OCL 2024, 31, 8

https://doi.org/10.1051/ocl/2024002

OCL Oilseeds & fats Crops and Lipids

Available online at:
www.ocl-journal.org

RESEARCH ARTICLE OPEN ACCESS

Seeds and plant protection substances for French organic oilseed crops: what are the challenges for tomorrow?☆

Cécile Le Gall[1,*], David Hidrot[2], Pauline Girolami[3] and Patrice Marchand[4]

[1] Terres Inovia, Avenue Lucien Brétignières, 78850 Thiverval Grignon, France
[2] GEVES, 4790 route des Vignères, 84250 Le Thor, France
[3] SEMAE, 44 rue du Louvre, 75001 Paris
[4] ITAB, 149 rue de Bercy, 75595 Paris, France

Received 18 May 2021 – Accepted 8 January 2024

Abstract – Organic production systems rely on different combinations of agronomic levers to ensure their sustainability, notably seeds and crop protection products. These inputs were mostly developed for conventional farming, which is the main market, and then evaluated under organic conditions. However, the growth of organic farming raises the question of producing inputs more specifically designed for this type of production, with its technical constraints, concepts and ethics. Recently, changes to European regulations on organic farming have opened up new perspectives, particularly in terms of varietal selection and evaluation, with introduction of the notions of "organic variety" and "organic heterogeneous material". These two notions challenge and question the concept of variety, as well as the classic methods for evaluating their performance. With regard to crop protection products, a number of products can now be used on oilseed crops, including basic substances, low-risk substances and biocontrol agents but, the list remains limited, particularly for sunflower and soybean. However, new innovations are emerging, particularly in biocontrol agents, which augur new possibilities for controlling diseases and pests for which no solution is currently available. It is therefore necessary to support research in order to provide rapid solutions, and also to ensure that regulations evolve to promote their integration and availability to farmers. The use of inputs (seeds and plant protection products) in organic farming is governed by a number of European regulations, which are sometimes difficult to harmonize.

Keywords: organic production / breeding / seed multiplication / oilseed / crop protection / inputs

Résumé – Les systèmes de production biologiques reposent sur différentes combinaisons de leviers agronomiques pour assurer leur durabilité. Parmi eux, l'utilisation de différents intrants dont notamment les semences et les produits de protection des cultures. Pour la plupart, ces intrants ont été élaborées pour l'agriculture conventionnelle, qui constitue le débouché majoritaire, puis évalués en conditions biologiques. L'essor de l'agriculture biologique pose néanmoins la question de produire des intrants plus spécifiquement élaborés pour ce type de production, ses contraintes techniques mais aussi ses concepts et son éthique. Récemment, les évolutions du règlement européen sur l'agriculture biologique ouvrent de nouvelles perspectives notamment en matière de sélection et d'évaluation variétale, notamment avec l'introduction de la notion de « variété biologique" et de "matériel hétérogène biologique". Ces deux notions bousculent et questionnent le concept de variété ainsi que les schémas classiques d'évaluation de leurs performances. Concernant les produits de protecion des cultures, plusieurs produits sont aujourd'hui utilisables pour les cultures oléagineuses au sein des substances de base, des substances à faibles risques ou encore des agents de biocontrôle. La liste des produits autorisés reste néanmoins limitée, notamment pour les espèces de grandes cultures (tournesol et soja). De nouvelles innovations apparaissent cependant, en particulier pour les agents de biocontrôle, qui augurent de nouvelles possibilités pour contrôler des maladies et ravageurs pour lesquelles aucune solution n'est disponible pour le moment. Il est ainsi nécessaire de soutenir la recherche

☆ Contribution to the Topical Issue: "Organic foods in the oil & protein crop supply chain / Le « Bio » dans la filière oléoprotéagineuse".

*Corresponding author: c.legall@terresinovia.fr

pour faire émerger ces solutions plus rapidement mais aussi faire évoluer la réglementation afin de favoriser leur intégration et leur mise à disposition des agriculteurs. En effet, l'utilisation des intrants (semences et produits phytosanitaires) en agriculture biologique est co-encadré par plusieurs règlements au niveau européen leur utilisation en agriculture biologique, qui parfois peinent à s'harmoniser.

Mots-clés : production biologique / sélection variétale / multiplication des semences / oléagineux / potection des cultures / intrants

Highlight

- Organic production systems rely on different combinations of agronomic levers to ensure their sustainability, notably seeds and crop protection products. The article takes stock of the inputs available today, the rules governing their production and use, and the outlook for tomorrow, in the light of potential regulatory changes and the needs expressed by industry players.

1 Production of organic annual oilseed crops in France

Organic production of annual oilseed crops has risen sharply since 2007, increasing 11-fold (see Fig. 1). This evolution is similar to that of the other field crops. Today, the main oil crops grown organically are soybean and sunflower, with winter rapeseed and linseed to a lesser extent (see Fig. 2). Historically, sunflower dominated French organic production, concentrated in the South-West but since 2014, organic soybean has a similar production area. Historically, these crops have been driven by growing demand for human food (oil and soyfood products), then also for livestock feed, mainly for poultry (laying hens in particular). The current decline in consumption of organic food products could challenge these trends, but it is currently difficult to predict market trends over the next few years.

The increase in oilseed acreage was first seen in the historic organic production basins of the South-West (Gers department in particular) and the South-East (Drôme department). Over the past 10 years, however, more northern zones have increased their organic production, particularly of winter rapeseed (in the north-west) and sunflower. The latter, which offers good drought resistance, is of growing interest to growers in the current climate change context.

