INSTITUTE OF LIFE SCIENCES

Scuola Superiore Sant'Anna

C.I.R.A.A.

UNIVERSITÀ DI PISA

centro interdipartimentale di ricerche agro-ambientali *Enrico Avanzi*

Agricoltura Bioconservativa

Un nuovo modello per la rigenerazione territoriale

Agrobiodiversità funzionale: esperienze di approccio agroecologico all'agricoltura conservativa

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PSR Unione Europea / Regione Marche PROGRAMMA DI SVILUPPO RURALE 2014-2020

Unione Europea

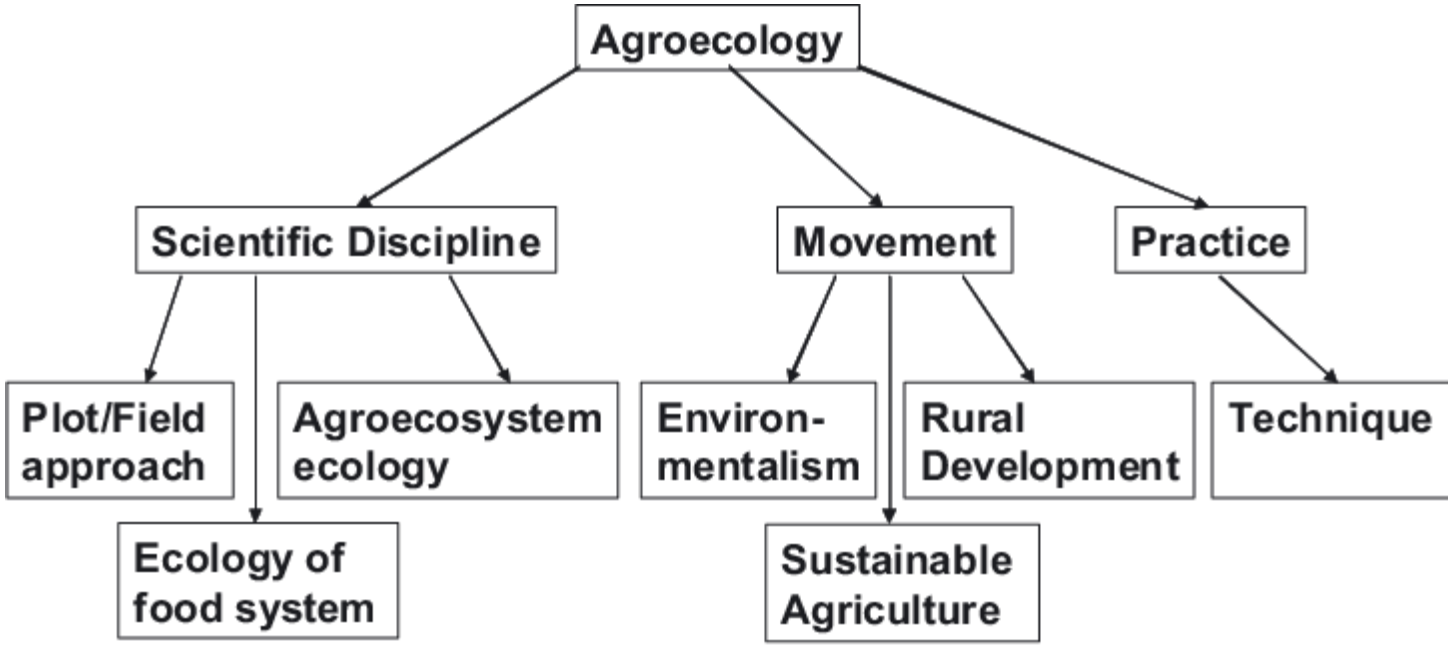
REGIONE MARCHE

Struttura della presentazione

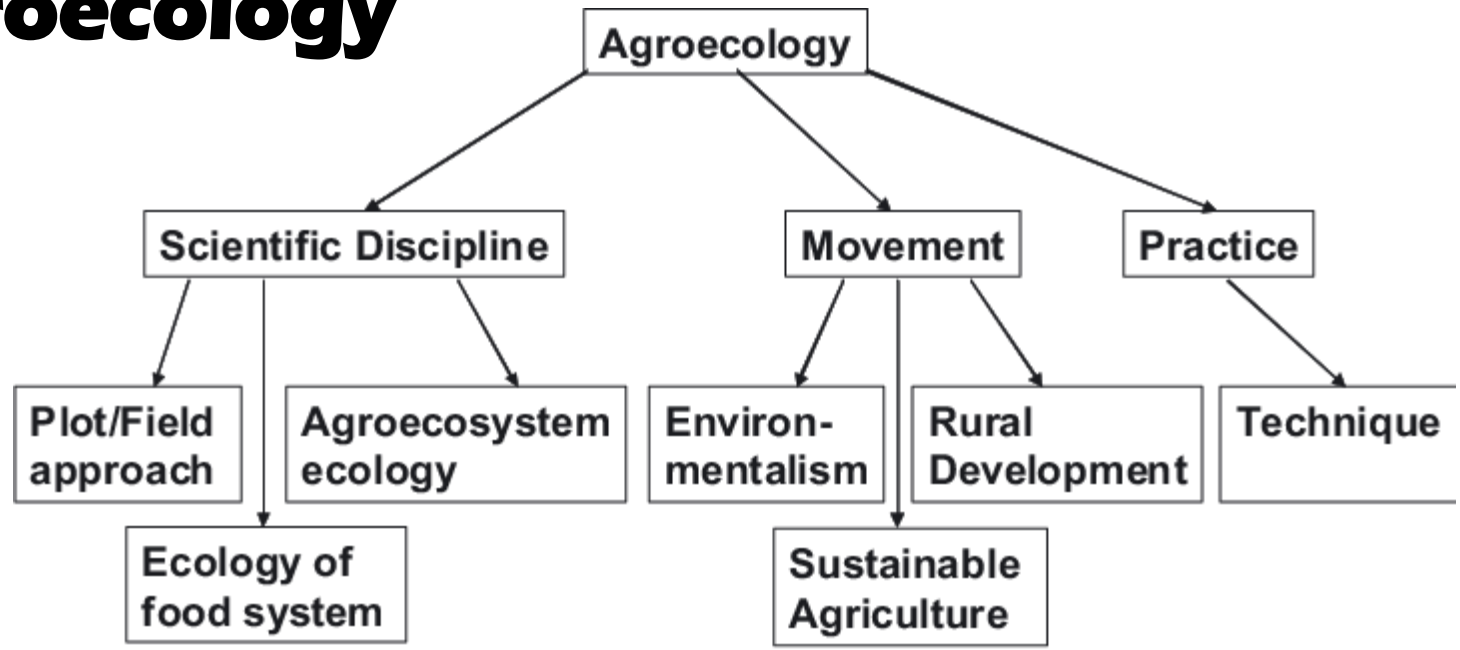
- Agrobiodiversità funzionale
- **Caso 1** Utilizzo coltura di copertura, riduzione input chimico in agricoltura conservativa
- **Caso 2** Utilizzo della biodiversità funzionale, agricoltura biologica conservativa
- Discussione e Conclusioni

I principi Agroecologici

- maintenance of production stability (resilienza)
- optimization of local resources use (indipendenza)
- minimization of the negative environmental and socio-economic impacts (approccio di sistema)

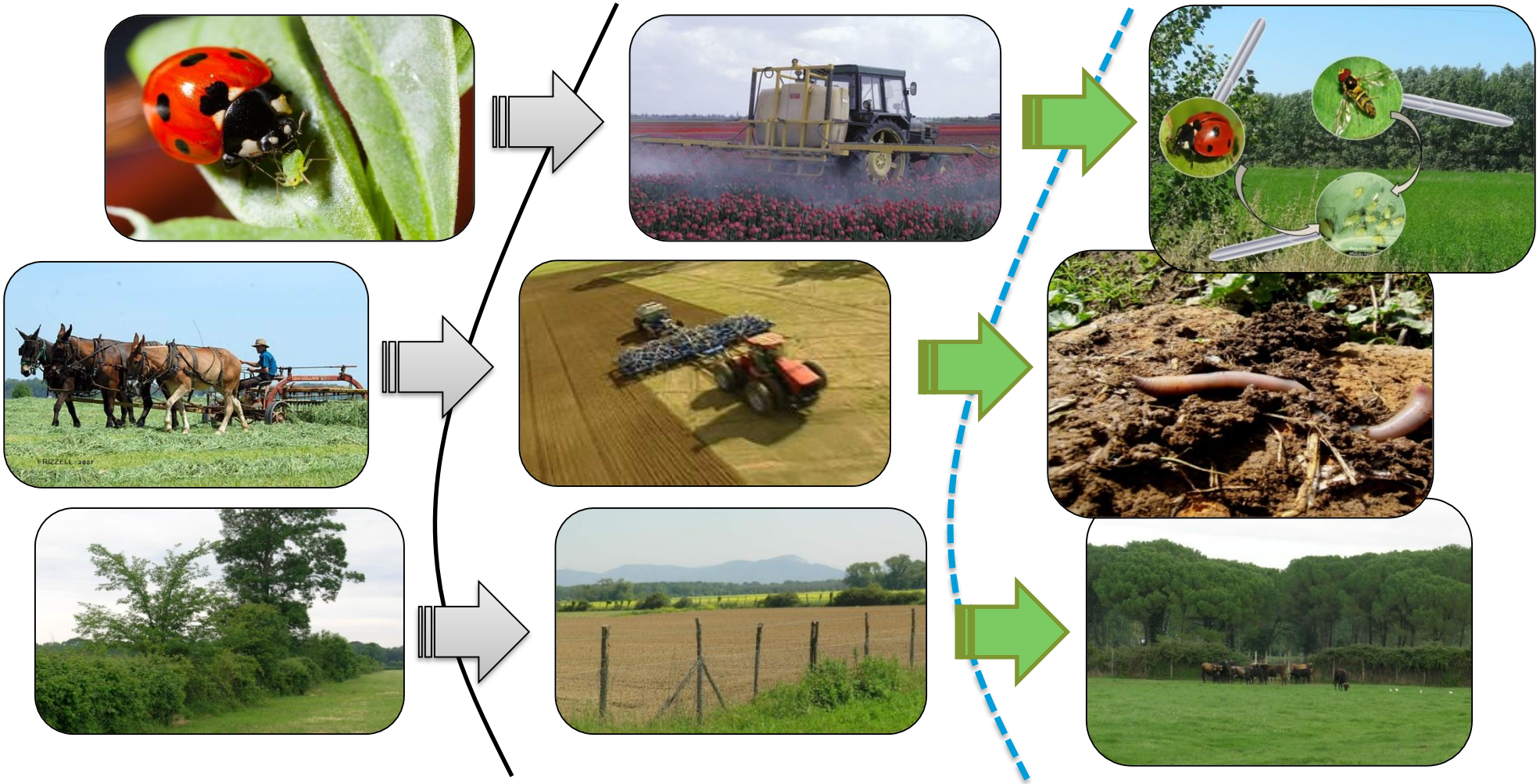


Agroecology



Agroecology

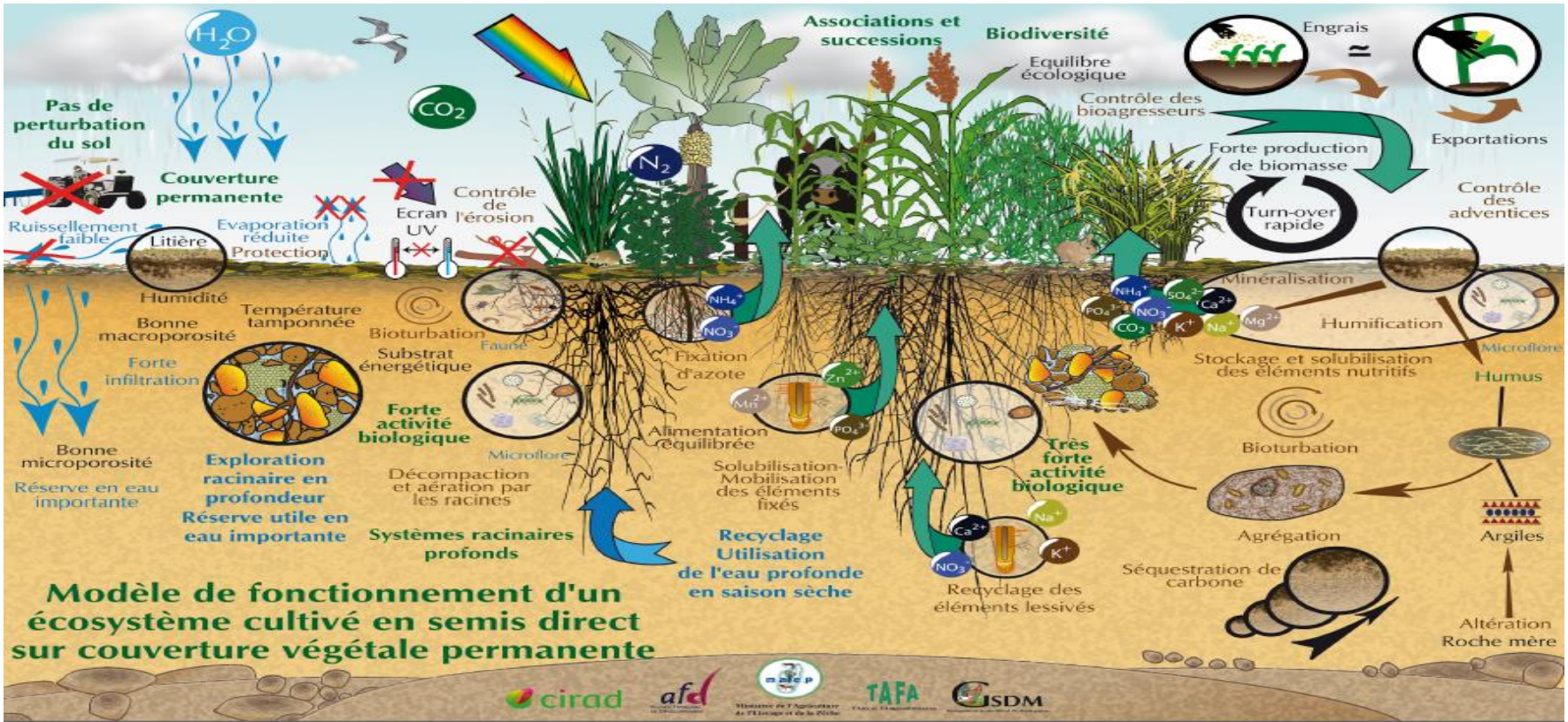
Practice: Agricultural practices which valorise ecological process and ecosystem services



