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# Food security, food safety and pesticides: China and the EU compared

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**Abstract**
To control pests that may damage crops during production, storage or transportation, chemical pesticides are usually used. On the one hand, the use of pesticides can help to reduce yield losses caused by pests, pathogens, and weeds and thereby help feed the world's population; on the other hand, such agricultural practices can profoundly affect limited natural resources. Starting from these premises, the main objective of this paper is to explore the relationship between food security and food safety, while pointing out the role played in this relationship by pesticides, focusing on the case studies of the EU and China. To this purpose, the paper outlines the international framework on pesticides and the legal framework in the EU and China, analyzes pesticide markets, and considers the concerns related to their use. The overview of the situation in the EU and China allows us to identify challenges and opportunities for future developments in terms of food security and safety and food trade relationships between Europe and China. Tension and mutual disputes have occurred in the past due to increasing risks for consumers and workers handling pesticides, food scandals and difficulties in the mutual recognition of food quality certification schemes, which call for sustainable production methods.

**Keywords**
Agriculture, Sustainability, Pesticides, Integrated Pest Management, Food security, Food safety, EU, China

**JEL Codes**
I18, N65, O13, O53, Q15, Q18, Q24, Q25

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## 1. Introduction[1]

Pathogens, weeds, and pests cause significant crop losses worldwide, thus presenting a barrier to the achievement of global food security (Pretty and Bharucha, 2015).

In order to avoid losses and to feed the population, humans started fighting pests a long time ago. The use by ancient Sumerians of sulfur compounds to kill insects in 2500 B.C. is the earliest record of insect pest control. In the 1930's the trend of synthesizing new compounds, e.g. DDT increased, but the real "Revolution" happened in the 1950's and early 1960's, with the development of chemical synthetic pesticides and fertilizers presented as the answer to world hunger and the way to achieve food security.

If the use of pesticides has been key to the significant increase in per capita food availability and meeting the growing population needs, the consumption of pesticides and fertilizers has direct consequences on the environment in terms of water pollution, soil productivity damage, loss of insects and other animals, and on human health, in terms of chemical risk to farmers, workers in pesticides industries and consumers, related to their handling and application on crops. Furthermore, pesticide residue in food (the traces pesticides leave in treated products) represents a risk if it exceed certain limits, raising food safety issues.

With a population projected to reach above 9 billion people by 2050 (FAO projections), food needs are expected to constantly increase and the main challenge will be to achieve global food security, ensuring, at the same time, food safety (FAO, 2013). This goal could be achieved by promoting sustainable and safe agricultural production methods and valorising agricultural outputs. First of all, this should mean a reduction in pesticide use.

Different countries have different pesticide regulations. They include limits for pesticide residue on food, product registration requirements and pesticide use restrictions. The certification schemes adopted in different countries are varied, playing key roles in terms of pesticides, food trade and consumption.

The main objective of this paper is to explore the relationship between food security and food safety, pointing out the role played in this relationship by pesticides and focusing on the case studies of two key actors, the EU and China. Accordingly, the paper firstly outlines the international framework on pesticide use and the legal framework in the EU and in China, then analyzes pesticide global markets and finally addresses related concerns. Furthermore, the comparison between these various legal frameworks will allow the identification of challenges and possible future developments in terms of food security and safety in food trade relationships between the EU and China.

## 2. Pesticides International Framework

The UN, WTO, FAO and WHO represent the main international institutions involved in policy formulation highlighting the impact of pesticide use on agriculture, human health, but also on food and trade and ruling on their use and trade.[2]

[1] This research was largely based upon work supported by the EUCLID project – EU-China Lever for IPM Demonstration. The project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 633999.

There are more than 250 multilateral environmental agreements (MEAs) and about 20 of these can affect trade. For our purposes, two multilateral environmental agreements should be mentioned. The Rotterdam Convention, dated 1998, entered into force in February 2004. It is based on the Prior Informed Consent (PIC) procedure for certain hazardous chemicals and pesticides in international trade.[3] The Stockholm Convention, dated 2001, on Persistent Organic Pollutants (POPs), entered into force in May 2004.[4] The former applies to banned or severely restricted chemicals and to severely hazardous pesticide formulations (listed in Annex III to the Convention), facilitating information exchange about these products, providing for a national decision-making process on their import and export and disseminating these decisions to members. The latter applies to POPs, chemicals (including several pesticides) that remain intact in the environment for long periods, become widely distributed geographically, accumulate in human tissue and have a harmful impact on human health or on the environment. It defines the criteria and procedures to identify these kinds of chemicals and establishes prohibitions and restrictions on the manufacture, use and trade of them.

It is also appropriate to remember a third agreement, the Basel convention (1989), related to the previous two, dealing with the management and disposal of the substances regulated by the Stockholm and the Rotterdam Conventions when they become waste, thus representing a relevant reference for pesticide legislation in the context of managing obsolete products.

These three MEAs have legal autonomy but in 2011 a Joint Executive Secretariat was established.

The WTO is the leading political and legal institution responsible for (free and fair) trade among states. Among the factors it takes into account is food safety related to the traded products and in this context pesticides are considered. The level of risk and harm associated with pesticide use was defined by the Recommended Classification of Pesticides by Hazard and approved by the WTO in 1975, distinguishing between the more and the less hazardous forms of each pesticide on the basis of the toxicity of the technical compound and of its formulations.

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS), which entered into force in 1995, governs trading practices at the international level, in order to protect human, animal or plant life or health. According to the agreement, all WTO members have to adopt[5] sanitary (relating to human and animal health) and phytosanitary (relating to plant health) measures[6] to ensure that food is safe for consumers, and to prevent the spread of pests or diseases among animals and plants. These measures have to be defined using international standards, guidelines and recommendations. With regards to food safety issues, members have to take into consideration the standards established by the Codex Alimentarius Commission (FAO-WHO Codex Alimentarius international food standards, including 51 codes of practices, 73 guidelines and 212 standards) and with regards to plant health, the standards and guidelines

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[2] The World Trade Organization, Food and Agriculture Organization and World Health Organization are all organizations of the United Nations.

[3] In 1989 the PIC procedure was jointly introduced for the first time by the FAO and UNEP as a voluntary tool within the Code of Conduct on the Distribution and Use of Pesticides and in the London Guidelines for the Exchange of Information on Chemicals in International Trade. These two instruments were developed and promoted voluntarily, respectively by the FAO and UNEP in the mid-1980's to ensure that governments had the necessary information to enable them to assess the risks of hazardous chemicals and to take informed decisions on their future import.

[4] Signed by 152 countries. It entered into force in the EU in February 2005 and in China in November 2004.

[5] Countries are allowed to set their own standards, but they must be based on science.

