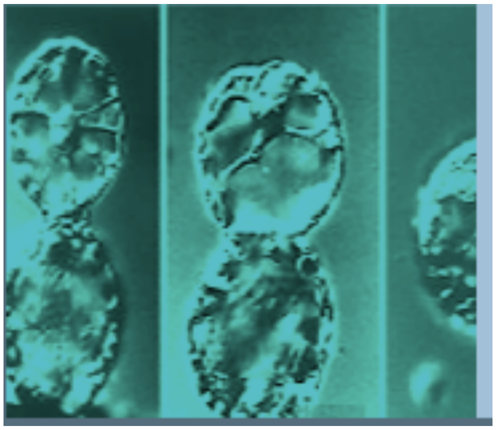

Situation Analysis and Strategy for Replacing Cell Fusion Cultivars in Organic Systems

IFOAM – Organics International

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Prepared by the IFOAM-Organics International Working Group on Replacing Cell Fusion Cultivars and approve by the IFOAM World Board August, 2017

Working Group Members

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Terms

Cytoplast: The inner part of the cell without the cell wall, cell nucleus, and plasma membrane. It includes the cytoskeleton, organelles and cytosol. Sometimes used to describe a cell in which the nucleus has been removed.

Cultivar: A variety selected and cultivated by humans. This includes all cultivated varieties that result from plant breeding. Considering its topic, this paper uses the term "cultivar" in preference to the term "variety."

F1 hybrid: The first filial generation resulting from cross-pollination of parents from two inbred plant lines with one or more differing characteristics.

Open pollinated (OP): Describes seeds that will "breed true." When the plants of an open-pollinated cultivar self-pollinate, or are pollinated by another plant of the same cultivar, the resulting seeds will produce plants within the type of the cultivar.

Protoplast: A cell of a plant, fungus, bacterium, or archaeon from which the cell wall has been removed, leaving the protoplasm and plasma membrane

Self-incompatibility (SI): The inability of a plant producing functional male and female gametes to set seed when self-pollinated. In plant breeding, use of SI parent plants to prevent inbreeding and promote outcrossing enables the production of F1 hybids. An important application of SI is breeding in the genus *Brassica*.

Background and purpose

History of the initiative

In 2002 the first IFOAM draft standards were set for organic plant breeding. They stated that only breeding techniques on plant level are compatible for organic principles. This implies that from the process point of view, plant breeding techniques that operate on cell tissue or directly at DNA level violate the integrity of life. Respecting the concept of integrity of life also means that organic agriculture aims to support autonomy and self-regulative ability of the living farm-ecosystem. It implies that measures are designed in a way that supports life processes within the farm-ecosystem and does not try to deconstruct and reconstruct life in a test tube. From a biological point of view cells are the lowest entity of self-organized life, and working below that level, such as is the case with manmade protoplasts or cytoplasts, is not in line with the values of organic agriculture. The use of cytoplast delimits the target of transfer even further: the aim is mainly to combine certain traits, e.g. transfer a piece of mitochondrial DNA that conveys Cytoplasmic Male Sterility (CMS). This mimics the aims of other GM-based techniques. Moreover, most hybridization through protoplast fusion is a way to hybridize sexually incompatible species and thus enables to cross natural crossing barriers.

Originally, IFOAM definitions of genetic engineering included examples of its techniques, but did not take cell fusion into account. In 2008, via a motion of the IFOAM Assembly cell fusion, (including protoplast and cytoplast fusion) was determined to not to be in line with the principles of organic agriculture. The motion also urged the IFOAM World Board to develop clear guidelines on how to deal with varieties derived from cell fusion, including protoplast and cytoplast fusion breeding techniques.

Subsequently, IFOAM revised its definition of genetic engineering to include cell fusion and therefore prohibited it in its standards. However, practical aspects of the prohibition posed challenges for implementation. Entire commercial seed lines of certain cultivars are derived from cell fusion breeding techniques, challenging implementation of the prohibition in these cultivars. General regulatory frameworks of countries provide different definitions of genetic engineering. Cell fusion is mostly not in the scope of these definitions. This results in lack of transparency in the market because plants and seed stemming from it do not fall under risk assessment and labeling requirements. Most organic regulations either do not address cell fusion or address the technique in ways that are not consistent with the IFOAM definition.

Given such conundrums, further actions were not undertaken until after the 2014 General Assembly passed a motion containing more specific guidance. The motion requested the IFOAM World Board to:

- *Develop a **strategy for the replacement of varieties derived from cell fusion**, including protoplast and/ or cytoplast fusion from organic farming practices.*
- *Define **guidelines for** the socio-economic **implementation of such strategies**.*
- ***Promote alternative breeding programs like organic plant breeding** to foster the development of cell fusion free varieties.*

The motion also advised that in order to achieve these goals by the next General Assembly in 2017, a working group should be established.