Agroecology

Practice: Agricultural practices which valorise ecological process and ecosystem services

Science: study the ecological process involved in agricultural practices



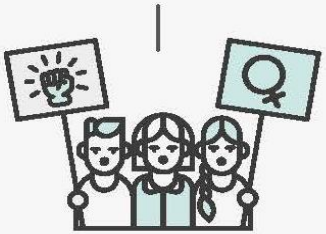
Agroecology

Practice: Agricultural practices which valorise ecological process and ecosystem services

Science: study the ecological process involved in agricultural practices

Movement: Valorise rural culture and community, to achieve social and environmental justice

Promotes farmer to farmer exchanges for sharing knowledge



Encourages diversity and solidarity among peoples, encourages women and youth empowerment

Agrobiodiversità funzionale

How can diversity affect services provisioning in **agro**ecosystems?

Functional Identity

Presence of a set of **homogeneous** phenotypic **traits** that are related to the expression of given Ecosystem Services (ES).

e.g. High performing pure crop

Functional Composition

Complementary effect of different traits, expressed by co-occurring elements, on the provision of given ES.

e.g. Legume + Grass intercrop

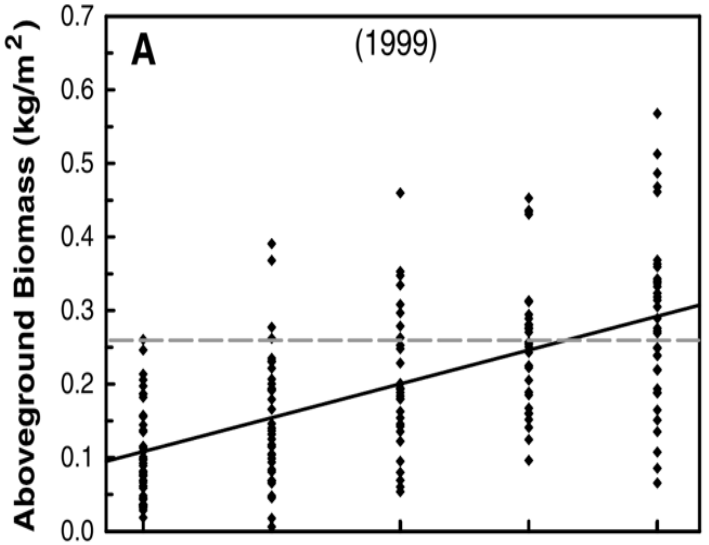
Functional Diversity

The expression of ES is modulated by genetc **diversity** *per se.*

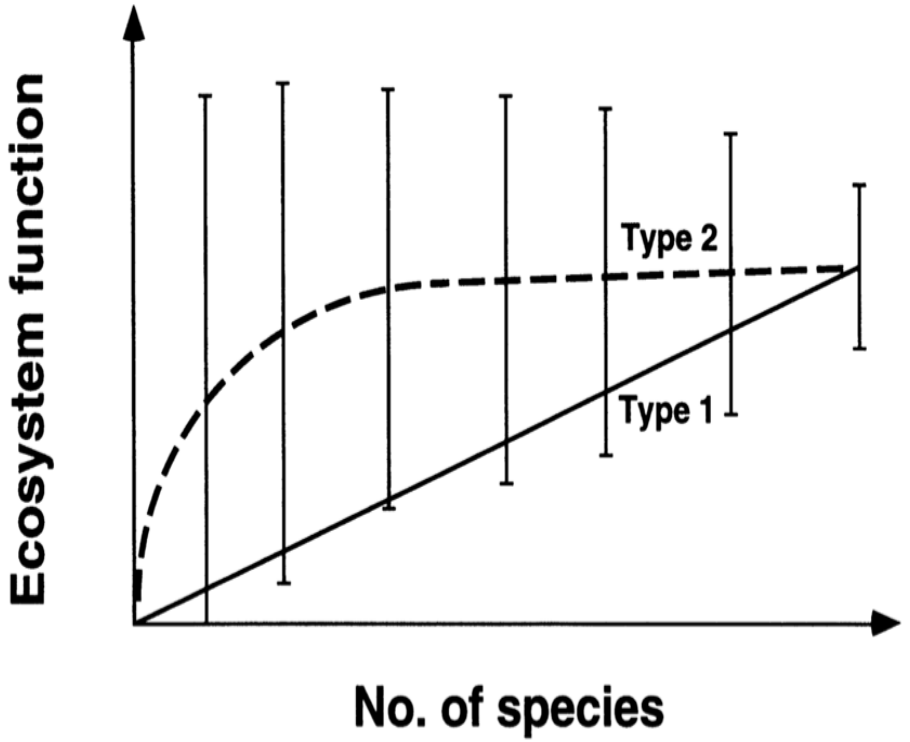
e.g. more than one functional group, more than one species in each functional group

Adapted from Costanzo and Bàrberi (2014). *Agronomy for Sustainable Development* 34, 327-348

How biodiversity can enhance services provisioning?



Tilman et al., (2001). *Science 295, 843*



J. Bengtsson (1998) *Applied Soil Ecology* 10, 191-199

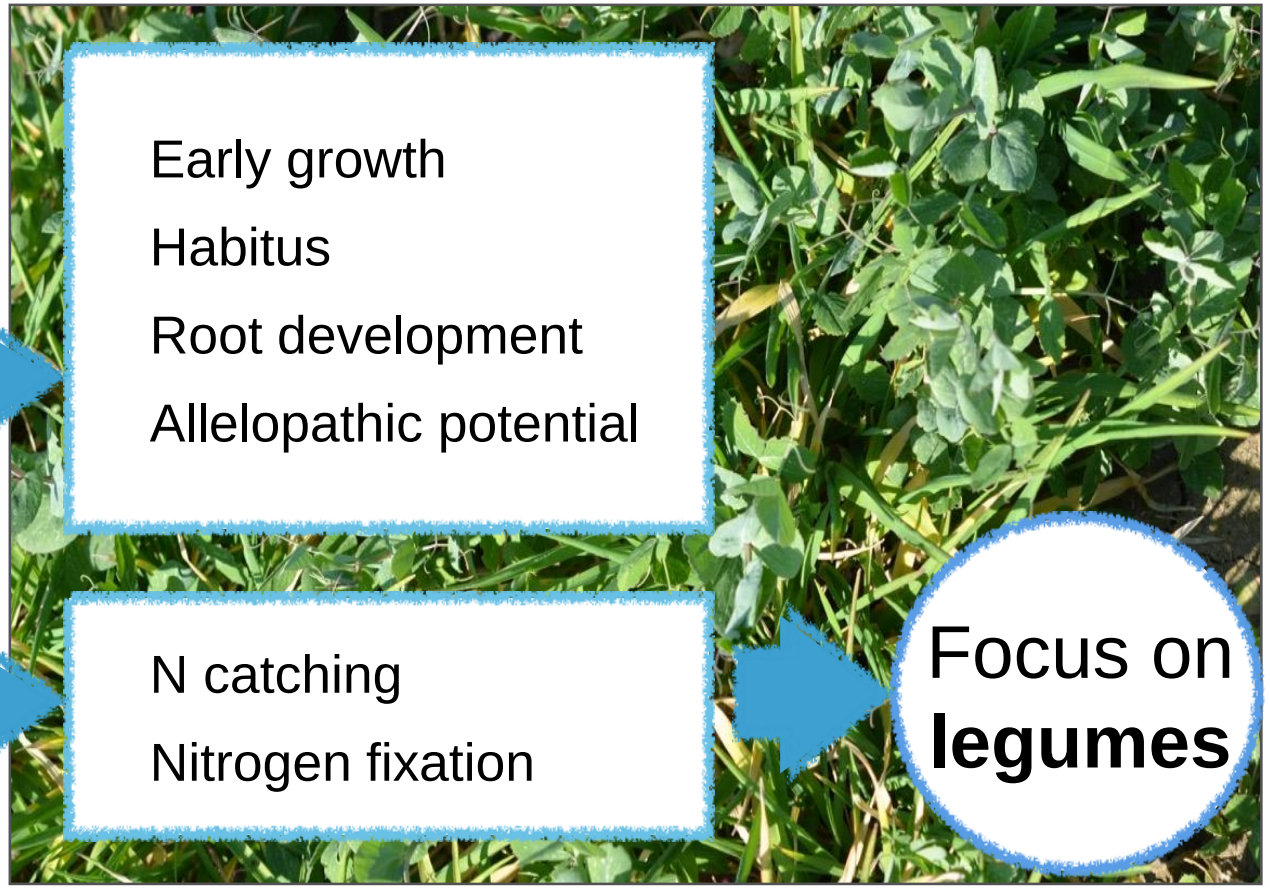
The Functional Approach

Identify functional traits

Target services in organic agriculture:

Weed suppression

Nitrogen provision



Caso 1 - Utilizzo coltura di copertura, riduzione input chimico in agricoltura conservativa (Applicazione dell'identità funzionale)

Conservation agricolture: growing winter cover crop in combination with direct sowing of a spring cash crop on the cover crop dead mulch

Hairy vetch (*Vicia villosa* Roth.):

- high N supply → N_2 fixation
- high biomass → high weed suppression ability

Hairy vetch:

- high capacity of re-sprouting [non-chemical termination]

Crimper roller: very effective only at Vetch late stages (~70% of flowering)…

Mediterranean climate: drought season → too late for sowing spring cash crop

Key ELEMENT: termination efficiency

Farm practices

- TIMING: **Which is the best time to terminate the cover crop?**

earlier termination, lower vicia biomass, lower killing efficency, higher crop production

- METHOD: **Which is the best dose of herbicide?**

systemic herbicide integration, higher efficency, higher costs

Research question:

WEED

- Reduction of herbicide application increase weed pressure (quantity &quality)?
- Moving up termination time, reduce the cover crop weed suppression capacity?

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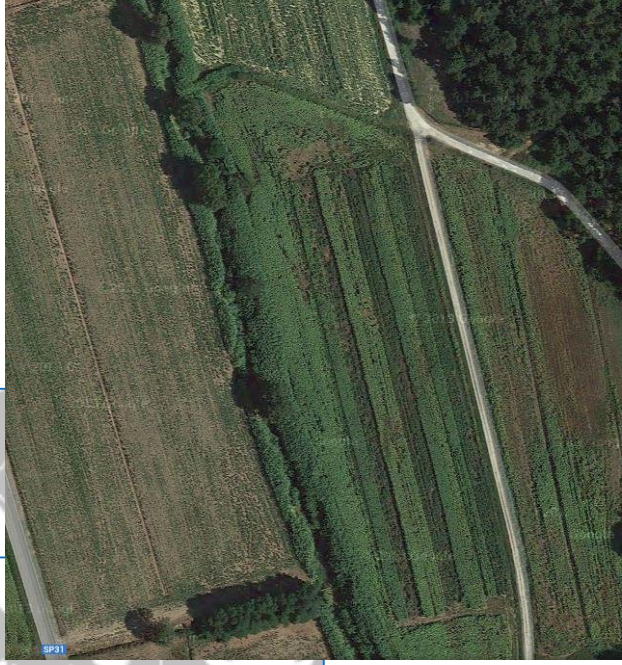
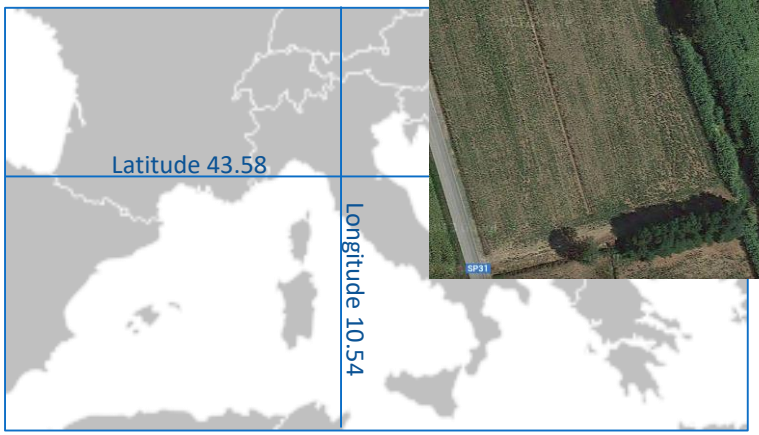
FIELD EXPERIMENT





Site: Martello Nadia Farm, Ceppaiano -Pisa- (ITALY)
Climate: precipitation 900 mm/y, mean annual temperature 15°C
Soil: sandy-loam
Years: 2012/2013, 2013/2014, 2014/2015

Cover crop: **Hairy vetch** (*Vicia villosa* Roth.)

