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Low-Level Presence of New GM Crops: An Issue on the Rise for Countries Where They Lack Approval

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This study addresses a new issue in the commercialization of GM crops, namely the occurrence of traces—or "low-level presence" (LLP)—of nationally unapproved GM material in crop imports. The commercialization of GM crops is a regulated activity, and countries have different authorization procedures. Hence, new GM crops are not approved simultaneously. This "asynchronous approval" (AA), in combination with a "zero-tolerance" policy towards LLP, is of growing concern for its potential economic impact on international trade. To forecast the future evolution of this issue, we compiled a global pipeline of GM crops that may be commercialized by 2015. This pipeline is analyzed by crop and likely LLP scenarios are discussed. While currently there are about 30 commercial GM crops with different transgenic events worldwide, it is expected that by 2015 there will be more than 120. Given that problems of LLP have already occurred with the 30 current events, these issues are likely to intensify when more events become available in more countries.

Key words: R&D pipeline, GM crops, regulation, authorization, asynchronous approval, low-level presence, zero tolerance, supply chain, international trade, European Union.

Introduction

The commercial cultivation of genetically modified (GM) crops began in 1996 and has been continuously expanding ever since, both in industrialized and developing countries, and by 2008 it had reached a global area of 125 million hectares that were cultivated by more than 12 million farmers in 25 countries (James, 2008). However, acceptance of GM crops is very heterogeneous. Public opinion in Europe is mostly seen to be critical (whether because of a lack of perceived personal benefits, higher perceived certainty of potential risks, evaluations that are embedded in a wider range of values and attitudes, ideologically motivated judgements, emotional responses, or diffuse mistrust of governments and the media; Brook Lyndhurst, 2009), while most people in the rest of the world are rather indifferent—or increasingly in favor of GM crops if they are farmers.

Differences also exist regarding both the number of GM crops authorized in different countries and the timing of their authorization. At the same time, the major GM crops—soybeans, maize, cotton, and rapeseed—are also those crops that are the most heavily traded internationally, providing vital export revenues for many countries and industries but also providing a crucial supply of cheap feed and fibers for many importing countries, including in Europe (Backus et al., 2008; European Commission [EC], 2007, 2009a). At the international level, problems already exist because there is no consistent and harmonized set of rules to facilitate international trade of *approved* GM crops and related products due to the substantial differences in the laws and regulations (e.g., governing tolerance levels for GM material in non-GM products). For instance, in the United States, Canada, Japan, and Taiwan, food with a content of up to 5% of approved GM material can be classified as "non-GM;" however, in Australia, New Zealand, South Africa, Brazil, or China, all food with more than 1% (and in the EU, all food with more than 0.9%) approved GM material has to be labelled as "GM" (Ramessar, Capell, Twyman, Quemada, & Christou, 2008).

These issues are all recognized, but there is increasing apprehension of another problem: namely low-level presence (LLP) of *unapproved* GM material in a country's food and feed supply (EC, 2007; US Department of Agriculture [USDA], 2008). We differentiate between three sources of LLP.

1. There can be "asynchronous approval" (AA), i.e., at least one cultivating country has already authorized a GM crop while other (importing) countries have not.
2. There can be "isolated foreign approval" (IFA, or "asymmetric approval"), i.e., a cultivating country has authorized a GM crop, but its developer

does not seek approval in (potential or unattractive) importing countries.

3. There can be LLP of research events, i.e., a country has authorized the cultivation of a GM crop in field trials only, but due to accidental admixture, traces end up in the commercial crop supply.

Such incidents already happened in 2006 for EU imports of maize and rice from the United States, in which traces of GM material from Herculex maize and LibertyLink rice were found (Mitchell, 2007; Vermij, 2006). At that time the Herculex maize was not yet authorized for use as food or feed in the EU, and LibertyLink rice was only authorized for experimental cultivation in the United States itself.