An expert working group was convened in 2015. The group decided that its first work should be to prepare a global situation analysis which would cover the presence of cell fusion cultivars in the seed supply and in organic farming, the legal and political frameworks of the issue, and current actions to reduce the presence of cell fusion cultivars in organic systems. The first efforts of the working group centered on exploring regional situations, and these contributed to the development of the global overview. The situation analysis proved challenging to prepare. For example, lack of transparency from seed companies, low awareness of the topic, and limited ability to probe some regional situations such as Latin America were some of the obstacles. Nevertheless, the analysis provided enough information and insight to undergird the proposed strategy, which comprises the other main section of this paper.

This paper consists of the following main sections:

- Terms
- Background and Purpose
- Situation Analysis
- Strategy for Replacement of Cell Fusion Cultivars
- References

What is cell fusion? [1]

Cell fusion (including cytoplast and protoplast fusion) is a technique in use for about 30 years now. To develop fused cells, protoplasts (cells without a cell wall) are isolated from plant cells by treating the cells with enzymes until the cell walls dissolve. Chemical or electric stimulants are then used to fuse protoplasts from different sources, which may be either cisgenic (from the same or other cross-breeding species) or not. This results in the fusion of the two nucleoli and combination of both organelles. Cytoplast fusion, on the other hand, is the fusion of one protoplast with one cytoplast where the nucleus has been

[1] The sections "What is cell fusion" and Why use cell fusion" are based on publications of EcoPB, the European association of organic plant breeders, and contributions from Monica Messmer, FiBL.

destroyed before e.g. by X-ray. Cytoplast fusion results in a fused cell containing the nucleus of one and the organelles of both. A cell wall regenerates and the cell fusion products divide and regenerate into whole plantlets using tissue culture techniques. The resulting plant has characteristics from both parents, although not all will be expressed.

Why is cell fusion used in plant breeding?

For plant breeding, cell fusion is used to produce cultivars that combine complementary dominant genes of both parental lines, e.g. virus resistance genes in potato and black rot resistance in certain cabbages. This would be very difficult to achieve by cross breeding. But globally it is most commonly used to incorporate cytoplasmic male sterility (CMS) in the female line in order to produce F1 hybrid seed in plant species where CMS is not known to occur. For many crops hybrid seed production is possible if the emasculation of the mother plants can be done efficiently. While maize can be mechanically emasculated, other crops like wheat or broccoli are much more difficult to handle. The fusion of cytoplasm from wild relatives often causes some imbalances between the cytoplasm and the nucleus DNA resulting in cytoplasmic male sterility (CMS) with reduced anthers or sterile pollen grains, without affecting the fertility of the female flowers.

Cytoplasmic male sterility is desirable for plant breeders because plants with such characteristics do not self-pollinate and allow production of nearly 100% F1 hybrid seed. This is an advantage for breeders because it avoids the need to hand-pollinate or perform other interventions. Thus, it overcomes propagation challenges and increases the efficiency of hybrid seed production. For farmers, F1 hybrids used in good nutrient and climate conditions may have outstanding production performance. But F1 hybrids based on cytoplasmic male sterility also established disadvantages. CMS F1 hybrid seeds are not useful in seed saving and therefore producers using them must purchase new seed each year. If farmers stop seed-saving because they turn to sterile hybrids, there is a drastic loss of landraces and old varieties. Furthermore, because the cultivars are sterile, other breeders are unable to use CMS lines for their breeding work. So it affects breeders' rights. Some countries, such as the US and Australia, allow for patenting of the sterile hybrids by seed companies, and thus their long-term control over the hybrid seed lines. In effect, it causes radical decrease of variability for future breeding and therefore supports the market concentration process.

What are we ultimately aiming to replace?

Use of certain terminology tends to confuse communication on this topic, and therefore we provide some clarification of terminology and our aims.

Natural vs. cell fusion derived CMS

Cytoplasmic male sterility occurs naturally in some species such as onions and carrots, but in other plant taxa it has not been discovered to have occurred naturally. In the cases of natural CMS the trait can be incorporated in new cultivars of the same species by natural crossing. The focus of this replacement strategy is only on cultivars derived from cell fusion technology and not on those cultivars where CMS naturally occurs.

Cisgenic vs. transgenic breeding

Cell fusion techniques may be used to hybridize both cisgenic (i.e. within species and sexually compatible) and transgenic plants (between species and not sexually compatible). IFOAM - Organics International considers all cell fusion techniques to be in the scope of genetic engineering, regardless of the ability or not of the plants to cross breed naturally.