Cash Crop: **Sunflower** (*Helianthus annuus* L.)

Factor 1: **Three termination techniques**
(crimper roller with: null/half and full dose of Glyphosate)

Factor 2: **Three termination dates**
(before flowering/beginning of flowering/70% of flowering)

Experimental design: **combined factorially according to a split-plot design with 3 replications, with termination technique as sub-plot factor. HSD as post hoc test.**

Measurements

vetch termination date: vetch and weed biomass, weed cover

harvest maturity: plant density, grain yield and weed biomass, weed cover

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Direct seeding+crimper roller

time 1

Sunflower seeded
before vetch flowering

time 2

Sunflower seeded
at beginning of vetch flowering

7 June 2013

time 3

Sunflower seeded
at 70% vetch flowering

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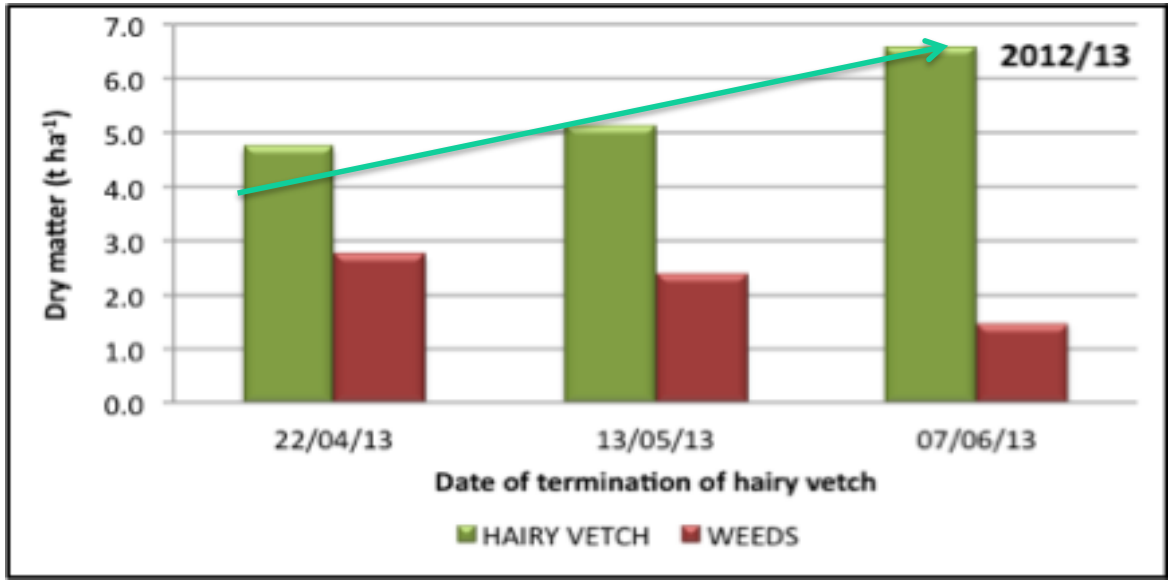
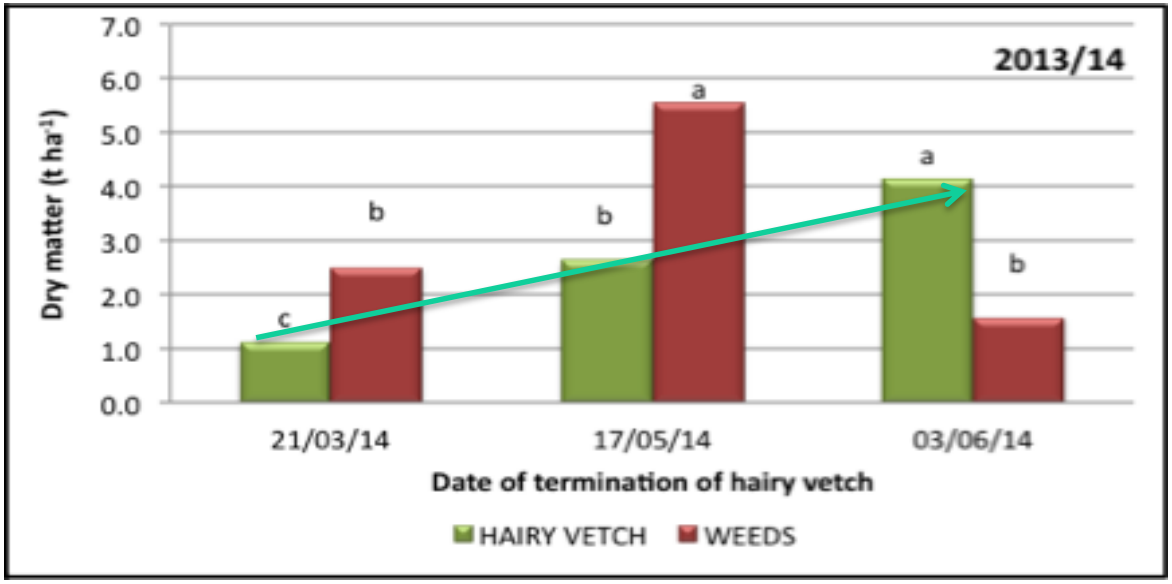
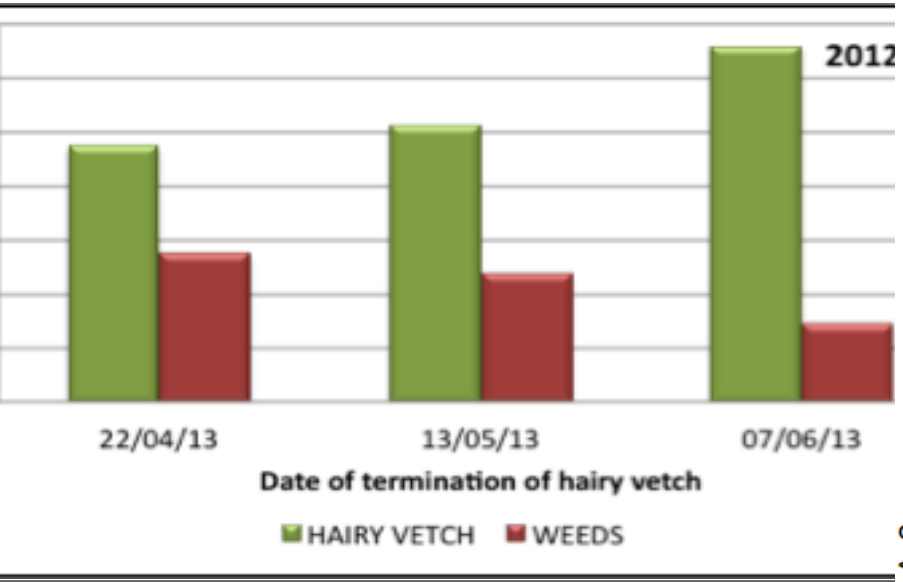
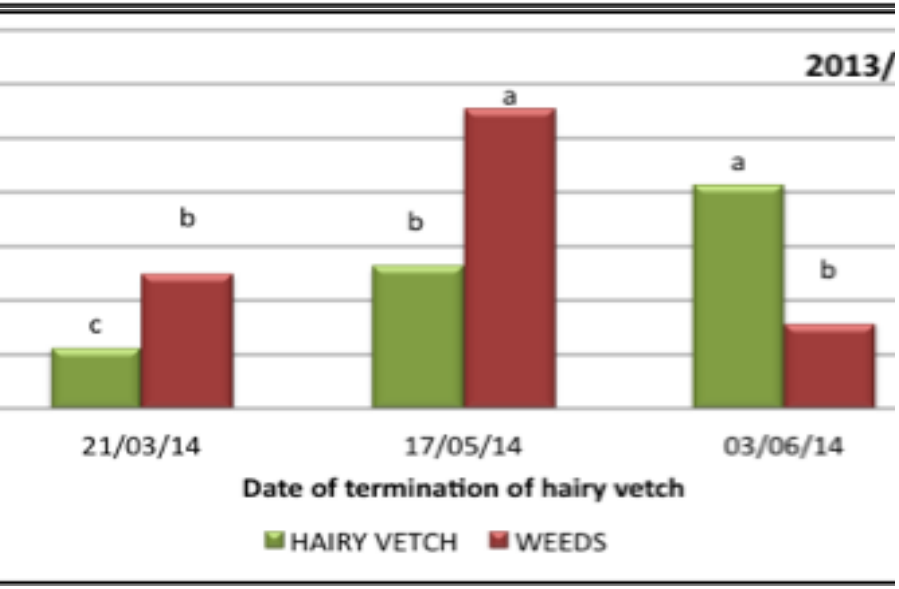
Risultati biomassa: veccia e flora infestante alla semina del girasole

