

## Mix your crops with legumes!

- > Rizodeposition
- > Sustainable cropping systems
- > Isotopic methods, experiments, modelling
- > Conditions for the adoption of innovations



- > Nitrogen management
- > Proteins
- > Weed management
- > Agroecology
- > Soil biology and fertility

### Editorial



**Joëlle Fustec,**  
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with INRA)  
[Ecole Supérieure d'Agricultures](#) of Angers

The sustainable management of plant health is one of the main research topics of [SFR Quasav](#) (Structure Fédérative de Recherche Qualité et Santé du Végétal). Since 1998, the [LEVA](#) group (Legumes, plant ecophysiology, agro-ecology) conducted research in this field. [LEVA](#) is a unit of the [Ecole Supérieure d'Agricultures](#) of Angers under contract with [INRA](#).

Their research is aimed at addressing several major societal challenges: reducing the use of nitrogen fertilizers and greenhouse gas emissions, increasing protein production and improving the resilience of cropping systems. The research done by [LEVA](#) laboratory into legume-based intercrops is recognised at a national and international level. Their work aims to improve nitrogen resource management, soil biological fertility and weed control in annual crops.

### Looking for partners?

Two contacts to support your projects:

COMPANIES

Collaborative &  
innovative  
projects

EDUCATION

RESEARCH



**Emeline Defossez**, contact to support your R&D projects  
and to put you through  
[emeline.defossez@vegepolys.eu](mailto:emeline.defossez@vegepolys.eu)



**Tanegmart Redjala**, close interface with the laboratories  
of the Research Federative Structure Quasav.  
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# REVIEW OF THE MAIN CONCEPTS

## Legumes are sources of proteins and free nitrogen

They are plants of the Fabaceae family. They are mainly used for three goals :

### Grain legumes

Production of protein rich grains  
*Soya, pea, fava bean, green bean...*



Protein rich food or feed



### Forage legumes

Production of protein rich fodder  
*Alfalfa, clovers, vetches, trefoil...*



Protein rich forage



### Green manure

Enrichment of the soil with nitrogen  
*Clovers, black medick, alfalfa...*



Nitrogen supply for the following crops, savings in nitrogen fertilizers



## Legumes are ecological biofertilizers

### Atmospheric nitrogen

(free and unlimited source of nitrogen)

Fixation of atmospheric nitrogen by the nodules

**Nodule**  
(root-soil bacteria symbiosis)

Root absorption

Mineral nitrogen in soil  
(nitrates, manure)



Legumes have the particularity to draw nitrogen both from soil and air. They are characterised by their symbiotic activity of nitrogen fixation through bacteria lying in their nodules.

Legumes fix more nitrogen from the atmosphere when the soil is poor in nitrates.

Figure : Root system of legume with its nodules

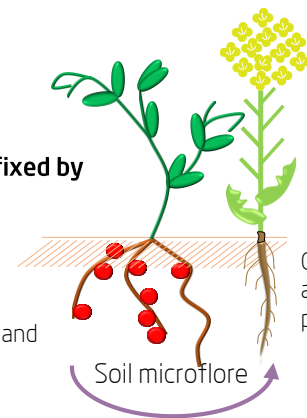
Legumes roots can bring to the soil 15 % to 30 % of the total nitrogen accumulated by the plant during its growth until grain maturity. This nitrogen is brought as organic molecules that are less harmful for the environment than nitrate. Moreover, intercropping helps to reduce leaching.

After maturity, the residues also bring nitrogen from the atmosphere into the soil. Nitrogen is then transformed by fauna and microorganisms before mobilization by the plants.

### 1. Atmospheric N<sub>2</sub> fixed by nodules

### 2. Rhizodépôtion

- > Turnover of roots and nodules
- > Root exsudation



Organic nitrogen available for other plantes

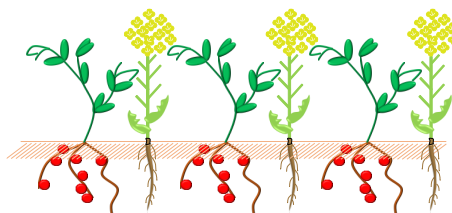
→ Legumes are a good way to save nitrogen fertilizers.

## Legume-based intercrops : a solution to be developped

### Benefits of intercropping when the legume is the main crop:

Stabilize legumes yields: legumes are very susceptible to weeds, diseases and pests when cultivated on themselves.

Example : pea/cereal, lupine/cereal



### Benefits of intercropping when the crop is associated with a legume:

Fertilize the soil and limit the pressure of weeds, pests and pathogenic agents

Example : oilseed rape/ legume

# RESEARCH RESULTS

The **architecture of the crop cover** influences the partition of the solar radiation between the two species. For pea, varietal traits like the **height** and the **number of ramifications** influence the proportions of each species in the mixture at harvest.