In these cases, implicitly according to EU regulations, any import containing traces of these crops should be rejected. In practical terms this meant that a "zero-tolerance" policy was followed, under which imports had to be rejected when they tested positive at the detection level, and products that had already entered the EU had to be withdrawn from the market. These rejections and the ensuing disruptions to trade are estimated to have cost millions of Euros already. For instance, Brookes (2008) provides an upper figure of €111 million that the aforementioned LLP incident in rice in the United States has cost the EU rice sector between 2006 and early 2008, and in the context of the AA incident in maize, Backus et al. (2008) report estimates of the EU feed industry that the problems with US maize imports may have caused additional costs in the EU livestock sector of about €1.6 billion in 2007/08. Similarly, problems of AA in soybean imports with significant increases in feed expenditure costs were expected for the case of Roundup Ready 2 (RR2) soybeans, whose commercialization in the United States was anticipated for 2009 (EC, 2007). However, for soybean imports the problem has, at least temporarily, been solved by the timely authorization of RR2 soybeans by the European Commission (EC, 2008).[1] Otherwise, a related AA incident could have cost around €100 million in a single user sector of soy derivatives and surpassed €1 billion in total (Brookes, 2008).

In other countries, LLP is handled differently. For instance, in the United States genetic engineering per se is not treated differently from traditional plant breeding because laws are product-specific (i.e., they regulate the use of products like foods or pesticides, not the underlying process; US Executive Office of the President, Office of Science and Technology Policy, 1986). Hence, as long as a GM crop is similar to a conventional crop, no authorization is needed for its cultivation or use; only if the crop fulfils, for example, the function of a pesticide (as insect-resistant or herbicide-tolerant crops do) does it need to be regulated as such. Consequently, if there is LLP of an event[2] that had not been submitted voluntarily to the regulatory agencies and if the latter determine that the GM material could pose a risk, they will do a case-by-case risk assessment and take proportionate measures (e.g., USDA, 2007). In Switzerland traces of unapproved GM material of up to 0.5% are tolerated in food if the respective GM crop is already authorized in another country where comparable procedures are followed or if a danger to human health can be excluded after an ad-hoc science-based evaluation by the responsible authorities and if detection methods and reference materials are available (Federal Authorities of the Swiss Confederation, 2008). And even in the EU the unintentional presence of other substances is treated differently. For instance, for certain chemical substances that are present in the environment as pollutants, levels higher than zero have been set to protect public health (EC, 2009b; for maximum levels, see EC, 2006).

Approach

In the context of above-mentioned trade disruptions, on November 12-13, 2008, the Institute for Prospective Technological Studies (IPTS) of the European Commission's Joint Research Centre (JRC) organized a workshop entitled "The global commercial pipeline of new GM crops" to collect data and agree on the global pipeline of GM crops that may be commercialized in the short-to-medium term, and to discuss potential implications of LLP (Stein & Rodríguez-Cerezo, 2009a). The

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1. *Groups opposed to GM crops highlight that the impact of AA between the United States and the EU would only have been minor anyway, because RR2 soybeans were not even submitted for authorization in either Argentina or Brazil—and that these countries could therefore have compensated any shortfall in the EU import of soybeans from the United States (Friends of the Earth [FoE], 2009). This situation actually corresponds to the "minimal impact scenario" of an analysis by DG AGRI that finds that under certain conditions "the approval of a new GM soybean in the United States is not likely to cause a major market disruption. The US quantity would have to be diverted to other destinations, and Brazil and Argentina could fill the gap [...] The net effect on EU soybean/meal supply can therefore be considered to be low" (EC, 2007, pp. 6).*
2. *An event "refers to the unique DNA recombination event that took place in one plant cell, which was then used to generate entire transgenic plants" (Co-Extra, 2006).*

Table 1. Events in commercial GM crops and in pipelines worldwide, by crop.

Crop	Commercial in 2008	Commercial pipeline	Regulatory pipeline	Advanced development	Total by 2015*
Soybeans	1	2	4	10	17
Maize	9	3	5	7	24
Rapeseed	4	0	1	5	10
Cotton	12	1	5	9	27
Rice	0	1	4	10	15
Potatoes	0	0	3	5	8
Other crops	7	0	2	14	23
All crops	33	7	24	61	124

*Notes: * The total number of GM crops by 2015 represents an upper limit, given that by then some of the current GM crops may have been phased out.*
Source: Stein and Rodríguez-Cerezo (2009a).

underlying implicit hypothesis—which we intend to accept or reject in this paper—could be formulated as follows.