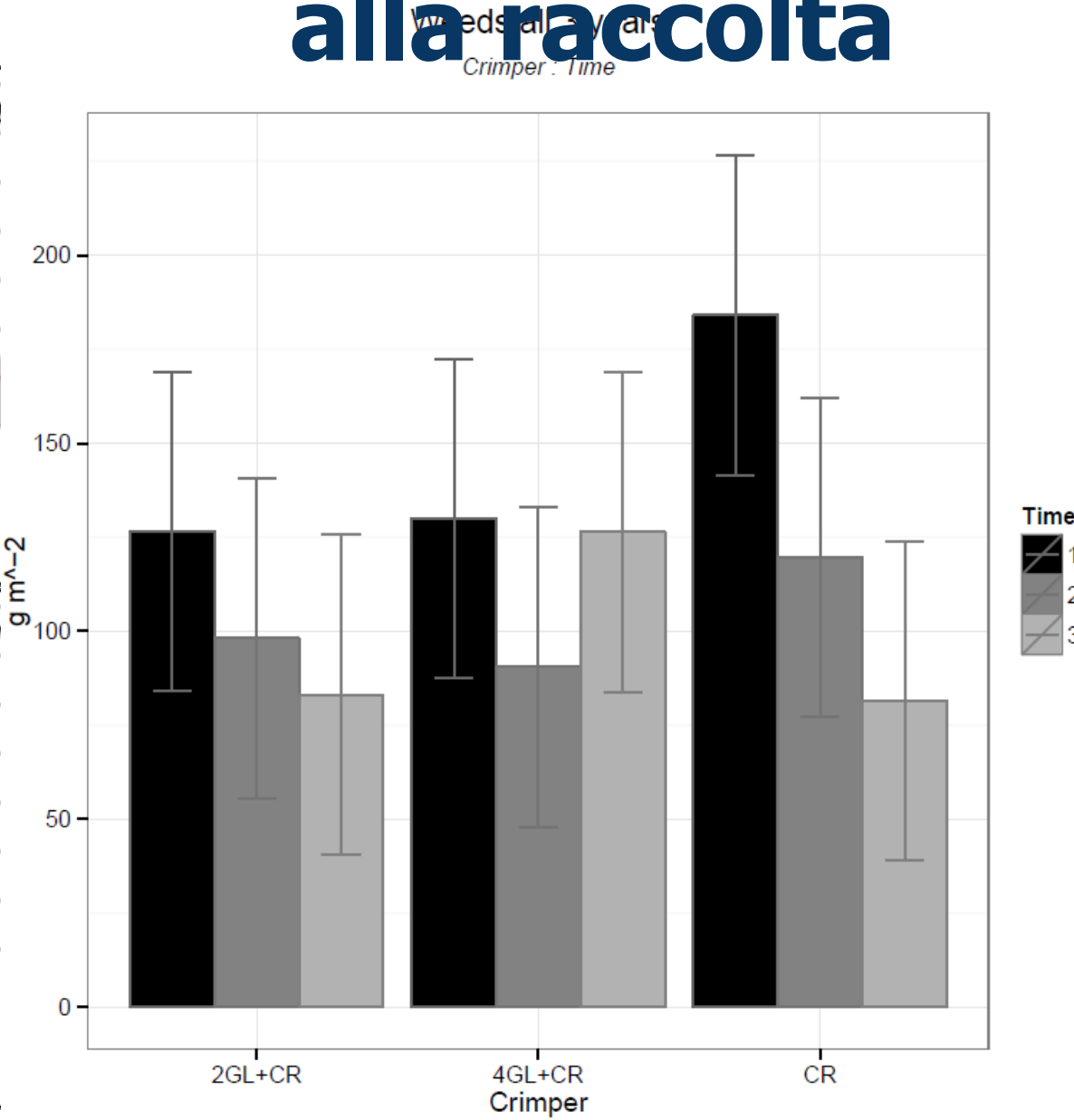




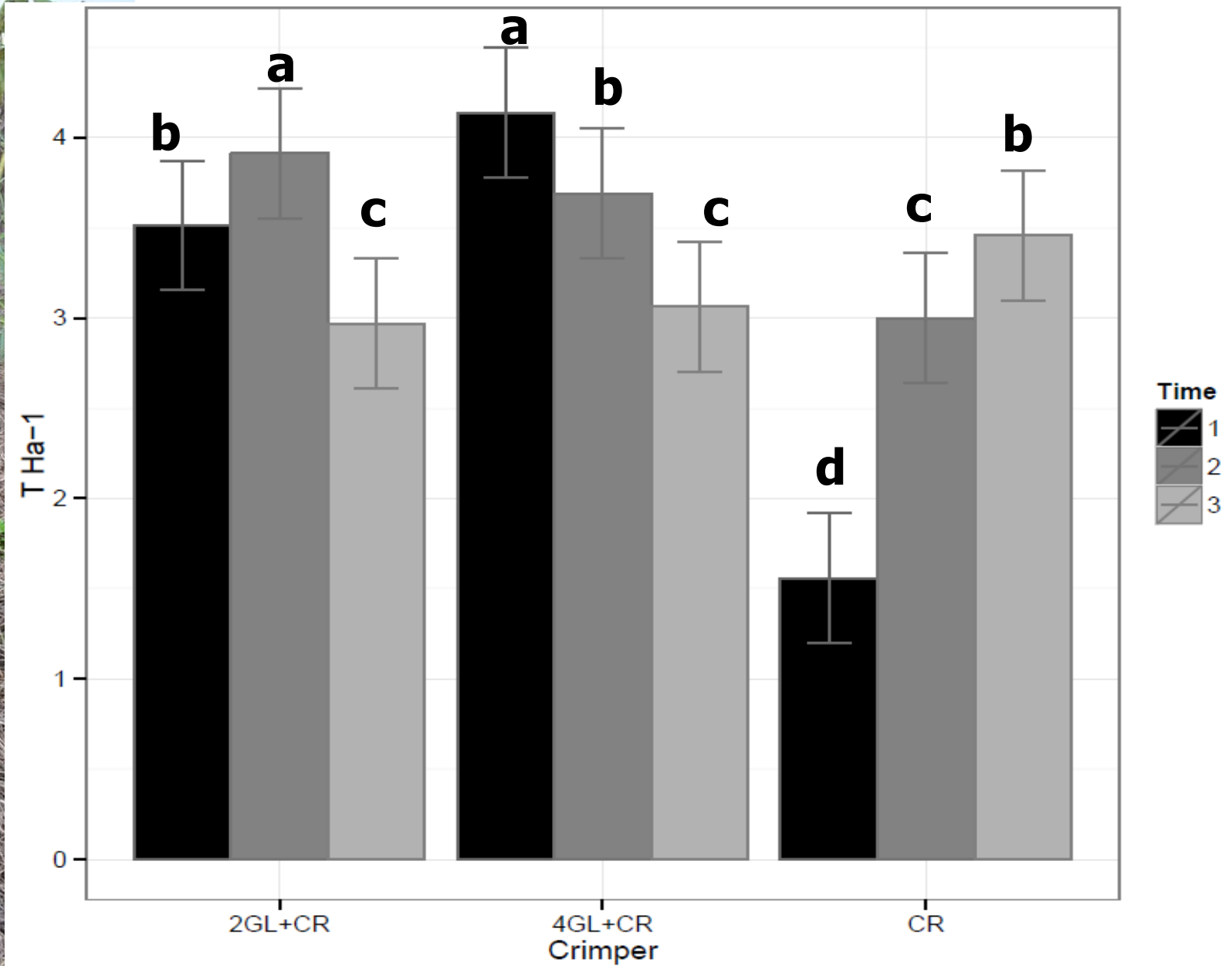
Risultati: biomassa infestanti alla raccolta







Risultati: granella alla raccolta



Discussione

Tecnica di terminazione

- **uso di erbicidi** è necessario per il controllo della flora infestante solo se si vuol terminare la veccia ad uno stadio fenologico precedente la piena fioritura
- **Roller crimper applicato a piena fioritura (**70%) porta ad un controllo della flora infestante comparabile con le tecniche standard basate sull'applicazione di erbicidi

Tempistica

- Il **momento di "terminazione"** è cruciale nel determinare controllo (e composizione – germinazione della flora infestante)
- **Ritardare** la terminazione della cover crop (migliora efficacia del crimper) aumenta la biomassa della veccia (ticker mulch)
- **Compromesso** tra resa e servizio **(!!!)**

Per anticipare la fase fenologia si potrebbe lavorare sulla scelta genetica

Per incrementare la biomassa **(???)**

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Caso 2 - Utilizzo della biodiversità funzionale, agricoltura biologica conservativa

(Applicazione della diversità funzionale)

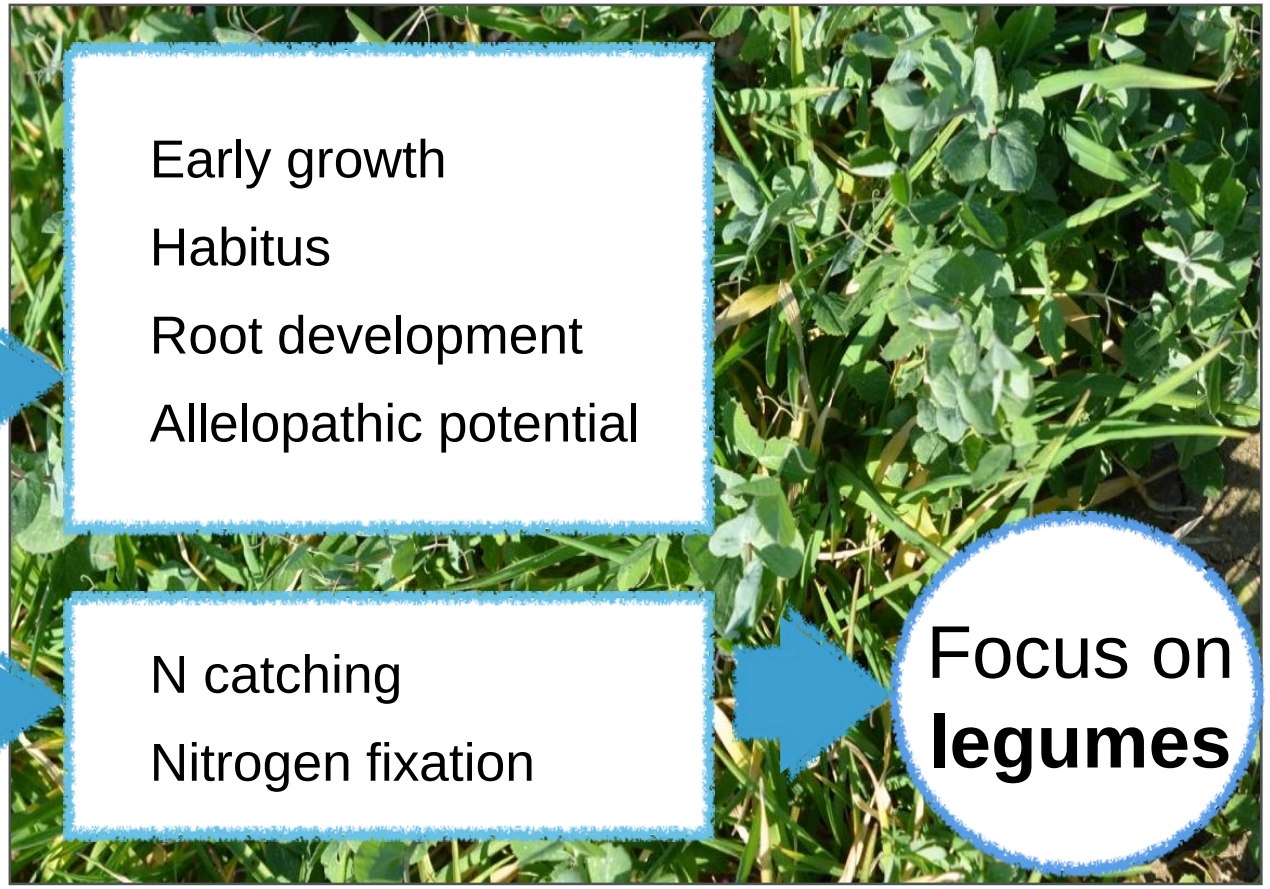
The Functional Approach

Identify functional traits

Target services in organic agriculture:

Weed suppression

Nitrogen provision



The Functional Approach

Identify functional traits

Trait based characterization of cover crops

Selection of genetic material

Searching for available species (forages) characterized by:

- functional traits related to target services
- compatibility to mixtures

Design cover crop mixtures to enhance agroecosystem services

Functional Groups (FG)

Pure stands

Large Seeded Legumes

Pisum sativum L.
Vicia sativa L.

- Nitrogen fixation
- Development in height
- Vining habitus

Small Seeded Legumes

Trifolium incarnatum L.
Trifolium squarrosum L.

- Nitrogen fixation
- Early development and soil cover
- Deep root system

Poaceae

Hordeum vulgare L.
Avena sativa L.

- Nitrogen catching
- High compentitive ability
- Fascicled root sytem

Brassicaceae

Raphanus sativus L.
Brassica nigra Koch

- Nitrogen catching
- Allelopathic potential (residues)
- Tap-root sytem

Design cover crop mixtures to enhance agroecosystem services

Functional Groups (FG)

Pure stands

Large Seeded Legumes

Pisum sativum L.
Vicia sativa L.

Small Seeded Legumes

Trifolium incarnatum L.
Trifolium squarrosum L.

Poaceae

Hordeum vulgare L.
Avena sativa L.

Brassicaceae

Raphanus sativus L.
Brassica nigra Koch

Eight-species

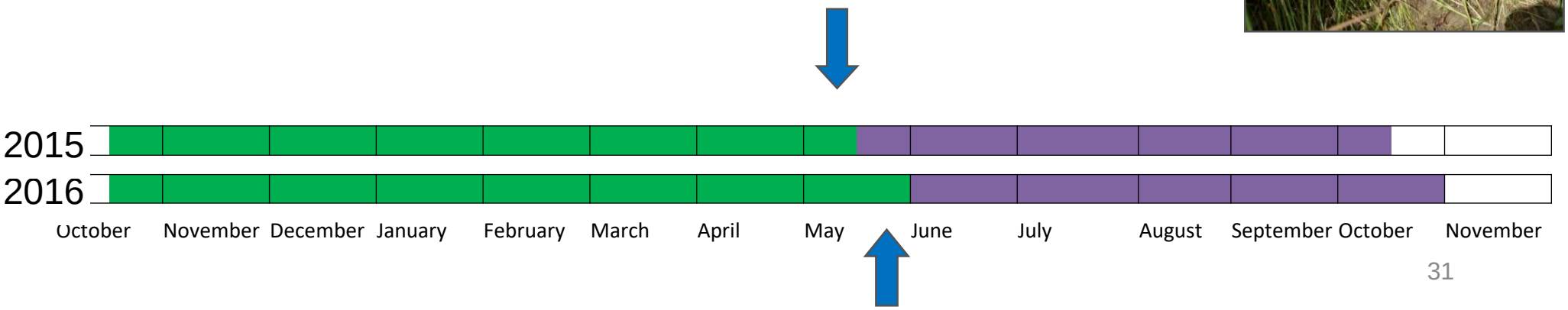
4 FG	Pea	Vetch	Crimson c.	Squarrosum
	Oats	Barley	Black mustard	Radish

Four-species

4 FG	Pea	Squarrosum c.	Barley	Black mustard
3 FG	Pea	Vetch	Barley	Radish
	Crimson c.	Squarrosum c.	Oats	Black mustard
2 FG	Pea	Vetch	Barley	Oats

Two-species

2 FG	Squarrosum clover	Black mustard
	Crimson clover	Oats
	Pea	Barley
1 FG	Crimson clover	Squarrosum clover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2016
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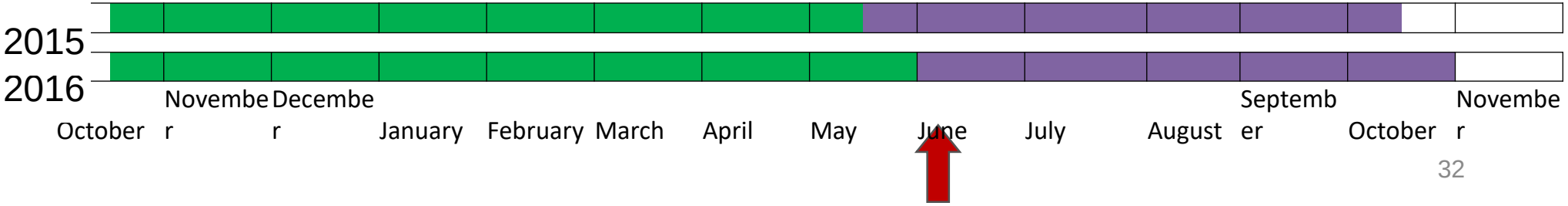
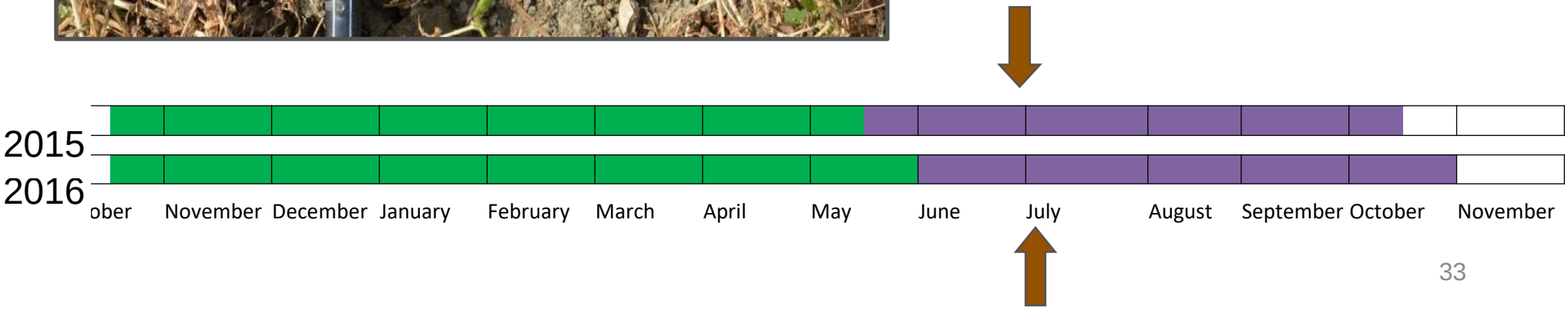
Cover crop termination

