Portugal study site experiment 1:
ROTATIONS FOR IMPROVING SOIL HEALTH

The problem

Nitrogen is difficult to manage under organic crop production. Various commercial organic N fertilizers are available, but their costs are prohibitive. In the Baixo Mondego valley, manure can provide substantial N for organic flood rice cultivation, but it is difficult to spread correctly at soil surface and it is challenging to synchronize the N release with the plant demand, with risk of nitrogen stress by plants or undesirable environmental impact in case of excess. Intensive agriculture has led to a depletion of the soil organic matter content that it is urgently necessary to mitigate in order to increase soil fertility and quality and maintain crop production. It also exists in organic rice production a severe handicap in managing efficiently weed control that is actually one of the main challenge problem to solve in organic cropping system.

The proposed solution

The introduction of perennial Lucerne in the organic rice cultivation system could respond to these 3 challenges as it will represent an important organic source of Nitrogen due to the biological nitrogen fixation capacity of the legumes, also increase soil organic content due to the introduction of biomass in the soil, and also limits the weed infection due to the diversification of the principal crop.
A rotating organic rice with perennial Lucerne was then trialed in Bico da Barca near Montemor o Velho municipality. The experiment was established in 2004 and set up in control versus treatment experimental (elementary) design. The SICS treatment, as a rotation system is installed in two adjacent fields, that are cultivated in alternate 2 years of perennial lucerne / 2 years of organic rice and a control field also adjacent that is cultivate with monoculture of conventional rice.

Experimental design

Treatment	Type of treatment
Organic rice in rotation	SICS
Organic Lucerne in rotation	SICS
Conventional rice in monoculture	Control

Rice is sown in May with a seed density of 200kg/ha and harvested in October. Perennial lucerne is sown in April with a seed density of 30kg/ha and suffer 3 to 4 cut (for hay) the first year and about 5 cut the second year. Fertilization plan only included the application of 80 kg of Phosphorus at the seeding, annually for rice and only the first year for lucerne, no Nitrogen or Potassium are applied. Any pesticides are applied in this system, weed control is managed manually.
The conventional monoculture of rice refers to a system where rice is sown annually with a seed density of 200kg/ha. Annually a ternary fertilizer NPK is applied 100 kg of Nitrogen 50kg of phosphorus and 50kg of Phosphate.
18 samples were taken during each campaign (0-30cm) . The variables which were measured included:

- Rooting
- Bulk density
- Penetration resistance
- Available nutrients
- Soil organic carbon (SOC)
- pH
- Erodibility
- Pest abundance
- Weed disease
- Crop yield
- Costs and benefits of the SICs
- Socio-cultural dimensions

SoilCare is funded by the EU's Horizon 2020 research and innovation programme.
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Results

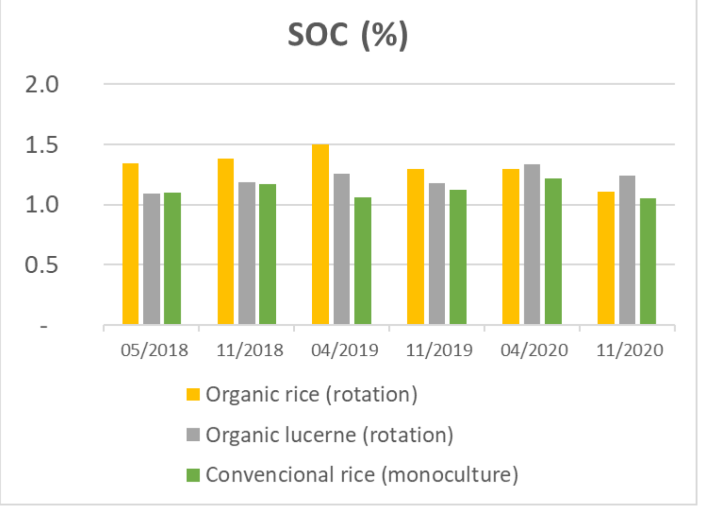

Figure 1. Soil organic carbon
Soil organic carbon is low, nevertheless the SICS fields (organic rice and organic lucerne) presented a SOC content slightly higher that the control field.

