Guidelines for adapted DUS and VCU testing of organic varieties

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1 Executive summary

In the new Organic Regulation EU 848/2018 two new categories of plant reproductive material have been introduced in order to embrace diversity in cultivars from organic plant breeding. Organic plant breeding aims to meet the different needs of the organic sector by producing a diversity of cultivars from a range of different crops with special qualities and agronomic performance adapted to the environmental challenges faced in organic plant production.
Cultivars of organic heterogeneous material and organic varieties in the new regulation are both defined by a high degree of genetic diversity. In the existing testing regime organic breeders face challenges when the level of genetic diversity is too high in cultivars. Compared to traditional varieties the new regulation aims to allow a higher degree of diversity. The new category of organic heterogeneous material is not intended to be uniform or stable, and cannot meet the requirements of Distinctness, Uniformity and Stability (DUS) in the existing testing system. The intention of organic heterogenous material is the ability to evolve and adapt over time/growing conditions. The user is guaranteed an identity (based on the origin, history and traceability) and a certain seed quality (sanitary, analytical purity and germination). Organic Varieties are defined as plant varieties according to EU 2100/94 and thus "*considered as a unit with regard to its suitability for being propagated unchanged*". Users are thus guaranteed a variety that can be described and whose characteristics of interest are stable over time. When VCU is relevant (agricultural crops), performance is also guaranteed.
The Commission has introduced a seven-year temporary experiment to describe the characteristics of organic varieties and to determine the production and marketing conditions of organic varieties. This LIVESEED report gives recommendations for this upcoming temporary experiment on organic varieties as laid out in the new organic regulation (EU) 2018/848.
This temporary experiment will allow Member states certain derogations from existing testing protocols for Distinctness, Uniformity and Stability (DUS) and for Value for Cultivation and Use (VCU). In order to feed input to this temporary experiment LIVESEED has collected experiences on existing VCU testing and protocols to describe variety characteristics of importance in organic cultivars. It is also discussed whether VCU for agricultural crops in some cases could be voluntary. For DUS testing a new method has been described, and LIVESEED recommends this to be tested further in the temporary experiment. A basic idea of this suggestion is to allow more diversity in the cultivar description by dividing DUS characteristics in voluntary and obligatory characteristics and describe all characteristics, but for the acceptance of the organic variety with adapted DUS only the obligatory characteristics - of interest for users - should meet the requirements. The usability of this methods has still to be tested and proven in different species. For the purpose of gaining plant variety protection, the allowance of increased diversity is not compatible with the strict requirements for uniformity and distinctness. The system of plant variety protection is a foundation of the existing breeding setup, but for organic breeding this is not equally important in all cases due to different financing models. The possibility of plant variety protection should still be kept open by allowing organic breeders the opportunity to let the cultivar pass all criteria in the DUS test. LIVESEED recommends this to be investigated during the temporary experiment.
Not only testing protocols pose a challenge to organic breeders, sometimes the registration procedure itself is a challenge, and possibility's for testing market acceptance are described in this report and LIVESEED recommends that such testing procedures are also included in the temporary experiment.
In order to serve clarity as regards the boundaries between different types of cultivars, this report also provides a proposal for a working definition on organic varieties. This includes a discussion on breeding techniques in the breeding process and parent material, number of years under organic management and testing conditions. LIVESEED recommends that there is a minimum number of years under organic management, and that breeding techniques are in line with organic principles, and that adapted protocols are applied when applicable. The report also provides background information regarding

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organic varieties and their relevance in organic farming. This includes breeding strategies for organic farming, the existing registration procedure, existing definitions and aims of organic plant breeding.
Challenges experiences with the existing system have been collected from different sources including organic breeders and variety officials.
Several meetings have taken place involving CPVO, breeders, policy makers and other stakeholders in the discussions and different inputs have been integrated in the report, although consensus has not been reached on all matters.

- LIVESEED, ECO-PB, CPVO workshop with examination officers on heterogenous material and organic varieties, December 2018
- LIVESEED, ECOBREED, BRESOV meeting with DG Sante, DG Agri and DG Env., January 2020
- LIVESEED, INVITE, ECO-PB workshop with breeders, seed companies, examination offices, policy makers on the impact of new organic regulation on variety testing, February 2020
- CPVO workshop with VCU officials, June 2020
- LIVESEED workshop on definition of organic varieties, November 2020
- LIVESEED stakeholder workshop, November 2020

Acknowledgement

The report is a compilation of work from several LIVESEED partners including Clemens Flamm (Ages) providing expertise on VCU testing, Abco de Buck (LBI) and Gebhard Rossmanith (Bingenheimer Saatgut) providing input for the upcoming experiment regarding DUS testing protocols, Monika Messmer for organizing workshops with examinations offices and representatives from the Commission and stakeholders and continuously providing ideas and input, Frederic Rey (ITAB) for assisting in the writing process, Ambrogio Costanzo (ORC) and other project partners for exchange of ideas and opinions.

All input provided by organic breeders, variety officials and all other stakeholders is also appreciated.

A special thank also to Véronique Chable, Frederic Rey and Monika Messmer for reviewing.

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2 Introduction

The future Organic Farming Action Plan (planned for 2021) aims at achieving the Farm to Fork and the Biodiversity strategies' target of at least 25% of European agricultural land under organic farming by 2030 and will support the organic sector in its growth. The action plan will complement the new organic regulation (EU) 2018/848[1]. If this Action Plan is being constituted organic farming and organic breeding can likely look into a new future with significantly increasing market share (7,5 % organic farmland in 2018 according to Eurostat).

Organic breeding is often challenged by the small market share and specialized production, that has not always fit well with the conventional system for registration of new varieties. In the new organic regulation (EU) 2018/848 organic varieties has been introduced in the legal text together with organic heterogeneous material, in order to take into account, the higher level of diversity in some organic cultivars and to foster innovations in organic breeding.

The aim of this report is to provide guidelines for a definition on organic varieties in the new organic regulation and adapted testing protocols and procedures for the registration and marketing of organic varieties. Testing protocols should aim to meet the needs of organic varieties and breeders. The report provides input for the upcoming seven-year temporary experiment (expected from 2021-2028), on how to work with adaptation of testing protocols.

Due to the complexity of the topic, the report provides background information on the needs of organic farming and the aims of organic plant breeding, legal issues, organic principles and the existing setup for variety registration.

Input regarding experiences and challenges with the existing system have been collected through surveys, interviews, workshops, meetings and practical trials at Naktuinbouw (funded by Raad voor plantenrassen). As an essence of this information the report provides a set of guidelines on how to work with the adaptation of testing protocols. It has not been possible to reach consensus on all matters, but different views are represented in the discussions and as widely as possible integrated in the suggested guidelines. The suggested guidelines thus represent the view of the majority of the LIVESEED project group and not the authors view.

N.B. For the readers understanding: The term cultivar is used as a generic term of reference for any crop and as such includes the different categories of plant reproductive material and in this context covers the different types of variety terms, organic variety and organic heterogeneous material.

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018R0848

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3 Background

3.1 Organic reproductive material in the new organic regulation

The new organic regulation has new essential objectives regarding organic plant breeding and organic plant reproductive material.

In article 4 of 2018/848/EU some main objectives are listed:
(h) contributing to the development of the supply of plant genetic material adapted to the specific needs and objectives of organic agriculture;
(i) contributing to a high level of biodiversity, in particular by using diverse plant genetic material, such as organic heterogeneous material and organic varieties suitable for organic production;
(j) fostering the development of organic plant breeding activities in order to contribute to favourable economic perspectives of the organic sector.

Regulation regarding plant reproductive material that are usually handled under the seed directives of the Common Agricultural Policy (CAP) is now partly moved to the new organic regulation with the introduction of Organic Heterogeneous Material (OHM) and Organic Varieties suitable for organic production.

In figure 1 there is a schematic overview of the new categories of organic plant reproductive material in relation to the seed directives under the Common Agricultural Policy and the relation of Organic Heterogeneous Material to the temporary experiment on Heterogeneous Population 2014/150/EU[2], which was prolonged until 2021.

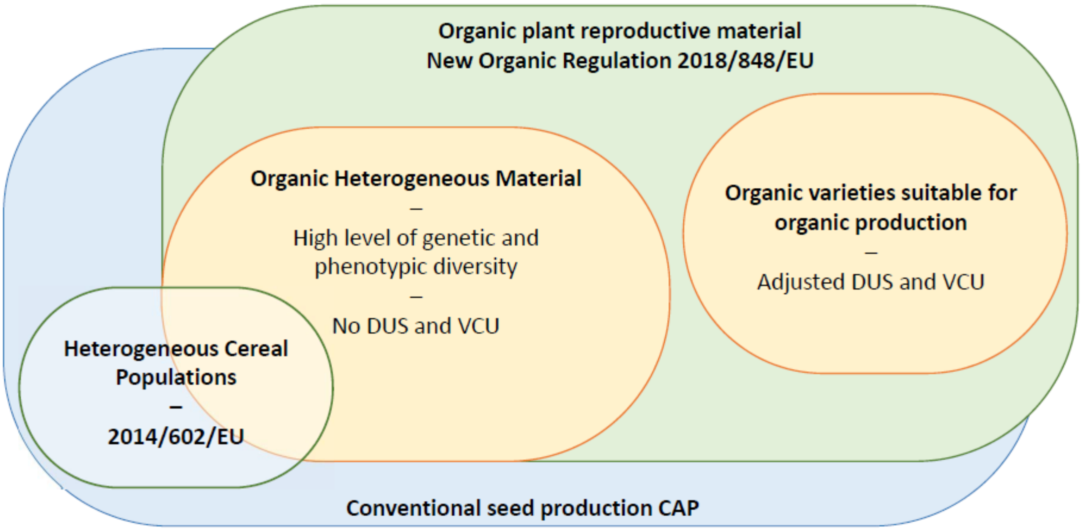

Figure 1. The figure shows the differentiation between populations defined in Temporary Experiment 2014/150/EU and new cultivar types of organic heterogeneous material and organic varieties implemented in the new Organic Regulation (EU) 2018/848. Constanzo, A. et al., 2019[3].

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014D0150
[3] https://www.liveseed.eu/wp-content/uploads/2020/01/LIVESEED_D2.8_heterogeneous_material_toolbox.pdf

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3.1.1 Organic heterogenous material, (EU) 2018/848 and delegated acts

Organic heterogeneous material (OHM) is intended to adapt to various stresses due to natural and human selection and therefore change over time.
In Article 3 of EC 2018/848 organic heterogeneous material is defined as
(18) '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 (1);*
(d) is not a mixture of varieties; and
(e) has been produced in accordance with this Regulation;

Delegated acts on the rules governing production and marketing of plant reproductive material of organic heterogeneous material have been in consultation of Member states experts in expert group on organic production.

In Article 4 (2) of the **draft** of the delegated act (Jan. 2021):
The material referred to in paragraph 1(b) may be generated by one of the following techniques:
(a) crossing of several different types of parental material, using crossing protocols to produce diverse organic heterogeneous material by bulking of the progeny, repeatedly re-sowing and exposing the stock to natural and/or human selection, provided that this material shows a high level of genetic diversity which is in accordance with Article 43(18) of Regulation 2018/848;
(b) on-farm-management practices, including selection, establishing or maintaining material, which is characterized by a high level of genetic diversity in accordance with Article 43(18) of Regulation 2018/848
(c) any other technique used for breeding or production of organic heterogeneous material, taking into account particular features of propagation.

According to Article 13 of (EU) 2018/8484 the specific provisions for the marketing of plant reproductive material of organic heterogeneous material are:
"Plant reproductive material of organic heterogeneous material may be marketed *without complying with the requirements for registration* and without complying with the certification categories of pre-basic, basic and certified material or with the requirements for other categories, which are set out in Directives 66/401/EEC, 66/402/EEC, 68/193/EEC, 98/56/EC, 2002/53/EC, 2002/54/EC, 2002/55/EC, 2002/56/EC, 2002/57/EC, 2008/72/EC and 2008/90/EC or acts adopted pursuant to those Directives."

It was suggested by the LIVESEED project that organic heterogeneous material should be bred and developed under certified organic conditions for three years for annual crops and five years for perennial crops. This has been removed from the draft of the delegated act.

The cultivars or breeding populations, which answer to the OHM characteristics, are characterized by a high level of phenotypic and genotypic diversity and its capability to adapt to local growing conditions, and it may be marketed without complying with the registration for varieties. Organic heterogeneous material should not be confused with variety mixtures where varieties are mixed on an annual basis, or synthetic varieties that also originate from crossings of several parental lines.

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3.1.2 Organic varieties and a temporary experiment according to EC 2018/848

In the preface of (EU) 2018/848 it is stated that:
(39) In order to meet the needs of organic producers, to foster research and to *develop organic varieties suitable for organic production*, taking into account the specific needs and objectives of organic agriculture such as enhanced genetic diversity, disease resistance or tolerance and adaptation to diverse local soil and climate conditions, *a temporary experiment* should be organised …. for a term of seven years,… It should help to establish the criteria for the description of the characteristics of that material and to determine the production and marketing conditions for that material[4].

An organic variety is defined in Article 3:
(19) 'organic variety suitable for organic production' means a variety as defined in Article 5(2) of Regulation (EC) No 2100/94[5] which:
(a) is characterised by a *high level of genetic and phenotypical diversity* between individual reproductive units; and
(b) *results from organic breeding activities* referred to in point 1.8.4 of Part I of Annex II to this Regulation.

Annex II: 1.8.4. For the production of organic varieties suitable for organic production, the organic breeding activities shall be conducted under organic conditions and shall focus on enhancement of genetic diversity, reliance on natural reproductive ability, as well as agronomic performance, disease resistance and adaptation to diverse local soil and climate conditions.
All multiplication practices except meristem culture shall be carried out under certified organic management.

The definition of a variety according to Article 5(2) of Regulation (EC) No 2100/94:
"For the purpose of this Regulation, 'variety' shall be taken to mean a plant grouping within a single botanical taxon of the lowest known rank, which grouping, irrespective of whether the conditions for the grant of a plant variety right are fully met, can be:

- defined by the expression of the characteristics that results from a given genotype or combination of genotypes,
- distinguished from any other plant grouping by the expression of at least one of the said characteristics, And
- considered as a unit with regard to its suitability for being propagated unchanged."

Article 5(4). The expression of the characteristics referred to in paragraph 2, first indent, may be either invariable or variable between variety constituents of the same kind provided that also the level of variation results from the genotype or combination of genotypes.

This new category of plant reproductive material and the temporary experiment will be discussed in more detail in later chapters of this report.

[4] Expected to start July 1st 2021, but there are uncertainties due to the Covid19 situation.
[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31994R2100

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3.2 The challenges and needs of organic crop production

In organic crop cultivation there is a need for cultivars that are adapted to the specific conditions and purposes of organic farming. This regards adaptation to local soil- and climatic conditions, weed competition, disease/pest resistance or tolerance (e.g. seed borne diseases as common bunt or leaf diseases as yellow rust) and nutrient use efficiency. Farmers face diverse environmental stresses in their fields, and cultivar adaptation is an important part of the solution to overcome these challenges. Cultivar adaptation cannot stand alone though, as illustrated in figure 2, challenges must be solved at the right level, and proper farm management is an essential first priority.

Figure 2: Crop rotation and farm management is important in organic farming, and as the icing on the cake the choice of cultivar is an important part of the organic farming system.

