Virtual Conference 23rd March 2021
ReMIX and DIVERSify projects

Intercropping to boost agroecology in European Agriculture

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Introduction

ReMIX
Species mixtures for redesigning European cropping systems

THIS PROJECT HAS RECEIVED FUNDING FROM THE **EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME** UNDER GRANT AGREEMENT N. 727217

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Why boosting intercropping in EU?

Opportunities and challenges

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Coordinators of the ReMIX project

Current challenges for EU agriculture

- Climate Change, a reality more and more visible!
  Adaptation of agriculture needed, **compromise production / GHG emissions**

- Another challenge is to limit the severe biodiversity loss
  → **need to strongly reduce the use of pesticides**

- **Species diversity as an insurance against risks** (climate, pests, prices) and element of flexibility in crop management and as support of health diets

- Redesign of EU cropping systems based on **high biodiversity (ecological intensification)** → **agroecology & species mixtures or intercropping**

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What is intercropping in practice?



Definitions & main characteristics of intercropping

- **Simultaneous** growth of **two or more species** in the **same field** for a **significant period** not necessarily sown and harvested together (Willey 1979)

  → **Intercropping or species mixtures or crop mixtures**

- Intercropping is a **way to manage agroecosystems** based on ecology principles (biodiversity, species interactions, integrated protection; Vandermeer, 1989)

- **Traditional practice** but rarely cultivated except for animal feeding
  Corresponds to a wide **diversity of systems** (intercropping & agroforestry):

Annual cash crops

Multispecies Pastures

Crops and trees (agroforestry)

Trees and pastures (and animals)

Trees and trees

Examples of arable intercrops

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Sunflower – Soybean
in strip intercrooping

Triticale – Faba bean
In row intercropping

Durum Wheat – winter Pea
In mixture on the row

Spatial structures of intercrops

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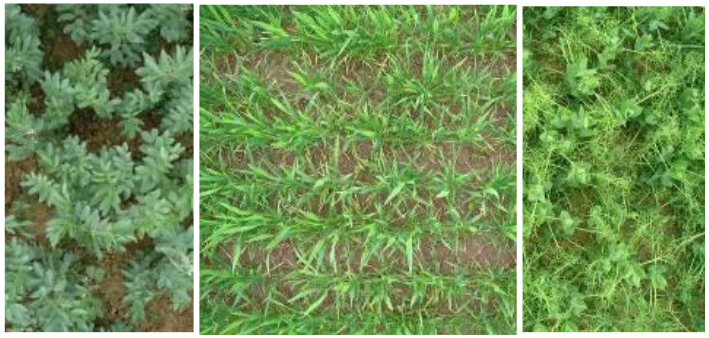
Cereal and grain legume

Various types of spatial pattern:
- on row mixing
- alternate rows
- strip intercrop



Alternate rows

On row mixing

Other types of intercropping

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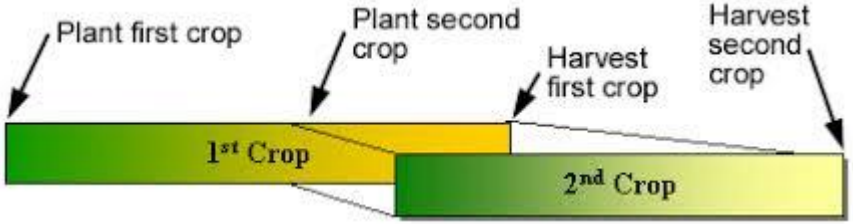
Relay intercropping



Compagnion species e.g. oilseed rape

Crop mixtures for animal feeding

Species mixtures cover crops

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What are the main benefits of intercropping?



