Is returning to non-GM rapeseed varieties doomed to fail?

Antoine Messéan[1], Christophe Sausse[2], Jacques Gasquez[3], Henri Darmency[3]

[1] Present address: Eco-Innov, INRA, 78850, Thiverval-Grignon, France) Email: messean@grignon.inra.fr
[2]CETIOM, Centre de Grignon BP 4, 78850 Thiverval Grignon,
[3] UMR BGA, INRA-ENESAD-UB, BP 86510, 21065 Dijon, France E-mail: darmency@dijon.inra.fr

Abstract

Is returning to a conventional crop possible after growing a genetically modified (GM) variety? Here we show that the rate of GM seeds admixture in the harvest of a conventional oilseed rape variety grown on the same field five years later can largely overstep the European threshold and varies considerably according to the varieties used. It is the responsibility of seed breeders and farmers to determine and use appropriate varieties and field management in order to prevent seed admixture.

Key words: Transgenic crop, seed persistence, volunteer, seed admixture, co-existence, *Brassica napus*

Introduction

European regulations have introduced a 0.9% labeling threshold for the adventitious presence of GM material in non-GM products. For instance, the 0.9 % threshold for oilseed rape could be shared out into 0.3 % for seed purity, 0.3 % for field events including pollen flow among GM and non-GM fields, and volunteers, and 0.3 % for fortuitous mixture during transportation of harvest, storage and transformation processes. Most of the studies carried out on the feasibility of complying with such threshold at the field level focused solely on the coexistence regulations that would make it possible for farmers to grow non-GM crops side by side with GM crops (Messéan et al., 2006). We address here the question of the reversibility of the GM system, which is the possibility to grow a conventional non-GM crop several years after growing a GM crop in the same field while complying with the labeling threshold. It is a matter of freedom for farmers who could found more interest and more returns in growing conventional non-GM on some years or turn to organic crops. So the question is to determine how many years after a GM oilseed rape, and under which conditions, is growing non-GM oilseed rape possible? Admixture of GM seeds in the harvest of a conventional variety depends on the quantity of GM seed shed onto the soil during the harvest of previous GM varieties, the tillage system that buried the seed in the soil, and the seed survival and capability of germination on the following years. This is what ultimately determines the frequency of volunteer plants growing together and harvested in mixture with the sowed crop (Lutman et al., 2005).

Materials and Methods

Exploring experiments and models have been conducted in the case of oilseed rape (Colbach et al., 2001; Pekrun et al., 2005), but they still need to be confirmed with various set of data from the field. The farm-scale studies set up in 1995 in France provide such data. This series of experiments aimed to reflect conventional production systems under the supervision of Institutes CETIOM, AGPM, ITB and INRA (Champolivier et al., 1999). Platforms in Dijon (northeast of France) and Toulouse (south of France) consisted of several one ha fields rotating with GM oilseed rape (OSR), beet or sunflower, conventional wheat and set-aside. There were three herbicide resistant OSR varieties provided by industrial partners: resistant to ioxynils (Rhone Poulenc), glufosinate (Agrevo) and glyphosate (Monsanto). Because these varieties were not commercial materials but experimental lines, we called them thereafter varieties A, B and C, irrespective of the order.

After the harvest of the GM varieties, a rough counting of volunteers growing in the field was carried out, then the field was tilled (at Dijon) or not (at Toulouse) according to regional farming practices. After three to eight years of rotation, a conventional OSR variety was grown on the same field. Several seed samples collected from the harvest were sown in the greenhouse and seedlings were scored for resistance (dead versus alive) after two herbicide spray at two-three weeks interval.

Results and Discussion

The results obtained in the 2002 harvest at Toulouse sum up the situations that occurred at the various platforms over the years (Table 1). We never found seeds belonging to GM varieties A and B grown in 1997 at a higher rate than the 0.9% threshold in the harvest of the conventional OSR grown five years later. In contrast, fields where the C variety was grown five years prior showed 4 to 18 % of the harvest consisting in GM C seeds. Thus, this harvest cannot be marketed as conventional OSR. In fields where a semi-dwarf conventional variety was grown, the contribution of the volunteers of all the varieties increased, and especially the C variety that exploded to more than 18% of the total harvest. Such a larger seed output by volunteers was certainly due to a low competition exerted by the semi-dwarf variety against volunteers, therefore allowing more seed production by volunteers because the grain yield of the conventional and the semi-dwarf varieties were similar.

Further results to be reported in a detailed paper confirm that seed mixture can still be observed in the harvest of the conventional variety eight years after growing the transgenic OSR. Some cases observed after variety A also bordered the labeling threshold (Figure 1). Therefore, some GM varieties could have the genetic capacity to be more or less prone to loose seeds at harvest, have dormant seeds, survive in the soil and grow as volunteers in a subsequent OSR such as to contribute significantly to the harvest. This capacity could be more or less expressed according to weather conditions and the habitat, this later being determined by the density and competition of the hosting variety.

Table 1: Percentage of GM seeds found in the harvest of a conventional non-GM and a semi-dwarf non-GM variety grown at Toulouse in 2002, five years after a GM variety in the same field, and belonging to that GM variety or originating from adjacent fields (exogenous GM seeds).

