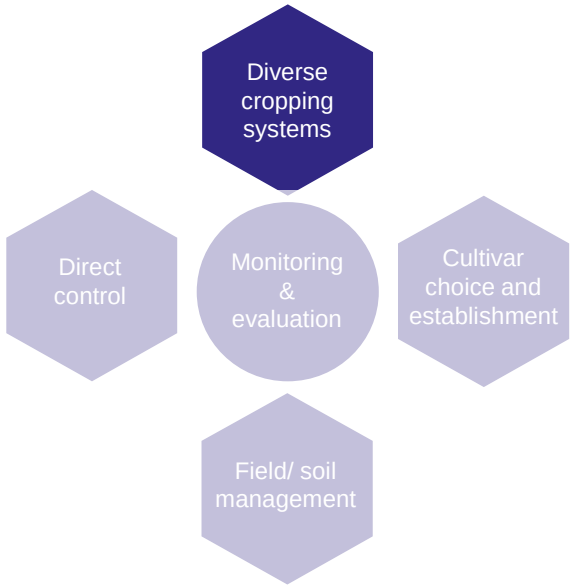

Crop diversification - Intercropping,

Camilla Moonen & Federico Leoni, Scuola Superiore Sant'Anna

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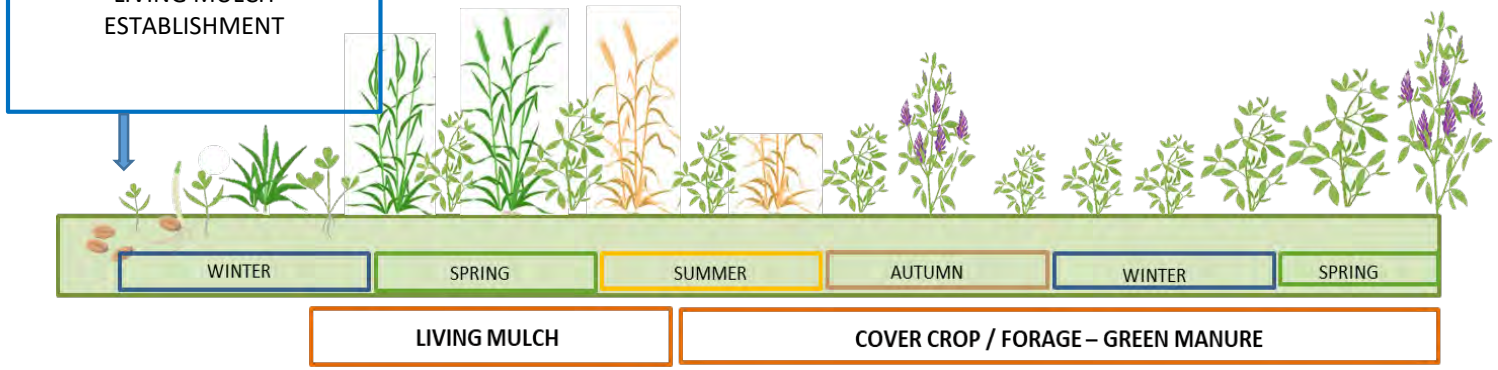
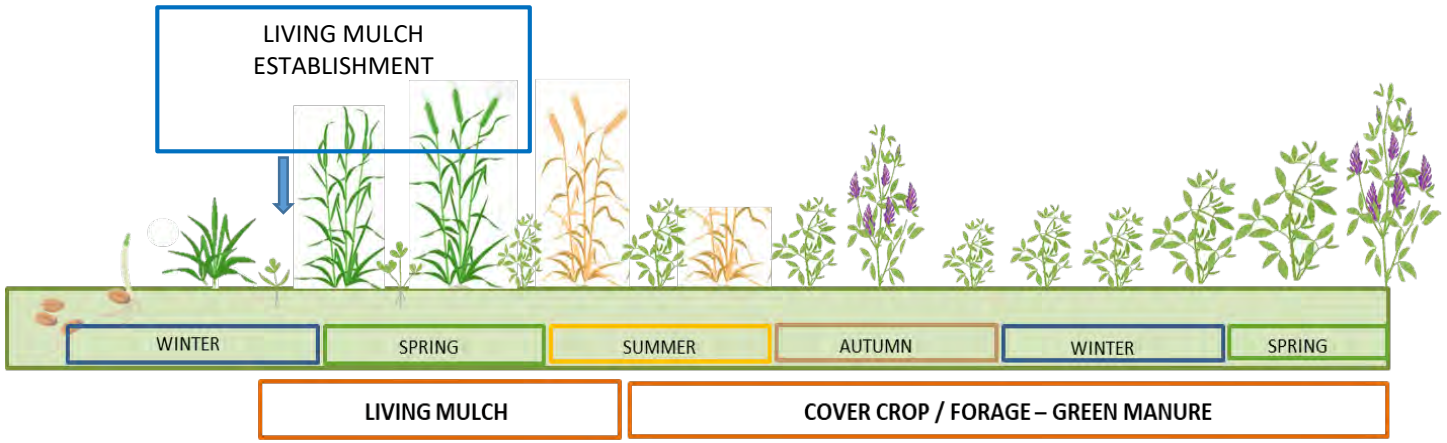
Sant'Anna
Scuola Universitaria Superiore Pisa



