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Pollen-mediated gene flow in maize in Mallorca: effect of flowering time as a strategy to improve coexistence

J. A. Vives Vallés

Research Group on Plant Biology under Mediterranean Conditions
Departament de Biologia
Universitat de les Illes Balears
juanantonio.vives@uib.eu

J. L. La Paz

GMO analysis Service
Centre de Recerca en Agrigenòmica CSIC-IRTA-UAB (CRAG)
joseluis.lapaz@cragenomica.es

M. Corujo

GMO analysis Service
Centre de Recerca en Agrigenòmica CSIC-IRTA-UAB (CRAG)
maria.corujo@cragenomica.es

A. Martínez Cañellas

Research Group on International Trade and Uniform Law
Departament de Dret Privat
Universitat de les Illes Balears
anselmo.martinez@uib.es

J. Galmés

Research Group on Plant Biology under Mediterranean Conditions
Departament de Biologia
Universitat de les Illes Balears
jeroni.galmes@uib.cat

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Abstract:

The co-existence between GM and non-GM crops is still a major goal of the EU policy. However, in some member states, like Spain, national co-existence strategy is still lacking and regional attempts to regulate this issue have been unfruitful. A previous field study in Mediterranean insular conditions suggested that an isolation distance of 30 m between GM and non-GM maize fields might be sufficient to keep the adventitious presence below the EU threshold of 0.9% (see Vives-Vallés contribution in this congress). Nevertheless, this isolation distance was obtained in an experimental design where cross-fertilization was favored in terms of the synchrony of flowering between GM and non-GM fields. In view of this, we are currently undertaking a field trial to study the effect of flowering de-synchrony on cross-fertilization between MON810 GM and non-GM maize in Mallorca. In particular, our aim is to determine whether the delay in flowering might be an effective strategy to improve coexistence. We expect that the results of this study will be useful for a future regulation on co-existence based on the best scientific data.

Keywords: Corn / co-existence / cross-fertilization / GM-crop-free zones / isolation distances / maize / pollen barriers / pollen flow / thresholds / *Zea mays* L.

JEL codes: I1, K13, K2, K32, K33, L65, L66, O13, Q1.

1. Introduction

Spain is by far the EU member state with the greatest MON 810 maize acreage, concentrating in 2013 approximately 90% of EU total MON 810 cropping area (GMO Compass, 2014). EU regulations demand both actively and implicitly (*e.g.* European Commision, 2003; European Union, 2001, 2003a, 2003b) the need of science-based measures on co-existence between GM and non-GM crops. Numerous studies have been performed on this matter (*e.g.* Della Porta et al., 2008; Ma, Subedi, & Reid, 2004; Messeguer et al., 2006; Riesgo, Areal, Sanvido, & Rodríguez-Cerezo, 2010), however little has been done to stablish a national Spanish regulation on co-existence strategy.

According to the results of the first field trial over cross-fertilization between MON 810 maize and non-GM maize performed in Mediterranean insular conditions in full flowering synchrony, a pollen barrier of 10-30 m is enough to maintain the remaining maize harvest below the threshold of 0.9% (see Vives-Vallés contribution in this congress). In the present contribution, we show the experimental design of three field trials performed during summer 2015 in Palma Bay, one of the main maize cropping area in Mallorca. The aim was to analyze the effect of flowering asynchrony over cross-fertilization in order to determine the need of a pollen barrier and its recommended width.

The results of this field trial serve, along with other maize gene flow studies, as a initial scientific basis for creating future regional regulations on co-existance between GM and non-GM maize.

2. Experimental design

2.1. Field experiment

Field trials were located in a countryside in Palma Bay (Mallorca), without alien maize plantations in more than 1 km in all directions. All source fields sized 45 m long by 45 m width. Recipient fields had the same width as the donors but were longer (343 m long), separated from the donors by a strip of 2 m free of plants. A buffer zone of non-GM maize separated each one of the field trials with a width of 30 m. Buffer non-GM maize was also extended to the North and the East of the countryside (Fig. 1).

