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REDESIGNING EUROPEAN CROPPING SYSTEMS BASED ON SPECIES MIXTURES – OUTCOMES AND LESSONS LEARNT FROM THE H2020 PROJECT REMIX

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Abstract: ReMIX is a H2020 multi-actor project that will allow to redesign cropping systems based on the agroecological principle of crop diversification for the benefit of farmers and the whole EU agricultural community. ReMIX exploits the benefits of species mixtures to design more diversified and resilient agroecological arable cropping systems. Based on a multi-actor approach, ReMIX produces new knowledge that is both scientifically credible and socially valuable in conventional and organic agriculture. The project tackles practical questions and co-design ready-to-use practical solutions. The project spans from the specification of end-user needs and the co-design of in-field and on-farm experiments to demonstrations with evaluation of new varieties and practices. ReMIX contributes to the adoption of productive and resilient agricultural systems.

Introduction: The goal of the Horizon 2020 project "Redesigning European cropping systems based on species MIXtures" (ReMIX) is to exploit the benefits of species mixtures to design productive, diversified, resilient agroecological cropping systems less dependent on external inputs and lower environmental negative impact than current systems. ReMIX aims at delivering a scientific assessment of the performances of mixed cropping and operational responses (farming practices and cultivars) that will improve the sustainability of European cropping systems, for both conventional and organic agriculture. Species mixtures can enhance water and nutrient use efficiency while increasing crop productivity and resilience to biotic and abiotic stresses, including those triggered by climate change (see e.g. Brooker et al., 2015; Raseduzzaman and Jensen, 2017). In contrast, common agricultural practices focus on sole crop strategies with high

inputs on large scales using current commercial cultivars that narrow crop genetic diversity. The integration of species mixtures within crop sequences has to compete with other existing practices and provide benefits to farmers and other actors in the agri-food value chain (e.g. Altieri, 2004; Joao et al., 2015) – as well as for the entire society with qualitative agricultural production and preservation of the environment.

Material and methods: ReMIX is organised on six research Work Packages (WP), one dissemination and technology transfer WP and one project management WP, all of them strongly interacting with each other. The project is conducted over four years (2017-2021) consisting of the following WPs:

WP1 - Multi-actor co-design of species mixtures and on-farm testing

WP2 - Analysis and modelling of plant interactions, abiotic factor use efficiency and yield performance in species mixtures

WP3 - Analysis of factors and management practices determining the efficiency of species mixtures to control insect pests, diseases and weeds

WP4 - Screening, breeding and phenotyping methods for species mixtures

WP5 - Modelling and simulating the performance and resilience of species mixtures to identify optimal species traits and management practices

WP6 - Species mixtures management for farmers

WP7 - Outreach, dissemination and knowledge/technology transfer

WP8 - Consortium coordination and project management

Results: ReMIX advances current species mixture knowledge following a demand-driven multi-actor approach in order to efficiently tackle end-users' practical questions and propose ready-to-use feasible, practical solutions adapted to diverse European pedo-climatic conditions (**Figure 1**). The project includes eleven local ReMIX multi-actor platforms across Europe to challenge perceptions, routines and rules at the level of the cropping system and the social and economic context in which farmers operate. In addition, the project makes use of current cereal and legume species diversity. Specific lines/populations suited for species mixtures are selected from a panel of modern and traditional varieties and new genetic resources. Process-based crop models and functional structural plant models as well as meta-analysis methods are used to explore plant teams, complementary plant traits, and management options that support efficient and resilient resource capture and production under current conditions and under climate change. Thus, the project ranges from the specification of practical needs and the co-creation of experiments and simulation models to improve the prediction of mixed cropping performance to the evaluation of new varieties and practices in on-farm platforms. In order to achieve this, ReMIX benefits from the participation of several partners in flagship EU projects in the fields of crop breeding, cereal and grain legume cultivation, plant disease and pest control and modelling.

ReMIX studies three types of species mixtures:

- Cereal-grain legume bi-specific cash crops, simultaneously harvested producing grains of high nutritional quality for both human consumption and animal feed
- Cereal cash crops associated with non-harvested leguminous "companion" species, which can substitute chemical inputs (e.g. nitrogen fertilisation and pesticides)
- Relay intercrops, involving the under-sowing of annual or perennial legumes into a cereal crop

Discussion: We will discuss outcomes and lessons learnt from the first three years of the ReMIX project highlighting:

- Multi-actor co-design of species mixtures to identify local practices using participatory methodologies involving the agri-food chain actors

- Barriers to stimulate the adoption of species mixtures by farmers and in agri-food chains

- Mechanisms of plant-plant interactions to maximise resource use efficiency (water, nitrogen, phosphorus, light)

- Role of species mixtures in controlling diseases, pests and weeds to propose strategies that will alleviate yield damages

- Role of species mixtures to improve ecosystem services and develop resilience to biotic stress

- Key traits and novel breeding and phenotyping methods to use existing genetic resources adapted to species mixtures

- Generic rules to assemble species for efficient cash crop production using process-based simulation models that support efficient production

- Develop new management techniques to optimise species mixtures performance.

