

Which varieties for agroecology?



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Abstract

Agroecological transition is now seen as a pathway with many opportunities to improve the sustainability and resilience of agricultural systems. Many agricultural policies and recovery plans emphasize this pathway.

Agroecology, by maximizing the use of ecological processes and particularly positive interactions between plants and between plants and their abiotic or biotic environment (soil microorganisms in particular), allows the minimization of the use of synthetic inputs (fertilizers and pesticides). To achieve this, it is not enough to seek the best possible use of resources, which would lead to a "weak" agroecology, but it is also necessary to make a qualitative leap in the efficiency of input use, and to redesign low-energy production systems in order to explicitly call upon biological processes that promote soil fertility or the regulation of pests and diseases, in order to move toward a "strong" agroecology (Duru *et al.*, 2014).

The Plenary Committee of the CTPS (Permanent Technical Committee on Plant Breeding) asked the Scientific Committee of the CTPS to shed light, based on the scientific and technical literature, on what the agroecological transition implies in terms of variety species, breeding, evaluation, and seed and plant production.

Needs and diversity of species, varieties, seeds and plants in an agroecology-based model

As agroecology is largely based on increased crop services, it leads to a need for more species, varieties and functional diversity. Diversity can be achieved by growing varietal associations or mixtures of species, but also by arranging a greater diversity of varieties and species in space and time. Minor species, intercropping, and spring species have an important role to play in this diversification. Agroecology is characterized by the increasing dependence of varieties on local conditions. Therefore, more varieties will have to be selected and evaluated for adaptation to specific situations.

There are many important traits to select and evaluate in agroecology. They include vigour, phenology, and ability for association. Other diversified traits are also to be considered (including resistance to diseases and other pests). The root compartment is little explored today. Finally, the interactions between the plant and its environment are of importance in agroecology, especially the interactions between varieties and microbiota, which are leading to a broadening of the characterisation of varieties to their holobionts.

The agroecological transition multiplies the goals of breeding (services) and reinforces the need for access to easily modulated and adaptable diversity, which will necessarily move agriculture away from the dominant concept of homogeneity, single variety or pure variety. It may therefore be useful to select a diversity of varietal profiles that are complementary to each other, rather than seeking a very limited number of optimal profiles, and thus enable the creation of more stable and resilient variety portfolios able to make better use of resources, that fluctuate over time, and to limit the impact of occasional stresses that are difficult to predict. For example, having a variety of earliness profiles within the same plot or farm can be an interesting strategy for making the most of resources over a longer period and avoiding accidents in the event of strong and specific stresses.

While the evaluation of varieties is generally multi-criteria today (the productivity of varieties is evaluated according to their quality, their resistance to certain pests, or even their production mode), the evaluation of varieties for agroecological systems implies an increase in the number of criteria to be considered. This evaluation will have to take into account all the services expected from crops (including increased soil fertility, carbon storage or the ability to regulate weeds), the diversity of possible uses of crops (including "minor" sectors), practices and growing environments, this diversity being a specificity of agroecological systems.

Place of participatory approaches in plant breeding and agroecology

A participatory approach is, for a person in charge of solving a problem or designing an innovation, to involve in his or her approach the actors directly concerned by the outcome of his or her work (Hazard and Audouin, 2016). Participatory approaches can take several forms in innovation processes: at the beginning of the process in the design phase, or throughout the process until deployment. The specificity of participatory approaches lies in the diversity of actors and the diversity of their mode of intervention in the innovation process. Thus, defining a common framework is a key factor in the success of these approaches.

All participatory approaches are based on the definition of a common object and objective, i.e. a shared vision of the future (Schmid and Mambrini, 2019). In the case of varietal innovation and the implementation of participatory breeding, this dimension is essential. Today, this occurs in particular in the CTPS, in a very implicit way through the definition of registration criteria. Varietal innovation built around the agroecological transition is creating a new context, favourable to open varietal innovation. For more than 15 years, there have been participatory breeding programs and experiments in France, generally co-constructed between INRAE research teams and farmers' and citizens' associations (Desclaux *et al* 2019). These programs aim to respond to a diversity of needs in terms of adaptation to organic and/or agroecological farming practices, new markets, and very varied pedo-climatic conditions.

The deployment of agroecology on a large scale may benefit from participatory approaches: variety creation for agroecology will have to introduce these approaches for the breeding, evaluation, characterization and conservation phases. These approaches could respond to the complexity generated by agroecology, and also create value for the different actors involved (intellectual, financial, social value). Recent initiatives at the European level, particularly in organic agriculture and cereals, provide feedback that can be used to accelerate participatory approaches in the varietal creation process.

Participatory approaches are complementary to other breeding and evaluation methods. Moreover, these approaches seem to be appropriate for orphan species or for agro-climatic situations that are not well covered by conventional breeding methods. Barriers have been identified: financial, organizational (support of the approaches by an adapted animation) and sometimes methodological, as "data science" can be a real opportunity for the success of participatory approaches, or the sharing of new knowledge and know-how among the many groups involved in participatory breeding.

Questions raised by participatory approaches at the level of registration concern the description of registration rules, the evaluation of more heterogeneous plant material, the integration of "participatory" into the regulations, the devices to be activated in order to obtain a maximum of information on varietal behaviour, the guarantees for breeders and users, the analysis of participatory evaluation data, without forgetting the sharing of the values generated.

Variety evaluation methods for agroecology and impact on variety registration

The trial networks and systems will have to be adapted to consider more services, environments and agricultural practices. Variety evaluation will be based on a combination of field trials, some of which will be agroecological, aimed at characterising the adaptation of varieties to different cropping systems, and trials under controlled conditions dedicated to studying characteristics of interest (allelopathy, resistance to biotic or abiotic stresses, etc.). These trial networks must be designed taking into account the risk of loss of trials, which may be increased due to the reduced use of chemical inputs, and the adaptation and training time for new practices for the teams carrying out the experiments (transition time).

Registration rules will have to evolve in order to be able to register varieties for agroecological systems. This will involve both the integration of new characteristics into the rating and the weighting given to the different characteristics. Given the diversification of the conditions of cultivation and use of varieties, agility in the registration rules will be particularly important.

It will be necessary to carry out these reflections keeping in mind the competitiveness of the variety registration systems within the EU (European Union) and to maintain the attractiveness of the French official catalogue.

Integration and dissemination of varietal results for agroecology

In an agroecological context that implies more and more diversity and requires the evaluation of more and more characteristics, the CTPS has a role of trusted third party and guidance to play through the dissemination and integration of varietal data in an agroecological context, because of its ability to integrate results at the national level, in relation to the continuum (pre and post registration data) and in relation to European data. The integration of varietal data at the European level will require common criteria evaluated in relation to agroecology, while maintaining national specificities in relation to the current specific needs of the sectors and insisting on local adaptations. The added value of registration and of the CTPS could be to focus on the evaluation of specific characteristics essential to the common goods provided by the varieties (resistance to pests, tolerance to extreme conditions, etc.), or on the evaluation of the global performance of varieties in agroecological situations, in order to orientate towards more sustainable agriculture and to encourage the breeding of varieties better adapted to agroecology.

Within the framework of the agroecological transition of agricultural systems, it will be necessary to think, create, and thus evaluate, a variety in its production system, leading to a more refined combination of genetic improvement, agronomy, but also and more broadly, all the modalities and resources for the management and protection of these agroecological crops.

The field of possible successes is considerable, and the CTPS, through the richness of its contributing communities, will have a key role to play in achieving them.