Stresses should be minimized by using the proper crop rotation and choice of crops with the desired abilities to avoid aggravation of weeds, pests and diseases, and this management should, besides agronomic performance, also contribute to building and maintaining soil fertility and nutrients, and minimize environmental and climatic damaging effects through loss of nutrients and gases. When the foundation has been laid with proper farm management the choice of cultivars is the next and very important step for the organic farmer.
Cultivars must also serve specific purposes for food or feed qualities of special interest in organic farming. For food purposes this could be specific baking qualities, nutritional and health aspects, taste or colour and for feed purposes an example is cereals with a high content of natural phytases to exploit phosphate in feed rations, as organic farmers cannot add artificial enzymes to feed rations.

3.3 Breeding strategies in organic farming

Organic farmers are commited to use organically propagated seed, but the cultivars can originate from different breeding strategies. If no organic seed is available there is a possibility to get derogations for the use of conventionally untreated seed. In the new organic regulation this possibility is expected to gradually be phased out until 2036.

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Three main breedings strategies can be identified:

Conventional breeding:

- Selection with the use of seed treatments, herbicides, highinput nutrients with commercial fertilizer
- Breeding goals and variety development for conventional conditions
- Registered varieties can be tested in organic post-registration cultivar trials
- Either last multiplication step under organic farming conditions or sold as untreated conventional seed

Breeding for organic farming:

- Selection partly under organic conditions
- Focus on specific breeding goals for organic agriculture
- No use of GMO or critical breeding techniques listed in IFOAM Position Paper 2017
- Cultivar testing under organic conditions
- Last multiplication steps under organic farming conditions

Organic plant breeding:

- Breeding specifically /exclusively for organic agriculture
- Selection steps under organic conditions
- Breeding techniques in harmony with organic principles
- Multiplication steps under organic conditions

These are the main strategies but the boundary between the different strategies can be a bit blurry.

Still after decades of organic farming many organic farmers rely on conventionally bred varieties that are multiplied for one year under organic conditions or are sold as conventional untreated seed. Conventional varieties bred for conventional farming does not take into account the specific needs of organic farming. Varieties bred under conventional growing conditions with selection of specific traits for organic farming can to some extend have adaptations to the conditions of organic farming.
Several breeders combine conventional and organic breeding programs. An increased focus and restrictions on the use of pesticides and fertilizer in conventional farming endorses the same breeding goals in conventional as well as organic farming. During the first generations traits like disease and pest resistances can be selected in the combined programmes and a broad diversity is withheld in the selection field for later selection of other traits that are more specific for either conventional or organic farming, and these generations can be carried out in organic fields and cultivar tests. This is a possibility for breeders to make an affordable and thereby economically sustainable breeding program for organic farming. In organic breeding programs often more stakeholders from the value chain are involved in the process, and new concepts of financing of breeding programs emerge, and additional value is added to the product by the labelling of organic varieties.
The different strategies will indeed depend on the type of species of concern, as there are large differences in the needs to have specific traits for organic farming. For grass and clover most of the desired traits are of interest for both conventional and organic farming, and therefore it makes less sense to have separate breeding programmes (and testing protocols). For vegetables some organic farmers depend on varieties with specific qualities or growth characteristics that are only achievable in organic breeding programmes and other organic farmers rely on the use of varieties that are not yet available from organic breeding programmes.

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3.4 Aim of organic plant breeding

Diversity at different levels on farm is considered important in organic breeding to increase agrobiodiversity and thus system resilience[6] and to minimize the risk of crop failure. Increased agrobiodiversity can be achieved by organic breeders providing a palette of crops for the farmers to choose from in a diversified crop rotation. At field level increased genetic diversity within a crop can increase yield stability and resistance to diverse environmental and climatic stresses. The aim of organic breeding is to provide new cultivars adapted to the target environment under organic growing conditions with limited external inputs and sustainable use of resources. In the breeding process there is a selection for traits of specific interest in organic farming as resistance to seed-borne diseases, weed competitiveness, lodging resistance etc. It is also an aim to meet the market requirements of both farmers, processors, traders and consumers, as regards quality characteristics and agronomic performance, and that cultivars can be reproduced as farm saved seed. The preservation of genetic resources for future generations is a long-term aim.

3.5 Breeding for diversity

Diversity is a pillar stone of organic farming, and it is important to be clear about the meaning of diversity in the different contexts of breeding, as these concepts are often mixed up in discussions.

There are several levels of diversity:
Genetic diversity in the genomes of the breeding material is a prerequisite in the first breeding steps to create new variation and to find and select for the desired traits to produce new and adapted cultivars. The diversity can originate from breeder's nurseries, mutations, landraces, gene bank material, wild relatives etc.

Breeding for genetic diversity within a crop can be used in the adaptation to diverse growing conditions resulting in increased yield stability and disease tolerance due to the difference in genotypes that can compensate and thereby counteract unpredictable environmental and climatic stresses. Different cultivar types have different levels of genetic diversity (see next chapter). Populations have the highest level of genetic diversity. Genetic diversity within the crop can also be achieved by using variety mixtures.

Agrobiodiversity is the diversity within the agricultural land (including crops, soil microbes, pollinators, insects etc.), and at crop level it can be stimulated by using diverse crops, species mixtures, companion crops, catch crops etc. In the sense of breeding this includes breeding for a diversity of minor as well as major crops, breeding for mixed cropping systems and interactions with soil microbes in certain crops. Agrobiodiversity is important for humans to sustain biological resources for food and agricultural purposes. Agrobiodiversity is a subset of biodiversity, which is the manifold of living organisms. Biodiversity deliver humans ecosystem services as food, feed, clean water, fresh air, energy, production materials and medicine, and a rich biodiversity minimizes the risk of inbreeding and disease susceptibility in nature.

3.6 Different cultivar types

The inherent diversity in a cultivar is very much dependent on the type of breeding method used and the pollination type of the species. This is important for the discussion on adapted testing protocols for organic varieties and below examples of cultivar types are described.

[6] http://www.diversifood.eu/portfolio_category/booklets-reports-english/

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The genetic drift is the change in frequency of an allele over time in the genome. Self-pollinators have a low degree of genetic drift and they change only very little over time, whereas cross-polinators will have a larger genetic drift and will have better options to adapt to environmental changes over time.

3.6.1 Clones

Clones originate by vegetative propagation of a selected motherplant, and thus have the same genotype and very high homogeneity.

3.6.2 Inbred varieties

Inbred varieties are typically from self-pollinating species. Selections are done after crossing between two parents. Progeny is propagated through self-pollination which occurs, when pollen is transferred from the anther to the stigma in the same flower or to another flower of the same plant or clone.

3.6.3 Open-pollinated varieties/population varieties

Open-pollinated varieties are in general based on cross-pollinators, where the pollen is transferred from the anther from one plant to the stigma of another plant with another genotype, which could be plants of the same or other varieties. Selection can be done by mass-selection or specific paired crosses followed by selection. Cross-pollination increases the genetic diversity in the offspring by producing new genotypes. It can be expected that there will be a change in the genome after generations of seed production. This type of pollination and thereby genetic diversification is important in nature for evolution and to avoid inbreeding depression. For breeders it poses a challenge to keep varieties seperated from other varieties for breeding and maintanance purposes to avoid contamination.

3.6.4 Polycross varieties

Polycross varities originate from a limited number of crosses of open-pollinated parents. This allows a high level of heterozygosity and at the same time more homogeniety as compared to open-pollinated varieties. The variety can be resown for several generations without loosing performance.

3.6.5 Composite cross populations

Composite cross populations are based on a larger number of controlled crossings of parent lines that are subsequently subjected to natural selection. These populations thus have a high level of genetic diversity within the cultivar and do not fall under the variety definition. Composite cross populations can be produced from both self-pollinating and cross-pollinating species. The cross-pollinating species will further cross within the population, and will have a better possibility to adapt when subject to selection pressure. Some species can do both self-and cross-pollination.

3.6.6 Hybrid varieties

Hybrid varieties as opposed to open pollinated varieties originate from controlled crossing of inbred breeding lines. In the inbred lines self-pollination is brougt about artificially to create homozygousy. The inbred lines suffer from inbreeding depression and will not have high yields on their own, but combining two inbreed lines each with desirable traits, will cause a heterozygous effect and the first generation (F1) is known to have hybrid vigor, with a more vigourious growth and higher yields during the first generation. The F1 generation of a hybrid variety is, due to the inbreeding, very uniform.
Some F1 hybrids are produced with the use of CMS (cytoplacmatic male sterility), this technique is used to avoid that inbred lines cross during the breeding process, this is the case for e.g. rape seed, rye, maize and cabbage. In some species CMS occurs naturally as offtypes in the mitochondria. The male sterility cannot be introduced by breeders crossings sinces it is a cytoplamatic sterility related to the mitochondria, and therefore breeders can introduce it by cell fusion techniques where cytoplasm

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and genes from one species is transferred to another species. This techniques is not
in accordance with the organic principles and F1 hybrids produced with cell fusion techniques are controversial in the organic sector. Although allowed according to the current regulation some private labels do not accept the use of cell fusion induced CMS. A voluntary database for cellfusion free varieties is available at www.iqseeds.eu.

3.6.7 Synthetic varieties

Synthetic varieties are developed by crossings in all combinations between a limited number of inbred lines with known combining ability, instead of only two inbred lines as in the above hybrids. Either equal amounts of parental lines are crossed and harvested as bulk seeds or the seeds of the first generation resulting from the crossings are mixed in equal amounts, both resulting in a synthetic variety that can be multiplied by open pollination. The synthetic varieties are less uniform than hybrid varieties.

For further elaboration on cultivar types the FiBL dossier on plant breeding techniques is recommended[7] together with Diversifood factsheets[8][9]. There are other types of cultivars, but these are some main types of relevance for the discussion of cultivars for organic farming. In figure 3 examples of cultivar types are listed with increasing inherent diversity.

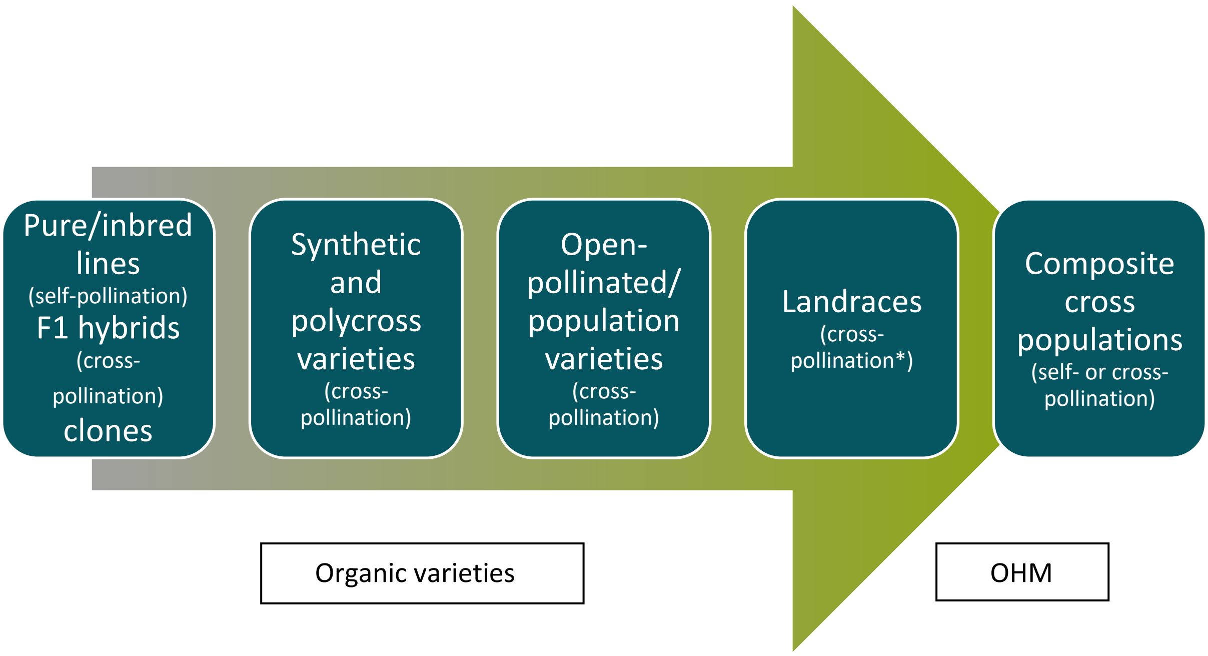

*Figure 3. Increasing level of genetic diversity within the cultivar. Main pollination type referred to in brackets. *Landraces can also be self-pollinating species with less inherent diversity.*

3.7 Cultivar type and farm-saved seed

As a derivative consequence of the nature of the breeding process, seeds produced from the F1 generation in hybrids are less vigorious and much less stable and are not suitable for farmers own seed production of the same variety. There is a need for repeated controlled cross-pollination. This inability to reproduce the variety from the F1 generation can be percieved as an insurance for

[7] https://www.fibl.org/fileadmin/documents/shop/1202-plant-breeding.pdf
[8] http://www.diversifood.eu/wp-content/uploads/2018/06/Diversifood_innovation_factsheet2_VarietiesPopulations.pdf
[9] http://www.diversifood.eu/wp-content/uploads/2018/06/IF3-Types-of-populations.pdf

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seedcompanies to sell more seed, but on the other hand seedcompanies will claim that they produce and sell these varieties because they are demanded by farmers.
In countries with strong tradition for buying new seed every season, the inability to reproduce the same variety at own farm is not percieved as a major problem. The yearly purchase of seed is considered to be an ensurance to have healthy seed with high performance and it is an easy solution with low labour effort.
Other countries have a tradition for the use of farmsaved seed, which may be due to a desire for local adaptation, unavailablity of sufficient quantities of organic seed, economic reasons, tradition or other considerations. An increasing dominance of hybrid varieties can pose a problem for such farmers, due to the difficulty to produce own seed from this type of cultivar, and the need to purchase new seeds every season, which can be an economic burden, although farmers that produce own seed still are obliged to pay a license to breeders if varieties are protected by Plant Breeders Rights.
Inbred varieties, open-pollinated varieties and the other types of cultivars mentioned in figure 3 can be used for farmers own seed production and the next generation of seed will be more or less similar to the parent material depending on the pollination type and farmers's efforts. Cross-pollinating types will, as explained above, be more likely to change over time.

There are farmers who are involved in Community Seed Banks or seed associations in which they are creating new open-pollinated populations (from landraces, mixtures or CCP). This activity is different from normal farm saved seed. In France, they name these cultivars "semences paysannes". Their definition is: "Peasant seeds (i) are a common good, result of a co-evolution between cultivated plants, communities and territories. They are selected within dynamic populations (ii) reproduced by the farmer, within a collective with an objective of seed autonomy. They are and have always been selected and multiplied with natural methods (respecting the plant cell) and easily manageable by the final grower, in fields, gardens, orchards conducted in peasant, organic or biodynamic agriculture. These seeds are renewed by successive multiplications by open pollination and / or by mass selection, without forced self-fertilization over several generations. Peasant seeds, with the knowledge and know-how associated with them, are freely exchanged while respecting the rights of use defined by the collectives who support them."

The different needs and cultural differences of organic farmers across the European Union and the functional diversity of different cultivar types calls for the possibility of the farmer to have a range of options to choose the level of desired diversity within the crop that complies with the given purpose of cultivation and production.
The increasing use of hybrids highlights a need to promote also breeding and registration of alternative cultivar types as open-pollinated varieties.

3.8 Implications of demand for homogeneity vs cultivar diversity

With the introduction of genetic diversity into the definition of organic varieties and organic heterogenous material it is important to discuss the implications of the demand for homogeneity in the existing registration procedure and at the same time the demand for increased cultivar diversity in organic farming.