Roller crimper & weed flaming

Aubergine transplanting

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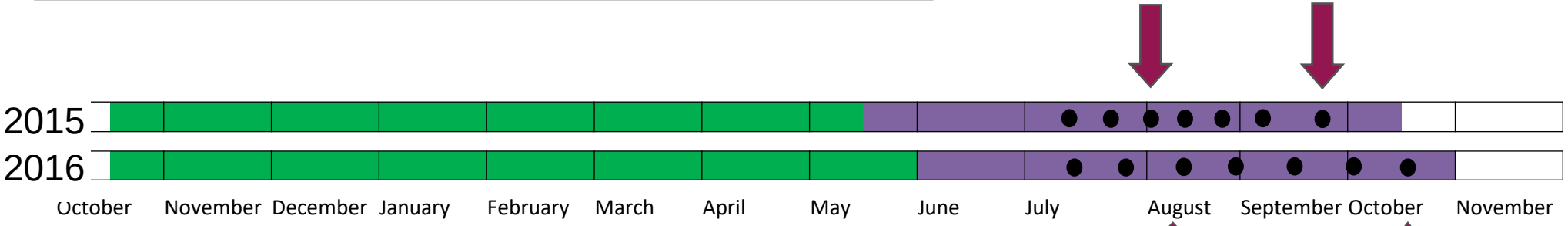
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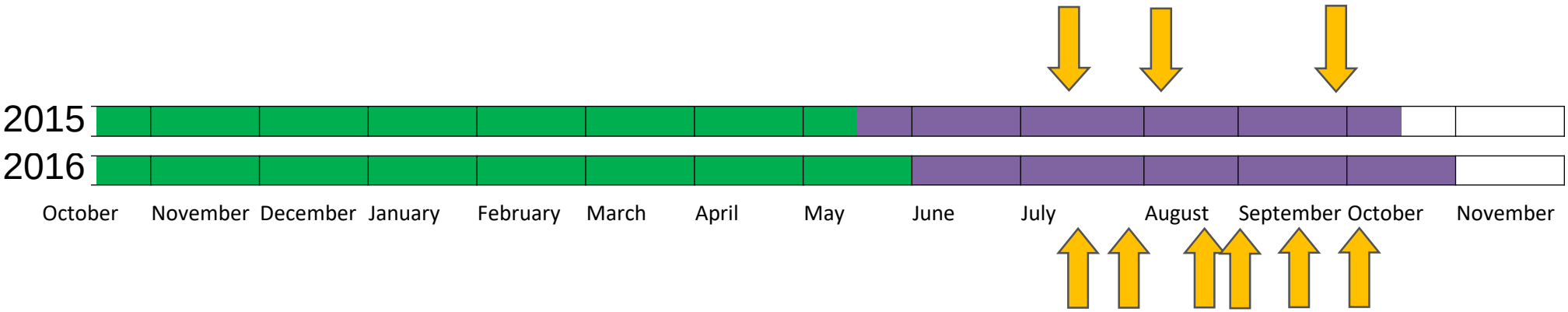
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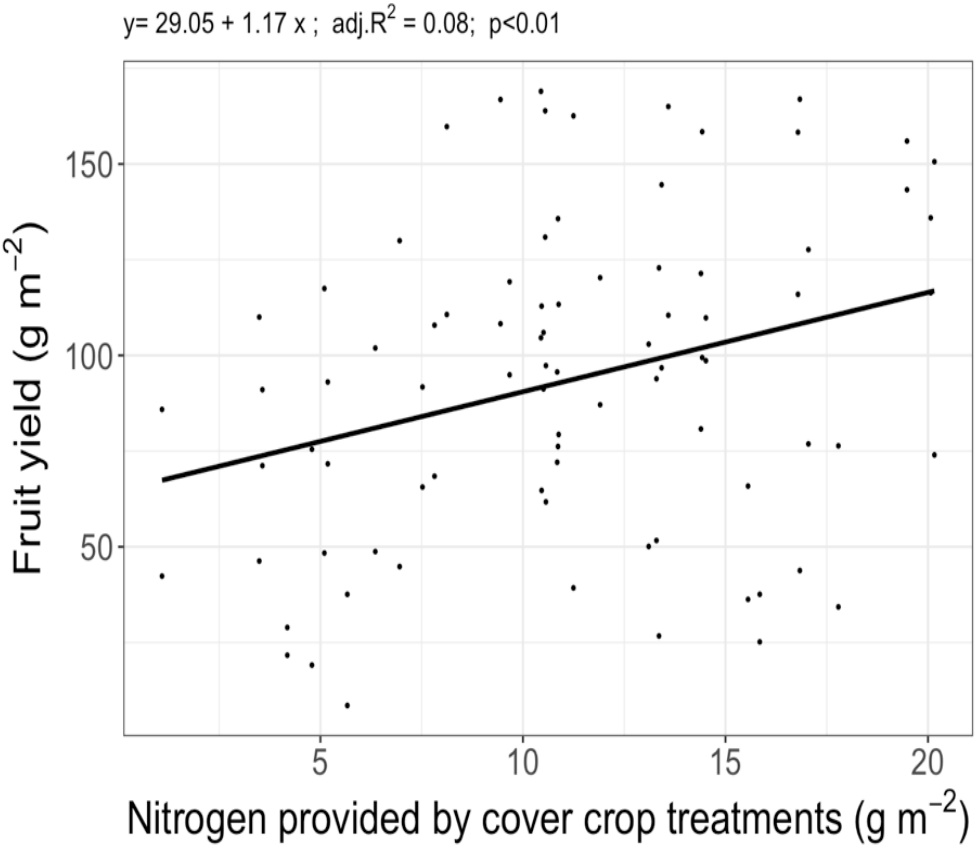
Does cover crop mulch have an effect on services provisioning during cash crop cultivation in no-till?

Mulch different decomposition rate among treatments determines their effectiveness in:

- Weed suppression
- Nitrogen provision

Effect of mulch nitrogen provision on aubergine yield

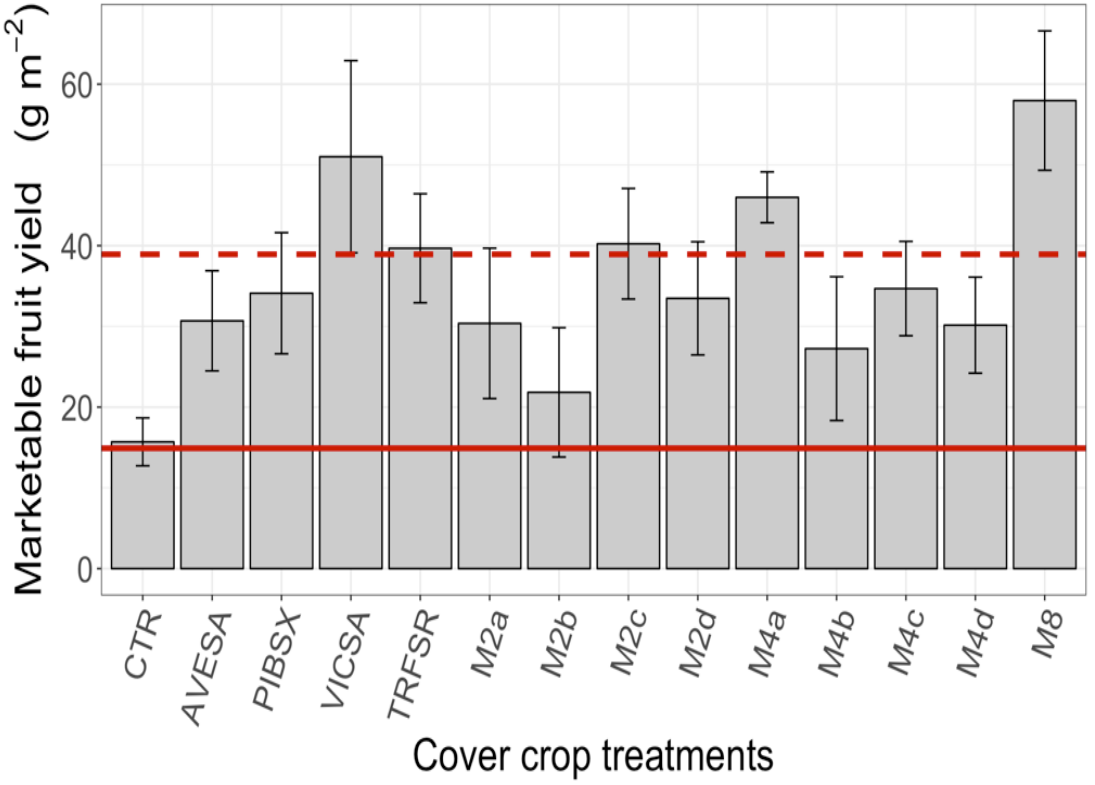
2015



2016

47.2 kg ha^{-1} N

No fertilization



Aubergine yield

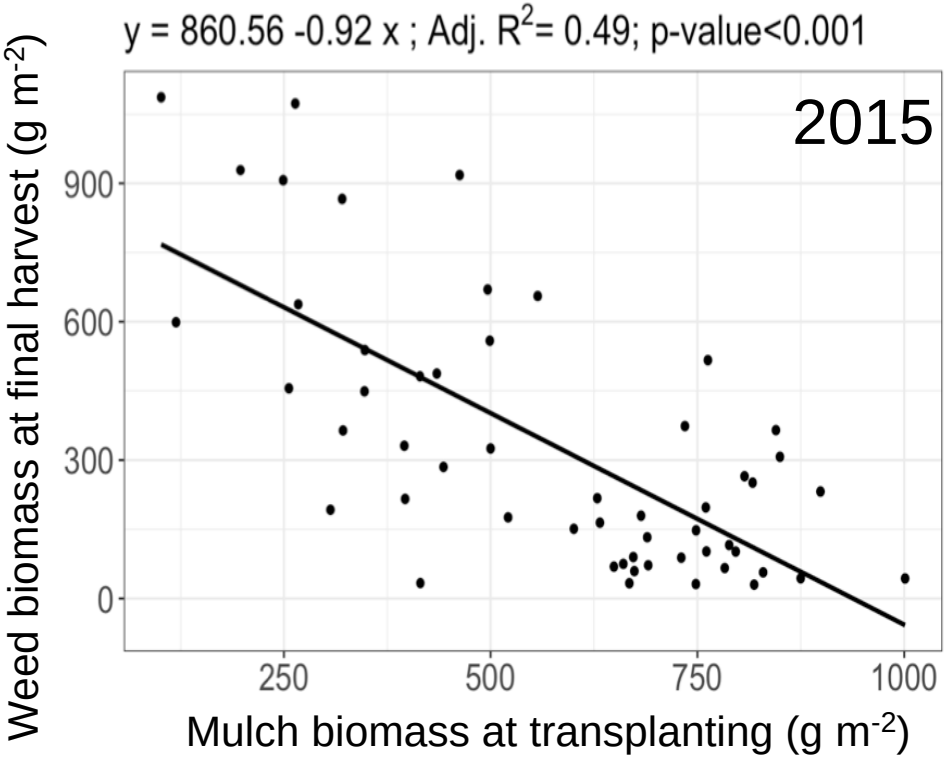
- No effect of treatment on Yield
- Yield is not increased by high fertilization

