CO-EXISTENCE & TRACEABILITY

GM and non GM supply chains: Their CO-EXistence and TRAceability

SIXTH FRAMEWORK PROGRAMME

Outcomes of Co-Extra

Bio-containment of maize by cytoplasmic male sterility and xenia

Munsch M.[1,2], C. Weider[1], N.K. Christov[3], X. Foueillassar[4], A.Hüsken[5], K.-H. Camp[2], and P. Stamp[1]

1 - ETH-Z, Institute of Plant Science, Switzerland

2 - Delley Seeds and Plants, Switzerland

3 - AgroBioInstitute, Bulgaria

4 – Arvalis, Institut du Végétal, France

5 - Julius Kuehn Institute, Institute for Biosafety of Genetically Modified Plants, Germany.

While the genetically modified (GM) cultivations are spreading all over the world, the question of coexistence between the different farming systems is a main concern in Europe. For GM maize cultivation, the main issue is the release of GM pollen in the environment and the potential fertilization of conventional and/or organic neighboring fields. Beside studies on isolation distances between the fields, another approach for gene flow mitigation consists of the biological containment of the transgene in cytoplasmic male-sterile (CMS) plants. Cytoplasmic male sterility in maize (*Zea maize* L.) is a natural trait due to a dysfunction in the mitochondrial DNA affecting sporogenesis. CMS plants do not produce and release functional pollen. Three major types of male-sterile cytoplasm (T-, C- and S-type) has been defined in maize according to the specific nuclear restorer genes (*rf* genes) that are able to countermand the male sterility and restore fertility. Breeders used this maternally inherited trait since the 1950s to minimize the costs in hybrid seed production. The Plus-hybrid system, i.e. growing suitable mixtures of GM cytoplasmic male-sterile plants (80%) and unrelated non-GM male-fertile plants (20%), the latter acting as pollen donors, is an interesting way for controlling the release of pollen from genetically modified maize. The Plus-hybrid system relies on the fact that the female fertility of CMS plants is not affected, and seeds can be set if vital pollen is provided. One prerequisite is however essential; the male-sterile trait must be reliable under various environmental conditions.

European CMS hybrids are reliable bio-containment tools [1]

Our hypothesis in this study was that one or more environmental factors may influence the expression of the male sterility. Therefore, field investigations were carried out in 2005 and 2006 in the frame of the European project Co-Extra. Twenty modern CMS hybrids from different European breeding companies representing all three cytoplasm types were tested in 17 environments in Switzerland, Bulgaria, Germany and in France. Stable and unstable male-sterility occurred in all three

CMS types. The reversion to fertility was due to an interaction between genetic (presence of minor *rf* genes) and climatic (air temperature, photoperiod and water vapor) factors. CMS-T was identified as the most stable type of male-sterile cytoplasm; nevertheless, due to its susceptibility to the fungi *Bipolaris maydis*, its use may be limited to the growth of small-scaled transgenic fields, e.g. molecular farming. While CMS-S was often subject to restoration of fertility, the C type of male sterility was similar to the T type with regard to maintaining the male sterility and could be applied in a larger scale for the growth of e.g. *Bt*-maize (in mixture with non-transgenic male-fertile plants). Even in situations, where the male-fertile component of the Plus-Hybrid needs to be genetically modified too (e.g. herbicide tolerant trait), such a cultivation system can reduce the release of transgenic pollen by 80% compared to a regular GM maize stand, where 100% of the hybrids release transgenic pollen.

Maize Plus-Hybrids increase grain yield [2, 3]

Beside their potential as a bio-containment tool, maize Plus-Hybrids combine benefits of male sterility (CMS effect) and allo-pollination (xenia effect) regarding the grain yield. They often outperform the corresponding male-fertile sib-pollinated hybrids. The potential gain in yield afforded by modern European Plus-Hybrid was investigated in a preliminary field trial in 2005 (3 locations in Switzerland) and in a European ring trial in 2006 and 2007 (12 locations in Switzerland, Bulgaria, Germany and in France). Many Plus-Hybrids increased grain yield, on average, by 10% or more and by up to 20% in specific environments. The Plus-Hybrid effect affected both yield components, CMS leading mainly to a higher number of kernels and the xenia effect mainly to an increase in the thousand kernel weight. While the CMS effect depended strongly on the environment, the xenia was consistent in all environments but its extent varied.

Cytoplasmic male sterility is an elegant way to minimize or even eliminate the problem of GM pollen flow of adjacent conventional or organic fields if stable T- and C-cytoplasm is used. The Plus-Hybrid system would be a useful tool to achieve an agricultural bio-containment system. For this system, a high level of male sterility must be maintained, as shown by this study. Furthermore, appropriate combinations of CMS hybrids and fertile pollinators can lead to a significant gain in yield that would definitely boost the acceptance of a bio-containment system with cytoplasmic male sterility.

References:

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