> The incidents of LLP, in particular due to AA, so far were singular cases, and after the approval of RR2 soybeans by the European Commission there will be a period of respite without new threats to the EU's food and feed supply.

The workshop panel was sampled to cover national regulators, representatives of private technology providers, scientists from public research institutes, and stakeholders of the agrifood supply chain from all major countries where GM crops are developed or cultivated. All experts were given time to present an overview of the current GM crops and the pipeline of new GM crops in their field of competence or jurisdiction and for their region. This information was then compiled, structured, and complemented by us with additional desk research before the overall pipeline was sent around to the experts for verification and additional comments. The reviewed data that emerged from this process was then published as a database by the IPTS (Stein & Rodríguez-Cerezo, 2009b). In the remaining sections of this article, this information will be presented and assessed in light of the above-mentioned hypothesis. We will in particular present the GM crops that are currently commercialized and new GM crops that are likely to be commercialized until 2015. Based on these developments, we will discuss whether—judging by current patterns and speeds of authorization in various relevant countries—the issue of LLP and its implications are likely to become a bigger problem in the future or not.

To predict the potential evolution of LLP for the EU agrifood sector, we compiled separate pipelines for the dominant crops (soybeans, maize, rapeseed, cotton, potatoes, and rice) for which GM varieties already exist or are likely to be marketed in the near future, which we complemented by a category for all other GM crops. As only a fraction of the GM crops in the research pipeline eventually reach the market, we focused on those crops that already overcame the technical and scientific barriers in their development and that were close to commercialization (e.g., for which the data for the dossiers for the regulatory authorities have already been generated) or that are already in the regulatory pipeline to obtain a realistic idea of how many crops actually may be commercialized. The time horizon for this exercise was 2015. Within this framework, the GM events were classified in five categories according to their proximity to market.

- Commercial crop: commercialized GM events (those currently marketed in at least one country worldwide)
- Commercial pipeline: GM events authorized in at least one country but not yet commercialized (commercialization only depends on the decision by the developer)
- Regulatory pipeline: GM events already in the regulatory process to be marketed in at least one country
- Advanced R&D: GM events not yet in the regulatory process but at late stages of development (large-scale multi-location field trials, generation of data for the authorization dossier)
- Other crops: GM events authorized in at least one country but not commercialized, or commercialized once but phased out commercially or legally afterwards

