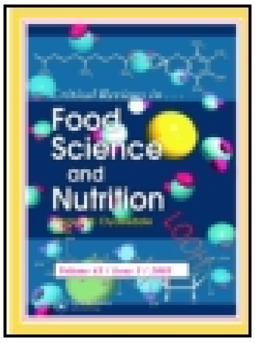

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Co-existence of GM, Conventional and Organic Crops in Developing Countries: Main Debates and Concerns

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Abstract

The co-existence approach of GM crops with conventional agriculture and organic farming as a feasible agricultural farming system has recently been placed in the center of hot debates at the EU-level and become a source of anxiety in developing countries. The main promises of this approach is to ensure “food security” and “food safety” on the one hand, and to avoid the adventitious presence of GM crops in conventional and organic farming on the other, as well as to present concerns in many debates on implementing the approach in developing countries. Here, we discuss the main debates on (“what”, “why”, “who”, “where”, “which”, and “how”) applying this approach in developing countries and review the main considerations and tradeoffs in this regard. The paper concludes that a peaceful co-existence between GM, conventional, and organic farming is not easy but is still possible. The goal should be to implement rules that are well-established proportionately, efficiently and cost-effectively, using crop-case, farming system-based and should be biodiversity-focused ending up with “codes of good agricultural practice” for co-existence.

Key words

Co-existence; GM Crops; Conventional Farming; Organic Farming; Food Policy; Developing Countries.

1. Introduction

1.1. Co-existence: an old concept with new advocates?

Co-existence of different crops is not a new concept. Traditionally, farmers are used to producing different crops side-by-side. They are often asked to produce certified and certain crops to meet defined purity standards in the market. This manner of production shows that co-existence is not a new concept for a wide range of production methods (CropLife, 2006). While the co-existence of biotechnology[1] and organic farming has received much attention lately, farmers, producers and consumers can rest assured that previous generations have successfully addressed the challenges of other forms of co-existence. According to the International Seed Federation, which represents the seed industry, "The farming community and the seed industry have a long history of growing different crops side-by-side and of producing pure seed stocks" (ISF, 2004). Many scholars and practitioners argue that in many developed and developing countries, the organic[2] farming system that usually comprises of a relatively small proportion of the agricultural sector has existed along with conventional systems (Jukesa & Stoutb, 1997; Byrne & Fromherz, 2003). Indeed, co-existence was tracked as soon as scientists could produce primary synthesized products with use in agriculture.

In the old days, farmers and later, the other agricultural stakeholders (i.e. scientists, policymakers, practitioners, businessmen, and consumers) tried to provide people with “secure food” in different indigenous and scientific ways. Currently, the stakeholders are trying to

[1] GM technology aims to introduce a new trait to the plant which does not occur naturally in nature. Given that GM crops are not the same as conventionally cross-bred crops, in this study, GM crops and conventional crops are considered as separated farming systems.
[2] It should be noted that organic agriculture is a science-based (and not a traditional) approach which is originated in the 1920-30s. There is indeed a big difference between “traditional agriculture” and “organic agriculture” as the latter is science-based but the former is indigenous-based approach (Vogt, 2007).

provide people with “safe foods” while saving the environment. Conventional agriculture may provide short-term gains in production (e.g., compared to organic agriculture), but in most cases, it is not sustainable in the long run. It undermines the viability of small farm units and does not guarantee safe food. In particular, conventional production methods are inappropriate for food security problems and are thus not a suitable solution for many of those who face food shortages (Rundgren, 2006). Steadily, when conventional agricultural method is not sustainable enough to supply the world with both “food security” and “food safety”, the stakeholders have been divided into three parties: i) those who believe that the co-existence of GM crops with conventional products are the unique solution for both food security and safety (Azadi and Ho, 2010; Bazuin et al., 2011); ii) some believe that organic farming is the sole answer for the two issues (Sligh and Christmann, 2007; Halberg and Muller 2013); and iii) others believe that a co-existence approach of GM crops with OF can properly challenge the two issues (Fontes, 2007; Charles at al., 2010). The third group believes such an approach can benefit from the advantages of both GM and organic farming whilst avoiding their disadvantages. However, there are some important debates on the application aspects of this approach which some are rarely addressed. Opponents raise some important questions mainly on three main concerns about the co-existence approach of GM crops with OF: i) environmental aspects; ii) socio-economic aspects; and iii) policy aspects. This paper endeavors to discuss the main debates and concerns of a co-existence approach. First, the concept of “co-existence” is clarified to understand “what” is meant by its definition, followed by several important questions on its application as to mainly “why”, “who”, “where”, “which”, and “how” this approach should be implemented. Next, several technical, socio-economic and policy based issues are addressed. Lastly, conclusions are drawn in regards to the main discussed debates and concerns.

2. Main debates

2.1. What is co-existence?

Coexistence refers to a state where different primary farming systems such as organic, conventional or/and GM are concurrently implemented or stand alongside each other, while each performs independently, affecting the others as little as possible (Altieri, 2005). Within an agricultural society, cultivation of the same crops may be carried out by dissimilar farming methods in the framework of different farming systems. On the contrary, what might be considered as incompatible crops could be grown in the same farming systems or even on the same farm. The question is then asked as to which one can be called a "co-existence" approach? The answer can either be both of the systems or none depending on their temporal profile. The point is to realize whether the different farming systems exist "at the same time".

Co-existence is the practice of growing crops with different quality characteristics or intended for different markets in the same vicinity without becoming commingled and thereby possibly compromising the economic value of both. It is based on the premise that farmers should be free to cultivate the crops of their choice using the agriculture system they prefer, whether they are GM, conventional or organic. Co-existence is not about environmental or health risks because it refers only to the growing of crops (including GM crops) that have been authorized as safe for the environment and for human health by the country in which it is being grown. Concerns about co-existence relate to potential economic loss through the admixture of GM and non-GM crops

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that may result in a reduction of the crops value, and with costs as well as time associated with identifying workable management measures to minimize such admixture.

