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A Quinquennium of Coexistence in Portugal

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Portugal is one of the few European Union countries that experience the "coexistence" of a coexistence legal framework with a regular coexistence practice. Since 2005, Bt maize crops have been grown in different regions—either in small or large farms—in compliance with a law that envisages coexistence procedures for either individual farmers or groups of farmers that agree to establish the so called "production zones." The monitoring of Bt maize crops is annually run and reported by the Ministry of Agriculture.

Here we report on the first quinquennium of coexistence in Portugal, bearing down on regional distribution and evolution, farm sizes, coexistence measures, GM farmers' profile and their assessment of Bt crops and coexistence rules, and Bt maize destination. Opportunities and constraints are also pointed out.

***Key words*:** Bt maize, coexistence, hectarage, production zones (PZs), regulation, segregation.

Introduction

Informed consumers' choice has entailed labeling policies for genetically modified organisms (GMO) and food and feed containing, consisting, or derived from GMOs. Labeling policies differ across the world (Gruère & Rao, 2007). The essential framework of the European Union (EU) regarding GMO labeling consists of Directive 2001/18/EC on the deliberate release into the environment of GMOs, Regulation (EC) No. 1829/2003 on GM food and feed, and Regulation (EC) No. 1830/2003 concerning the traceability and labeling of GMOs and the traceability of food and feed products produced from GMOs (Commission of the European Communities [CEC], 2009). The threshold for GM labeling of food and feedstuffs is 0.9%.

Coexistence stands for the choice of consumers and farmers between conventional, organic, and GM crop production, in line with legal obligations, which raise the need to segregate between products according to their labeling or purity requirements.

As the possibility of adventitious presence of GM crops in non-GM crops cannot be excluded, suitable measures are needed during cultivation, harvest, transport, storage, and processing to ensure coexistence. In 2003, the EU Commission released a recommendation on guidelines for the development of national strategies and best practices to ensure coexistence, and each member state was compelled to develop and implement its own management measures for coexistence (CEC, 2003).

In September 2005, Portugal was the second member state (the first being Denmark) to publish a law to rule coexistence (Decree nº 160/2005 of September 21st), particularly between conventional, organic, and Bt maize (GM maize varieties carrying the MON810 event). Therefore, in the maize-growing season of 2006, stakeholders could count on a set of coexistence rules. Since then, coexistence of Bt and conventional maize varieties has summed up five years of experience and monitoring that generated a set of data whose summary, analysis, and discussion are the scope of this communication.

An Overview of Maize Cultivation in Portugal

Portuguese farms represent about 3% of the holdings and 2% (3,668,000 ha) of the utilized agricultural area (UAA) in the EU. The average size of holdings is 12.0 ha (Figure 1), which is 5 ha below the EU average and half the Spanish average, though it is larger than the Italian average (Statistics Portugal, 2011b). Farms below 5 ha of UAA are largely prevailing, though 65% of UAA is held by farms with 50 ha or more (Figure 2). The maps in Figure 3 show the uneven prevalence of farm sizes across Portugal and the agricultural regions: North, Center, Lisbon and Tagus Valley (from now on LTV), Alentejo, Algarve, Azores, and Madeira. Moreover, Table 1 provides the average UAA of holdings by agricultural region, according to the census of agriculture of 2009 (Statistics Portugal, 2011b).

Table 1. Average UAA by holding (2009).

Region	North	Center	LTV	Alentejo	Algarve	Azores	Madeira
Average UAA (ha)	5.8	5.6	9.8	61.5	7.1	8.9	0.4

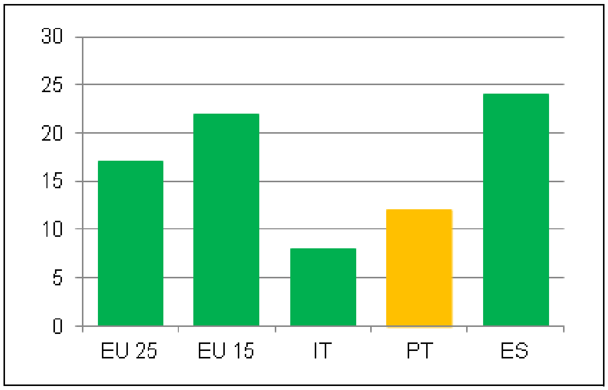

Figure 1. Average size of holdings (ha).
Note: Green=2007 data; yellow=2009 data.

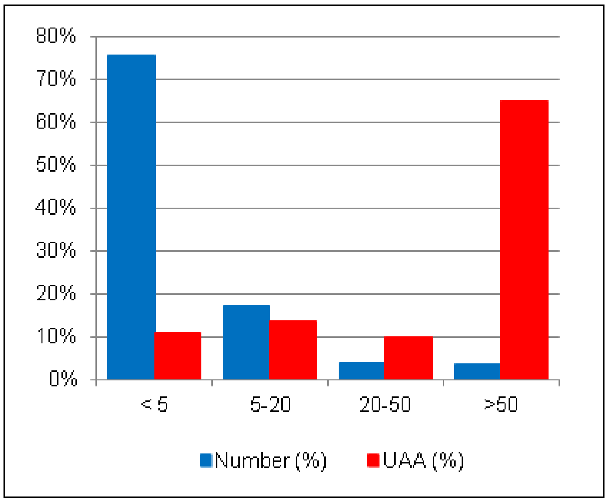

Figure 2. Relative number of holdings and UAA (%) by class of UAA (ha).