CONTEMPORARY LIVING MULCH



RELAY LIVING MULCH

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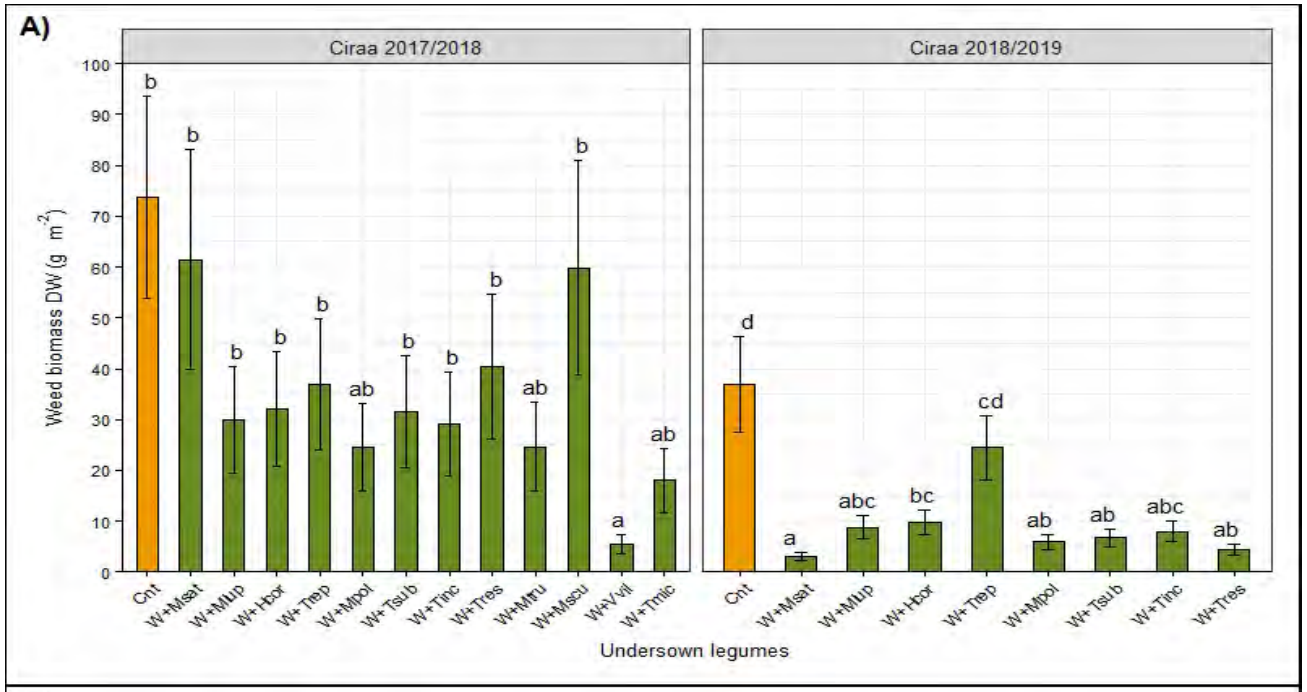
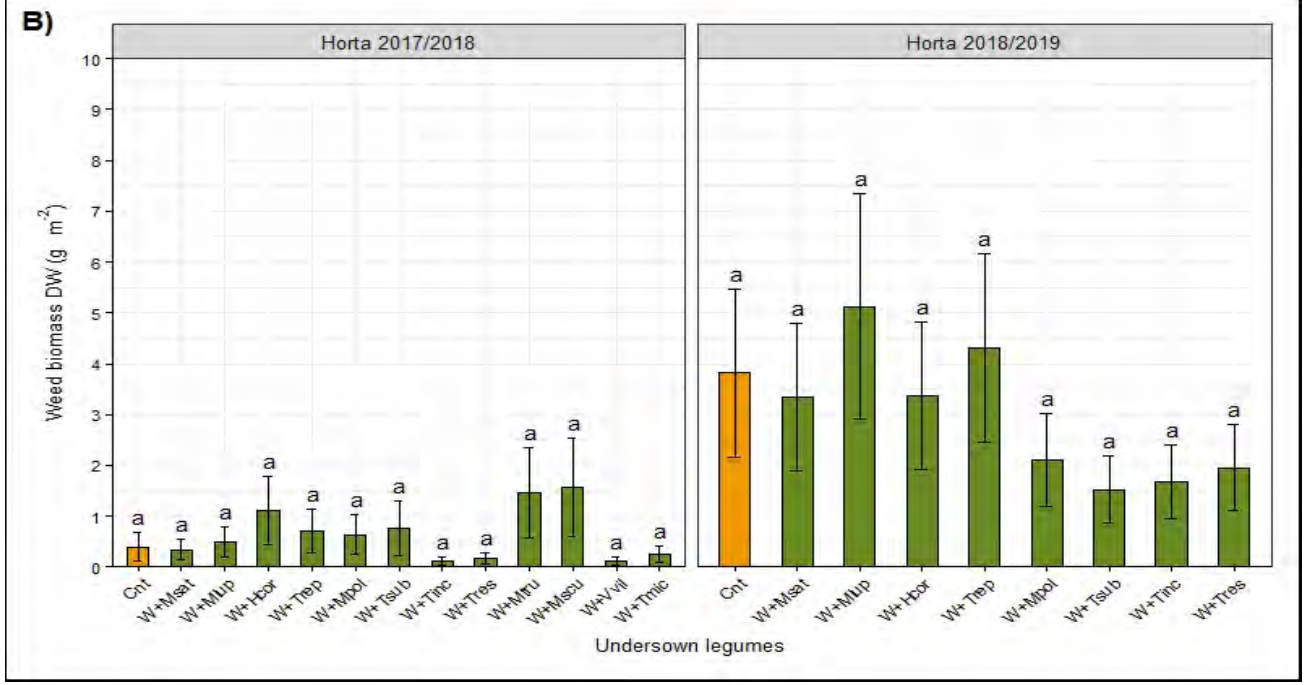
Weed dry biomass at harvest in two locations in Italy and legume height at harvest