The issue is, therefore, neither about product/crop safety nor about environmental or health risks but rather deals with the economic impact of the production and marketing (Brookes and Barfoot, 2004) despite the economic impacts which, in the long term, can be influenced by health and environmental risks (Taube et al., 2011). The reason for this is because it refers to the growing of crops that have previously been authorized[3] as safe for the environment and human health, and which are therefore available commercially to farmers (CropLife, 2006). Thus, the main concern remains the socio-economic consequences of adventitious presence of GM crops in organic crops and vice versa (Sahai, 2008). The main concern is regarding the potential for economic loss through the admixture of GM and organic crops which could lessen their value in the view of both farmers and consumers alike (EC, 2003). The concern is also related to the spent costs and time on determining practical management measures to minimize such admixture (Jank et al., 2006).

2.2. Why co-existence?

While GM crops may offer great benefits to agriculture and farmers and also potentially to consumers, in particular to the poorer people in developing countries, biotechnology has not yet come without risks and still faces uncertainty. There are still many fears linked to perceived threats of biotechnology to human, animal and plant life, as well as to biodiversity and the environment at large (Schoonbeek et al., 2013).

[3] Although some (Taube et al., 2011) have currently raised some serious questions whether the authorities evaluation is fair and sufficient.

For the first time, in 2012, developing countries planted more GM crops than developed nations, with 52% of global biotech crops. By 2015, out of the 28 countries which grew biotech crops, 20 were developing whereas only 8 were developed countries (James, 2015). Latin American, African and Asian farmers together grew 97.1 million hectares (54%) of the global 179.7 million biotech hectares (compared to 53% in 2014), whereas industrial countries planted 83 million hectares or 46% (versus 47% in 2014). This rejects the pessimistic assumption (before the biotechnology commercialization in 1996) that GM crops could only be effective and utilized in industrial countries and would not be accepted and adopted by developing countries (James, 2014). During the period between 1996-2013, the economic benefits achieved in all industrial countries reached US$65.2 billion compared with US$68.1 billion in economic benefits achieved in developing countries (Brookes and Barfoot, 2015).

One main fear is that GM technology may change the toxicity and allergenicity of food, thus fostering allergic reactions or altering antibiotic resistance (OECD, 2000; Wolt, 2008). Another concern is that the GM crops resistant to herbicides may increase the growth of the so-called super weeds[4]. The other related concern is that GM crops may threaten the diversity of both flora and fauna and result in excessive dependency on few varieties (Zarrilli, 2005a).

On the contrary, there is also a growing body of literature that demonstrates the positive impacts of GM crops in relation to food security and poverty reduction (Azadi et al., 2015b). Many food-insecure people in developing countries live in rural areas, earn a significant share of their income from agriculture and meet a substantial share of their food needs from their own

[4] Such weeds result from accidental crosses between neighboring crops that have been genetically modified to resist different herbicides. Farmers are often forced to resort to older stronger herbicides to remove them (Randerson, 2002).

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production. For them, increasing agricultural productivity and thereby real income is a high priority, and for the urban poor in those countries, anything that effectively lowers the price of basic foods and/or boosts the nutritional value of those foods is highly desirable. Given the large value shares of agriculture and textiles in production and food in consumption in developing economies, GMO technologies for crops such as rice and cotton can have the potential to generate significant economy-wide benefits that may well dwarf any costs as perceived in those countries in terms of environmental and food safety risks (Anderson and Nielsen, 2000). A good example of positive impact of GM on increasing food security can be found in India where Qaim and Kouser (2013) analyzed the food security impacts of GM crops on a micro scale. They concluded that the adoption of GM cotton raised family incomes and consequently had substantially enhanced calorie consumption and the quality of daily diets. This technology has decreased food insecurity by around 15–20% among households who were producing cotton. Similarly, through conducting a case study in Pakistan, Ali and Abdulai (2010) found that adopting Bt cotton had a positive and significant impact on yield, household income and poverty reduction. Finally, GM techniques are questioned in terms of their ethical and religious concerns (Moseley, 1999; p. 30). Nevertheless, studies of consumers' attitudes draw a vague picture. Surveys on the consumers' tendency to buy GM foods show three different categories: one-third of the consumers absolutely refuse the buying of any GM products, one-third would accept such foods if they were convinced on their benefits, one-third did not show any refusal GM foods (Co-Extra, 2004). Because some consumers reject GM foods, this has caused a dichotomy in the market. Some consumers desire food completely free of GM traits whereas others are more open to purchasing food containing GM traits. Certain countries, especially in the EU, and most recently in the US, have regulations that mandate the labeling of GM foods. In this situation, it is more probable that countries that are the most capable to guarantee co-existence of GM and organic crops and create reliable traceability all along the food chain would get rather decisive benefits in the international market as they will be able to guarantee freedom of choice for all of the stakeholders, from producers to consumers.

According to Co-Extra (2004), this is especially true for countries like EU member states, Japan, New-Zealand and South Korea which have established regulations on GM foods related to labelling. However, also among the EU member states, there are large differences regarding the perception and legislation in terms of co-existence. In most member states, preparatory discussions are still on-going. The first specific co-existence legislation was adopted by some member states in 2004 (some Austrian Länder, DE, DK) and 2005 (CZ, PT, some Austrian Länder). The rule applies to all products that contain a trace of more than 1% of GMO content. In some member states, competence for rules on co-existence lies at regional levels (AT, BE, IT, and UK). In some other member states, for example in Spain, competence for co-existence rules lies with the federal government while certain responsibilities are regionalized, such as those for defining planting dates, monitoring and enforcement authorities, etc. (EN, 2006).

