Analysing the methods used to isolate GM from non-GM maize in France in 2007

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Abstract

We studied how coexistence of GM and non-GM maize crops was managed in the south of France at the farm level by surveying 23 different farms in a region where nearly half of the maize grown in 2007 was GM. Using semi-directive interviews, we identified factors explaining the choice of GM or NGM maize cropping, like the presence of maize specialty crops, scope for technical progress for maize yields, perception of corn borer as a risk or return time of maize in the rotation. We will use these results to build a multi-criteria model of maize allocation.

Introduction

In the European Union, the principles of coexistence of GM (Genetically Modified) and non-GM (NGM) crops have been defined by several directives and recommendations that, at the agricultural production level, aim to limit the accidental presence of GMO in conventional crops (EC, 2003a).

Under European regulations a product containing more than 0.9% of one of its ingredients coming from GM material is labelled as GM (EC, 2003b).

Several studies have been made to test the effect of production methods and conditions on the level of GMO in a conventional harvest. Several models of gene dissemination on a small landscape scale have been developed (Colbach *et al.*, 2001a,b; Angevin *et al.*, 2002) to measure the probable level of GM present in the harvest at the field level according to the landscape and the cropping systems in each field (Angevin *et al.*, 2008; Messéan *et al.*, 2006).

Bt maize (resistant to corn borer) is the only GM crop commercially grown in the EU and it has already been grown in France, especially in 2007.

After harvest, the risk of GM-NGM admixture is especially high in maize during drying. Previous papers have described the effect of the decisions of grain merchants on crop production and subsequently on harvest admixture (Coléno *et al.*, 2009; Le Bail, 2003).

The response of farmers to these decisions has been conceptualised in a simple economic model based on the maximisation of expected gain for the farmer (Coléno *et al.*, 2009). However this model is concerned only with economic considerations, whereas adoption of GM maize involves other factors. GM crops are also an answer to organisational or technical constraints (Chevassus-au-Louis, 2001, Gardner and Nelson, 2007). They also place new constraints on the production system and on the sale of the crop by the farmer.

In order to improve this model of farmers' allocation of GM and non-GM maize at the landscape level, we studied real cases of the adoption of GM by farms, the factors which determined its adoption, and the cropping systems associated with both GM and NGM maize on these farms.

We chose to study the south-west of France, where maize is one of the main crops and where corn-borer is present, often with two generations per year.
We studied how coexistence was managed in maize in the south of France at the farm level in 2006 and 2007.

Material and methods

Region surveyed

We chose the Midi-Pyrénées region (France) because of the importance of maize in farm incomes in this region. The high corn-borer pressure also ensured that GM maize would be attractive to farmers.

Our goal was to survey a wide diversity of farms which had experienced GM-NGM maize coexistence in 2006 and/or 2007, producing GM or NGM maize, or both. We thus chose an area where mixed farming production systems could be found, using the French Ministry of Agriculture's statistical data (Agreste Midi-Pyrénées, 2009) and where GM maize represented a high proportion of the maize crop, using government data (République Française, 2008).

Two departments accounted for 73% of the GM maize grown in the Midi-Pyrénées in 2007: Haute-Garonne and Tarn-et-Garonne. In the Verdun-sur-Garonne county ('canton') especially, GM maize was grown on 63% of the total maize area in 2007. We chose to survey an area in and around Verdun-sur-Garonne extending over both Haute-Garonne and Tarn-et-Garonne departments.

The area surveyed covered 6 counties, where GM maize was grown on 25 to 63% of the total maize crop. However, a little over half of the farms surveyed were situated in the Verdun-sur-Garonne County.

We surveyed 23 contrasting farms near Verdun sur Garonne, where maize is the main crop and nearly half was GM in 2007. Some of the farms surveyed were organic, producing cash or feed crops, with orchards, vines, vegetables or cattle.

Survey and analysis method

Our sample was built using the « snowball » method, first finding farmers via the phone directory and then adding contacts provided by the farmers themselves. These farms were thus first chosen from a general database with no relation to the agricultural sector and there was not the usual bias introduced by the use of a database obtained from grain merchants or technical advisors.