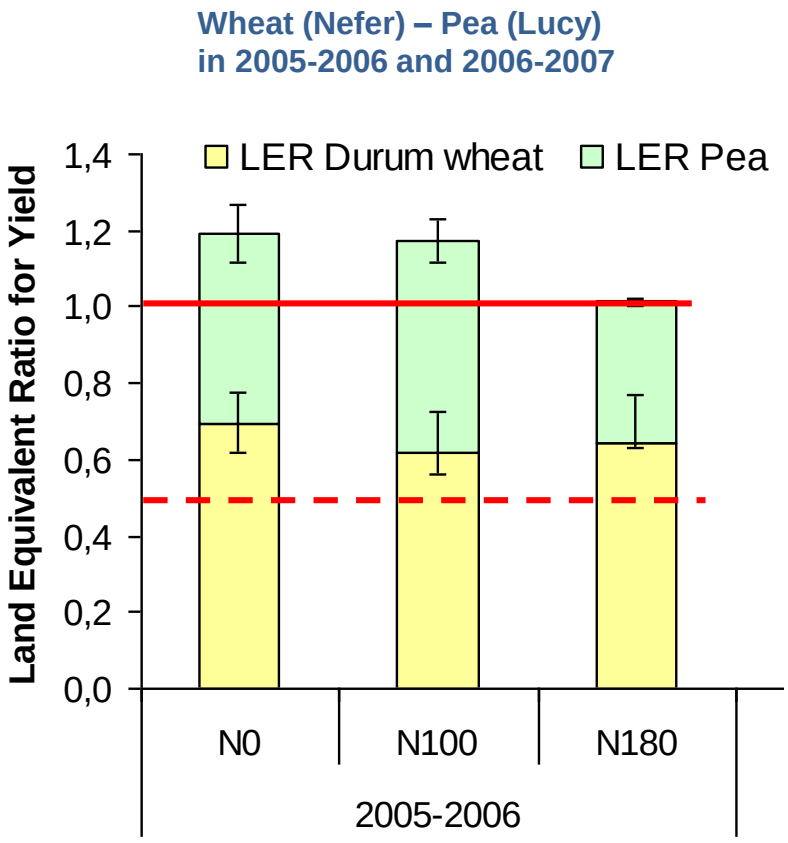
Intercrops are efficient mostly in low inputs farming

- Improve **cereal grain quality** (grain protein content)
  (Jensen, 1996; Hauggaard-Nielsen et al. 2001a; 2009, Bedoussac & Justes, 2010a)
- Increase **global yield** (compared to low input sole crops)
  (Hauggaard-Nielsen et al. 2001a; Zhan et al., 2010; Bedoussac & Justes, 2010a)
- Reduce **weeds** (compared to legume)
  (Hauggaard-Nielsen et al. 2001b, Corre-Hellou et al., 2011)
- Potentially reduce **pests** (e.g.pea aphids) and **diseases**
  (hypotheses widely cited, e.g. Vendermeer, 1989; Meta-analysis under review)
- Reduce the **nitrate leaching risk** (compared to sole legumes)
  (Hauggaard-Nielsen et al. 2003; 2009, Bedoussac & Justes, 2010b)
- Increase **yield stability** (compared to sole crops)
  (hypotheses widely cited, e.g. Vendermeer, 1989; but no demonstration published)
- Increase or stabilise over years the farmer **gross margin**
  (Bedoussac, 2009; Pelzer et al., 2012; Viguier et al., 2028)
- Other hypothesis…

Lots of references for cereal-grain legume intercrops

Few limits highlighted by the scientific community, despite knowledge gaps still exists…

Efficiency for yield: example of durum wheat-pea intercrop



(Bedoussac & Justes, 2010a & b)

Land Equivalent Ratio (LER): an indicator of IC performances (e.g. Willey, 1979);
LER = relative land area under SC required to produce the yield achieved in IC. LER is the sum of partial LER for each species **(LER_P and LER_W)**

$$LER = LER_P + LER_W$$

$$LER_W = \frac{Y_{W-IC}}{Y_{W-SC}} ; LER_P = \frac{Y_{P-IC}}{Y_{P-SC}}$$

- **LER ≥ 1 in LOW N inputs conditions**

→ **IC up to 20% more efficient**

- **LER_W ≥ 0.5 and LER_P ≤ 0.5**

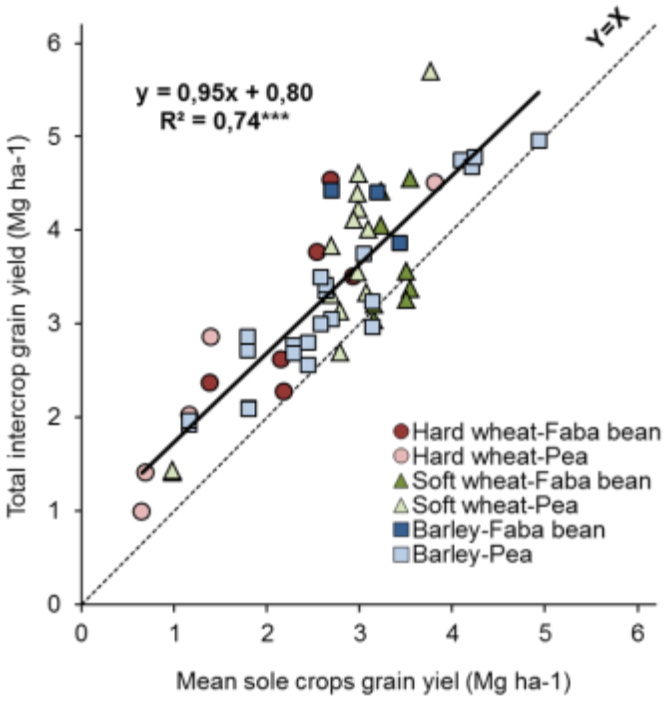
→ **Wheat took advantage of IC, not Pea**

