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Topic 3 - Transition towards organic and sustainable food systems

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COMBINATION OF TEMPORAL AND SPATIAL DIVERSIFICATION IN ORGANIC SYSTEMS IN EUROPE

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Abstract: There is a need to re-diversify current cropping systems in Europe to improve their sustainability and their resilience. A network of field experiments was built to study the benefits of crop diversification in time and space in organic systems in five countries in Europe. Different strategies of crop diversification are combined at the rotation scale. The insertion of spatial diversification (cereal-grain legume intercropping, strip cropping both in arable and vegetable systems) in a cropping system should be encouraged owing to positive effects on yield and ecosystem services, based on the first results obtained in the network.

Introduction: Current cropping systems are very simplified (short rotations and low genetic diversity in the field) even in organic systems. The sustainability of such systems is questioned. There is a need to re-diversify agri-food systems both in time and space. Spatial diversification consists of growing two or more species together on the same field. In current cropping systems in Europe, temporal diversification (extending the length of the crop rotation, adding new cash crops and cover crops) is much more used than spatial diversification. The fields are more often genetically uniform. However, increasing the crop diversity within the field could improve pest and disease control and weed suppression. Spatial diversification could also increase crop productivity and its stability. To help the transition of current simplified cropping systems towards diversified systems, the European project DiverIMPACTS (2017-2022; https://www.diverimpacts.net/) consists of several case studies and a network of field experiments across Europe to demonstrate the benefits of crop diversification on yield, ecosystem services and resilience to environmental stresses. The aim of this paper is to describe the innovative organic systems tested in diverIMPACTS including temporal and spatial diversification and their preliminary results. Such systems can be a source of inspiration for the design on sustainable organic cropping systems.

Material and methods: A network was built including 5 sites (Sweden, France, The Netherlands, Italy, Switzerland) testing organic cropping systems in arable and vegetable systems. Innovative systems were designed in each site according to their own context and objectives and compared to current systems less diversified. Different strategies of spatial diversification are included within the rotations. Field experiment leaders interact with a diversity of actors for a mutual learning on crop diversification and to share the positive results and also the difficulties encountered.

In Sweden (SLU) and Switzerland (FIBL), in arable situations, organic rotations with recommended fertilization, are compared with rotations enriched with legumes (as cash crops and cover crops) and using intercropping (two species sown and harvested together or a cover crop added to a main crop) to reduce the use of external inputs and to increase the level of productivity and resilience. The risk associated to a very high proportion of legumes in the rotation will be also studied. In Sweden, the reference is a six-year crop rotation with undersown red clover (for seeds) and spring pea as nitrogen suppliers, but where 295 kg N/ha need to be imported because of crops requiring high inputs, e.g. winter oilseed rape. Three cereal crops complete the rotation: winter rye, spring oats and winter wheat. With farmers and advisors, an alternative crop rotation was designed based on the same six main crops but including multi-species cover crops and intercrops. This rotation introduces a frost-sensitive legume, faba bean, together with winter oilseed rape, and includes high value cash crops lupin and malting barley in intercrops as well as mixed species cover crops. In Switzerland, an organic rotation barley-rapeseed-faba bean-maize is compared to a rotation enriched with legume and intercropping and adjusted management: pea/barley-rapeseed undersown with a legume mixture- faba bean/oat-maize undersown with a legume mixture.

In the Netherlands (WUR), strip cropping is investigated: the practice of growing two or more species in alternate, multi-row strips wide enough to allow independent cultivation but narrow enough to support ecological interaction. Strips are 3 m x 60m. The rotation (grass-grass-cabbage-leak-potatoes-wheat) is based on the dominant crops of organic growers in the Netherlands and local constraints. Crops are planted as pairs in adjacent strips, and within these pairs different treatments are tested: a single crop species of a single variety, a mixture of varieties or two species intercropped per strip.

In Italy (CREA), strip cropping is also studied in organic vegetable systems. A temporal strip cropping based on faba bean and tomato is studied. Faba bean was harvested (May) for fresh pod production on strips 2.8 m wide alternated with 2 m strips where the faba bean was left for dry grain production. The residues of 2.8 m wide strips were flattened by the In-Line Roller Crimper technology and tomato was transplanted (May) without soil tillage on the obtained mulch (harvest: August). Tomato was grown in strip crop system with faba bean for dry grain production that was left growing until harvest (July). The two species cultivated in the striped system were compared with the same species grown in pure stands. A same layout was studied with wheat and Zucchini.

In France (INRA), strip cropping is included in vegetable systems under tunnels to see its impact on different criteria: how intercropping can suit to diversity commercial demand and productivity and global soil health enhancement? The reference is a triennial rotation scheme with 2 to 3 vegetable crops a year giving a large place to lettuce production in winter and a large place to tomato or cucumber in summer. A medium diversified crop rotation was built with a triennial rotation reducing salad relative part compared to the first system and avoiding as far as possible too long bare soil periods between cash crops using a green manure. A summer on 3, weeds and soil-borne pathogens are controlled through solarisation for these first two systems. A third system includes row intercropping of 3 species with one species per row (6 to 8 rows of 50m long under the tunnel). The 3 species are chosen from 3 botanical families. There is at least 2 to 3 crops a year per row. No soil solarisation will be applied in this system.

Results: The first results highlight positive effects of spatial diversification. Cereal-grain legume intercropping has a positive effect on yield as shown by LER (Land equivalent ratio) values higher than 1 in several sites. Another main result is that intercropping appears a relevant practice for weed suppression. Moreover, several sites have suffered from a

severe unusual drought during the first experimental year. It seems that intercropping can secure yield in the case of hard conditions compared to sole crops more sensitive to such constraints.
In Italy, the first results indicate a major effect of strip cropping on yield. For example, tomato total biomass was significantly higher in strip than pure cropping systems (+44.5%). Farmers have shown great interest but also highlighted difficulties in mechanization, especially in the hilly areas. The width of the strips has to be adapted case by case when the technique is scaled-up at farm level, depending on the crop system, soil properties, field shape and slope.
In the Netherlands, natural enemy abundance appeared to be higher in strips than monocultures, and pest damage lower. The agro-ecosystem services obtained by spatial diversification will be analysed in relation to the dimension of crop diversification (temporal, spatial and genetic) and their interaction. A major effort was made in communicating strip cropping and a large audience was reached. A network on famers who are willing to experiment with strip cropping is growing every week.
Strip cropping seems also feasible under tunnels for vegetable production. Planning rotations and intercropping system design at a long-time scale (several years) is not obvious at all, since there is a broad range of crops possible and still many unknown. Decision rules to design step by step the crop sequences of each system but keeping rooms for crops choice at year scale, using what have been learned, is the approach used in this experiment.
Discussion: At this stage, and in agreement with previous studies, spatial diversification can be encouraged as a way to facilitate the growing of legumes or other “minor” species known for their high yield interannual variability and sensitivity to different biotic and abiotic factors. Moreover, strip cropping seems a relevant way to influence different ecosystem services both in arable and vegetable systems. Interactions with different actors are needed to facilitate the mutual learning on crop diversification and the design of innovations at different scales.

Disclosure of Interest: None Declared

Keywords: Diversification, intercropping, Legumes, strip cropping