2 Introduction to the principles of organic agriculture regarding the use of inputs

Like any other type of agriculture, organic plant production (OP) is based on the rotation of various species. This production is based as much as possible on natural processes. Nevertheless, it is sometimes necessary to introduce external inputs to improve productivity. However, the founding principle of organic farming is to cause as little disturbance as possible to the ecosystem. Consequently, the use of these inputs must be kept to a minimum by reuse, recycling and efficient management of materials and energy.

The other consequence is that production system management needs to be adapted locally, because even if ecosystem processes are universal, they function differently in different contexts. The production and use of inputs must therefore follow the same logic and be adapted to the production site. Moreover, they must be of natural origin and cause as little damage as possible to the functioning of ecosystems, and therefore to the living organisms present in them.

These principles may appear highly theoretical, but they have very concrete implications that form the basis of the differences between organic and conventional farming:

– No use of synthetic fertilizers or pesticides: because, by definition, they are not natural.

– Authorized pesticides and fertilizers should only be used as a last resort to generate the least possible disturbance to the functioning of the ecosystem; consequently, farmers must rely on other levers, largely prophylactic, to limit the pressure of pests, diseases and weeds. The use of disease- and pest-tolerant varieties that are also highly competitive with weeds is one of the pillars of organic production systems.

– For fertilizers, organic matter must be produced primarily on the farm or on a farm in the region; similarly, and if it is possible, seeds should be produced on the farm or in the region; nevertheless, resources are often limited locally, and these inputs are often produced much further away.

– Moreover, the variety chosen should be adapted to the local context. This principle may therefore call into question the prevailing model of seed production and even breeding, based on centralized production and a limited number of varieties chosen to perform well on average everywhere.

– Use of GMOs is prohibited because they are, by definition, (IFOAM, 2014) not natural; the definition of GMOs has evolved considerably in recent years, calling mutagenesis into question, which is commonly used in breeding programmes. IFOAM considers (IFOAM, 2017) that varieties used in organic production must not have been bred using techniques that break the integrity of living organisms. The use of techniques such as Oligonucleotide directed mutagenesis (ODM), Zinc finger nuclease technology, CRISPR/Cas, Meganucleases, Cisgenesis, Grafting on a transgene rootstock, Agro-infiltration, RNA-dependent DNA methylation (RdDM), Reverse Breeding, Synthetic Genomics, is today a source of debate.

The application of these principles is still evolving, however, and tomorrow's vision will undoubtedly be different. Producers will have to adapt to changes for which they can also be the driving force. Adaptation needs to be considered over a long timescale, as a production system cannot be transformed overnight.

Changes must also keep pace with equally long legislative processes. Organic farming is governed by a large number of

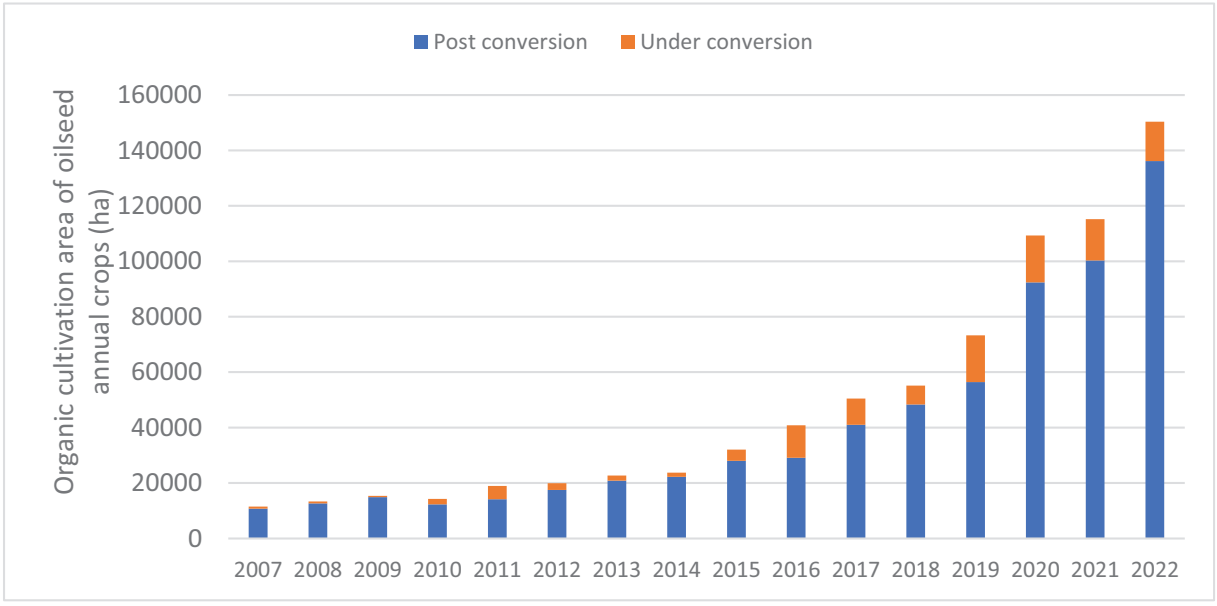

Fig. 1. Evolution of the area of organic crops of the main annual oilseed species (winter rapeseed, linseed, sunflower and soybean) from 2007 to 2022.