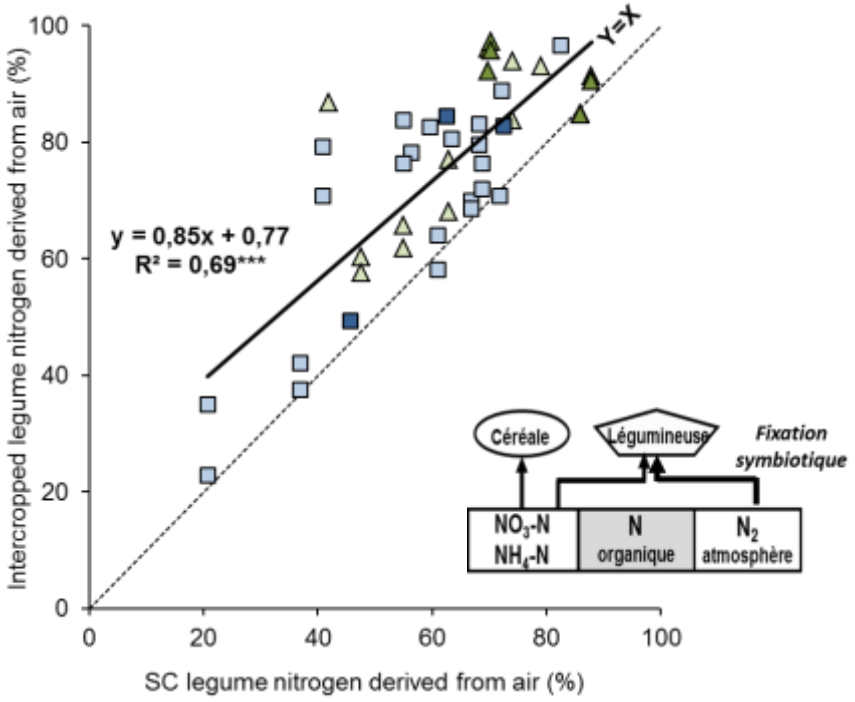
LER widely used and abused while doesn't compare species yields

→ **Use other indices**

(Bedoussac & Justes, 2011)