A genetically diverse cultivar has the potential to compensate under stressful conditions, which is known from variety mixtures, resulting in a higher level of resilience, disease resistance and yield stability than a homogenous cultivar. If variety mixtures are mixed by seed companies or farmers prior to sowing the mixtures will not change over time, only if components are replaced. Organic heterogeneous material as composite cross populations or mixtures of multiple out-crossing breeding lines will have the potential to adapt over time if subject to environmental or climatic stresses for natural selection or farmer selection. If the population lose performance over time more active

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selection or renewal of the population may be needed. Farmers can perform selection on open-pollinated populations in order to stabilize the commercial traits and to promote diversity for other traits resulting in so-called "stabilized populations".
Genetically diverse cultivars may also have more diverse microbiomes related to the root system.
The experience from organic vegetable breeder Bingenheimer Saatgut is that the pursue of homogeneity in open-pollinated cultivars for registration purposes may come at the cost of quality and taste.
Another implication of the demand for homogeneity for variety registration is increased cost for breeders as the pursue for sufficient homogeneity will require more breeding generations. Organic breeding is challenged due to a smaller market compared to conventional breeding, and financing is a profound challenge.

A homogenous cultivar has the advantage of a minimal within crop competition and maximised yields, especially under high input conditions. Besides the homogeneity, hybrid cultivars are also seen to be popular among some organic farmers due to the vigorious growth which can give advantages of good weed competition and high yields. Homogenous cultivars are in demand by some organic farmes as genetically diverse cultivars can pose a problem in relation to weeding, harvesting and processing and due to demands for uniformity by retailers and feedstuff companies. If vegetables do not mature at the same speed, this might cause a significantly higher number of field operations for the professional operator and thereby more labour, climate impact and expenses. For automated processing irregular shaped vegetables may cause challenges. Millers or feedstuff companies may also reject cultivars that are not homogeneous due to specific requirements at factories.

3.9 Formal seed sector – cultivar registration

Common rules apply for the seed sector in the European Union. In the current regulatory framework, there are different options for cultivar registration.
Variety registration is a precondition for certification and marketing of a variety. Different requirements for registration apply to different categories. The new category of Organic Heterogeneous Material does not fall within the variety definition.

3.9.1 Conservation and amateur varieties

In 2004 the International Treaty on Plant Genetic Resources for Food and Agriculture[10] entered into force, and as a consequence the formal seed sector included conservation varieties in the regulation to legalise the commercialisation of landraces and to promote in situ conservation of varieties. The regulation came with quantitative restrictions.

- Directive 2008/62/EC[11]
  Marketing of agricultural landraces and varieties naturally adapted to local conditions, threatened by genetic erosion
- Directive 2009/145/EC[12]
  Marketing of vegetable landraces and varieties traditionally grown in certain regions, threatened by genetic erosion and amateur varieties with no intrinsic value for commercial production developed under particular conditions
- Directive 2010/60/EU[13]

[10] http://www.fao.org/plant-treaty/en/
[11] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32008L0062
[12] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009L0145
[13] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32010L0060

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Marketing of fodder plant seed mixtures for use in preservation of the environment

For the registration of conservation and amateur varieties no official tests are required but criteria for distinctness, uniformity and stability still apply for a description of the material. There is no option for Plant Breeders Rights. This type of varieties is mainly for niche markets targeting special food quality.

3.9.2 Organic Heterogeneous Material

The regulation on Organic Heterogeneous Material is awaiting to enter into force.
It is recognized that established methods to describe varieties of plant reproductive material are not appropriate for organic heterogeneous material.

The following is written in the **draft** delegated (Jan. 2021) acts which have not yet been finalized.

Plant reproductive material of organic heterogeneous material may be marketed *following a notification of the organic heterogeneous material by the supplier to the responsible official bodies.* The description of the OHM must include applicable elements as:

- description of the type of technique used for the breeding and production
- history of the material and the on-farm management practices,
- the parental material used to breed and produce the organic heterogeneous material, own production control programme;
- phenotypic characterisation of the key characters, degree of heterogeneity;
- documentation of its characteristics including agronomic aspects such as regards yield, yield stability, suitability for low input systems, performance, resistance to abiotic stress, disease resistance, quality parameters, taste or colour;
- any available results from tests, country of breeding and production, year of production, description of pedo-climatic conditions,

During the temporary experiment on the commercialization of heterogeneous populations in the European Union (2014/150/EU) is has been possible to market populations of certain species of cereals and maize.

3.9.3 Varieties

A plant variety is a plant grouping within a species/sub-species having a common set of characteristics. A variety must be defined by phenotypically expressed characteristics resulting from a given genotype or a combination of genotypes. A plant grouping consists of whole plants or parts of plants capable of producing whole plants.
The definition of a plant variety is broader than the definition of a protectable variety (see next chapter). It is not a requirement that all conditions for granting plant variety rights are met to have a variety.
The purpose of the seed legislation is to ensure production and marketing of new varieties with improved traits through plant breeding. Varieties must be technically examined before certification and marketing in EU. The seed directives set the minimum requirements for testing a variety.
The impartial and independent testing of varieties guarantees farmers that the variety they purchase are what they pay for and they are ensured high quality. The registration system also guarantees traceability.

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In order to be approved a variety must meet standards on

- Distinctness
- Uniformity — DUS-criteria
- Stability
- Value for cultivation and use - for agricultural crops.

This value for cultivation and use is based on:

- Yield
- Resistance to harmful organisms
- Response to the environment — VCU-criteria
- Quality

After technical examination and approval, varieties can be registered in national variety lists and in the common catalogues at EU level:

- Common catalogue of varieties of agricultural plant species[14]
- Common catalogue of varieties of vegetable species[15]

For fruit trees and vine there are separate registers:
- EU variety register[16] – Frumatis (fruit trees)
- EU list of varieties of vine propagation material

And for forest trees
- EU- information system – Forematis (forest reproductive material)

Legislation concerning the listing, marketing and denomination of varieties are listed below:

Agricultural and vegetable species:
- Council Directive 2002/53/EC[17](common catalogue of varieties of agricultural plant species)
- Council Directive 2002/55/EC[18](marketing of vegetable seed)
- Council Directive 2008/72/EC[19](marketing of vegetable propagating and planting material)
- Commission Directive 2003/90/EC[20](minimum characteristics and conditions for examining agricultural plant species)
- Commission Directive 2003/91/EC[21](minimum characteristics and conditions for examining vegetable species)
- Commission Regulation 637/2009/EC [22] (denominations of varieties of agricultural and vegetable species)

Fruit trees
- Council Directive 2008/90/EC[23](marketing of fruit plant propagating material and fruit plants)

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[14] https://ec.europa.eu/food/plant/plant_propagation_material/plant_variety_catalogues_databases/search/public/index.cfm?event=SearchForm&ctl_type=A
[15] https://ec.europa.eu/food/plant/plant_propagation_material/plant_variety_catalogues_databases/search/public/index.cfm?event=SearchForm&ctl_type=H
[16] https://ec.europa.eu/frumatis/
[17] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32002L0053
[18] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32002L0055
[19] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32008L0072
[20] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32003L0090
[21] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32003L0091
[22] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009R0637
[23] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32008L0090

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- Commission Implementing Directive 2014/97/EU [24](registration of suppliers and varieties and the common list of varieties - fruit)

Vine

- Council Directive 68/193/EEC[25,26](marketing of material for vegetative propagation of vine)

Forest trees:

- Council Directive 1999/105/EC[27] (marketing of forest reproductive material)
- Commission Regulation EC 1597/2002[28](national lists of forest reproductive material)

3.10 Overview of the official testing system for varieties

In figure 4 the two pathways for DUS are outlined to give an overview of the registration process. The initial step is application for national listing with or without application for variety protection. To be registered in the national list and the EU common catalogue the variety must pass DUS-test and for agricultural crops also VCU-test and this allows for certification and seed sale. To be protected by Plant Breeders Rights at national level or by CPVO-PVP (Plant Variety Protection) the variety must be new and pass the DUS test. This allows seed companies to claim seed license.

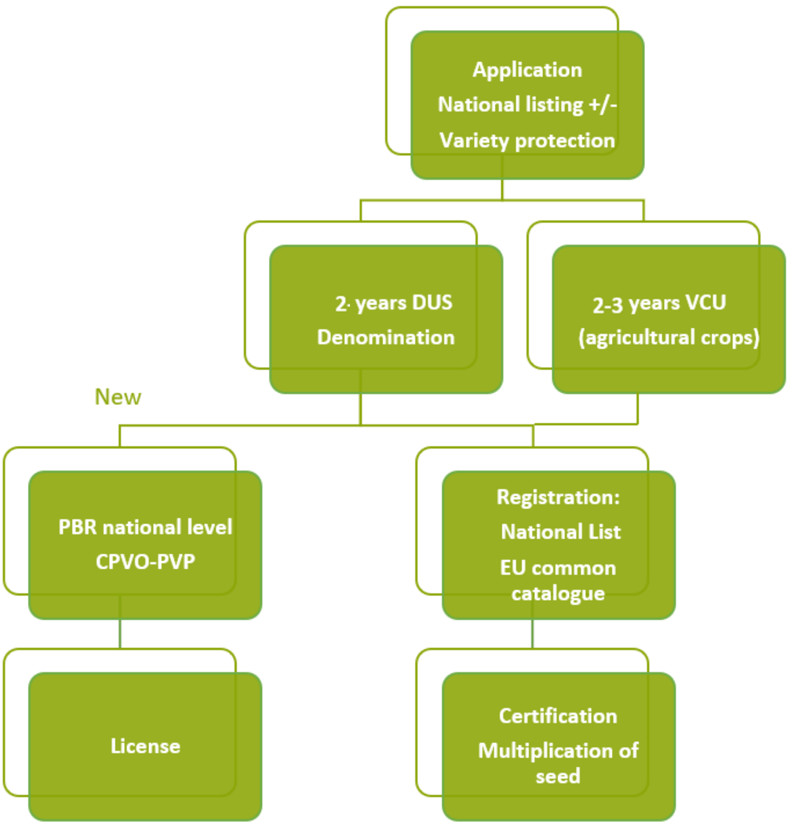

Figure 4. Schematic overview of the official testing regime. DUS = Distinctness, Uniformity and Stability, VCU = Value for Cultivation and Use, PBR = Plant Breeders Rights, CPVO-PVP = Community Plant Variety Office-Plant Variety Protection.

[24] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0097
[25] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31968L0193
[26] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:31999L0105
[27] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32002R1597
[28] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32017D0478

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4 Definitions of organic plant breeding and organic varieties

4.1 Definitions of organic plant breeding

A basic definition of organic plant breeding was provided by IFOAM International in the Norms from 2012 and in an updated version in 2014[29], and a more detailed definition is available in the ECO-PB (European Consortium for Plant Breeding) Position Paper on Organic Plant Breeding 2012[30]. This definition was an agreement among European organic breeders and research organisations.
There are also private labels that have guidelines for organic breeding like Bio Suisse, Demeter and Bioland. Bioverita[31] is a label for products derived from organically bred cultivars.

4.1.1 Definition of organic plant breeding according to IFOAM Norms 2014

4.8 Breeding of organic varieties
General Principles

- Organic plant breeding and variety development is sustainable, enhances genetic diversity and relies on natural reproductive ability. Organic breeding is always creative, cooperative and open for science, intuition, and new findings. Organic plant breeding is a holistic approach that respects natural crossing barriers. Organic plant breeding is based on fertile plants that can establish a viable relationship with the living soil. Organic varieties are obtained by an organic plant breeding program.

Requirements:

- 4.8.1 To produce organic varieties, plant breeders shall select their varieties under organic conditions that comply with the requirements of this standard. *All multiplication practices except meristem culture shall be under certified organic management*.
- 4.8.2 Organic plant breeders shall develop organic varieties only on the basis of genetic material that *has not been contaminated by products of genetic engineering*.
- 4.8.3 Organic plant breeders shall *disclose the applied breeding techniques*. Organic plant breeders shall make the information about the methods, which were used to develop an organic variety, available for the public latest from the beginning of marketing of the seeds.
- 4.8.4 The *genome is respected as an impartible entity*. Technical interventions into the genome of plants are not allowed (e.g. ionizing radiation; transfer of isolated DNA, RNA, or proteins).
- 4.8.5 The *cell is respected as an impartible entity*. Technical interventions into an isolated cell on an artificial medium are not allowed (e.g. genetic engineering techniques; destruction of cell walls and disintegration of cell nuclei through cytoplast fusion).
- 4.8.6 The *natural reproductive ability of a plant variety is respected* and maintained. This excludes techniques that reduce or inhibit the germination capacities (e.g. terminator technologies).

4.1.2 Position paper on organic plant breeding from ECO-PB 2012

Principles of Organic Plant Breeding (OPB) - main points of the position paper is provided below:

Dignity of living organisms

- promotes gentetic diversity and takes into account the ability to natural reproduction
- respects the integrity of a plant, its crossing barriers and regulatory principles

[29] https://www.ifoam.bio/our-work/how/standards-certification/organic-guarantee-system/ifoam-norms
[30] https://www.eco-pb.org/fileadmin/eco-pb/documents/discussion_paper/ecopb_PostitionPaperOrganicPlantBreeding.pdf
[31] https://bioverita.ch/en/825-2/organic-breeding-international/

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Aims of organic plant breeding

- match the needs of the complete value chain
- sustainable use of natural resources and account for dynamic equilibrium of the entire agro-ecosystem
- sustain food security etc. by satisfying nutritional and quality needs of animal and human beings
- sustain/improve genetic diversity and agrobiodiversity, adaptation to future growing conditions

Ethical criteria

- genome and cell integrity to be respected
- reproductive capacity must be maintained
- possibility for further breeding to be kept open
- respect for crossing barriers
- reproducibility by production of non-hybrid varieties

Strategic breeding criteria

- phenotypic selection under organic conditions
- field selection can be supplemented with additional selection methods (e.g. molecular markers)
- no contamination with genetically engineered products

Socioeconomic criteria

- no patenting
- transparency regarding starting material and breeding techniques
- promotion of participatory breeding
- promotion of diverse breeding programmes to enhance agrobiodiversity

4.2 Definition of organic varieties

Organic breeding as defined by IFOAM and ECO-PB is enforced in a number of organic breeding programmes, some of the resulting cultivars are certified and marketed under the private label "Bioverita – seed from organic breeding", and others are marketed without a specific label.
The Bioverita association has existed for almost ten years and will be introduced here as an example of a private label.

4.2.1 Bioverita

Bioverita is for both organic and biodynamic breeders and is a value driven association with a holistic approach to support a sustainable and social development of agriculture.
Varieties should be bred for regional and organic conditions by use of organically compatible methods, and all breeding steps must be performed under organic conditions. Hybrid varieties are not accepted with the argument that hybrids limit the free availability of seed. In the breeding methods no interference below the cellular level is allowed. Reproductive ability must be respected, and no patents are allowed. Read more about the background here:
https://bioverita.ch/wp-content/uploads/bioverita-Leitbild_06152.pdf
Bioverita regulations

In table 1 cultivar types allowed under the Bioverita label are listed. Hybrid varieties are not included.