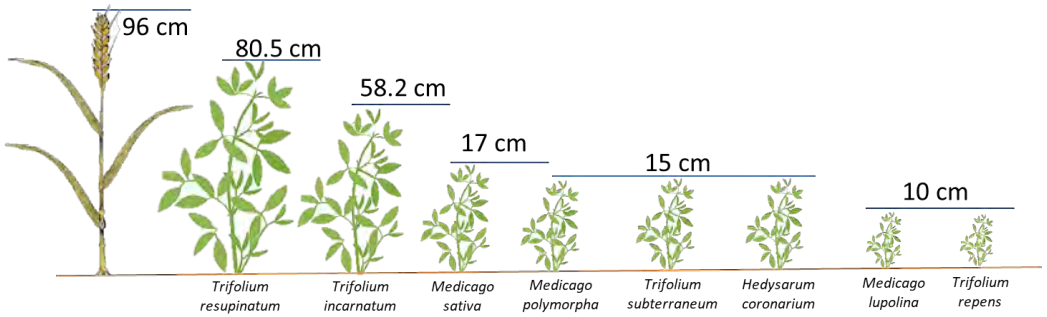




LEGUME CHOICE

Legume choice for living mulch

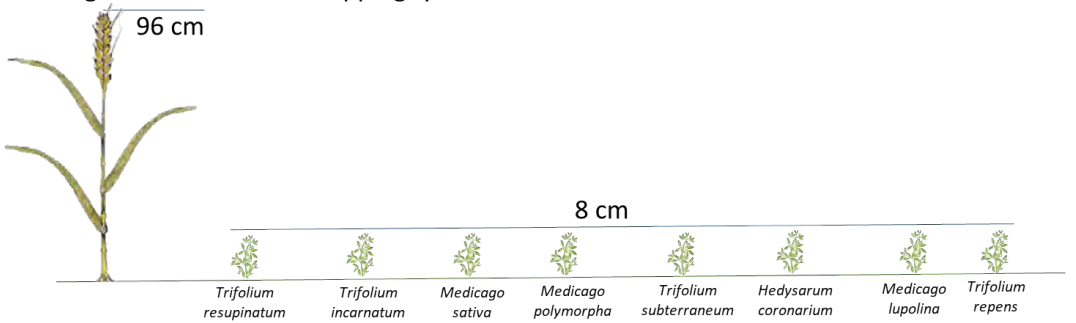
Low-input cereal based cropping system



LEGUME CHOICE

Legume choice for living mulch

Integrated cereal based cropping system



Implementation

	High input system	Low input system
Sowing time	Contemporary intercropping because crop is more competitive	Relay intercropping to give advantage to crop, depending on legume choice.
Sowing method	Drill or Broadcast seeding based on available machinery.	Drill seeding important because broadcast seeding under suboptimal conditions requires higher seeding dose and therefore higher seeding cost.
Legume choice	***Medicago sativa*** and ***Trifolium repens.***	***Medicago sativa, Trifolium repens*** and ***Hedysarum coronarium*** *or* ***Trifolium subterraneum***

M. sativa

H. coronarium

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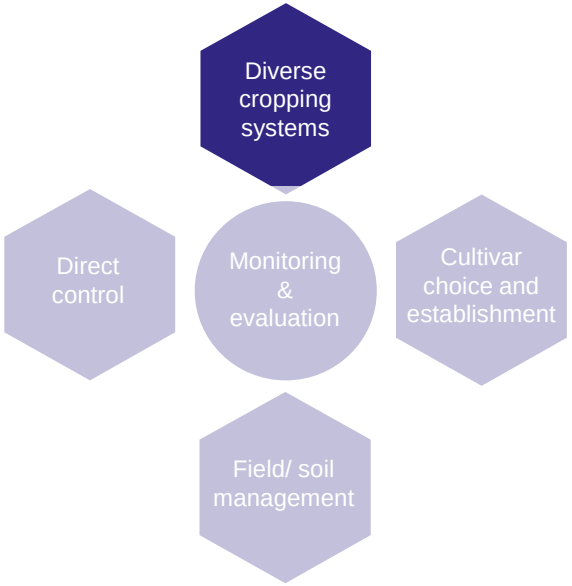
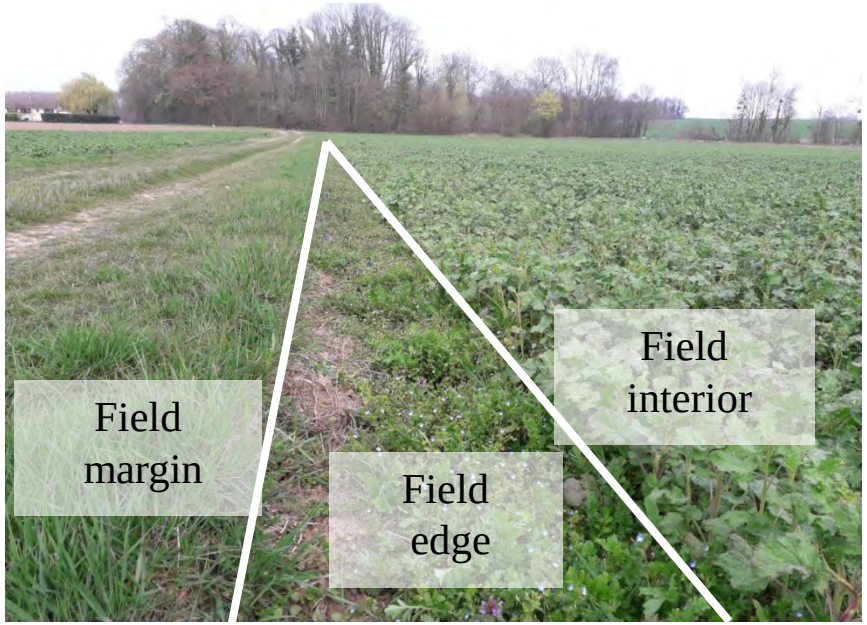