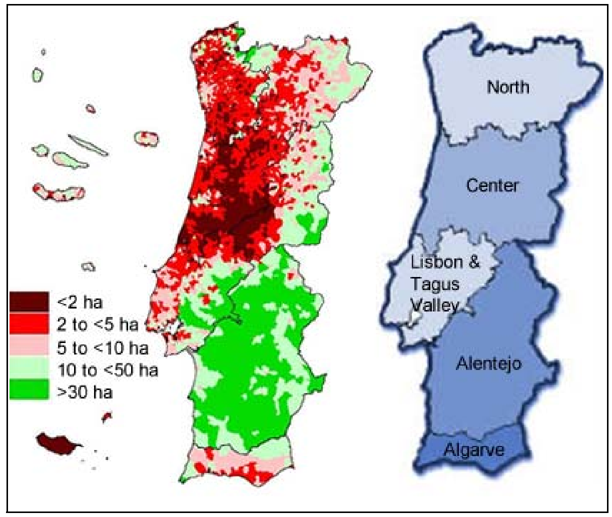

Figure 3. Average size of holdings in Azores (top left), Madeira (bottom left) and continental Portugal (middle), and continental agricultural regions (right).
Source: RA 2009.

Maize is cultivated all over Portugal, though negligible in Madeira (< 100 ha), whose data will not be further considered here. Maize is an important crop in small farms (<5 ha) that account for 33% of the crop hectarage (Statistics Portugal, 2011b), as shown in Figure 4. Grain crop prevails over silage crop (Associação Nacional de Produtores de Milho e Sorgo [ANPROMIS], 2011), with 64% against 36% of the maize area, but is much reduced in Azores and equals the area of silage in the North region (Figure 5). Figure 6 reports the changes in maize area along the quinquennium 2006-2010 (ANPROMIS, 2011). Algarve data were not included, as they are too low: between 208 ha in 2010 and 350 ha in 2008. While Azores showed a slight but continuous increase, North and Center regions have experienced a continuous decrease and LTV and Alentejo did not keep their maximums of 2008. The overall variation was congruent with EU variation (Eurostat, 2010). Average grain yield is 6.9 t/ha, but two groups within the main regions should be distinguished: North and Center, whose average yield is 6.3 t/ha, and LTV and Alentejo, whose average is 11.4 t/ha (Statistics Portugal, 2011a). Two clusters of maize growers that only persist in North and Center regions greatly account for the difference: those who cultivate flint-type maize varieties, either for bread or for bird feed, and those running subsistence agriculture, following either multiple cropping or low input farming (often no irrigation).

Main Features of Portuguese Coexistence Law

Given the subsidiarity principle, the legal framework of coexistence varies across EU member states (CEC, 2009). The essential features of Portuguese coexistence law are presented here.

In order to grow GM maize, farmers must: (i) undergo mandatory training; (ii) notify GM crop cultivations (GM variety, area, place, and intended coexistence measures) to the regional agricultural authority; and (iii) inform their immediate neighbors and the oper-

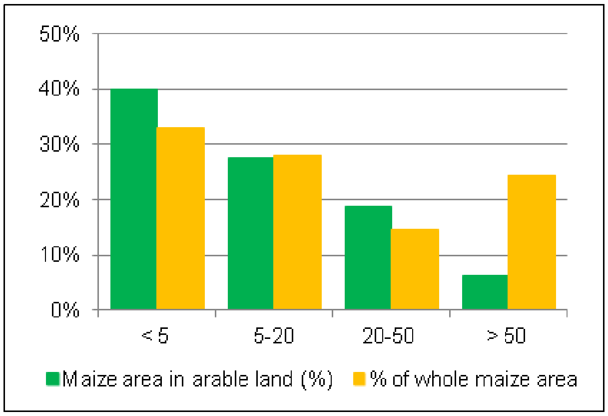

Figure 4. Maize share in arable land by UAA class (green) and share of each UAA class in total maize area (yellow).

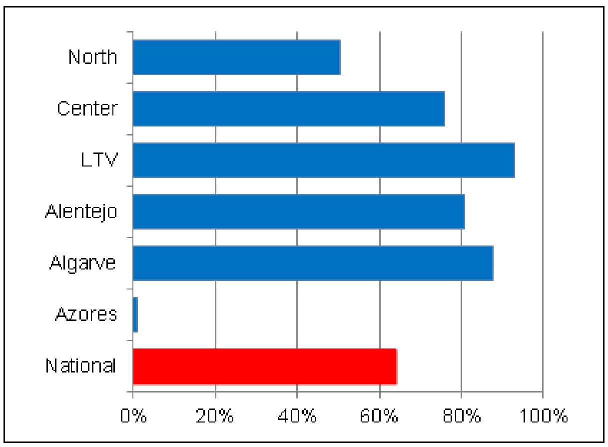

Figure 5. Average (2006-2010) grain maize share in total maize area (grain + silage).
Source: ANPROMIS (2011).

ators with whom they share agricultural machinery. In addition, they must cooperate with agricultural authorities in all control and monitoring actions, namely by record keeping.