[6] These sanitary and phytosanitary measures can take many forms, such as requiring products to come from a disease-free area, inspection of products, specific treatment or processing of products, setting of allowable maximum levels of pesticide residue or permitted use of only certain additives in food.

developed by the International Plant Protection Convention[7] (IPPC) Secretariat (FAO-IPPC International Standards for Phytosanitary Measures – ISPMs).[8] Sanitary and phytosanitary measures apply to domestically produced food or local animal and plant diseases, as well as to products coming from other countries: member states are obliged to comply with the control, inspection and approval procedures called for in the agreement, especially as regards tolerances for contaminants in agricultural products. There are a large number of animal and plant diseases and pests that, given their ability to spread and because of the economic losses they cause, are considered to pose a high risk. Consequently, they deserve special attention in international agricultural trade operations. The control and eradication of such diseases and pests are essential in order to improve agricultural health in the affected countries, and to avoid exclusion from trade with those countries free of same (IICA, 1998). More specifically, exporting countries are obligated to guarantee that the sanitary and phytosanitary certificates they issue comply with the requirements imposed by an importing country, and must make special efforts to strengthen their export certification services. These measures may result in restrictions on trade or in discrimination between countries: the WTO recognizes, however, that the need to safeguard public policy interests (such as in health, safety and the environment) requires exceptions to the application of trade rules.

Among existing voluntary tools addressing pesticide management it is worth mentioning the FAO-WHO International Code of Conduct on Pesticide Management, which provides a framework guiding public and private stakeholders on best practices in managing pesticides throughout their lifecycle (FAO-WHO, 2014).[9] In this document great attention has been paid to Integrated Pest Management (IPM), an ecosystem approach to crop production and protection that combines different management strategies and practices, i.e. biological control, mechanical control, cultural control and chemical control, to grow healthy crops and minimize the use of pesticides. The Code of Conduct presents IPM as a tool to reduce pesticide use and improve yields, food quality and income for farmers.[10] Since 2007 highly hazardous pesticides are a special focus area for the FAO in implementing the Code of Conduct (WHO, 2010).

## 3. Legal framework: the EU and China

### *3.1. The European Union*

Policies and legislation on pesticides were first introduced at EU level in 1979, with the Council Directive prohibiting the placing on the market and use of plant protection products containing certain active substances.[11]

[7] The FAO International Plant Protection Convention (IPPC) is the main international agreement related to pests control and management. It promotes cooperation in plant protection, with the aim to prevent the spread and introduction of plant pests and to adopt appropriate measures for their control. The IPPC was adopted in 1951 and it has been amended twice, most recently in 1997; this last revision aimed to incorporate phytosanitary concepts, adapting the convention to the WTO Sanitary and Phytosanitary Measures (SPS) Agreement

[8] Including standards on pest risk analysis, requirements for the establishment of pest-free areas, and others which give specific guidance on topics related to the SPS Agreement.

[9] In 2013 the fourth version was approved. The first one was dated 1985.

[10] Articles 1.7; 3.7; 3.8; 3.9; 5.1 and 8.1 are dedicated or related to IPM.

[11] Over the years, it evolved considerably, culminating in the adoption of Directive 91/414/EEC concerning the placing of plant protection products on the market, followed by Directive 98/8/EC on the placing of biocidal products on the market. According to this legislation all pesticides need to be evaluated and authorized before they can be placed on the market (EU, 2007).

The European approach in the field of pesticides was strengthened with the 1992 reform of the CAP (Common Agricultural Policy) that integrates environmental issues in agricultural processes (European Commission, 2007). Particularly significant is Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels (MRL) of pesticides in or on food and feed of plant and animal origin (amending Council Directive 91/414/EEC), i.e. the highest level of pesticide residue that is legally tolerated when pesticides are applied correctly (Good Agricultural Practice). The regulation aims at limiting the exposure of consumers at the end of the food chain. Furthermore, monitoring compliance with MRL makes it possible to assess whether professional users have implemented the good agricultural practices set out in the authorizations for plant protection products granted by the member states (ENDURE, 2010).

On July 12, 2006 the European Commission adopted the thematic strategy on the sustainable use of pesticides ("the Strategy"). Its roots are in the 6th Environmental Action Program (6th EAP), that includes coherent and integrated strategies on the sustainable use of pesticides.

The year 2009 was quite important for legislation on pesticides: Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market was introduced.[12] It followed Directive 2009/127/EC of the European Parliament and of the Council of 21 October 2009 amending Directive 2006/42/EC with regard to machinery for pesticide application.

Directive 2009/128/EC, establishing a framework for Community action to achieve sustainable use of pesticides (Sustainable Use Directive - SUD), was adopted in 2009. This Directive establishes the obligation for member states to adopt National Action Plans (NAPs) to reduce risks and the impact of pesticide use by encouraging the development and introduction of Integrated Pest Management and of alternative approaches or techniques in order to reduce dependency on the use of pesticides. The key provisions introduced by the directives are:

1. Training of all professional users, distributors and advisors;

2. Restriction of sales of pesticides to professional users holding a certificate;

3. Information and awareness-raising of the general public on the risks and the potential effects of pesticides for human health, non-target organisms and the environment, and on the use of non-chemical alternatives;

4. Regular calibrations and technical checks of the pesticide application equipment of professional users;

5. Prohibition of aerial spraying, except in a few special cases;

6. Specific measures to protect the aquatic environment and drinking water (pesticides not classified as dangerous for water, low-drift equipment, mitigation measures for buffer-zones, etc.);

7. Restriction on the use of pesticides in specific areas like public parks, sports, school and recreation grounds;

8. Introduction of measures to promote low-pesticide input pest management, giving priority to non-chemical methods. This includes integrated pest management as well as organic farming. The general principles of integrated pest management should be implemented by all professional users from January 1, 2014;

[12] Repealing Council Directives 79/117/EEC and 91/414/EEC.

9. Harmonized risk indicators shall be established.

It is worth mentioning the *White Paper on Food Safety* (European Commission, 2000) establishing that the driving force of the EU approach towards food sanitation is that market access is not granted to unsafe products, a principle that must apply “whether the food is produced within the European community or imported from third countries”.

### *3.2. China*

More recent is the history of pesticide legislation in China, where the Regulation on Pesticide Administration introduced in 1997 and amended in 2001, also known as the Regulation on the Control of Agrochemicals, represents the first comprehensive legislative and regulatory framework to manage pesticides in the country. It states that all the pesticides produced in China or imported to China must be submitted for registration. The Regulation also requires production licensing which means pesticide production in China must obtain a production license or approval document. In November 29, 2001, the Regulation was revised to meet the requirements of the WTO, which China joined that year. The Chinese government began revising its Regulations on Pesticide Administration, in 2010. The Legislative Affairs Office of the State Council published the draft of the revised regulation on its website, www.chinalaw.gov.cn, in 2011 but the process is still ongoing. The related local governments and departments also established relevant rules and regulations to comply with the *Regulation on Pesticide Administration.* Every province, municipality directly under the central government and autonomous administration regions issued their own local *Regulations on Pesticide Administration (USDA, 2016).*

In 2007, the Chinese government issued six new regulations to enhance pesticide management aiming at regulating pesticide names, label requirements and registration procedures (Yang, 2007). Early in 2008, the Chinese government released a well-enforced ban on the production, distribution and use of five highly-toxic organo-phosphorus pesticides (Methamidophos, Parathion, Parathion-methyl, Monocrotophos and Phosphamidon), which represented nearly 60 percent of the total domestic pesticide market.[13]

The Chinese Ministry of Agriculture (MOA) launched on March 17, 2015 a campaign for zero growth of fertilizer and pesticide consumption by 2020. The target of the MOA is to achieve an over 40 percent fertilizer use efficiency rate and pesticide use efficiency rate by 2020, an increase of 7 percent and 5 percent respectively over 2013, and to achieve zero growth of fertilizer and pesticide consumption. [14]

The Food Safety Law (2009, revised in 2015) is also relevant, emphasizing the importance of agro-product quality and safety and underlining a transformation of the agricultural development mode, promoting standard, ecological, large-scale and brand-building approaches to production, and also, bringing production sources under control. It regulates, among others, the formulation of standards for food safety, establishing that they must also include limits on such pollutants as invasive organisms, pesticide residue, veterinary drug residue, biotoxins and heavy metals, and other materials endangering human health, contained in food, food additives, and food-related-products (Bian, 2012).