Co-existence of GM and non GM, (including organic) crops has been occurring in North America. The production system in the US has effectively facilitated the co-existence of GM, conventional and organic production without government interventions since the first release of GM crops in 1995. The USA has confirmed the concept of substantial equivalence in relation to GM products: if a GM product is significantly the same as its conventional counterpart, it should be regulated the same as the conventional product. There is a big difference between the situation in the EU where the choice of farming practices is limited due to legislation (ban in many EU member nations on growing GM crops of any kind) and North and South America where there is a full choice of preferred system by grower to employ. The co-existence of GM, conventional and organic production systems without legislation in the US can be as considered as an alternative model for developing countries. Nevertheless, the infrastructure is different in developing countries and therefore there may be a greater need for legislation. In these countries, policymakers need to develop their own rules on the basis of their local farming systems and the realities of their agricultural sector.

The rapid and continued growth of organic markets in the developed world, particularly Europe provides an impetus for farmers in developing countries to change practices to meet this demand. The rejection of conventional agriculture and GM crops in EU might be a simple explanation for the trend of increasing organic production that poorer countries are taking advantage of; the opportunities to export high-value agricultural products to EU markets. Accordingly, a co-existence approach is needed so that developing countries can take advantage of various agricultural systems (including GM, organic and conventional agriculture) to feed their people while increasing economic goals. Therefore, the rapid and continued growth in organic markets in the EU can be filled by developing countries if a co-existence approach is successfully implemented.

Principally, reliable co-existence and traceability systems can revive the consumers' trust in the labeling which might be broken by unexpected GM contamination in food supply chains. Alternatively, a reliable co-existence approach which holds a consistent traceability system may improve the commercialization of the added value by GM products.

All in all, there are some significant advantages for a co-existence approach, particularly considering the opportunities offered by different crops for coping with different production systems and varying environmental conditions, including climate change (Fontes, 2007). Recently, some research papers highlight the term “sustainable intensification” as another strategy for the co-existence concept driven by eco-efficiency as the driving force (Charles at al., 2010). Allocating more farmlands planted by conventional and organic methods might lead us to more environmental loss so the answer is to dedicate more land to co-existence farming which is more likely to ensure food security and safety (Hristozova, 2009) while meeting market demands.

2.3. For whom?

From the perspective of global food security, scientists argue that further research and implementations of new GMO crops with improved input traits (e.g. salt and drought tolerance) and output traits (e.g. nutritional quality) are necessary to ensure public health (Charles et al., 2010). One of the main premises of the co-existence approach is that farmers should be free to make their choice whether they prefer to cultivate GM, conventional or organic crops. Farmers, seed developers, dealers and food companies want to be able to supply all consumer demands in different markets. Co-existence farming is also important to large-scale growers who, according to Fontes (2007), want to be able to take on different farming systems as they wish, as well as family farmers and indigenous communities, who often decide on cultivation of crop varieties due to their religious or cultural values and different tastes or cooking priorities.

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The European Commission (2003) also refers to co-existence as the issue of "farmers" ability and preference to provide "consumers" with a choice between conventional, organic and GM products. According to Jank et al. (2006) strategies and best practices for the co-existence of GM and non-GM crops need to be developed and implemented with the "participation of farmers" and other stakeholders.

On the other hand, the possibility of the adventitious presence of GM crops in organic foods raises the question "who should be aware of such adventitious presence?" Definitely nobody should be more concerned in this regard than consumers, who demand to know the source of their food. Therefore, the co-existence approach is directly linked to consumer choice: to provide consumers with trustworthy information to let them make an informed choice between GM, conventional and organic foods. This right to information should not simply be meant as "traceability" and "labeling" system that should also function properly, but also as a duty of the agricultural sector that is responsible to feed people, that should provide the different types of foods. Otherwise, when people do not have several choices, they are unconsciously forced to buy whatever is presented to them at market. Therefore, the question of "who" should take care of co-existence should not be an easy answer such as "farmers" or even "consumers" but also, it is the responsibility of the "food industry" which starts from farmers whom are the producers, followed by the food process engineers, before reaching the consumers who use the foods. Political stakeholders also may need to play a role in legislating a co-existence strategy and safeguarding its implementation by other stakeholders.

2.4. Which farming system?

It should be regarded that there is no general rule on the loss or gain of GM and organic farming systems to ensure food security and safety on the one hand, and their environmental failure and benefit on the other, especially when considering the huge environmental diversity and variety of farming systems in developing countries. Some believe that this is an economic issue. Preference of one system over another must not be the result of unproved, discriminatory or impractical assumptions. Different agricultural systems can co-exist and play an important role in sustainable agri-food production systems globally (CropLife, 2006). It should be noted that all forms of agriculture should be respected as none of them are perfect. The diversity of farming systems should be appreciated not only as a human need for the time being, but also as a goal to preserve fauna and flora. This means that we need to protect and possibly enhance the existing diversity in agriculture and never let one system dominate the others (which might be not realistic anymore in the US and increasingly within Latin America due to a widespread use of GMOs). It is therefore very important to note that all forms of agriculture should be available to future generations. They should be able to practice different agricultural systems and use their products and make their own informed choice. Furthermore, future generations should be able to make new developments in GM that may not implicate the use of GMO's today. Excluding either GM or organic will lessen the options available for future generations. We need to ask whether the use of specific farming systems (like GM) may impair the future generations' options. Given the probable negative impacts of GM crops, we may run into a contradiction if we emphasize the necessity of using such crops today. On the contrary, by ignoring the positive impacts of GM crops we may lose the benefits of GM crops for future generations. Beside, it is very important to note that every change in farming systems requires time and many arrangements. If we set up a

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mono-farming system, we may lose the benefits of others. It can be very expensive and time consuming if we need to switch back to other farming systems but is still possible to do. Therefore, what we make as a decision now, is very important and will increase or lessen the future generations' choices. Consequently, some critical questions could be asked: do we need to distinguish between and separate GM crops with negative and positive impacts? What are the main drivers for selecting a specific farming system in a specific situation? What are the producers' main supply abilities? What are the consumers' main demands? What are the society's main present and future preferences?