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Table 1. Cultivar types allowed under the Bioverita label

Cultivar types recognized by Bioverita	
	Explanation
Clones	Vegetatively propagated varieties (e.g. potatoes, apple).
Line varieties	Homogeneous variety that has been produced by self-pollination (e.g. barley, wheat, soy, pea, tomato).
Bulk evolution	Genetically broad population resulting from multiple targeted crossings, for example CCP of winter wheat, which adapts to the environment through natural selection.
Population varieties	An open-pollinated population, which is in a genetic equilibrium and is therefore stable over generations.
Multicomponent varieties (Polycross varieties, synthetics, FIC = Family Intercross)	Varieties that are made from several components and are reproducible, e.g. polycross varieties of fodder crops, synthetic varieties of broad beans or FIC varieties of pumpkins.
Population crossing	An open-pollinated population resulting from the crossing of at least two open-flowering population varieties.

Source: www.bioverita.ch (Bioverita Board – Version 29.4.14)

In table 2 methods allowed in the first steps of the breeding process with the creation of genetic diversity are listed, and in table 3 methods that are not allowed. In table 4 methods allowed during the rest of the breeding process are listed, and finally in table 5 methods allowed during the propagation of seed are listed.

Table 2. Methods allowed for the creation of genetic diversity under the Bioverita label.

Creation of genetic diversity – methods allowed	
Use of spontaneous mutations	Changes in the genetic material occur naturally, so-called mutations. This genetic diversity can be used in breeding. May occur during cultivation but can also be targeted, e.g. by growing under stress conditions.
Use of natural high-altitude irradiation	The mutation rate can be increased by targeted cultivation at high altitudes, provided that the ground on which the plants are grown is organically certified.
Castration	Manual removal of male flower buds.
Selfing	Natural or manual pollination control.
Crossing within the species	
Crossing across species	For example, crosses of dessert apples with wild apples in order to insert scab resistance genes in the cultivar.
Bridge crossings	Applied, for example, for crossing in of resistances from related wild species if the cultivar and the species concerned do not cross. Initially a species closely related to the wild species is crossed, and the resulting crossing is crossed with the cultivar in a second step.
Mentor pollen techniques	Mixing pollen of various species to achieve fertilization in crossbreeds which would otherwise not be possible (e.g. pumpkin).

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Grafting	
Eurythmy	
Tone frequencies	
Naturally occurring, genetic or cytoplasmic male sterility with restorer genes. For deliberate use of this technique the breeder must first submit and justify an application to Bioverita. This request must be approved before proceeding.	Male sterility, which is inherited via cell nucleus or via cytoplasm, occurs naturally in many species (carrots, onions, gentian etc.). This can be used in breeding if it is ensured that the male fertility can be restored by appropriate core genes (restorer genes). This male sterility can be used to simplify crosses and create a polycross. It is shown here to distinguish it from artificial CMS sterility, which is based on cytoplast fusion, which may not be used.

Source: www.bioverita.ch (Bioverita Board – Version 29.4.14)

Table 3. Methods NOT allowed for creation of genetic diversity for the breeding process under the Bioverita label.

Creation of genetic diversity – methods NOT allowed	
Direct and indirect gene transfer	Transfer of isolated foreign (transgenic) or genotypic (cisgen) genes in the cell nucleus of the plant through agrobacteria, particle bombardment, injection methods, endocytosis, infiltration, etc. (e.g. Bt maize).
Cisgenesis	Transfer of isolated heterologous or species-specific genes into the plant using agrobacteria, particle bombardment, injection methods, infiltration, endocytosis etc, (e.g. cisgenic apple varieties with scab resistence).
Grafting of a scion onto a genetically modified rootstock	Transfer of isolated heterologous (transgenic) or species-specific (cisgenic) genes into the nucleus of the plant by agrobacteria, particle bombardment, injection methods, endocytosis, infiltration into the root stock. (E.g. Phylloxera resistance in vine rootstock, fire blight resistance in the rootstock of apples).
Plastid transformation	Transfer of isolated heterologous (transgenic) or species-specific (cisgenic) genes into the mitochondria or chloroplasts of the plant by agrobacteria, particle bombardment, injection methods, infiltration, etc.
Artificial minichromosomes	Inserting additional artificial chromosomes that contain a variety of new genes.
Synthetic biology	Creation of organisms by creating new DNA blueprints from the basic building blocks of DNA.
Site-specific mutation triggering using zinc finger nuclease, oligonucleotides, TALEN, CRISPR/Cas9, etc.	In targeted mutation triggering, individual building blocks of a certain gene are altered. For this purpose, synthetically produced DNA segments are introduced into the cell temporarily or permanently. (E.g. Clearfield rape with broad herbicide resistance).
RNA interference, DNA methylation	Change in the expression of individual genes by short RNA pieces that are temporarily or permanently introduced into the cell and specifically influence the reading of genes.

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Artificially induced mutation release	Increase in the mutation rate for example through γ-radiation, chemical mutagens.
Tilling	Inducing mutations and subsequent selection of mutants of a certain gene.
Cell fusion (protoplast fusion and cytoplast fusion)	Forced fusion of two cells (protoplasts or cytoplasts), which are neither ova nor pollen. This somatic hybridization can be induced between member of the same or different species by means of chemical or electrical stimuli. (e.g. cytoplast fusion between radish and cauliflower to produce CMS cauliflower).
Reverse Breeding	Elimination of the naturally occurring recombination of genes during meiosis in order to reproduce a heterozygous single plant via seeds. To achieve this, short RNA fragments are (for example) introduced temporarily or permanently into the cell, which prevent this.
"Early Flowering"	In apple cultivation, this means gene transfer of a gene from a poplar into the apple, so that a flower induction takes place during first growth already. This can result in accelerated generation cycles. This transgene is eliminated later on, so that it is no longer present in the final product.
CMS Sterility without restoration	Use of CMS without the restoration of the pollen fertility prevents further breeding and is therefore not allowed.
In vitro selection	Selection of individual cells, plant lines or seeds on artificial nutrient medium for a specific property, for example salt tolerance.

Source: www.bioverita.ch (Bioverita Board – Version 29.4.14)
Further information about breeding techniques can be explored in FiBL dossier "Plant Breeding Techniques – An assessment for organic farming", 2015.

Table 4. Methods allowed for the breeding and selection under the Bioverita label.

Breeding and selection – methods allowed	
Phenotypic selection under organic conditions	Phenotypic selection on certified organic sites is a prerequisite for the genetic and epigenetic adaptation to the organic cultivation system and a core component of organic plant breeding.
Additional selection under controlled conditions	E.g. in greenhouse cultivation, under polytunnel etc.
Artificial selection stress (for example increased disease pressure)	E.g. selection after artificial septic infection in the field or selection for fire blight (Erwina Amylovora) -resistance in the greenhouse.
Indirect selection	E.g. selection for increased wax layer of the spike to increase the resistance to glume blotch (Phaeosphaeria nodorum) by wheat.
Imaging techniques	E.g. copper chloride crystallization, paper chromatography, chroma-test.
Organoleptic selection	
Analytical / Technological methods	E.g. brix content in the case of carrots or onions, amino acid content in maize, selection on the basis of baking properties

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	determined in the laboratory for cereals or oil properties in sunflowers.
Marker-assisted selection*	Genetic markers are used only for diagnosis, as a complement to phenotypic selection. Pure genomic selection only on the basis of DNA analysis is excluded.
Eco-Tilling*	Search for naturally occurring mutations for a defined gene, using diagnostic DNA methods as a complement to phenotypic selection. This method is listed here to contrast with the impermissible tilling method which induces artificial mutations.
Proteomics*	Comprehensive analyses of the protein composition of a plant (resulting from the expression of the genes at a particular development time) are used only as a supplement to the phenotypic selection. Pure proteomic selection is excluded.
Metabolomics*	Comprehensive analyses of the composition of all metabolic products of a plant (resulting from the expression of the genes at a particular development time) are used only as a supplement to the phenotypic selection. Pure metabolomic selection is excluded.

* This method can be used if the breeder submits and justifies an application to Bioverita before starting a breeding program. This request must be approved before proceeding.
Source: www.bioverita.ch (Bioverita Board – Version 29.4.14)

Table 5. Methods allowed for the propagation under the Bioverita label.

Propagation – methods allowed	
Seed multiplication	
Vegetative propagation	
Apomictic multiplication, if this naturally occurs in the species in question.	In some plants, apomixia occurs naturally. This produces seeds that develop from the female ovum without true fertilization and are thus genetically identical to the mother plant. (e.g. dandelion, citrus, St. John's Wort).
Stratification	Cold treatment of seeds simulating winter rest to induce germination.
Vernalization	Cold treatment of seeds with a winter phase in order to induce flowering.

Source: www.bioverita.ch (Bioverita Board – Version 29.4.14)

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The concept of the Bioverita label is summarized in figure 5.

Different variety types with inherently differing levels of genetic diversity allowed, excluding hybrids. Reproductive ability respected. No patents allowed.

All breeding methods applied during the entire breeding process from creation of diversity to propagation comply with organic principles.

All breeding generations from first crossings must be conducted under certified organic conditions.

Figure 5. Summary of the value driven definition of organic varieties according to the private label Bioverita.

4.2.2 Suggestion for EU organic variety label

For the purpose of a common EU-regulation it would be beneficial to adopt a broader definition of organic varieties than the one presented above for the Bioverita label. The Bioverity label or other private labels can be an add on with stricter and more value driven guidelines to an EU label. One should not exclude the other, meaning that if the cultivar applies to the criteria of both labels it should be feasible to have both labels on a product.

The common rules should support the diverse organic breeding initiatives around Europe.
Breeding initiatives, that use the strategy of breeding for organic farming, do not have all breeding generations under organic management. In these breeding programmes the first generations of selections are performed under conventional conditions for e.g. diseases to avoid “disturbance” from weeds and other “interferences” from the organic system. And in later generation weed competitiveness and other traits are selected. Many varieties for organic production originate from such breeding programs, that are not organically certified in all breeding generations. This type of breeding strategy should also be considered in the registration process especially with respect to adapted VCU protocols. Varieties bred for organic farming may not qualify as organic varieties in the scope of the legislation, but it is important to also improve the registration process of such varieties. And it is important to keep open all options to give access to a diversity of suitable cultivars for organic farming, including both organic varieties and varieties bred for organic farming for the benefit of organic farmers. For the scope of the legislation and the temporary experiment it should be clearly defined how many years organic breeding should be under organic management to qualify as an organic variety.

In the following text suggestions for a precision of the definition of organic varieties in (EU) 2018/848 is presented.

Number of years under organic management

Organic varieties are a result of organic breeding activities under certified organic management. But it is not always easy to define at which point in time the breeding process begins. If a new variety is the result of crossings between parental lines, it can be clearly defined, but a new variety does not always originate from a defined crossing between parental lines. A new variety can also result from

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an off type of another cultivar. And for this type of origin it is not in the same way possible to clearly define the start of the breeding process.
For all origins it should apply that the number of generations or years under organic management should allow for proper adaptation of the cultivars to the conditions of organic farming.
To ensure this for all origins, it would be beneficial to introduce a minimum number of years under certified organic management. For the implementing acts on Organic Heterogeneous Material a minimum number of three years for annual crops and five years for perennial crops was suggested by LIVESEED, although rejected by the Commission. For the development of new organic varieties this minimum number of years under organic management is proposed to be five years for annual crops and eight years for biannual and perennial crops regarding organic varieties. There is not entirely consensus as regards this distinction though, as it is also argued that varieties bred for organic farming should be allowed to fall under the scope of organic varieties. Others argue that all breeding generations must be under organic certification.
It should be considered if the official registration testing of the variety should be included in the minimum number of years under organic management. Some argue on one side that there is also some selection process in the final testing steps, and that these should be included, and on the other side there are arguments that this would be very limited selection activity, since the testing of varieties is so expensive, that only the most promising and validated breeding lines will be tested. The general recommendation from the LIVESEED project would be to not include the testing in the minimum number of years under organic management.
But as organic varieties, with these minimum requirements, should be marked/promoted as organic varieties – and possibly tested with adapted DUS - varieties bred for organic farming should at the same time be marked/promoted as suitable for organic farming and tested under organic conditions (organic VCU), if they have been approved in trials as suitable for organic conditions. This is important in order to recognize both types of varieties. This recognition is important to breeders, as they place a lot of effort into the development of suitable varieties.
Another option suggested by a LIVESEED partner is to certify the organic breeders instead of the varieties.

Parent material

The parent material used for crossing or other origin of organic varieties should not involve cultivars derived from breeding methods that are not allowed in organic farming according to the organic regulation. This would exclude all GMO techniques including the new genetic engineering techniques. In addition, it is recommended by LIVESEED to also aim to exclude parent material of cultivars with CMS derived by protoplast/cell fusion, which by a large proportion of the organic sector is also perceived as GMO. If new genetic engineering techniques will be removed from the GMO regulation, it will be a huge challenge to effectively exclude parent material derived by the new genetic engineering techniques. Traceability and labelling of varieties derived by genetic engineering techniques should be highly prioritized to avoid contamination.
There is also a risk that organic breeding programmes in that case will be set back in its breeding progress, as it can be expected that a majority of conventional breeders will adopt the new genetic engineering techniques for the development of new varieties, and this will exclude a large proportion of available parent material for further breeding purposes in organic farming.
Some breeding techniques are considered to be unacceptable in organic breeding according to IFOAM International, 2017[32] (Table 6). Some of these techniques, that are not considered as acceptable in organic breeding, are considered acceptable for use in organic farming though. Such techniques include double haploids - in vitro, induced random mutagenesis by chemicals or irradiation, plus hybrids with xenia effect, apomixis and tilling. The recommendation from LIVESEED would be to allow techniques in parent material that are generally accepted in organic farming, although not accepted

[32] https://www.ifoam.bio/sites/default/files/2020-03/Breeding_position_paper_v01_web_0.pdf

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in organic breeding according to IFOAM. Mutagenesis derived by chemicals or irradiation are in ongoing discussions whether they can be accepted, but yet difficult to trace and exclude.

There seem to be consensus in the organic sector that new genetic engineering techniques should be kept excluded from organic breeding, and this would as a natural extension also exclude the techniques from parent material to avoid contamination. There are arguments from branches of the organic sector though, that new precision breeding techniques should be evaluated for their acceptance in organic farming based on the principle type instead of the specific techniques in question, with some types being considered relatively harmless and similar to natural mutation with the cell repairing itself, and other types to definitely be considered as GMO. See further discussion in the following chapter on applied breeding techniques in organic breeding programmes.

Cultivar types

In addition to the variety types that are accepted under the Bioverita label (table 1), also hybrids should be recognized as organic varieties according to the legal definition if they originated from organic breeding programmes and are adapted to organic conditions. This can be perceived as contradictory to the organic variety definition, as there is a conflict in the legal definition due to the wording “high level of diversity” in the variety definition. Organic breeding programs produce variety types with an inherent different degree of genetic diversity as for example inbred lines and open pollinated varieties (figure 3), both types can be organic varieties adapted to organic conditions. The legal definition should be considered for each type of cultivar and not exclude cultivar types with an inherent lower genetic diversity. Not all cultivar types would have the same demand for adapted DUS though, as it is expected that an organic hybrid variety would be sufficiently homogeneous to pass a regular DUS test regarding uniformity requirements.

In conclusion – if a cultivar originates from an organic breeding programme, the cultivar should be considered an organic cultivar. In the temporary experiment different cultivar types should be tested in order to determine which cultivar types would benefit from adapted DUS.

Breeding techniques

IFOAM International adopted a position paper on the compatibility of breeding techniques in organic breeding and organic farming in 2017. New technologies that do not respect the integrity of the cell are not considered to be compatible with the organic principles. And after a ruling by the Court of Justice in July 2018 organisms obtained by mutagenesis according to new mutagenesis techniques developed after the adoption of Directive 2001/18[33] on GMO’s was deemed as GMO. In the EU no GMO is allowed in organic agriculture according to the current Regulation 834/2007[34], Art. 4 and new organic regulation 848/2018, Art. 5.