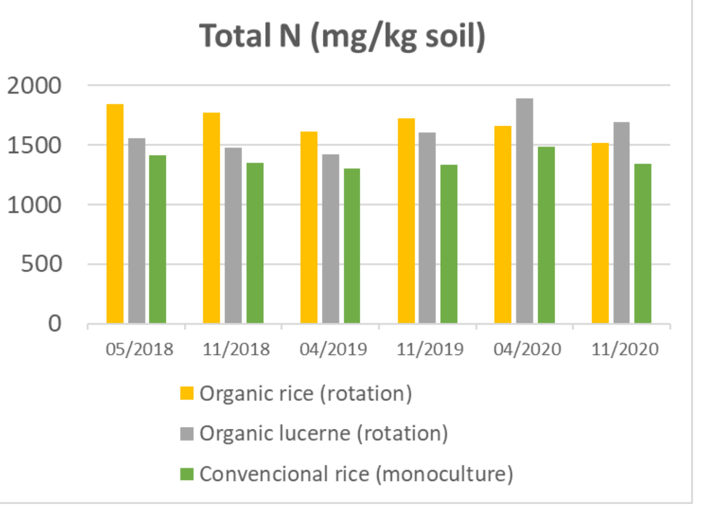

Figure 2. Total Nitrogen
Total Nitrogen content is higher under organic rotation (above 1500 mg-N/kg of soil) even if any amendment of Nitrogen is performed since many years at the SICS fields.

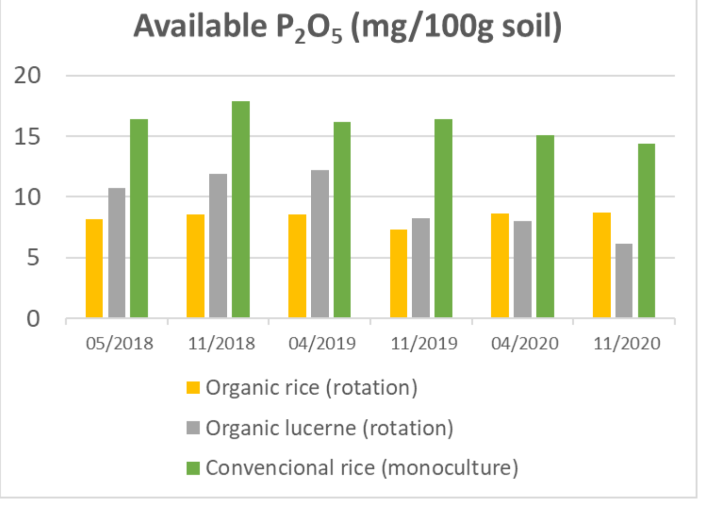

Figure 3. Available Phosphorus (P_2O_5).

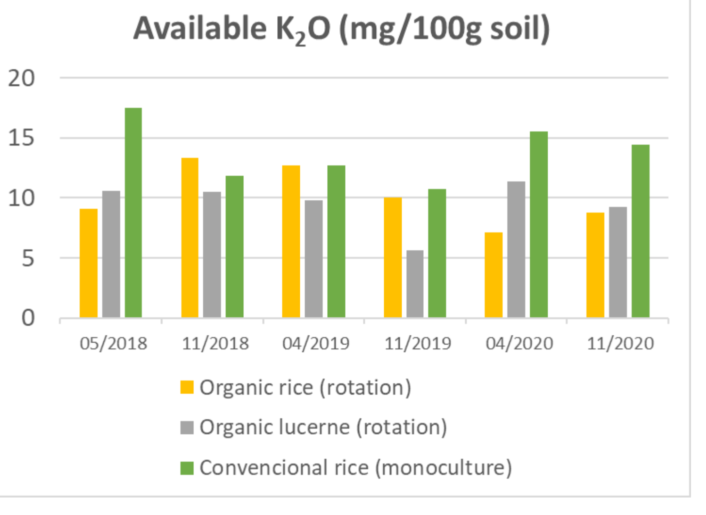

Figure 4. Available Potassium (K_2O).

