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Resilience of grassland-based production systems, addressing climatic, environmental and economic issues

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I ett sammanhang med ökande osäkerhet beroende på såväl miljö som ekonomi måste jordbrukets produktionssystem söka mer resiliens, alltså förmåga att upprätthålla ekonomi och produktion efter måttliga störningar, eller kunna återhämta sig från stora störningar. I Inno4Grass-projektet ansågs klimatförändringar med mer extremt väder och marknadstillträde vara de största störningarna bland projektets deltagande jordbrukare. De lösningar som tillämpades för ökad resiliens var i) en ökad diversitet av arter och sorter i blandvallar samt en ökad variation av valltyper, framför allt i Sydeuropa där störningarna har större strukturell betydelse ii) förändrad skötsel av vall och bete samt andra fodergrödor iii) mer lagringsmöjligheter för foder med bättre kvalitet och längre hållbarhet. För att bli resilienta mot marknadssvängningar, var en överraskande stor andel av lantbruken ekologiska för att få ett ökat mervärde. De utvecklade också egen förädling och gårdsbutiker för att öka konsumenternas betalningsvilja.

Sökandet efter resiliens innebär ett avgörande paradigmskifte där lösningar kräver både tekniska och organisatoriska innovationer, med stort beroende av lokala förhållanden och där samskapande med lantbrukare kommer att vara av godo.

Summary

In a context of increasing uncertainties related to both environment and economy, agricultural production systems must look for more resilience, i.e. the ability to maintain economic and productive performances after a moderate perturbation, or to recover them after a strong one. In the Inno4Grass project, climate change with more extreme events and market access were considered as the major perturbations by the farmers involved in the project. The solutions implemented to be resilient against climate change were i) an increasing diversity of varieties and species in mixed swards and an increasing diversity of the grasslands types, the diversity being larger in the South of Europe where the perturbations are structurally more important; ii) changes in grasslands and fodder crops management and iii) more feed stocks with better quality and long-term duration. To become resilient against market volatility, a surprisingly high share of farms was organic to get higher added value. They also developed on farm processing workshop and on farm shops to capture the willingness to pay of the consumers.

Searching for resilience is a major paradigm shift where solutions will require both technical and organisational innovations, with a strong dependency to local conditions and where co-creation with farmers will be beneficial.

Introduction

Agriculture is today facing a societal context where it is expected to simultaneously provide several performances. It must i) ensure a secure provision of high-quality food, at low prices, ii) ensure the economic viability of the farms and contribute to the viability of associated industries, iii) limit the environmental impacts of plant and animal production or even restore environment (storing carbon in the soils to limit climate changes, restoring biodiversity), and iv) do all this under strong expectations from the society (societal acceptance).

These very challenging objectives are becoming more complex because agricultural activity is exposed to increasing uncertainties. It is especially true in two domains. The first one refers to the climate, where, as a consequence of climate change, there are more and more variation among years and an increasing frequency of extreme events. The second one refers to the market, with an increasing price volatility due to globalisation of the world market of commodities.

Because of these uncertainties in the context of actions, it is expected that the farming activity reaches its objectives whatever the conditions. It means that farming systems must consider not only the average performance, but also the variation among years or among seasons. This is where the paradigm of resilience has been defined and has to be implemented to define the optimum systems and adapted practices (Knickel *et al.*, 2018).

What is resilience?

Resilience is a concept that arose from several domains under various names. In ecology, resilience of an ecosystem defines its ability to recover a stable functioning after a severe perturbation (Holling, 1973; Greenwell *et al.*, 2019). In economy, it includes risk management, while in agronomy, the words stability and robustness have been more often used to define the ability of a system to maintain its performances under a variable environment (Urruty *et al.*, 2016). Gathering the definition from ecology and agronomy, and applying it to grassland-based farming systems, resilience refers to the ability of a production system, exposed to an increasingly variable context (economy, environment), to maintain its performance and to ensure its capability to recover a favorable state even after a difficult period.

It is always necessary to define the resilience regarding "of what", "to what" and "for what".

Of what: the resilience concept only applies to systems that are able to vary, be reshaped and recover, and over sufficient periods of time. So, it applies to farming systems. It does not make sense to analyse resilience of a wheat crop. Here, we focus on grassland-based farming systems. In the case of a dairy farm, it could also be envisaged to analyse the resilience of the production of a given animal, such as the milk yield of a dairy cow, but this would give a very narrow vision of the possible option.