This has been subject to much debate and the ruling by the Court of Justice is under pressure. On one side the conventional sector argue that it is irresponsible to block progress in the achievement of more sustainable and climate adapted varieties, and that not all the new breeding techniques carry the same level of risk. On the other side the organic sector relies on the principle of caution and consider the risks by genetic engineering too high, and value the concept of naturalness and integrity of the genome of the plant, and the consumers right to have a free choice to exclude GMO.

In order to maintain the integrity of the organic sector, genetic engineering techniques should not be allowed in organic breeding programmes, including the very first breeding generations that may or may not be performed under organic conditions, depending on the definition. The same rules on breeding techniques should apply for all breeding generations for organic varieties.

[33] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02001L0018-20190726

[34] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02007R0834-20130701

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Techniques are not accepted according to IFOAM position paper if they:

- Technically or physically modify the genome of the plant.
- Technically or physically modify the cells of the plant.
- Repress the reproduction ability of the cultivar.
- Overcome plant-specific reproductive barriers.
- Restrict further breeding by other breeders

The criteria for prohibiting breeding methods for organic plant breeding are in alignment with the IFOAM principles for organic plant breeding. Breeding techniques that are not accepted by IFOAM International are listed in table 6.

In the case that new breeding techniques of genetic engineering are no longer regulated as GMO, this will potentially have a negative impact on organic breeding activities due to a reduced amount of available starting material for breeding. Many conventional breeders are expected to adopt new techniques if removed from the GMO regulation, and conventional and organic breeding programs would have to be separated if these techniques are applied, possibly resulting in fewer organic cultivars for the organic farmer, and a profound difficulty to avoid contamination.

Table 6. Breeding techniques not accepted in organic breeding, IFOAM International Position paper, 2017. This is an excerpt of the total list and may not be exhaustive.

Breeding techniques not accepted in organic breeding, IFOAM International Position paper, 2017
Agrofiltration
Apomixis
Cisgenesis
Cytoplast, protoplast or cell fusion including CMS derived hereby
Double haploids obtained by anther, ovary, microspore or egg culture, in vitro
Fast track breeding by integration of transgenes during breeding process but not in the final cultivar
Gene drives
Gene Editing or induced targeted mutagenesis: induced small changes of DNA in defined target gene using sequence specific nucleases by Oligonucleoids, Zinkfinger nucleasis, CRISPR-Cas, TALENs
Gene Silencing – RNA interference (RNAi) RNAdependent DNA methylation (RdDM)
Induced random mutagenesis by chemicals or irradiation
Intragenesis
Mega nucleases
Plastid Transformation
Plus-hybrids with xenia effects
Reverse Breeding (isolated DNA or RNA brought into nucleus)
Synthetic biology (genetically engineering)
TILLING = Targeting Induced Local Lesions in Genomes
Transduction (used in gene transfer)
Transformation via mini- chromosomes
Transgenesis (transfer of genes from one species to another)

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It is recommended that double haploids - in vivo - and in vitro selection with natural substances should be allowed under the EU-label of organic varieties. Double haploids are widely used in barley breeding. Methods for creating genetic diversity, selection and multiplication mentioned in table 2, 4 and 5, should all be allowed under the EU definition of organic varieties.

Breeders should be obliged to disclose the utilized breeding methods on request. Not patents should be allowed.

Overview of suggested definition on organic varieties
In conclusion the main difference from the private Bioverita label to the suggested EU-label is the inclusion of F1 hybrids, allowance of double haploids (in vivo) or in-vitro selection on natural substances and the acceptance of organic breeding programmes if a minimum of five years are bred under certified organic conditions for annual crops and eight years for biannual and perennial crops.

Suggestion for EU-definition/label:

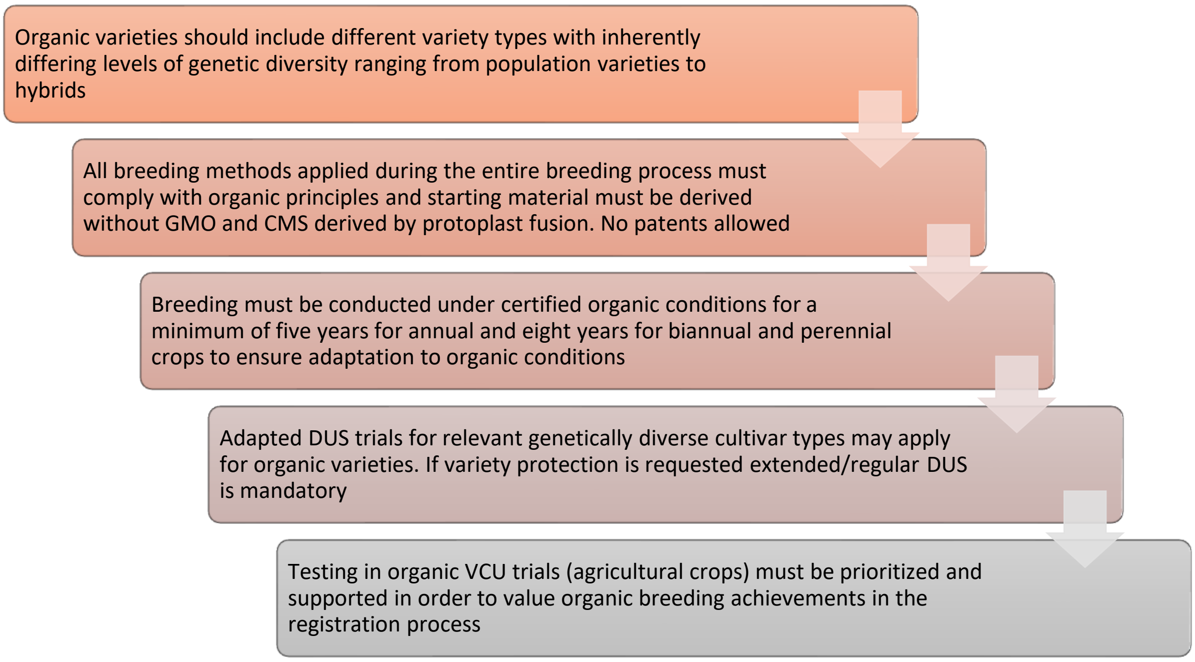

Figure 6. Schematic illustration of a LIVESEED recommended definition for organic varieties under EU-label in the context of the EU regulation, that should apply as a minimum common requirement for organic breeding programmes in EU member states.

For the registration process of organic varieties an adjusted set of testing protocols should encounter for more genotypic and phenotypical diversity and for specific traits in organic varieties. It has also proven difficult for some breeders – especially vegetable breeders - to reach the requested level of uniformity in organic varieties.

Adapted protocols for the registration process must be outlined and tested during the temporary experiment, as existing protocols do not take this diversity into account considering all species/cultivar types. To a certain degree testing protocols already consider the inherent diversity within cultivars of the different species, so the need for adaptation will be species-specific.

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5 DUS test

DUS testing is a key to both the registration of a variety on the national list and to the granting of variety protection (figure 4), and it is possible to register a variety without claiming protection of the variety.
DUS trials are carried out by entrusted examination offices throughout the EU. The chosen office will depend on the region of origin of the variety, on the ability of nearby offices and the wishes of the breeders. The harmonization of practices means that tests can be performed on behalf of other authorities and do not have to be performed on a national level.
When applying for a DUS test a variety description must be filed, this will be used to find appropriate reference varieties.

5.1 DUS criteria

Distinctness
A variety must be clearly distinguishable from any other variety of the species of common knowledge at the time of application and variety description. Phenotypic characteristics must differ from the characteristics of varieties of common knowledge. These characteristics may or may not have commercial relevance.

Uniformity
The variety must be uniform in the expression of the phenotypic characteristics from the variety description, that are also partly included in the examination for distinctness. When uniformity is tested only a limited number of off types are allowed for the characteristics examined.
These characteristics resulting from the relevant genotype/combination of genotypes must be consistent and reproducible in a certain environment and after repeated propagation. The type of variety – e.g. hybrid or open-pollinated is taken into consideration.

Stability
Stability means that the variety must express the relevant characteristics in the same way over time, and thus remain unchanged after repeated propagations. In practice stability is normally predicted based upon the assessment of uniformity.

5.2 Protocols

Technical protocols must be in accordance with CPVO test protocols at EU-level. If no CPVO protocols are available UPOV test guidelines must apply. And if there are no UPOV guidelines national protocols may apply.
CPVO protocols[35]
UPOV test guidelines[36]
National protocols[37]

The typical duration of a DUS test is two years.

Protocols are harmonized and therefore adapted protocols for organic varieties must be handled in cooperation with CPVO.

[35] https://cpvo.europa.eu/en/applications-and-examinations/technical-examinations/technical-protocols/cpvo-technical-protocols
[36] https://www.upov.int/test_guidelines/en/list.jsp
[37] https://cpvo.europa.eu/en/applications-and-examinations/technical-examinations/technical-protocols/national-protocols

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5.3 Variety protection

The International Union for the Protection of New Varieties of Plant (UPOV)[38]was established by the UPOV Convention[39] first adopted in 1961 with the recognition of plant breeder's rights on an international basis. The aim was to protect new varieties and thereby encourage breeders to develop new varieties for the benefit of the society.
At EU level The Community Plant Variety Office (CPVO)[40]has been running since 1995 following Council regulation (EC) No 2100/94 on community plant variety rights. The CPVO Plant Variety Protection (CPVO-PVP) grant the breeders exclusive rigths to market the variety within the European Union.
Plant Breeder's Rights (PBR) can also be granted at national level.
In order to be granted PBR or CPVO-PVP, a variety must be novel and apply to the DUS criteria and have a proper denomination. The variety protection gives the breeder exclusive marketing rights or the possibility of licensing others to market a variety. Anyone using protected varieties are obliged to pay a license/tax. The farmers privilege from UPOV 1991 Act at EU level provides the list of species to which the FSS exemption applies. This means that farmers using farm-saved seed (FSS) must still pay a licence but remarkably lower than the corresponding licence fee on commercialised propagating material of the same variety within the same area exempting small-size farmers. Other exemptions are used for non-commercial, experimental or further breeding purposes.
Plant variety protection lasts up to 25 years (up to 30 years for trees) without prolongation. Annual renewal fees are required to maintain the rights. Commission Regulation (EC) No. 1238/95 regulate the fees.[41]
The possibility to grant variety protection is a catalyst of the testing and registration system in the current seed legislation system, ensuring reinvestment in innovations in the breeding process. Plant breeding is a long-term investment – it is not unusual for the breeding process of one variety to take ten years, and the protection of a variety is an insurance for the breeder for return on investment in the work to provide new and improved varieties. This financing model is extremely important for conventional breeders of agricultural crops especially.

5.4 Survey results organic breeders

A survey was distributed among organic breeding companies, LIVESEED partners and ECO-PB members (and also to ECOBREED and BRESOV partners) in order to collect information on challenges experienced in the past with the registration of organic varieties. At the same time, they were asked to suggest candidate crops for the upcoming temporary experiment.
Below the reported challenges are listed divided by VCU trials and DUS trials and by the specific crop or crop group in mention. Most of the reported cultivars are open-pollinated varieties, inbred lines but also clones, multiline and synthetic varieties.
For both surveys and interviews it is important to note, that these statements are not necessarily representative for all, but are the opinions of single persons/institutions.

5.4.1 DUS challenges (agricultural crops)

For the DUS challenges some of the reported cultivar types are written in brackets, these are closely related to the reported challenges. The type of cultivar and also the aim of the cultivar (niche/professional) are reflected in the specific challenges.

[38] https://www.upov.int/portal/index.html.en
[39] https://upovlex.upov.int/en/convention
[40] https://cpvo.europa.eu/en
[41] https://cpvo.europa.eu/en/about-us/law-and-practice/legislation-in-force/regulation-ec-no-123895

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Wheat (inbred lines, multilines, population varieties)

- Not enough uniformity
- Cost of registration due to limited market
- Criteria used in DUS protocols are not relevant and could be replaced by more relevant criteria
- Assessed parameters for uniformity are not relevant for farmers, processors or consumers
- Many of the assessed parameters for uniformity are influenced by the climate
- For the observation of one trait (seed: coloration with phenol) toxic substance have to be used, which does not seem to be compatible with the principles of organic plant breeding; for another trait the line in question is not uniform enough (coleoptile: anthocyanin coloration). This trait is of no agronomic importance

Rye (population varieties)

- Not uniform enough
- Cost of registration due to limited market

Oat (inbred lines)

- Not uniform enough
- Cost of registration due to limited market

Barley (inbred lines)

- No challenge
- In general, no challenge - might be a problem with uniformity
- Uniformity, and cost of registration due to limited market

Spelt (inbred lines)

- Cost of registration due to limited market
- Aiming for enough uniformity

Durum wheat (inbred lines)

- Traits for organic, tested in conventional station
- Uniformity, and cost of registration due to limited market

Spring wheat (inbred lines)

- Generally, no challenge - uniformity might be a problem
- Aiming for enough uniformity

Millet (inbred lines, population varieties)

- Uniformity, and cost of registration due to limited market

Maize (population variety)

- Difficult to reach uniformity in all DUS criteria
- OP varieties are too heterogenous to pass conventional DUS test
- Many of the assessed parameters for uniformity are influenced by the climate
- Assessed parameters are not relevant for farmers, processors or consumers

Sorghum (population variety)

- Phenotypic plasticity, no testing of newly bred traits in present set up as DUS is in south of France not 51 degrees NL - no adaptation for long day and cool growing conditions from sowing to harvest
- OP varieties are too heterogenous to pass conventional DUS test

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Sunflower (population variety)

- Not uniform enough
- Many of the assessed parameters for uniformity are influenced by the climate
- Assessed parameters are not relevant for farmers, processors or consumers
- OP varieties are too heterogenous to pass conventional DUS test

Winter pea (Two-line varieties, lines)

- Isogenic lines are tested single, with double costs and payment for one variety (2 line type)

Spring pea

- Not uniform enough

Lentil (line)

- Not uniform

Potato (clones or open-pollinated varieties)

- Uniformity in case of TPS production (OP populations)

The survey indicated some general issues regarding the challenges with DUS:

Uniformity
The overall reply is that the challenge is to meet the requirements of uniformity, depending on the type of crop.

Criteria for assessment of uniformity
There are also some general and more specific comments regarding the relevance of specific assessments in the DUS protocols. It should be mentioned here, that the DUS criteria have not been chosen for their agronomic relevance, but for the option of distinction between cultivars. It is also mentioned in the survey, that some traits are influenced by climate. There is one mention of the use of toxic substances in one type of assessment.

Cost of registration
Cost of registration is reported several times, but by only one breeder, except an example of a two-line variety with double costs.