[13] Furthermore, the law on Agricultural Products Quality and Safety (2006) includes clauses on pesticide use and agricultural products quality and safety.

[14] The efficiency rate has to be measured as the quantity of fertilizer (or pesticides) needed to get the maximum economic yield with minimum inputs.

It is also worth mentioning two Acts indirectly related to pesticide issues: the Provisions on Organic Product Certification Management (November 5, 2004) regulate the production, processing, trade and certification of organic products; the Regulations for the Implementation of Organic Products Certification (June 1, 2005), ensure the validity of organic certification and the consistency of certification procedures and management. Since the 1980's the Chinese government has paid attention to the sustainable development of agro-ecosystems and began to develop a green food industry in 1990. After developing over two decades, the Chinese green food industry has reached a significant size and is expanding rapidly (Lin et al., 2010), thanks to different certification standards and systems.

## 3. The Pesticide market

### *4.1. Pesticide supply*

The global agrochemicals market is an oligopolistic market, dominated by a few big players: the world's five largest companies producing pesticides (based on revenue in 2013) are multinationals headquartered in different countries.[15]

**Table 1. Leading 5 global agrochemical multinational companies based on revenue in 2013 (US$ millions)**

| Company | Headquarter's country | Typology |
|---|---|---|
| Syngenta | Switzerland | seed and agrochemicals company |
| Bayer | Germany | chemical and pharmaceutical company |
| BASF | Germany | chemical company |
| Dow Chemical | USA | multinational chemical corporation |
| Monsanto | USA | agricultural biotechnologies company |

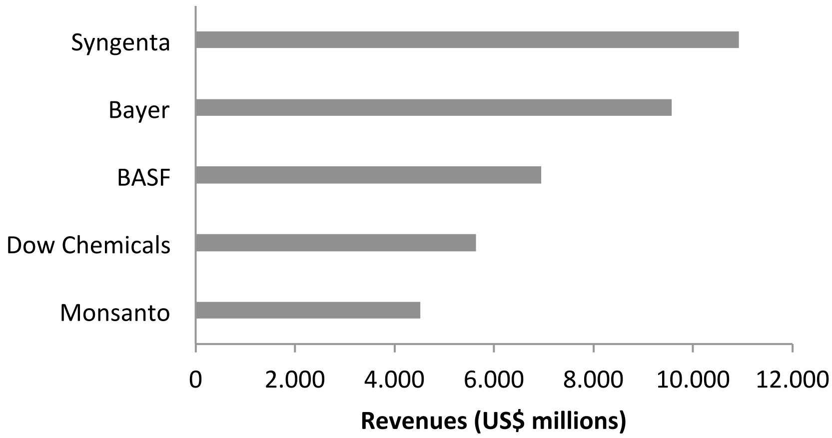
*Source: Seeking Alpha, 2013*

According to Greenpeace research (2008), these five leading companies control three-quarters of the world's pesticide market and nearly two-thirds of the commercial seed market. The largest company, Syngenta, is also the third largest seed company; Monsanto, is also the world's largest seed company and Bayer is the seventh largest seed company (PAN Europe, 2013). The number of active ingredients sold by these companies are 512, with 47 percent of these classified as dangerous for the environment and for health.

The concentration of power in a small number of companies and, as a consequence, their ability to set prices and determine varieties available, has been and is a cause of concern among farmers. Furthermore, some of these giants have agreed to merge with their competitors in the future (such as Bayer and Monsanto, Syngenta and China National Chemical Corporation, Dow Chemical and DuPont). The EU has expressed concerns that these mergers could very likely lead to higher prices for consumers as well as creating high barriers to market entry (Neumeister, 2014).

[15] The total revenues of the top five companies in 2013 is equal to more than US$ 37 billion (Seeking Alpha 2013).

**Figure 1. Revenues of the 5 leading global agrochemical companies in 2013 (US$ millions)**

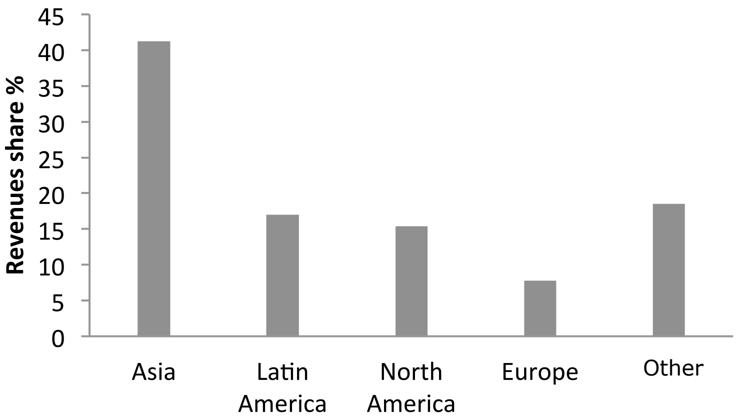



*Source: Seeking Alpha, 2013*

According to the 2015 Annual Review on the Global Agrochemical Industry (Agropages, 2015), the European market, in terms of active ingredient volume was estimated at 639.4 KT in 2011 and is expected to reach 741.9. KT by 2018. Europe is the second largest market for herbicides and it is expected to reach more than US$ 15 billion in revenue by 2018.

Currently, pesticide production tends progressively to be concentrated in Asian countries (Figure 2), and, more specifically in China. China's compound annual growth rate is expected to grow by 5.1 percent (globally 2.7 percent) between 2014-2019. The Chinese production of pesticides in 2011 was more than 2.6 million tons (compared to 0.2 million tons in 1991). Production surpassed consumption in 2007 and since 1994 Chinese pesticide exports have exceeded imports (Zhang et al., 2011).

