Avec la contribution financière du compte d'affectation spéciale «développement agricole et rural»

Assessment of the biofumigation potential of services plants against Sunflower Verticillium Wilt (*Verticillium dahliae*)

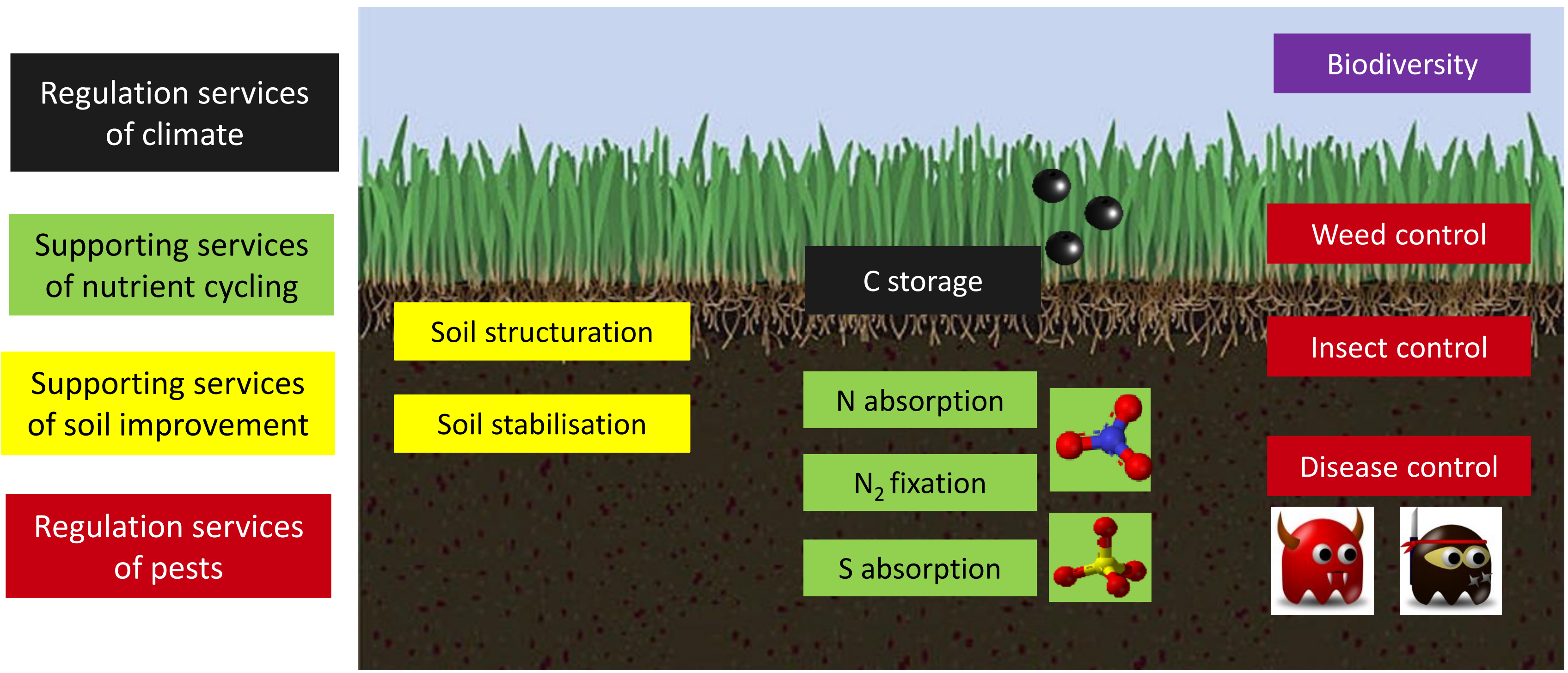
A field-experiment approach

Neila Aït Kaci Ahmed, Grégory Déchamp-Guillaume and **Célia Seassau**

Some definitions

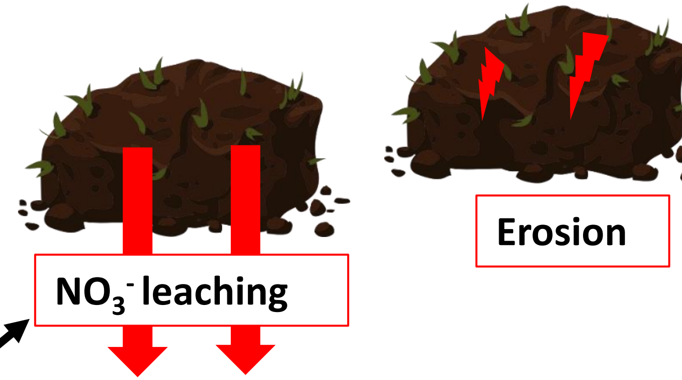
Services plants: species planted before, during or after a cash crop, intended to provide one or more ecosystem services to the following crop or crops in the rotation