Field margins and field edges

Sandrine Petit & colleagues, INRAE

Presented by Jonathan Storkey, Rothamsted Research



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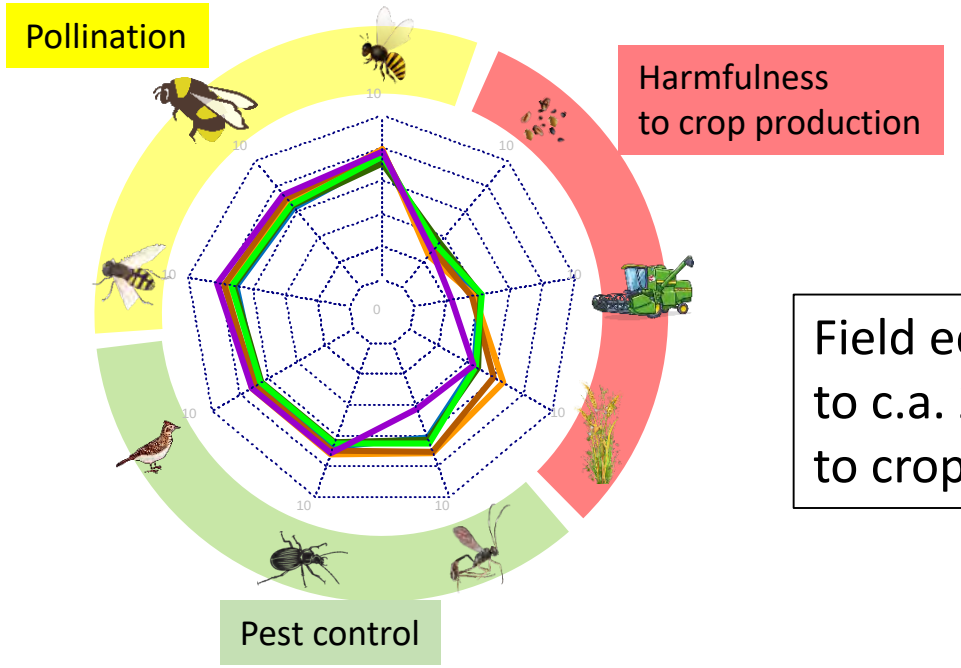
Field edges to enhance weed services

- Field edges are up to three times more weed rich than field interiors
- The weed flora in field edges is affected by crop management

	Mean annual richness per field	
	Field core	Crop edge
Winter cereals (n = 225)	5.2 (3.1)	15.5 (5.3)
Winter Brassicacae (n= 114)	5.8 (4.3)	17.3 (5.6)
Spring crops (n = 44)	7.6 (4.9)	20.1 (5.7)
Summer crops (n=25)	8.0 (3.5)	14.1 (5.8)



9 indicators (Yvoz et al., 2021, Ecological Indicators)

Field edges cover less than 2% of cropped fields but contribute to c.a. 25% of services provided by weeds , with limited harm to crop production

Implementation

Field edges to support important services in agriculture

- *Maintain wide field edges along field margins*
- *Smaller fields = more field edges*

- *Monitor possible weed spread into the field*

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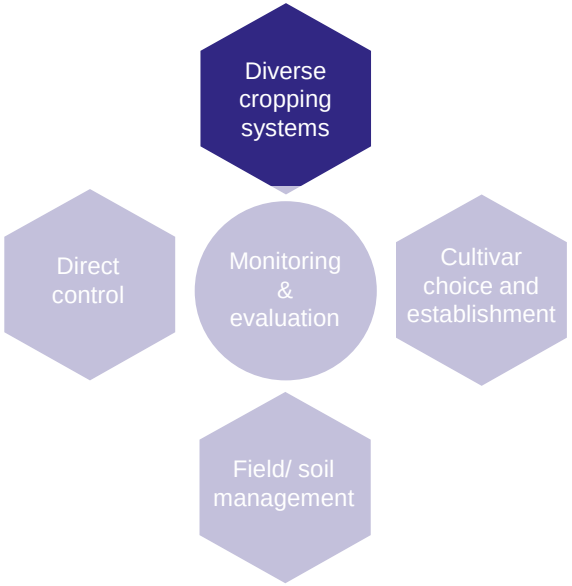

