



Department of  
**Agriculture, Fisheries and Food**  
An Roinn  
**Talmhaíochta, Iascaigh agus Bia**

**Research Stimulus Fund**

**Final Report**

Coexistence of GM and non-GM crops: modelling the effects of cropping systems on gene flow from herbicide tolerant oilseed rape.

**DAFF Project Ref No:** 06 342

**Start date:** 02/10/06

**End date:** 26/09/08 (extended to 25/02/09)

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Dr. Nathalie Colbach, INRA Dijon, France

**Please tick below the appropriate area on the research continuum where you feel this project fits**

BASIC/FUNDAMENTAL                       $\longrightarrow$                       APPLIED/PRE COMMERCIAL

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**Key words:** Coexistence, oilseed rape, genetically modified, herbicide tolerant

## **1. Rationale for Undertaking the Research**

In 2003, the European Commission established the principle of coexistence, which refers to the “ability of farmers to make a practical choice between conventional, organic and GM-crop production, in compliance with the legal obligations for labelling and/or purity standards” and devised guidelines to assist member states in producing national specific measures<sup>1</sup>. In effect, coexistence underpins the right of farmers to cultivate freely the crops they choose. A strategy for the coexistence of GM and conventional/organic crops in Ireland was published in 2005 but recommendations for the cultivation of GM oilseed rape were intentionally omitted from the report; *“due to a lack of Irish-specific research on the propensity and consequence of gene flow from GM oilseed rape cultivated fields”*. The goal of this 2 year desk-top study was to address this knowledge gap, by developing coexistence-specific production measures for the cultivation of GM herbicide tolerant (HT) oilseed rape that are both agronomically sustainable and economically viable. Therefore assisting potential early adopters of GM oilseed rape and supporting policy makers in devising recommendations for the cultivation of GM oilseed rape in Ireland. The relevance of this approach is real as the EU approval process for GM crop cultivation grants that if cultivation is granted for one member state and that GM line is placed on the EU common catalogue, Irish farmers will be able to purchase seed for cultivation, thereby highlighting the need generate an Irish-specific policy for the coexistence of GM and non-GM oilseed rape, prior to the potential EU-wide commercialisation of GM oilseed rape.

## **2. Research Approach**

The project did not require the cultivation of GM oilseed rape. Rather, a computer simulation (‘GeneSys’) was utilised to model the potential of crop practises to minimise gene flow from GMHT oilseed rape cultivated fields. GeneSys has been developed to forecast the effects both in time and in space, of cropping systems and of rapeseed varieties on gene flow from oilseed rape crops to oilseed rape volunteers (Colbach et al 2001a,b). Suitable for both seed and crop production, the model has been employed to design coexistence-compliant GM oilseed rape systems in Denmark (Ostergard & Colbach 2005), France (Colbach et al 2004a; Colbach et al 2005) and was the basis of two reports commissioned by the Joint Research Centre of the European Commission (Bock et al 2002; Messean et al 2006). At a practical level, utilising GeneSys avoids the financial cost, logistical challenges and regulatory constraints associated with GM field trials. In addition, the flexibility afforded by GeneSys permits the user to alter individual processes (e.g. variety height, male sterility, varying soil tillage practises) during the

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<sup>1</sup> Commission Recommendation of 23<sup>rd</sup> July 2003  
([http://ec.europa.eu/agriculture/publi/reports/coexistence2/guide\\_en.pdf](http://ec.europa.eu/agriculture/publi/reports/coexistence2/guide_en.pdf))

simulation. Hence, providing a way to use additional experimentation at the process level to draw conclusions about the overall system (Messean et al 2006).

The economic analysis of modified cropping systems was similar in nature to the risk assessments conducted in an Irish context for a number of other potential GM crops including: herbicide tolerant sugar beet, *Septoria* resistant winter wheat, *Fusarium* resistant winter wheat, *Rhynchosporium* resistant spring barley and blight resistant potatoes (Flannery et al 2005b); Thorne *et al.*, 2005). Furthermore, utilising the Teagasc National Farm Survey, an adoption factor profile analysis was conducted to inform the debate regarding possible adoption rates of GM technology into the Irish tillage industry.