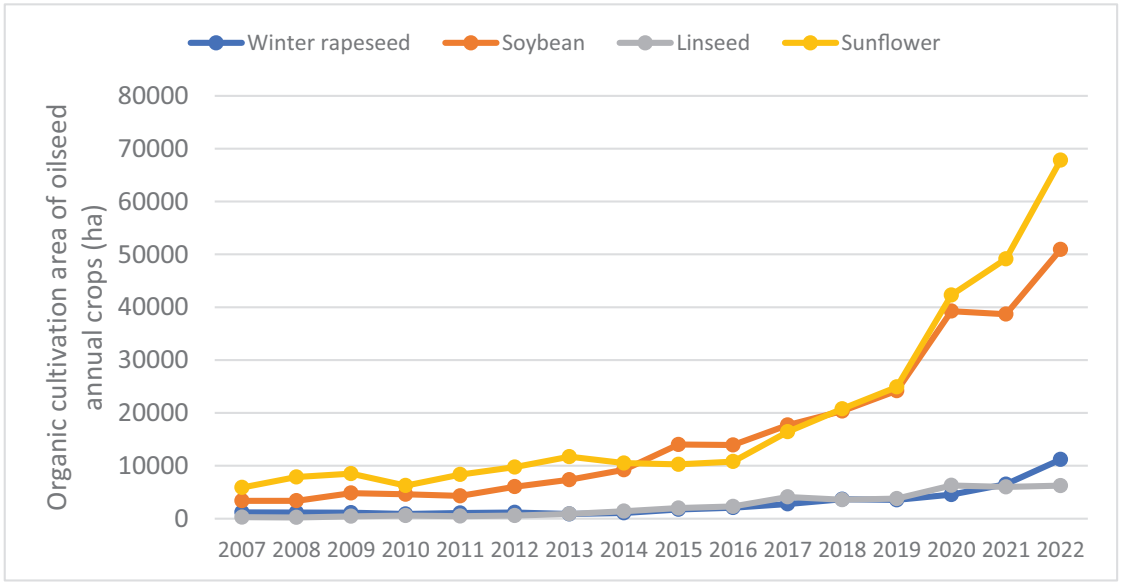

Fig. 2. Evolution of the production area for winter rapeseed, linseed, sunflower and soybean from 2007 to 2022.

regulations. In Europe, the Regulation (EU) 2018/848 of 30 May 2018 (after being approved at general phytopharmaceutical Regulation (EC) No 1107/2009) sets out the principles and concrete production rules, with a harmonized vision at European level. Nevertheless, there are several private labels that offer a different interpretation of the key principles of organic farming.

3 Which varieties can be used in organic farming?

For field crops, including oilseeds, varietal selection is often the first lever for ensuring competitiveness and sustainability of species within a cropping system. The most obvious of these is disease management, with a large number of varieties now available that are tolerant or resistant to the main diseases found in oilseeds. For sunflower, these include downy mildew (with its various races), phomopsis, verticillium and sclerotinia head rot, as well as sclerotinia on soybeans. More recently, varietal differences have been identified for certain types of insect damage, such as flea beetles on winter rapeseed; several varieties have been identified as being able to reduce the number of insect larvae present inside plants and/or the damage observed. In addition to the impact on the insects themselves, the variety's vigour at emergence also makes a difference. This vigour, not easy to

characterize experimentally, is also the key to ensuring better competition with weeds: a taller plant with a more developed leaf mass will have greater competitive power for the acquisition of resources than an "undersized" plant. This vigour, essential for a good crop start, must also be maintained over time to ensure that the crop "wins the race" against weeds and, limits weed seed production for the following crop. While this criterion is not currently studied for many oilseed crops, research is in progress to find the best field indicators which could be used by breeders to produce varieties with improved performances.

For several of these criteria, such as disease resistance, varieties with traits of interest for organic production exist already. Current research for varieties with higher yields and improved protein and/or oil content are also traits that organic farmers are watching very closely. However, the use of technologies commonly used to accelerate the breeding programmes for characteristics such as disease tolerance, is questioned. Some farmers would like to have access to varieties that do not require these technologies.

In addition, some farmers would like to see greater genetic variability in the varieties marketed. This could lead to greater phenotypic plasticity and thus greater adaptability to local field conditions.

This demand thus runs counter to several of today's key principles for evaluating and then marketing varieties, namely that a variety should be distinct from other varieties, uniform and stable.[1] The other way to increase genetic variability is to mix several varieties in the field.

These different points, the source of debates in the various organisations, have recently led to a modification of the European regulation on organic farming to accept new types of germplasm corresponding to these expectations[2]. However, the inclusion of these new types of germplasm does not prevent farmers from using current varieties derived from non-organic breeding processes. Its main aim is to encourage the marketing of new genetic resources, in order to broaden the range of products on offer.

The proposed new types are:

– Organic varieties suitable for organic production.
– Organic heterogeneous material (OHM).

Organic varieties suitable for organic production are defined as being a variety[3] which is "characterized by a high level of genetic and phenotypical diversity between individual reproductive units; and results from organic breeding activities [...]. All propagation practices except meristem culture are carried out under certified organic management". Nevertheless, a recent regulation evolution moderates the obligation of genetic and phenotypical diversity: it has become a possibility rather than an obligation[4].Even if an organic variety is less homogeneous than another non-organic variety, it still must be distinct from other varieties, at least on certain characteristics. And for theses characteristics, phenotype of individuals mut remain stable over the generation.

Organic heterogeneous material is defined as 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[5]". OHM is not an organic variety suitable for organic production because it is too heterogeneous, and the phenotypes of individuals change over the generations.

For this last category, which does not belong to the world of varieties, marketing conditions have yet to be defined, as there is no precedent at European level. For the moment, they are limited to the compilation of files enabling buyers to trace the history of the material (origin, selection type, main characteristics, uses) and its compliance with the sanitary rules (absence of contaminants, impurities, *etc.*) inherent to seed production and sale. First OHM could be notified from January 1, 2022. However, no applications for oilseeds have been received to date. Applications have been made mainly for wheat and maize.

For the category of "organic varieties", the issue is more complex and calls for a review of current breeding and variety evaluation methods.