**Figure 2. Worldwide agrochemicals revenue markets share by region in 2012**



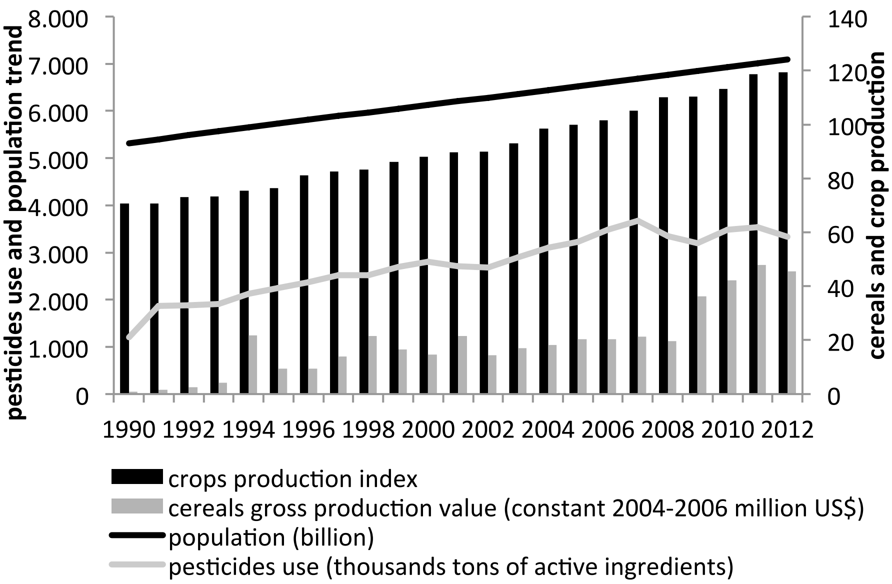

*Source: Seeking Alpha, 2013*

According to the China Crop Protection Industry Association, in 2014 the list of the top 10 Chinese pesticide companies is led by Zhejiang Wnyca Chemical, which produces glyphosate, followed by Nutrichem Company Limited (its products primarily include herbicides and safeners, insecticides and acaricides, fungicides, plant growth regulators), Nanjing Red Sun Co., Shandong Weifang Rainbow Chemical (producing a variety of products from herbicides to insecticides), Zhejiang Jinfanda Biochemical (glyphosate pesticide and chemical intermediate products), Hubei Sanonda (acephate, paraquat, glyphosate, dipt), Jiangsu Yangnong Chemical (producing a large variety of products from herbicides to insecticides), Sichuan Leshan Fuhua Tongda Agro-Chemical Technology, Zhejiang Zhongshan Chemical Industry Group and Jiangsu Lianhe Chemical Technology. These 10 companies in 2014 registered total annual sales of more than 30 billion Yuan.[16] Considering the top 100 list, in 2014 the Chinese agrochemicals companies achieved total sales of more than 100 billion Yuan, up 9 percent year on year (Agropages.com, 2015).[17]

### *4.2. Pesticide consumption and trade*

The worldwide production and consumption of pesticides have been increasing in parallel with human population and crop production (Figure 3).

**Figure 3. Pesticide use, population growth and crop production compared: 1990-2012**

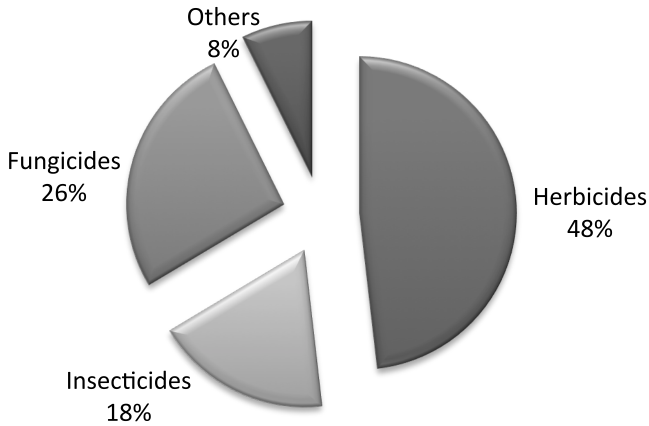



*Source: Authors' elaboration on FAOSTAT data, 2015*

In 2012 the worldwide consumption of pesticides was about 3.3 million tons (active ingredients). The trend from 1990 shows an overall increase (about 2 million tons from 1991 to 2012) although frequent fluctuations occurred over time.[18] Analyzing the percentages of the main pesticides used, it can be observed that (Figure 4) 48 percent are herbicides, 26 percent fungicides, 18 percent insecticides and others account for 8 percent. Since the 1990's herbicides have become the most used pesticide (their utilization was about 20 percent of total pesticides in 1960 compared to 48 percent in 2012), with the aim of enhancing agricultural intensification and productivity. Consequently, the proportion of insecticides and fungicides have declined (Zhanget al., 2011).

[16] About US$ 4.5 billion.
[17] More than US$ 15 billion.
[18] This could be due to lack of data for some countries in some years.

**Figure 4. Main types of pesticides used worldwide in 2012**




*Source: Authors' elaboration on FAOSTAT data, 2015*

Glyphosate has become the most used pesticide by volume due to the decrease in price and a higher share of reduced tillage, where glyphosate replaces ploughing as a weed control measure (Greenpeace, 2015). Globally, agricultural glyphosate use has risen almost 15-fold since the so-called "Roundup Ready," genetically engineered glyphosate-tolerant crops were introduced in 1996, rising from 51 million kg (113 million pounds) in 1995 to 747 million kg (1.65 billion pounds) in 2014.[19] The largest segment (72 percent) of glyphosate used in the last 40 years was applied in the last decade. The major glyphosate manufacturer, Monsanto, has typically not competed directly or solely on price; instead it has been successful in holding or expanding market share by selling higher-price Roundup herbicides together with the purchase of Monsanto herbicide-tolerant seeds (Benbrook, 2014).

The Americas register 50 percent of world consumption, followed by Europe (30 percent) and Asia (16 percent).[20] China, the USA, France, Brazil and Japan are the largest pesticide producers, consumers or traders in the world (Zhang et al., 2011). Use of pesticides has risen in developing countries and the fastest growing markets are in Africa, Asia, South and Central America and the Eastern Mediterranean. Although developing countries use only 25 percent of the pesticides produced worldwide, they experience 99 percent of the deaths related to pesticide use. This is because the use of pesticides tends to be more intensive and unsafe, and regulatory, health and education systems are weaker in developing countries (WHO, 2008).

According to FAOSTAT data (2010), the highest intensity of pesticide utilization is registered in China (17.8 tons of active ingredients per 1,000 ha) and in the countries of South America. In the EU the values range from a minimum of 0.75 tons per 1,000 ha in Romania and Sweden to a maximum of 8.75 tons per 1,000 ha in the Netherlands.

[19] Monsanto brought glyphosate to market in 1974 under the trade name Roundup. 'Roundup Ready' are those crops genetically modified to tolerate herbicides glyphosate.

[20] The total per continent has been calculated summing data (FAOSTAT database) for each country comprised in the continent, but data were not available for some countries.

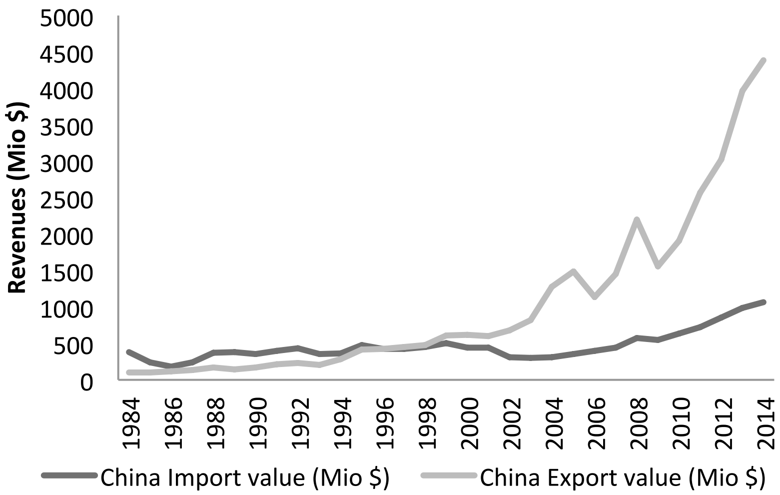
In the EU, in 2013, the main consumer countries were Spain, France, Italy and Germany.[21] Since 1991 the number of pesticide active ingredients in the EU has decreased by about 50 percent and currently about 500 active ingredients are authorized compared to about 650 in 2004 (Neumeister, 2014).