Using semi-directive interviews, we surveyed 23 farms using the method described by Miles and Hubermen (1994). We used an interview guideline but let the farmer speak freely and choose the order in which he talked about the different points.
Our questions were about the farm and its management: farm resources (Usable Arable Area (UAA), soils, distances between farm and plots, equipment, labour, products of the farm (crops, livestock, and their share in total income), maize crop management (cropping system, crop location, crop rotations, presence of pests and their management, coexistence methods used etc.), commercial and advisory relations and also the farmer's view on the advantages and constraints of GM maize.
These interviews were then synthesised and analysed to identify the relations between the data about farm, farm management and the possible presence of GM maize on the farm as well as the methods of coexistence used.

Results and discussion

Global sample analysis

Global structure

The 23 farms surveyed represent a very diverse sample: 15 combinations of production were found from the cereals and oilseed-protein crop producer (5 farms) to the cereal/duck/seed/fruit producer (1 farm).

In this sample we found cereals in every farm since this was a necessary condition for inclusion in the sample (presence of maize). Livestock farming was present in 6 farms (cattle, chicken, and duck), seeds in 7 farms, orchards in 8 farms and vegetables in 3 farms.

In 7 of the 23 farms the farmer had another activity (primary or secondary) either related to farming (6 farms) or not (2 cases on one farm).

Farm size varied from 33ha to 280ha with 1 to 4 individuals working on the farm.
Maize was grown on 7.6% to 80% of the UAA (Table 1).

Maize area in % of the UAA	<11%	11-25%	25-50%	>50%
Number of farms	4	1	13	5

Table1. Proportion of maize grown on the farm

Maize was the main source of income for 13 farms.
The majority of the farms had a very concentrated field pattern, with the most distant plot less than 5km away in 12 of the 20 farms where this data was available.

Maize management
The sowing date was more or less the same between farms: it is highly dependent on the rain in April and May, which is frequent. Sowing date varies from the beginning of April to the end of May depending on the year and the rainfall pattern.
Except on organic farms, maize is routinely treated with an herbicide before emergence. This treatment is supplemented if necessary or routinely with another herbicide depending on the farm.

Nitrogen doses varied considerably between farms from 80 to 300kg N/ha for no apparent reason (Figure 1). As shown in Figure 1, no clear relation can be found between nitrogen input and maize yield. The lone point corresponding to a 40q/ha yield with a 215kgN/ha input represents the maize seed producing farm.

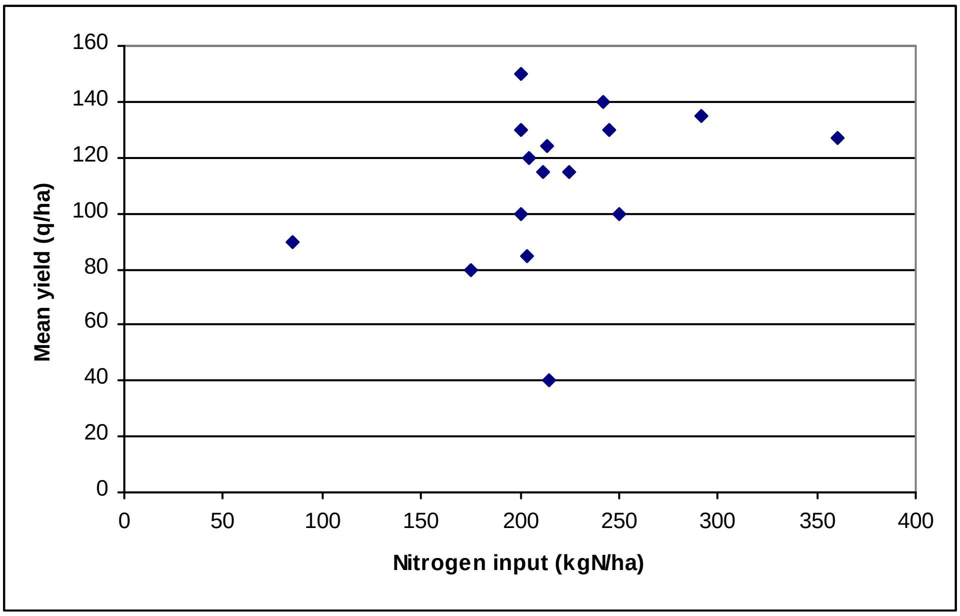

Figure 1. Mean maize yield according to total nitrogen input in the 16 farms where both data were available.