### **3. Research Achievements**

Each of the original project objectives from both sub-project 1 and 2 have been achieved. For sub-project 1, the rate of gene flow that would be expected from GMHT oilseed rape cultivated fields if they were integrated into existing cropping regimes was quantified. It was clear from the initial simulations that if farmers were to adopt GMHT oilseed rape without specific guidelines, that any attempts to maintain an effective segregation of GM and non-GM oilseed rape crops would not be possible. Following on from this, novel crop practises were designed to ensure that efficient coexistence can be achieved. These include modifications to the standard crop rotations, introduction of more stringent volunteer control and the organisation of GM cropping into GM zones of production ('GM clusters'). This presents an additional approach that will provide early adopters with the security of achieving coexistence with minimal effort while using the otherwise inefficient standard rotation of oilseed rape followed by three winter wheat crops. By 'grouping' their GMHT fields adjacent to each other and including a 50m separation distance from the cluster to adjacent conventional oilseed rape sites, this novel approach for tillage systems will reduce the potential spread of harvested seed and pollen at a landscape level. In effect, this will result in de-facto GM cooperatives which will allow adopters to collectively decide which fields are sown with GM seed in any given year based on each other's rotation strategies; further minimising the potential for GM admixture in non-GM oilseed rape crops. Clustering will also facilitate the sharing of machinery; the inspection of GMHT fields by DAFF and critically does not present any additional costs to the early adopters. It should also alleviate the concerns of neighbouring farmers growing conventional oilseed rape as this approach presents a robust method of preserving the genetic integrity of adjacent non-GM oilseed rape crops.

For sub-project 02, a comprehensive review of literature regarding the costs and benefits arising from the adoption of GM herbicide tolerant (HT) oilseed rape was undertaken. This provided the necessary knowledge base to complete the baseline cost/benefit model datasets from the 2006/7 Teagasc Farm Management Data Handbook and Teagasc Crop Costs and Returns Data. The results from the baseline model illustrate the potential for significant economic benefits for Irish winter oilseed rape producers if they choose to adopt GMHT technology and that the crop has the potential to outperform its conventional equivalent. A separate analysis of each of the crop management regimes designed through the Genesys

modelling indicated that the annualised net present value (ANPV) for scenario 1 (OSR/WW/WW/WW) is larger than the rotation which includes spring barley but significantly both ANPVs are greater than zero. Therefore, a rotation using spring barley in years 3 and 4 of the rotation interval is plausible, and also a profitable method of making coexistence a feasible prospect for Irish farmers.

The results of the probit model designed to determine the likelihood of a farmer adopting GM technology were collated as described in the original proposal. In short, the results demonstrated that both farm and farmer specific characteristics are important in the adoption process. Farm size had a significant and positive effect on the decision to adopt indicating that larger farmers are more likely to consider adoption of new GM technology than smaller farmers. None of the land tenure variables, representing the proportion of land owned or whether the farmer rented additional acreage, had any significance in the model once farm size was accounted for. The agricultural education level of the farmer was a highly significant variable and indicated that farm operators with higher levels of agricultural education are more receptive to new ideas and more willing to investigate alternative farming systems such as the adoption of GM crops. The marginal effects indicated that a one unit change in the agricultural education variable means that farmers who have completed formal agricultural education are 13% more likely to grow GM crops than those who have not, all other things being equal.

#### **4. Impact of the Research**

The completed work has addressed a specific knowledge deficit as previously highlighted by policy makers. By developing regimes to ensure the efficient coexistence of GM and non-GM oilseed rape and evaluating the economic viability of the aforementioned regimes the project has:

- increased understanding of the gene flow process as it relates to GMHT oilseed rape cultivation from an Irish context
- provided the necessary datasets to policy makers to assist them in making informed decisions on coexistence
- increased collaboration amongst a core group of Irish researchers and forged new collaborations with European colleagues (INRA Dijon).
- provided several deliverables which have been disseminated at both national and international conferences/meetings, raising the profile and reputation of Irish GM-based research.
- Produced farmer-friendly guidelines that will be made available on the project's website [www.gmoInfo.ie](http://www.gmoInfo.ie), once they have been accepted for publication in a relevant scientific journal (data is currently being prepared for submission to the European Journal of Agronomy).