2.5. Where?

The ability of an agricultural sector to preserve different farming systems is also fundamental (Schiemann, 2003). It is very important to know that not every agricultural sector is suitable to implement a co-existence approach. There are some critical questions which should be answered by agricultural policy makers and practitioners within a given society before implementing co-existence to ensure food security and food safety on the one hand and to avoid the adventitious presence of GM crops in conventional and organic farming on the other: how can smallholders growing GM crops be integrated into global value chains? Is a given society prepared enough for co-existence products? Is the market developed enough for co-existence products? Is the market easily reachable for both farmers and consumers? Are the farmers and consumers aware of gene technology and organic farming? Are the farmers trained how to implement the approach? Do they benefit from a strong management in their farming activities? Do the consumers know what they eat? Are they aware of the ingredients, labeling and measurements of those ingredients? One may raise more questions here but most importantly, the necessary most relevant 'socio-

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economic' elements to find a proper place to implement the co-existence approach are "market" and "awareness", but also the 'environmental' prerequisite of the avoidance of significant "negative impacts" on the other production systems. If the three main elements are not met, it might be very hard to implement the approach successfully, whether in developing or developed countries though it is more likely to find a developed market and higher consumer awareness in developed countries. For instance, co-existence is reportedly successful in North America. In this region the market has effectively facilitated the approach without government intervention. In the region, while the first GM crops were introduced in 1995, there had been acknowledgment that if farmers wished to steer clear of GM contamination in their farming systems, the responsibility for implementing the measures to facilitate the approach, falls upon special products (including organic) which are, in turn motivated by price premiums for the costs associated with meeting the requirements of the customers and certifications (Chopra and Kamma, 2005). However, meeting the elements might not be easy, because it can be very expensive and time consuming if we need to switch back to other farming systems, but is still possible to do. According to Alcalde (2003), although co-existence of Bt maize between the different types of farming systems successfully stimulated the market in Spain, further modifications to agricultural practices are necessary in the future in order to let the market share of GM-crops increase, whilst ensuring co-existence between other farming systems.

Conversely, in most developing countries, GM crops have not yet been commercially grown. Government authorities in these countries have not given farmers official approval for the planting of any GM crops mainly because of concerns about biological safety (Azadi & Ho, 2010). Furthermore, the GM approach in these countries is not primarily driven by (small scale) farmers but by multinational corporations in export oriented cropping systems on a very large scale of farming (e.g. Brazil and Argentina). Such global players have their own private extension service while the state sector lacks the basic infrastructures for those training programs and environmental awareness (Hecht, 2005). The countries also lack the state capacity and civil society effectively forced to consider, monitor and enforce bio-safety policies. Consequently, such a shortage might hamper the technological and knowledge capacity required to initiate a successful co-existence approach. Accordingly, do we need to cope with a third dimension beyond developing and developed countries?

2.6. How to start?

Before understanding “how to start”, it is very important to note that given the socio-economic dominant aspect of the coexistence approach (see 2.1), some hierarchical prerequisites (e.g. good governance, gender issues, infrastructure, education, etc) which mostly deal with poverty, should be addressed on a country by country basis before implementing the approach. Then, the “potential” implementation of the approach can be regarded.

Indeed, it is often easy to speak about the co-existence approach but hard to provide policy makers and practitioners with concrete actions in this regard. It is very important to ask: what is the first step and how should the approach go forward? How should a country implement co-existence?

While the EC guidelines are based on the principle that co-existence is about providing farmers and consumers with a practical choice between conventional, organic and GM food productions, they do not give any policy start-up which is absolutely important for policy makers to find a way forward. Indeed, the guidelines are mostly focused on the measurements, labeling, and

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traceability but do not make sense policy wise on how to switch the approach from the "current" status of an agricultural sector, particularly in developing countries. In other words, what adjustments are needed in the farming systems as well as market when implementing the co-existence approach? The following presents some strategies in this regard. It should be noted that all the mentioned strategies should be considered as "start-up" policies and over time, should be adjusted according to the profile of a country's agricultural sector.

Farming plots in developing countries are small in size. Farmers do not have the capabilities and necessities required to meet their basic needs or are living with the fear of losing their resources. The critical elements in all definitions are livelihood, low earnings, profits and illiteracy (Azadi et al., 2015a). Accordingly, we need to find a solution to increase the living standards of farmers and consumers especially within developing countries. Development in agriculture refers to many related activities that can promote the total value of goods and services produced, improve human welfare, quality of life and social well being. Such a development can ultimately reduce poverty and save lives by promoting better farming conditions, so that agricultural operations can be conducted more efficiently. Agricultural development can help subsistence farmers have enough to eat, be able to send their children to school, and earn enough money to have some savings. Development in agriculture can be accelerated by investing in human capital within the rural households, through education and diffusion of new agricultural technologies in rural areas (Azadi et al., 2015b).