Summary

We are ultimately aiming to replace all seeds and other planting material in organic systems that are derived from cell fusion technology, regardless of whether the technology is used within or between species. We recognize the widespread use of cell fusion to achieve cytoplasmic male sterility in F1 hybrids. However, we also recognize that, especially in Asia, cell fusion is used to develop other traits, and therefore the full scope of the problem is broader that just cell fusion derived CMS hybrids.

Situation Analysis

Seed Supplies

Problem species and crops

Cell fusion has been used extensively for developing F1 hybrids in cruciferous vegetables of the species *Brassica oleracea*, for example in broccoli, cauliflower, kohlrabi, brussels sprouts, certain cabbages, and in certain subgroups of the species *Brassica juncea* as well as in canola (*Brassica napa*). Certain cultivars of the species *Cicorium intybus* and *Cicorium endivia,* notably Belgian endive, have been hybridized with cell fusion techniques. According to one source (Organic Market News Online), 63 chicory varieties have currently been authorized across the whole of Europe. 52 are clearly hybrids "as stated by the breeder," and of these 13 are known to be CMS hybrids resulting from cell fusion. Asian seed breeders in India, Korea, China, Indonesia, and Japan have used cell fusion to develop improved cultivars of japonica rice, wheat, potato, rapeseed, radish, citrus, cabbage, and cotton. In India, much of the work on protoplast fusion has been on mustard *Brassica juncea* (Kirti, et al, 2003). Rapeseed mustard is the second most important source of edible oil in India.

It is difficult to differentiate which genotypes are cell fusion-free. Brassica vegetable hybrids are also available based on the self-incompatibility breeding modus (SI), which is allowed for organic breeding. Canola hybrids are only partly based on cell-fusion derived CMS. Also, spontaneous genetic male sterile mutants of Brassica vegetables have been identified. Detection can be done on phenotypic level, looking at fertility level of the pollen and the segregation of the trait for male sterility to differentiate SI systems and systems based on genetic male sterility. Some years ago, a qPCR laboratory test for the most common cell fusion derived CMS (using male-sterile Ogura radish) became available on contract basis.

Use of cell fusion cultivars in organic systems through use of conventional seed.

According to the last Organic Seed Alliance survey of US organic farmers, half or more seeds used are conventional (although untreated) seeds. This is especially the case for vegetables.

From the Report of the 2013 EcoPB Workshop on Organic Seed in Europe, it appears that the usage rate for organic seed is in the neighborhood of 50% and derogations for use of conventional seed in most countries are stable, neither increasing or decreasing. It appears that organic seed use is problematic in both grains (cereals) and vegetables for some regions of Europe, whereas in North America and other regions in Europe the problem is mostly in vegetables.

Data from other regions has not been available. However, it can be reasoned that the rate of conventional seed use for organic farming is likely to be significantly higher in other regions growing the problematic cultivars where organic seeds supplies are not developed to the extent that they are in Europe and North America. Organic sector advocates in some developing countries have reported that organic seed is virtually unavailable in their commercial seed supplies. That said, there is light on the horizon in countries such as the Philippines, where there are now government and civil society programs in organic breeding in rice, vegetables, coffee, selected fruits etc.

Cell fusion cultivars in organic seed supply

Market situation: The use of cell-fusion derived cultivars is not just a function of conventional seed. One major seed company, Vitalis, has publicly committed not to include cell fusion derived cultivars in its organic seed supplies of broccoli and kohlrabi and it has started a self-incompatibility breeding program for these cultivars. However, many seed companies are not screening cell fusion cultivars out of their organic seeds supplies. However, in order to serve the organic market they may be motivated to offer more alternatives to F1 hybrid seeds derived from cell fusion than in conventional seed lines or leave older hybrids not from cell fusion. Although there is progress in some European countries, seed companies are often not transparent about which seed lines, conventional or organic, are derived from cell fusion. Therefore. it is probable that some organic seed supplies of cultivars in “problematic” species and crops are also cell fusion derived. Some smaller organic seed companies in North America and Europe have avoided offering cell fusion derived organic seeds, but their supplies are currently insufficient to satisfy the number and needs of organic farmers.

Based on data collected in Switzerland, where cell fusion has not yet been banned in organic farming, the percentage of cell-fusion derived CMS hybrids accounted for 75%, 44%, 24%, 18%, 17% of the seedlings produced in 2015 for cauliflower, broccoli, savoy cabbage, white cabbage and brussels sprouts, respectively. Chicory has not been assessed in this study.

Seeds bred in decentralized community plant breeding clusters, whether or not "certified organic" generate seed supplies that are unlikely to have a lineage including cell fusion techniques. Seeds bred for organic conditions in these communities, e.g. in participatory plant breeding projects, when combined with seed saving, are important sources of organic seeds. They are also cell-fusion-free repositories of germplasm for future plant breeding, which may eventually be useful to commercial seed producers who could someday scale up supply. These plant breeding communities are in globally diverse regions ranging from community breeding in Brittany to participatory breeding research in Southwest China. They are providing ethical seed supplies now and hope for the future.