Weeds affect yield

- 39 % **in unweeded treatments**

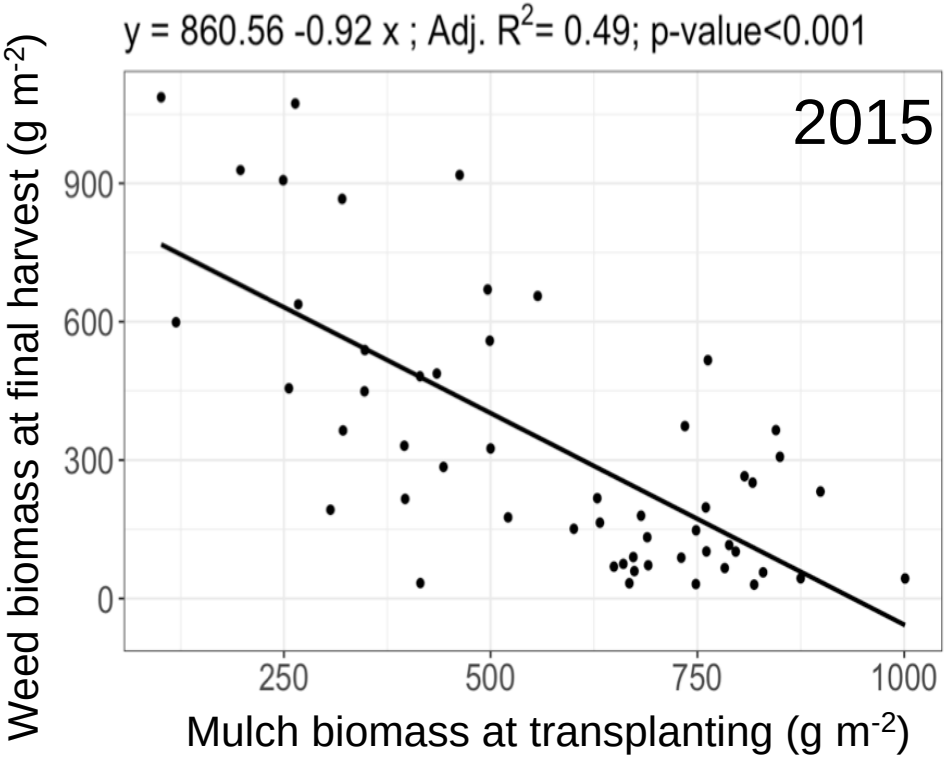
Weed suppression during aubergine cultivation: **the effect of mulch**

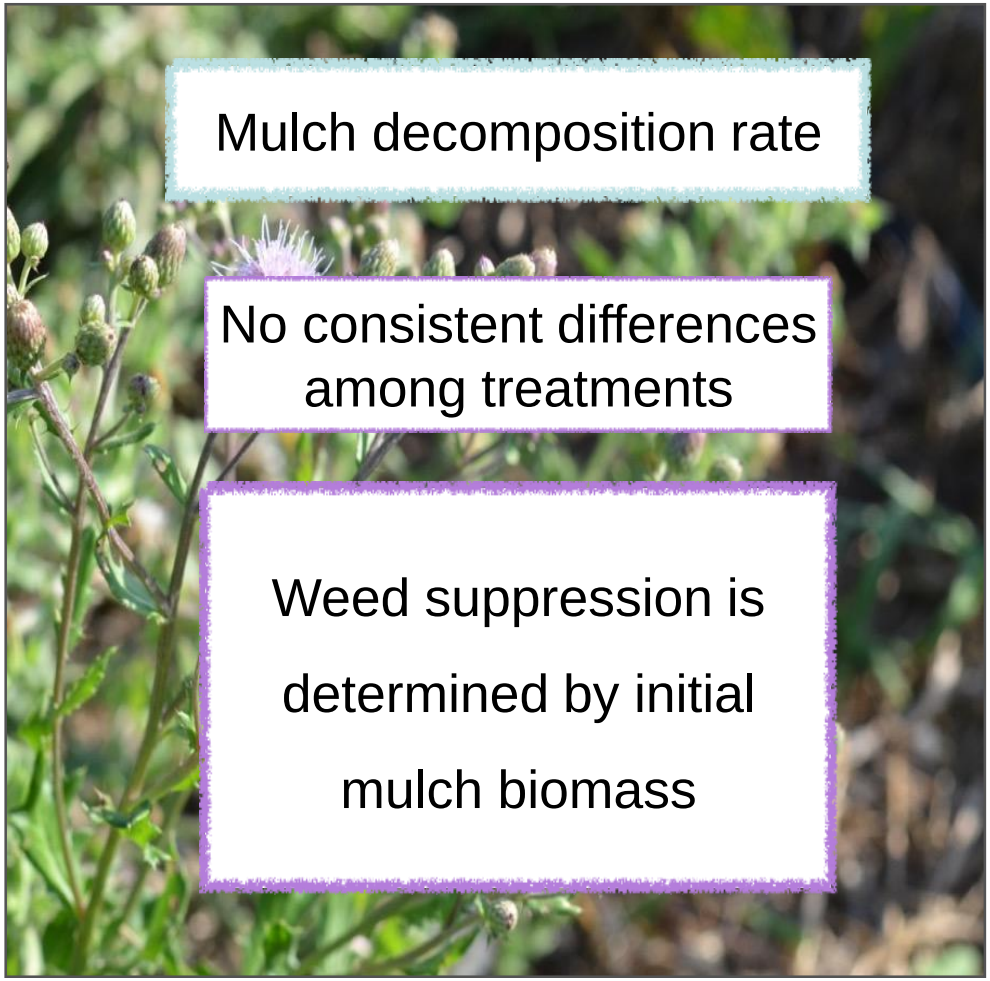
Initial mulch biomass



Weed suppression during aubergine cultivation: **the effect of mulch**

Initial mulch biomass





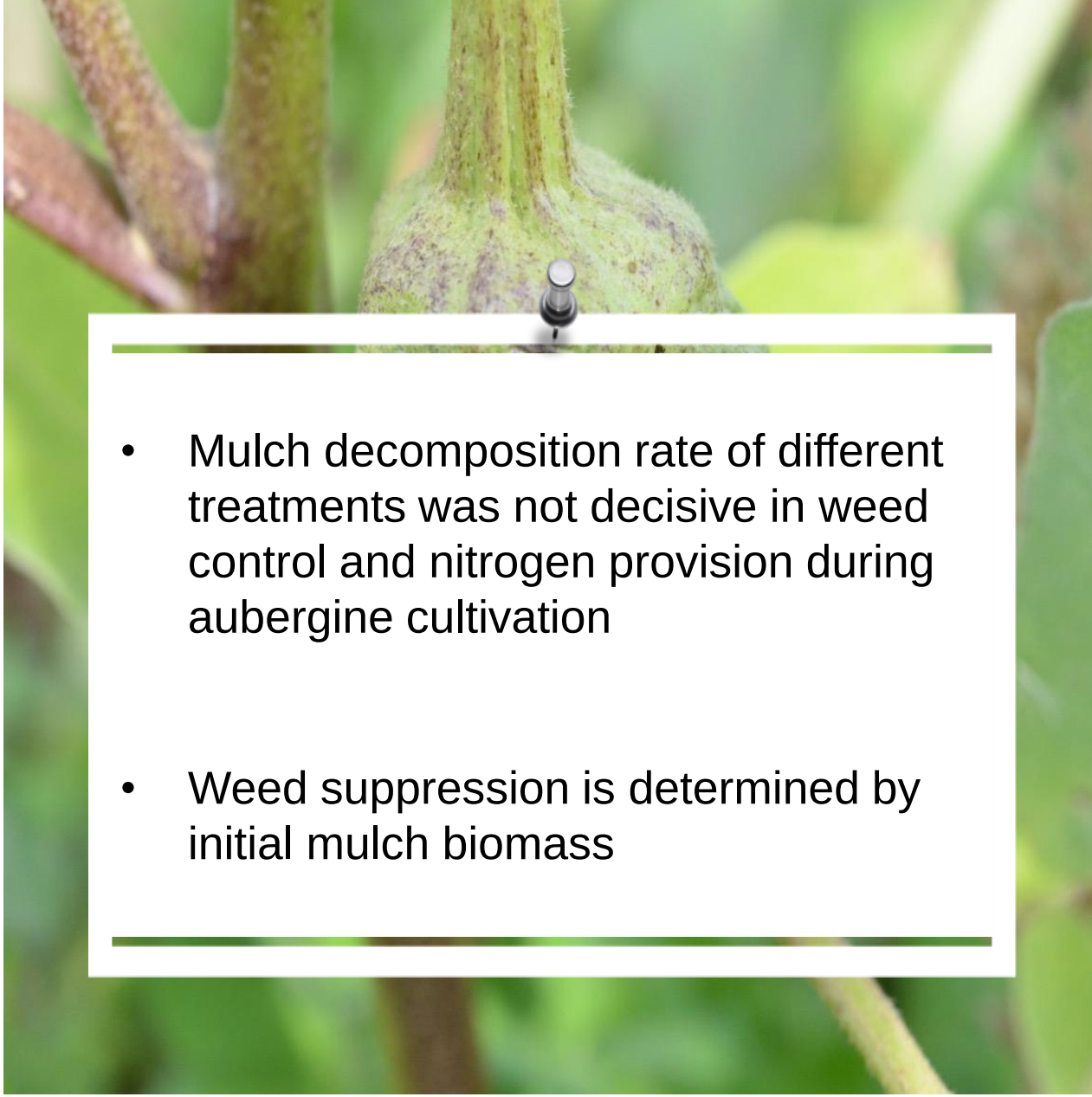
Mulch decomposition rate

No consistent differences among treatments

Weed suppression is determined by initial mulch biomass

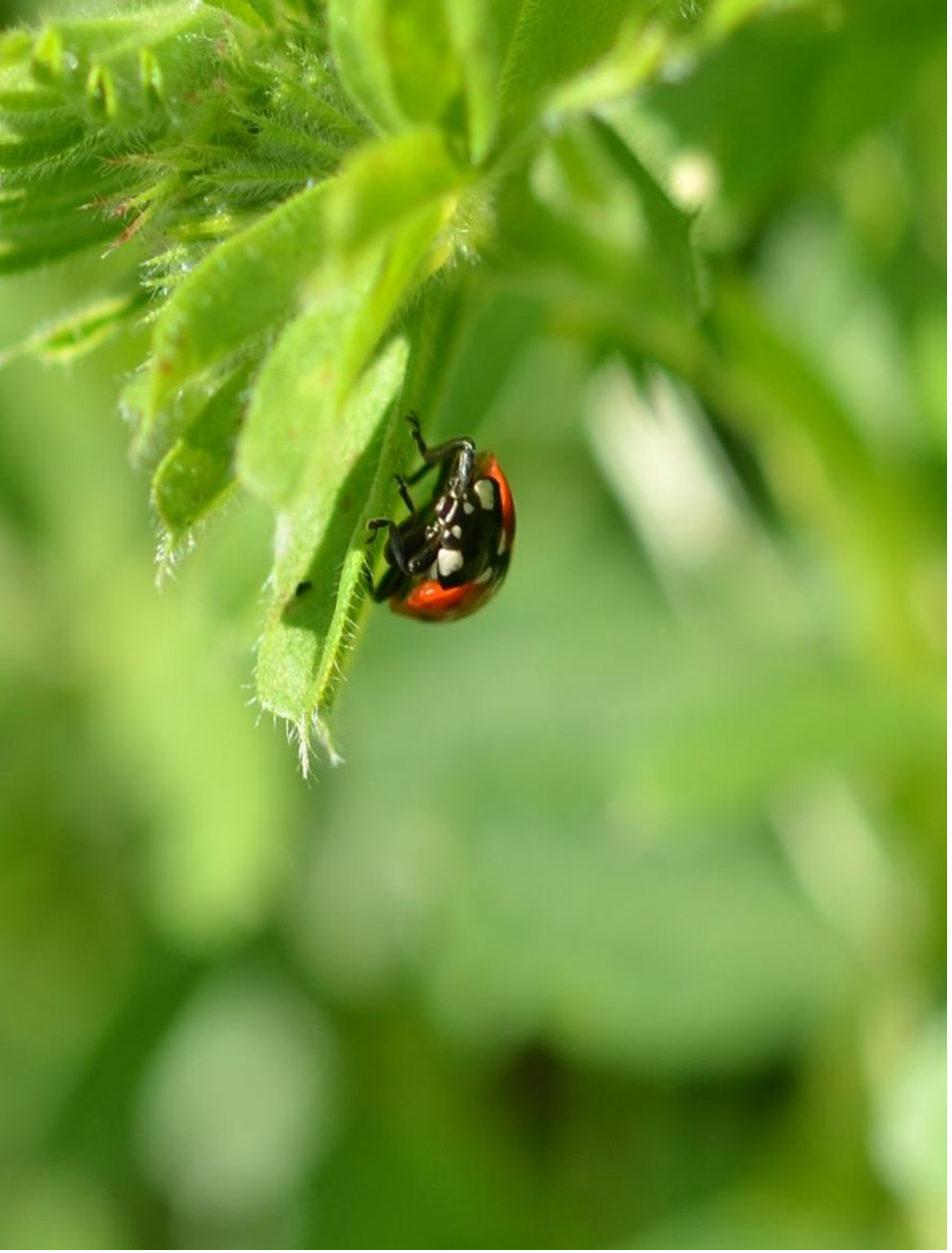
Mulch different decomposition rate among treatments determines their effectiveness in:

- Weed suppression
- Nitrogen provision



- Mulch decomposition rate of different treatments was not decisive in weed control and nitrogen provision during aubergine cultivation