To what: it is essential to define the perturbations that are anticipated, as the solutions that will be searched for will differ depending on the type of perturbations. We will here mainly focus on two types of perturbations: climatic and market.

For what: the objectives must be clearly identified. In animal systems, the objective may be resilient animal production or resilient farming activity.

The peculiarity of resilience is that it is strongly dependent on the context where the farming activity is run. This dependency to local conditions has often been reported as a difficulty for implementing innovations. Indeed, it means that there is no recipe applicable to all farms; but the generic principles are holding true in various contexts.

How to analyse resilience?

The analysis of resilience is achieved through four questions. It is first necessary to assess 1) the variability over time of the perturbing factor and 2) the variability of the results (e.g. the milk yield of the farm). The next step is to 3) analyse the relationship between these two factors. In a simplistic representation, once the severe perturbation has been released, milk yield will recover. This vision may be true when a single animal is considered. When considering a more complex system (a farm), it could however easily be envisaged that beyond a certain level of perturbation, the system will not be able to recover its initial state. If a farm is concerned, it clearly means a danger for the preservation of the farming activity. This defines the level of resilience of a system, which may be improved through 4) technical and organisational levers.

The sources of perturbations for grasslands-based farming systems

In the Inno4Grass project, run from 2017 to 2019, a survey has been undertaken in 87 case study farms to analyse the innovations that have been implemented by the farmers. In the results, including the description of the farms and the objectives, as well as expectations and feelings expressed by the farmers, it was possible to identify what was considered as threats for the farming activity. Among these threats, two groups have been identified, that could be named as perturbations and as structural issues (Table 1). The table clearly shows that climate change and market access are among the major perturbations for grassland-based farming. It thus makes sense to search for resilience against these two types of perturbations.

Table 1. Frequency of the threats expressed by farmers in the Inno4Grass project.

Threat		Frequency (%)
Perturbations	Climate change	42.5
	Market access	13.8
	Regulatory and agricultural policy issues	18.4
Structural issues	Workload and team structure	11.5
	Knowledge and mindset	18.4
	Plant material	13.8
	Farm structure	10.3

Resilience to climate change

The climate change is becoming an increasing evidence, and the present curves of worldwide temperature and concentrations of greenhouse gases are following the most pessimistic prediction of IPCC (IPCC, 2018). In the coming decades, the consequences for European agriculture will be i) higher average temperature both in winter and summer, ii) a modified rainfall regime with more rain in autumn and winter and less in the summer, and iii) more extreme events. The consequences are expected not to be homogeneous over Europe, the most deleterious incidences are expected in Southern Europe and on the border of the Black Sea.

The impacts on grasslands-based systems will be due to the impacts on the production and growth of grasslands and fodder crops. On average, the modified temperature and rainfall regime will potentially increase mean grass production in Ireland, UK and Northern Europe, with a longer growing season. On the opposite, the consequences will be negative in Southern Europe, and will further reduce the availability of biomass in the late spring and the summer months.

This situation is clearly a case where the analysis of resilience is essential. Indeed, the poor capability of predicting the coming weather requires the feed source, i.e. grasslands and fodder crops, to be able to ensure a sufficient production of biomass (digestible energy and proteins) every year, whatever the weather conditions.

The analysis of the case study farms of Inno4Grass showed the strategy implemented by the farmers in different countries. It is interesting to see that change in the type of animal production is never mentioned as an option, all efforts are devoted to the feed source and they mainly concern the sources of feed, the stocks and the management of grasslands and fodder crops.

Regarding the sources of feed, two opposite strategies have been investigated.

In Ireland, under a wet and mild average climate where the scenarios of climate change are not too severe, and where grasslands are mainly based upon grazed perennial ryegrass, the privileged option is the search for more stability in biomass production, by using mixtures of varieties and species. In the mixtures of varieties, it is proposed to combine varieties with different ploidy levels, as tetraploid varieties exhibit a better behavior in case of a limited drought. Mixtures of species are proposed, including legumes such as clovers.