Agricultural Production: The case of the crucifers

In terms of our aim, to replace cell fusion cultivars in organic systems, we take a look at production. The highest share worldwide of cell fusion derived seeds and products resulting from it, is likely to be in broccoli, cauliflower and cabbage production, especially on large commercial operations. These crops are commonly found in diets in several of the world's regions, especially in Asia, Europe and North America. According to WorldAtlas.com (Jan 2016), China produces close to half of the world's broccoli and cauliflower, with 20% increases in production annually from 2010-2015. Annual output approaches 10 million tons. India is next, having dedicated 6.7 million acres to production of these crops for domestic use and export. Together, China and India account for 75% of world production. In Europe, major broccoli and cauliflower production also occurs in Poland, Spain, Italy and France. In the Americas, the United States (mainly California) at 290,000 tons and Mexico at 480,000 tons are major producers. It is not clear if organic production of these crops is similarly distributed, but there are some hints towards it. China is known to be a major supplier of frozen and IQF (individually quick-frozen) organic broccoli and cauliflower to international markets (North America, Europe, East Asia, Oceania). India organic cauliflower is available on the Chinese ecommerce website, Alibaba. A web-search has turned up Chinese seed suppliers of organic broccoli and cauliflower seeds and numerous supplies of frozen organic broccoli and cauliflower. It can be assumed that most Chinese organic producers are sourcing their seeds domestically and using conventional seed.

According to the IARC Handbook of Cancer Prevention, Vol 9, per capita consumption of cruciferous vegetables is very low in Latin America and Sub-Saharan Africa compared to other world regions, and there is no indication of major production of these crops in the region except for export by some western Latin American countries such as Mexico, Ecuador, and Peru, which supply vegetables to Northern countries.

Legal/Political Frameworks and impact on use of cell fusion cultivars in organic systems

The treatment of cell fusion in regulatory systems is diverse. The United States organic regulation addresses "excluded methods" and included in these is cell fusion. However, a 2013 policy memo from the National Organic Program interprets that in this context cell fusion refers only to techniques for fusing protoplasts from different taxonomic plant Families, whereas cell fusion technology for producing F1 hybrids uses parents within the taxonomic Family. This includes cell fusion between species, for example radish and cabbage, or sunflower and chicory, which cannot exchange genetic material through traditional breeding methods.

EU legislation defines genetic engineering in Directive 2001/18/EC, outside of the organic regulation, which views cell fusion as "the fusion of two or more cells by means of methods that do not occur naturally". However, an exception is included. Fusion of plant cells from organisms which can exchange genetic material through traditional breeding methods is not considered a technique of genetic modification under the Directive. Thus, cell fusion is not (yet) completely banned in the European organic regulation. In its practical implementation of the Directive the EU applies an interpretation of this exemption wherein fusion of plant cells is not regarded as a method of genetic engineering if the cells are derived from plants of the same family.

The EU and US interpretations appear to be based on the definition of "modern biotechnology" in the terms defined in the Cartagena Protocol on Biosafety to the Convention on Biodiversity, Article 3. But all these definitions and interpretations are derived from the flawed rationale that the result of using plants within the same Family, whether or not they could always (or almost always) exchange genetic material and reproduce naturally, cannot be distinguished from results of traditional plant breeding. Thus, laboratory techniques to perform the exchanges are allowed

In the regulations of some countries e.g. China, cell fusion is expressly included in the scope of genetic engineering, but inquiry has led to the conclusion that this point is not enforced in China. Organic regulations in some other countries, such as the Philippines, are silent on whether cell fusion is included or not as a form of genetic engineering. Some countries' organic regulations include cell fusion in their definitions of genetic engineering. The narrow definition of genetic engineering in Japan's organic standard (JAS) does not include cell fusion. One country, New Zealand, expressly mentions and excludes cell fusion techniques in the scope of genetic engineering in its "reference" organic standard (New Zealand does not have an organic regulation), thus allowing it for seeds used in organic production systems.

Private Organic Standards and Labels

Private organic standards operate in countries where regulations permit organic standards and labeling that goes beyond the regulatory requirements. Private label programs also operate in unregulated environments such as on the African continent and in the Pacific Islands.