Seed distributors have to: (i) inform farmers about the coexistence rules, by means of a leaflet approved by the national agricultural authority and provided with each seed bag and (ii) report to the regional agricultural authority the farmers that bought GM seeds and their amount.

Regional agricultural authorities must: (i) publish farmers' notifications; (ii) monitor GM growers, including sampling of neighbor maize crops; and (iii) convey all information to the national agricultural authority. This one must: (i) supervise training and information provided to farmers; (ii) publish an annual monitoring report; and (iii) propose eventual updates to the law.

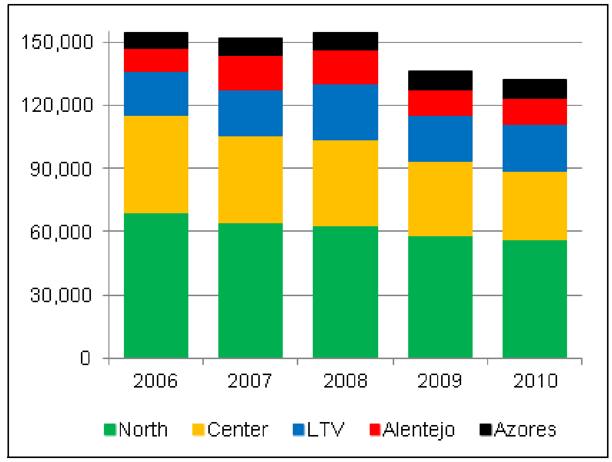

Figure 6. Maize areas (1000 ha).

Coexistence measures are aimed at reducing admixtures by both pollen and seed. To prevent admixtures due to pollen, GM maize growers can choose between: (i) isolation distances of 200 m or 300 m to conventional or organic maize crops, respectively; (ii) buffer zones, whose production will be pulled together with the GM crop production and consist of 24 conventional maize border rows, or 28 conventional maize border rows plus an isolation distance of 50 m between GM field and conventional or organic maize crops, respectively; or (iii) use of different flowering times, either by keeping an interval of at least 20 days between sowing dates of GM and non-GM varieties of the same FAO class, or by simultaneous sowing of GM and non-GM varieties that differ by two or more FAO classes.

To prevent admixtures due to seed, GM maize growers must: (i) segregate, clearly identify, and close GM seed bags; (ii) clean on-site agriculture machinery after work with GM seed or grain, including, for combines, the need to harvest at least 2,000 m^2 of a conventional variety, whose grain will be added to GM grain, after the harvest of a GM maize crop; and (iii) segregate and tag (name of variety and GMO unique identifier) each stock of GM grain.

For GM varieties carrying insect-resistance events, such as MON810, an additional measure was included; this additional measure concerns the establishment of refuge zones by Bt maize growers, where conventional varieties should be cultivated, and whose minimum area must be 20% of the area devoted to Bt maize. Buffer and refuge zones can overlap.

A particular feature of Portuguese regulation regards production zones (PZs) of GM varieties, which are freely organized groups of neighbor farmers aimed at growing either varieties sharing the same event or dif-

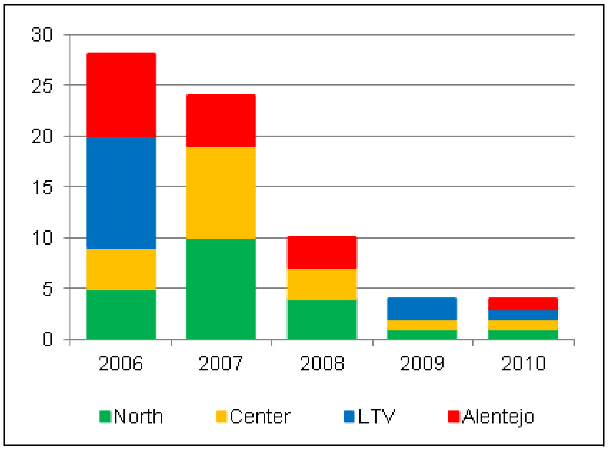

Figure 7. Number of training actions.

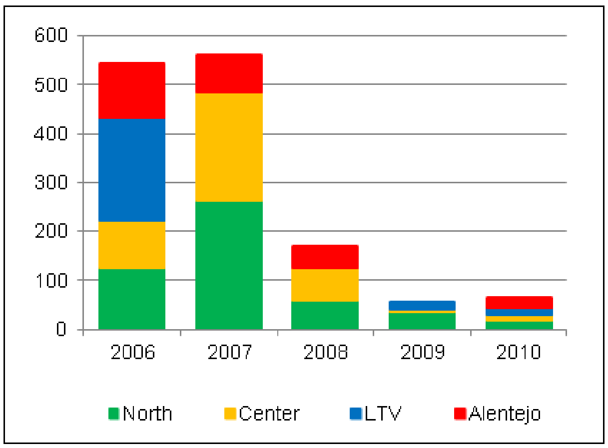

Figure 8. Number of farmers in training actions.

ferent varieties (including non-GM varieties) whose products will be pulled together to make GM labeled lots. Within a PZ, farmers have no need to avoid admixtures; therefore, coexistence measures will only be expected between the PZ farmers and their neighbors outside the PZ.