► **Multi-Services Cover Crops** (MSCC) : a key-lever to store C in various cropping systems (Pellerin et al., 2020) but not only…



MSCC can be introduce during a **fallow period**: period between two cash crops

► **up to 9 months …**



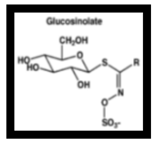
Sunflower cropping system in France :

Bare soil during the fallow period

Emergence or increase of
Verticillium dahliae
Soil born fungus
-30 % yield

An interest to introduce MSCC for pests regulation services

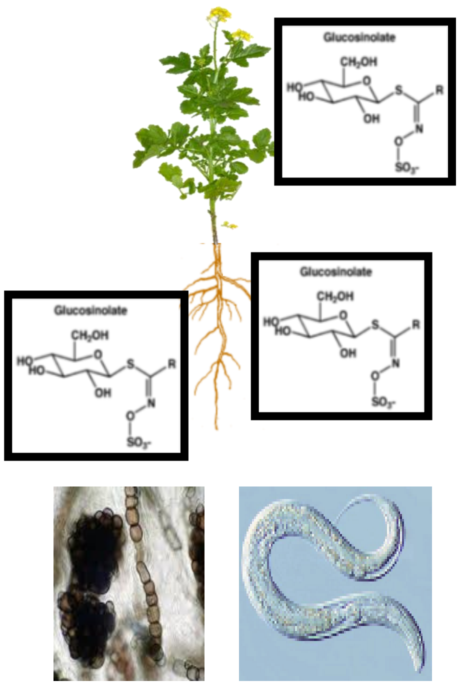
Services provided by MSCC Brassicaceae and biofumigation:

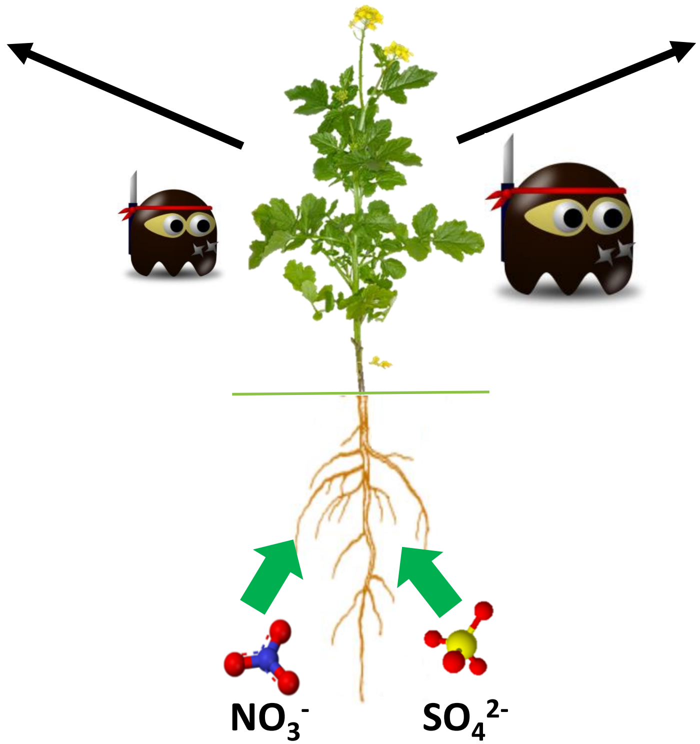


Metabolites II
8 amino acid
140 GSL identified

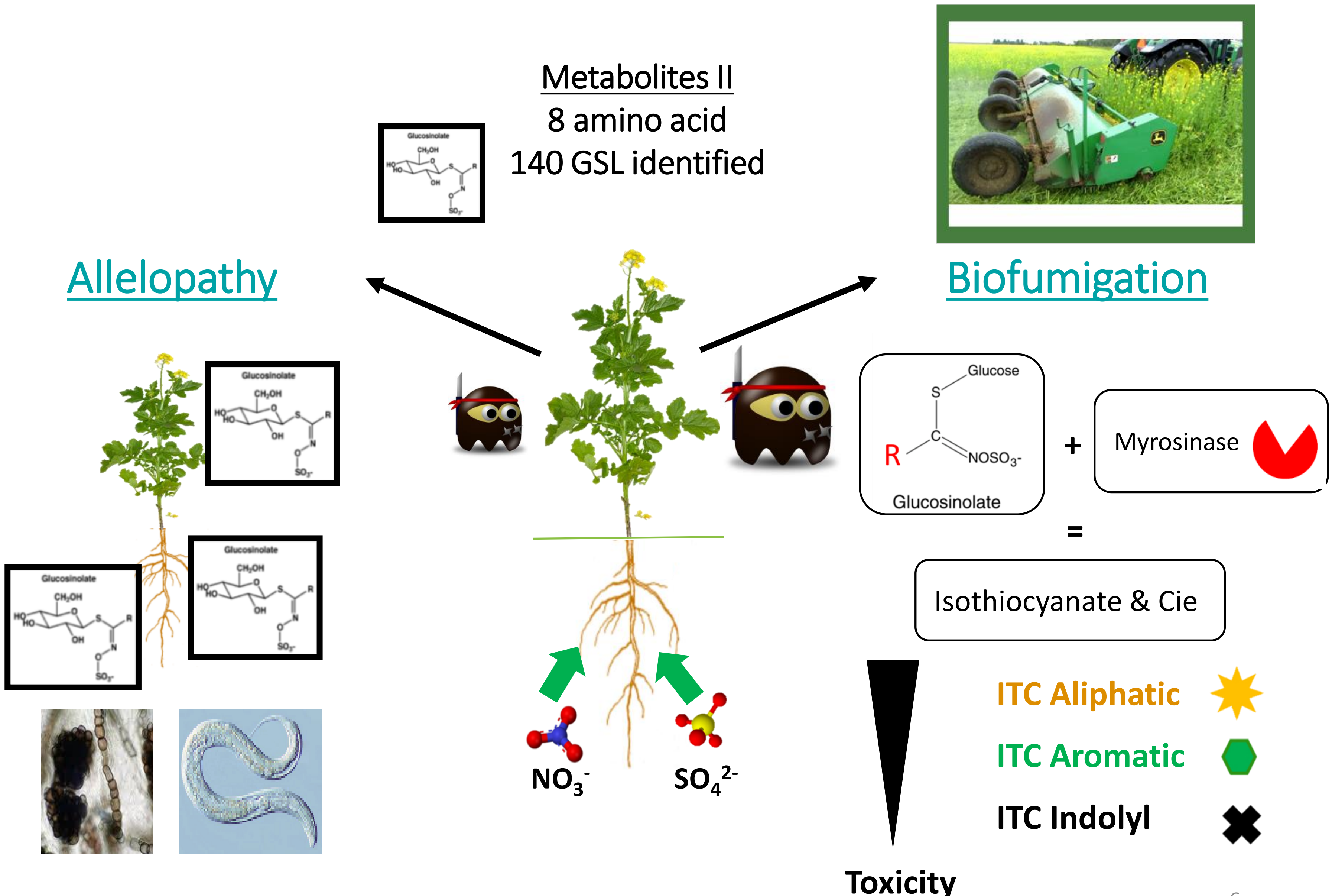
Allelopathy

Biofumigation





Services provided by MSCC Brassicaceae and biofumigation:



Fahey et al. (2001) ; Matthiessen and Kirkegaard (2006), Agerbirk and Olsen (2012)

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REVIEW OPEN ACCESS

Biofumigation to protect oilseed crops: focus on management of soilborne fungi of sunflower☆

