

**Topical issue on:**

**NEW IDEOTYPES OF OIL & PROTEIN CROPS**  
**NOUVEAUX IDÉOTYPES D'OLÉOPROTÉAGINEUX**

REVIEW

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# Ideal oil and protein crops – what are users ideotypes, from the farmer to the consumer?

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**Abstract** – Oil & protein ideotypes might be “ideal” in terms of agronomy, they cannot be grown if they do not meet a demand. And while plant breeding takes years to develop new varieties, consumers can change their habits very quickly. Understand the “ideal” crops from the downstream point of view is therefore of paramount importance for R&D. In this review, we look at the current and what may be the future demands for the oil and protein crops. Because of diversity of products and consumers around the world, we chose to focus on French and Western Europe productions and markets: 1) consumers are in a quest for quality, traceability and sustainability (economic, social and environmental) with specific focus on GMO-free and organic demands. Some go vegan and more and more people switch from animal to vegetal protein intakes. And they want to rethink the agriculture model. 2) The food industry must adapt to all these demands while develop solutions for technological obstacles and remain cost-competitive. 3) The farmer needs crop profitability that relies on high and steady yields, eco-friendly and cost-competitive crop management techniques and decent price.

**Keywords:** oilseeds / pulses / ideotype / market / demand

**Résumé** – **Les idéotypes des oléoprotéagineux vu par l'aval de la filière: de l'agriculteur au consommateur.** Les idéotypes d'huile et de protéines peuvent être « idéaux » en termes d'agronomie, ils ne pourront pas être cultivés s'ils ne répondent pas à une demande du marché. Et si la sélection des plantes met des années à développer de nouvelles variétés, les consommateurs peuvent changer leurs habitudes très rapidement. Comprendre ce que sont les cultures « idéales » du point de vue aval revêt donc une importance primordiale pour la R & D. Dans cette revue, nous examinons la demande actuelle en cultures oléagineuses et protéagineuses et ce que pourraient être les demandes de demain. En raison de la diversité des produits et des consommateurs à travers le monde, nous avons choisi de nous concentrer sur les productions et les marchés français et d'Europe occidentale : 1) les consommateurs sont à la recherche de qualité, de traçabilité et de durabilité (économique, sociale et environnementale) avec un accent particulier sur l'absence d'OGM et le bio. Certains deviennent végétaliens et de plus en plus de personnes réduisent leurs apports en protéines d'origine animale au profit d'origines végétales. En outre, ils veulent repenser le modèle de l'agriculture. 2) L'industrie alimentaire doit s'adapter à toutes ces demandes tout en développant des solutions aux obstacles technologiques et en restant compétitive en termes de coûts. 3) L'agriculteur a besoin d'une rentabilité des cultures reposant sur des rendements élevés et réguliers, des techniques de gestion des cultures respectueuses de l'environnement et concurrentielles économiquement, ainsi que de prix décents.

**Mots clés :** oléagineux / protéagineux / idéotype / marché / demande

## 1 Introduction

The breeding of “ideal” seeds is capital to produce crops with satisfying yield and quality while limiting the natural

resources use in a given environment – especially in the context of climate change. But even with such an ideal seed, the agriculture needs to meet a demand for crop production to occur.

It is even more important for the breeding players to anticipate the demand as their time scale is very different from downstream stakeholders: on the one hand, consumers can

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change their habits very quickly so that retail usually sets only one-year contracts with the food industry. On the other hand, plant breeding takes ten years or so to launch new products.

This review goes through the current and what may be future demands for the oil and protein crops. Because of diversity of products and consumers around the world, we chose to focus on French and Western Europe productions and markets.

Let's keep in mind that oil and protein crops are commodities that are traded on a global scale to feed the world. That represents most of the demand which must satisfy two simple criteria: quantity and low price. This explains the recent development of soybean and palm intensive farming in South America and South-East Asia to meet the ever growing demand for proteins and oils.

However, new demand trends have emerged in developed countries in terms of environment, social responsibility, industrial footprint... and will keep on changing the demand for food production. What is now happening in Europe gives us an idea of what could be tomorrow world demand and on what should plant breeding focus on.

In this review, we start with those who make the demand—*i.e.* the consumer: what are the new consuming habits and demand criteria from the consumers, society and what is transferred into regulation. We then focus on the food industry, which needs economic competitiveness together with adaptation to the new demands. Finally, we take a look at the farmer level and his/her expectations.