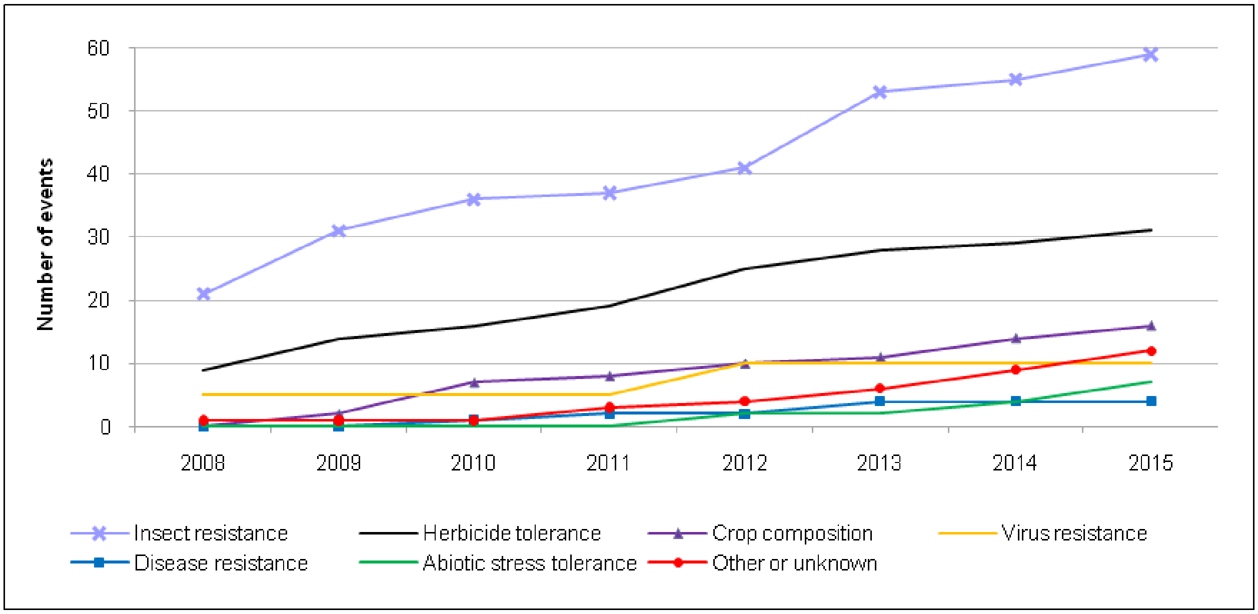

Figure 1. Projected number of events in GM crops worldwide, by trait.
Source: Stein and Rodríguez-Cerezo (2009a).

Table 2. Events in commercial GM crops and in pipelines worldwide, by region of origin.

Developer country*	Commercial in 2008	Commercial pipeline	Regulatory pipeline	Advanced development	Total by 2015
United States & Europe	24	7	10	26	67
Asia	9	0	11	34	54
Latin America	0	0	2	1	3

*Note: * While also in other parts of the world and there is current R&D on GM crops underway, it is not expected that these crops will be cultivated before 2015.*
Source: Stein and Rodríguez-Cerezo (2009a).

Results

The analysis of the pipeline of new GM crops shows that a significant global increase in the number of individual commercial GM events can be expected. While currently there are about 30 commercial GM events that are cultivated worldwide, the forecast is that by 2015 there will be more than 120 (Table 1); this development shows a particularly pronounced potential increase in the number of GM events in rice. When looking at the traits introduced into the new GM crops, it is clear that the currently dominant traits (herbicide tolerance and insect resistance) continue to play a major role in the upcoming GM crops. However, crop composition (mostly type and proportion of oil and starch content in the crop) becomes an important feature in new GM crops, and crops that are tolerant to abiotic stress (mostly drought) are also expected to become available (Figure 1).

Another development in the R&D of GM crops is the emergence of more players; while currently it is private companies from the United States or Europe that develop most of the GM events and crops (which are generally first authorized and cultivated in the United States), over the next few years more GM crops will be supplied by private and public entities from Asia (Table 2), in particular from China and India. And in the longer-term, even more developing countries may commercialize GM crops (Food and Agriculture Organization of the United Nations [FAO], 2009). Hence, while in the past GM crop adoption spread from North America to other parts of the world (with asynchrony of approvals following the same path), in the future the adoption pattern may change fundamentally, with more new GM crops being adopted first in Asia and then potentially spreading from there.

Table 3. Asynchronous and "isolated foreign" approvals as potential sources for LLP.

Crop	Asynchronous approvals*	Isolated foreign approvals#	Total sources for LLP
Soybeans	2	1	3
Maize	6	5	11
Rapeseed	0	1	1
Cotton	3	9	12
Rice	1	4	5
Potatoes	0	2	2
Other crops	0	8	8
All crops	12	30	42

*Notes: * Number of individual events authorized for commercial use in at least one country worldwide, and submitted but not yet authorized in the EU.*
 # Number of events not submitted for authorization in the EU but already in the regulatory pipeline in at least one country worldwide.
Source: Stein and Rodríguez-Cerezo (2009a).

This changing pattern, with more new GM crops coming from Asia, has consequences for the issue of LLP. In Asia, GM crops are usually developed for domestic consumption and not for export (as opposed to those developed for cultivation by large exporting countries in the Americas), and therefore the respective events are less likely to be submitted for approval in the EU (or the United States, for that matter). Hence, incidents due to isolated foreign approval (IFA), or asymmetric approval could become more common (Table 3). Taken together, as of early 2009, there were already more than 40 individual GM events that may become potential sources of LLP. And although some of the major exporters of agricultural commodities—like Argentina and Brazil—so far have considered trade implications when authorizing new GM crops, it is by no means guaranteed that this situation will last: other countries (e.g., China) could gain importance as importers of these commodities (of soybeans in particular), or the advantages of cultivating certain new GM crops in exporting countries could simply outweigh the potential loss of sensitive markets. Moreover, increasing biotechnology know-how in emerging economies themselves can strengthen "South-South" technology transfers, which could boost the acceptance and adoption of GM crops in cultivating countries. In this case, the number of alternative suppliers of non-GM crops decreases, thereby making it more and more difficult to simply redirect trade flows by matching exporters of GM crops with "easy" importing countries and letting the remaining exporters supply the more sensitive markets (see also Vaidyanathan, 2010). Hence, in an assessment of the *potential* impact of LLP relying on the assumption that the status quo will not change—in particular in a policy context where forward-looking decisions may be required—may not be the most appropriate approach. Therefore, we opted for describing a possible, albeit not necessary, scenario of LLP.