Corn-borer (*Ostrinia nubilalis*) and Sesamia (*Sesamia nonagrioides*) were perceived as a risk for maize yield in 12 of the 19 farms where this data was available, but only 8 of those 12 farmers treated their maize crop with a pesticide. Some applied this by helicopter until 2006.

All maize crops were irrigated but several kinds of sprinklers and driplines were found, sometimes on the same farm. Water input usually begins at the ten-leaf stage with an input of 30mm per round for the sprinklers for a total of 5 to 8 rounds of irrigation during maize cropping. The usual input of water per round for the dripline is 16mm. However, we had some difficulties in obtaining homogeneous data on this subject and we still need to work on it.

In all cases surveyed where GM maize was grown in 2006 and/or 2007, GM maize was managed in the same way as the non-GM maize, except that only the latter was sometimes treated with pesticide against corn-borer.

Maize harvesting was mainly done by private firms (14 farms). On 8 farms only, the farmer harvested his maize himself (in one case with the help of neighbours) and in the only case of maize seed production, the seed company harvested the seed itself. Maize monoculture was also the main crop sequence in the sample surveyed (14 farms) but some farmers waited up to 6 years before growing maize again on a given plot.

Twelve farmers identified localisation constraints on the maize. In 6 cases, these constraints were due to the impossibility or difficulty of irrigating certain fields.
The only difference in technical management between GM and NGM maize we found in the region was that no insecticide was sprayed on the GM maize when corn borer had previously been perceived as a problem.

Methods used to limit GMO/non-GMO admixture

In 2007, 14 farms grew GM maize and one farm grew GM maize in 2006 but not in 2007. All others grew only NGM maize both years. For the 15 farms which grew GM maize, it covered 5% to 80% of the maize area.

GM maize covered 80% of the maize area on 7 farms. This 80% coverage was the maximum proportion recommended in the good practices booklet given with each bag of seeds (AGPM, 2006; MAP, 2007).

In only one case did the farmer have no near neighbours growing maize and thus did not attempt to limit pollen dispersal from the GM maize.
In the other 22 cases surveyed, farmers had a maize plot in an area where both GM and non-GM maize coexisted.

In 15 of these cases, buffer zones of non-GM maize were put in place around the GM maize. In the case of some of the non-GM maize producers, we did not obtain information about the presence or otherwise of a buffer zone around the GM maize of their neighbours, so that the number of cases of buffer zones may well be higher than that.

Five farms isolated their maize crop from their neighbours': two farmers isolated their GM maize to keep it from pollinating non-GM maize, two farmers isolated their organic maize to keep it from being pollinated by GM maize and one farmer isolated his maize seed production from all maize.

In 6 cases, farmers coordinated among themselves to observe a minimum distance or a minimum buffer width between GM and non-GM maize (in one out of two cases of organic maize production, two cases of maize seed production, one case of duck feed production and one case of maize production for labelled cattle).

In just two cases the farmer producing GM maize did not take any precautions for coexistence. In one of these there was no neighbouring non-GM maize. In the other, the neighbouring non-GM maize was his own and was popcorn maize, which cannot be pollinated by grain maize.

Other methods of coexistence were used: in two farms, non-GM maize was harvested first so as not to mix harvested grain; in one farm, non-GM buffer zones were sown first so that they would be more developed than GM maize; and in one farm GM maize was sown first.

The main method of coexistence used by farmers was thus the buffer zone of non-GM maize. These buffer zones were usually 24 rows wide (in 12 cases out of 15) but ranged from 18 to 24 rows. Information and coordination with the neighbours was used mainly where specialty maize was grown.

As for the advantages and disadvantages of GM maize perceived by the farmers who had grown them in 2006 and/or 2007, 8 farmers noticed a yield increase of their GM over the non-GM maize the same year. This yield increase was less than 15% in 6 cases and more than 15% in 2 cases. 6 farmers did not notice any difference

between GM and non-GM maize and one farmer noticed a yield loss of 12% due to a germination problem with the GM seed.
6 farmers considered the GM maize to be healthier than the non-GM maize. In 2 cases, the use of GM maize enabled the farmer to gain flexibility in his work organisation.

General synthesis

One of the conclusions of this sample analysis is that no GM maize is found in specialty crops (organic maize, seed maize and duck feed maize). These farmers are contracted to use and produce only non-GM maize.