China was one of the earliest countries to use pesticides and it is today the world's largest producer and exporter in terms of quantity as well as the second largest consumer of pesticides, using alone half of pesticides worldwide (Pretty and Bharucha, 2015). The Chinese consumption of pesticides in 2011 was equal to 1.8 million tons (compared to 0.76 million tons in 1991), with diversification across the country: the maximum values are registered in southern China, due to the warm and humid weather that favors pests' diffusion. However, the highest pesticide application dosage (measured as kg of active ingredients per ha of cultivated land) is located in the South-East of China, more specifically in Hainan, Fujian, Guandong, Jiangxi and Zhejiang (from 32 to 65 kg/ha) (Li et al., 2014).

As far as pesticide trade is concerned, according to FAOSTAT data, from 2000, China's pesticide exports with the rest of the world have been greatly increasing, passing from an overall value of US $500 million to almost US $4.5 billion in 2014. (Figure 5).

The EU's pesticide trade with the rest of the world is increasing both for exports and imports, which show similar trends and overall value, even if exports exceed imports (Figure 6).

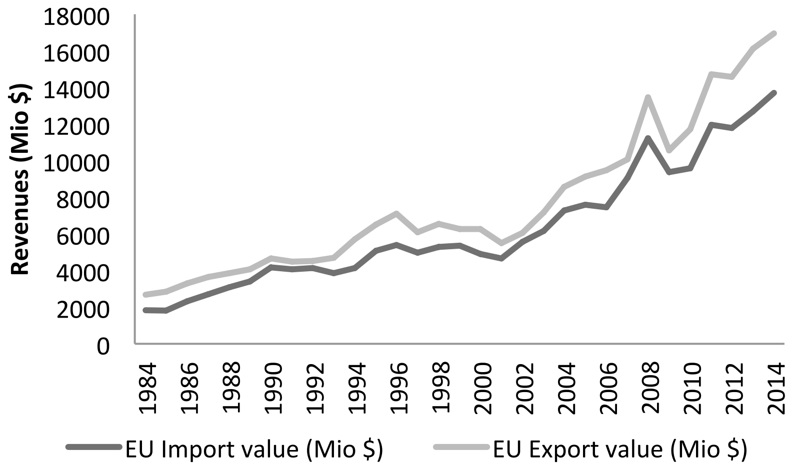
**Figure 5. China's pesticide imports and exports with the rest of the world**




*Source: Authors' elaboration on FAOSTAT data*

**Figure 6. EU's pesticide imports and exports with the rest of the world**

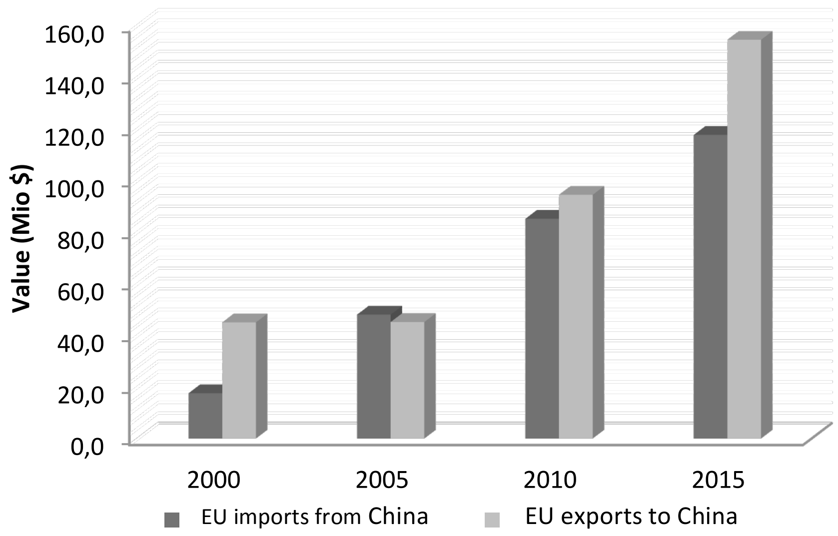
[21] It is impossible to conduct a European pesticides use trend analysis over many years because of the different reporting systems and timing utilized by the member states. Eurostat statistics assess pesticide use by the amounts of pesticides sold but the data are not homogeneous as they are not available for many countries in some years.




*Source: Authors' elaboration on FAOSTAT data*

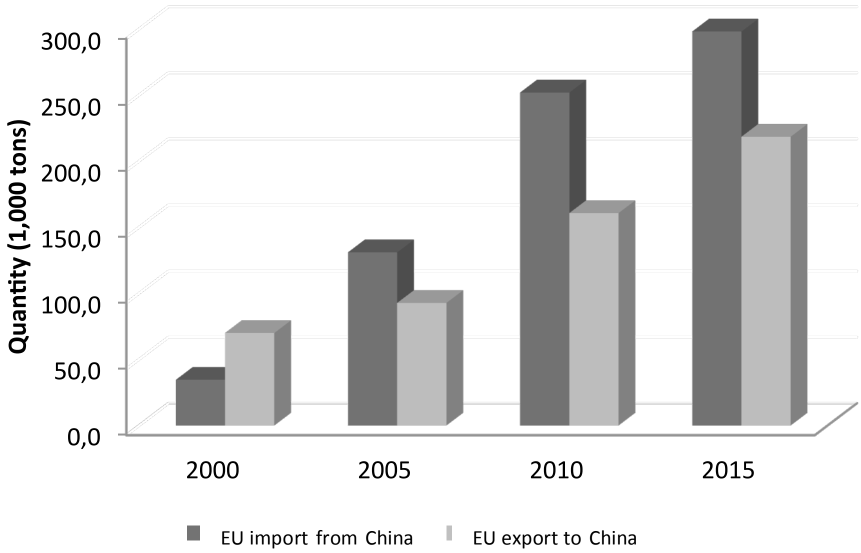
Focusing on the pesticide trade between the EU and China, data shows that, on the one hand, the value (Figure 7) of the EU's exports to China (equal to €154 million in 2015) exceeds the value of imports (equal to €117 million in the same year) but, on the other hand, considering the quantity of imported and exported pesticides it can be observed that, since 2010 (Figure 8), the EU's imports from China (298,000 tons in 2015) exceed exports (218,000 tons in 2015). This result highlights the higher value added of European products.