Breeding a variety under entirely organic conditions is very complicated, because in the initial phases, with a very limited number of plants available, they must not suffer from excessive competition from weeds, nor be affected too severely by diseases or pests. The process is therefore risky.

Furthermore, the availability of a variety characterized by high phenotypic variability calls for a review of the evaluation rules that lead to its marketing. The methods used to assess its distinctness, uniformity and stability over time must evolve to adapt to this new varietal type. To achieve this goal, a seven-year trial was started in 2022 to make it possible to change the rules governing evaluation of varieties for registration, concerning both DUS (Distinction Uniformity Stability) and VCU (Value for Cultivation, Use, and Sustainability).

4 Which varieties are available in France?

Currently, almost all varieties grown in France have not been bred under organic conditions. Nevertheless, the rapid development of organic production encourages breeders to invest in this market, and to propose varieties more adapted to organic market demand. Consequently, increased investment of R&D resources are necessary to identify varieties which are the most suited to this market (Bernicot and Renard, 2019). Breeders have thus adapted their selection to include new criteria required by

[1] More precisely, the definition of a variety in the council Regulation (EC) NO 2100/94 on Community variety rights (Article 5(2)) is "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"

[2] Thes new types of germplasms are defined in articles 3–18 and 3–19.

[3] Defined in Article 5(2) in the council Regulation (EC) NO 2100/94 on Community variety rights.

[4] For more information see: Directive 2022/1647 annex IV and directive 2022/1648 annex III.

[5] And moreover, which is not a variety or a mixture of varieties.

organic farmers, particularly for major crops like wheat. For certain criteria, the demand for variety characterization is greater for organic agriculture than for conventional (Fontaine *et al.*, 2019; Fernier. 2016). Many criteria already evaluated for non-organic farming are also required by organic farmers: disease tolerance, productivity, grain quality. However, in addition, the evaluation of weed competitivity is a recurrent demand, identified for many years (Lammerts van Bueren, 2002). It is closely linked to the dynamics of canopy architecture: rapid covering capacity, plant height, relevant leaf characteristics including early vigour. For oilseeds, the most important criteria are disease tolerance. For sunflower, the present range of varieties include varieties tolerant to a large range of diseases making this crop quite resilient.

In addition to considering the new criteria, the inclusion of varieties more suited to organic farming has prompted breeders to introduce experimental sites run under organic farming conditions. Depending on breeder and species, the proportion of sites under organic conditions varies. For oilseeds, the proportion remains generally low, but is tending to increase as the market becomes more structured. Depending on breeders, evaluation conducted specifically under organic conditions occurs at different stages of varietal evaluation.

These developments are closely linked to changes in organic markets. The increase in area planted with organic oilseeds and other field crops has generated a strong demand for diversified varieties adapted to the constraints of organic agriculture, and by extension for certified organic seed. This demand has been particularly strong in sunflower, with hybrid varieties, initially focused on mid-early varieties, but rapidly expanding to include early varieties to adapt to the expansion of acreage in northern France. In soybeans, the range of varieties on offer quickly expanded to include early varieties, better suited to northern France or the higher altitude regions to the south, which do not, however, account for most of the production. The market for later varieties, grown in the South of France, has been slower to develop. This paradox can be explained by the fact that soybean is a self −pollinated species making it possible to produce farm-saved seed, which is used for almost 75% of the crop in the South but only 30% in the North. So, despite the larger acreage in the South, the seed market has remained underdeveloped. For winter rapeseed, few varieties have been developed as this market has until now remained very limited in France, but several studies are underway to assess the impact of varietal choice on crop performance, and thus support the potential development of this market. For rapeseed, farmers are more interested in inbred lines than in hybrids because they want to be able to multiply seed themselves and reduce investment costs for this rather risky crop, but conventional breeding has invested more in hybrids.

In parallel with (or in anticipation of) the work undertaken by breeders, varietal registration has evolved in order to offer varieties adapted to organic production. For some years, before the new regulation, several countries in Europe set up adapted procedures to register varieties for organic agriculture (Kovács, 2019). These specific procedures concern mainly cereals and notably winter bread wheat (*Triticum aestivum* L.). For example, in France, a specific procedure for winter wheat was created in 2011 (Rolland, 2017) and 17 varieties have been registered for organic agriculture. This procedure is also possible for sunflower and soybean but is much less widely used. Only one variety, currently under evaluation, has been proposed for sunflower with the label "suitable for organic farming".

The Ministry of Agriculture wishes to enrich the catalogue of varieties of all crops to include those adapted to organic production. A commission dedicated to Organic Agriculture was created in 2017 within the CTPS (Permanent Technical Committee for Plant Breeding), the Ministy's advisory committee for preparation of varietal registration policies. In order to be able to register varieties suitable for organic farming, it was necessary to develop specific evaluation networks, both by developing evaluation methods to incorporate new criteria and by including sites under organic management. For soybeans, there are one or two organic sites per year; for sunflowers, several sites were set up in 2023 and since 2022 the trial network for flax has added 2 organic sites.

5 From breeding to on-farm use: the role of seed multiplication

Breeding for organic agriculture is important but not sufficient to give farmers access to adapted varieties. The varieties chosen must be multiplied under organic conditions in order to provide enough organic seed. If insufficient organic seed is available, the EU regulation 834/2007 allows derogations for the use of non-organic (but untreated by any product forbidden by the organic regulation) seeds or vegetative propagating material. However, with the new European regulations (2018/848), these derogations will be forbidden after 2035 for all crops. However, national regulations can impose a faster end to the derogatory regime; in France, derogations are no longer authorized for certain species, in particular soybean and sunflower (since 2022); for winter rapeseed, marginally produced under organic conditions in France, the deadline is 2025 (until further notice). France is recognized as being one of the European countries most advanced concerning provision of organic seeds and ending of derogations. This anticipation of the abolition of the European derogation system should make it possible for the seeds and plants value-chain to organize the organic seed sector with the view to satisfying present and future needs.