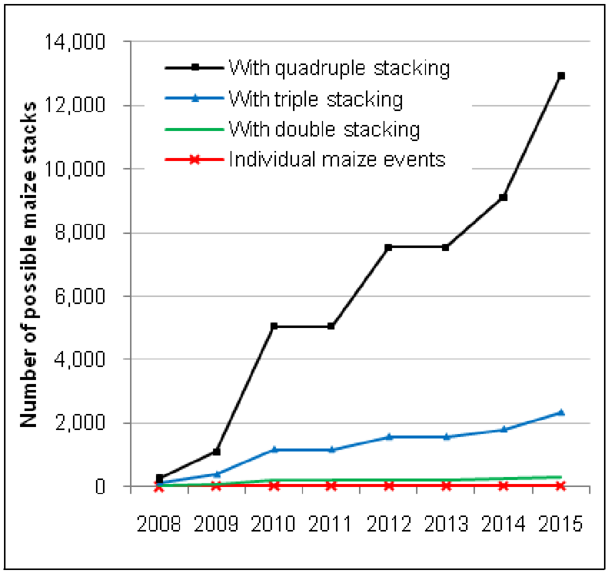

Figure 2. Theoretical combinations to produce new GM maize by stacking.

Note: Obviously not all trait combinations would make sense, but this graph illustrates how the number of possible stacked crops increase disproportionately with the number of new events and the number of stacked events that can be put into one plant.
Source: Stein and Rodríguez-Cerezo (2009a).

In addition to the increasing number of new GM events, there is also the tendency to generate new products by combining different GM traits in one plant, i.e., through the stacking of already approved GM events. When individual authorized GM events are "stacked" by conventional crossing, the resulting new plant may have a different regulatory status in different countries.