<u>IFOAM Accreditation</u>: Some of the private systems are in the scope of IFOAM Accreditation. Two IFOAM norms for organic production are associated with IFOAM Accreditation, and use the same definition of genetic engineering as follows: "Genetic engineering is a set of techniques from molecular biology (such as recombinant DNA) by which the genetic material of plants, animals, microorganisms, cells and other biological units are altered in ways or with results that could not be obtained by methods of natural mating and reproduction or natural recombination. Techniques of genetic engineering include, but are not limited to: recombinant DNA, **cell fusion**, micro and macro injection, encapsulation. Genetically engineered organisms do not include organisms resulting from techniques such as conjugation, transduction and natural hybridization." Although the IFOAM definition is very similar to the regulatory definition, IFOAM – Organics International has adopted motions stating that all laboratory techniques of cell fusion are considered to be genetic engineering, even if using parent material from within the same taxonomic family. The IFOAM Standard addresses breeding of organic varieties, and in this section states that "the cell is respected as in 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). However, this section applies to plant breeding activities. It does not address the compliance of cultivars derived from conventional breeding for organic production. Although the exclusion of cell fusion derived cultivars is clear in the IFOAM Standard, this is not currently enforced in the IFOAM Accreditation Program. It is too difficult to ask certification bodies to force organic producers to acquire seed proven to be cell fusion free, or stop producing certain crops.

A few private label standards programs have begun to address cell fusion more strictly, taking steps to prohibit seeds derived from any kind of cell fusion involving technical inventions at the cell level. Such programs are usually associated with initiatives to provide operators with information about sourcing alternatives in the problematic cultivars. Demeter International and Demeter Germany have taken a lead role in this initiative. Other private organic labels in Germany (e.g. Bioland, Naturland and Gäa) also banned cell fusion derived cultivars. BioSuisse is currently running a working group aimed at replacing cell fusion based vegetable hybrids. It is focused on screening of self-incompatibility hybrids and open pollinated cultivars, promoting the sourcing of cell fusion free breeding material, and developing a positive list of cultivars not derived from cell fusion. In the BioSuisse's annual cultivar recommendations, the cultivars are indexed in four categories: 1. derived from certified organic plant breeding, 2. derived from breeding companies devoted to the organic sector refraining from cell fusion and genetic engineering, 3. derived from conventional breeding (usually no further information is available), and 4. derived from undesirable breeding methods (negative list).

Awareness and Opinion

Awareness of this issue is quite low outside of a few circles in Europe, which are described in the European situation analysis. Elsewhere opinion is usually either non-existent or divided. The topic is technically complex, which is a barrier even to awareness of both producers and consumers. Awareness and opinion are also limited by the regulatory contexts, which essentially bless the status quo. There are some exceptions to these generalizations. Public scandals in 2014 fueled by media stories in Germany and the Netherlands have increased public awareness throughout northern Europe. The German association for organic food processing and trading, BNN, is raising concerns and calling for compulsory labeling of CMS hybrids, which are the most common output of cell fusion in European plant breeding. Articles have begun to appear in organic sector publications.
In North America, awareness is dawning within NGOs such as the Organic Seed Alliance, the National Organic Coalition and Northeast Organic Farming Association, but has not yet risen to any priority agenda in these organizations. IFOAM keeps the topic alive within its membership in reporting on the Working Group for Replacing Cell Fusion Cultivars. Otherwise, there is no evidence of awareness or public opinion on this issue outside of Europe and North America.

Current breeding initiatives to replace cell fusion cultivars:

Currently there are several scattered activities in different countries to replace cell fusion cultivars. Some examples are:

- Collection and maintaining of older open pollinated and CF free breeding material as stock for further breeding (Sativa Rheinau AG, Kultursaat e.V.);
- Development of SI hybrids in cauliflower (Tozer Seed Company UK);
- Development of open pollinated cultivars for cauliflower, kohlrabi, broccoli, cabbage by organic breeding initiatives (Sativa Rheinau AG, Kultursaat e.V. Saat:gut e.V in Switzerland and Germany, participatory breeding projects in Brittany). Development of composite cross populations and farmer participatory breeding of broccoli in France (INRA), Italy (Univ. Perugia), and in USA (Oregon State university) for red curly kale, an early maturing broccoli (Organic Seed Alliance, USA);
- Cultivar testing under organic conditions to identify most suitable cultivars.

Challenges

Changing from cell fusion cultivars to those from other breeding methods constitutes a challenge from several perspectives, including that:

- Open pollinated cultivars and self-incompatibility (SI) hybrids are less homogeneous than CF derived F1 hybrids. If this is manifested in products in the markets, they may not easily be accepted by wholesalers, retailers and consumers,

who are used to a very homogenous cauliflower and broccoli;
- If SI hybrids are used, it is difficult to produce sufficiently reliable seeds;
- Open pollinated cultivars and SI-hybrids are less homogeneous and therefore in some countries it may be more difficult to get approval for cultivar release compared to F1 hybrids (in Europe only cultivars approved for release are allowed to be commercialized);
- Farmers are reluctant to change to open pollinated cultivars as it requires different management (several or prolonged harvests), and marketing them is more difficult**.**

Collaborative Models from Europe

Initiatives to replace CF cultivars in Europe demonstrate the value of communication and collaboration along the organic value chain.

