# ADVANCES TO **DEVELOP** **ORGANIC** HETEROGENEOUS

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LIVESEED

## WHAT IS ORGANIC HETEROGENEOUS MATERIAL?

To understand the term "Organic Heterogeneous Material", it is first important to look at the definition of a variety. In the EU regulation (2100/94/EC), a variety is a plant grouping defined by the expression of certain phenotypic characteristics such that an individual plant is representative of the whole plant grouping.

To be registered in the EU common catalogue of varieties, to obtain plant breeders' rights, and to market seeds thereof, crop varieties must fulfil the criteria of 'Distinctness', i.e. different varieties are distinguishable from one another; 'Uniformity', i.e. the phenotypic homogeneity of the plant grouping, and 'Stability', i.e. its identifying characteristics will not change during propagation.

These criteria are known under the acronym 'DUS'. Arable crop varieties are also tested for their Value for Cultivation and Use (VCU).

In contrast, heterogeneous plant reproductive material, displays a higher genetic and phenotypic diversity, and thus, cannot be considered as a variety because it cannot fulfil the DUS criteria.

The new organic regulation (EU) 2018/848 acknowledges the importance of heterogeneous material especially for organic production. Organic Heterogeneous Material (OHM) is defined as follows:

'organic heterogeneous material' means a plant grouping within a single botanical taxon of the lowest known rank which:

(a) presents common phenotypic characteristics;

(b) is characterised by a high level of genetic and phenotypic diversity between individual reproductive units, so that that plant grouping is represented by the material as a whole, and not by a small number of units;

(c) is not a variety within the meaning of Article 5(2) of Council Regulation (EC) No 2100/94 (33);

(d) is not a mixture of varieties; and

(e) has been produced in accordance with this Regulation;" (Article 3 (18)).

Costanzo & Bickler (2019) described OHM as an umbrella term for three types of material which are not considered to be a variety:

- Farmer selections: A farmer makes targeted selections from heterogeneous material (population, landrace) over a certain period of time and in a specific region.

- Dynamic populations: A mixture of cultivars (varieties, landraces, niche varieties, breeding lines, gene bank accessions) is cultivated together. This mixture is multiplied, without making selections, over generations; thereby, allowing the dynamic population to evolve and adapt to the local conditions.

- Composite cross populations (CCPs): A breeder makes targeted crosses within a population. The population is left to evolve under natural conditions, resulting in a greater diversity than the other types.

## WHY DO WE NEED ORGANIC HETEROGENEOUS MATERIAL?

**Functional diversity:** One of the biggest merits of OHM is its genetic diversity, that entails several advantages. In fact, its genetic diversity enhances crop robustness by buffering variable and unpredictable environmental stresses, thereby generating resilience. The best term to describe these advantages is that of 'Functional Diversity'.

**Disease resistance:** Well-investigated is the ability of OHM to reduce disease severity. Modern uniform varieties, with the same level and mechanism of disease resistance across the plant grouping, can create a strong selection pressure for the pathogen to evolve and overcome the resistance. In contrast, crops in a heterogeneous plant grouping display different levels and mechanisms of disease susceptibility, thereby preventing the spread of the pathogen and slowing down the evolution of resistant pathogen strains (Finckh et al., 2000).

**Adaptation:** Thanks to its genetic diversity, OHM has a great ability to adapt to local growing conditions through both natural and farmers' selection. According to the Darwinian evolution theory, a heterogeneous population responds to the environment's pressures by increasing the prevalence of the most fit types, thereby adapting the crop to the local pedo-climatic conditions. In addition, a farmer growing an OHM has a wide pool of genetic diversity available to make selections according to his/her needs and the demands of the local value chain. This dynamic nature of OHM is in sharp contrast with a normal, 'DUS'-registered homogeneous variety.