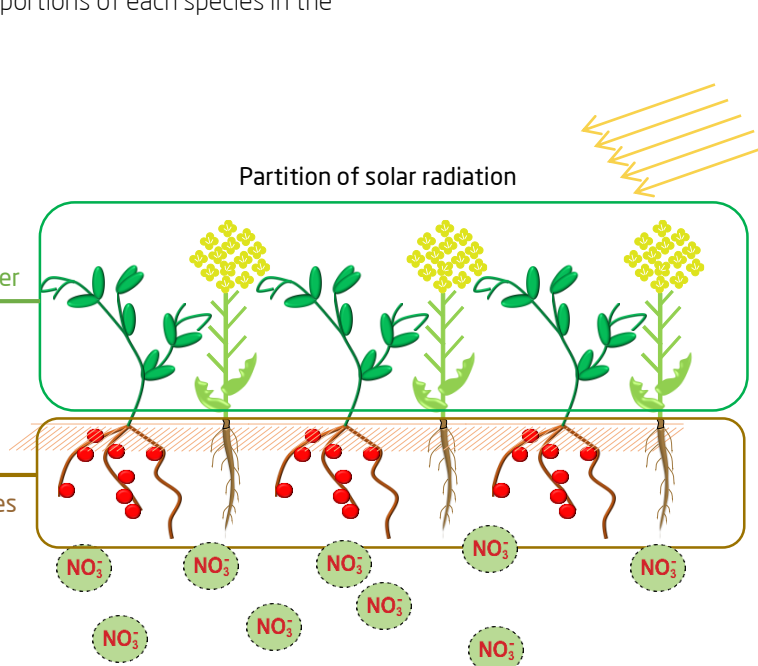
**Differences in early growth** between species, related to :

- > the seed weight,
- > the sprout duration,
- > the nutrient availability

have consequences on the performances of the association.

Architecture of the vegetation cover

Root architectures



Cereal-legume intercrops are more competitive towards **weeds** than pure legume crops due to a better competition for soil nitrogen.

**Complementarity** for **nitrogen** sources (air and soil) between the species plays a crucial role in the performances of intercrops.

Growth of each specie **depends on the dynamics of soil nitrate availability**.

**Complementarity of root architectures** during the installation of the associations play a crucial role in the nitrogen status of the associated oilseed rape. The effect of **nitrogen transfer** from the legume to the associated crop is **negligible**.

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## RECENT PROJECTS

### APPLIED RESEARCH PROJECTS

**European project DiverSify** (2017-2020) run by [James Hutton Institute](#) (UK). Choose the best species crop teams to favour synergies and optimize production and other services.

**European project DiverIMPACTS** (2017-2021) run by [INRA](#). Crop diversification through rotation, intercropping, multiple cropping, promoted with actors and value-chains towards sustainability.

**Safari Projet** (2013–2017). Interactions between crop cover diversity and soil biodiversity in relation with crops yields.

**Interregional project Prograssive** (2016–2018). Intercropping lupine with a cereal to control weeds in lupine crops.

**ANR project Légitimes** (2014–2017). Build the conditions for a wider insertion of legumes in agricultural systems and assess the expected effects, for a sustainable management of territories and resources.

### PHD THESES



**Elana DAYOUB**. Competitiveness of different legumes towards weeds, associated traits and interactions with the intercrop design and the services related to nitrogen and weeds provided by legumes in the cropping systems. [g.hellou@groupe-esa.com](mailto:g.hellou@groupe-esa.com)



**Hélène BOBILLE**. Regulation of root exudation in Fabaceae and consequences in the response to abiotic stresses. [j.fustec@groupe-esa.com](mailto:j.fustec@groupe-esa.com), [anis.limami@univ-angers.fr](mailto:anis.limami@univ-angers.fr)



**Nicolas CARTON**. Trophic interactions induced by lupine intercropped with another specie and consequences on the productivity of both species and weed management. [g.hellou@groupe-esa.com](mailto:g.hellou@groupe-esa.com)



**Baptiste DRUT**. Interactions between the crop cover and the soil organisms in relation with the crop diversity in the field: consequences on soil fertility and crop yield. [j.fustec@groupe-esa.com](mailto:j.fustec@groupe-esa.com)

# OFFERS TO COMPANIES

## Examples of topics for collaboration

- Choose the **species/varieties** to be intercropped and the intercrop design according to the cropping system and the objectives to reach
- Use and conduct intercrops to **manage weeds**
- Choose the **most appropriate space-time schemes**
- Quantify the **nitrogen flows** in the agrosystems
- Understand the interactions between the vegetation cover and soil ; study the consequences on the quality of organic matter and **soil fertility**
- Improve **the diagnostic of soil quality** for a better driving of soil quality



- ➔ **Strengthen your R&D team** by recruiting a **CIFRE PhD student** (financial support by [ANRT](#) and [CIR](#)), a **recent PhD graduate** (financial support by [CIR](#)) or a **working student** (in contract of professionalization or apprenticeship)



## Training for enterprises

- Biological fertility of soils
- Driving of legume-based intercrops

[Catalogue online : groupe-esa/formation-tout-au-long-de-la-vie](http://groupe-esa/formation-tout-au-long-de-la-vie)

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**or share your needs with us!**

## Services

- **Diagnostic of soil biological activity**  
Diagnostic in the field of the ability to degrade soil organic matter using the new indicator [LEVAbag<sup>MD</sup>](#)  
> Contact : [LEVAbag@groupe-esa.com](mailto:LEVAbag@groupe-esa.com)



**Objectif Végétal**, Research, Education & Innovation in Pays de la Loire is a regional program (2014-2019) established by the Pays de la Loire Regional Council and that involves the teaching and research institutions ([Université d'Angers](#), leader of the program, [Agrocampus Ouest](#), [ESA](#), [Inra](#), [Université de Nantes](#)) as well as the international French cluster [Végépolys](#).  
Objectif Végétal program mainly aims to reinforce the visibility of the regional centre for education and basic research, to boost translational research and reinforce the processes of economic valorization of research findings, and to develop international partnerships.

Contact **The innovation box of Objectif Végétal:**

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