Landscape arrangement

Sandrine Petit & colleagues, INRAE

Presented by Jonathan Storkey, Rothamsted Research

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Agroécologie Dijon Unité de Recherche

INRAE

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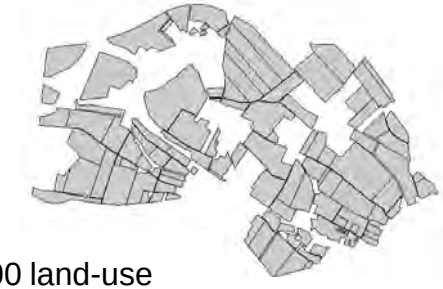
Diversity of cropping systems in the landscape

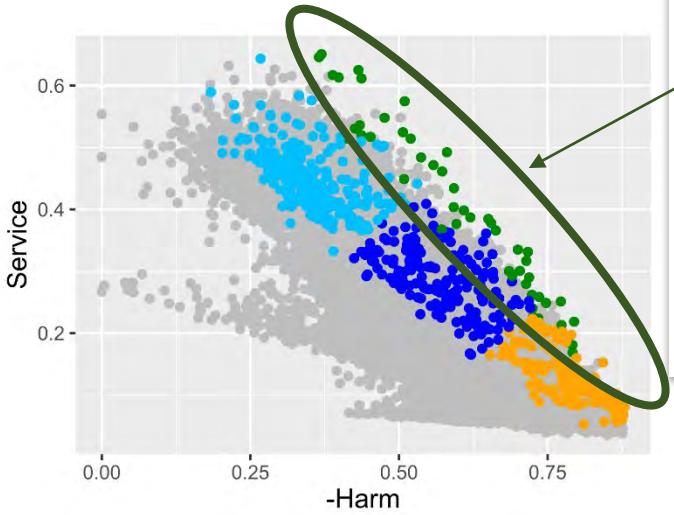
Scenario of allocation of 8 cropping systems within the landscape



24000 land-use simulations

Evaluation of weed harmfulness and weed services

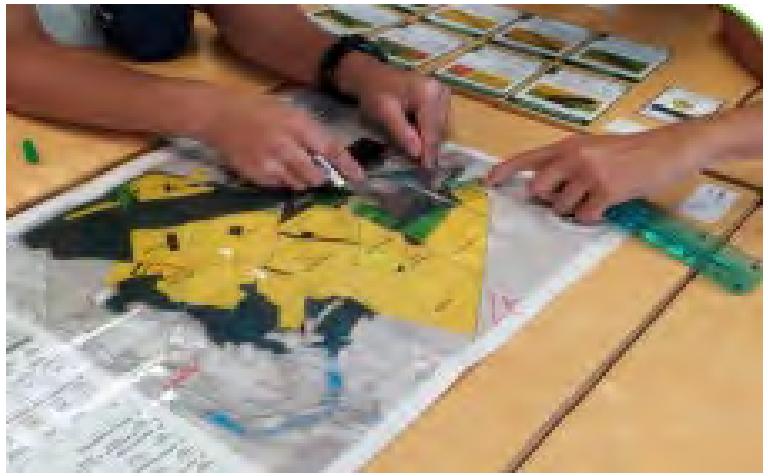
The coexistence of diverse cropping systems within a landscape ensures optimal trade-offs between weed harmfulness and weed services