Thus, to ensure the sustainability of organic agriculture, rapid development of a solid network of farms involved in seed multiplication is necessary. At present, in France almost one third of breeding companies have already started to multiply seed under organic conditions. The objective is to satisfy 95% of the demand for organic farming seeds by 2025.

For sunflower, on-farm multiplication (mainly of hybrid varieties) has been multiplied by 30 since 2015 (2015: 21 ha – 2022: 577 ha); for soybean, the increase is still greater (2015: 20 ha – 2022–1046 ha). Especially since 2018, this dynamic is clearly linked to the timetable scheduled for the deadline of derogations for use of non-organic seed (see below "More varieties adapted to organic agriculture: a commitment from the French seeds and plants value-chain"). Nevertheless, the French production of seed for these two species is not sufficient to cover the demand: for sunflower, organic growers still used 40% to 50% of non-organic seeds in 2020.

For sunflower, 24 varieties were multiplied under organic conditions in 2022 and 46 in 2023. The change in European regulation concerning organic cattle feeding will continue to boost the demand for sunflower in the next years and this figure

will probably continue to grow. However, one of the difficulties for breeders is to correctly anticipate market and producers' needs for oleic and linoleic varieties Until 2017, the market required only linoleic varieties but at present, the market is driven by oleic varieties, whose availability is still limited because forecasts made two years ago underestimated the use of such varieties. Moreover, the general decrease in multiplication area in 2021 led to a shortage of seed of oleic varieties. Faced with this shortage, imports of organic seeds from other European countries exploded to cover the demand. Producers and breeders find it difficult to determine if this strong demand for oleic varieties will be maintained or will switch back to linoleic varieties. The choice of the "right" variety to multiply remains very complicated.

For soybean, the situation is different. Firstly, soybean seed production faces an important technical constraint: under organic conditions, sowing is later than under conventional conditions and harvesting is also later. This can affect the technological quality of the seeds, with poorer germination. Secondly, the dynamic of demand for organic seeds grows regularly (42 varieties multiplied in 2022 instead of 33 varieties in 2021) but "slowly" compared to the explosion of organic soybean production since 2015. In most farms, farm saved seeds are used (up to 70% of the total in Occitanie region (Terres Inovia Survey, 2017) to increase profitability and self-sufficiency for the farm. This massive use of farm-saved seed does not encourage seed companies to invest in organic propagation of their varieties because the market is too small and too uncertain. Lack of investment ultimately backfires on the growers themselves, as they still need to renew their foundation seed on a regular basis to take advantage of improved germination vigour and genetic progress. Over the past two years, organic seed production has not been able to keep up with demand, so the transition to non-derogation status for soybean, originally planned for 2021, has been postponed to 2022 for some types of varieties. However, the use of farm-saved seed varies between production areas, with barely 20 to 40% of the seed used in the Pays de la Loire, Eastern and South-Eastern basins. This can be explained by the fact that the soybean crop is more recent in these regions, so the practice of using farm-saved seed is not yet widespread. In addition, while the Southwest focuses on groups I and II, the varieties produced in these regions are mostly groups 00 and 000 which are more difficult to produce with farm-saved seed. Consequently, the dynamic of seed multiplication for early varieties is much greater than for those in groups I and II. Combined with a lower demand (the Pays de Loire and the East are minor production basins), this dynamic has provided sufficient seed for these earliness groups, making possible the maintenance of the date of end of the derogation initially planned, contrary to variety groups I and II.

In 2022, total on-farm multiplication under organic conditions was 1635 ha for oilseed crops (sunflower, soybean and winter rapeseed). It represented only 5.1% of the total oilseed multiplication area in France (organic and conventional) but has increased since 2021 when organic production for oilseed crops represented only 2.4% (mainly sunflower). This level is too low to satisfy the rising demand for organic seed, leading to an increased dependence on imported seed and raising the question of sanitary quality, which must agree with French standards as defined in the technical regulations for each species. Seed remains the basis of all plant production and varietal choice is a key factor in successful production, in conventional agriculture, but even more so in organic agriculture. Construction of sustainable organic value-chains for oilseed crops but also for other crops, must integrate solid seed multiplication networks to provide farmers with organic seeds adapted to their needs. Seed multiplication must be integrated in the value-chain by long-term contracts with growers in charge of multiplication. This commitment would guarantee the traceability and quality of seed production, which are essential in organic agriculture.

6 Crop protection: from variety to plant protection substances

As mentioned below, the selection of varieties tolerant or resistant to diseases (or pests) and more competitive against weeds is the key to ensuring sustainability of organic systems. Nevertheless, this lever used alone is often not sufficient. It must be combined with other levers, of an agronomic nature (crop rotations, choice of crop *etc*.), and/or the use of plant protection substances, always acting as a last resort.

However, the market of plant protection substances is driven mostly by specialty crops (such as olives and not by field crops such as soybeans or sunflowers. For the latter, the list of authorized products is very restricted. The submission of a registration application is a long and costly process, which is only profitable if the market is sufficiently buoyant. This is often the case for the specialized crop market, where the profitability of the crops is sufficient to allow farmers to invest in crop protection products that are rarely 100% effective, and that justify several applications. In field crops, profitability is often lower and moreover, very few other inputs are used during the crop. The use of crop protection products therefore requires specific applications, unlike specialized crops where other inputs are applied regularly during the crop and can with the application of crop protection products.