2.6.1. GM for cereals and organic for luxury crops

In the context of developing countries, the most urgent need is "food security". This need has already kept policy makers very busy so that their first expectation from the agricultural sector is to make the country independent in producing cereals crops (mainly wheat, rice, and maize) which are the most demanding foods in the world. This need should not be at risk, policy wise, to decrease the yield of cereals which would therefore threaten food security. Otherwise, the policy makers will not be able to meet the needs of the growing population in the developing world, especially pertaining to dry zones (e.g. Sub-Saharan Africa) where the environment can facilitate emerging famine (Bazuin et al., 2011). Furthermore, the policy makers should be very careful when dealing with cereals because most of the farmers in developing countries mainly produce cereals and therefore is their main source of income. This means any change in the policy can directly affect their productions, and cause less income. In conclusion, any change in cereals' policy is very critical and will affect both the farmers and consumers' benefits. A successful policy should therefore, not only help the famers to increase their cereal yield but also provide consumers with enough food. Putting the benefits of these two target groups together, it seems that GM technology is potentially a more secure strategy to attain higher yields and therefore income for the farmers on the one hand, and sufficient food for the growing population on the other. Biotechnology creates new GM crops that can potentially produce more food with fewer chemicals as well as higher nutritional values (Qaim and Zilberman, 2003). For instance, rice yields in India rose from 2 t/ha in 1960 to 6 t/ha in 1990, with a simultaneous reduction in price from 550 USD/t in 1970 to 200 in 2001 (Barta, 2007). Aside from the increase in yields, GM crops may have other advantages over conventional crops. For example, pest and herbicide resistant crops are cheaper to grow and smaller amounts of pesticides are used for GM crops (Hristozova, 2009). A review on the economic impact of insect-resistant (Bt) maize indicates that farmers may gain improved gross margins of up to 70 USD/ha. According to a study by Gouse et al. (2006), farmers that adopted Bt varieties of white maize in South Africa did benefit from planting Bt maize in high maize stalk borer infestation years, but when planted in locations or years when stalk borers were not a problem, Bt was not profitable due to the higher seed costs (Gouse et al., 2006). Furthermore, GM crops have some resistance potential to external stressors such as cold weather conditions, drought, salt, and heat (Sanghera et al., 2011). GM technology has also produced plants that can provide alternative resources for industrial use. This is accomplished by using plants to produce fuels, starches, and pharmaceuticals, which are things that could never be cultivated conventionally (Azadi et al., 2015b).

On the contrary, organic farming systems might be a good strategy for luxury crops (e.g. tobacco, coffee, saffron) which are neither urgent to feed people nor many farmers are busy with. On the other hand, in case of expected yield's drop for such crops when cultivating organically, the prices can be presented higher to the market where usually wealthy people, who are the main consumers of luxury crops, are still happy to meet the higher prices that are demanded in order to afford those products. Numerous studies suggest that small-scale farmers in developing countries have crucial importance in food security (Tscharntke et al., 2012; Azadi et al., 2015b). OF is considered as an approach for food security and poverty reduction specially for smallholder and resource restricted farmers in developing countries (El-Hage Scialabba, 2007; Seufertet al., 2012; Auerbach et al., 2013). A number of successful organic projects for small-scale farmers like organic coffee in Northern Nicaragua (Bacon, 2005), cotton in Tanzania and Uganda (UNEP, 2008), cocoa in Ghana (Nalley et al., 2012) and pineapple in Ghana (Kleemann, 2011) are some examples of the potential for cultivation of luxury crops in developing countries.

Furthermore, organic farming might also be beneficial for the poor countries where poverty impairs the farmers' abilities to buy basic agricultural chemicals/fertilizers. In this case, access to basic agricultural knowledge and education can facilitate these farmers to attain a sufficient income from agricultural commodities.

While such a strategy could be seen as a 'start up strategy' for implementing co-existence approach in order to increase farmers and consumers awareness towards both GM and organic foods in developing countries, it might not be a very good start in developed nations where, on the one hand, the concern of "food security" is replaced by "food safety" and both the farmers and consumers are more aware of the impacts of implementing different agricultural approaches on human and environment health (Schoonbeek et al., 2013) and on the other hand, the market is developed enough to present organic luxury products.

2.6.2. GM foods for internal market and organic for external

As already discussed, the need for increased yields of agricultural products is highly acknowledged by almost all food policy makers in the developing world. After introducing HYVs in the "Green Revolution" by the policy makers, they are now thinking of a new alternative that can still significantly increase the yields of cereals in the developing world (Wu and Butz, 2004).

The alternative is called GM crops, which has lately been introduced as the so-called "Gene Revolution" (Bazuin et al., 2011). Indeed, the GM alternative is highly sought after by internal markets in developing countries where a rapid demand is repeatedly reporting to place a lot of pressure on the shoulders of farmers to produce more food for the growing population (Bazuin et al., 2011; Liu, 2011). While such a demand cannot be ignored, the new alternative has shown

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many successes, among others, in increasing the yields (Gouse et al., 2006; Carpenter, 2010; Bazuin et al., 2011). Higher economic performance as a result of adoption of GM crops was approved in previous reviews in the world (Finger at al., 2011; Brookes and Baroof, 2012; Gruère et al., 2007; Gómez-Barbero and Rodríguez-Cerezo, 2006). According to Finger et al. (2011), these positive economic effects are more significant for developing countries in comparison to developed nations. Such evidence has currently directed the policy makers to think more seriously about the possibility of meeting the growing demands of internal markets by supplying GM foods.

On the other hand, the demand for organic products that cannot be grown in developed countries has resulted in the development of international trade for organic foods and has led to developing countries such as Turkey, where they have suitable ecological conditions, to become a producer and exporter of organic products and foods to developed countries. Accordingly, local markets are also growing significantly in Turkey in line with external demands (Demiryürek et al., 2008). Many governments, international organizations, NGOs and other organizations are paying greater attention to the development of organic agriculture and the promotion of international trade in organic products focusing on developing countries (Yussefi and Willer, 2003). However, to have the level of public interest and support that can sustain such changes in agricultural sectors; agricultural development must be respected as being crucially important from the policy maker's perspective. Without public policy support, cooperation among stakeholders in the co-existence approach will be thwarted (Chopra and Kamma, 2005). Nevertheless, if organic products should be grown in developing countries, governments should focus not only on export markets, but also on domestic consumption and how it can be stimulated. In addition to these shortcomings, there has been limited support for organic producers in terms of subsidies, credits, extensions and training activities for farmers (Demiryürek et al., 2008).