The Portuguese coexistence law provides the creation of a compensation fund to support economic losses due to accidental admixtures.

A further topic addressed by the coexistence law regards GM-free zones, whose regulation was established in 2006 and updated in 2007 (Ordinance nº 904/2006 of September 4th and Ordinance nº 1611/2007 of December 20th).

Five Years of Coexistence Monitoring

The data that follow have been compiled from the monitoring reports of the national authority (Direcção Geral de Protecção das Culturas [DGPC], 2006, Direcção

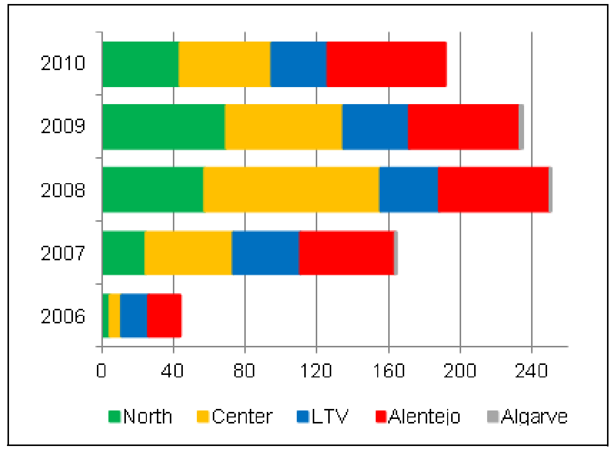

Figure 9. Number of notifications of Bt maize cultivation.

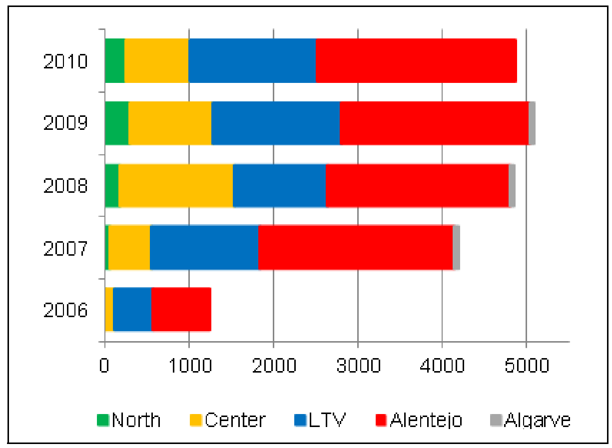

Figure 10. Bt maize growing area (ha).

Geral de Agricultura e Desenvolvimento Rural [DGADR], 2008b, 2009, 2010, 2011).

Training

Training actions are carried out by seed industry and farmers organizations under the supervision of the national agricultural authority that certifies trainers and defines the training plan. In addition, a manual of good practices was published and distributed in 2008 (DGADR, 2008a).

As expected, the amount of training actions (Figure 7) and the number of farmers they gather (Figure 8) were high in the first years and apparently reached a steady stage in 2009. Data of LTV region deserve a remark: being the most innovative agricultural region of Portugal, it experienced the highest training rate soon after the release of the coexistence law; this fact might well explain the absence of training actions during the next two years.

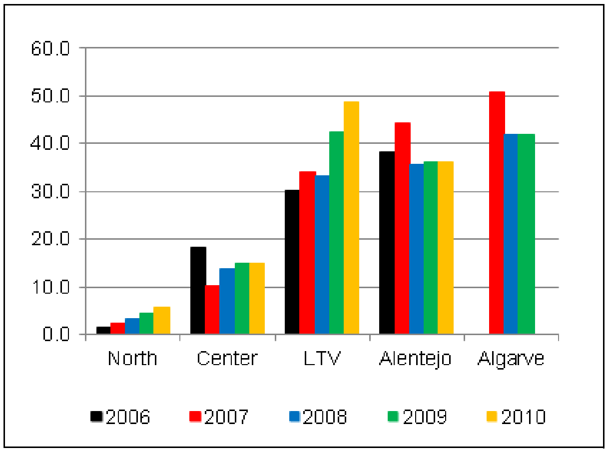

Figure 11. Average area of Bt maize by notification (ha). Algarve data refer to a single notification/year.

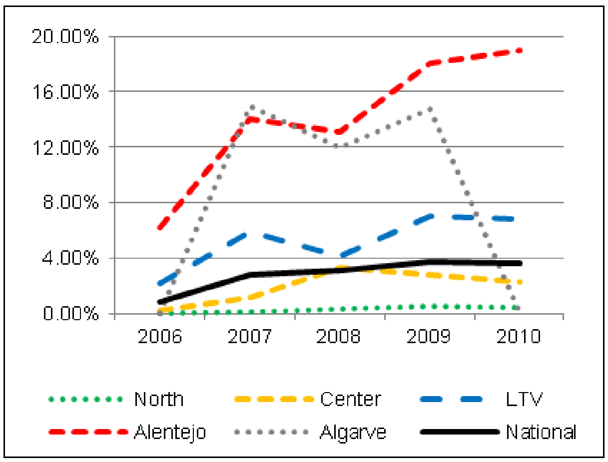

Figure 12. Share of Bt maize area in total maize area.