**Figure 7. Pesticides: EU imports from China and EU exports to China (value)**




*Source: Authors' elaboration on Eurostat – Comext database data*

**Figure 8. Pesticides: EU imports from China and EU exports to China (quantity)**




*Source: Authors' elaboration on Eurostat – Comext database data*

## 4. Food Trade: the EU and China

China and the EU's economic relationship has been continuously increasing in importance over the years. As far as total goods trade is concerned, in 2015, China was the EU's largest trade partner for imports and the second largest partner for exports. Also, EU trade with China shows that, while EU imports of goods from China (amounting to more than €350 billion in 2015, compared to €130 billion in 2004) are higher than exports (about €170 billion in 2015, compared to €50 billion in 2004), the EU is a net food exporter to China: in 2015, exports of agricultural products (in €million) were double that of imports. Moreover, considering EU agro-food exports, China was the second largest EU partner after the USA (with more than €10 billion), and considering EU agro-food imports, China ranked fourth largest, after Brazil, the USA and Argentina (Table 2). On the whole, primary goods represent 10 percent of the total goods exported from the EU to China and 3 percent of the total goods imported from China. These quite low percentages are compensated by the high image value of these kind of products (European Commission, 2016). Food safety is one of the major causes of conflict in the exchange relationship between the EU and China (Schibler, 2014).

**Table 2. EU top 5 agro-food trade partners, 2015**

| Rank | Top importers | Value € millions (EU exports) | percent extra EU | Rank | Top exporters | Value € millions (EU imports) | percent extra EU |
|---|---|---|---|---|---|---|---|
| **1** | USA | 19,407 | 15 | **1** | Brazil | 13,203 | 11.7 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2** | China | 10,342 | 8 | **2** | USA | 11,986 | 10.6 |
| **3** | Switzerland | 7,670 | 5.9 | **3** | Argentina | 5,756 | 5.1 |
| **4** | Russia | 5,569 | 4.3 | **4** | China | 5,150 | 4.5 |
| **5** | Japan | 5,354 | 4.1 | **5** | Turkey | 4,993 | 4.4 |

*Source: Source: EC- DG Agriculture and rural development AGRI-FOOD TRADE STATISTICAL FACTSHEET European Union – China*

The top five agro-food products exported (Table 3) from the EU to China (12.6 percent of the total agro-food exported) are infant food, with a constantly increasing value (+48 percent solely between 2014 and 2015), followed by raw hides and skins (11.4 percent), offal and animal fats (9.8 percent), pork meat (9.0 percent and with a growth rate between 2014-2015 equal to +117 percent) and wine, cider and vinegar (8 percent).

As far as imports from China are concerned (Table 4), vegetables rank first, processed vegetables and fruits rank third and tropical fruits fourth (representing more than 27 percent of the total agro-food imports altogether). These data are of special interest to this paper, considering that vegetables and fruits may contain pesticide residue, more than other agricultural products. Among the top five imported products, offal and animal fats (second, 9.4 percent) and wood and silk (fifth, 6.4 percent) are also listed.

**Table 3. Top 5 EU Agro-food exports to China, 2011-2015 (€ million value)**

| Rank | Product | 2011 € million value | 2012 € million value | 2013 € million value | 2014 € million value | 2015 € million value | Share in all Agro 2015 ( percent) | Change 2014-2015 ( percent) |
|---|---|---|---|---|---|---|---|---|
| 1 | Infant foods and other cereals | 318 | 522 | 740 | 877 | 1 299 | 12.6 | 48.1 |
| 2 | Raw hides, skins and fur skins | 808 | 997 | 1 256 | 950 | 1 179 | 11.4 | 24.1 |
| 3 | Offal, animal fats and other meats | 431 | 605 | 668 | 723 | 1 011 | 9.8 | 39.8 |
| 4 | Pork meat | 211 | 361 | 446 | 431 | 935 | 9.0 | 116.9 |
| 5 | Wine, cider and vinegar | 697 | 769 | 666 | 655 | 828 | 8.0 | 26.4 |

*Source: EC- DG Agriculture and rural development*

**Table 4. Top 5 EU Agro-food imports from China, 2011-2015 (€million value)**

| Rank | Product | 2011 € million value | 2012 € million value | 2013 € million value | 2014 € million value | 2015 € million value | Share in all Agro 2015 ( percent) | Change 2014-2015 ( percent) |
|---|---|---|---|---|---|---|---|---|
| 1 | Vegetables | 597 | 505 | 527 | 514 | 542 | 10.5 | 5.4 |
| 2 | Offal, animal fats and other meats | 551 | 564 | 493 | 482 | 486 | 9.4 | 0.8 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3 | Processed vegetable & fruits | 490 | 520 | 444 | 404 | 485 | 9.4 | 20.0 |
| 4 | Tropical fruits | 221 | 213 | 279 | 321 | 398 | 7.7 | 24.0 |
| 5 | Wood and silk | 318 | 285 | 330 | 308 | 330 | 6.4 | 7.1 |

*Source: EC- DG Agriculture and rural development*

## 5. Concerns related to pesticide use

Pesticide residue in food represents a risk to human health if they exceed certain limits. Pesticides can also produce environmental pollution. Pesticide contamination is rarely due to a single substance but to a mix of substances as Greenpeace research (2015) shows.[22]

Moreover, farmers and workers in the pesticide industry and exterminators of house pests can be exposed to pesticides' negative effects, often as a consequence of improper or careless handling (Fait et al., 2001). Every year thousands of farm workers experience short- and long-term effects of pesticide poisoning.[23]

The above mentioned issues are found in both the EU and in China.
The European legislative framework provides an annual pesticide monitoring program (aimed at analyzing pesticide residue on food), carried out by EU member states plus Iceland and Norway. In 2013, 80,967 samples were analyzed for 685 pesticides. Of the samples, 68.2 percent originated from the EU and two European Free Trade Association (EFTA) countries (Iceland and Norway) and 27.7 percent of the samples were from products imported from third countries. For 4.1 percent of the cases the origin of the products was not reported. The analysis shows that:

- 97.4 percent of the samples analyzed fell within the legal limits;
- 54.6 percent were free of detectable residue;
- 1.5 percent of samples clearly exceeded the legal limits.[24]

Among the samples from EU/EEA countries, 57.6 percent were free of measurable residue, and 1.4 percent contained residue that exceeded the legal limits.[25] The percentage of samples from Iceland and Norway free of detectable residue was 46.2 percent, with 5.7 percent clearly exceeding legal limits (ESFA, 2015).

[22] This is important because the cocktail effects of mixtures of pesticides are not routinely assessed.

[23] Short- term (acute) effects may include stinging eyes, rashes, blisters, blindness, nausea, dizziness, headaches, coma, and even death. Some long-term health effects are delayed or not immediately apparent such as, infertility, birth defects, endocrine disruption, neurological disorders, cancer (Farmworker Justice, 2013). Some research refers to Parkinson's disease and Alzheimer's disease, depressive and anxiety disorders and death due to mental disturbance (Zhang et al. 2009).

[24] MRL excesses for unprocessed products were most frequently noted in 2013 for guava, lychees, passion fruit, tea leaves, okra, basil, parsley, spinach-type vegetables, turnips, papaya, cassava, leafy vegetables and pomegranates. Processed products most frequently exceeding legal limits were wild fungi, tea leaves, peas with pods, peppers, herbal infusions, tomatoes, beans with pods, pomegranates, table grapes, rice, grapefruit and rye.
With regards to European countries, the highest percentages of residue exceeding the legal limits were found in products from Bulgaria, Portugal and France.

[25] The remaining 41 percent contained residue but within the legal limits.