Species complementarity for N sources in cereal-legume intercrop



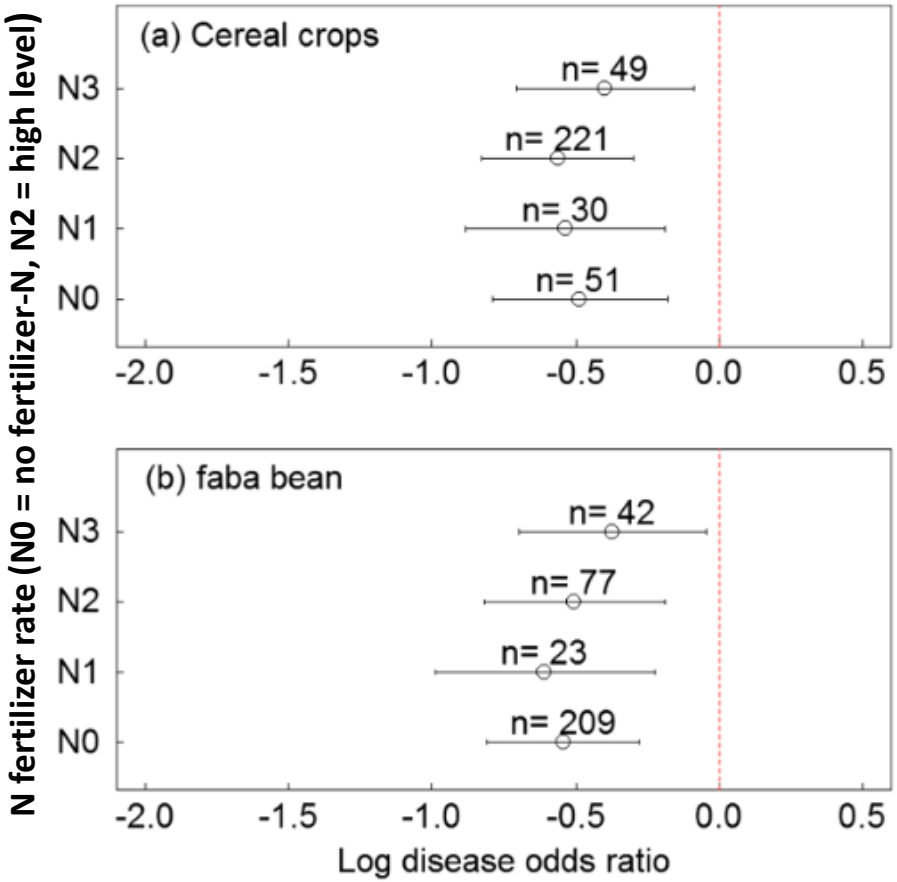


- **Intercrop yield higher than the mean sole crops (3.3 vs 2.7 t.ha-1)**
  - **Highest efficiency for low N**
- **Intercrop grain yield more stable**
  - **Higher resiliency**
- **Proportion of cereal > 50%**
  - **Cereal more competitive**

- **Higher legume N2 fixation rate in intercrop (75% vs. 62%)**
  - **Niche complementarity for N sources**
  - **Most of soil N mineral available for cereal**
  - **Intercrop efficiency higher in low N**

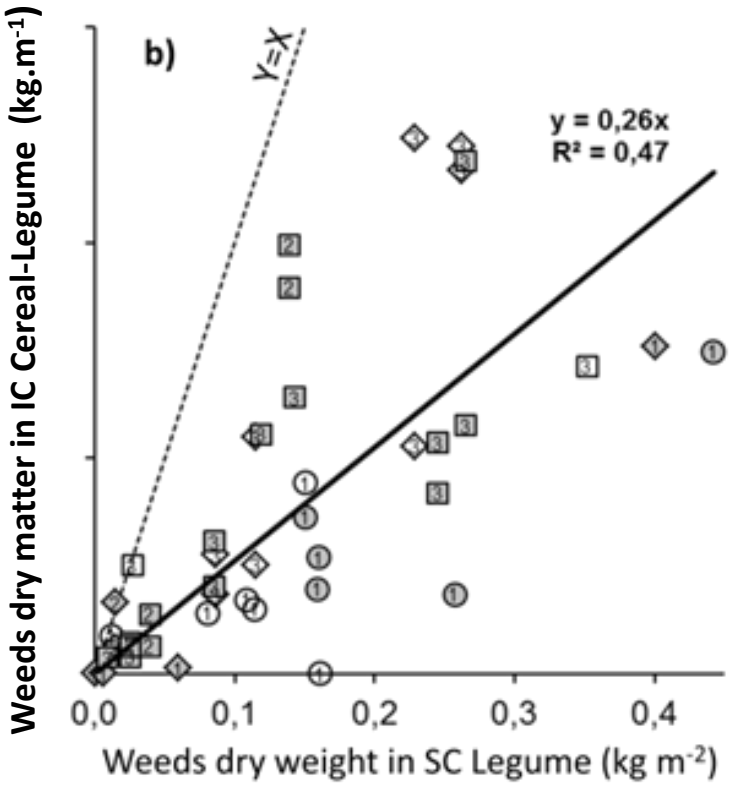
Bedoussac et al. (2015, ASD)

Intercropping for controlling pests, diseases and weeds



- **Less incidence of diseases in intercrops vs. Legume or Cereal sole crops (results from Meta-analysis)**

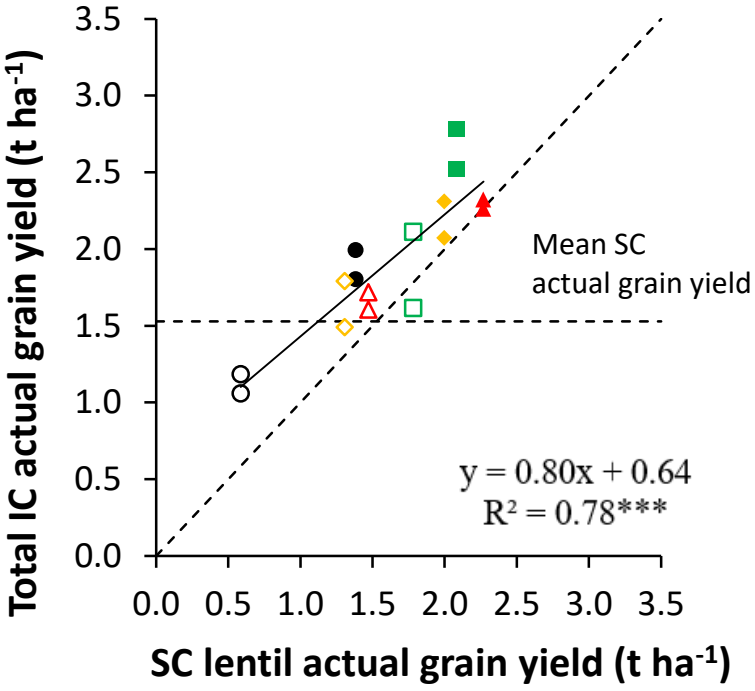
Zhang C. et al. (2019, EJPP)