In Germany the specialized organic market/value chain developed a strategy to replace cell fustion cultivars in 2013. In summer and autumn, the supply of cell fusion free produce is relatively easy in Germany because all organic farmers' associations have excluded the use of cell fusion cultivars in their private standards (Bioland, Demeter, Naturland etc). Farmers who are certified only to EU organic regulation do grow cell fusion cultivars but they mainly supply supermarkets. There is also a fairly good supply of cell fusion free cauliflower in winter from Brittany (France) where a regional farmers association (Bio-Breizh) has equally decided to exclude cell fusion cultivars. For other products as broccoli or kohlrabi the German specialized organic market depends on growers in the Mediterranean, especially Spain and Italy. Starting 2013/2014 suppliers were asked by the specialized organic wholesalers to start growing cell fusion free cultivars in order to gain experience and successively replace cell fusion cultivars. In 2016 there was only a very short period where cell fusion free broccoli was unavailable in specialized organic shops and supermarkets (source: BNN). The dialog along the value chain is accompanied by laboratory analysis of the produce. Major challenges remaining are the absence of a reliable information source on which cultivars are cell fusion free and the fact that still cell fusion cultivars are grown in the supplying regions for other organic markets such as the UK, so that there is a constant risk of confusion at different levels: seed companies, producers of seedlings, growers, and packaging facilities.

Representative projects

Project "Fair Breeding": Some retailers from the association "Naturata" realized their responsibility for cultivar decisions on the farmers' level. Also, realizing the potential loss of all CF-free cauliflower they decided to support biodynamic breeders of Kultursaat e.V. in developing new open pollinated cauliflower cultivars. This project has been running for 11 years. Three new cultivars are officially registered and two others are applied for registration.

Project "Saat:gut": A new initiative of organic breeding emerged in northern

Germany. Recognizing the replacement of “traditional” hybrids of cauliflower and broccoli by CF cultivars, a large-scale producer decided to start its own breeding programs for these crops. It convinced some wholesalers to support the work. The organic breeding program broadened to include other objectives and cultivars and now includes carrots, red beet, parsley etc.

Project “labor no more”: This project was set up by the wholesaler, Naturkost Elkershausen. Its director was shocked by the scandal of CMS cultivars in 2014. He decided to take responsibility by himself and set up a study to determine if there are problems with open-pollinated cultivars compared to CMS cultivars on farmers, traders or consumers level. The study concluded that there could be difficulties on the farmer level, especially if there would be no price premium for the open pollinated cultivars. At consumer level, the study did not identify any major problems. This information is useful to pinpoint strategies for taking the next steps to develop open pollinated cultivars in the organic value chain.

Project “Bioverita”: The project started before the scandal and it became more important after it. Italian farmers and a wholesaler began to replace kohlrabi hybrids by open pollinated new breeds from Sativa AG, Switzerland, to find a way out of the dilemma from the creep of cell fusion cultivars in seed supplies. A partnership with a big trader in Germany (Tegut) was set up for supplying the market in winter. Two newly bred kohlrabi cultivars from Sativa (supported by Kultursaat) are in the application process for registering (becoming approved) in the official EU catalogue.

Strategy for the Replacement of Cell Fusion Cultivars

The rationale accompanying Motion 61 on the replacement of cell fusion (CF) cultivars states that " *it is of utmost urgency to combine forces and develop a global master plan and guidelines how to enable cell fusion free organic production chains and to find socially acceptable solutions to replace cultivars derived from cell fusion by alternative cultivars. A common strategy for replacement of such cultivars of the whole Organic Agriculture Sector under the roof of IFOAM should be developed."*

The global strategy that we propose is:

- underpinned by the situation analysis;
- enriched by information and practical models and lessons learned from CF cultivar replacement approaches in Europe;
- addressing both the supply and demand side for non-CF seeds and seedlings.
- flexible for selective use in various regions of the world with different situations;
- dependent for implementation on commitment and initiatives in individual regions and countries;
- focused on initial implementation in a few priority crops while still promoting awareness of the larger scope of cell fusion cultivars in organic production;
- incorporating implementation guidance as possible;
- taking overarching issues and constraints into consideration.

We propose the following flexible blueprint to enable international, national and regional action networks to form and develop action plans. The blueprint includes representative activities for implementation.