By the end of 2009, more than 26,000 pesticides had been registered in China (Li et al., 2014) and from 2012, the Chinese food standards system includes 2,319 pesticides residue limits, involving 322 types of pesticides (Wu and Zhu, 2015). Research shows that in China crop pollution and pesticide residuals in crop products are frequent, with consequential damages in terms of yield and quality of products and of human health. A study conducted on fruits and vegetables collected from Xiamen in China from October 2006 to March 2009, demonstrated that 37.7 percent of the samples contained pesticide residue: pak choi cabbage, legumes, and leaf mustard were the commodities in which pesticide residue were most frequently detected, with 17.2 percent, 18.9 percent and 17.2 percent of the samples exceeding the maximum residue limits (MRLs), respectively (Chen et al., 2011). A 2013 Greenpeace East Asia investigation revealed that traditional Chinese herbal products being exported to Europe and North America are laced with toxic cocktails of pesticide residue, many of them exceeding levels considered safe by food and agriculture authorities (Greenpeace, 2015).[26] Greenpeace China, furthermore, conducted an analysis of pesticide residue in China's markets (located in Beijing, Shanghai and Guangzhou), showing that 89 percent of the samples contained pesticides and 20 percent contained illegal or highly toxic pesticides (Zhang et al., 2011).

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## 6. Coupling food security and food safety

### *6.1 Integrated Pest Management*

Food safety, nutrition and food security are inextricably linked. This calls for alternative methods to reduce pest damage while avoiding the cost and negative outcomes associated with synthetic pesticides (Pretty and Bharucha, 2015) and Integrated Pest Management is often proposed as a solution (Bajwa and Kogan, 2002). The modern IPM concept is defined by the FAO as "the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment" (FAO - WHO, 2014, p. 4). Thus, IPM aims to maintain pest damage at economically acceptable levels while protecting the environment and human health.

Since the 1970's entomologists and ecologists have urged the adoption of IPM for pest control and, as highlighted by Parsa (2014), IPM has become the dominant crop protection paradigm.

The overview of EU legislation highlights the great effort made to withdraw poisonous active ingredients from the European market (Lefebvre et al., 2014). Of great interest is the recent approach of the EU, which, as underlined by Lamichhane et al. (2016, p. 148), "creates an opportunity to build a common IPM framework in agriculture, based on sustainable crop protection approaches that are flexibly adapted for cropping systems, changing pest pressures, changing climatic conditions and regional agronomic practices". In particular, as already mentioned, Directive 2009/128/EC establishes the obligation to implement the IPM principles for

[26] In total, 36 samples of Chinese herbal products collected from Germany, France, Italy, the Netherlands, the UK, the US and Canada were tested. It was found that 32 samples contained three or more kinds of pesticides. For example, samples of honeysuckle collected from Canada and Germany had 24 and 26 types of pesticides respectively; 17 samples showed residue of pesticide classified by the World Health Organization as highly or extremely hazardous. Some 26 samples showed pesticide residue levels that exceeded what the European authorities consider the maximum level for safety (MRLs).

all professional users starting from January 1st, 2014. Great importance is given to the training of all professional users, distributors and advisors. Time will tell if it is effective in promoting IPM in the EU, where this approach is not yet broadly implemented (Movses, 2015).

As underlined by Wang et al. (2003), the development of IPM in China was a gradual, but continuous process, which had already started in the 1950's. A big boost to IPM was given by the first Nationwide Conference on Integrated Pest Control for Crop Diseases and Insect Pests held in Shaoguan City, Guangdong Province, in 1974. Since 1983, the Chinese government have funded IPM Technique Research Projects as one of the State Key Research Programs in four successive state five-year plans, testifying to the importance it gives to these solutions. The 40 plus years IPM experience in China gave ample proof that this strategy can decrease pesticide use without lowering crop yields, and help to improve farmers' income and protect the environment (Yang et al., 2014). On the other hand, the conventional assumption that pesticide use and yields are positively correlated is showing weakness. Recent studies carried out by Pretty and Bharucha (2015) on over 85 IPM projects report that at least half of the pesticides used in Asia and Africa do not need to be used. At the same time, they show that IPM can deliver substantial reduction in pesticide use coupled with increased yields.

According to these results, IPM seems to be the right solution to achieve a sustainable intensification in agriculture, but its adoption should involve a majority of farmers. In the case of China we are talking about the enormous number of smallholder farmers, who characterize Chinese agriculture, where the average farm size according to Yang et al. (2014) is less than 0.5 ha.

As underlined by Pretty and Bharucha (2015, p. 174) "IPM is much more than just a simple resource-conserving technology. As with other forms of sustainable intensification, techniques of IPM are knowledge-intensive" and therefore requires training of farmers. The need for "training and education of farmers, extension workers and policy makers to deliver new information in the developing countries" was mentioned by Zeng already in 1993 as key for IPM implementation. Considering the case of China, training that many smallholders is not an easy task and requires ad hoc policies and support.

Policies are broadly considered as a fundamental means to promote IPM adoption, as shown by the reports on declining growth in pesticide use in China due to the implementation of IPM and related policies - mainly focused on the banning of highly poisonous pesticides - and the use of low volumes of more toxic pesticides (Peshin and Zhang, 2014). Yet IPM adoption remains low as well as the reduction of pesticide use (Pretty and Bharucha, 2015).

Last but not least, it has to be considered that IPM must adapt to changing ecological and economic conditions. As well described by Pretty and Bharucha (2015, p. 173), "pests, diseases, and weeds evolve, new pests and diseases emerge (sometimes because of pesticide overuse), and pests and diseases are easily transported or are carried to new locations (often where natural enemies do not exist)". In addition to these, the new challenges introduced by climate change to pest management have to be considered.

### *6.2. Food quality certification schemes in the EU and in China*

Food safety should encourage the promotion of agricultural food obtained from low pesticide agriculture. From this perspective the definition of adequate product quality certification systems is extremely useful, as well as the mutual recognition of these systems among different states.

As far as the European Union is concerned, an inventory compiled for the European Commission (Aretè, 2010) counted 441 quality schemes for agricultural products and foodstuffs marketed in the EU. The main requirements are provided by Regulation (EU) No 1151/2012 on quality schemes for agricultural products and foodstuffs and by the European guidelines on certification schemes. There are also a number of optional quality terms, and separate rules on organic farming (Council Regulation (EC) No. 834/2007). Since July 1, 2010, producers of packaged organic food have been required under EU law to use the EU organic logo. Furthermore, at national or local level, many European countries have adopted labels for certifying the use of Integrated Pest Management methods.

Certification schemes for agricultural products and foodstuffs in the EU provide assurance that certain aspects of the product or its production method, as laid down in a specification, have been observed. They cover different kinds of initiatives that function at different stages of the food supply chain, ranging from compliance with compulsory production standards to additional requirements relating to environmental protection, animal welfare, organoleptic qualities, "Fair Trade", etc. These schemes and their labels help producers/groups of producers to better market their products, protecting them from misuse or falsification of a product name.[27]

In particular, three EU schemes known as GIs (Geographical Indications) promote and protect names of quality agricultural products and foodstuffs, attributable to a specific origin.[28]

Over the past few years, China has reviewed and issued thousands of new food safety and hygiene standards mainly because of continuous food scandals and rising consumer concerns. Most notably, in 2015 China's revised Food Safety Law came into effect.