7 Plant protection substances available for oilseed crops

Mainly biorationals (pest control materials that are relatively non-toxic with few ecological side-effects) like natural substances of mineral, plant, animal or microbial origin, microorganisms and semiochemicals are allowed in organic production (OP).

These biorationals are classified in several categories:

1 Basic substances
2 Low-risk substances
3 Microorganisms
4 Active substances not included in any of the above categories (*i.e.* natural substances (minerals, semiochemicals in traps)

A **basic substance** is an active substance that is not placed on the market primarily as a plant protection product, but which may be of value for plant protection and so does not go through the full active substance approval process. It is approved for an unlimited duration, in all-EU zones and with no market authorisations (Marchand, 2015, 2017). Thus, the

end-user is responsible for its use (Marchand, 2016). Although only few basic substances are allowed for Oilseed crop Production, some functions like fungicide capacity of *Equisetum arvense, Salix* cortex or the recent *Allium cepa* extract may be of interest to experiment in the future. Substances based on chitosan (chitosan hydrochloride and chitosan) have been used for other crops and could be of interest to Oilseed crops.

Low-risk substances are active substance which have been evaluated as having a low risk for human and animal health and the environment. Some of these substances have been traditionally used by farmers and may include foodstuffs. Currently only two low risk active substances (EU, 2018b) are allowed in Oilseed crop Production. The first is molluscicide for all species, the second, *Coniothyrium minitans*, currently allowed for winter rapeseed/ canola for soil decontamination may be extended to other oilseed crops if needed. Differentiation of active and low-risk substances is artificial but also an anticipation of the ongoing modification of the Organic Production PPP Annexe, Present or future renewals may decide that substances defined as active (EU, 2017) may be accepted as low-risk substances especially concerning microorganisms (*i.e. Bacillus pumilus* QST 2808, *Bacillus subtilis* strain QST 713, *Pythium oligandrum* M1 or aluminium ammonium sulphate) (EU, 2017, 2018).

Biological control agent (BCA) is an organism, such as an insect, bacterium or fungus, that is used to control a pest species. BCA authorised in Oilseed crop management are issued from microorganism active substances and listed below in Tables 1 and 2. Furthermore, most Plant Protection substances authorised in Organic Oilseed crop management are also allowed as Bio Control Agents (BCA) under the Biocontrol concept. (Robin and Marchand, 2019a). Other biological control agents, such as beneficial insects, mites and nematodes, are not covered by Regulation (EC) No 1107/2009. They may be used in organic production as natural enemies of pests in accordance with point 1.10.1 of Part I of Annex II to Regulation (EU) No 848/2018 (Table 3).

Semiochemicals are pheromones or other chemicals that convey a signal from one organism to another so as to modify the behaviour of the recipient organism. They are active substances corresponding to insecticide (IN) n, attractant (AT) or repellent (RE) functions. Some are coupled with chemical insecticides in traps (and still allowed in OP), following the "Attract and kill" method. Unfortunately, no semiochemical are dedicated to Organic Oilseed crop Production because they are highly depending on Straight Chain Lepidopteran Pheromones (SCLP) attractant research. Other substances, listed as natural substances, are also authorized. However, these substances, currently representing half of the BioControl Agents (BCA), are not represented in Oilseed crop Production. Consequently, there are relatively few authorized plant protection solutions for Organic Oilseed crop Production.

8 Plant protection substances: a complex regulation for organic agriculture

To be used in organic production (Marchand, 2017, 2018), these substances must be approved under the general phytopharmaceutical Regulation (EC) No 1107/2009 (REC 1107) (EC, 2009) and listed in Regulation (EC) No 540/2011 in one of the Parts (A to E) (EC, 2011; Robin and Marchand, 2019b).

Table 1. Basic substances in OP oilseed crop production.

Crop	Substance	Function	Nature
All crops	Beer	Molluscicide	Food stuff
Sunflower	–	–	–
Rapeseed	*Urtica* spp.	Insecticide	Plant extract
Soybean	Cow milk	Fungicide	Food stuff

These approvals are necessary, together with Market Authorisations when needed, but not sufficient: listing in the plant protection Annexe of the Organic Regulation (actually Annex I "Pesticides — Plant protection products referred to in Article 24(1)" of Regulation 2018/848 (EU, 2018) but under full revision) is also compulsory. In fact, Market Authorisations are compulsory for usual active substances (Art. 12 or13 of REC 1107) or low-risk substances (Art. 22 of REC 1107 in Part. D) as well as Candidate for Substitution (Art. 24 of REC 1107 in Part. E). Of course, for basic substances (Art. 23 of REC 1107 in Part. C), no market authorisations are needed (Robin and Marchand, 2019b; Marchand, 2015) but they should not be used as herbicides, but only for the control of pests and diseases.

All the basic and most of the active substances including low risk substances in Organic Oilseed crop Production do not have MRL (Charon *et al.* 2019). After this first general phytopharmaceutical Regulation approval, microorganisms and semiochemicals are directly permitted. In contrast, natural substances must be separately permitted if voted by the Regulatory Committee on Organic Production (RCOP) after deposit in a Member State and evaluation by the expert group for technical advice on organic production (EGTOP).

Many changes (inclusion, withdrawal, modifications, precisions) have occurred since 2014 when the of Implementing Regulation (EU) No 354/2014 (EU, 2014) in OP plant protection came into force and numerous Implementing Regulations have been published with the idea that the most recent repealed the previous. Implementing Regulation (EU) No 2016/673 (EU, 2016) introduced basic substance partial automatic transfer in OP for that are covered by the definition of "foodstuff" in Article 2 of Regulation (EC) No 178/2002 of the European Parliament and of the Council and have plant or animal origin. Minerals are therefore subject to inclusion application after approvals as basic substance under general phytopharmaceutical Regulation.