Governments should encourage producers' organizations (e.g. cooperatives), private companies and NGOs to motivate suitable farmers to shift towards organic farming through financial incentives such as subsidies, low-credit rates , premium prices, cheap organic inputs and more importantly market guarantees. The encouragement of organic agriculture is considered as an approach for poverty reduction especially by the governments of some developing countries. A number of successful organic projects for small-scale farmers including organic rice in Thailand (Setboonsarng, 2006), coffee in Northern Nicaragua (Bacon, 2005), cotton in Tanzania and Uganda (UNEP 2008), cotton in India (Eyhorn et al., 2007) and pineapple in Ghana (Kleemann, 2011), these are some examples of its potential. Reducing external inputs and access to organic markets by organic farmers and the opportunity to sell their products for a premium price are among the most important economic advantages of OF (Giovannucci, 2006; Rundgren and Parrott, 2006; Kilcher, 2007). The potential of OF to eradicate poverty in developing countries suggests that the price premiums for organic products are between 10-300% and it is estimated that farmers get 44-50% of this premium price (Setboonsarng, 2006). With regard to production cost, OF has the potential to decrease costs by substitution of chemicals inputs with locally available organic inputs (Setboonsarng, 2006). Research, training and extension activities should also support organic farmers. Local organic producer associations and marketing companies should also be supported financially. In parallel to this, regulations for facilitating organic production need to be developed. At the moment, R&D activities conducted by public and

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private institutions on organic farming are very limited in developing countries, although universities and research institutes have recently initiated some debates.

3. Main concerns

The co-existence of GM and organic crops does not come without any risk. As soon as different farming systems are simultaneously implemented, there will be a few threats from one to the other. Here, we discuss the main technical, socio-economic and ecological concerns to this approach.

3.1. Technical issues

3.1.1. Adventitious presence

For the co-existence approach to stay below the EC threshold (0.9%), it is very important to avoid adventitious presence of GM and organic crops. Shunning the contamination, it is necessary to keep them segregated from the transgenic ones throughout the production, storage, transportation, processing and distribution (Moschini, 2001). While policy makers try to give a promise to protect growing organic farming from GM crops, environmentalists believe that organic farmers are being deceived (Vidal, 1999). Estimating and managing the risk gene flow is important to GM and organic growers alike. On the one hand, organic farmers want to ensure their crops do not contain GM material that might cost them their organic certification. Farmers who manage high-value GM farms (such as soybean) might also require satisfying a given level of purity, and thus cannot accept being contaminated by organic farms (Fontes, 2007).

Adventitious presence can be caused differently. There are a number of ways reported in which contamination may occur in a co-existence approach; i.e. human, animals, wind and water (GeneWatch, 2009). Generally, sources of adventitious presence in a co-existence approach are well identified, and divided into four main origins: seed impurities, cross-pollination, volunteers and harvesting-storage practices. The relative importance of each source for the final level depends on the crop, varieties, farm size and type. For instance, volunteers are the main source of adventitious presence of GM crops for rape seed in organic farms but might be recognized to be of lessor importance in maize farms, where seed impurities and cross-pollination contribute to the majority of the adventitious presence in GM maize farms (JRC, 2002). However, cross-pollination, among others, has received the most attention as the most effective source of adventitious presence.

3.1.1.1. Cross-pollination

One of the main concerns about a co-existence approach is of the likely threat caused by so-called cross-pollination which takes place via transference of genes from one farming system to the other. Cross-pollination is most recognized between contiguous farms within a co-existence approach (Fontes, 2007). No matter how carefully organic farmers work to control their farms, pollen from GM farms can be drift up to a kilometer away via wind as well as insects which can do this quite easily. Suzuki (2003) believes this can be a very big problem. According to Suzuki, there is no guarantee that an organic crop is completely free of GM products.

According to Watson (2003), in Canada, the degree of GM contamination was so high that the country could no longer revive organic farming: "The effects of pollution are visible only after many years. As is the case of North American countries which have switched to GM and can no longer go back organic crops." This non-return situation is draws a tragic picture which should be taken into account as a serious alarm. Even in a developed agriculture like in Spain, Spendeler

(2005) believes that the ambiguity on the environmental, farming and health threats from GM farming asks for the protection of agriculture and food chain from GM contamination.

Apart from the EC guideline which highlights a threshold of 0.9% contamination, at the farm level, some technical measures and management methods based on separating crops should also be applied. Such separation may include “spatial” isolation measures, creating GM free zones, producing GM and organic crops far from each other, or even installing physical barriers against pollen drift. The isolation can also be “temporal”; e.g. crop rotations or time-lags consideration between GM and organic plantings (Fontes, 2007). However, some studies (Devos et al., 2005; Messeguer et al., 2006; Weber et al., 2007) preferred “spatial” isolation than “temporal”. Pollen barriers are identified as the most effective method to avoid cross-contamination. Klein et al. (2006) also showed that cross-fertilization decreases proportionately to when farm size increases. However, in the context of many developing countries with small-scale but diverse and indigenous farming systems, the cross-fertilization can put an end to serious losses in local diversity (Azadi et al., 2011).

Finally, CropLife (http://www.croplife.org/public/coexistence) has also posted some important points with regards to cross-pollination showing the extent of cross-pollination and how such a concern could somewhat be controlled:

- “Crops will only pollinate other varieties of the same crop. Thus, for example, GM oilseed rape plants would have no influence on a farmer’s ability to grow organic maize in adjacent fields;
- Cross-pollination will only occur to a significant degree if the crops are sufficiently close, the flowering periods are the same, and the receiving crop has not already self-pollinated;

- Scientific studies show that for all crops, the majority of cross pollination occurs at the edge of the fields with a rapid decrease as the distance from the pollen source increases; and
- The potential for cross-pollination is only present in certain well-defined cases. Good communication between nearby farmers and other codes of conduct can ensure problem-free co-existence through agreement to separate crops of the same type." [although the problem of volunteers is still there]

However, in regards to the above four points, CropLife neglects some crucial aspects: in the first point, organic farmers are excluded from growing canola and in the third point, seeds from GM crops might also be spread by vectors other than wind (e.g. wild animals) over long distances.