Sea breezes (main wind in the area) were favorable to pollen mediated gene flow from each of the donor fields to its correspondent recipient. Seeds of the same growing cycle were used for both donor and recipient fields of the three trials. All donor fields were sown with the same GM seeds, and so the recipients, with non-GM seeds. Buffer zones, donor fields and recipient number 1 were sown on the same day (June 2nd 2015); recipient number 2 was sown two weeks later (June 16th 2015) and recipient number 3 over the previous (June 30th 2015).

Soil preparation, fertilizing, irrigation and other farming practices were homogeneous for all fields (donors and recipients of all three trials), with the exception of seeding rate, which was higher for buffer zones and recipients (88,000 seeds/ha vs. 80,000 seeds/ha for the donors). Higher seeding dose in buffer zones was set in order to promote barrier effect. Rows were parallel to field's length.

2.2. Sampling

See Vives-Vallés contribution in this congress, but in this case have been taken 34 samples instead of 32, as shown in Fig. 2.

2.3. Laboratory analysis

See Vives-Vallés contribution in this congress.

2.4. Statistical analyses

See Vives-Vallés contribution in this congress.

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5. References

Della Porta, G., Ederle, D., Bucchini, L., Prandi, M., Verderio, A., & Pozzi, C., 2008. Maize pollen mediated gene flow in the Po valley (Italy): Source-recipient distance and effect of flowering time. *Eur. J. Agron.* 28(3), 255–265.

European Commision, 2003. 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. *Official Journal of the European Union*, 46(July), 36 – 47.

European Union, 2001. Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC. *Official Journal of the European Communities*, 2000(February), 1–38.

European Union, 2003a. Regulation (EC) No 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed. *Official Journal of the European Union*, 268(October), 1 – 23.

European Union, 2003b. Regulation (EC) No 1830/2003 of the European Parliament and of the Council of 22 September 2003 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. *Official Journal of the European Union*, 268(October), 24 – 28.

GMO Compass, 2014. GM Maize Cultivation in Europe 2013. Retrieved September 4, 2015, from http://www.gmo-compass.org/eng/agri_biotechnology/gmo_planting/392.gm_maize_cultivation_europe_2013.html

Ma, B. L., Subedi, K. D., & Reid, L. M., 2004. Extent of Cross-Fertilization in Maize by Pollen from Neighboring Transgenic Hybrids. *Crop Sci.* 44(4), 1273.

Melas, D., Lavagnini, A., & Sempreviva, A.-M., 2000. An Investigation of the Boundary Layer Dynamics of Sardinia Island under Sea-Breeze Conditions. *J. Appl. Meteorol.* 39(4), 516–524.

Messeguer, J., Peñas, G., Ballester, J., Bas, M., Serra, J., Salvia, J., … Melé, E., 2006. Pollen-mediated gene flow in maize in real situations of coexistence. *Plant Biotechnol. J.* 4(6), 633–45.

Riesgo, L., Areal, F. J., Sanvido, O., & Rodríguez-Cerezo, E., 2010. Distances needed to limit cross-fertilization between GM and conventional maize in Europe. *Nat. Biotechnol.* 28(8), 780–782.

Vives-Vallés, J. A., La Paz, J. L., Corujo, J. & Galmés, J., 2015. Field cross-fertilization between GM and non-GM maize in Mallorca: a Mediterranean insular approach.