- Weed suppression is determined by initial mulch biomass

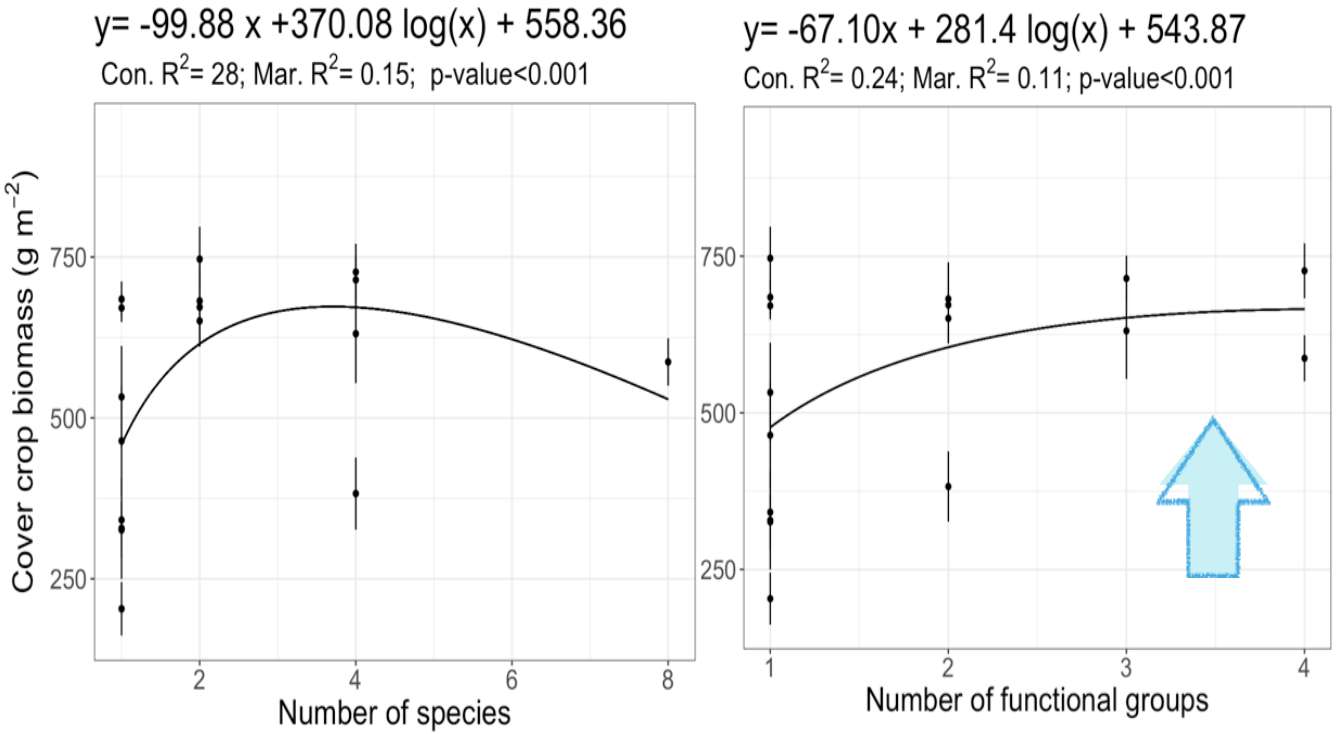


2

Which is the relationship between diversity and the extent of agroecosystem services expression?

Functional diversity can better explain services provisionig compared to species diveristy *per se.*

Effect of diversity on services provisioning: **Biomass** 2015



Effect of diversity on services provisioning: **Biomass**

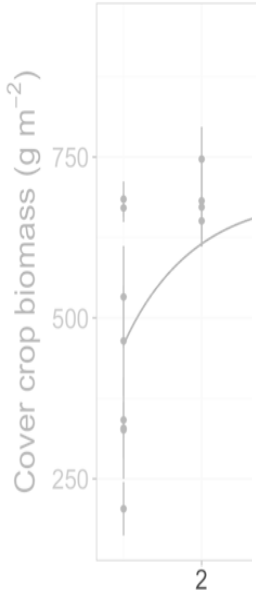
2015

y= -99.88 x +370.08 log(x) + 558.36

Con. R^2= 28; Mar. R^2= 0.15; p-value<0.001

y= -67.10x + 281.4 log(x) + 543.87

Con. R^2= 0.24; Mar. R^2= 0.11; p-value<0.001



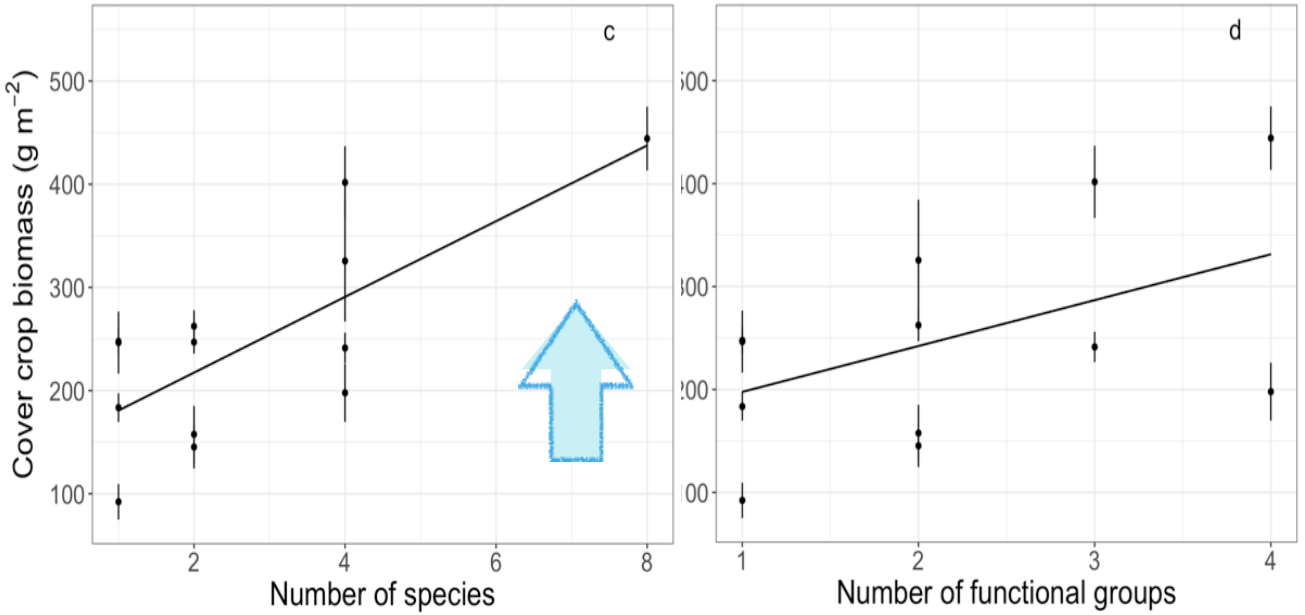
2016

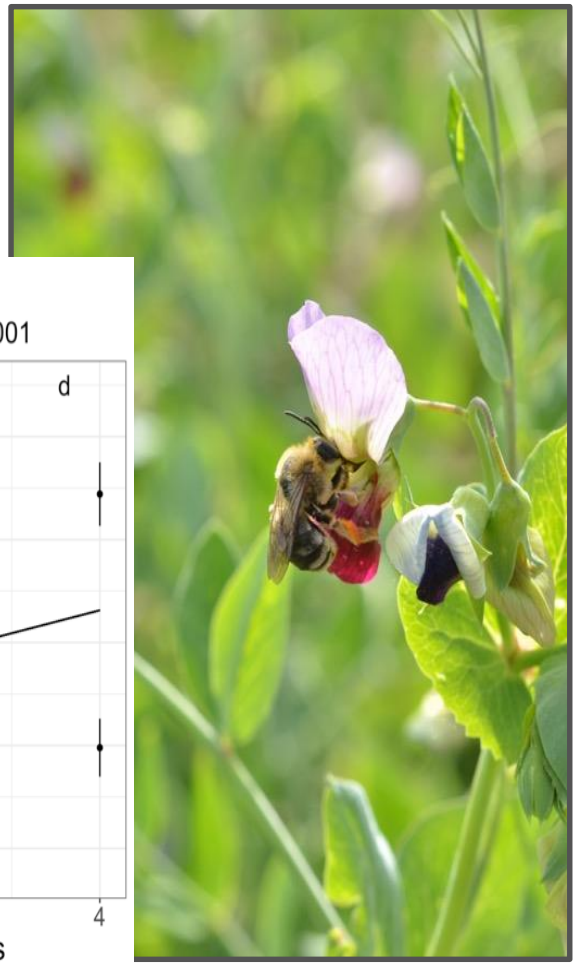
y= 36.69 x + 144.05

Con. R^2= 0.33; Mar. R^2= 0.33; p-value<0.001

y= 44.54 x + 153.15

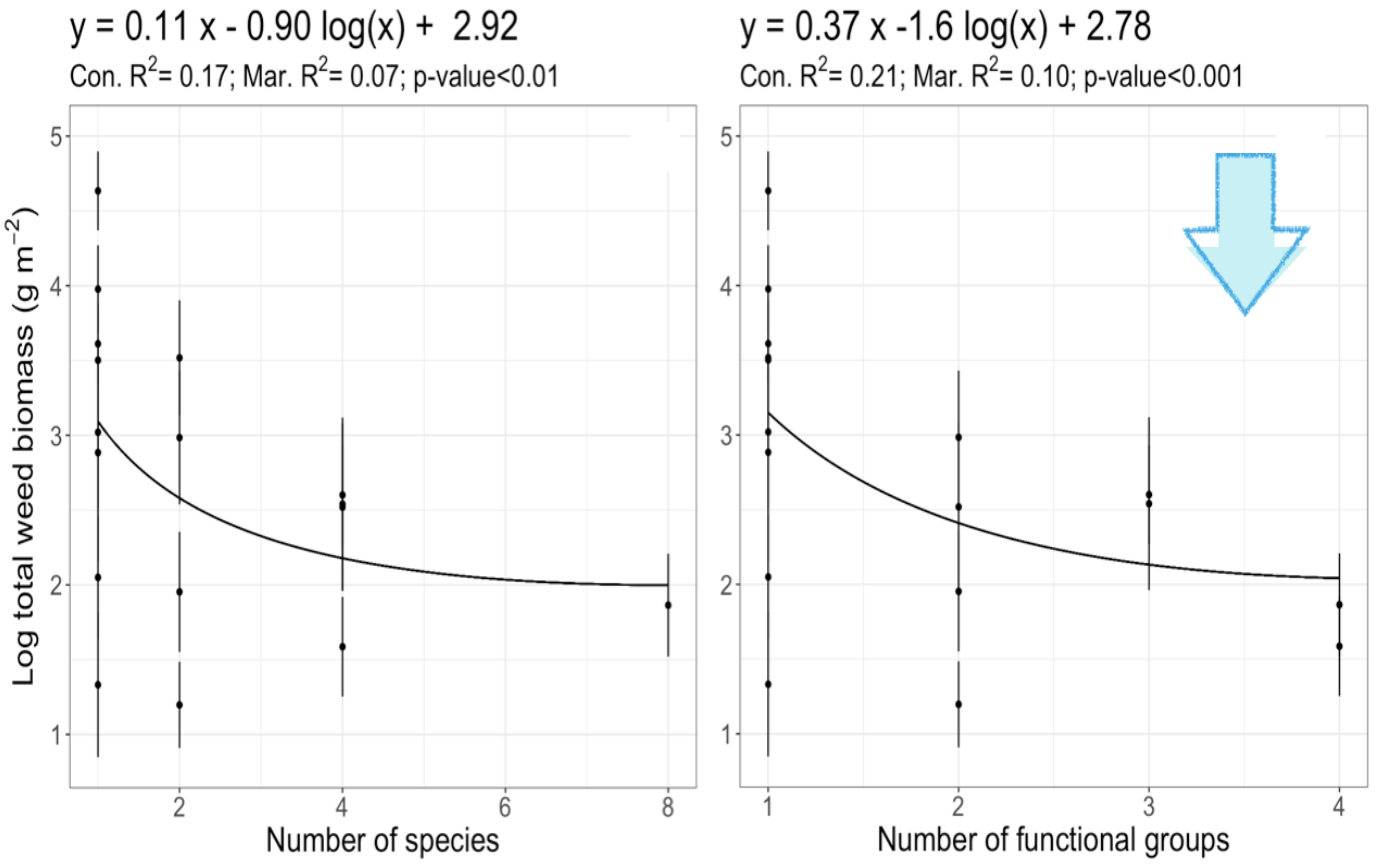
Con. R^2=0,15; Mar. R^2= 0.15; p-value<0.001