## 5. Exploitation of the Research

The research completed in this project is of a 'public good' nature. As such it will deliver a direct economic benefit to the tillage sector should GM oilseed rape be authorised for cultivation in Ireland in the near future by providing adopters with the confidence to farm in a coexistence-based regime. While the research has not delivered patents or intellectual property it has generated an Irish-specific dataset which can be exploited by the tillage sector in deciding whether to adopt GM technology in oilseed rape.

## 6. Summary of Research Outputs

- (a) Intellectual Property applications/licences/patents
  - Not applicable to this research project
- (b) Innovations adopted by industry
  - Not applicable to this research project
- (c) Number of companies in receipt of information
  - Not applicable to this research project
- (d) Outcomes with economic potential
  - A designated suite of Irish-specific crop guidelines have been developed and their economic viability assessed. This information will underpin the decision making process of early adopters of GM oilseed rape.
- (e) Outcomes with national/ policy/social/environmental potential
  - The GENESYS simulations from sub-project 01 along with the accompanying economic cost-benefit analysis of sub-project 02 mean that an optimal strategy to facilitate the coexistence of GMHT oilseed rape has now been prepared. This fulfils a direct request by policy makers for Irish-specific research and will complement the existing National Coexistence Strategy.
- (f) Peer-reviewed publications, International Journal/Book chapters.
  1. Keelan, C., Thorne, F., Flanagan, P., Newman, C. and Mullins, E. (2009). *Willingness to Adopt GM Technology at Farm Level*. AgBioForum, The Journal of Agrobiotechnology Management and Economics (in press).
  2. Tricault, Y., Flanagan, P., Fealy, R., Colbach, N. and Mullins E. (2009). *Towards an optimal management regime to facilitate the coexistence of GM and non-GM oilseed rape*. Submitted to European Journal of Agronomy for peer-review.
- (g) Scientific abstracts or articles including those presented at conferences
  1. Thorne, F., Keelan, C. and Mullins, E. (2009). *The cost effectiveness of the coexistence of GMHT oilseed rape in Ireland: an analysis of crop management strategies*. Co-Extra International Conference, Paris, June 2<sup>nd</sup>-5<sup>th</sup>.
  2. Mullins, E., Tricault, Y., Colbach, N., Flanagan, P. and Fealy, R. (2009). *Towards an optimal management strategy for the coexistence of GM and non-GM HT oilseed rape in Ireland*. Co-Extra International Conference, Paris, June 2<sup>nd</sup>-5<sup>th</sup>.