These last modifications are still under revision since all basic substances were still dispersed in Parts 1, 2 and 4 of the organic PPP Annex (previously n° II). The few substances allowed only in OP with no approval under general PPP Regulation 1107 have had to be withdrawn (*i.e. Quassia amara*/ beewax). The new PPP Annex lists plant protection substances voted on October 29, 2020, Implementing Regulation (EU) No 2021/1165 is now numbered Annex I (active substances to be used in plant protection products authorised for use in organic production referred to in Article 24.1 (a)) (EU, 2021). In 2023, Implementing Regulation (EU)

Table 2. Low-risk substances in OP oilseed crop production.

Crop	Substance	Function	Origin (mineral, plant, animal or microbial origin, microorganisms + semiochemicals)
All	Ferric pyrophosphate	Molluscicide	Mineral
All	Ferric phosphate	Molluscicide	Mineral
Rapeseed	*Coniothyrium minitans*	Soil decontamination	Microorganism
Rapeseed	*Trichoderma atroviride* strain AGR2	Fungicide	Microorganism

Table 3. Microorganism Active substances in OP oilseed crop production.

Crop	Substance	Function
Sunflower	*Bacillus thuringiensis* subsp. *kurstaki* strain: SA-12 (*Bacillus thuringiensis* subsp. *kurstaki* strain ABTS 351)	Insecticide
	Helicoverpa armigera nucleopolyhedrovirus	Insecticide
Rapeseed	*Helicoverpa armigera* nucleopolyhedrovirus	Insecticide
	Bacillus subtilis str. QST 713	Fungicide
	Bacillus pumilus QST 2808	Fungicide
	Pseudomonas sp. strain DSMZ 13134	Fungicide
	Pythium oligandrum M1	Fungicide
Soybean	*Helicoverpa armigera* nucleopolyhedrovirus	Insecticide

No 2023/121 (EU, 2023) modified Annex I and included more active substances in organic production (like the low-risk substance sodium hydrogen carbonate), the latest regulation validating automatically low-risk substances from animal and plant origin in OP, where microorganisms and semiochemicals already were.

9 Specific derogations in organic oilseed crop Production for use of plant protection substances

The general phytopharmaceutical Regulation (EC) No 1107/2009 (REC 1107) (EC, 2009) allows temporary uses for 120 days under Emergency Authorisations (derogations) under Article 53, Organic Oilseed crop Production. Sector or specific interest parties may apply for these emergency derogations which are important since most of them foreshadow the deposit or arrival of a Market Authorisation. However, since 2017 no derogation has been obtained in France for any substance allowed in Organic Production (and only one chemical in conventional plant protection for sunflower). However, some were requested in other EU Member States (Azadirachtin, natural pyrethrins, orange oil, *Bacillus thuringiensis*, *Beauveria bassiana*, *Trichoderma harzianum*, and *Metarhizium brunneum*). With the rarefaction of chemical active substances, this opportunity may be more exploited, and more derogations requested in the future. This could help to obtain new market authorizations for more substances permitted in OP.

The substances concerned are:

– *New biorationals*: recently approved BCA active substances, including low-risk substances, may be of interest for Organic Oilseed crop protection, like ferric pyrophosphate already applying for inclusion in the PPP Annex of Organic Regulation.

– *Pending active substances*: 67 active substances, including a majority of BCA AS, are considered as "pending" from the EU pesticide database analysis; however, it is not possible to forecast how many will be approved, and among these, how many will be of interest for organic Oilseed crop protection. From our ongoing enquiry on biorational active substances, no specific usages are requested or listed for Oilseed crop Production, however, specific functions like insecticide, repellent or fungicide may be of interest. More specifically pending substances like pending microorganisms *Aspergillus* spp. (MUCL 54911), *Bacillus* spp. (AT-332, FZB42, FMCH001, F727, FMCH002, RT1477, RTI545, RTI301), *Beauveria* spp. (BOV1, R444), *Fusarium* spp. (L13), *Metarhizium* spp. (BNL102, Cb15-III, CF62, CF69, CF78), *Pythium* spp. (B301), *Trichoderma* spp. (Th2RI99, 77B, B97, T78) or natural substances like L-Carvone, caffeine, D-tagatose, Black Pepper Oleoresin or choline conjugates may be of interest.

– *New basic substances*: The main concern and target for the basic substance list in the initial applications was to decrease the use of copper. However, interesting functions shown by many basic substances (elicitor, fungicide) could be developed and tested for Oilseed crop Production although, at present, no new pending basic substances or requests for extension of use for already approved basic substances are specifically dedicated for these crops. Many extensions of use for other crops are ongoing and their increase in number may help to increase use in Oilseed crop Production. In this context, an ongoing application for Oleoresins from *Capsicum frutescens* may be of interest for protecting sunflower seeds and seedlings.

10. Conclusions: what inputs should be used in the future and how should they be integrated in production systems?

The future development of agriculture will require the development of inputs specifically adapted to organic production.

For the seed sector, the guidelines proposed by the new European regulation aim to place the "ethics" of organic agriculture at the heart of plant breeding challenges. To achieve this, current selection and evaluation methods will have to be rethought. Some of the proposed concepts, such as heterogeneous organic material, have yet to be clarified. The evaluation processes are also questioned in their fundamentals: what new criteria should be integrated; how should they be evaluated? These changes also raise the question of how to adapt varieties evaluation networks, in terms of design and management. Beyond the development of "adapted" varieties, the growth of organic agriculture requires that these varieties be made available to producers via certified organic seed. Varietal evaluation and seed multiplication must work together to maximize rapid transfer of new varieties (and genetic progress) to producers. This requires the development of multiplication networks in all production basins and the continuous consultation of all members of the seed industry.