5.4.2 DUS challenges (vegetables)

Most of the reported vegetables are open pollinated population varieties

Carrots

- Diverse problems with uniformity, some of the assessed parameters for uniformity are not relevant for farmers, processors or consumers

Kohlrabi

- Sometimes problems with uniformity, some of the assessed parameters for uniformity are not relevant for farmers, processors or consumers

Broccoli

- Very hard to reach uniformity in open pollinated populations

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- Some of the assessed parameters for uniformity are not relevant for farmers, processors or consumers

Tomato
- Uniformity e.g. in resistances
- Trial locations

Cauliflower
- Uniformity in DUS criteria
- Some of the assessed parameters for uniformity are not relevant for farmers, processors or consumers

Brussels sprouts
- Uniformity in DUS criteria.
- Some of the assessed parameters for uniformity are not relevant for farmers, processors or consumers

Sweet corn
- To reach uniformity in the 38 required DUS criteria. Many of them are not relevant or agronomically important. Up to now, only one sweet corn population variety has been registered yet. The main challenge is the high level of uniformity required for all DUS criteria. Even with intensive methods of population improvement, as we applied them in the last years, we do not think that we will be able to reach the required homogeneity required by CPVO

Leek
- Uniformity in DUS criteria
- Not all criteria used in DUS protocols are relevant for market and could be replaced by more relevant criteria

Lettuce
- Challenge to have uniformity of large set of resistance traits

A summary of the challenges reported on vegetables in the survey:

Uniformity
The requirements are too strict.

Criteria for assessment of uniformity
The relevance of the criteria for assessing uniformity is questioned. And uniformity in resistance traits is a specific challenge.

Trial locations
Trial locations are mentioned for tomato and zucchini squash.

5.4.3 DUS challenges (fruit trees)

Apple
- very high costs for registration, without any guarantee that market will accept the variety afterwards

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5.5 DUS and registration procedure challenges, interviews

In the process of "D.2.1 Overview on the current organizational models for cultivar testing for Organic Agriculture over some EU countries" not many challenges regarding DUS were reported from the people in charge of cultivar trials and official trials. In some cases, because there was no national option to perform DUS tests, or because there was no organic breeding. In some cases there were positive experiences.

Interviews were performed by personal communication and with a number of organic breeders by Kaja Gutzen, visit Kajas Master's Thesis for detailed transcripts[42].

According to Kaja Gutzen: "Two conflicting views regarding the DUS system can be identified: Some interviewed breeders express the wish to lower the number of testing criteria, whereas others wish to include additional criteria, such as taste, to highlight a special distinctness of a variety. Interviewed coordinators do not have a strongly biased view. In general, interviewees do not criticize the DUS system per se, as it is important for identification of a variety and as it acts as a consumer protection law. However, interviewed breeders criticize that the combination of variety protection and identification of a variety has led to a rigid system with low tolerance levels. This rigid system restricts the access of varieties to the market, and thus, contributes to the loss of agricultural biodiversity."

Reported challenges by cereal breeders:

- Problems occur when maintaining under organic conditions and DUS-testing under relatively high fertilization conventional/traditional farming – suggestion to test organic
- A variety was rejected, because it had minor differentiation in the waxy layer of the hulls and more differentiation in length under intensive growing at the seed office station
- Specialized crops for specific purposes do not meet demands of uniformity
- Trade-off between uniformity level and inbreeding depression for open pollinated varieties (vegetables)
- OP varieties are heterogenous by nature and the uniformity criteria need adjustment
- DUS criteria are not made to be relevant, but to distinguish cultivars, and the criteria are not relevant/important to farmers, processors, traders etc.
- Cost of registration compared to market size
- Toxic substances used for observation of specific trait
- Different day length and temperature at trial site influence criteria
- Isogenic lines tested single with double costs
- Lack of uniformity in resistance traits
- The use of Markers for characterizing means a loss of diversity (spelt)

Fruit is a special case and is different from arable crops and vegetables. Due to the vegetative propagation there are no issues with homogeneity. But the registration process is a challenge.
The registration for plant variety protection of a table fruit variety is expensive (e.g. 10.000 € plus 1000 € annually). This is financed by royalty from tree sale, but this requires a successful market acceptance of the new cultivar, which is not an easy task. This causes the breeder to limit the registration to a few varieties, but this is not enough to keep up with the market speed.
Introduction of more new varieties would increase the chances of finding varieties that will prove successful in the long term.

[42] https://www.liveseed.eu/wp-content/uploads/2020/02/MASTER-THESIS_Organic-Variety-Testing_Kaja-Gutzen.pdf

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6 VCU test

As set out in the two directives Council Directive 2002/53/EC and Commission Directive 2003/90/EC varieties of agricultural crops must pass a test for Value for Cultivation and Use (VCU). This is not the case for other crop groups.
A variety "shall be regarded as satisfactory if, compared to other varieties accepted in the catalogue of the Member State in question, its qualities, taken as a whole, offer, at least as far as production in any given region is concerned, a clear improvement either for cultivation or as regards the uses which can be made of the crops or the products derived there from. Where other, superior characteristics are present, individual inferior characteristics may be disregarded."

6.1 VCU criteria

Criteria to be considered are defined in Annex 3 of Council Directive 2003/90/EC:

- Yield;
- Resistance to harmful organisms;
- Behaviour with respect to factors in the physical environment
- Quality characteristics.

6.2 Protocols

The general definition of VCU provides member states with flexibility regarding the exact testing procedures and possibility to adapt to specific conditions and needs. The legislation allows for the adaption of protocols for organic VCU-testing.

6.3 Survey results organic breeders

A survey was distributed among organic breeding companies, LIVESEED partners and ECO-PB members (and also to ECOBREED and BRESOV partners) in order to collect information on challenges experienced in the past with the registration of organic varieties and at the same time they were asked to suggest candidate crops for the upcoming temporary experiment.
Below the reported challenges from VCU trials and by the specific crop or crop group in mention. Most of the reported cultivars are open-pollinated varieties, inbred lines but also clones, multiline and synthetic varieties.

6.3.1 VCU challenges (only agricultural crops)

Winter wheat:

- Cost of registration due to breeding goals being different to standard traits assessed in registration
- Important traits are not being evaluated in existing VCU trials
- No specific organic VCU in some countries
- Organic cultivars perform different under conventional testing
- Highly relevant traits for organic are not taken into account as criteria in the (organic) VCU tests in Germany: in particular the resistance to seed borne diseases such as common bunt or loose smut
- Too long straw compared to modern

Spring wheat

- Too long straw compared to modern

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- Harvest level

Durum wheat:
- Cost of registration due to breeding goals being different to standard traits assessed in registration
- Performance under conventional testing does not correspond to performance under organic

Rye:
- Cost of registration
- No organic VCU available, has to compete with hybrid rye
- Open-pollinated varieties have to compete against (conventional) hybrid varieties as reference varieties; currently there are no organic VCU trials in Germany, yield stability and yield potential under low input conditions are not sufficiently taken into account
- Too long straw compared to modern

Oat:
- Cost of registration due to breeding goals being different to standard traits assessed in registration

Barley:
- Reduction of light competitiveness of organic bred varieties, because of up to three times of harrowing, which destroys the fast-growing types and additional type of resistance to seed transmitted diseases
- Current VCU does not include specific traits important for organic, e.g. competitiveness against weeds; there is no request to use organic seeds, no proper evaluation of seed borne diseases
- Cost of registration due to breeding goals being different to standard traits assessed in registration
- Highly relevant traits for organic are not taken into account as criteria in the (organic) VCU tests in Germany: in particular the resistance to seed borne diseases such as loose smut and barley leaf stripe.

Spelt:
- Cost of registration due to breeding goals being different to standard traits assessed in registration
- Straw length

Foxtail millet and Proso millet:
- Cost of registration

Maize (for grain and silage)
- No VCU trial with OPV reference varieties seems to be available
- Performance under conventional testing does not correspond to performance under organic, e.g. ultra-earliness for organic double cropping systems - lower yield vs. late high yielding varieties for conventional mono cropping + Important traits are not being evaluated in existing VCU trials
- Seed of reference varieties used in VCU trials represent uneven competition (conventional seed vs. organic seed) e.g. seed treatment

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Sorghum

- Testing requirements not realistic and holding back innovations based on small scale breeding
- Daylength, cold tolerance and sea climate are not anticipated: VCU testing is performed far from the region of origin, and the variety traits are not expressed in the same way in the VCU trials as in region of origin

Sunflower

- Seed of reference varieties used in VCU trials represent uneven competition (conventional seed vs. organic seed)
- Daylength, cold tolerance and sea climate are not anticipated: VCU testing is performed far from the region of origin, and the variety traits are not expressed in the same way in the VCU trials as in region of origin

Pea for mixture

- VCU are only in pure stand in most countries except Austria
- Pure growing conventional gives no description for organic mixed growing (with barley for early and triticale for late peas)

Winter pea

- Winter hardiness is not tested + pure growing conventional gives no description for organic mixed growing (with barley for early and triticale/rye for late peas)

Spring pea

- Testing only in pure stand and not in mixture with cereals, which is the main cultivation method in organic farming. No specific testing of organic varieties, even if the breeding institute exclusively breed varieties for organic and low input agriculture

Potato

- Performance under conventional testing does not correspond to performance under organic. Traits as virus resistance, competition with weeds and quality.

In summary the survey indicated some common issues, country- and crop-specific issues, issues related to size of breeder and cultivar type e.g. old varieties, mixtures.

Small market size vs. high demands/costs

The cost of registration and level of testing requirements is a challenge for small scale breeding and can prevent innovations in breeding for niche production and small-scale production. It should be noted that although cost of registration is represented several times in the survey – these are all statements from the same breeder. The market size is also hampered by the lack of request to use organic seed, which may be related to the country specific differences in implementation of the EU regulation on the use of organic seed.

Lack of nearby VCU trial sites

VCU performed far from region of origin causes traits to be expressed differently than in region of origin.

Lack of organic VCU trials

Cultivars perform different under organic and conventional conditions and important traits are not evaluated in conventional trials (e.g. competitiveness against weeds). Reference varieties used in VCU trials represent uneven competition, due to variety and seed type. Yield stability and yield potential

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under low input conditions are not sufficiently taken into account. Not enough emphasis is put on other traits than yield.

Organic VCU trials shortcomings
Important traits are not being evaluated e.g. resistance to seed borne diseases such as common bunt or loose smut, barley leaf stripe. Repeated harrowing destroys fast-growing and competitive types.

Crop-mixtures tested in pure stand
Testing only in pure stand for crops that are grown in species-mixtures.

6.4 Interviews with organic breeders and variety officials

6.4.1 VCU challenges

In the LIVESEED report "Overview on the current organizational models for cultivar testing for Organic Agriculture over some EU countries" interviews were conducted in 15 countries regarding cultivar testing including VCU testing for organic agriculture. The countries in table 7 had implemented organic VCU trials or supplementary organic trials in parallel with conventional trials, and the rest did not have organic VCU trials. Variety officials or other responsible persons were interviewed.

Table 7. Countries with organic VCU trials

Country	Organic trials	Supplementary organic trials
Germany	x (wheat, barley, oat)	
Austria	x (winter wheat)	x (several crops)
Denmark	x (winter wheat)	
France		x (winter wheat)
Latvia		x (several crops)
Switzerland		One organic location

SWOT analyses for the five first mentioned countries in table 7 were made based on the information provided in the interviews with variety officials and the following challenges were located:

- Expensive if only few varieties are available
- Application fee not compatible when small market size
- Financing in some countries depend on political landscape
- Double price due to both conventional and organic trials (e.g. LV)
- Few organic locations
- No assessment of seed borne diseases (except AT)
- No assessment of weed competitiveness (LV)

Interviews were performed by personal communication and with a number of organic breeders by Kaja Gutzen, visit Kajas Master's Thesis for detailed transcripts[43]

In summary the challenges experiences by breeders and variety officials

- In some countries no possibility for organic VCU
- Low demand for trials in many species -> higher expenses

[43] https://www.liveseed.eu/wp-content/uploads/2020/02/MASTER-THESIS_Organic-Variety-Testing_Kaja-Gutzen.pdf

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- Lack of infrastructure for organic trials
- Organic cultivars perform differently in conv. trials
- Important traits not evaluated in existing trials e.g. seed borne diseases
- OP varieties compared to hybrids as references
- Reference varieties from conventional seed – uneven competition[44]
- Cost of registration compared to market size
- Harrowing destroys fast growing competitive cultivars
- Testing requirements not realistic for small scale breeding – prevent innovations
- Testing site far from region of origin – variety traits are not expressed the same
- VCU in pure stand only – mixture often used in organic
- Spelt – trials with long intervals
- Too much focus on yield and induced diseases
- VCU testing takes place on high-yielding locations, this is challenging when assessing baking quality which depends on the fertilization level of the soil.

7 Temporary experiment

7.1 Temporary experiment – legal provision and process

A temporary experiment on organic varieties is expected to start late 2021 and run for a period of seven years.

EU regulation 2018/848
*"(39) In order to meet the needs of organic producers, to foster research and to develop organic varieties suitable for organic production, taking into account the specific needs and objectives of organic agriculture such as enhanced genetic diversity, disease resistance or tolerance and adaptation to diverse local soil and climate conditions, **a temporary experiment should be organized**.... That temporary experiment should be for a term of seven years, should involve sufficient quantities of plant reproductive material and should be subject to yearly reporting. It should help to establish the criteria for the description of the characteristics of that material and to determine the production and marketing conditions for that material."*

The Commission has started a process to gather experts for ten subgroups of experts to establish adapted DUS protocols, together with the CPVO, for organic varieties.
The subgroups will discuss the establishment of adapted DUS protocols before the start of the temporary experiments. Each group is expected to have five members or more including a CPVO expert, Member States experts and stakeholder representatives accompanied by a representative from DG Sante.
Participating Member States will be authorised to derogate from certain existing legal provisions on DUS and VCU testing.

7.2 LIVESEED suggestions

LIVESEED recommends that the temporary experiment should include both DUS and VCU.
At the beginning of the temporary experiment adapted DUS and VCU protocols should be developed for relevant species, starting with a few species as suggested by the Commission. More species should be included during the 7 years experiment, in order to include all relevant species. For minor

[44] https://orgprints.org/14227/

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specialized crops with only limited marked share it may also be relevant to investigate if DUS and VCU criteria can be integrated, or if VCU can be voluntary.

For the temporary experiment LIVESEED recommends using the existing DUS trial sites, as it is not realistic to have organic trial sites for this purpose. In some cases, observations could be carried out at breeder´s locations.

The habitual thinking of examination offices, and proper implementation for open pollinated varieties should be challenged.

An added goal of the temporary experiment could be to get experience of usability of adapted DUS protocols for testing also for variety protection.

For VCU trials it would be valuable to test if new low-cost organization models for organic variety trials proposed in LIVESEED Deliverable 2.3 can be used to supplement official VCU-testing of organic varieties, and this would include also the suggested crop-specific testing protocols.

In the temporary experiment it should also be investigated how to ensure relevant and equal reference varieties for both VCU and DUS testing.

Different types of cultivars that are in the grey zone between the categories of OHM and organic varieties should be tested in DUS tests to define methods to distinguish between them. This could be by use of trait frequencies.

All candidate crops that enter the temporary experiment should be described by their potential value in organic farming and also how they differ from conventional varieties in the level of heterogeneity.

Besides adjustment for DUS and VCU the temporary experiment could also embrace experiences on how to ease the procedure of registration for some species. As an example, the DUS for registration of apple would cost around 10’000 € and breeders need to obtain virus free grafts from defined nurseries. In Germany there is a simple registration procedure allowing to market only a few trees. This allows for the breeder to identify the market potential of the variety. In case of good performance under organic practice it would be desirable to have an upgrading of the variety allowing to market larger number of trees in a stepwise manner.

Overall, according to LIVESEED the temporary experiment should cover criteria for description of organic varieties and determine the conditions for the production and marketing.

DUS – adaptation of protocols and procedures, Plant Breeders Right to be discussed

VCU – adaptation of protocols and procedures, voluntary/obligatory

Registration procedure – rethink procedures – e.g. test market potential

Working definition OV – variety type, breeding methods, parent material, years organic..