3.1.2. Farming systems' potentials

The potential contamination caused by farming systems should also be taken into account. It is indeed hard to use the co-existence approach in a single farm. In other words, it might be an unrealistic scenario, even for larger farms, to plant GM and organic crops simultaneously as the farm will stand at a much bigger contamination risk. Although, some initiatives could be taken such as: growing organic potatoes with the GM ones could protect the plant against the *phytophtera infestans* virus. Overall, the potential contamination issue caused by farming systems is much more important in the developing countries where most of the farmlands are in small scales and often (for many reasons) getting fragmented over time although such small scale situations also exists within many European countries such as Southern Germany and Eastern Europe. Furthermore, agricultural systems and traditions are widely different in these countries. Farm size and crop rotation have an influence on the probability that two different varieties of the same crop are grown alongside or in close succession. They might also affect the collaboration between neighboring farmers to make crop isolation (Schiemann, 2003). In such circumstances, it seems impossible to keep away from adventitious presence if a small-scale farm should implement a co-existence approach. For example, because of the possible presence of volunteers, oilseed rape seed producers may reject cultivation of GM crops on the same field to shun adventitious presence of GM seeds in their organic seeds. Also for maize, sugar beets and potatoes, it may create a rather difficult handling situation of the crops (Bock et al., 2002).

Anyway, whichever farming system is implemented to successfully manage the gene flow risk, isolation from planting to harvesting, should carefully be segregated. Segregation is an issue that is well-understood in seed production as seed companies often need to meet a certain level of purity for market standards. Likewise, organic farming systems and even non-food seed productions (e.g. for feeding animals or oils industries) will also need to deal with segregation (Schahczenski and Adam, 2006).

3.2. Socio-economic issues

3.2.1. Job losses

“Job losses” is a multi-faceted concept which should be deemed in socio-economic but also “technological” framework. Therefore, “technological arrangements” is also one of the five essentials to develop agricultural sector (Mosher, 1966). According to Vint (2003), almost every farmer and food manufacturer in developing countries may be hit financially in three ways: first, they will need to pay for the avoidance of GM contamination through land segregation, testing GM products, agricultural and food processor machinery as well as vehicle cleaning. Secondly, they will have to accept some other costs when contamination occurs. Such costs can be suffered by them through lost sales and being forced to dump their crops and even withdraw contaminated products from supermarket shelves, and finally, the long-term negative publicity resulting from some bad experience of the previous buyers and customers whose products are realized to have been contaminated. In short, this means that more farmers and food processors would not be able to compete in neither the internal market nor external. Consequently, they may lose their jobs and can hardly get back to the primary situation they started due to the bad reputation. As a result, the rate of food exports may considerably fall and the food prices may significantly increase. This is indeed very important in the context of developing countries where the farmers may be encouraged to cultivate organic products mostly for external markets (see section 2.6.2).

Furthermore, the bee industry may also be affected, as both beekeepers and sellers may lose their jobs. According to Vint (2003), beekeepers won't be able to stop the bees flying to collect pollen from GM fields up to six miles from their hives. There are multiple risks involved. Wholesalers and retailers will switch to buying honey from other countries to maintain the standards to which they are committed.

3.2.2. Costs

According to Bock et al. (2002) cost reductions may be possible when segregation is considered as an integrated part of agricultural practices and by diminishing the costs for GM risk analyses. In general, organic farming is more expensive, especially when addressing insurance cost. Nevertheless, when concerning the product costs and fees, the price premium for organic crops may cover the difference. Based on Fontes' (2007) analysis, acceptance of up to 1% thresholds through changes in farming activities and the introduction of a monitoring system in addition to insurance needs may cause additional costs increases of up to 1% to 10% of the current product price for the co-existence approach. However, such costs are often calculated without any consideration to changes in demand or market prices that might probably accompany an increased level of GM crops in agriculture.

3. Policy issues

3.3.1. Government support

Normally, the government would have to payout compensation to farmers who are polluted, but some policy leaders have already decided that in the case of GM contamination in organic farms, as the polluters are not liable, there cannot be any compensation (Vint, 2003) and those businesses that can endure will not be covered for increased financial risks. Vint (2003) also believe that “normally the victims of pollution are entitled to compensation - the Government calls this the "Polluter Pays Principle" - but the Government has decided that in the case of GM contamination the polluters will not be liable and therefore, that there will be no compensation”. This means that many governments are unconsciously biased in favor of GM.

Building on experience with existing segregation practices, governments need to develop a realistic transparent way, based on scientific evidence and in co-operation with all stakeholders, when speaking of possible pollution caused by a co-existence approach. They should make sure a fair balance between the interests of farmers of all framing systems is made. National strategies and best practices should support all the farmers by legal labeling thresholds and purity standards for GM food, feed and seed. The need for strategies that ensure a fair balance between the interests of farmers of all types of agricultural systems is also emphasized by the European Commission (2003). Farmers should be able to choose the production type they prefer, without feeling forced by the government to change their production systems. As a general principle, during the introduction phase of a co-existence approach to a region, farmers who introduce their new products have to bear the responsibility of implementing the actions necessary to limit pollution/admixture. Finally, short/long terms monitoring and risk assessment studies and the timely sharing of best practices should be supported by governments as imperatives for improving the measurements over time (Azadi et al., 2011).

3.3.3. Monitoring rules

It is widely recognized that keeping GM and organic ingredients entirely separate is indeed impossible. So many countries require GM food products to be labeled as such, in order to protect consumers' rights to choose (Fontes, 2007). The implementation of a co-existence approach in existing farming systems will urgently require monitoring rules. The rules should take into account the interests of both GM and organic farmers on the one hand, and consumers on the other. They should clearly be defined and all required details should be addressed. Moreover, they should easily be applicable to different farming systems, particularly in the diverse and complicated situation of the farmers in developing countries. In other words, the rules should be compatible with farming operation systems and not too expensive to be implemented. Such measurements should be efficient and gainful, without going beyond what is essential to fulfill the EC threshold. They should be precise with different crop varieties, because the admixture likelihood varies significantly from one crop to another. Whilst for some crops the likelihood is high (e.g. oil seed rape) for others is rather low (e.g. potatoes). Moreover, local and regional issues should fully be regarded (EU, 2003).