Action networks on cell fusion replacement

Implementation will require customization and implementation at national and regional level. This will require national and regional organizing and coalitions-of-the-willing. Whole value-chain education and cooperation is useful. The action networks can support the initiation of individual projects within the value chain, such as those described in the section on Collaborative Models from Europe. National and regional CF cultivar replacement networks will develop action plans to replace CF cultivars based on the global strategy and customized to reflect the situation in their country/region. These networks should include value chain representation from plant breeder to retailers. In regions where there have efforts to replace cell fusion, impacts should be assessed and taken into account for the action planning. The networks are encouraged to consider initially focusing on replacement of cultivars in the species *brassica oleracea such as cauliflower and broccoli*. The reason for this focus is a better chance to achieve total global replacement in a few crop types from which lessons are learned and then the experience can be the basis for replacement strategies for other crop types. This approach could establish a common core for future global action. Also, broccoli, cauliflower and cabbage are widely planted vegetable crops throughout parts of Asia, Europe and North America, and figure into many typical cuisines in those countries. This does not rule out that national/regional action networks will target other species which may be more relevant to them (such as in France and India, where rapeseed may be a higher priority for replacement). In cases where another species is higher priority, such as in rapeseed, various regional action networks targeting the species could share information about action plans share results, thus creating another common core for future action.

Most components of this strategy will be further developed and implemented at, national and regional or other local level. At global level, IFOAM - Organic International supports the effort primarily by disseminating information for general awareness raising and on initiatives taking place at other levels.

Strategic Objectives and Activities

A. Awareness is raised and opinion against CF increases among plant breeders, value chain actors, and academic and government institutions.			
Remarks	For most of the world, low awareness and motivation to take action is the first challenge that must be addressed. Specific actions can be taken at the international level to support awareness raising activities, but the activities themselves require implementation at regional/national levels. Messaging should strongly position CF as genetic engineering with clear arguments for this.		
Activities		*Global Level*	*Regional/ National/ Local Level*
	Communicate this topic to members, regional structures and network groups.	✓	
	Encourage regional structures to initiate action networks.	✓	
	Include cell fusion replacement in outwardly-directed campaigns, events and publications	✓	✓
Indicators			
	Uptake of topic by regional groups and other partners		
	Action networks established		
	Response to campaigns (donations, activists, further dissemination of communications.		
B. Alternative cultivars are developed by plant breeders			
Remarks	The aim is to encourage plant breeders to use alternative breeding techniques to develop cultivars similar to CF cultivars, especially those		

	in high demand. This includes plant breeders in academic institutions, seed companies, national laboratories, and community plant breeding initiatives.		
Activities		*Global level*	*Regional/ National /local level*
	Identifying the cultivars most in demand for alternative versions		✓
	Identifying non-CF germplasm sources, including in various contexts including commerce and academia, seed banks, and community breeding/seed saving initiatives.		✓
	Identifying and including breeders working on CF cultivar replacement or at least not using CF germplasm for breeding		✓
	Supporting networking among breeders working on non-CFC in priority crops e.g. database, discussion fora, and shuttle-breeding (for breeders in regions not conducive to breeding targeted cultivars).	✓	✓
	Mobilizing financial support for plant breeders to work on CF cultivar replacement breeding		✓
	Organizing farmer organizations to guarantee demand so that a breeder can rely on the promise that additional costs for CF-free breeding will be covered through sales.		✓
	Advocating a tax on CF cultivars which would be directed to research on alternatives. (This is feasible if there is transparency about the breeding history of commercial seed lines and a list of taxable seeds.		✓
Indicators			
	Specific cultivars targeted for replacement		
	Evidence of networking among breeders		
	Increase in number of alternative cultivars of sufficient quality for producers to use		
C. Farmers have access to alternative seeds and seedlings			
Remarks	Transparency for farmers is needed in order to access alternatives.		
Activities		*Global Level*	*Regional/ National /local level*
	Encouraging seed companies towards transparency on the breeding techniques associated with their cultivars		✓

	Advocating for regulations that require disclosure of breeding techniques for cultivars.		✔
	Developing cultivar databases which indicate the status of information about their breeding techniques. *Remark: The database may depend on initiatives to identify CF cultivars through testing, as described in the situation analysis. Action networks may explore cooperation with other action networks so as disseminate information and avoid duplication of costly testing*.		✔
	Developing databases of breeders working on cultivars with CF history but employing other breeding techniques. *Remark: Initially this could be a global initiative since there this group is a small community where networking has begun.*	✔	✔
	Advocating to reduce barriers to registration/approval of new cell fusion replacement cultivars, where there are legal requirements for this, for example, setting separate requirements for organic cultivars. *Remark: For example, European countries require registration of new cultivars and impose requirements for this such as homogeneity*.		✔
Indicators			
	Availability of information on breeding methods for specific seeds/seedlings		
	Number of commercialized alternatives to CF cultivars		
	The area dedicated to production of the targeted crops holds steady or grows.		
D. Consumers accept non-CF produce and are empowered to choose them.			
Remarks	Open pollinated cultivars are less homogeneous than F1 hybrids bred with cell fusion. They may vary in appearance and flavor profiles from typical cultivars.		
Activities		*Global*	*Regional/*