Certification of the organic breeding process

Seed marketing and labelling

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7.3 Proposed pathway for registration of organic varieties

In figure 7 a proposed pathway for registration of cultivars for organic farming is outlined disregarding conservation and amateur varieties. Conventional breeding and varieties originating from pure conventional breeding programmes follow the red arrows and can result in organic seed of conventional varieties, if seed is propagated under organic conditions for a year. Part of the conventional breeding program can also be organic, and the result would be varieties bred for organic farming following the light green arrows in normal DUS and organic VCU. The option of organic VCU may not always be available though.
Organic breeding and cultivars originating from organic breeding activities are marked with dark green arrows. Cultivars can be either OHM or organic varieties specifically adapted to organic growing conditions. OHM will require a notification with no demand for DUS or VCU trials. Organic varieties are proposed to be tested in DUS and VCU trials, that are adapted to organic conditions depending on the cultivar type.
More homogeneous variety types may not need adapted protocols, and there should still be an option to test the organic variety in traditional DUS trials if the breeder wishes to pursue variety protection.

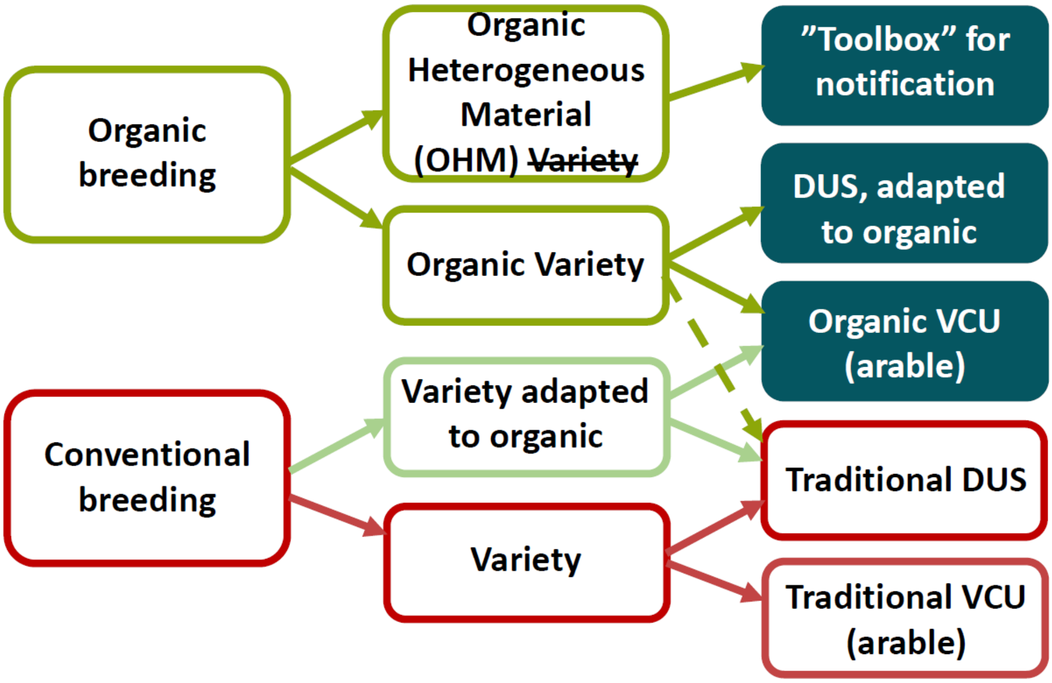

Figure 7. Pathway of registration procedures for organic varieties and organic heterogenous material.

7.4 Candidate crops for temporary experiment

A list of candidate crops for the temporary experiment has been collected after a LIVESEED partner and stakeholder consultations including ECO-PB members. Based on this list of around fifty species a recommendation list of candidate crops was provided to the Commission.

The crops were prioritized by the LIVESEED group based on economic and agronomic importance in organic farming, challenges experienced with DUS and VCU testing and available candidate varieties or breeding lines. For the agricultural crops some of them are mostly challenged on the VCU testing and others on both DUS and VCU testing.

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The agricultural crops had most respondents, and they are listed in table 8. In addition to the breeders mentioned here, there are several more breeding initiatives that could possibly provide candidates for the upcoming experiment.

Table 8. List of candidate agricultural crops. The list is not exhaustive.

Species and pollination type	Breeders that may contribute with breeding lines, own trials, advice or discussions
CEREALS	
Winter wheat, *Triticum aestivum* (self-pollinating)	Getreidezüchtung Peter Kunz (CH) Forschung & Züchtung Dottenfelderhof (DE) Saatzucht Donau GesmbH & CoKG (AT) Agrologica (DK) UBIOS (FR) NARDI Fundulea (RO) M. Selenius (FI)
Winter rye, *Secale cereale* (cross-pollinating)	Forschung & Züchtung Dottenfelderhof (DE) Agrologica (DK) M. Selenius (FI) ÖkoBeratungsGesellschaft (DE)
Spring and winter barley, *Hordeum vulgare* (self-pollinating)	Forschung & Züchtung Dottenfelderhof (DE) Agrologica (DK) Cultivari Getreidezüchtungs-forschung Darzau gGmbH (DE) AREI (LV)
Durum wheat, *Triticum durum* (self-pollinating)	Agrologica (DK) Rete Semi Rurali (IT)
Spring wheat, *Triticum aestivum* (self-pollinating)	Forschung & Züchtung Dottenfelderhof (DE) M. Selenius (FI) AEGILOPS (GR)
Oat, *Avena sativa* (self-pollinating)	Agrologica (DK)
Winter and spring spelt, *Triticum spelta* (self-pollinating)	Getreidezüchtung Peter Kunz (CH) Agrologica (DK) M. Selenius (FI)
Triticale, *Triticum secale* (self-pollinating)	Getreidezüchtung Peter Kunz (CH)
Emmer, *Triticum dicccocum* (self-pollinating)	Getreidezüchtung Peter Kunz (CH)
Foxtail Millet, *Setaria itálica* (self-pollinating)	Agrologica (DK)
Proso Millet, *Panicum milleaceum* (cross-pollinating)	Agrologica (DK)
FORAGE	
Maize, *Zea mays* (self and cross-pollinating)	Forschung & Züchtung Dottenfelderhof (DE) M. Raaphorst (NL) NARDI Fundulea (RO)

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Sorghum, *Sorghum spp.* (self and cross-pollinating)	W. A.J. de Milliano and E. de Meijer (NL) M. Raaphorst (NL)
Lucerne, *Medicago sativa*	Agroscope, CH
OIL	
Sunflower, *Helianthus annuus* (self and cross-pollinating)	M. Raaphorst (NL) Getreidezüchtung Peter Kunz (CH) NARDI-Funduela (RO)
LEGUME	
Pea, *Pisum sativum* (Self-pollinating)	Cultivari (DE) M. Raaphorst (NL) Getreidezüchtung Peter Kunz (CH) AREI (LV)
Soybean, *Glycine max* (Self-pollinating)	Saatzucht Donau GesmbH & CoKG (AT)
White lupine, *Lupinus albus* (mainly self-pollinating)	FiBL (CH)
Faba bean, *Vicia faba* (partial self and cross pollinating)	Öko-BeratungsGesellschaft (DE)
Lentil, *Lens culinaris Medik.* (Self-pollinating)	D. Paolo (IT)
POTATO	
Potato, *Solanum tuberosum* (vegetative multiplication, and can be OP as TSP)	R. Ruiz de Arcaute/ NEIKER, Spain (E)

In addition to the agricultural crops, vegetable species of carrot, kohlrabi, broccoli, cauliflower, zucchini, red beet, sweet corn, brussels sprouts, leek, pumpkin, eggplant, cucumber, sweet pepper, hot pepper, onion, celery, cabbage, lettuce, swiss chard, parsnip, bean and chicory have been suggested. Of the vegetables, carrot, kohlrabi, broccoli, tomato, cauliflower, pumpkin and lettuce were by the LIVESEED group chosen as main priorities. Seed and effort can be provided by Bingenheimer Saatgut (DE) for carrot, kohlrabi and tomato, tomato can also be provided by M. Petitti/G. Campanelli (IT) and cauliflower from France (contact F. Rey), brussels sprouts by J. Hons't Eikelenhof, sweetcorn by Sativa and leek by G. Lambrecht/L. Mertens.

Apple can be provided by PomaCulta and was also chosen as a priority species by the LIVESEED team.

Most respondents can deliver seed material for the beginning of the temporary experiment, and some later in the 7-year period. Some are willing to provide only seed, others can contribute with own trials, expertise and involvement in discussions. The level of engagement will also depend on the financing options.

7.5 Priority species

The Commission has chosen ten priority species, identified by Member States and stakeholders in a consultation process spring 2020.

1. Wheat
2. Rye

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3. Maize
4. Soybean
5. Potato
6. Carrot
7. Kohlrabi
8. Tomato
9. Onion
10. Alfalfa/lucerne

The chosen crops are important crops in organic agriculture. And it is expected that the temporary experiment will be expanded to other important crops as well. Faba bean is another important candidate.

7.6 DUS experiences from Bingenheimer and Naktuinbouw

In the Netherlands an exploratory one-year investigation of organic varieties in **carrot** and **kohlrabi** received funding from the Raad voor plantenrassen - the Dutch registration authority. The investigation is a preparation for the upcoming Temporary experiment for organic varieties, and fortunately carrot and kohlrabi have also been chosen as priority species for the Temporary experiment. The project is led by Abco de Buck from Louis Bolk Institute and Gebhard Rossmanith from Bingenheimer Saatgut on behalf of ECO-PB; the European Consortium for Organic Plant Breeding.

The overall aim of the project is to support the market access of organic varieties. The more specific purpose is to explore possibilities for adaptation of DUS protocols for registration of organic varieties with a more heterogeneous character; in this case two Open Pollinated varieties of carrot and kohlrabi.

This includes an inventory of new and existing elements; for instance:

- focus on the distinction of a variety over uniformity and stability in reproduction
- focus on a limited set of characteristics that is homogeneous as well as important for the market
- only use morphologic and plant-architectural traits that are uniform
- quantitative or qualitative description of degree of heterogeneity of certain traits; what would be an acceptable bandwidth or acceptable frequencies of deviations from the average?
- flexibility to include unique traits in the variety description
- flexibility in different sets of criteria for sub-types of the crop
- a distinct protocol for variety registration, that allows heterogeneity on some characteristics and a more strict protocol on uniformity for the entitlement of Intellectual Property Rights

The suitability and practicability of alternatives to the current UPOV protocols for DUS research are addressed for application of two organic cultivars in vegetable species. Kohlrabi ad carrot are chosen as species with many different properties that serve as a model for many other vegetable species. Kohlrabi is chosen as an ‘easy’ crop (relatively few characteristics) in the ‘difficult’ category of cross pollinators. Carrot is a commercially important ‘difficult’ crop in the ‘easy’ category. It is a ‘difficult’ species, because carrot varieties are rather heterogeneous by nature; even hybrid varieties (although less than OP varieties, obviously).

Two kohlrabi cultivars and two carrot varieties (OP) of the Nantes 2 type were included under real conditions in the DUS fields at Naktuinbouw and treated as regular candidate varieties. This implies

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that they are compared with reference varieties of the OP type. A parallel trial was conducted in Bingenheim, to compare experiences. The proposed new elements of an alternative protocol are discussed with Naktuinbouw, other national registration authorities and breeders.

With the help of organic farmers and organic breeders, the existing DUS characteristics (UPOV/CPVO) were classified according to usefulness for the users (farmers, traders, processors, consumers). The priority is to come to a limited set of characteristics that are important for production and market for mandatory evaluation. Other characteristics (e.g. botanical traits) within the official protocol should be optional on request of the applicant when they are needed for distinction.

			relevance of utility for			importance for selection	ECO-PB proposal for adapted protocol	
UPOV Nr.	asterix characteristics	characteristics of the UPOV protocol for carrots usable for fresh market (bundling and marketing with leafs)	farmers / producers	trade / processors	consumers	organic carrot breeders	Characteristics to be considered mandatory	characteristics to be considered optionally on request (or recommendation) of the applicant
			(0=none, 1=medium, 2=great)			(0=none, 1=medium, 2= great)		
2		Leaf: attitude	2	1	0	1	1	0
4	(*)	Leaf: division	0	1	0	1	0	1
6	(*)	Leaf: anthocyanin coloration of petiole	0	1	0	1	0	1
14	(*)	Root: external colour	1	2	2	2	1	0
17		Root: extent of green colour of skin of shoulder	2	2	2	2	1	0
18		Root: ridgning of surface	2	2	1	2	1	0
19	(*)	Root: diameter of core relative to total diameter	0	1	1	2	0	1
22	(*)	Root: colour of cortex	1	2	1	2	1	0
25	(*)	Root: extent of green coloration of interior (in longitudial section)	2	2	2	2	1	0
31			*characteristics in total:*				20	11

Figure 8: Example of the carrot protocol, and how criteria have been characterized by their relevance to different actors and how they have been divided in mandatory and optional criteria.

Procedure

1. Examination of the official testing protocols (CPVO / UPOV) of the chosen crops with the aim to differentiate the traits regards to:
    a. Expression of characteristics:
        i. genetically: recessive / dominant;
        ii. phenotypically: qualitative / quantitative /pseudo quantitative
    b. Standard - criteria / asterisk - criteria
    c. Value for producers / trade / processors / consumers – or only for distinction
    d. Focus of breeding activities

2. Developing of proposals for reduction of traits to be used in registration tests with the aim to focus on traits with intrinsic values for variety users. New categories for testing:
    a. **Mandatory criteria**: used for decision (see under 3a).

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   b. **Optional criteria** (not mandatory): ***not used*** for decision (derogation see under 3c)

3. Set up **codes of practice** for handling with reduced protocols:
   a. Adequate uniformity in case of **mandatory criteria**: description and distinction of a new variety must be ensured.
   b. **Optional criteria** should be described too, but not used for decision. Therefore, a normal uniformity is not requested. Descriptiveness see under 4.
   c. In case of not enough distinctness within the scope of **mandatory criteria** additionally use of some **optional criteria** might be allowed for distinction. But these chosen criteria must show normal uniformity as demanded for distinctness.

4. Developing of proposals for **more flexibility** regards to relative uniformity:
   a. No use of parameters for comparison as value testing (equal or better value).
   b. Description possible by using frequencies (in case of optional criteria).

5. Management of stability demand regards to small changes (frequently noticeable at population varieties) within ten years, with the aim to enable adaption of the variety description. Precondition: the individuality of the mentioned variety is guaranteed furthermore, which means: no identity to another existing variety is generated by the realized change. And in case of mandatory criteria the changed trait must show enough uniformity again.

Experiences learned:
First results from the trials indicate that the UPOV protocols, as practiced by Naktuinbouw, to a large extent (but not completely) are sufficient for the registration of Open Pollinated organic carrot varieties. One cultivar (an existing amateur variety with very good properties for professional organic farmers) does not meet the uniformity standard for some traits. The other carrot cultivar is a new breeding line that probably would pass the current DUS examination.
The kohlrabi trial yielded interesting results. Quite some leaf characteristics were not uniform (enough), while traits that are important for the market were sufficiently uniform.
The results of the DUS examination for the two model species will be used to design an alternative protocol according to the proposed new and existing elements and procedure.

7.7 DUS - Suggestion for adaptations of protocols and registration procedures

Open pollinated cultivars are less uniform and adjusted DUS-protocols could potentially foster increased release of varieties.
In the temporary experiment it should be investigated if uniformity requirements can be adjusted to also fulfill requirements for quality, and thresholds for uniformity should be tested to investigate if they can allow more adaptation and yield stability. Assessments should be restricted to morphological traits with no effect on yield stability.