- Optimise settings and specifications for agricultural machinery for harvesting and grain separation

- Technical, economic and sociological drivers that hamper the adoption of species mixtures by farmers, and more generally by different actors in agri-food sectors

- A tool box for farmers and advisors through the compilation of technical booklets and EIP-AGRI 'practice abstracts', and the design of a serious game

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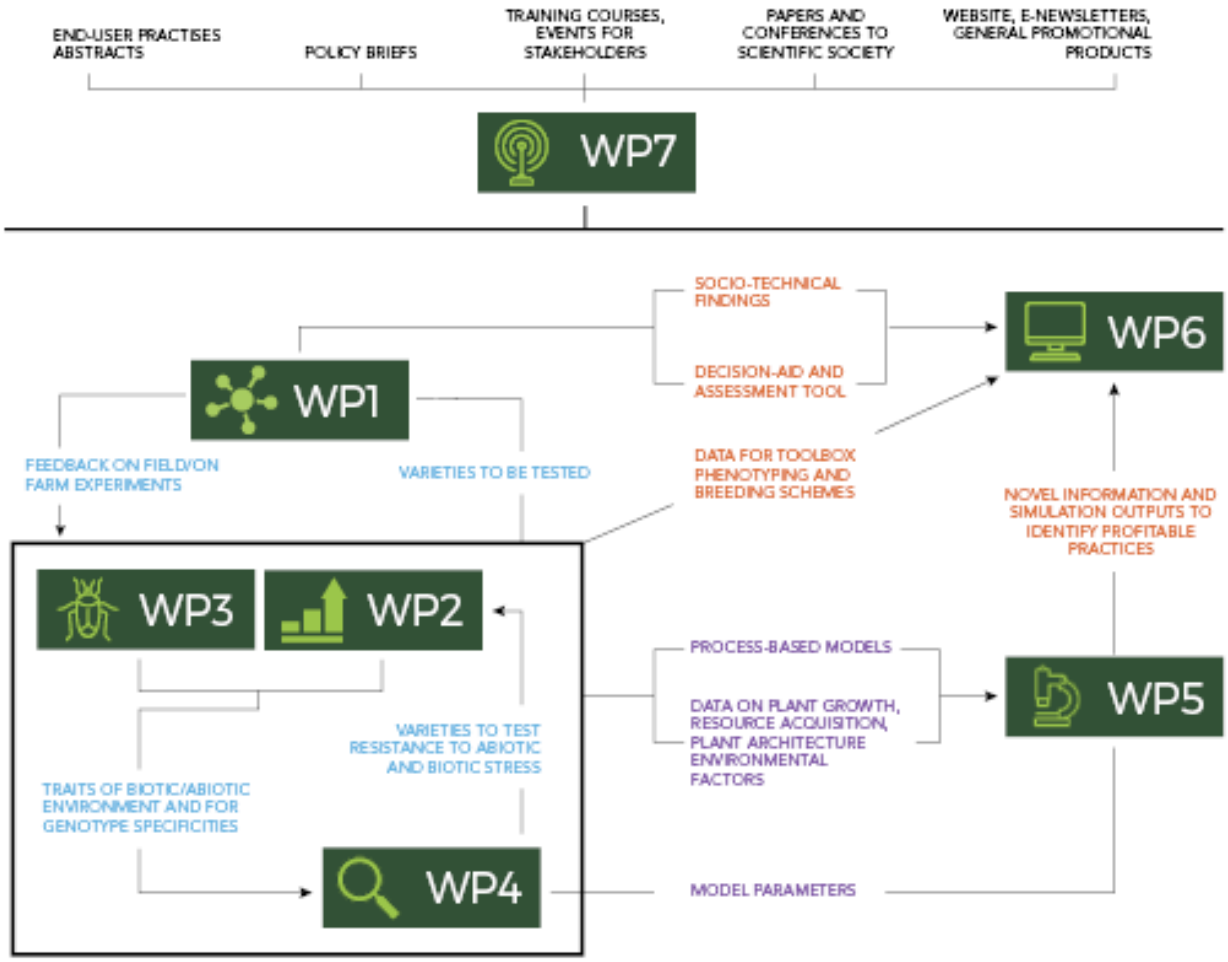

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