## 2 Ideal oil and protein crops for consumers, society & regulation

Although oil and protein crops are seldom used directly for food—most of them are processed by crushing or *via* animals—their end markets are strongly impacted by new consumption patterns and associated regulation.

### 2.1 First and foremost: quality, leading to more and more traceability

Whatever consumers may say, in the end, they want quality before anything else. Just have a look at how the food-related scandals from the mad cow crisis in the 90's to the Fipronil® eggs last year have impacted the food industry and European regulation. Sanitary quality is and will remain the #1 criteria when describing ideal crops.

Therefore, the consumer wants to know more about what is in his food and how it was produced. To keep in pace with this growing trend, initiatives flourish to help increase transparency and traceability. More and more labels proposed to the consumer to guarantee the fact that this or that product is free from antibiotics, GMO, endocrine disruptors, etc. Or that it meets with production specification. Thanks to the development of new technologies, whole databases are created to list all the ingredients of food products, including additives and preservatives. With a simple smartphone app, you can now easily scan any barcode and the safety of the food.

Besides transparency of the ingredients, consumers are also interested to look at the value chain up to the producer. There, digital development will also play a key role with

emerging technology: the blockchain. This technology has first been used for the cryptocurrency Bitcoin® but is now applied to many fields, including agriculture and the food industry. More than just a buzzword, a blockchain is an opened ledger of every transaction between the stakeholders. The records are permanent and verifiable, and are not managed by a central authority. A few examples of blockchain applications have occurred over the last few years from grain purchase in Australia to pork quality monitoring in China and poultry marketing in France... We can easily imagine that it will also impact the oil & protein sector, starting with animal feed transparency.

### 2.2 Seeking sustainability

Consumers are more and more mindful to the sustainability of the food production. Of the three pillars of sustainability, environment is definitely the major driver leading to completely new markets for oil & protein crops.

Environmental general awareness has led to new consumption habits in Western Europe in parallel with environmental regulation strengthening. It would be impossible to summarize in only a few lines how the European regulation impacts agriculture and the food industry. Therefore, we will rather look at the major trends and their links with oil & protein crops.

Sustainability criteria are of paramount importance for the biofuel markets. Only biofuels that meet the requirements of the Fuel Quality Directive and the Renewable Energy Directive (EUR-Lex, 2009a, b) can be counted as renewable fuels. Their greenhouse gas emissions must be at least 50% lower than the fossil fuel they replace if they were produced within installations older than 05/10/2015 and at least 60% for newer plants. Moreover, the feedstock used for their production cannot be sourced from land with high carbon stock or biodiversity. Most of the greenhouse gas emissions produced from the life cycle of biofuels are due to the agricultural production. Therefore, environmental regulation impacts directly the oilseeds growing conditions.

Biodiversity is also a major concern that impacts the oil & protein crop markets through 3 ways: i) pesticides and fertilizers restriction—for instance the ban of the bee-harming neonicotinoids, ii) crop diversification with the reintroduction of pulses without pesticides in crop rotation within “Ecological Focus Areas”, and iii) fight against imported deforestation which chiefly concerns palm and soybean productions and their uses in food, feed and energy markets. France for instance has launched a public consultation on its national plan against imported deforestation (Alim'agri).

The social and economic pillar of sustainability also leads to new trends of interest. A key driver that has grown considerably in importance over the last years is animal welfare, although it does not specifically impacts the oil and protein demand. Fair trade is another driver and can apply to European agriculture too. Indeed, consumers are more and more mindful about farmers working conditions and their need to be paid for their work. For instance in France, several initiatives and labels have been created for bottled milk with guaranteed price to farmers. Some of the population is willing to pay a premium for this “local” fair trade, as long as they are guaranteed product quality and traceability.

### 2.3 GMO-free demand is booming...

Another emerging market driven by consumer demand is the GMO-free market, whether for environmental or sanitary concern. This trend is especially observed in Germany where the “Ohne Gentechnik” label has been created (VLOG), and in France. This impacts the oil & protein crop demand since vegetable oil produced from GMO crops are allowed for food uses as long as the GMO origin is written on the package (as there is no DNA material in the oil). But more importantly, it affects the animal feed market to provide oilmeals and pulses for “GMO-free fed” animals. In 2017, already 40% of German milk production and 80% of retail eggs were “GMO-free” labelled. In France, already 21% of poultry and 17% of pork productions were subjected to GMO-free specifications (Cereopa, 2018). And these figures are growing year after year...