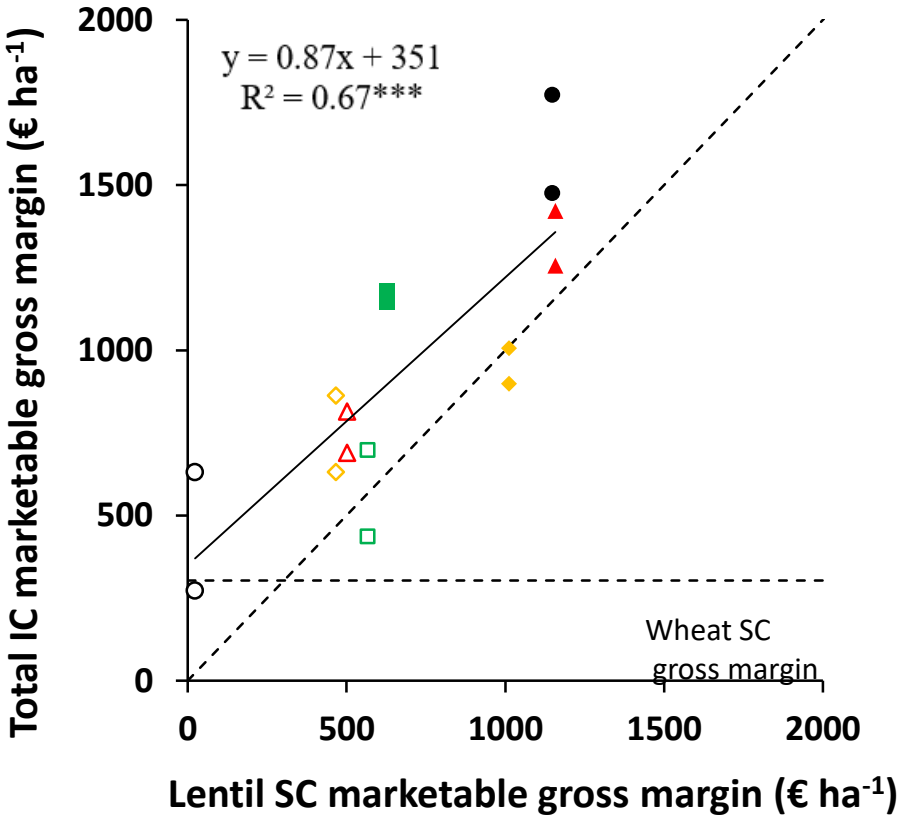


- **Less weeds in intercrops vs. Legume sole crop, but no difference versus cereal sole crop**
  - Cereal induce competition for soil mineral-N
  - Less light available for weeds

Bedoussac et al. (2015, ASD)

Intercrop improves farmer's profit





- Total IC actual grain yield > lentil SC

→ **Complementary use of resources (N)**

- Lentil IC actual grain yield < lentil SC

→ **Strong competition of wheat on lentil**

Viguier et al. (2018, ASD)

→ **Intercrop of lentil + wheat is most profitable, it provides:**

an insurance + a bonus

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Future challenges on intercropping