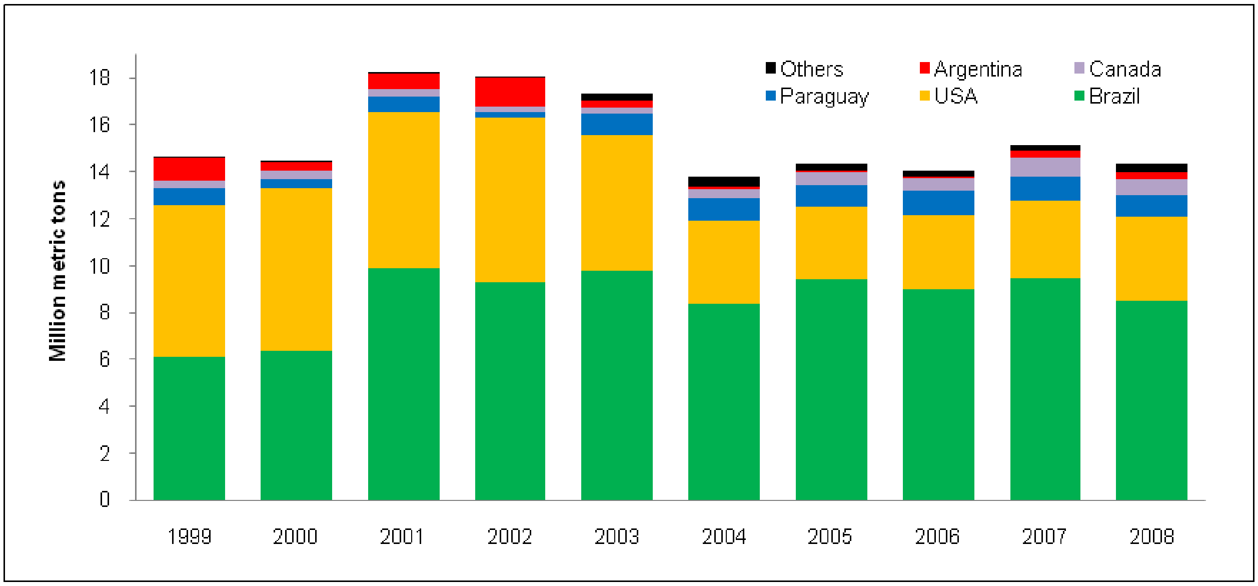

Figure 3. Net imports of soybeans into the EU-25 from the rest of the world, 1999-2008, by country in million tonnes (excluding soybeans for sowing).
Source: Based on data from Eurostat (2009).

For instance, the EU requires each stacked GM crop to go through the regulatory system as a new GM crop, irrespective of whether the parental GM events were already authorized or not. Given the increase of individual GM events that are to come to market in the next years, eventually hundreds of combinations of these events can be quickly developed by stacking—meaning that the number of GM crops that could be submitted for approval could increase dramatically. As an example, currently there is already a quadruple maize stack in the EU's regulatory pipeline (namely MON-89Ø34-3 × DAS-Ø15Ø7-1 × MON-88Ø17-3 × DAS-59122-7). We forecasted 24 different individual GM events to be available by 2015 in maize (Table 1). This gives a theoretical number of 10,626 possible quadruple maize stacks; 2,024 possible triple maize stacks; and 276 possible double maize stacks—altogether 12,926 possible maize stacks (Figure 2). And even if (obviously) it doesn't make sense to combine all available events indiscriminately, the number of "approvable" GMOs is bound to increase exponentially.

Discussion and Conclusions

As already mentioned in the introduction, a possible situation of AA of RR2 soybeans was avoided by their approval by the European Commission before first commercial plantings took place. And indeed, soybean imports are vital for the EU agrifood sector: more than 90% of the soybeans used in the EU are imported, and more than 80% of these imports come from only two suppliers, namely Brazil and the United States (Figure 3). Therefore, AA in soybeans could not only result in economic losses for traders and users of soybeans, but in combination with zero tolerance towards traces of unapproved GM material, it could pose a real threat to the EU supply of food and feed. However, the approval of the RR2 soybeans has not solved the problem of AA in soybeans in the long run. As of early 2009 there were already two new GM soybean events in the commercial pipeline in the United States, namely Bayer CropScience's A5547-127 and Pioneer's 356043; Bayer's A5547-127 was also already pending approval in Argentina. For a comparison of GM crop approvals between the United States and the EU, see Table 4. In addition, there are two new GM soybeans in the regulatory pipeline and nine more in the advanced R&D pipeline worldwide (i.e., future problems due to LLP in soybeans cannot be excluded).

Although the EU depends much less on imports for maize than for soybeans, the experience with the Herculex maize (see introduction) has shown that LLP in maize can still have considerable economic repercussions throughout the EU's supply chain. And for maize, AA is a reality: two GM maize events that are not yet approved in the EU are already cultivated in the United States (Monsanto's MON88017 and Syngenta's MIR604), four events are ready to be commercialized in

Table 4. Asynchrony of first approvals of GM crops (for any use) between the United States and the EU, status in early 2009.