The decision in July 2018 of the Court of Justice of the European Union to classify organisms produced by mutagenesis as GMOs has reignited the debate. Organisms obtained from older mutagenesis techniques with a long safety records – several European oil & protein crops are concerned – will not fall under the restrictive laws of GMO use.

### 2.4 ... as well as organic demand

The organic market has boomed over the last few years. In France, the organic market turnover has reached 8.4 billion euros in 2017 when it was only 1 billion euros in 1999 (Agence Bio, 2017). The development pace has been especially high around 16%/year since 2014, simultaneously with the increased organic distribution in conventional supermarkets. However, the organic market represented only 4.4% of the total food market in France in 2017, mostly through groceries, fruits, vegetables and alcoholic beverages. This specific market impacts – to a lesser extent – our oil & protein sector in several ways. First, we observe an increased demand in organic vegetable oil – especially olive oil – and pulses for food uses. Secondly, as for GMO-free demand, the animal feed sector is strongly impacted. In France, the egg market is the fastest growing one within the organic animal products markets. In 2017, already 8% of the production was under organic specifications, 3% for milk, 1% for bovine meat and poultry and less than 1% for pork meat (Cereopa, 2018). Thirdly, it is an opportunity for pulses production since organic crop rotations are longer with more frequent pulses.

In order to follow the increasing demand, Europe will have to switch towards organic oilseeds and pulses production. In 2016 in France, only 357kha of field crops were organic – forage, vineyards, fruit and vegetable areas account for most of the 1.5 Mha of organic agriculture. We are living the early stage of organic oilseeds and pulses production in France an Europe, but this sector must tackle important obstacles and get more structured in order to succeed (Tonin, 2018).

### 2.5 Flexitarianism / vegetarianism / veganism

In connection with the sustainability trend, more and more consumers in developed countries are reducing or eliminating their animal products intake. From flexitarianism to vegetari-

anism and even veganism, those expanding diets are both an opportunity and a threat for our protein crops. On the one hand, the decrease in meat consumption has reduced the animal feed market. On the other hand, high value-added plant protein ingredients markets are emerging to supply consumers with animal products substitutes. In 2016, the global plant protein ingredient market was worth 6.4 million USD and is expected to grow to 12.7 million USD by 2027 (TMR, 2017). Soybean is the most used crop for those ingredients, followed by wheat. Pea protein use is also developing. However, technical barriers must be lifted for rapeseed and sunflower proteins to be used directly for food.

### 2.6 NGO's claim that citizens want to rethink the agricultural model

A last trend we would like to share is about how agriculture is seen by the public and how the civil society brings changes to European farming. With the help of social medias, more and more consumers and NGOs bring to light topics such as animal welfare, pesticides, etc. To the point that it induces changes in the regulation. A recent example is France's position to ban glyphosate following last year debate. Such a trend leads to direct impacts on oil & protein crops, both as threats and opportunities, and must be anticipated as far as possible by plant breeders.

However, oil and protein crops remain globalized commodity markets. If more stringent regulation is applied on European agriculture but the consumer is not willing to pay for it, importations from more relaxed countries may replace domestic production. To prevent this situation, the European agriculture must differentiate itself from the foreign commodities through quality approach and labels.

## 3 Ideal oil and protein crops for the agro-industry

In the 2000's, European Union biodiesel industry has expanded considerably. Biodiesel gradually became the main oil outlet and represents more than 35% in 2016 (Oilworld, 2017) of the total oils consumption. Sunflower oil being a premium quality oil is barely used in biodiesel industry. Rapeseed and sunflower seed crush expansion also helped EU to increase its protein self-sufficiency.

### 3.1 Food oil industry: good fat vs. bad fat

Despite steady oil consumptions in the human diet, consumers from Western Europe are developing negative perception of certain oils compared to others. They are looking for healthy and environmental friendly diet. Due to rainforest destruction to settle more plantations, palm oil is bashed from NGOs, Green activists or consumer associations. French government even tried to implement the Nutella<sup>®</sup> tax in 2016. Following this trend, food industrials are progressively switching their sourcing. As a first step, they decided to use certification schemes such as RSPO (Roundtable on Sustainable Palm Oil) to certify palm oil and they sometime go further by reformulating their recipes away from palm oil.