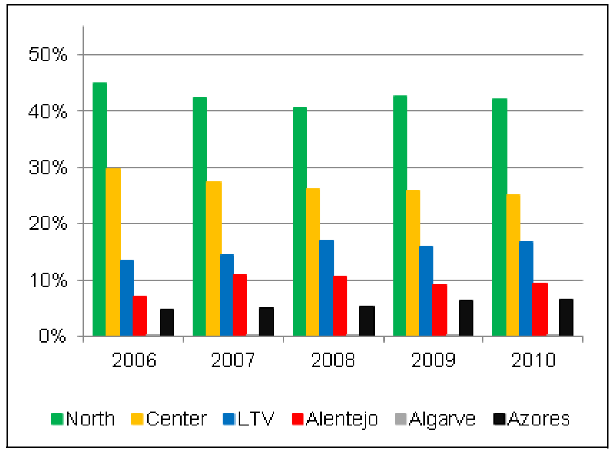

Figure 13. Regions share in total maize area.

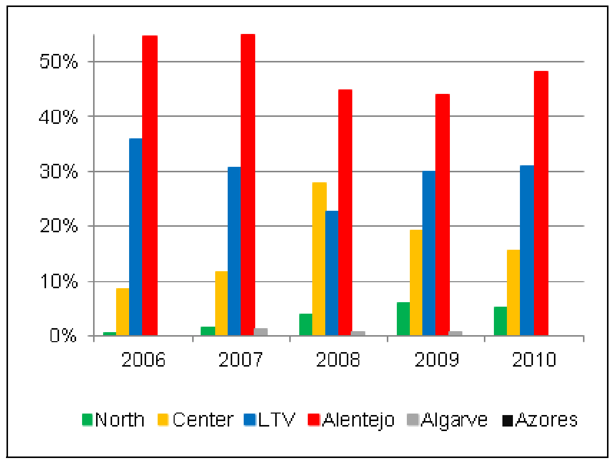

Figure 14. Regions share in Bt maize area.

Coexistence in Place

Notifications and areas of Bt maize cultivation are shown in Figures 9 and 10, respectively. Notifications and Bt maize area have consistently increased till 2008. The governmental decision to stop providing the subsidy of environmental measures to GM maize farmers from 2008 onwards can explain the decline of the total number of notifications afterwards; the area, however, did not shrink and slightly increased in 2009. It should be noted that the number of notifications in North and Center regions remarkably increased in 2008, amounting to 50% or more of the total since then.

Regional averages of Bt maize area by notification are presented in Figure 11. In spite of a continuous increase since 2006, the average Bt maize area by notification in the North region did not exceed 5.6 ha in 2010. When compared to the regional average UAA (Table 1), this value suggests that Bt maize growers might correspond to the average farmer in this region. However, in the Center and LTV regions an analogous comparison suggests that Bt maize is being grown mostly in above-average farms. Given the low maize share in UAA exhibited by large farms as shown in Figure 4, the Alentejo data are consistent with Bt maize cultivation by average sized farms in this region. In Algarve a single farmer grew Bt maize and, as stated before, maize crop is poorly represented in the region.

The share of Bt maize in total maize area in each region (Figure 12) clearly indicates that Alentejo shows the highest rate of adoption of Bt maize—close to 20% in 2010. LVT follows (Algarve is peculiar, as the variation is due to a single farmer) and its share is consistently above national average, with a maximum of 7% in 2009. The North region share is negligible, while the Center region—though generally below the national

Table 2. Departure (2007) and current (2010) data of production zones (PZs).

	Number of PZs		Bt maize grown in PZs (ha)		Bt maize grown in PZs Share in Bt maize area (%)		Bt maize growers in PZs Number		Bt maize growers in PZs Share in all PZ growers (%)	
Region	**2007**	**2010**	**2007**	**2010**	**2007**	**2010**	**2007**	**2010**	**2007**	**2010**
North	1	7	13	31	20.5	12.5	6	11	33.0	25.0
Center	4	6	152	508	31.0	66.4	22	35	33.0	68.6
LTV	3	3	476	428	36.8	28.3	8	7	100.0	22.6
Alentejo	3	5	1186	1285	51.4	54.8	18	18	100.0	27.7
National	11	21	1827	2252	43.5	46.3	54	71	49.0	37.2

average—shows an increase in 2008 that opposes the decline of the other regions and that will be discussed later, as it is related to the development of Bt production zones.