The measurements should also be proportionate and applied at the appropriate scale. In no case should they lead to the strict restriction or dominance of one type of farming system. The thresholds should not be very solid and constant. Instead, they should be established based upon the different techno-socio-economic and ecological context of the target farming systems. They should be based upon organic production and certification and not product-based. The same regulations should be respected for organic products. In case lower thresholds are considered for organic products, the responsibility to promise and attain them should be with organic producers but the alarming consequence of their decision should not be shared with the farming community at large (ISF, 2004). On the contrary, some believe that such consequences should not be shared with the farming community at large. The International Federation of Organic Agriculture Movements (IFOAM) does not appreciate this view and believes that some obligatory assessments for GM products should not be set up for the verification of organic products (CropLife, 2006).

Different measurements of purity should be requested for different markets (Schiemann, 2003). Since different types of farming systems are not naturally separated, proper measures from planting to harvest, from transport to storage and during processing the products should be regarded in order to lessen the possible accidental admixture (CropLife, 2006). Decisions should be made at an apt scale and the highest priority should be given to specific management measures and to those that aimed at harmonization between adjacent farms. Lastly, ‘GM free zones’ is not acceptable as long as they ignore the farmers and consumers’ rights (ISF, 2004).

For traceability, the EC (2003) has offered a "unique identifier" which is given to any GM product once it is approved. The identifier must be respected in all stages of processing. Many organic bodies have established their own labeling regulations and guidelines on co-existence and traceability. Some research projects such as Co-Extra, SIGMEA and Transcontainer are aimed at establishing improved methods for ensuring co-existence and trying to provide the stakeholders with the valid tools necessary for the implementation of co-existence and traceability (Wapedia, 2009).

The disagreements on the regulations are recently playing itself out of the case before the WTO determines whether the EC regulations on co-existence are motivating an illegal trade obstacle.

For the moment, policymakers in some African nations have decided not to permit co-existence approach despite the fact that it might be beneficial to their agricultural sector, since they are afraid of losing financial support from some EU members in case it is obvious that they cannot meet the EC threshold. With an adjusted threshold that seriously tries to take into account the local circumstances, such countries might be more optimistic to implement co-existence approach. At the same time, policymakers worldwide must ensure that risk assessments of thresholds are conducted in those nations to address the specific concerns of the nations (Schoonbeek et al., 2013). A risk assessment of transgene outflow in the United States, for instance, might be unlikely to be applicable to ecological circumstances in Africa and the Middle East. In assessing risks, policymakers in developing countries should, among other factors, consider the indigenous diversity that may be affected by implementing the co-existence approach in long-run (Chopra and Kamma, 2005).

4. Conclusion

The co-existence approach of GM and organic farming systems is critical for a number of reasons: a developing country may stay more hopeful with the approach to ensure both food security and safety in the long-run. It seems the approach is also more promising to open more market opportunities, maintain cultural values, conserve biodiversity and cope with dissimilar ecological conditions. However, a peaceful co-existence between GM, conventional, and organic farming is not easy but still is possible. The goal should be to implement rules that are well-established proportionately, efficiently, cost-effective, crop-case, farming system-based and biodiversity-focused ending up with "codes of good agricultural practice" for co-existence. In conclusion, there is no unique solution, or generally accepted model for putting co-existence into practice. A co-existence farming system may be modeled spatially or temporally. Predictive models that function at the local level should highly be respected. The models should be set based upon crop attributes, farming systems and local necessities. Nevertheless, co-existence and segregation systems need to be adaptable with changing farming requirements. Yet, still enabling post-market monitoring with regard to ethical, health and even environmental issues is another important issue that should be taken into consideration. It is also important to note that agricultural crops can never be fully pure. Therefore, labeling systems should seriously be regarded as the consumers' absolute right.

Before marketing, predicting the impacts of co-existence is crucial and should be addressed in the framework of comprehensive risk assessment studies. The scientific community should be highly motivated to fill the knowledge gaps that have been identified. Pilot projects should be encouraged in order to evaluate the approach. A step by step managed introduction of co-existence farming, linked to bio-safety research, monitoring and validation should be supported as a basis for further studies which should be conducted on a "case by case" (country by country) basis, particularly in the developing world where a variety of farm and field sizes, production systems, cropping patterns and environmental conditions exist.

It should be noted that the co-existence approach is still in its infancy in within the developing world. Before implementing co-existence in developing countries, the policy makers need to put in place a number of local policies and laws and regulate them to come up with reliable labeling, traceability, liability and compensation methods for their own countries. Appropriate co-existence measures will then be needed for their development and implementation as close to the farm as possible. This means that local governments will need to play a key role in putting policy into practice and enforcing regulations. Any measures taken would have to address the rights and benefits of all farmers, ensuring their equal access to technology, legislation, training and credits. Lastly, one thing is clear, as long as the farmers in developing world are struggling with poverty, they cannot go further than their current basic needs. This simply means that they will not make any efforts towards co-existence farming as long as they are not sure that they can earn at least the same amount of income that they currently earn.

Finally the success of a co-existence approach is mainly governed by both the consumers and farmers appreciation and therefore acceptance of the benefits of GMO crops. Today, only Bt and rr GMO’s dominate the international markets and as shown above, the acceptance is quite limited, but a new generation of GMO’s, which is promised by the seed industry since more than a decade, but not ready for implementation on commercial farms new practical agriculture yet, may shift their perception totally. Hence, the strategies shown above of howto deal with co-existence might be much more relevant in the future than today.

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