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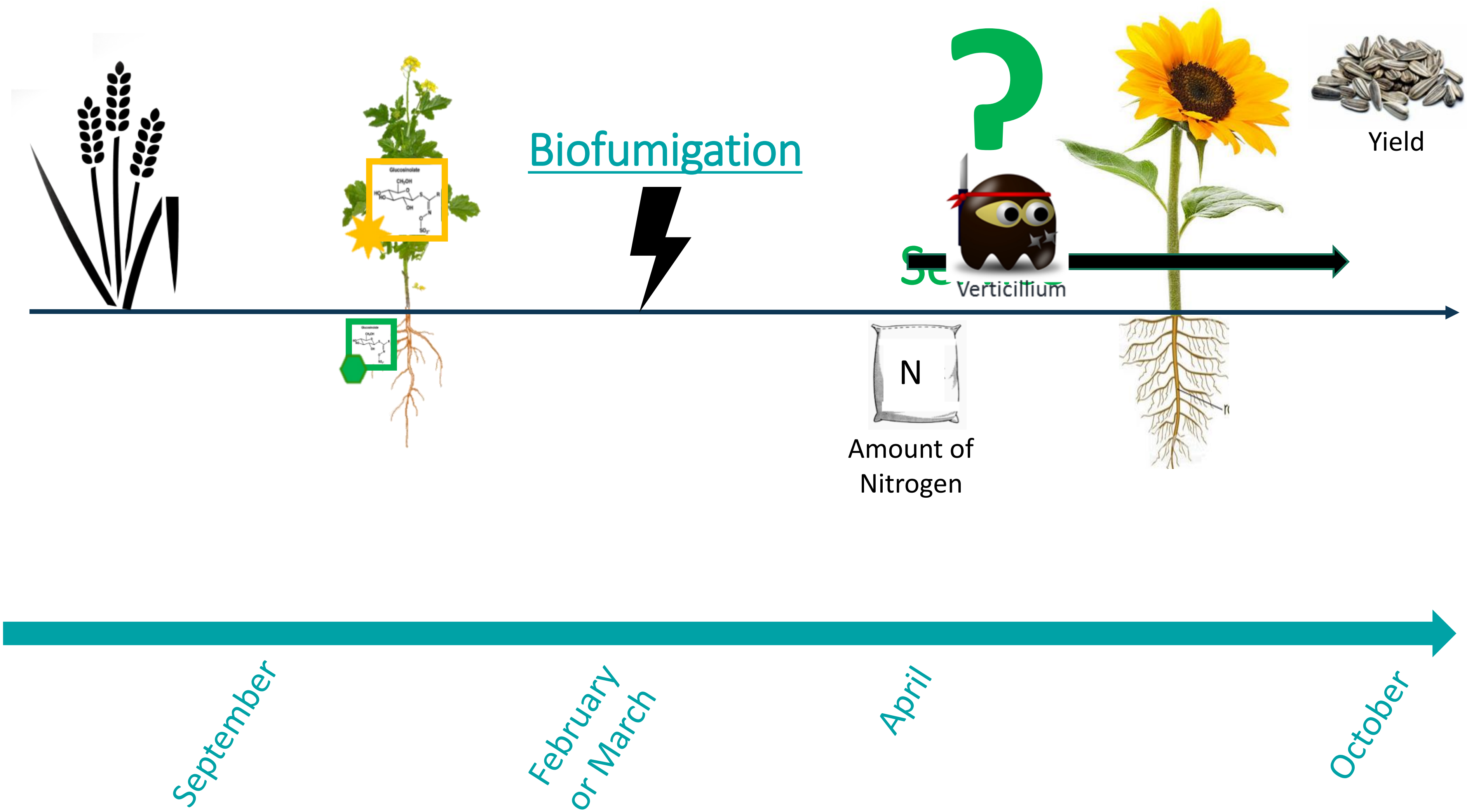
Abstract – Sunflower (*Helianthus annuus* L.) is one of the three most productive oilseed crops worldwide. Soilborne diseases limit yields and are challenging to manage. The fungi *Verticillium dahliae*, *Sclerotinia sclerotiorum* and *Macrophomina phaseolina* can survive in the soil for many years and spread. Following the ban on fumigants, biofumigation, which consists of growing, chopping and incorporating a Brassicaceae cover crop to allow biocidal compounds production in the soil, may be an alternative. Biocidal effects of the hydrolysis of glucosinolate into active compounds, such as isothiocyanates, have been shown in laboratory studies, but the effectiveness of biofumigation varies more in the field. The present study reviews the main factors that determine effective biofumigation to protect sunflower. Since the toxicity of isothiocyanates to pathogens varies widely among the latter, we reviewed studies that assessed the suppressive effect of products of glucosinolate hydrolysis on *V. dahliae*, *S. sclerotiorum* and *M. phaseolina*. Farmers can use many mechanisms to increase isothiocyanate production, which may protect sunflower crop effectively. Increasing biomass production and chopping the cover crop during mild temperatures and before rainy periods could increase biofumigation effectiveness. Further field experiments are needed to confirm the potential of biofumigation to control soilborne diseases of sunflower and assess potential disservices to beneficial soil communities, given their potential key role in the control of soilborne pathogens.