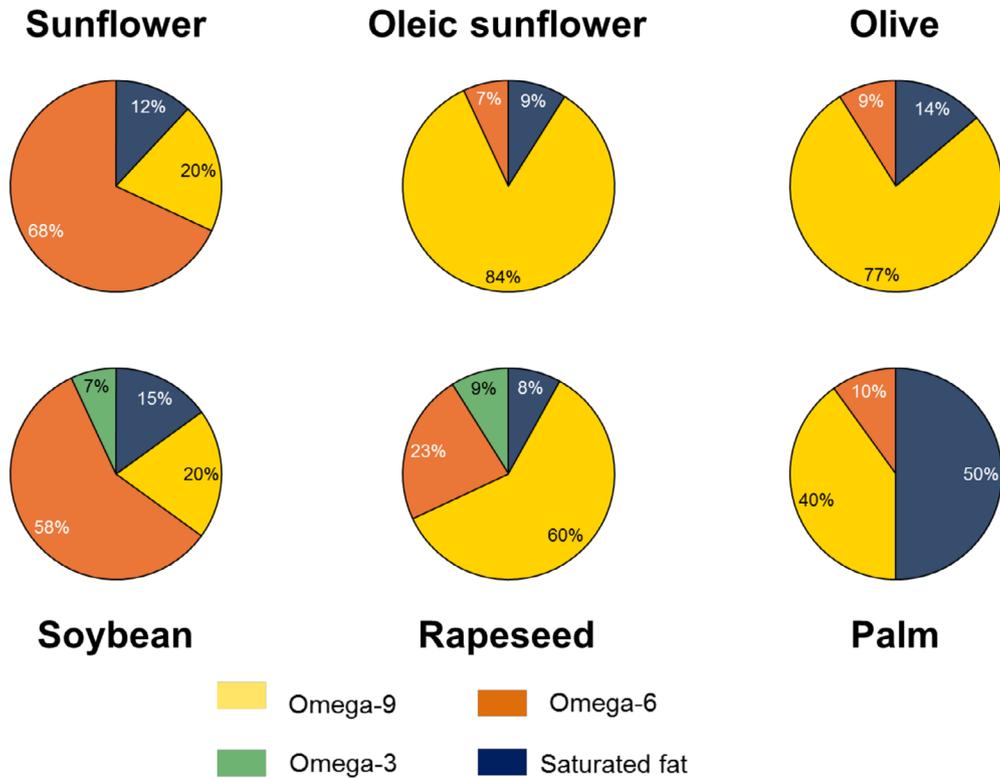


Fig. 1. Fatty acids profiles of main vegetable oils. Source: AVRIL.

However, getting palm out of the formulation is challenging for the industrials. Indeed, palm oil has many interesting properties such as low flavor impact, good stability to oxidation and high level of saturated fatty acids leading to stability/low fluidity of the oil at ambient temperature.

High Oleic oils (sunflower or rapeseed oil) with their reduced saturated fat levels and low trans-fat acids once fried (thanks to high smoking point) reduce the cardiovascular risk and represent healthy option for food manufacturers. High Oleic Sunflower Oil (HOSO) is the more developed market but recently suffered from high price volatility. Indeed in 2014, East European countries involved themselves in this crop, for the EU guarantees an oleic premium. With higher volumes on the market, this premium plummeted. Currently, the volumes produced are around 40–50% from the Black Sea countries and 40–50% from France and Spain. From a niche market, it became a more commoditized market directly linked to supply and demand with price and supply risks for the food industry. Securing the supply is a key and HOSO consumers could be looking for some alternatives. High oleic rapeseed or soybean oil could offer similar properties as HOSO and diversifying the supply is of interest (Fig. 1).

### 3.2 Biodiesel industry: going greener

Sustainability challenges lead to the quest of higher Green-House Gases (GHG) savings. GHG biodiesel value is based on Life Cycle Analysis (LCA) and is the sum of the crop, transport and industrial emissions values. EU rapeseed is facing high competition:

- from others origins – Australia and Canada are farming more extensively their rapeseed – and;
- from other crops such as soybeans and sunflower as per lower fertilizers and insecticides consumption.

Palm oil can also be more interesting than rapeseed when the industrial process is including methane capture even if it has a negative image like in France where people are against the use of palm oil in biofuels at 71% according to a survey conducted by Odoxa institute.