In situations with more variation among years, the preferred option is to increase the diversity of grassland types exploited on the farm. This includes

- the combination of natural, permanent and temporary grasslands that will have contrasting cycles of biomass production,
- the introduction of new species, especially perennial legumes. This includes lucerne (*Medicago sativa)* and birdsfoot trefoil (*Lotus corniculatus*) in the northern part of Europe, sainfoin (*Onobrychis viciifolia)* in Central Europe and sulla (*Hedysarum coronarium*) in the South,
- the introduction of annual crops as part of the feed source, where it is possible to have a rapid production of extra feed. In such cases, it is proposed to use mixtures of cereals and annual legumes, which is harvested as silage or hay at soft grain stage. This makes it possible to sow a new crop after harvest.

It is noticeable that the use of more diverse of grassland types is often in place in Southern conditions, where more variation among years have already been anticipated.

In terms of ***grassland and fodder crops management***, there are three options. In Ireland again, under limited variation among years, it is mainly a strategy based upon an improved efficiency with a better use of the available biomass. The decision support tools for an improved management and their accuracy are listed by the farmers as critical.

In most situations, the establishment of the grasslands is considered to be essential, and many farmers consider regular reseeding and overseeding as options to keep the swards in the best conditions, including the capability of restoring the swards' density after climatic or management impacts.

As high sward quality is a key objective over years, development of machinery adapted to different soils has also been identified.

When exposed to less predictable conditions, the ***availability of stocks*** is essential. The strategies developed by farmers are related to

- the volume of stocks, that have to be adapted to the most severe conditions that are likely to be met,
- a better quality of the stored feed (energy and protein content),
- the possibility to store feed over very long periods of time.

This can be met in two different directions, depending on region. In Northern and Central Europe, the main option is the search for high quality silage and haylage, including silo structures in order to minimise the losses. In France, Belgium and Italy, the proposed options are mainly based upon high quality hay, including construction of barn-drying structures, either independently or as collective system to reduce the costs.

Resilience to market volatility

The options implemented by farmers who expressed market volatility as a threat are all based upon an increasing value on the farms.

The farms that were surveyed as case studies in Inno4Grass were selected independently in every country, and the selection was done upon the single criterion of their innovative approach for grassland-based systems, i.e. from grassland management to animal production and marketing. It is surprising to see that, as a result, the proportion of organic farms was very high, reaching 32 %, while the share of organic area in total agricultural area in Europe is 7 % (from Eurostat). In Ireland only, no organic farm was included into the panel, while the highest share was reached in Sweden.

The resilience to market volatility is also achieved through diversification of the animal products, e.g. through a cross-breeding strategy in dairy cattle which makes it possible to produce calves with a higher market value. The most frequent and innovative option for increasing on-farm added value is however to implement a processing workshop (18 % of the farms) and to look for direct markets (17 %). By doing so, the farmers are aiming at capturing the willingness to pay of the consumers (Emberger-Klein *et al*., 2016). The on-farm processing workshops are producing liquid milk, and above all, local cheeses. Only two Belgian farms of the network was processing meat. The direct market is done through on-farm shops, local markets and retailing to local restaurants. In most cases, this is a major change in farm organisation, requiring new competences and special advices. Alongside with the traditional advisory support for grasslands and animal management, these farms are appointing advisors from the processing industry, such as a professional cheese-maker.

Conclusion

It is not possible anymore to implement agronomic practices that would compensate for climate change, and the European and national public policies are not able to avoid market volatility. As a consequence, European farmers are exposed to increasing intensities of perturbations, and must voluntarily become resilient. Considering resilience in agriculture is a major paradigm shift, as it implies to consider the variance of response at the same level as the average performance. It is increasingly important as the level of perturbation is increasing. This induces large differences among European countries and among types of productions. Moreover, the options must be adapted to the types of perturbations to be addressed and to the local conditions and local environments.

Resilient systems will implement technical and organisational innovations, but moreover, structural changes will be required. They include a change in the national brokering systems and in the training of the young farmers. It is both a question of knowledge and a question of mindset. It also calls for a marked change in the innovative process, with more co-conception with the farmers and with the actors of the value chains. Such co-conception procedures, based upon the principles of the living labs (Hagy *et al*., 2017; Zavratnik *et al*., 2019), are offering new perspectives for out-of-the-box innovations and for a quicker adoption of innovations.

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