GM crop	United States	EU	Delay (years)
Roundup Ready soy (MON 40-3-2), Monsanto	1994	1996	2
Bollgard cotton (MON531), Monsanto	1995	1997	2
Roundup Ready cotton (MON1445), Monsanto	1995	1997	2
NaturGard KnockOut maize (Bt176), Syngenta	1995	1997*	2
LibertyLink maize (T25), Bayer	1995	1998	3
YieldGard CB maize (MON810), Monsanto	1996	1998	2
Agrisure CB maize (Bt11), Syngenta	1996	1998	2
Agrisure GT maize (GA21), Syngenta	1997	2005	8
LibertyLink canola (T45), Bayer	1998	1998	0
LibertyLink soy (A2704-12), Bayer	1998	2008	10
Roundup Ready canola (GT73), Monsanto	1999	1996	-3
InVigor canola (MS8xRF3), Bayer	1999	1999	0
LibertyLink rice (LLRICE62), Bayer	2000	Assessment	Current AA
SeedLink canola (MS1xRF1), Bayer	2002	1996*	-6
SeedLink canola (MS1xRF2), Bayer	2002	1997*	-5
TOPAS19/2 canola (HCN92), Bayer	2002	1998*	-4
Roundup Ready 2 maize (NK603), Monsanto	2000	2005	5
Herculex I maize (1507), Dow/Pioneer	2001	2006	5
Bollgard II cotton (MON15985), Monsanto	2002	2003	1
YieldGard RW maize (MON863), Monsanto	2002	2006	4
LibertyLink cotton (LLCotton25), Bayer	2003	2008	5
Widestrike cotton (210-23x24-236), Dow	2004	Assessment	Current AA
Herculex RW maize (59122), Dow/Pioneer	2005	2007	2
Roundup Ready sugar beet (H7-1), KWS/Monsanto	2005	2007	2
YieldGard VT maize (MON88017), Monsanto	2005	Assessment	Current AA
Roundup Ready Flex cotton (MON88913), Monsanto	2005	Assessment	Current AA
Mavera High Value maize (LY038) Renessen/Monsanto	2006	Assessment	Current AA
Roundup Ready 2 soy (MON 89788), Monsanto	2007	2008	1
Agrisure RW maize (MIR604), Syngenta	2007	Assessment	Current AA
Amylase maize (3272), Syngenta	2007	Assessment	Current AA
YieldGard VT PRO maize (MON89034), Monsanto	2008	Assessment	Current AA
Optimum GAT maize (98140), Pioneer	2008	Assessment	Current AA
Optimum GAT soy (356043), Pioneer	2008	Assessment	Current AA
3 events in soy and cotton	Submitted	Submitted	(0)
1 event in potato (BASF's amflora)	**Not** submitted	Submitted	
7 events in maize, soy, cotton, and alfalfa	Submitted	**Not** submitted	Isolated foreign approvals
>60 events in maize, soy, cotton, canola, potato, rice, and sugar beet	Approved	**Not** submitted	

Notes: (i) Apart from asynchronous approval (AA) and isolated foreign approval of GM crops between the United States and the EU, there is also a rising number of GM crops from other countries (China, India) that contribute to this issue.

(ii) Differences in approval time can also be due to the timing of the submission of the respective dossiers by the developer.

(iii) Approvals in the EU that are marked with an asterisk (*) have already expired and no renewal has been sought by the developer.

(iv) In the case of canola, which is of less importance in US agriculture, there are also cases where the event was approved in the EU first.

Source: Stein and Rodríguez-Cerezo (2009b).

the United States (Monsanto's MON89034 and LY038, Pioneer's 98140, and Syngenta's 3272), five more are in the regulatory pipeline worldwide, and six new events are in the advanced R&D pipeline. Moreover, especially for maize the stacking of events can quickly generate more crops that are considered new GMOs under the EU's regulatory framework.

Similar to maize, a past incident in rice (see the introduction) has shown that the problem of LLP can be real—in this case rice imports from the United States are still far below pre-2006 levels. Given that the EU consumes less than 1% of the global rice production and that the United States is a relatively small producer, EU rice importers could replace the US imports. However, searching new suppliers and redirecting trade flows is not cost neutral (and even then LLP through commingling during transportation and storage cannot be completely excluded in the global bulk trading system). Moreover, especially in the medium term, the big rice-producing countries in Asia could start cultivating GM rice: of the 19 GM rice events that could be commercialized by 2015, 16 are in the pipeline in various Asian countries (China, India, Pakistan, Indonesia, Philippines, Iran), and it is not known whether their developers will submit these events for approval in the EU.

A similar situation to that which is expected for GM rice can be found for GM cotton: out of the 12 individual GM events of cotton cultivated worldwide, eight are currently not cleared for import into the EU and five of these are only approved locally in China and India. However, the EU's imports of cottonseed meal (for feed use) or of cotton oil (for cooking) are extremely small when compared with imports of other oilseed meals. From this point of view, LLP incidents in cotton will have far less economic impacts than similar problems in soybean or maize.