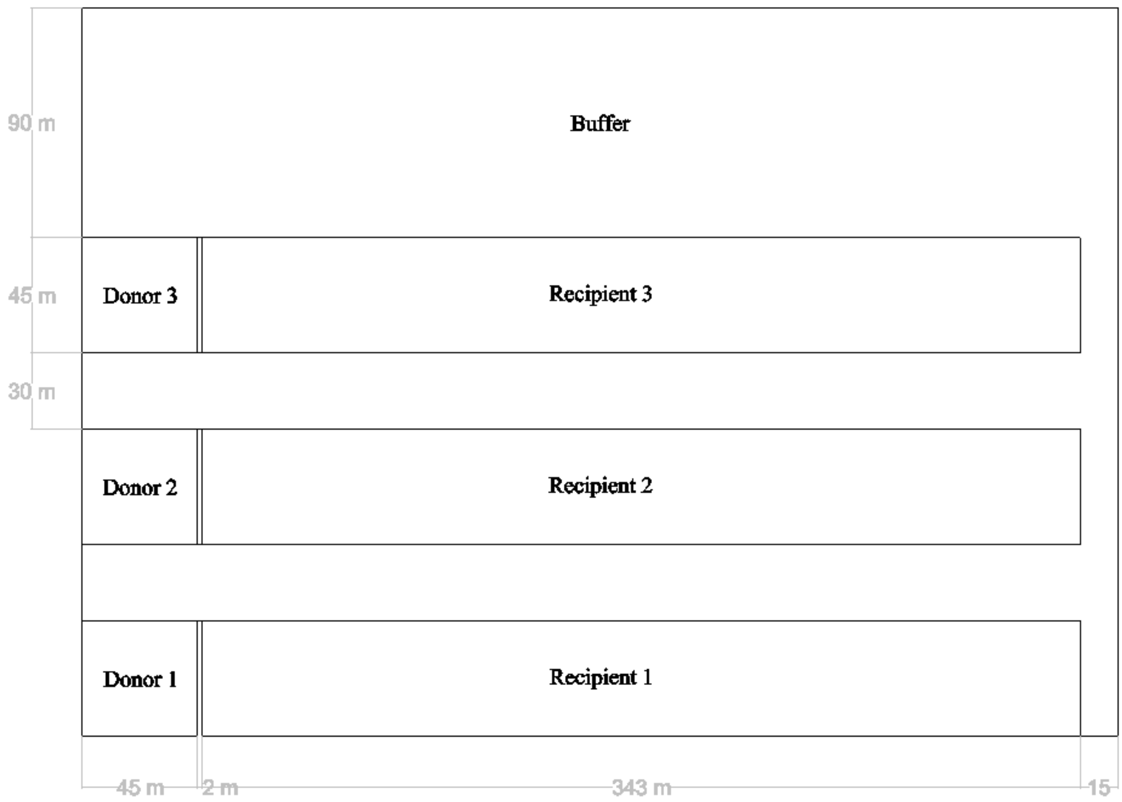

Figure 1. Schematic representation of field trials design. Each one of the experiments consisted of a donor field MON810 GM maize separated by a 2 m strip from its correspondent non-GM maize recipient field. A buffer zone of non-GM maize separated the three field trials. Donor, buffer and recipient fields in field trial number 1 were sown at the same day; in field trial number 2, recipient was sown two weeks after donor fields; in field trial number 3, recipient was sown four weeks after donor fields.

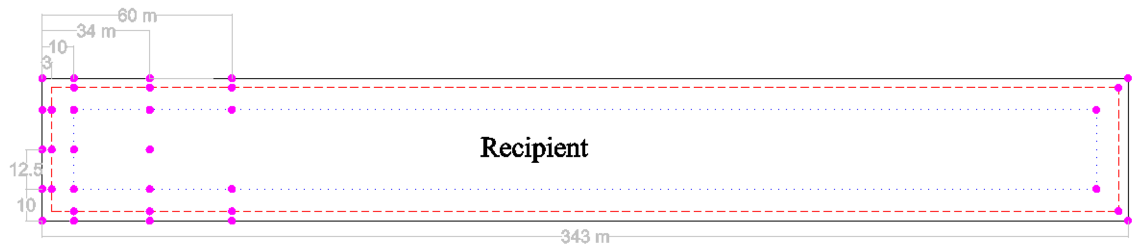

Figure 2. Schematic representation of sampling design in a recipient field (equal for each one of the field trials). 34 samples were taken in each one of the locations within the recipient field. Each sample consisted of three maize cobs randomnly collected in 1 m distance from the spot.