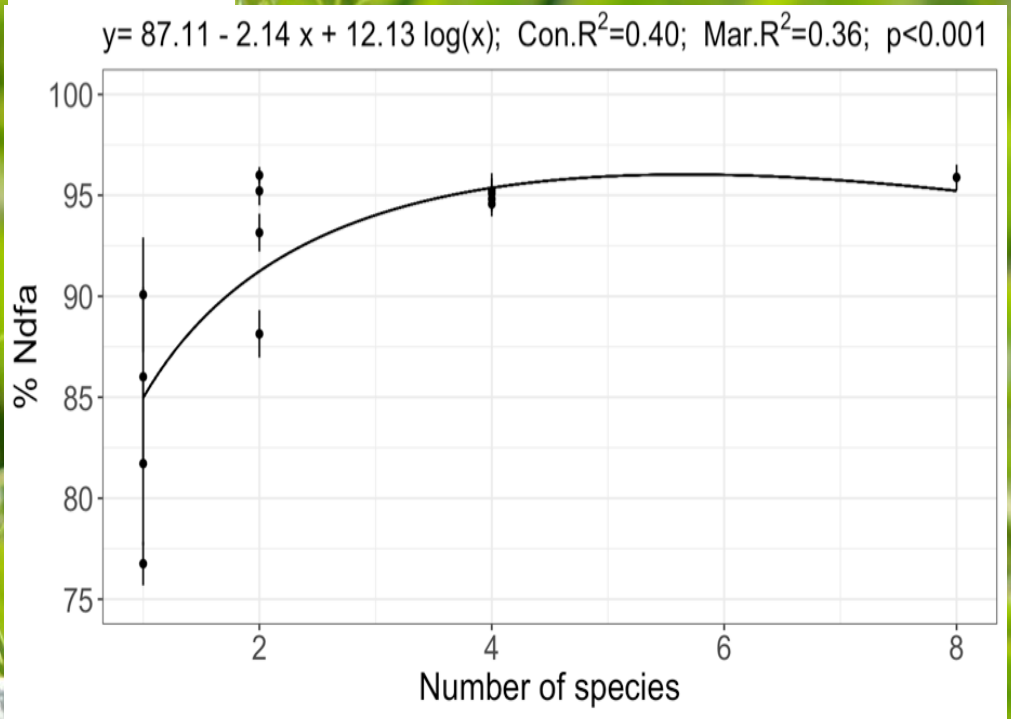
Effect of diversity on services provisioning: **Weed suppression**

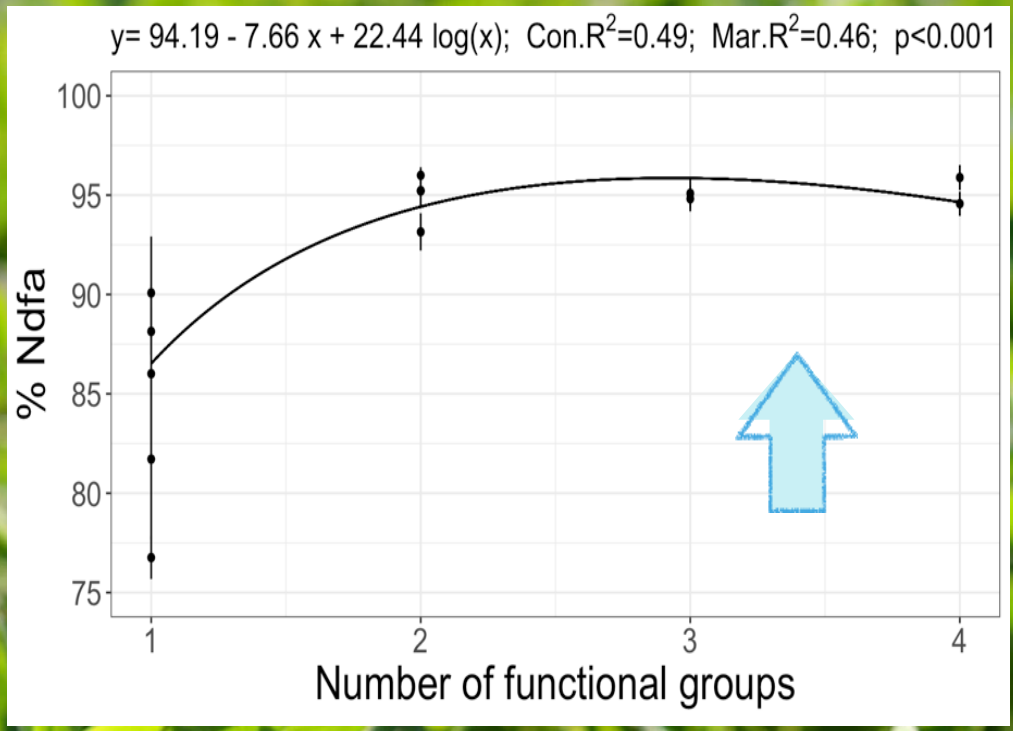
2015



Effect of diversity on services provisioning: **Nitrogen fixation**

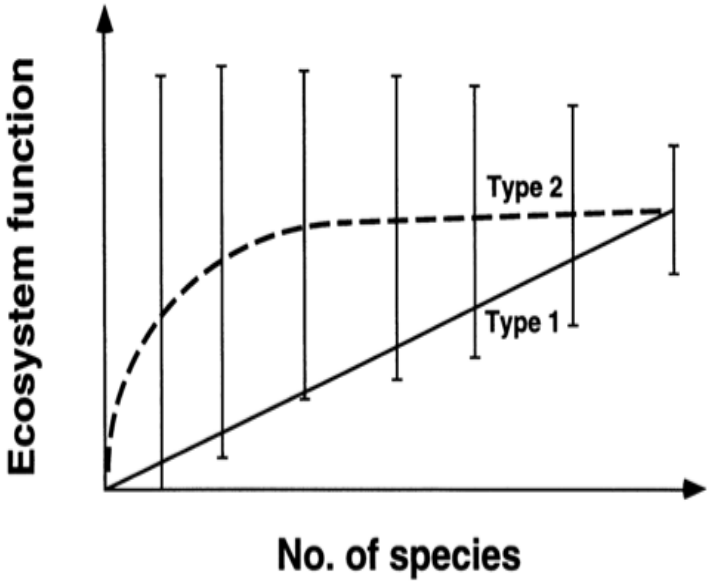
2015





Functional diversity can better explain services provisionig compared to diveristy *per se.*

- Services provisioning of cover crop mixtures can be more effectively improved increasing Functional diversity compared to diversity *per se*.
- The relationship linking functional diversity and ecosystem services is of type 2: redundancy hypothesis
- In difficult condistions the realtionship is linear or idiosyncratic



J. Bengtsson (1998) *Applied Soil Ecology* 10, 191-199

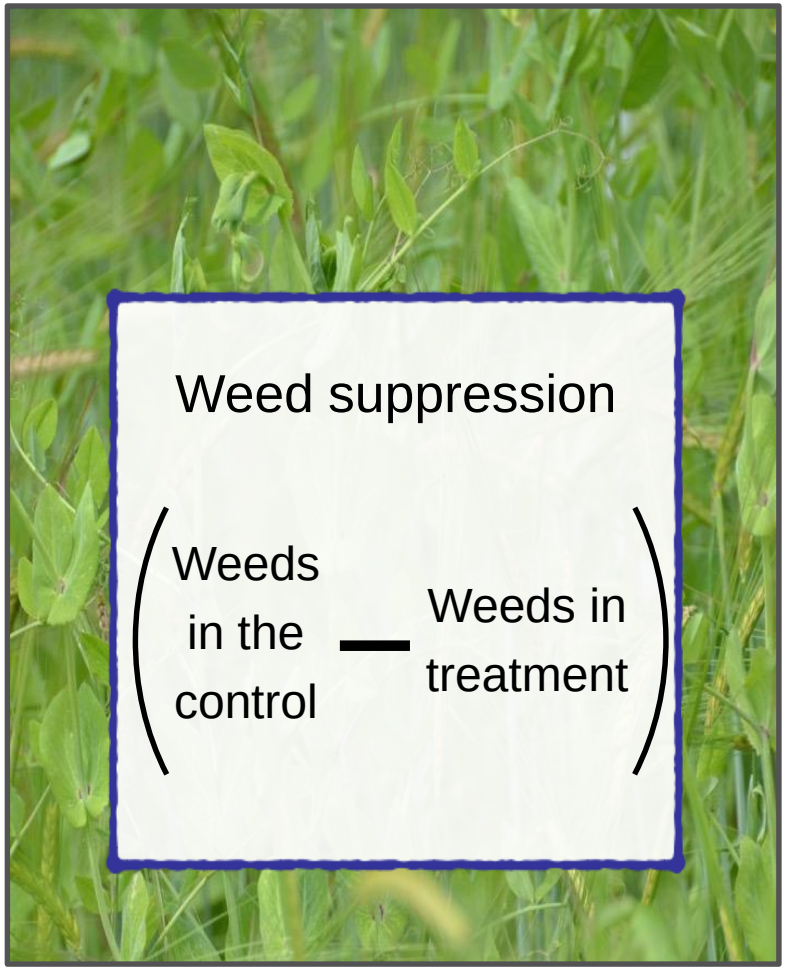
3

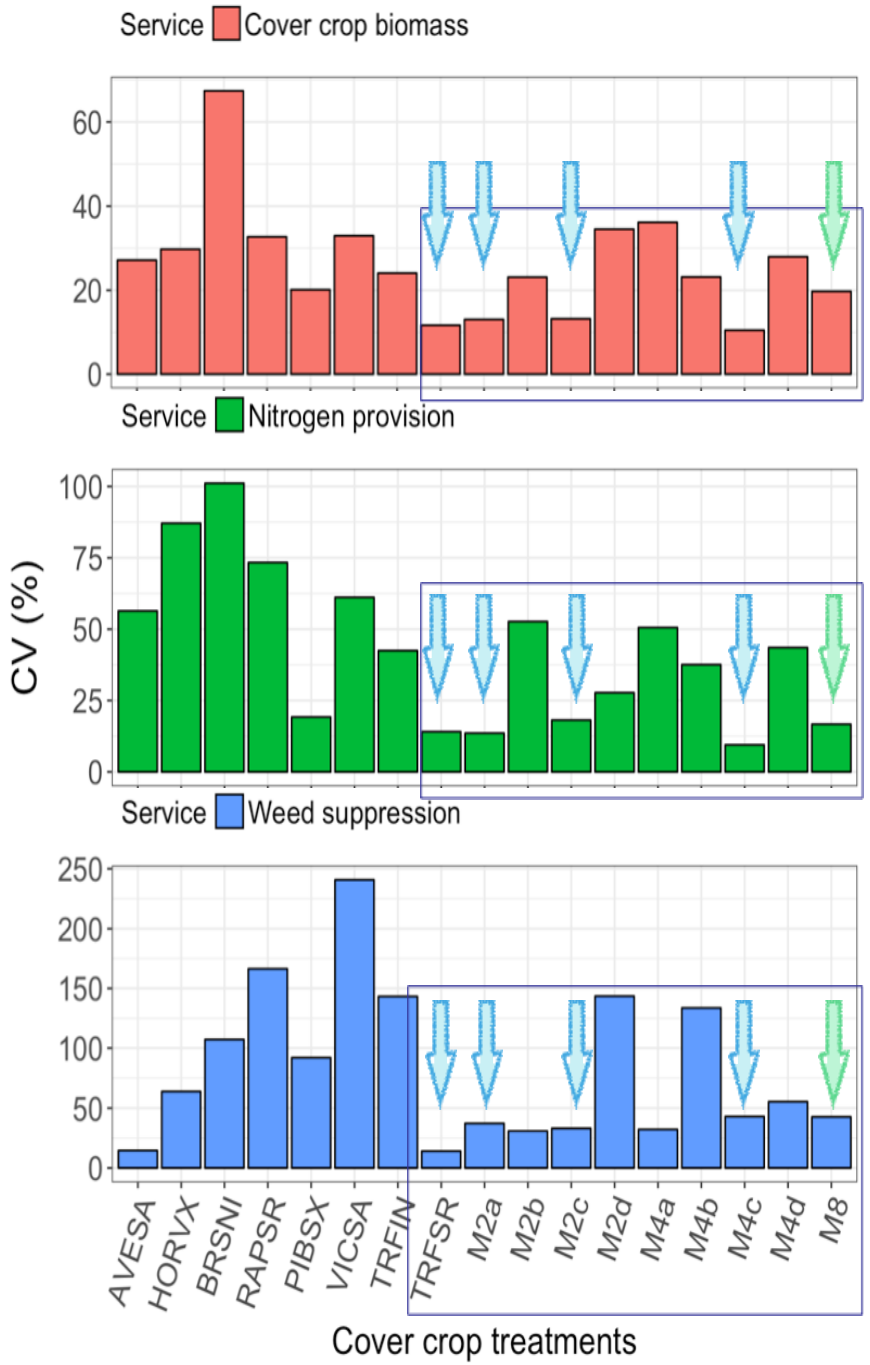
Stability of services provisioning can be enhanced by diversity in cover crop mixtures?

Stability of services provisioning is increased by functional diversity

The insurance hypothesis

Stability of services provisioning





Stability of services sprovisioning is increased by functional diversity

- Stability of services provisioning can be increased by both by functional diversity and functional identity
- The insurance hypothesys is confirmed in the case of the eight species mixtures.

Approccio agroecologico: necessità

- Aumento della complessità
- Incremento di disponibilità di conoscenze (applicate)
- Incremento di disponibilità di nuovi mezzi (meccanici e genetici)
- trovare compromessi tra produzione e servizi
- Flessibilità nelle scelte operative

Approccio agroecologico

- consente di individuare i rischi (gestione flora infestante) delle innovazioni (no till in biologico)
- trovare soluzioni pratiche (incremento della biomassa e stabilità)
- Ricorrendo a servizi disponibili (impiego di colture di copertura+CR) ottimizzandone la funzionalità e l'applicabilità in azienda (fase fenologica, functional diversity)

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Questions?

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