For GM rapeseed, the relevance of LLP will depend on how quickly the EU becomes a net importer of rapeseed (to supply a rising demand for biofuel within the EU). In this case any LLP issues will depend on the evolution of the five GM rapeseed events in the advanced R&D pipeline—which are not expected to be commercialized before 2012.

The first commercializations of GM potatoes are expected sometime before 2015. However, potato imports into the EU are very small compared to domestic production (and they are highly regulated for reasons of plant health and plant diseases), and of the three GM potato events in the regulatory pipeline, only one (Amflora) is under assessment in the EU. The other two events are being developed in Argentina with which potato trade is basically zero. Hence, LLP problems with (unprocessed) potatoes are unlikely, at least in the short-to-medium term.

Of the "other" commercial GM crops, only GM sugar beet is authorized in the EU for import (as food and feed); all the other events are not even submitted for EU approval. Also with regard to future developments, it seems rather unlikely that the developers of the various other new GM crops (mainly in India and China) will seek EU approval. To date, no incidents with such minor crops (papaya, tomato, squash, sweet pepper) have happened. However, as it is expected that an increasing number of crops are commercialized by 2015 (beans, eggplant, cabbage, cauliflower, okra, mustard, wheat, chilli, peanuts), future LLP incidents—especially in processed food products from Asia—cannot be excluded.

In conclusion, if LLP problems have already occurred in the past, when worldwide only about 30 events were marketed, these are not likely to disappear over the next several years when there may be more than 120 events in the global market. Individual ad-hoc measures like the quick approval of one new GM crop or the other will not and cannot address the underlying structural problem of LLP, as has been shown by the recent "cross LLP" of GM maize in soybean shipments (Hornby & Felix, 2009). Solutions proposed by stakeholders in the EU's agrifood supply chain cover the need to replace the EU's current zero tolerance towards traces of EU unapproved GM material by practical low-level marketing thresholds (i.e., above the detection limit). Moreover stakeholders highlight the need to address the current situation where the official testing of imports takes place only once the shipments have already reached the port of destination (thus increasing the economic risks of the rejection of the shipment). Other solutions proposed include the streamlining of the regulatory systems, mutual recognition of risk assessments of new GM crops, and the implementation of Codex Alimentarius guidelines.

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Author Notes

The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

Appendix

List of Workshop Participants

Next to members of the European Commission and EU authorities (Directorate General for Health and Consumer Affairs [DG SANCO], Directorate General for Environment [DG ENV], DG TRADE, Directorate General for Research and Technological Development [DG RTD], JRC, European Food Safety Authority [EFSA]), national regulators from the United States, Argentina, Brazil, Canada, India, Australia, Japan, and the Ukraine were represented; the Chinese regulator was absent and the South African regulator could not attend, but public scientists from both countries participated. Of the major private companies developing GM crops, representatives of Monsanto, Bayer CropScience, Syngenta, Dow AgroSciences, and BASF Plant Science attended the workshop; the representative of Pioneer only submitted his presentation. The remaining biotechnology companies were represented by two of their industry associations (the Biotechnology Industry Organization and the European Association for Bioindustries). Public research in the field of agricultural biotechnology worldwide was represented by members of the Brazilian Agricultural Research Corporation, the Indian National Botanical Research Institute, the Chinese Academy of Sciences, the South African Agricultural Research Council, the International Rice Research Institute, the Australian Cooperative Research Centre for Molecular Plant Breeding, the International Food Policy Research Institute, and the Spanish National Research Council. Stakeholders of the global agrifood supply chain came from Coceral, the European Feed Manufacturers' Federation, the EU Oil and Proteinmeal Industry, the Confederation of the Food and Drink Industries in the EU, the Federation of European Rice Millers, the Grain and Feed Trade Association, COPA-COGECA (European Farmers/European Agri-Cooperatives), the European Seed Association, the US Rice Federation, the American Soybean Association, the Canola Council of Canada, the North American Export Grain Association, the International Grain Trade Coalition, and the Food and Agriculture Organization of the United Nations.