High pesticides applications and the need of nitrogen are crippling rapeseed emissions. Any seed variety improving the environmental impacts will regain competitiveness for EU rapeseed growers and industry.

Despite lower GHG savings, rapeseed oil feedstock is still necessary in the biodiesel blend given its technical properties. Biodiesel technical specifications set the temperatures at which biodiesel is still liquid. The cold filtering plugging point (CFFP) is for instance between  $-10^{\circ}\text{C}$  and  $0^{\circ}\text{C}$  in France according to season. Rapeseed methyl ester (RME) CFFP ( $-12^{\circ}\text{C}$ ) is much lower than Palm methyl ester ( $+11^{\circ}\text{C}$ ) as it has less saturated fatty acids. RME is therefore interesting and needed in blends to meet the specifications.

As for sunflower use for biofuel, sunflower oil was historically more expensive than the other vegetable oils and therefore used for food. Moreover, sunflower methyl ester has a higher CFFP than rapeseed and even soybean methyl esters. Sunflower biodiesel should therefore remain a niche market.

The combination between low CFFP and high GHG saving is then the ideal feedstock to meet biodiesel expectations.

**Table 1.** Oil content in a selection of oilcrops.

	Oil content
Rapeseed	43%
Sunflower	44%
Soybean	18%
Olive	15%

### 3.3 Crushers: value to switch from the oil to the protein

Oil contents depend on the oilseed: rapeseed and sunflower seeds are “softseeds” with 43 to 44% of oil within the seeds while soybean or olive oil content are rather low at less than 20% (Tab. 1). At the other hand of the scale is palm culture which produces almost exclusively oil.

A key indicators for crushers is the oilshare. It is the value of the oil within the crush margin. Oilshare being higher than the oil content means the industry is paying more for the oil than for the meal. For soybean, the range is wide, roughly from 25 to 40%.

The oil value remains linked to biodiesel, with gasoil prices remaining a reference as source of energy. It also evolves with the political environment. In the process of RED II (the new Renewable Energy Directive that will set the European biofuels market from 2021 to 2030), biodiesel policies are uncertain and after 2020, food crop based biodiesel might be more capped than they used to be.

Due to oil values, protein could be considered as a by-product. However, the historical production of rapeseed meal is correlated to the relative decrease in soybean meal consumption and increase protein self-sufficiency in France and in EU. But, Europe remains a net importer of protein meals: in 2017, France consumed 2.5 million tons of rapeseed meal and 3.4 million tons of soybean meals (with a total of 8.4 million tons for the major 12 meals), out of which 58% were imported (total of 4.7 million tons, including almost 3 million tons of soybean meal).

Meanwhile, protein self-sufficiency is a key point in agricultural policies (new CAP and protein plan). According to OECD-FAO agricultural perspectives (<http://www.agri-outlook.org/fr/>), world protein demand will be growing faster than the oil demand. Crushers will definitely want varieties with higher protein contents.

### 3.4 Protein industry for food: refresh the image of vegetal protein

World vegetal protein intake represents 60% of protein food intake while it is only 35% in EU and 30% in France (Institut Carnot Qualiment). Along with the consumer approach on fats, their relationship to meat is also evolving. We can see more and more people being flexitarian, veggie or vegan. Taking away meat from their diet, lead them to find new sources of protein. Vegetal proteins for human food consumption are not new, but peas, beans, lentils... consumption is increasing. Historically, their image is rather

negative due to bad digestibility and cooking inconvenience, however, for a few years, new innovation appeared on the market trying to facilitate cooking and to copy meat. These new recipes are using textured, concentrated or isolated protein ingredients from peas, pulses, soybean and cereals. Rapeseed and sunflower proteins are not used for direct food uses yet and technological break-through are required to enter the market.

### 3.5 Protein industry for feed: how to deal with the self-sufficiency?

As revealed by the US-China trade war, protein sufficiency is strategic leverage at national level and any local grown protein sources is of interest offering independence and easier traceability. Furthermore, feed industry needs more and more efficient and sustainable feedstuff to reduce conversion rates and then environmental losses, it also needs to adapt and match consumers demand, for instance with non-GM products.

Non-GM and local soybean meal supply is very limited and could even be considered as niche. Non-GM rapeseed meal is the main protein source among meals available in Europe. However, rapeseed meal can replace only partially soybean meal in the feed mix due to its specifications.