The challenge of modeling intercropping systems

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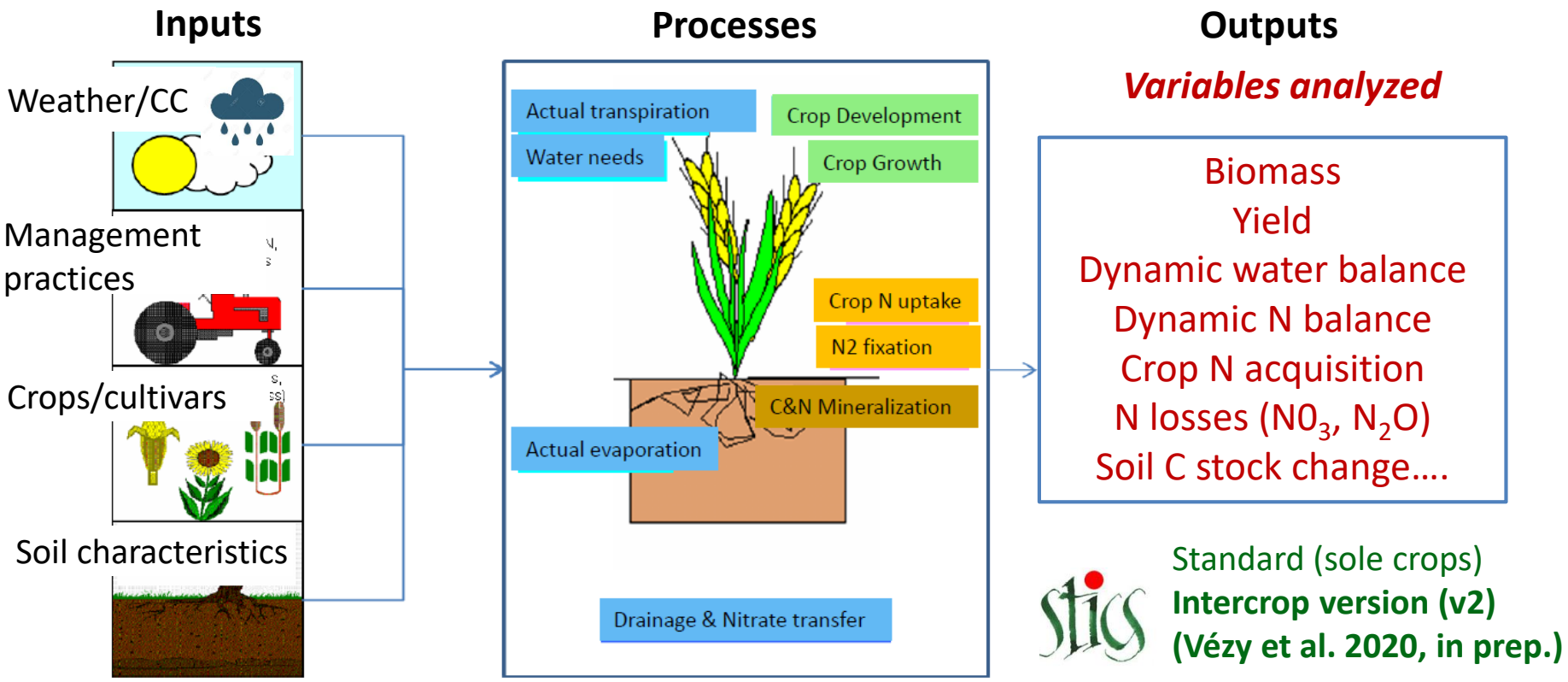

- Represent the system, and help to better understand and analyse the intercrop system functioning in dynamics for: i) plant-plant interactions, ii) capture of abiotic resources and iii) yield & performances → **for researchers & students**
- Allow to simulate agronomic scenarios: soil x weather (CC) x cropping practices to optimise the intercrop system → **for researchers & agricultural advisors**

Towards agroecological systems including intercrops: yes we can!

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- ✓ **RE-DESIGN with more species for providing multi ecosystem services**
- ✓ **Still needs optimization (species assemblages and management)**
- ✓ Scales: **Landscape** and the role of **Agro-food chain**

  → **Need to UNLOCK the system!**

- ✓ **How to return an added-value to farmers?**
- ✓ **Modeling is a NECESSARY TOOL for exploring solutions**

Intercropping in tropical systems needs also more research!

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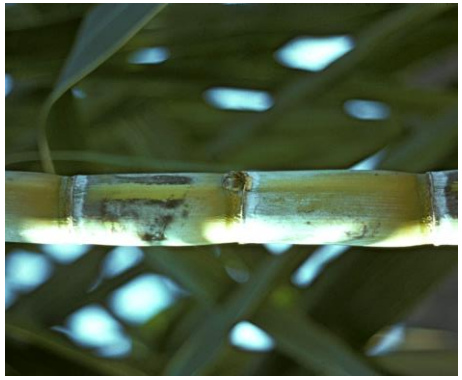
Fruits and vegetables