Another conclusion is that perceived corn-borer pressure may have an effect on the adoption of GM maize: in 12 cases of perceived corn-borer presence, 8 farmers decided to grow GM maize whereas in 9 cases of perceived corn-borer absence only 5 farmers grew GM maize but this cannot be proved without more information.

Crop rotation including maize and mean maize yield may also have an effect on GM maize adoption (Tables 2 and 3). Farmers with a high perceived presence of corn-borer or with a high corn-borer risk due to crop rotation (Table 2) used GM maize more often to limit this risk.

Crop rotation with maize on the farm	Monoculture	Maize 5 years/cereal	Intermediate	Long rotation
GMO presence	9 farms	2 farms	2 farms	1 farm
GMO absence	1 farm	1 farm	2 farms	4 farms

Table 2. Relation between crop rotation length and GM maize adoption. Intermediate rotation includes 3 years maize/3 years of other crops or maize alternated with another crop (wheat, triticale, soybean or sunflower). Long rotation includes rotation with a minimum of 4 years between 2 maize crops.

Mean maize dry yield	<100q/ha	>100q/ha
GMO presence	0 farm	15 farms
GMO absence	5 farms	2 farms

Table 3. Relation between mean maize yield and GM maize adoption

Table 3 shows that only farmers with a high mean maize yield use GM maize in our sample. Out of the two farmers with a high mean yield and no GM maize, one produces a specialty crop (duck-feed) and another is opposed to GMOs. The other farmers usually combine their high mean yield with maize monoculture and a high nitrogen input. The only scope left to increase their yield is to limit the hidden losses due to corn-borer. They are thus more likely to adopt GM maize. These results can be compared to that found on Bt cotton in Africa by Hofs et al. (2006). In their study, Hofs et al. (2006) found out that using GM crops could be an important component in cropping intensification strategies but that in farms with low or variable yields it did not always bring improvements. In our study, only farmers with an intensification strategy tried GM crops.

At the end of this survey, we identified 3 reasons given by farmers for growing GM maize:

- yield increase
- healthier crops
- more flexible work organisation.

We also identified 3 kinds of reason for not growing GM maize:

- technical and economic (no yield increase observed; high seed cost; other ways of increasing yield)
- strategic reasons (specialty crops)
- ideological reasons (given in only one case in our survey)

On farms where NGM maize behaved as well as or better than GM maize, farmers will not grow GM maize again. However where GM maize behaved better than NGM maize (better yield or healthier crop), GM maize will be grown again if authorised.
In 2006 corn-borer (and Sesamia) presence was high and GM maize grown in that year may have had a better yield (only one farmer out of the 7 who tried it in 2006 did not see a yield increase). However in 2007 corn-borer presence was much lower and the farmers who grew GM maize in that year only, did not see as much yield increase (only 3 farmers out of 9 who tried it that year observed a yield increase).

The results of testing GM maize in 2006 or 2007 seem decisive for future GM adoption: 5 out of 9 farmers testing GM maize in 2007 would grow GM maize again if authorised, whereas 6 out of 7 farmers testing GM maize in 2006 would grow GM maize again if authorised.

Thus, corn-borer incidence in the first year of testing seems to be a determining factor in GM maize adoption as it affects the benefits the farmer sees for the GM crop. However, even though farmers who grew GM maize both in 2006 and 2007 may not have seen a yield increase in 2007, they still declared themselves ready to grow GM maize again as a safety measure for years with a high corn-borer (or Sesamia) incidence.

Conclusions

We identified factors which could explain the choice of GM or NGM maize cropping like the growing of specialty forms of maize, the scope for technical progress towards higher maize yields in the farmer’s strategy, the perception of corn borer as a risk and the return time of maize on a field, distinguishing 3 kinds of reasons for growing GM maize or not.

Our survey also showed that farmers managed GM and NGM maize in the same way except that the GM crop did not require insecticides; however coexistence involves limiting pollen dispersal to NGM maize.

We will now begin to use these results and others from the MASCOTE project to build a multicriteria model of GM and NGM maize plot allocation in a small region taking into account agronomic, economic and legislative criteria.

To build the agronomic part of this model we will compare the data obtained from this survey with those obtained by Duquesne (2005) in Alsace (France) and by the IPTS Study (Messean *et al.*, 2006).