Keywords: *Helianthus annuus* / cover crops / Brassicaceae / glucosinolates / agroecological crop protection

4 years field study to evaluate the effet of MSCC and biofumigation on Sunflower Verticillium Wilt



MSCC Experimental design

Brassicaceae | **Fabaceae**


Bare soil


Brown mustard
cv. Etamine


Turnip rape
cv. Chicon


Fodder radish
cv. Anaconda


Vetch
cv. Titane

9 traitements
1 bare soil
3 blocs

4 years — **Monospecific (100 %)**

2 years — **Bispecific (50/50)** | **Trispecific (33/33/33)**


6 * 24 m

Measures on MSCC at biofumigation

- ► **Biomasse in roots & shoots**
- ► **GSL concentration in roots & shoots**

Sunflower experimental design and measures

2 different cultivars susceptible to *V. dahliae*

- ► 2017 and 2018 cv. 1 (RAGT) – out of production
- ► 2019 and 2020 cv. 2 (MAS Seeds)

Sunflower experimental design and measures

2 different cultivars susceptible to *V. dahliae*

- ► 2017 and 2018 cv. 1 (RAGT) – out of production
- ► 2019 and 2020 cv. 2 (MAS Seeds)

Measures on Sunflowers

- ► Soil Mineral Nitrogen Available for Sunflower before Sowing
- ► Disease severity index (DSI) of Sunflower Verticillium Wilt
  - 2019 and 2020 → 900 sunflowers recorded weekly from bud to maturity
  - 2017 → 675 sunflowers recorded
  - 2016 → 300 sunflowers recorded

$$\mathrm{DSI} = \frac{100 \times \text{number of diseased plants in each score} \times \text{value of the corresponding score}}{\text{total number of plants scored} \times \text{value of the maximum score}}$$

- ► Sunflower Yield

agronomy

MDPI

Article

Ecosystem Services Provided by Cover Crops and Biofumigation in Sunflower Cultivation