Available Phosphorus is present in high concentration for the control field under conventional rice monoculture (higher than 15 mg/kg of soil). The 2 SICS fields maintain a good level of fertility with only a reduce P_2O_5 fertilization of P and any K_2O fertilization.

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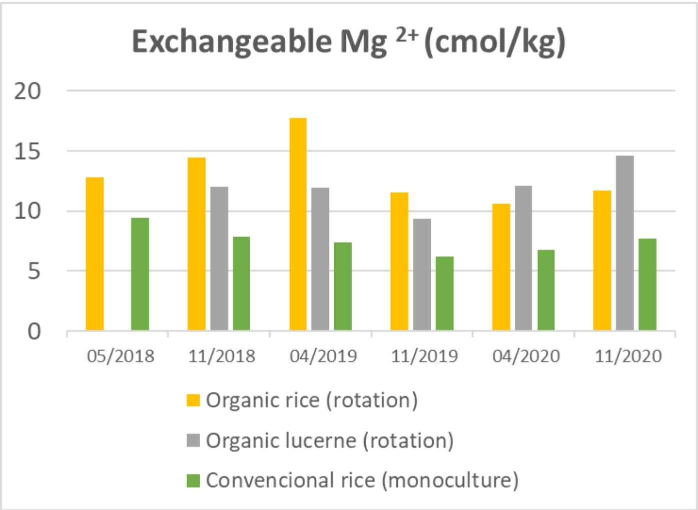

Figure 5. Exchangeable cation Mg^{2+}
The exchangeable cations Mg^{2+} are present in low concentration in the soil for the Control and medium concentration for the SICS.

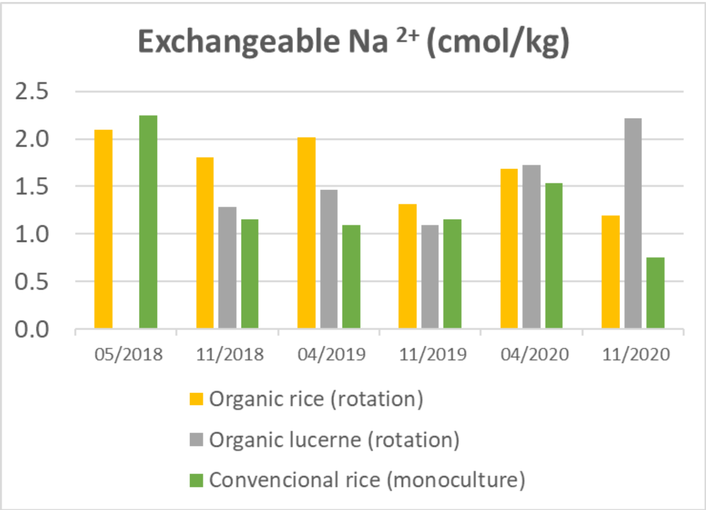

Figure 6. Exchangeable cation Na^{+}
The exchangeable cations Na^{+} are present in low concentration for SICS and Control fields with a high temporal variability.