GM variety	Harvested non-GM variety	Percentage of GM seeds	Percentage of exogenous GM seeds
A	Conventional	0.0	0.5
A	Semi-dwarf	0.7	0.2
B	Conventional	0.0	0.2
B	Semi-dwarf	0.1	0.3
C	Conventional	4.1	0.0
C	Semi-dwarf	18.7	0.0

In contrast, no exogenous GM seeds originated from adjacent fields in the case of the C variety, while varieties A and B permitted the migration of transgenes from outside the field. Seed migration was mainly independent of the variety but due to farming practices. In some instances, the C variety flowered earlier and was harvested first, thus allowing movement of seeds to next fields through harvesting machines. Pollen migration could also occur among fields: its impact on transgene flow depends on the selfing versus outcrossing ratio, which is a characteristic of the variety.

Finally, the amount of volunteers occurring post GM-harvest was not related to the final admixture percentage (Figure 1). It could be assumed that the amount of volunteer growing in the field after the harvest is probably roughly proportional to the total seed loss, which again is a characteristic of the variety. However, one could object that the soil seed bank is immediately deprived of this amount of germinating seeds, and that numerous events could occur after the seed were buried in the soil, so that it is not clear if post harvest emergence of volunteers could be an efficient predictor of future occurrence of volunteers in further OSR.

Conclusion

These results show two main findings. One, if the farmer grows conventional OSR five years after a GM variety, the presence of transgenic seeds in the conventional OSR harvest is highly variable and can occur at rate as high as 18 %, far above the European threshold. The 0.9% threshold was overstepped in 6 over the 14 cases recorded in Figure 1. Unless appropriate management is implemented, it will indeed be hazardous for a farmer to go back to a conventional non-GM farming system, even five years after the last transgenic OSR harvest. Seed breeders already face this situation as the farmers producing OSR certified seeds are not coming back to the same field before six years in order to avoid mixture of varieties, and in addition, they use appropriate farming systems promoting the germination and eradication of Brassica seeds meantime.

Second, the choice of both the GM variety and conventional variety is of the highest importance and offers a reliable way to prevent exceeding the threshold. On the one hand, seed breeders should avoid using transgenic varieties with early and high seed shedding, easy development of secondary seed dormancy, and long seed survival in the soil (Lutman et al., 2003). On the other hand, the year the farmer converts back to non-GM OSR, he should choose a highly competitive variety suitable to overcome the growth of volunteers (Fargue et al., 2004). There are actually different types of OSR with different growth characteristics: conventional offspring, hybrid varieties, composite varieties containing mixtures of male sterile and fertile plants, and dwarf varieties. He must also follow the agronomical guidelines to manage volunteers (Lutman et al., 2005), for instance delaying the date of tilling after the GM harvest in order to prevent the induction of secondary dormancy, awaiting for the emergence of seedlings from the shed seeds and destroy them, and controlling every year OSR volunteers in the other crops.

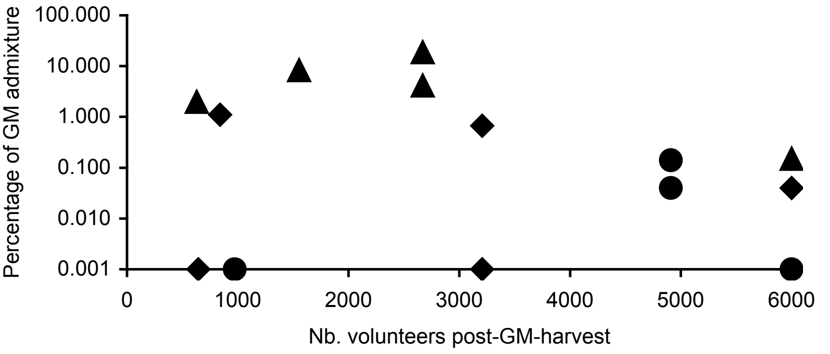

Figure 1: Lack of relationship between the abundance of post-harvest GM volunteers of varieties A (diamond), B (circle) and C (triangle), and GM admixture in the harvest of the conventional OSR grown 3 to 8 years later.

References

Champolivier, J., Gasquez, J., Messéan, A., Richard-Molard, M., 1999. Management of transgenic crops within the cropping system. in Gene flow and agriculture (eds Lutman P.J.W.) 233-240 (BCPC, Farnham, 1999).

Colbach, N., Clermont-Dauphin, C., Meynard, J.M., 2001. 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. Agric. Ecosyst. Environ. 83, 235-253. Agric. Ecosyst. Environ. 83, 235-253.

Fargue, A., Meynard, J.M., Colbach, N., Vallée, P., Grandeau, G., Renard, M., 2004. Contamination of rapeseed harvest by volunteers of other varieties : a study of intergenotypic competition. Europ. J. Agro. 21, 193-207.

Lutman, P.J.W., Freeman, S.E., Pekrun, C., 2003. The long-term persistence of seeds of oilseed rape (*Brassica napus*) in arable fields. J. Agric. Sci. 141, 231-240.

Lutman, P.J.W., Berry, K., Payne, R.W., Simpson, E., Sweet, J.B., Champion, G.T., May, M.J., Wightman, P., Walker, K., Lainsbury, M., 2005. Persistence of seeds from crops of conventional and herbicide tolerant oilseed rape (*Brassica napus*). Proc. R. Soc. B 272, 1909-1915.

Messéan, A., Angevin, F., Gómez-Barbero, M., Menrad, K., Rodríguez-Cerezo, M., 2006. New cases studies on the coexistence of GM and non-GM crops in European agriculture. Technical Report EUR 22102 EN, Eur. Com., pp116.

Pekrun, C., Lane, P.W., Lutman, P.W.J., 2005. Modelling seedbank dynamics of volunteer oilseed rape (*Brassica napus*). Agric. Syst. 84, 1-20.