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check for updates

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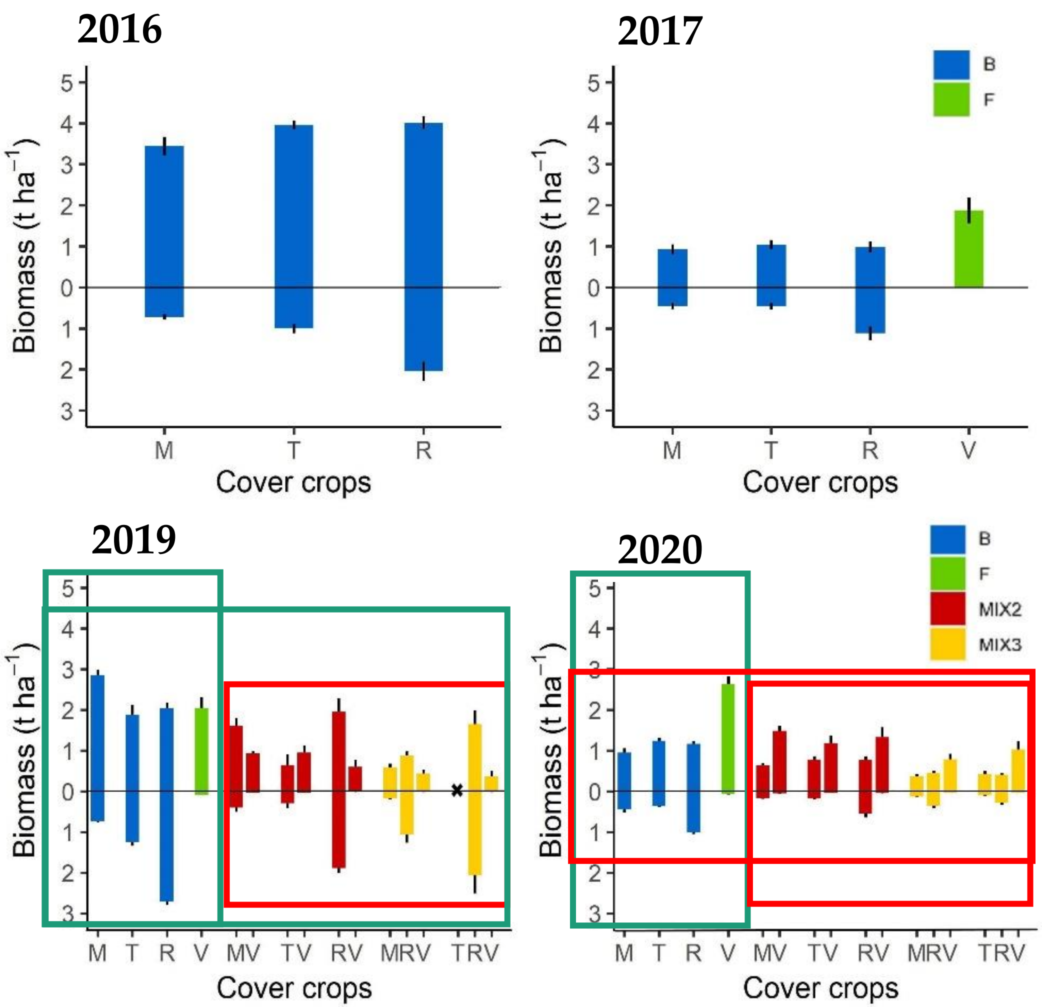
Abstract: In south-western France, sunflowers are usually grown in short rotations and after a long fallow period during which soils are left bare. This practice can favour diseases, caused by soilborne fungi, such as sunflower verticillium wilt (SVW), as well as nitrate leaching, both of which can decrease yields. Growing cover crops during a fallow period is an agroecological practice that could provide ecosystem services and mitigate SVW. A Brassicaceae cover crop that causes biofumigation produces glucosinolates and liberate biocidal compounds that might regulate SVW biologically. Moreover, the green manure effect of the Fabaceae might increase soil mineral nitrogen (SMN). To go further, mixtures of Brassicaceae and Fabaceae might mutualise the benefits that each cover crop has in sole crops. A four-year field study in south-western France tested Brassicaceae (brown mustard, turnip rape and fodder radish) and Fabaceae (purple vetch) in sole crops or a mixture with two or three species during the fallow period, followed by biofumigation, and sunflower crop. The cover crops were characterised, SMN was measured, the SVW and yield were assessed and compared to those of the crop grown on soils left bare during the fallow period. Purple vetch as a sole crop cover crop significantly increased SMN before sunflower sowing but only in 2019. Fodder radish as a sole crop reduced SVW severity significantly, overall, 80 days after sowing, except in 2019, when weather conditions were unfavourable to biofumigation. Purple vetch as a sole crop also reduced significantly SVW severity in 2017 and 2020. Finally, sunflower yields after cover crops were higher than those after bare soils, only after purple vetch as a sole crop in 2020, with a mean increase of 0.77 t ha^{-1}. Mixtures of Brassicaceae and Fabaceae sowed at these densities resulted in an intermediate SMN