Figures 13 and 14 allow a comparison between the relative regional hectarages of whole maize and Bt maize, respectively. The inversion of the relative weight of the four major regions (North, Center, LTV, and Alentejo) is pretty obvious. This is largely related to farm size, as small farms can hardly meet spatial isolation measures, but other factors must be taken into account—such as growing of flint-type maize, subsistence agriculture, and low-input farming in North and Center regions—and need further research.

Production Zones

PZs have been previously defined. The first PZs were established in 2007. Table 2 provides a characterization of PZ departing year (2007) and the last year of the quinquenium (2010). Both the area and the number of growers of Bt maize inside PZs have increased since 2007 in North and Center regions.

The striking data appear in the Center region, whose Bt maize area included in PZs reached 2/3 of the total Bt maize area in 2010; this rate was already 52.6% in 2008. The experience of PZs in 2007 and its enlargement in 2008 explain the shoot up in Figure 9 and the peculiar increase in Figure 12 exhibited by this region in 2008. In addition, while in other regions the share of Bt maize growers in the groups of farmers that make the PZ dropped, in the Center region more than 2/3 of the farmers that have gathered in PZs were growing Bt maize in 2010, meaning more than twice the initial proportion.

For the data in Table 2 regarding LTV and Alentejo regions, one needs to bear in mind that PZs must be established annually; therefore, similar areas and number of Bt growers do not necessarily mean the same areas and Bt growers.

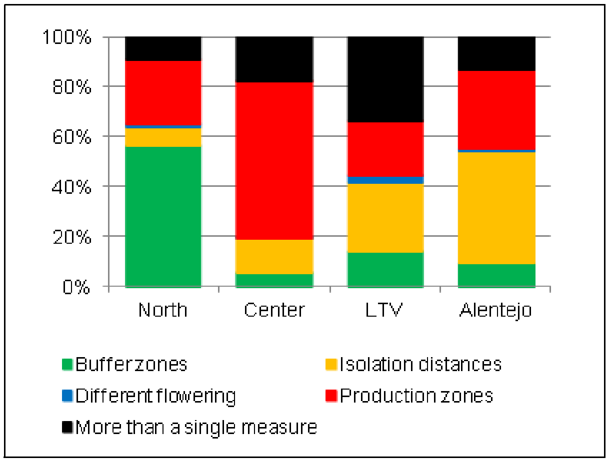

Figure 15. Share of coexistence measures.

Altogether, in 2010 PZs comprised 46.3% of the total Bt maize area, which clearly indicates that farmers find them a good coexistence approach, namely for smallholdings.

Share of All Coexistence Measures

Figure 15 presents the regional share of coexistence measures in the total number of notifications during the quinquennium 2006-2010. These data stress the above mentioned importance of PZs in Center Region. Also, they indicate that the option between buffer zones (border rows) and isolation distances largely depends on farm size, as buffer zones clearly prevail in North Region, where its share is four times the share in LTV, the region that ranks second in the use of this coexistence approach. The proportions of buffer zones to isolation distances have been 8:1 in North, 1:2 in both Center and LTV, and 1:4.4 in Alentejo region.

The coexistence measures that take advantage of the differences in flowering time were scarcely applied as a single measure: 2% in LTV and 1% in North and Alentejo. These results were quite predictable: on the one hand, the decision of date of sowing ultimately

Table 3. Rates of controls and inspections.

Year	2006	2007	2008	2009	2010
Controls/ notifications (%)	68.2	50.0	50.4	44.9	46.1
Controls/Bt maize area (%)	-	58.6	54.6	43.2	51.5

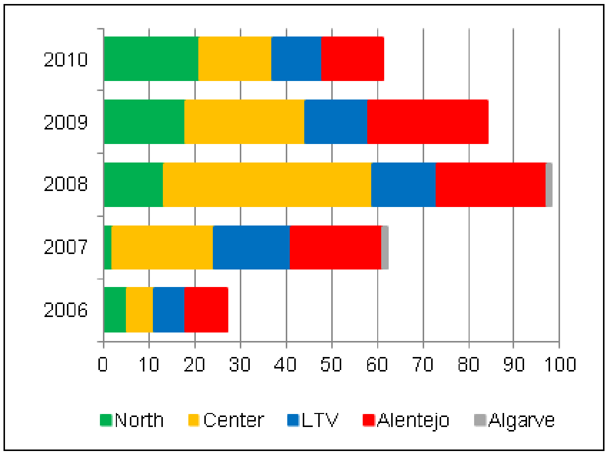

Figure 16. Number of survey respondents.

depends on weather conditions along the sowing season and, on the other hand, it is very unlikely that neighbors decide to grow varieties differing by more than a single FAO class.

It must be stressed that the rates of notifications that indicated more than one coexistence measure are remarkable, varying between 9% in North and 34% in LTV. Buffer zones are actually very common when more than a single measure is used—what might be explained by the need to include refuge zones close to Bt maize crop.

Control and Inspection

Regional agricultural authorities annually controlled and inspected Bt growers. Table 3 provides information about the percentages of control and inspection actions. The results of these actions were quite satisfactory, as noncompliance cases were very rare. Noncompliance situations are described below, as they are good paradigms for the discussion of coexistence.