In China there are both food safety standards (mandatory) and food quality standards (voluntary), that explicitly refer to pesticide residue. The main ones are analyzed below.

As far as **mandatory tools** are concerned, QS (Quality Supervision) are standards that guarantee the food has passed the necessary quality and safety tests; GMP (Good Manufacturing Practice) is a quality assurance which ensures that products are consistently produced and controlled according to the quality standards appropriate to their intended use.

Furthermore, various **voluntary tools** and labels exist and in particular it is worth mentioning:

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[27] In particular, three EU schemes known as Geographical Indications (GIs) promote and protect names of quality agricultural products and foodstuffs, attributable to a specific origin. To protect these products, the EU has signed various multilateral and bilateral agreements. Among these initiatives, it is worth mentioning the project "10 plus 10" (European Commission, 2012) started in July 2007. The EU and China formally adopted the protection of 10 agriculture GIs in each other's territories. With regards to European products as Geographical Indications in China and as part of the so-called "10+10 project", the list shows 5 cheeses, 2 oils, 1 ham, 1 salmon and 1 dried fruit. In parallel, the European Commission has examined and registered 10 Chinese food names with the last 2 Chinese names "Pinggu da Tao" (peach) and "Dongshan Bai Lu Sun" (asparagus) receiving protected status in the EU as Geographical Indications (European Commission, 2013).

[28] To protect these products, the EU has signed various multilateral and bilateral agreements. Among these initiatives, it is worth mentioning the project "10 plus 10" (European Commission 2012) started in July 2007. The EU and China formally adopted the protection of 10 agriculture GIs in each other's territories. With regard to European products as Geographical Indications in China and as part of the so-called "10+10 project", the list shows 5 cheeses, 2 oils, 1 ham, 1 salmon and 1 dried fruit. In parallel, the European Commission has examined and registered 10 Chinese food names with the last 2 Chinese names "Pinggu da Tao" (peach) and "Dongshan Bai Lu Sun" (asparagus) receiving protected status in the EU as Geographical Indications (European Commission, 2013).

1. “Pollution-free products”, which are unprocessed or primary edible products whose producing area environment, production processes and product quality meet the related national standards and norms, and obtaining the certificate after accreditation, are allowed to use the pollution-free agricultural products logo. The standards to be fulfilled are related to pesticide residue, veterinary drug residue, hazardous substances, water, soil and air quality in the producing area.
2. “Green food”, is a Chinese eco-certification scheme for food, created in 1990. It consists of a set of voluntary standards, including environmental quality standards, packaging and labeling standards, inputs control standards, as well as product quality standards. The Green Food standards cover a wide range of products including crop production, livestock, aquaculture and beverages among others. It certifies both the production process and the outcome. Two categories of green food, AA and A, are defined by it. AA green food is the standard used for organic food. ‘A’ green food is of a higher standard than normal food but lower than AA green food or organic food (Bian, 2012): it is produced with a controlled and reduced use of pesticides, together with a testing regime for pesticide residue. These kinds of products are easily recognizable thanks to the green logo which can readily be seen on a variety of food items in Chinese supermarkets. The Green Food label is also recognized abroad and in particular in Finland (Europe), Canada and Australia. China’s export of Green Food standards is an example of the Golden Rule - those with the gold make the rules - and demonstrates that China now has the purchasing power to impose its own eco-standards, and foreign producers have the motivation to meet and seek Chinese eco-certification (Paull, 2009). In 2011 more than 7,000 Chinese farms had a Green Food certification, more than 16,000 products carried a Green label and the domestic sales of Green food labeled products amounted to RMB 313.4 billion, with US$ 2.3 billion exports (Standarsmap.org, 2012).
3. “Organic products”, are products grown without the use of conventional pesticides, artificial fertilizers, OMG, etc. (Zhou and Jin, 2013). In more detail, Chinese organic farming officially started to be promoted in 1989 with the aim of addressing environmental concerns and later to meet the requirements of foreign markets and to make Chinese products more marketable in other countries. Indeed, most of the early development of Chinese organic agriculture was driven by export opportunities in the European Union and United States, and later on Japan. National regulations on organic agriculture were first introduced in the early 2000’s and the most recent one was applied in 2005, when compulsory organic standards and supervision systems were introduced and, as a consequence, all organic products, including imports, must comply with the national rules and standards (International Trade Centre, 2011).

## 6. Concluding remarks

Food security and safety (in terms of quantity and quality) are global strategic objectives. It might seem that the goal of food security is inconsistent with the one of food safety: global population growth and the increase in food needs have resulted in a broad use of pesticides to control pests in producing food; furthermore, globalization and changes in consumption patterns have made a vast amount of food goods available which make the food chain a complex system, with increasing food scandals and fraud and risks to human health.

A large part of these risks is related to pesticide use, which has consequences both in terms of the environment and health. The increasing use of these chemicals, under the adage, “if little is good, a lot more will be better” (Aktar et al., 2009) has generated risks in terms of environmental pollution and the health of humans and other life forms. In particular, a health impact can result from indirect exposure, via their residue in agricultural products and drinking water, or from direct exposure, in the case of industrial workers producing plant protection products and farmers applying them.

Consumers from food importer countries are more vulnerable and more likely to eat less healthy foods, and many states have adopted strong legislation on food safety, and control the use of pesticides and their trade. This is, for instance the case of the EU, but also of China, which has been introducing stricter laws over the last decades.

It is appropriate that public authorities pay particular attention to ensure food safety. Considerable progress has been made but commitment and international cooperation is still necessary. Trade has played an important role in bringing to development common rules and specific legislation in this field, as highlighted by the Chinese case analysis.

On the other hand, food safety needs to be coupled with food security and a further growth in terms of food production will be needed in order to feed the increasing population.

The adoption of sustainable production methods based on integrated pest management, in order to reduce the use and negative effects of pesticides, and the definition (and recognition among different states) of adequate product quality certification systems, could play a fundamental role in matching food security and food safety aims. The findings outlined in this paper show that both China and the EU are on this path and that they have been promoting IPM methods and certification schemes for food and agricultural products. What is still missing is a greater mutual recognition of labels, which could also support the marketing of these products abroad.

A big challenge for broadening the implementation of sustainable agriculture in China is to train and create the right capabilities in the large number of small-holder farmers forming the Chinese agricultural system. However, Peshin and Zhang (2014) report that growth in pesticide use is declining in China due to the implementation of IPM and related policies, but also because of the use of low volumes of more toxic pesticides.

The definition of common international strategies, measures, guidelines, codes of conduct, etc., in relation to negative environmental and human impacts of pesticide use is very important. It is appropriate that international organizations (UN, WTO, FAO, WHO) will continue to promote sustainable paths. On the supply side, international organizations may involve large multinational pesticide companies. In terms of demand, the same organizations and national public authorities could properly raise consumer awareness about the importance of sustainable farming systems and quality certification. The benefits would be huge for the world's population with a medium-long term positive impact. In this regard, the cases of China and the European Union are extremely important and interesting. As mentioned previously, domestic food regulations may hinder and limit international trade, but multilateral mechanisms can resolve potential trade conflicts (Roberts and Unnevehr, 2005), and food safety plays a key role in the food trade relationships between the EU and China.

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