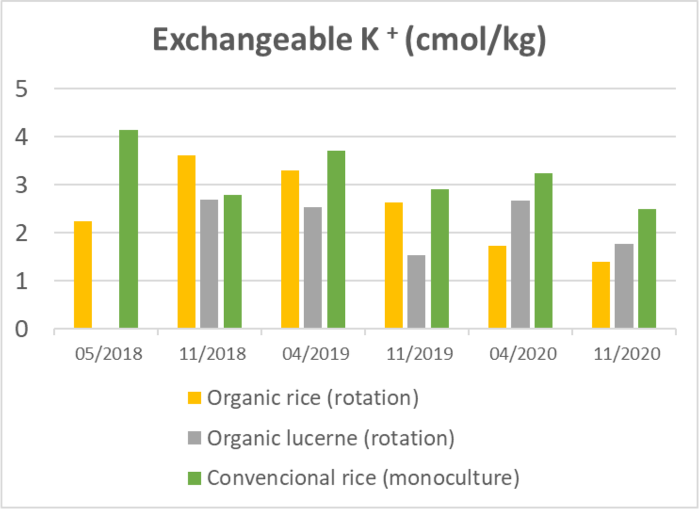

Figure 7. Exchangeable K^{+}
The exchangeable cations K^{+} present medium concentration in the soil, lower at organic lucerne field and with high temporal variability.

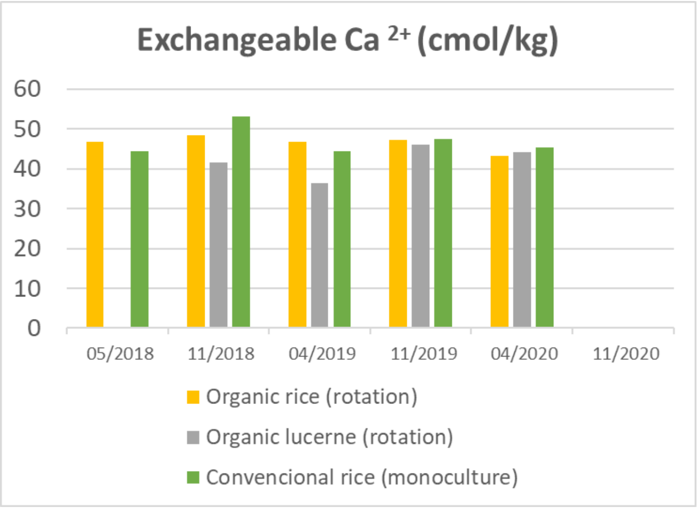

Figure 8. Exchangeable Ca^{2+}
The exchangeable cations Ca^{2+} present medium concentration in the soil, relatively stable in time and without any significant difference between SICS and control.

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Key findings

- SICS improves soil fertility in terms of soil organic matter content
- SICS using the Nitrogen biological fixation avoid any mineral nitrogen fertilization and is a very conservative technic in term of nutrient leaching and ground water pollution.
- SICS does not increase weed burdens, thus leaving corn yields unaffected. Blind seeding and rotation with perennial lucerne are efficient techniques in terms of weed control, with a significant seed bank reduction.

Fact sheet authors

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Conclusions

The SICS tested here were sustainable in terms of environmental issues. They led to: i) slight increase of the SOM content of the soil ii) decrease of use of mineral fertilizers, especially on nitrogen, mitigating the risk of nutrient leaching and groundwater pollution, iii) no use of pesticides leading to mitigate soil air and water pollution, improve biodiversity, and protected animal and human health; iv) improve the net income of the farmer.

There were, however, some limitations of the SICS: i) increased weed burdens led to increased human labour requirements; ii) challenges related to processing and commercializing the rice due to no existing organic rice sector in the region.

The organic rice production in rotation with Lucerne is a sustainable SICS that deserves to be promoted and developed by farmer associations and organizations with the ambition to trial innovative methods for weed control.

In terms of the market, there is an emergent market niche for high quality and differentiated products that should be organized in cooperation with cooperatives, or producer associations . The quality of the product (bio rice and lucerne hay) must be evidenced with the choice of differentiated rice varieties, with specified characteristics. Communication efforts are needed in order to value the quality of the products, sell the product at a fair price, and to make the industry less subsidy dependent. The development of a certification could also enable long-term use of this SICS.

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