Sugarcane

Cocoa

Coffee

Rice

Oil palm

Cotton

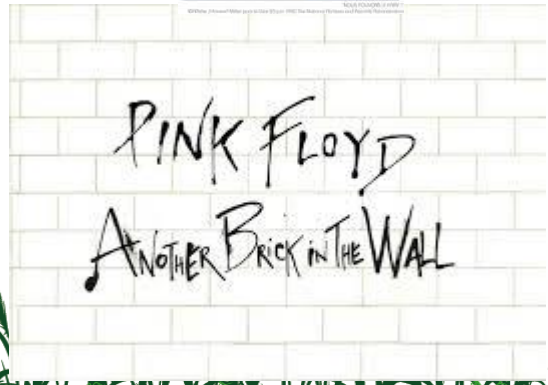
Banana and plantain

Today, we will think and discuss about:

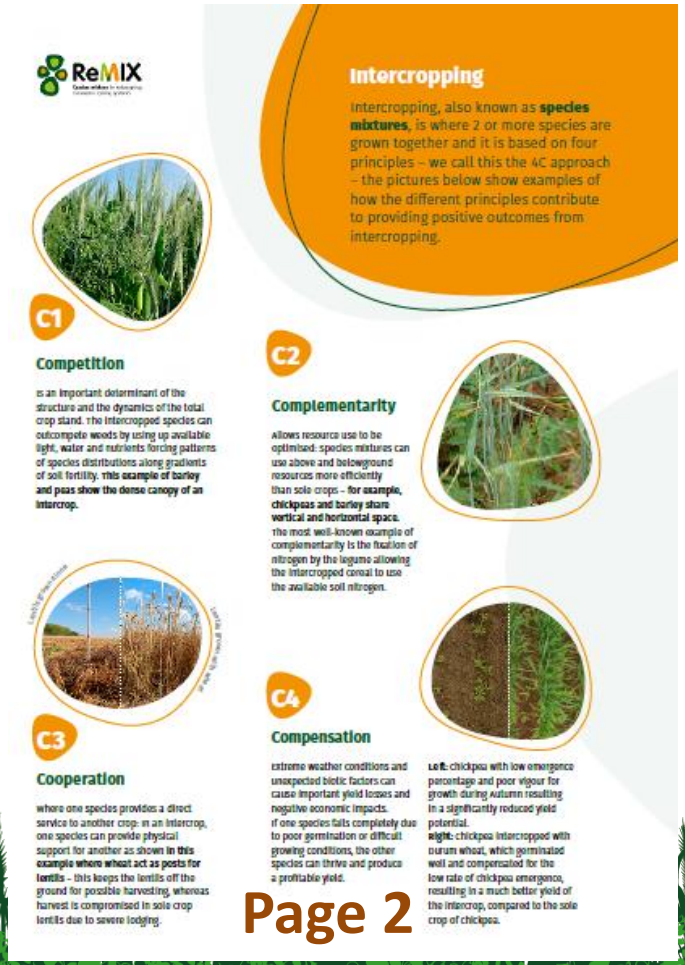
- Need for a **paradigm shift to agroecology**?

- Can we **boost Intercropping** in European agriculture?

- Intercropping, just a brick in the wall… of **The EU Green Deal?**



What is a real Policy brief? *an example:*



What is a real Policy brief?

How does the 4C approach of intercropping link to EU policy ambitions?

The EU is undergoing a fundamental change in the aims for its agriculture and food systems, with a significant emphasis on meeting sustainable goals and reducing reliance on imports from outside Europe. The ReMIX project collaborates with farmers and additional key partners such as agricultural advisors to achieve these ambitious goals within the context of application, arising from problem solving and not necessarily governed by the paradigms of traditional scientific disciplines. It is useful to consider how intercropping can contribute to the desired outcomes of different EU policies. The **4C approach** of intercropping contribute to crop yield as described above but in policy terms they also mean that intercrops deliver many public goods.

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C1

Competition

Intercropping in a broad sense addresses the challenges of sustainable food systems and the links between healthy people, healthy societies and a healthy planet. The outputs delivered by ReMIX support this ambition for a sustainable food system by increasing intercropping in EU agriculture. Through "positive" competition intercrops can compete strongly with weeds, reducing the need for herbicides. Delivering species mixtures supports a more nature-based solution to manage soil within temporal and spatial biotic and abiotic growth factors moving agricultural production away from a reliance on agro-chemicals through self-regulation.

example of contribution to policy target: e.g. halving pesticide application by 2030.

C2

Complementarity

Through complementarity, for example, intercrops which include nitrogen fixing grain legumes require less synthetic nitrogen fertilisers than other crops. This reduces the agricultural land area that receives artificial nitrogen fertiliser which in turn could reduce nitrogen fertiliser manufacture and nitrous oxide losses associated with it. This type of intercrop contributes to home grown protein food and thus the EU Protein Strategy but also to the EU Action Climate Targets and the Farm to Fork Strategy at the heart of the European Green Deal.

example of contribution to policy target: e.g. reduce the use of fertilisers by at least 20% by 2030.