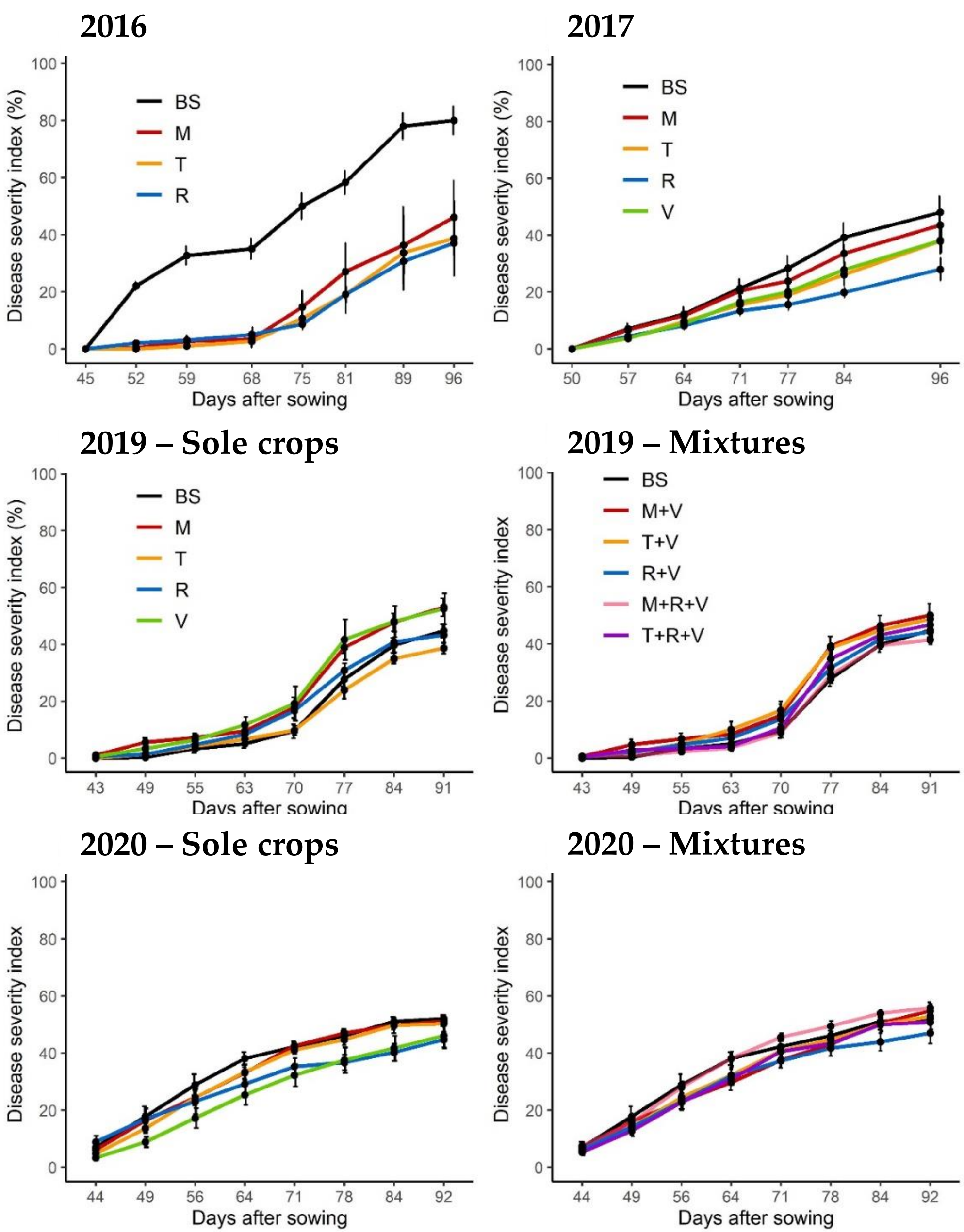
MSCC biomass results



- ▶ Fodder radish was the most productive Brassicaceae
- ▶ Brown mustard was the least
- ▶ Brassicaceae or Fabaceae sole crops produced significantly **, *** more biomass than mixtures
- ▶ 2019 : early sowing (28 Aug.), the biomasse were higher than in 2020, late sowing (9 Oct.)
- ▶ 2019 : mixtures performed better overall than sole crops
- ▶ 2020 : all Brassicaceae performed better in sole crops than in mixtures