The suggestion from the above investigation is that a set of mandatory criteria should ensure the distinction of the variety. Optional criteria should also be described, but not used in the decision of registration, but then they are available in case they will be needed later. If distinction is not sufficient in the mandatory criteria, selected optional criteria should be used for the distinction. The criteria used for distinction should be sufficiently uniform to ensure distinction.
And the use of only mandatory criteria would allow less uniformity in the optional criteria.

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The use of frequencies of traits in the DUS test should be investigated and defined with the registration offices to allow variability in protocols. The lucerne protocol can be used as a case. Here the variety can be compared to example varieties and the number of plants with certain traits is registered. This adapted protocol-type can be tested in species/cultivar types with different level of homogeneity.
And the frequencies of traits can also be tested on regular varieties versus OHM that are in the grey zone, where it may be difficult to distinguish.

Open-pollinated varieties are not necessarily stable over time, and it could be discussed during the temporary experiment whether there should be a possibility for adapting the variety description in case of changes in non-essential criteria over a ten-year period.

Even for more homogeneous cultivar types the temporary experiment should explore if it is meaningful to adapt the DUS protocols. VCU protocols may need more adaptation for these cultivar types – depending on the region and the species.

For the temporary experiment existing DUS trial sites should be used, as it is not realistic to have organic trial sites for now. For expressing genetic differences, normally the conventional trials sites will in most cases be useful. But in special cases where certain traits are not expressed clearly enough it could be investigated if trials can be set up differently or be supplemented with observations under organic field conditions, e.g. at the breeder's own trial sites – but this would require that the reference varieties would also be grown at the breeders site. To make experiences on that issue it might be useful to carry out some experiments in parallel: official conventional site and organic (breeder's sites)

References/standard varieties used for DUS-protocols should be reconsidered for organic cultivars. It is important to use the same cultivar types for the test.

It should also be investigated if it is possible to allow more parameters, including marker analysis, for distinctness.

Fruit
It is recommended to test a two-step procedure, with a provisional registration for a limited number of years e.g. 10 years of cultivation, with a limited number of trees. This would make it possible to test both cultivation and consumer acceptance. The fees for such a registration would be much lower than the regular fee. And the breeder would have the possibility, after end of provisional registration, to apply for a normal registration with plant variety protection if it proves successful. This two-step procedure would increase the number of good varieties.

7.8 Plant Breeders Rights and organic varieties

The granting of Plant Breeders Rights is an extremely important part of the financing model for conventional breeders, and it can also be an important source of financing for organic breeders who rely on seed royalty to partly finance breeding programmes, and within some crop species this may become increasingly important as seed sales are rising with increasing organic land use. This type of financing is often not sufficient though, and in some cases not suitable for existing organic breeding initiatives. To foster agrobiodiversity organic breeding initiatives breed a range of different crops with a small market share and instead they rely on involvement of and investment from other parts of the value chain – including stakeholders as farmers, processors, retailers or consumers in the local community. Therefore, new types of financing arise without the reliance on seed license from Plant Breeders Right for financing.

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In addition to the intrinsic challenge of financing of organic plant breeding, the Plant Breeders Rights rely on varieties being uniform and stable, whereas organic breeding in many cases would foster cultivars with a higher degree of genetic diversity. In the case DUS protocols require adaptation to embrace more heterogeneity, this would pose a challenge for the granting of Plant Breeders Rights, where demands for stability and uniformity are very high.
In order to solve this inherent entanglement of national listing and protection of varieties, it is proposed by LIVESEED to disconnect DUS for these two purposes respectively, in regard to adapted protocols for organic varieties. With this proposal no Plant Breeder's Rights will be granted for varieties approved with adapted DUS-protocols for organic, but the discussion should be kept open for the temporary experiment. If the organic breeder then wishes to pursue variety protection the variety must conform to conventional standards of uniformity and the variety must pass the conventional DUS instead. This will keep both options open for the breeder. Organic varieties should under no circumstances be open for patenting.

7.9 Distinction between OHM and organic varieties

In the new organic regulation (EU 2018/848), the two new categories of organic plant reproductive material "Organic Varieties" and "Organic Heterogeneous Material (OHM)" are both *"characterised by a high level of genetic and phenotypic diversity between individual reproductive units."*

However, in draft delegated act (released by the European Commission in January 2021), it is clearly stated that "*Organic heterogeneous material is characterised by its high level of phenotypic and genetic diversity, and its dynamic nature to evolve and adapt to certain growing conditions. (…) organic heterogeneous material is intended to adapt to various biotic and abiotic stresses due to repeated natural and human selection and therefore is expected to change over time".* In other words, Organic heterogeneous material has a high degree of heterogeneity that cannot meet the requirements of a DUS, it is neither Uniform nor Stable. There is a clear intention that this material is able to evolve and adapt over time and/or growing conditions. For this category, seed suppliers are guarantying to users an identity (based on the origin, history and traceability of an OHM and a certain seed quality (sanitary, analytical purity and germination).

Organic Varieties are defined as plant varieties according to EU 2100/94 and thus "*considered as a unit with regard to its suitability for being propagated unchanged*". For this category, seed suppliers are guarantying to users a variety that can be described and whose characteristics of interest are stable over time. If there is a VCU testing, a certain level of performance is also guaranteed.

This means that the "intention" of a seed supplier in putting an OHM or an organic variety on the market is different. The guarantees provided to end users are not the same for these two seed categories, nor customers' expectations.

However, despite this, it would be beneficial to test the distinction between the two categories during the temporary experiment. During the temporary experiment LIVESEED recommends testing different types of cultivars that are in the grey zone between the two categories in DUS tests to validate methods to distinguish between them and describe them. This could be by use of trait frequencies.

7.10 VCU - Suggestions for adaptation of protocols

Several variety offices took part in the COST860 – SUSVAR Action chaired by Hanne Østergaard (Risø National Laboratory, Denmark) developing the "Handbook on Cereal variety testing for organic and

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low input agriculture"[45], published in 2006, and more chapters were added later. The book was edited by Dingena Donner (Plant Variety Board, Netherlands) and Aart Osman (Louis Bolk Institute, Netherlands). This handbook gives a step by step guide to trial setup and statistical analysis, weed competitiveness, disease assessment, evaluation of lodging, nutrient use efficiency and processing quality in organic and low input agriculture. These methods are still applicable and can be recommended for starting up organic trials. Besides this Handbook, in LIVESEED D2.3 "Frugal, multi-actor and decentralised cultivar evaluation models for organic agriculture: methods, tools and guidelines", crop-specific protocols have been developed for inspiration.

For the temporary experiment it is recommended that testing protocols from "Handbook, Cereal variety testing" is implemented if existing organic trial sites are available.
Thresholds for diseases should be discussed for each species of concern during the temporary experiment, as there may be a need to adjust thresholds when organic growing conditions are applied.

If no possibility exists for organic trial sites, it should also be investigated if conventional trials can be adapted to better describe important traits for organic varieties. Trials can be set up with low input and no pesticides as a first step. In Denmark there are separate locations for yield trials and plots for disease assessments, where half of the plots are untreated.

It should also be discussed in the temporary experiment whether VCU testing can be optional for minor specialized crops for specific purposes. The return on investment for breeders on such cultivars is very low, and it is difficult to finance both VCU and DUS trials for such minor crops. And there might not be any proper reference varieties, and the crop might fail the test, if for instance a cereal for food purposes is compared directly to feed cereal.
VCU testing is normally important for the farmers, but for such specialized crops it may be of less importance.

In the following text examples of organic VCU trials from Austria, Germany and Denmark is proposed as inspiration for adaptation of VCU protocols for organic.

Austria
In Austria weed competitiveness and resistance against common bunt with artificial infestation are assessed in organic VCU trials only. If a variety is resistant to common bunt it is registered independently of other characteristics, because of the great importance of this resistance. Nitrogen use efficiency is an important parameter in organic trials and has also been included in conventional trials since 2017[46].

In the following paragraph, only the additional parameters concerning weed competitiveness in trials under organic conditions are described, which are performed in Austria in winter common and spelt wheat:

At BBCH 28 the rate of coverage (percentage scale) is estimated the first time. There only the covering due to the crop should be estimated. The covering of weeds should not be included in this estimation.

At BBCH 31-32 the rate of coverage is estimated the second time. Furthermore the "canopy height during shooting" (cm) is measured the first time.

[45] https://library.wur.nl/WebQuery/edepot/182385
[46] https://www.baes.gv.at/amtliche-nachrichten/kundmachungen/saatgutgesetz/

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At BBCH 34-47 the measurements and estimations of BBCH 32 are undertaken once more time. Furthermore, the frequency of plants with recurved flag leaves is judged with the scale 1-9.

1 all flag leaves are rectilinear
3 about ¼ of the plants with recurved flag leaves
5 about ½ of the plants with recurved flag leaves
7 about ¾ of the plants with recurved flag leaves
9 all flag leaves are recurved

Non useful is the growth habit during tilling. In addition to these parameters variety rank orders were established. The competition potency is defined by a number of characteristics.

The reaction of the genotypes has been similar in the different environments. However, variety by location interactions appeared.

So concerning weed competitiveness in Austria the following parameters are investigated:

Rate of coverage (BBCH 28)	%
Rate of coverage (BBCH 31-32)	%
Canopy height (BBCH 31-32)	cm
Rate of coverage (BBCH 34-47)	%
Canopy height (BBCH 34-47)	cm
Frequency of plants with recurved flag leaves	1-9

Denmark

In Denmark there have only been few organic VCU trials so far. In spring barley trials are carried out on four locations and weed coverage is assessed two-three times during the growing season. Straw length is measures and in spring barley weed competitiveness is also assessed by digital photos taken in the field at an early stage, before weeds are significantly present[47]. Photos are analyzed with a computer tool "Imaging Crop Response Analyser" to determine the percentage of leaf cover, which shows good correlation with weed competitive ability. This allows for registrations of weed competitiveness in varieties regardless of the weed cover in the field later in the season.

Germany

In Germany so far cereal varieties are being tested in organic VCU trials. Varieties of winter wheat, spring wheat, winter barley, spring barley and spring oat.

The organic VCU trial series is carried out on 14 locations with four replications.

The trial protocol for observations and measurements in the field is the same as in conventional VCU. Under organic conditions additionally following observations are made:

Ground cover %

The ground cover is assessed in the beginning until the middle of tillering (BBCH 21-25). The ground cover of the plants shall be estimated in %.

Mass during shooting/during juvenile development (1 – 9)

Mass during shooting shall be notified in BBCH 32 – 37.

[47] https://nfts.dlbr.dk/Forms/VisPlan.aspx?PlanID=19152&GUID=15159828-a16f-4e7d-b509-4118b548de11&applLangID=da

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Ground cover and mass during shooting are both means to judge the competitiveness of varieties to weeds.

For most diseases the susceptibility is assessed in field trials, but additional tests are also performed. In winter wheat the varieties are included in an extra series under artificial inoculation for the judgement of Pseudocercosporella, DTR, yellow rust and ear fusarium.

The quality judgement is made on the harvested material from the organic trials.
In winter wheat besides all milling and baking characteristics also the gluten content is analysed and described.

Resistance to seed and/or soil borne diseases are not being performed due to lack of Institution and/or safe methodology.

7.11 Importance of testing in target environment

For a thorough discussion on the need for testing in the target environment Kaja Gutzen did a literature study on this subject in her theses: "Organic Variety Testing – Qualitative content analyses approach to assess organic variety testing, case study of Germany", pp40-43[48].
Comparisons depend on the parameter assessed, cultivar types and species tested.
In some cases, low-input conditions and VCU trials with both conventional and supplementary organic trial sites can provide useful information for certain crop species and for certain traits, but organically managed trial sites are of high priority in the organic sector.
VCU-trials should preferably be conducted on organic soil where only organic fertilizer in limited amounts is allowed and nutrient efficient varieties will have an advantage. Due to the absence of herbicides and fungicides and insecticides there is a higher level of biotic stress and weed competitiveness and diseases can be assessed in the target environment. Disease pressure is expectedly lower due to the lower amount of fertilizer.

7.12 Labelling, certification of organic breeding and marketing of organic varieties

It should be possible to put organic varieties to the market equally to traditionally tested varieties. LIVESEED recommend that these varieties should have a specific label and be marked in the National List as well as in the EU Common Catalogue with "Adapted DUS for organic". The varieties must apply to the above definition regarding years of organic breeding, parent material, breeding methods and adapted testing protocols and a certification of the breeding process should come into place.
Varieties bred for organic farming could have a label "Adapted VCU for organic" or "Organic VCU".
This would make organic varieties more easily accessible within and across borders of Member states, if they can be recognized in the national list and in the EU Common Catalogue.

There should also be a special identification of organic varieties in the organic seed database for organic seeds. But it should not be a prioritization of varieties that are tested with adapted DUS protocols over varieties that are tested with traditional DUS-protocols – this should be the choice of the farmers. Some farmers, including hobby farmers, are seeking varieties with specific qualities, for them strict uniformity might not be an important issue. For other farmers, including professional farmers, uniformity can be important to minimize labor and to satisfy the wishes of large-scale

[48] https://www.liveseed.eu/wp-content/uploads/2020/02/MASTER-THESIS_Organic-Variety-Testing_Kaja-Gutzen.pdf

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retailers. The needs of multiple types of farm productions should be regarded, and the farmer should have free choice in the seed database to choose the better adapted variety for his production type.

7.13 Financing

Organic breeders may be able to finance own participation in experiments, but it will be only a few breeders that will be able to pay for trial costs of such costly trials without reassurance of the outcome. Some breeders have already stated that they can provide own organic trials, seed, knowhow and take part in discussions.
Variety officials are typically underlying strictly cost-efficient systems, and for some offices at least it is expected to be difficult to get their full engagement without financing options.
In order to ensure a widespread engagement in the temporary experiment LIVESEED request financing of trials and experts at EU-level.
This would also allow countries with little breeding activities to participate and gain experience.

8 Conclusion

Easier release of organic varieties is expected to generate new organic breeding initiatives.
The temporary experiment is welcomed by organic breeders to investigate the need for an adjustment in the variety release of organic varieties. In a LIVESEED farmers' survey[49] organic farmers state that the lack of organic seed of locally adapted and suitable cultivars is a bottleneck for organic production. A suitable cultivar is adapted to the specific needs of organic farming systems facing diverse biotic and abiotic stresses. At the same time organic breeding initiatives are challenged to finance breeding activities due to the market size and the nature of breeding initiatives, where a broad range of cultivars are bred to foster agrobiodiversity. Organic breeders cannot finance their breeding solely by royalties and seed sales and must constantly find other means of financing. This challenge also the pursue for registration of varieties with high registration fees and high demands to fulfill the necessary uniformity and stability criteria of the DUS tests.
The incentive for breeders to start breeding for organic adapted cultivars will furthermore be hampered if no possibility for organic testing for value and cultivation exist, and the traits of specific interest in organic farming will not be valued in the registration process.
It is important for the organic sector to exclude genetic engineering techniques in organic breeding and to progressively promote organic plant breeding from parents without use of breeding techniques, not compatible with IFOAM principles, e.g. from artificial mutagenesis such as in oleic sunflower or from interspecific crosses such as disease resistant parents in lettuce or tomato.

49 LIVESEED-D4.1-Report-on-relative-importance-of-factors-encouraging-or-discouraging-farmers-to-use-organic-seed-in-organic-supply-chains.Cpdf .pdf

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