3. Mullins, E. (2008). *Assessing the potential impact of GM crops for Ireland*. Presentation by Ewen Mullins at the Agricultural Biotechnology International Conference, University College Cork, August 23<sup>rd</sup>-26<sup>th</sup>.
  4. Mullins, E., Flanagan, P., Fealy, R., Tricault, Y. and Colbach, N (2008). *Developing strategies to facilitate the coexistence of GM and non-GM oilseed rape crops on an Irish landscape*. GMLS, International conference on Implications of GM crop cultivation at large spatial scales, University of Bremen, April 2<sup>nd</sup> – 4<sup>th</sup>
  5. Keelan, C., Thorne, F. and Mullins, E (2007). *The Coexistence of GMHT Oilseed Rape in Irish agriculture*. 3<sup>rd</sup> International conference on coexistence between GM and non-GM based agricultural supply chains, Seville, November 20<sup>th</sup>-21<sup>st</sup>
  6. Mullins, E., Hanrahan, K., Thorne, F. (2007). *The economic implications of a ban on imported GM feed ingredients for the livestock sector in Ireland*. 3<sup>rd</sup> International conference on coexistence between GM and non-GM based agricultural supply chains, Seville, November 20<sup>th</sup>-21<sup>st</sup>.
  7. Mullins E. (2007). *Using in planta transformation to deliver genes into novel crops (e.g. oilseed rape) and how this can facilitate co-existence based research*. Presentation at the Plant Transformation Conference in Vienna, Austria, February 4<sup>th</sup> - 7<sup>th</sup>.
  8. Mullins, E. (2008). *Modelling the consequences of temporal and spatial gene flow from coexisting GM and non-GM oilseed rape fields at a landscape level*. Irish Plant Scientists Association Meeting, NUIM, March 27<sup>th</sup>.
  9. Keelan, C. (2008). Adoption of GM Technology at Farm Level. *The Rural Economy Research Centre Working Paper Series Working Paper 08-WP-RE-10*.
  10. Keelan, C., Mullins, E. and Thorne, F. (2008). *The coexistence of GMHT oilseed Rape in Irish Agriculture* Agricultural Research Forum, Tullamore, March 14-15<sup>th</sup>.
- (h) National Report
1. The conclusions will be used to supplement an existing National Policy Report on the coexistence of GM and non-GM crops in Ireland.
- (i) Popular non-scientific publications
1. All datasets will be disseminated through [www.gmoInfo.ie](http://www.gmoInfo.ie) following the completion of the peer review process.
- (j) Workshops/seminars/ open days at which results were presented (excluding those in (g))
1. Mullins, E. (2007). Presentation to DAFF's Organic Marketing Development Group on GM crops suited to Irish agri-environment. Tullamore, January 16<sup>th</sup>.
  2. Mullins, E. (2007). Presentation to Strategic Committee for the Environment of Wicklow County Council on the potential impact of GM crops. January 17<sup>th</sup>.
  3. Mullins, E. (2006). Presentation to the European Parliament's Committee on Agriculture and Rural Development. Public Hearing on Coexistence: National Approaches and Public Perceptions, Brussels, Belgium, October 10<sup>th</sup>

## 7. Permanent Researchers

Institution Name	Number of Permanent staff contributing to project	Total Time contribution (months)	Average time contribution per permanent staff member
Teagasc Oak Park	2 E. Mullins R. Hackett	9.636	4.818
Teagasc RERC	2 F. Thorne J. Breen	2.952	1.476
<b>Total</b>	<b>4</b>	<b>12.588</b>	<b>6.294</b>

## 8. Researchers Funded by RSF

Type of Researcher	Number	Total Time contribution (months)	Average time
Post Doctorates			
Contract Researchers	1	24	24
PhD postgraduates			
Masters postgraduates			
Temporary researcher	1	4.4952	2.2476
Other			
<b>Total</b>	<b>2</b>	<b>28.4952</b>	<b>14.2476</b>

## 9. Postgraduate Research

Total Number of PhD theses:   0  

Please include authors, institutions and titles of theses and submission dates. If not submitted please give the anticipated submission date

Total Number of Masters theses:   0

## 10. Project Expenditure

Total expenditure of the project: € 165,377.57

Total Award by RSF € 169,301.00

Other sources of funding (specify) € 0

Not applicable to this project

### Breakdown of Total Expenditure

Category	Teagasc Oak Park Institution 1	RERC Institution 2	Name Institution 3	Name Institution 4	Total
Contract staff		97,940.00			
Temporary staff	11,587.33				
Post doctorates					
Post graduates					
Consumables	59.49				
Travel and subsistence	8,595.25	9,212.00			
Sub total	20,242.07	107,152.00			
Durable equipment					
Other	6,135.00				
Overheads	5,060.50	26,788.00			
<b>Total</b>	<b>31,437.57</b>	<b>133,940.00</b>			

## 11. Future Strategies

The construction of an Irish relevant Genesys model is dynamic resource for the Teagasc risk assessment research programme. Now that it has been created it will be available for follow up simulations which are likely to be required once GMHT oilseed rape cultivation commences. In the interim, additional simulations are to be completed to examine the GM clustering phenomenon in more detail, specifically at the higher rates of adoption of 15% and 30%. To ensure that the tillage sector is aware of the outcomes of the project, non-scientific articles will be prepared for the popular press once the first GM oilseed rape line is authorised. In addition, the Teagasc Advisory service will be briefed on the outcomes of the project so that they can disseminate the crop-specific guidelines to all interested parties.

**12. Industry Collaboration**

Not applicable for this research. All collaboration has been with INRA Dijon.