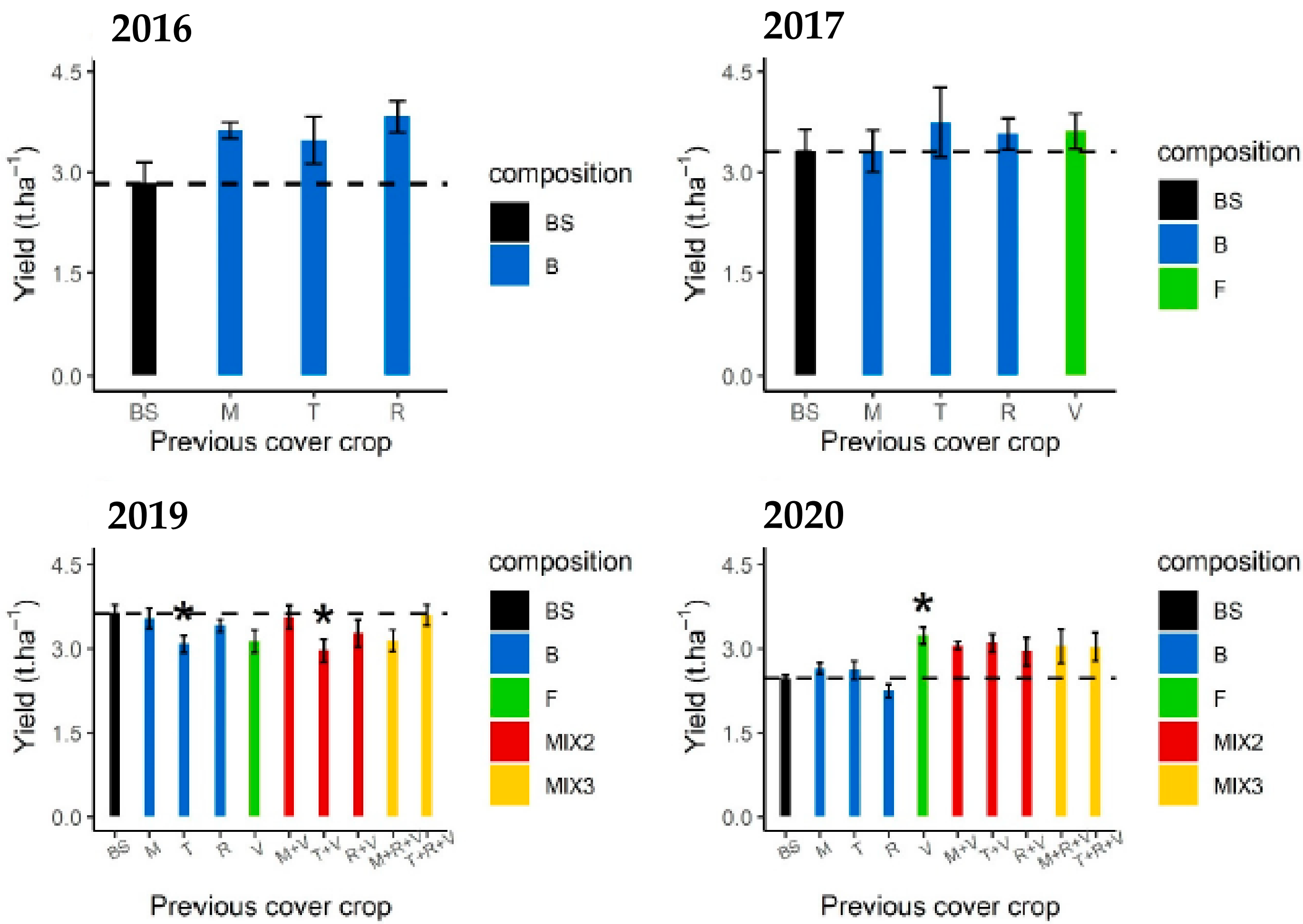
Sole crop total dry matter biomass production greater than 0.53 $t.ha^{1}$ was identified as an effective biofumigation threshold (Morris et al., 2020)

Disease severity index of Sunflower Verticillium Wilt



- ►Reduction of the SVW on sunflowers cultivated after Brassicaceae in 2016, 2017 and 2020
- ► Fodder radish was the most efficient to reduce SVW
- ► 2016 : the most effective regulations, the year with the highest MSCC biomass (± 4 $t.ha^{-1}$)
- ► No reduction of SVW in 2019 -> weather conditions
- ► No reduction of SVW in mixtures
- ► cv.1 $_{(2016,2017)}$ was presumably more sensitive than cv.2 $_{(2019,\ 2020)}$

Sunflower manual yield



► Brassicaceae did not reduced significantly the yield, except in 2019 after turnip rape in sole crop and in mixture

►In 2020, a significant gain of yield after vetch, and a tend to a better yield in mixture with vetch

Thank you for your attention and
Rendez-vous toworrow, section 9, for the effects of MSCC and artificial biofumigation on *Orobanche cumana*

Stéphane Muños

Mireille Chabaud

Neila Ait Kaci Ahmed

Célia Seassau

Grégory Dechamp Guillaume