**Performance stability:** Whilst an OHM is not stable in terms of its identifying characteristics, thanks to the above-mentioned aspects it can have enhanced yield stability, especially under organic, low-input agricultural conditions, or in regions with less favourable

# AND **COMMERCIALISE MATERIAL** IN THE EU...

growing conditions. Various experiments by the Organic Research Centre (ORC) and other researchers show that populations can have a yield advantage over homogeneous variety especially in low-productivity environments.

## TEMPORARY EXPERIMENTS WITH GENETICALLY HETEROGENEOUS SEEDS

Being in contrast with the DUS criteria, marketing seeds of genetically heterogeneous crops was, by default, illegal. However, under 2014/150/EU "providing for certain derogations for the marketing of plant populations", a temporary experiment has enabled marketing of seeds of heterogeneous material within the EU from 2015 to 2018 and extended under 2018/1519/EU until 2021.

The objective was to gather more experience on the registration, characterisation, marketing and traceability of heterogeneous populations of wheat, barley, oat and maize. To be released, a population must have a denomination and the applicant must submit a description of the population's characteristics as well as a representative sample. Marketing of seeds is quantitatively restricted.

The first population commercialised was the "ORC Wakelyns Population" in the UK, a "Composite Cross Population" (CCP) constituted by the Organic Research Centre starting from 190 crosses among 20 different parent wheat varieties and mixing all the resulting seed. Since then, six EU Member States (Italy, France, Germany, the Netherland, Denmark, the United Kingdom) participated in the temporary experiment under 2014/150/EU with 35 populations of wheat, barley or maize.

For example, within the scope of the EU FP7 project SOLIBAM and the EU H2020 project DIVERSIFOOD, Rete Semi Rurali (RSR, The Italian Farmers Seeds Network) tested a wheat population, constituted in 2009 in four different regions of Italy. Due to years of natural selection, three of the regional "sub-populations" showed adaptation to the local growing conditions, resulting in yields comparable to commercial control varieties. Under the 2014/150/EU, it was therefore possible to register these three "SOLIBAM" wheat populations.

However, whilst genetically heterogeneous crops can have a stable performance in the environment in which they evolved, they can be unstable when shifting environments, indicating that OHM should be tested in their growing conditions and not in experimental stations. The problem of identifying populations across environments and years will be explored under 2018/1519/EU.

Similar to the case of the Italian "SOLIBAM" wheat populations, RSR is conducting research with one tomato Composite Cross Population (CCP), tested in different environments and agricultural systems throughout Italy. The tomato CCP was obtained by crossing four local varieties selected for suitability under organic management.

Furthermore, Kultursaat is conducting research with spinach, lettuce and tomato in the Netherlands. However, due to the restriction of the current temporary experiment to four cereal species, research and experiences with vegetable populations are scarce.

## A TOOLBOX FOR IDENTIFICATION OF ORGANIC HETEROGENEOUS MATERIAL

Unlike the 2014/150/EU, according to the legislative text, OHM is not quantitatively restricted and covers all crop species and does not have to comply with the requirements for registration. This is however only valid in the domain of organic certification. Delegated acts will lay out rules for the production and marketing of OHM to ensure its quality and traceability.

In order to aid in the development and implementation of these delegated acts, within the scope of the LIVESEED project, Costanzo & Bickler (2019) developed a toolbox to identify and describe OHM, building upon the outcomes of the 2014/150/EU temporary experiment and also incorporating experiences with non-cereal heterogeneous material.

**Toolbox:** Due to the heterogeneous nature of OHM, a flexible toolbox is necessary with general and specific requirements. Figure 1 illustrates a checklist with general requirements applicable for all types of OHM.