The inspections led to four suits—one due to late information to neighbors and three due to lack of notification of Bt maize cultivation; however, in all cases isolation measures were in place. In some instances, variations of Bt maize areas—either by excess or default—or substitutions of varieties were observed, but they have all been insignificant. In another case isolation measures were not applied, but a neighbors' agreement was made and the Bt maize grower bought part of his neighbor's production. Finally, on the Spanish border, three Spanish Bt growers holding farms in Portuguese territory and having bought Bt maize seed in their country of origin were not aware of the need of notification, as it is not required in Spain.

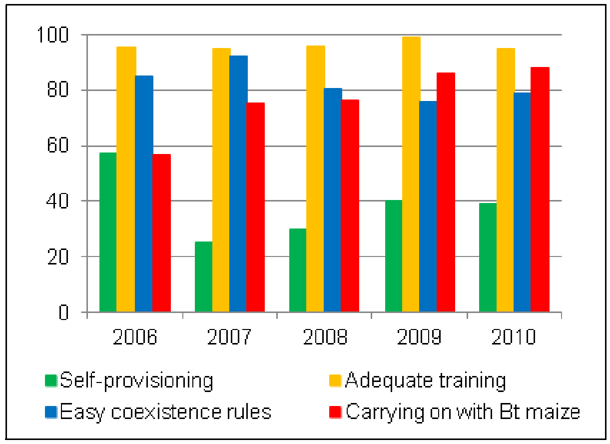

Figure 17. Survey results: Respondents (%).

Surveys

The monitoring program includes a survey to Bt growers. Figure 16 indicates the numbers of respondents by year and region. Social demographic variables (not shown) did not suggest any significant bias associated to Bt maize growers. Figure 17 points out the most important results of the surveys that regard: (i) Bt maize destination, distinguishing between self-provision and market (feed industry); (ii) evaluation of the adequacy of the training for growing of GM crops; (iii) ease of complying with coexistence rules; and (iv) will to carry on with Bt maize. A significant portion of respondents has grown Bt maize for self-provision (actually being the majority in the first year—57%), but since then, most have put Bt maize production on the market. However, in North Region self-provision remained the prevailing destination—at 81% in 2010. Training was considered adequate by 95% or more of the respondents. Those that found coexistence rules easy to comply with were always above 75%, though with obvious differences between regions; in North Region they were considered difficult by 48% of 2010 respondents. Finally the percentage of respondents that declared their decision to continue Bt maize growing consistently increased from 56.8% in 2006 to 88% in 2010.

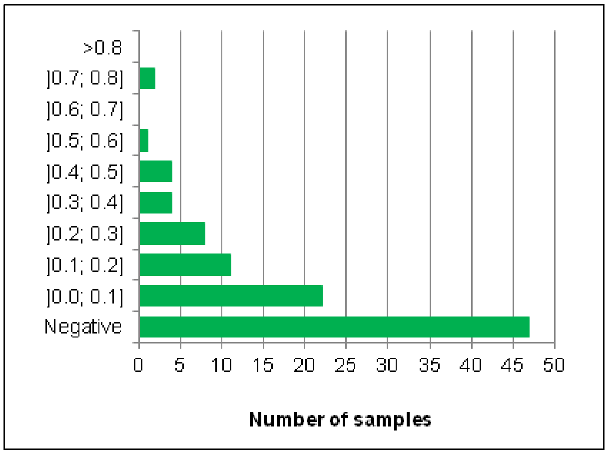

Figure 18. Number of conventional maize samples within each class of MON810 content.

Admixtures in Non-GM Fields

In order to evaluate the efficiency of coexistence measures in preventing admixtures, samples from maize crops around Bt maize crops were collected and analyzed for the presence of MON810 event. When present, the result was expressed as relative transgene copy number. Figure 18 gives a summary of the results of the 99 samples collected along the quinquennium. Forty-seven samples tested negative for the presence of MON810. In 69.7% of the samples, MON810 was less than or equal to 0.1%. Only 3% exhibited a relative transgene copy number larger than 0.5%, but none was above 0.8%. The results suggest that coexistence measures do keep admixture values far below the 0.9% threshold.

GMO-Free Zone and GMO-Free Region

As stated before, the establishment of GMO-free zones has also been regulated, and this has allowed the municipality of Lagos to be declared a GM-free zone. In compliance with the law, this declaration was released by the regional agricultural authority after full agreement of local farmers.

On May 4, 2010, Madeira became the first European GMO-free region; the EU Commission let pass the deadline for opposing the request submitted by the Portuguese following the regional government of Madeira's approval of a law envisaging the prohibition of cultivation of GM crops in the region.

Coexistence Research

Coexistence research in Portugal started in 2002 and has addressed maize pollen flux (Quedas & Andrade e Silva, 2009) and the costs and benefits of growing Bt maize (Skevas, Fevereiro, & Wesseler, 2010).

Concluding Remarks

Portuguese maize growers have so far experienced coexistence as feasible and successful. However, the adoption rate of Bt maize is still low (4%), and, therefore, results must be viewed cautiously.