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References

AGPM, 2006, 'Guide des bonnes pratiques pour la culture du maïs Bt' *AGPM*.
Agreste Midi-Pyrénées, 2009, 'L'agriculture, l'agro-alimentaire et la forêt. Mémento édition 2009', *Direction régionale de l'alimentation, de l'agriculture et de la forêt*.
Angevin, F, Colbach, N, Meynard, J-M & Roturier, C, 2002, Analysis of necessary adjustements of farming practices, A-K Bock et al. (Eds.) 'Scenarios for coexistence of genetically modified, conventional and organic crops in European agriculture', *Technical Report Series of the Joint Research Center of the European Commission*, EUR 20394 EN.
Angevin, F, Klein, EK, Choimet, C, Gauffreteau, A, Lavigne, C, Messéan, A & Meynard, J-M, 2008, 'Modelling impacts of cropping systems and climate on maize cross-pollination in agricultural landscapes: the MAPOD model', *European Journal of Agronomy*, vol. 28 pp. 471–484.
Chevassus-au-Louis, B, 2001, 'OGM et agriculture : options pour l'action publique', *Rapport du Commissariat Général du Plan*.
Colbach, N, Clermont-Dauphin, C & Meynard, J-M, 2001a, 'GeneSys: a model of the influence of cropping system on gene escape from herbicide tolerant rapeseed crops to rape volunteers, I Temporal evolution of a population of rapeseed volunteers in a field', *Agriculture, Ecosystems and Environment*, vol. 83 pp. 235-253.
Colbach, N, Clermont-Dauphin, C & Meynard, J-M, 2001b, 'GeneSys: a model of the influence of cropping system on gene escape from herbicide tolerant rapeseed crops to rape volunteers, II. Genetic exchanges among volunteer and cropped populations in a small region', *Agriculture Ecosystems and Environment*, vol. 83 pp. 255–270.
Coléno, F-C, Angevin, F & Lécroart, B, 2009, 'A model to evaluate the consequences of GM and non-GM segregation scenarios on GM crop placement in the landscape and cross-pollination risk management', *Agricultural Systems*, vol. 101 pp. 49-56.
Duquesne, S, 2005, 'Coexistence entre maïs OGM et non-OGM : quelles marges de manoeuvre dans les exploitations Haut-rhinoises ? Comparaison avec un exemple espagnol', *Mémoire de fin d'études*, ESA d'Angers.
European Commission, 2003a, 'Commission recommendations of 23 July 2003 on guidelines for the development of national strategies and best practices to ensure the co-existence of genetically modified crops with conventional and organic farming, 2003/556/EC (notified under document number C(2003) 2624)', pp. 36–47. *Official Journal of the European Union*, 29/07/2003, vol. 46, p. L189.
European Commission, 2003b, 'Regulation (EC) No 1830/2003 of the European Parliament and of the Council of 22 September 03 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and amending Directive

2001/18/EC', pp. 24–28. *Official Journal of the European Union*, L268, 18/10/2003, vol. 46, p. L268

Gardner, JG & Nelson CH, 2007, 'Genetically modified crops and labor savings in US crop production', *Southern Agricultural Economics Association Annual Meeting*, February 4-7 2007, Mobile (AL, USA).

Hofs, JL, Hau, B, Marais, D & Fok, M, 2006, 'Boll distribution patterns in Bt and non-Bt cotton cultivars, II. Study on small-scale farming systems in South Africa', *Field Crop Research*, vol. 98 pp. 210-215.

Le Bail, M, 2003, 'GMO/non-GMO segregation in the supply zone of country elevators', In Borupsgarrd (Eds.) *1° European Conference on the co-existence of Genetically Modified Crops with Conventional and Organic Crops*, pp. 125-127.

Messean, A, Angevin, F, Gómez-Barbero, M, Menrad, K & Rodríguez-Cerezo, E, 2006, 'New case Studies on the co-existence of GM and non-GM crops in European agriculture', *IPTS*, EU-Joint Research Centre.

Ministère de l'Agriculture et de la Pêche, 2007, 'Communiqué de presse du 20 mars 2007', *MAP*.

Miles, MN, & Hubermen, AM, 1994, 'Qualitative data analysis, an expended sourcebook', *CA: Sage Publications*.

République Française, 2008, 'Registre National des cultures OGM au 05/09/2007', http://www.ogm.gouv.fr/mise_marche/registre_cultures/registre_cultures.htm