Despite good fatty acid profile, rapeseed meal has lower protein content than soybean meal and is poorer in essential amino acids (lysine or methionine). Breeding enabled to drastically reduce the glucosinolate concentration, thus allowing the rapeseed meal to become more proper to animal consumption. Next steps would be to work on the amino acids or protein concentration. Meanwhile, rapeseed meal can be associated to feed peas to increase lysine intake.

Good quality protein sources are then supposed well balanced in essential amino-acids and highly digestible, preferably locally grown (Tab. 2).

### 3.6 How to meet the organic demand with oilseeds and protein crops?

Local origin of the products and short food systems is also of interest. Any new varieties/products meeting the EU consumers demand will gain in being grown locally. Local varieties will permit a better traceability avoiding the GM risk inherent to some countries.

Still for health and environmental reasons, consumers are switching their diet from conventional to organic. Organic demand is increasing for both meal and oil. The tolerance to disease and insect pressure becomes all the more a key point in the development of seed varieties, as many plant protection products are excluded from organic specifications. The exclusion as well of many plant nutrition products meets also the objectives of lower GHG emissions for the biodiesel (fertilization being a major contributor to GHG emissions)

Organic rapeseed crop is still hard to grow. And farmers switching their land to organic are eliminating rapeseed from their crop rotation. The most yielding rapeseed areas are too north to grow sunflower or soybean.

Some protein crops and in particular soybeans are better adapted to organic farming (15 to 20% of French soybeans)

**Table 2.** Average composition and nutritive value of oil meals, in Kcal/kg of raw product.

	Rapeseed	Undecorticated sunflower	Soybean 48
Protein (% unprocessed product)	34	29	45
Cellulose (% unprocessed product)	12	24	6
Raw energy	4100	4100	4180
Poultry metabolizable energy	1500	1370	2300
Pig digestible energy	2900	2030	3400
Pig net energy	1450	1060	1680
Milk feed unit	0.94	0.59	1.03
Meat feed unit	0.91	0.50	1.02

Source: [Terres Inovia](#).

and thanks to new cultivars growing area can be extended to northern regions.

#### 4 Ideal oil and protein crops for the farmer

Crops profitability is essential for farmers. Their crop rotation decisions are based on crops profitability, as well as agronomic and organizational criteria. Therefore, farmers need varieties that are adapted to the pedoclimatic conditions and which provide a good return on investment. They will be especially interested in robust varieties with a high and steady productivity. The yield stability has always been a limiting factor for farming, and is now becoming the strongest one, due to the lower predictability of the climate and of the economic environment.

Farmers remain attentive to consumers expectations and to environment preservation, the latter is now an integral part of their day-to-day job. For this reason, they will look for varieties which require fewer pesticides and fertilizers inputs, to be included in greener crop management techniques. Varieties with better nitrogen efficiency are also necessary to reduce nitrogen fertilization costs and GHG emissions. That's for instance the object of the Rapsodyn project.

Climate change is under way. In order to tackle its uncertain consequences, farmers will need a broad array of tools from public aids to plant protection techniques, insect resistant and drought tolerant varieties...

Last but not least, productivity alone – in terms of quantity – is not enough to guarantee a sustainable net income for the farmer, even with eco-friendly & cost-efficient crop management. Selling price is the last key component of the farmer income. To optimize his selling price, he must control the commercialization. This can be achieved thanks to increased storage capacity at the farm, a fairer distribution of the added-value along the production chain, the development of specific varieties for niche markets... Contractualization is a good way to cover all those requirements and ensure economic, social & environmental sustainability.

#### 5 Conclusion

In this review, we went through the current and what may be future demand trends for “ideal” oil & protein crops, from de consumer/citizen point of view, then for the industry and

finally for the farmer. It does not claim to be exhaustive but should rather be considered as a package of examples to illustrate the need for the plant breeding players to anticipate future demand.

These examples we gave are not oil & protein crops-specific. They highlight new trends that affect the whole agriculture and food sector. Our oil & protein crops are all the more concerned because their end markets are very diversified: food, feed, industrial uses...

If we want to keep on producing most of our food locally, to hold onto our self-sufficiency, European agriculture must adapt to market mutations. This cannot be done without R&D to undo the current technical locks for new varieties and crop management techniques in order to develop organic production, reduce greenhouse gases emissions, adapt to climate change, etc. In the middle of globalized and ultra-competitive markets, quality differentiation is key.

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