		level	*national/ local level*
	Campaigning to improve market and consumer acceptance for less homogeneous "CF-Free" products.		✓
	Establishing voluntary labeling in the marketplace of vegetables not derived from cell fusion		✓
Indicator			
	Sales of non- CF produce hold steady or increase in the stores where CF cultivars have been replaced.		
E. Norms and mandates for organic agriculture include prohibition of CF cultivars and this prohibition is enforced.			
Remarks	This objective should be addressed and related activities undertaken only when there is strong awareness and a common position of the organic value chain against cell fusion cultivars, and some alternative sources exist. It is recommended to address this objective with initial activities focused in private sector standard schemes, (unless such schemes are prohibited such as the case of the United States).		
Activities		*Global level*	*Regional/national/local level*
	Encouraging private organic standards schemes to develop plans for prohibiting the use of CF-derived cultivars and enforcing this. *Remark: this could be a step-wise plan at first targeting certain cultivars where alternatives are available.*		✓
	In IFOAM Organic Accreditation, addressing the current prohibition of CF-derived cultivars while also taking into account the global situation.	✓	
	Advocating to governments to prohibit and/or enforce prohibitions on CF-derived cultivars in national and regional organic standards and regulations. (Only when there is good transparency and alternatives for farmers.)		✓
Indicators			
	Number of private organic standards schemes addressing CF prohibition in their inspection		

	and certification.		
	Number of government regulations that prohibit and enforce use of CF cultivars.		
F. Overarching issues and challenges are addressed and advocated in the context of the cell fusion initiatives e.g. seed patents, global consolidation of seed companies, access to germplasm			
Remarks	The ability of organic systems to exclude GMOs including CF cultivars is increasingly hampered by overarching phenomena. CF replacement projects and advocacy are a good context in which the organic sector can amplify these issues.		
Activities		*Global level*	*Regional/national/ local level*
	Advocacy messaging that includes a systems perspective of the CF problem and replacement challenge. e.g. the contribution of seed patents to situation.	✓	✓
Indicator			
	Proportion of advocacy messaging on CF that includes overarching issues and challenges		

Risks

Cell fusion replacement carries with it a number of risks for success, which should be taken into consideration when planning and implementing strategies.

• The organic sector, either globally or in key regions/countries is not interested to replace cell fusion cultivars, as they have already been cultivated for many years and the sector is fully occupied to avoid GMO contamination and entrance of new breeding techniques into the organic system.

• Because of the worldwide intensive use of cell fusion cultivars in many main crops such as broccoli and cauliflower and without enough existing alternatives it will be difficult to replace cell fusion cultivars in organic farming.

• Liberal attitude of the young generation of sustainable plant breeders towards biotechnology, including cell fusion, may indicate that there will be an insufficient supply of breeders who want to do the breeding work.

•Increasing dependence of organic systems on conventional breeding combined with overarching phenomena such as global consolidation of the seed sector. This includes losing breeding material for future. In other words, the window for action may have closed.

• Organic farmers might not be competitive if cell fusion cultivars are banned while there is insufficient choice of cell fusion-free cultivars, and they might even stop production of crops such as broccoli and cauliflower if they cannot use cell fusion cultivars.

• Cell fusion-free and open pollinated cultivars might not meet expectation of markets and consumers with respect to product homogeneity.

• Scandals and the organic sector losing trust if consumers / critical media become aware about the presence (and current tolerance) of cell fusion technology in organic systems• The present strategy for replacement of CF cultivars is based on awareness raising and campaigning with the message that CF is genetic engineering and that it is widely used for certain crops even for organic farming. Wide awareness of this fact within the media and the consumers might undermine the credibility of the organic label as a label that people thought was effectively excluding GMOs, especially if replacement progress is too slow.

• The timeframe for implementation (and success) of this strategy is uncertain. In any case, it will take many years. During this period, other new plant breeding techniques (e.g. CRISPR/Cas9) will likely be developing/spreading in the same or other crops and potentially equal or even overtake CF in terms of its presence in organic systems. While the sector might be focused on this one CF-replacement strategy and may achieve some level of success, the bigger picture of New Plant Breeding presence in organic farming might meanwhile get worse and worse. Combined with the previous campaigns and messages that "CF is GE and that we will phase it out from organic system," this scenario might backfire into a big loss of credibility and an overall failure of the organic sector to deliver on its promises.

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