Implementation

- At field/farm level

Diversify crop sequences
Smaller fields



- At landscape level

Diversity of production systems
Concerted/collective action

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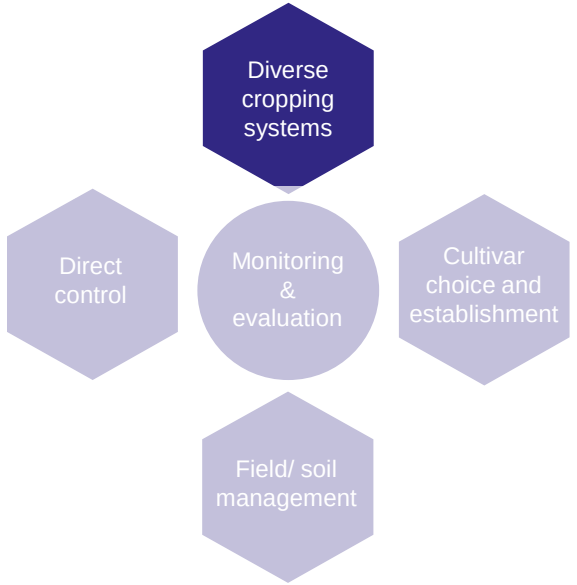
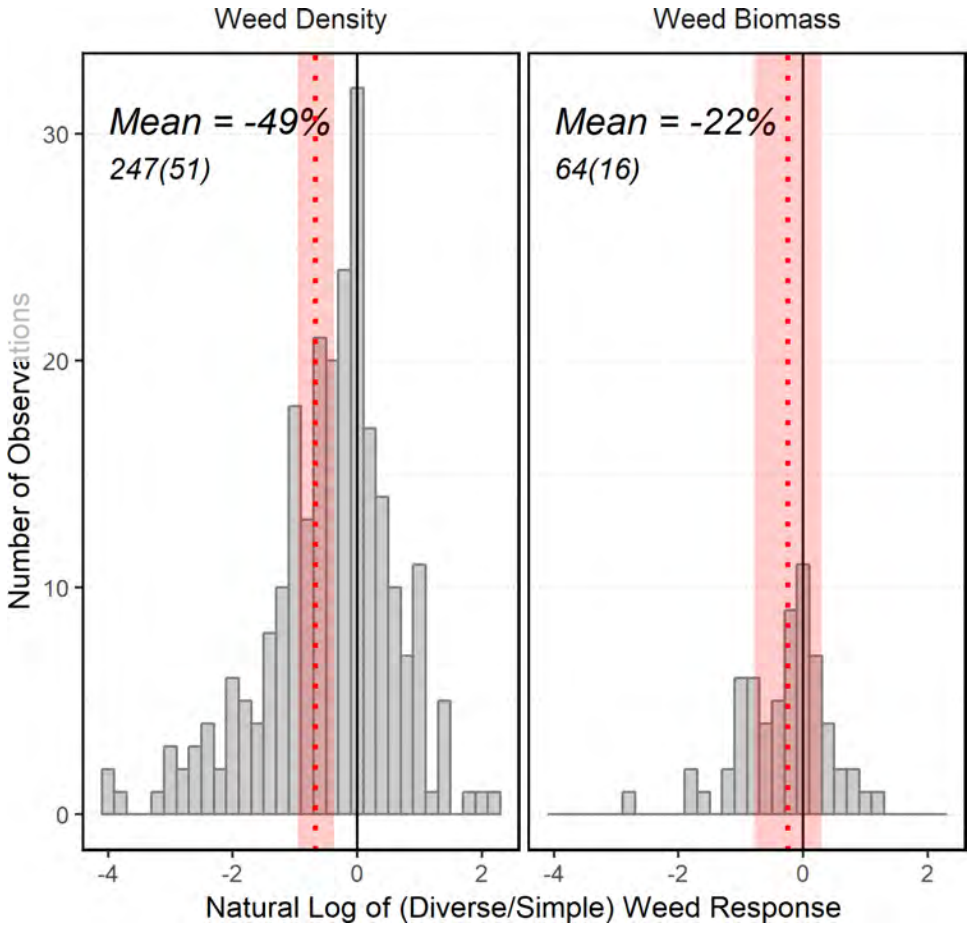
Diverse cropping system

Marleen Riemens, WUR



Histogram of weed response (weed density and biomass) to diversifying from a simple rotation.



Meta analysis
Weed density reduction by 49%:

Main influencers:

- **Variable planting interval**
- **Tillage system**

Weisberger D, Nichols V, Liebman M (2019) Does diversifying crop rotations suppress weeds? A meta-analysis. PLOS ONE 14(7): e0219847. https://doi.org/10.1371/journal.pone.0219847
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0219847

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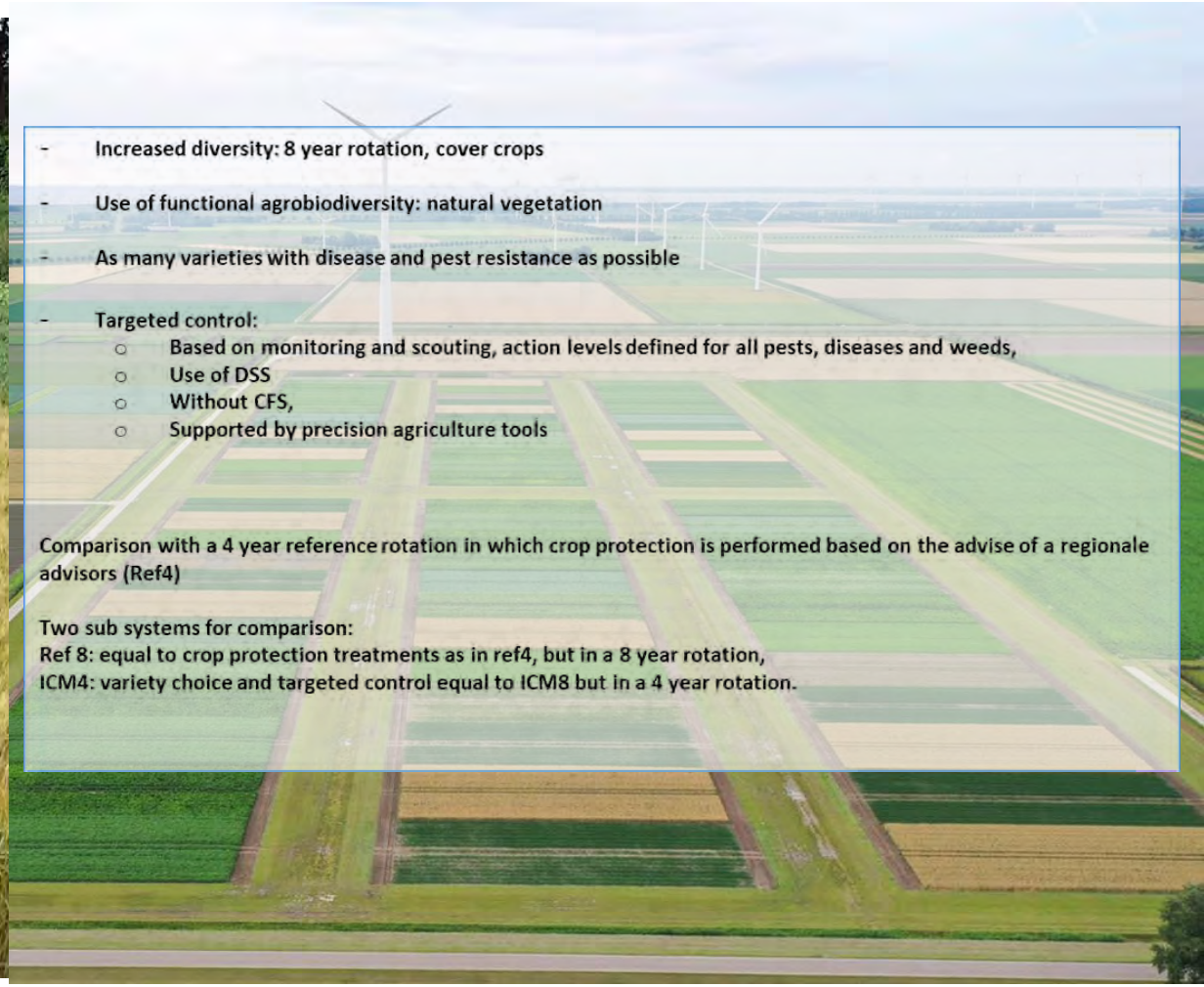
Envisioned use: In combination with Pest and Disease management