For crop protection products, approval of new innovations is handled through the European regulations. Although these regulations allow a relatively drastic control of product composition, efficiency, harmlessness, and environmental impact, they are sometimes criticized because of the cumbersome nature of the files required to approve products for the market. For substances considered by many as "low risk". In recent years, regulations have therefore evolved to facilitate a more rapid approval of this type of substance, listed as "basic substance" or "low risk substance". If the market for biocontrol products is booming, the adequacy between European regulations for this type of product and those concerning organic farming are not always in phase. Better harmonization should be sought to bring clarity and visibility to users. Finally, many innovations are emerging, and it would be advisable to facilitate their integration into current (and future) regulations. BioControl Agents (BCA) are in constant evolution, reducing risks and residues from the initial panel of active chemical substances, but biorational themselves should also further reduce negative impacts of plant protection. Extensive investigation on crop protection solution at PPP regulation for Organic Oilseed Production has so far, displayed only a small number of approved answers. Further research is needed to expand safer biocontrol solutions to offset the considerable contraction of plant protection substances available.

References

Bernicot MH, Renard M. 2019. *Favoriser l'inscription de variétés pour l'AB Actes des 2es Rencontres des Grandes Cultures Bio*, 22 janvier 2019, pp. 40– 42.

Charon M, Robin D, Marchand PA. 2019a. The major interest for crop protection of agrochemical substances without maximum residue limit (MRL). *Biotechnol Agron Soc Environ* 23, 22–29.

EC. 2009. Regulation (EC) No. 1107/2009, *Official Journal of the European Union* L 309 of 24.11.2009, p. 1–50 (2009).

EC. 2011. Regulation (EC) No. 540/2011, *Official Journal of the European Union* L 153 of 11.6.2011, p. 1–186 (2011).

EU. 2014. Implementing Regulation (EU) No 354/2014; *Official Journal of the European Union* L 106. 9.4.2014, pp. 7–14.

EU. 2016. Implementing Regulation (EU) No. 2016/673; *Official Journal of the European Union*, L 116. 30.4.2016, pp. 8–22.

EU. 2017. Implementing Regulation (EU) No. 2017/1432; *Official Journal of the European Union*, L 205. 8.8.2017, pp. 59–62.

EU. 2018a. Regulation (UE) 2018/848; *Official Journal of the European Union* L 150, 30.5.2018, pp. 1–92.

EU. 2018b. Commission notice concerning a list of potentially low-risk active substances approved for use in plant protection. C/2018/2164 *Official Journal of the European Union* C 265. 27.7.2018, pp. 8–11.

EU. 2019. Implementing Regulation (EU) 2019/2164; *Official Journal of the European Union* L 328. 18.12.2019, pp. 61–80.

EU. 2021. Implementing Regulation (EU) 2021/1165; *Official Journal of the European Union* L 253. 16.7.2021, pp. 13–48.

EU. 2023. Implementing Regulation (EU) 2023/121; *Official Journal of the European Union* L 16. 18.1.2023, pp. 24–31.

EU. 2023b. Implementing Regulation (EU) 2023/2229; *Official Journal of the European Union* L. 25.10.2023, pp. 1–8.

Fernier A, Fontaine L, Conseil M. 2016. Avis et attentes de la collecte sur les variétés en grandes cultures biologiques – Bilan 2015, *ITAB*.

Fontaine L, Bernicot MH, Le Gall C. 2019. Les enjeux de l'évaluation variétale pour les grandes cultures en AB. *Actes des 2es Rencontres des Grandes Cultures Bio,* 22 janvier 2019, pp. 36–39.

IFOAM. 2014. The IFOAM norms for organic production and processing, *Version* 2014.

IFOAM. 2017. *Compatibility of Breeding Techniques in Organic Systems*.xxx

Kovács T, Mariegaard Pedersen T. 2019. Overview on the current organizational models for cultivar testing for Organic Agriculture over some EU countries, *Liveseed H2020 Deliverable* 2. 1.

Lammerts van Bueren, E. T., Struik, P. C., & Jacobsen, E. (2002). Ecological concepts in organic farming and their consequences for an organic crop ideotype. NJAS: Wageningen Journal of Life Sciences, 50(1), 1-26. 258.

Marchand PA. 2015. Basic substances: an approval opportunity for low concern natural products under EU pesticide regulation. *Pest Manage Sci* 71: 1197–1200.

Marchand PA. 2016. Basic substances under EC 1107/2009 phytochemical regulation: experience with non-biocide and food products as biorationals. *J Plant Protect Res* 56: 312–318.

Marchand PA. 2017. Basic substances under EU Pesticide Regulation: an opportunity for organic production? *Organ. Farm* 3: 16–19.

Marchand PA. 2018. Novel plant protection regulation: new perspectives for organic production? *Org Farm* 4: 3–6.

Rolland B, Fontaine L, Maillard A, Gardet O, Heumez E, *et al.* 2017. From selection to cultivation with the support of all stakeholders : the first registration in France of two winter bread wheat varieties after value for cultivation and use evaluation in organic farming systems. *Organ Agric* 7: 73–81.

Robin DC, Marchand PA. 2019a. Biocontrol active substances: evolution since the entry in vigour of Reg. 1107/2009. *Pest Manage Sci* 75: 950–959.

Robin D, Marchand PA. 2019b. Evolution of Regulation (EU) No 540/2011 since its entry into force. *J Regul Sci* 7: 1–7.

Cite this article as: Le Gall C, Hidrot D, Girolami P, Marchand P. 2024. Seeds and plant protection substances for French organic oilseed crops: what are the challenges for tomorrow? *OCL* 31: 8.