C3

Cooperation

Cooperation is also important here where one crop can support another, as in the case of cereals and lentils, allowing both crops to be harvested where lentils grown alone can lie on the ground surface and could not be harvested mechanically or only in small quantities, leading to high grain losses.

example of contribution to policy target: e.g. to limit waste will help contribute to reducing greenhouse gases to at least 55% below 1990 levels by 2030.

C4

Compensation

Through compensation intercrops can reduce the risk of crop failure. The use of species mixtures allow the selection of species which are sensitive to different kinds of stress such as diseases or drought susceptibility. For example, if one crop fails to germinate or is affected by disease, then the companion crop can still ensure crop production and harvestable yield from the field.

example of contribution to policy: e.g. Improving resilience in farming income proposed within the EU Farm to Fork strategy.

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Policy Recommendations

To help support the development of intercropping in Europe for food and the delivery of public goods **we see the need for:**

1

Going beyond agronomy and working across the entire agri-food system all the way to consumers. All parts of the supply chain need to adapt. Suitable crop varieties are needed alongside modified machinery, processing plants willing and able to deal with mixtures, food processors with exciting ideas about how to use the products and expand their markets and consumers who want to purchase and consume the products.

2

Intercropping specific research, advice and tools to support decision making, since local adaptation of techniques are needed for growing optimised intercrops.

3

Improved understanding and modelling of intercrops to improve adaptation to local conditions.

4

Building on trust, acknowledgement and efficient peer learning between researchers and practitioners.

5

Courses and training for practical intercropping in the field and for processing at both practical and academic levels.

Finally, these recommendations apply across all intercropping systems in arable, horticultural and mixed farming as well as in agroforestry.

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What is a real Policy brief?

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Policy Recommendations

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Participation by farmers and other actors in the supply chain was a very important part of the ReMIX project **and this is what some of them said:**

Crop mixtures can provide high quality food early in spring when all the animal foods have finished.

Mixtures with a legume component are an ideal greening element: it increases biodiversity, is beneficial in crop rotation and additionally increases the production of native protein. They should be permanently entered in the CAP.

Being organic intercropping is a no brainer – higher yields, more protein, good livestock feed and noticeable soil improvements all with less inputs and disease pressure.

If species mixtures are adjusted to local conditions, we might be able to reduce pesticide use, working hours and possible also artificial fertilizers giving lower investment costs and thereby higher net profit.

The early soil coverage (from the intercrop) was remarkable and the weed pressure was low.

I am happy to see progress in agro-ecological solutions that allow me to reduce the use of fertilizers and pesticides.

The mixed culture helps to keep diseases and pest infestations much smaller, so to speak, that it cannot spread over the whole stand. That is to be seen quite positive.

I am happy with the mixtures, if one crop fails due to a severe pest or disease attack, I have the other crop to compensate.

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What is a real Policy brief?

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References

- Aare, A.K., Cooreman, H., Garayoa, C.V., Arrieta, E.S., Bellostas, N., Marchand, F. and Hauggaard-Nielsen, H., 2020. Methodological reflections on monitoring interactive knowledge creation during farming demonstrations by means of surveys and observations. sustainability, 12(14), p.5719.
  https://www.mdpi.com/2071-1050/12/14/5719
- Aare, A.K., Lund, S. and Hauggaard-Nielsen, H., 2021. Exploring transitions towards sustainable farming practices through participatory research--the case of Danish farmers' use of species mixtures. Agricultural Systems, 189, p.103053.
  https://www.sciencedirect.com/science/article/pii/S0308521X20309828
- Jensen, E.S., Carlsson, G. and Hauggaard-Nielsen, H., 2020. Intercropping of grain legumes and cereals improves the use of soil N resources and reduces the requirement for synthetic fertilizer N: A global-scale analysis. Agronomy for Sustainable Development, 40(1), pp.1-9.
  https://link.springer.com/article/10.1007/s13593-020-00631-6

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- ReMIX H2020 project (https://www.remix-intercrops.eu/)
- DIVERSify H2020 project (https://www.plant-teams.eu/)
- *With the* Crop Diversification Cluster (https://www.cropdiversification.eu/)

Crop Diversification Cluster

Joining forces to diversify European agriculture

DIVERSify

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We wish you an excellent conference!

Please be as interactive as possible on the chat!

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