IWM Framework – crop diversification



Benefits and Barriers of crop diversification

Benefits:

- **Relatively low costs**
- **Pest and disease management**
- **No additional labour requirements**
- **Crop diversification increase:→ biodiversity contribution**

Barriers:

- **Contractors**
- **Equipment for each crop**
- **Know how for new crop**

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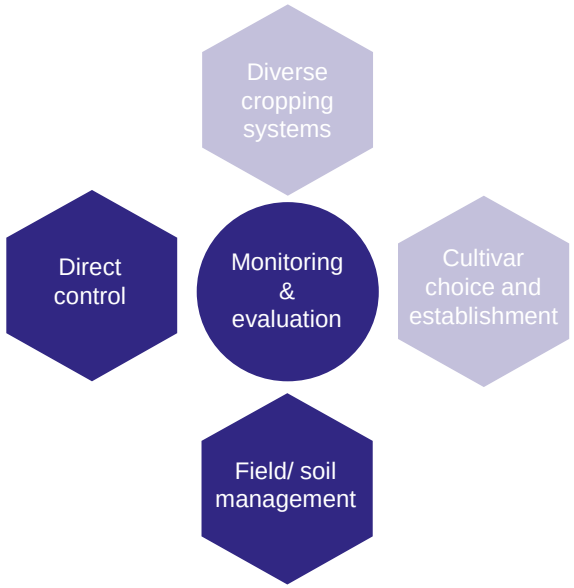

Detection and spraying of Rumex in grassland

Dirk de Hoog, Wageningen University and Research

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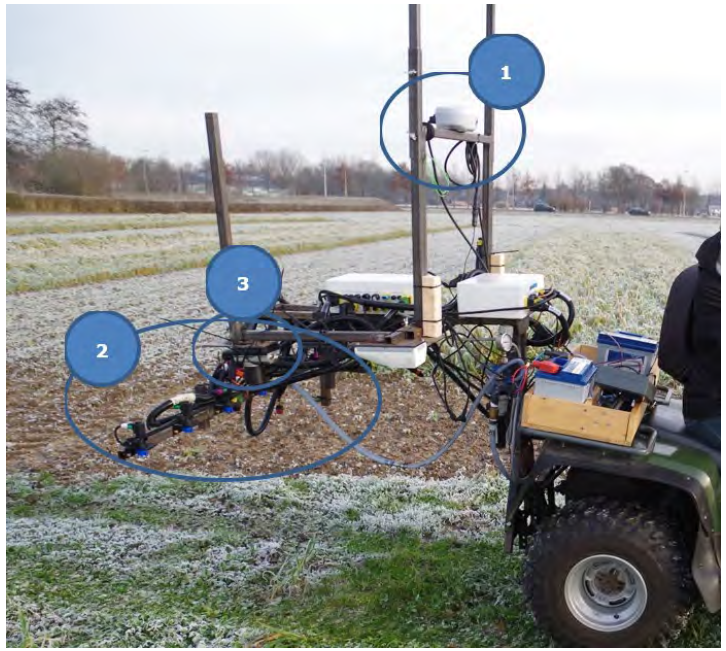
WAGENINGEN UNIVERSITY & RESEARCH

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727321

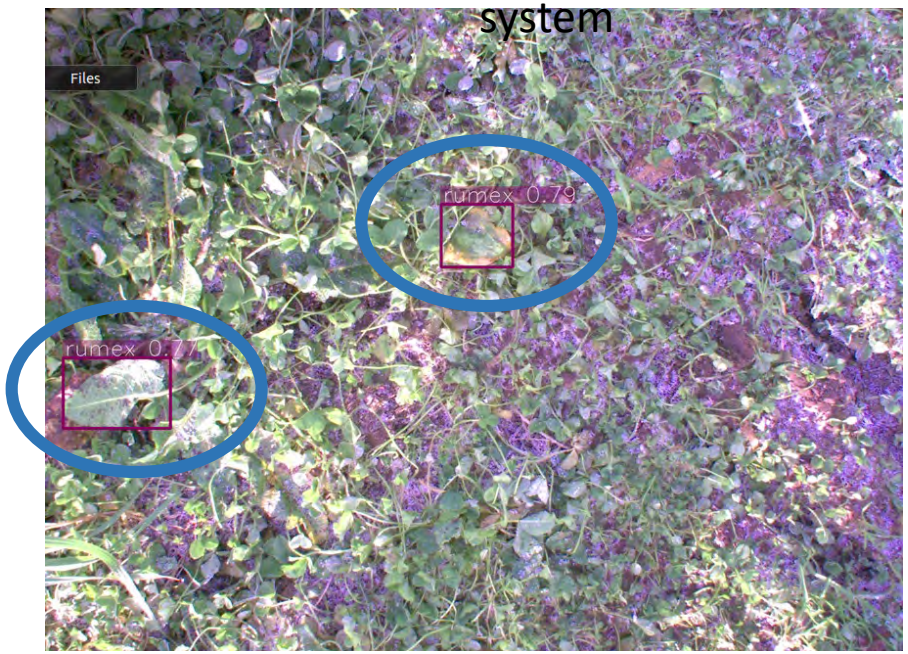
Detection and spraying of Rumex in grassland