Production zones make coexistence easier and enable small farms to adopt Bt maize varieties. But maize is a crop that is mainly directed to the feed chain and Portuguese feed industry equally pays for GM and non-GM maize since it labels almost all its production as GMO. Therefore, to be part of a PZ will not be a problem for most non-GM maize growers. However, in some food crops this approach will predictably be less successful. Moreover, policies that positively discriminate non-GM farmers (such as subsidy provisions) can limit the establishment of PZs and lead up to negative discrimination of small farms regarding the adoption of GM crops.

Conservation agriculture—namely, minimum tillage and direct sowing—interests 9% of Portuguese holdings and 24% of UAA. LTV and Alentejo clearly exceed the average; their shares in number of holdings are 20% and 32%, respectively, and in UAA they reach 25% and 37%, respectively (Statistics Portugal, 2011a). Herbicide-tolerant crops and varieties are known to play an important role in the adoption of conservation agriculture. In February 2011, the first herbicide-tolerant maize varieties (carrying the event T25, which confers tolerance to glufosinate ammonium) entered the European Union Common Catalogue of Varieties. This fact will predictably step-up GM maize cultivation and pose new challenges to coexistence and coexistence regulation. For instance, what might be the best equivalent to refuge zones in herbicide-tolerant maize growing: refuge zones or compulsory rotations of either crops or varieties to prevent continual use of the same herbicide?

Monitoring of coexistence has provided an interesting amount of information. But it must be complemented with further research, namely: (i) analysis of population dynamics of target and non-target populations of insects in relation to Bt maize cultivation; (ii) cost-benefit analysis of coexistence across the maize supply chain; and (iii) validation/improvement of gene flow models.

References

Associação Nacional de Produtores de Milho e Sorgo (ANPROMIS [National Association of Producers of Corn and Sorghum]). (2011). *Área de milho (2004-2010)* [Maize area (2004-2010)]. Lisbon, Portugal: Author. Available on the World Wide Web: http://www.anpromis.pt/dados-estatisticos.

Commission of the European Communities (CEC). (2003, July). Commission recommendation of 23 July 2003 on guidelines for the development of national strategies and best practices to ensure the coexistence of genetically modified crops with conventional and organic farming. *Official Journal of the European Communities*, *L189*, 36-47.

CEC. (2009, April). *Report from the Commission to the Council and the European Parliament on the coexistence of genetically modified crops with conventional and organic farming* (Report #COM 2009 153 Final). Brussels: Author.

Direcção Geral de Agricultura e Desenvolvimento Rural (DGADR). (2008a). *Manual de boas práticas de coexistência para a cultura do milho* [Manual of good coexistence practices for maize]. Lisbon, Portugal: Author.

DGADR. (2008b). *Coexistência entre culturas geneticamente modificadas e outros modos de produção agrícola—Relatório de acompanhamento de 2007* [Coexistence of genetically modified crops and other agricultural production methods—Monitoring report of 2007]. Lisbon, Portugal: Author.

DGADR. (2009). *Coexistência entre culturas geneticamente modificadas e outros modos de produção agrícola—Relatório de acompanhamento de 2008* [Coexistence of genetically modified crops and other agricultural production methods—Monitoring report of 2008]. Lisbon, Portugal: Author.

DGADR. (2010). *Coexistência entre culturas geneticamente modificadas e outros modos de produção agrícola—Relatório de acompanhamento de 2009* [Coexistence of genetically modified crops and other agricultural production methods—Monitoring report of 2009]. Lisbon, Portugal: Author.

DGADR. (2011). *Coexistência entre culturas geneticamente modificadas e outros modos de produção agrícola—Relatório de acompanhamento de 2010* [Coexistence of genetically modified crops and other agricultural production methods—Monitoring report of 2010]. Lisbon, Portugal: Author.

Direcção Geral de Protecção das Culturas (DGPC). (2006). *Coexistência entre culturas geneticamente modificadas e outros modos de produção—Relatório de acompanhamento de 2006* [Coexistence of genetically modified crops and other production methods—Monitoring report of 2006]. Oeiras, Portugal: Author.

Eurostat. (2010, October). *Agricultural statistics: Main results 2008-09*. Luxembourg: Eurostat Pocketbooks, Publications Office of the European Union.

Gruère, G.P., & Rao, S.R. (2007). A review of international labeling policies of genetically modified food to evaluate India's proposed rule. *AgBioForum*, *10*(1), 51-64. Available on the World Wide Web: http://www.agbioforum.org.

Quedas, F., & Andrade e Silva, E. (2009, November). *Maize pollen flow in contiguous and non-contiguous field plots*. Paper presented at GMCC-09 Conference on Coexistence, Melbourne, Australia.

Skevas, T., Fevereiro, P., & Wesseler, J. (2010). Coexistence regulations and agriculture production: A case study of five Bt maize. *Ecological Economics*, *69*, 2402-2408.

Statistics Portugal. (2011a). *Estatísticas agrícolas 2010* [Agricultural statistics, 2010]. Lisbon, Portugal: Author.

Statistics Portugal. (2011b). *Recenseamento agrícola 2009—Análise dos principais resultados* [Agriculture census 2009—Analysis of main results]. Lisbon, Portugal: Author.