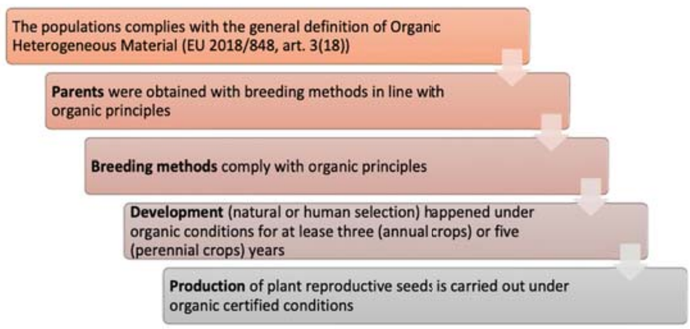


***Figure 1: Checklist in successive steps of the general provisions for registration of "Organic Heterogeneous Material" (Costanzo & Bickler, 2019).***

In addition to these general requirements, description and identification tools can be laid out and grouped into five categories:

(1) origin

(2) region of cultivation

(3) breeding methods

(4) phenotypic traits

and

(5) traceability.

Depending on the type of OHM, the categories can be evaluated from highly relevant to not relevant. For instance, human selection has an important role in the creation of farmer selections.

Therefore, focus is put on phenotypic traits that have been targeted during selection as well as the region of cultivation. To characterise dynamic populations the origin, i.e. the list of parents, is decisive. CCPs are subject to natural selection leading to a wider differentiation, giving the traceability of seed lots a priority. Table 1 summarises the key tools and their relevance for each type of OHM.

***Table 1: Key tools of certification and description and their relevance/specification for the three proposed categories of OHM (Costanzo & Bickler, 2019).***

| | Farmers' selection | Dynamic population | CCP |
|---|---|---|---|
| **Origin** | **Highly relevant** Original population | **Highly relevant** List of parents | **Highly relevant** List of parents |
| **Region of cultivation** | **Highly relevant** in terms of e.g. geographical origin | **Medium relevance** as related to natural selection during development | **Medium relevance** as related to natural selection during development |
| **Breeding method 1: constitution** | **Not relevant** | **Low relevance** as the starting point is always a physical mixture | **Highly relevant** for the methods used in the initial crosses |
| **Breeding method 2: development (pre-notification)** | **High Relevance** to describe which selection has been applied | **Medium relevance** if direct selection is applied, otherwise related to region of cultivation specifying management | **Medium relevance** if direct selection is applied, otherwise related to region of cultivation specifying management |
| **Breeding method 3: production / multiplication (post-notification)** | **Medium relevance,** and it may change significantly according to the species life cycle | **Medium relevance** and might change if self- or cross-pollinated species | **Low relevance** as progeny is supposed to be multiplied as bulk |
| **Phenotypic traits** | **High relevance** as related to selection as advised by the 'breeder' | **Medium relevance** if direct selection is applied as advised by the 'breeder' | **Medium relevance** if direct selection is applied as advised by the 'breeder' |
| **Traceability** | **Low relevance** | **Medium relevance** as also keeps track of natural selection | **High relevance** as also keeps track of natural selection |

## CONCLUDING REMARKS

Organic heterogeneous material complies with the objectives of the new organic regulation (EU) 2018/848 to safeguard a high level of biodiversity. Moreover, OHM fits to the needs of organic production and has the potential to contribute to yield stability under adverse environmental conditions.

To advance the development and the commercialisation of OHM, the developed LIVESEED toolkit serves as a first step to address the related opportunities and challenges.

### REFERENCES:


Costanzo, A., Bickler, C., et al. (2019). Main outcomes and SWOT of experiences from marketing populations under the Temporary Experiment into the commercialization of heterogeneous populations in the European Union. Milestone 2.8, LIVESEED project: **www.liveseed.eu**

Costanzo A., Bickler C., (2019). Proposal for a toolbox for identification and description of organic heterogeneous material. Deliverable 2.8, LIVESEED Project: **www.liveseed.eu**

Finckh, M., Gacek, E., Goyeau, E., Lannou, C., Merz, U., et al. (2000) Cereal variety and species mixtures in practice, with emphasis on disease resistance. Agronomie, EDP Sciences, 20(7), pp.813-837.



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