One system that can detect and spray Rumex spot spefically in a field of Grass

- Detection of Rumex by an image based detection system
- Very precise application of PPP's by the Rometron system, only on the target
- More efficient use of PPP's
- Reduction of negative impact of PPP's on other plants



system



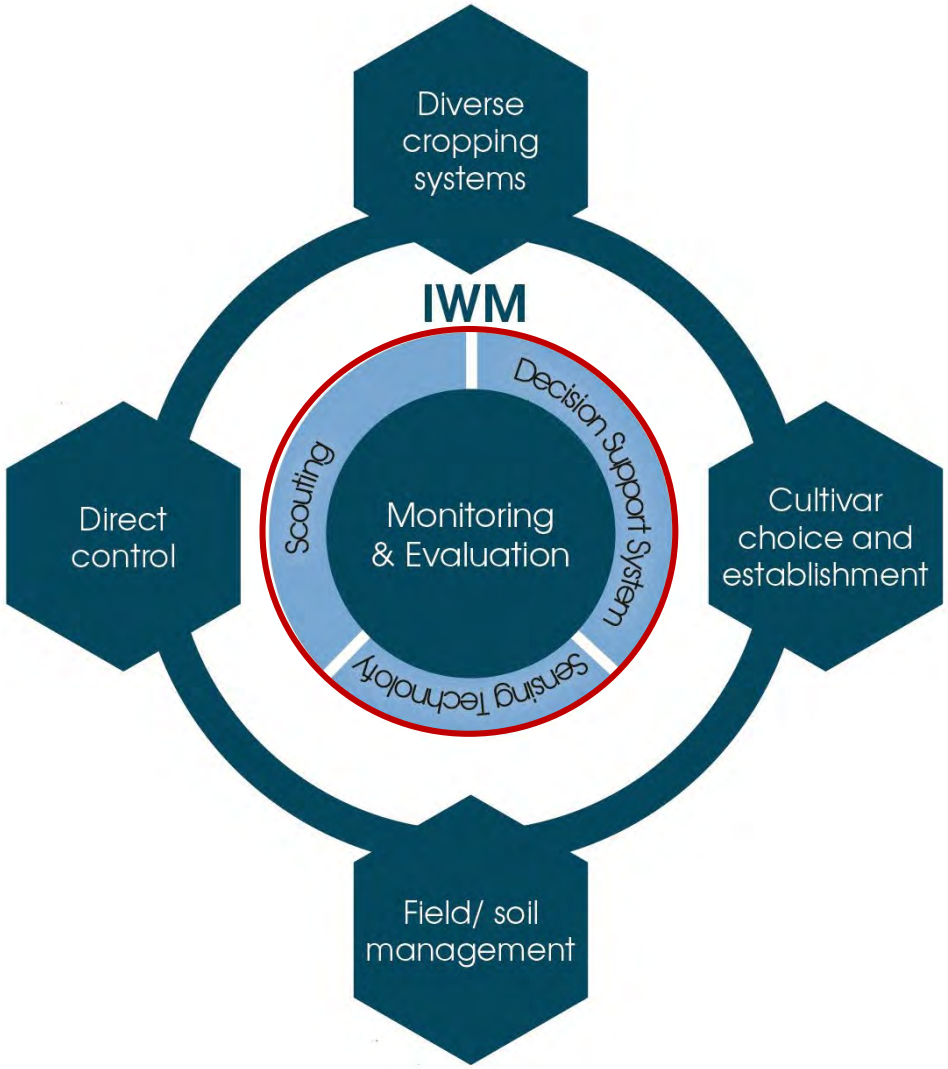
detection

Sprayed rumex

Implementation

This system has been developed for one specific application, there are limitations, but also possibilities.

- Currently, only tested for Rumex on grass and spraying based treatment
- However, more applications can be imagined:
  - More efficient use of PPP's
  - Other weed-crop combinations
  - Other weed treatment methods
  - Monitoring of weeds in the system


Diverse cropping systems
IWM
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Patch and band spraying
Pre-harvest herbicides
Weed seed collection and destruction
Direct control
Hand weeding
Mowing
Scouting
Monitoring and evaluation
Decision Support Systems
Sensing Technology
Sowing depth
Transplanting
Sowing date
Cultivar choice and crop establishment
Seed rate
Cultivar choice
Sowing pattern
Seed vigour
Field and soil management
Stubble management
Water management
Liming
Nutrient placement
Dead mulching
Cultivation depth
Tillage type
Seed bed preparation