Persistence of GM herbicide-tolerant plants

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Background and purpose The programme's science in whole plants, communities and fragmented populations has in recent years been used to solve several problems of land use and agricultural policy. An important question being investigated concerns the impurities that one type of crop might introduce to another, particularly if one is a GM crop. A GM trait has possible implications for agronomy, ecology, marketability, policy and public interest. It is also relatively easy to trace in and around experimental fields and is useful for getting basic information on mechanisms of survival, spread, success or failure of new organisms in the habitat. Studying the persistence of GM traits needs expertise in a range of specialisms, but without a fundamental knowledge of plants and their environment, such questions of a practical nature could not be answered.

Origin and dynamics GM material in the UK originates from experimental plots or fields of oilseed rape or occasionally from impurities in imported non-GM seed. GM plants have to face the challenges to existence that all plants face in the competitive environment of an arable landscape. At harvest, some seed drops to the ground, where much of it is eaten by animals, attacked by fungi or killed by drought or frost. Any survivors entering dormancy remain in the soil until they die or receive signals to make them germinate or emerge, when they compete with weeds and crops. If in flower, they may receive pollen from other oilseed rape, so their offspring become 'diluted', or they may donate pollen to other plants. Our findings show there is little ecological effect of this GM seed, unless it becomes advantaged by circumstances – for instance, if herbicide tolerant plants are sprayed with the herbicide to which they are tolerant. Agronomic or economic problems may arise from the buried seed that emerges in later oilseed rape as volunteer plants, or gets moved around the country in machinery. Under present regulations, a grower will be unable to market a crop as non-GM if it contains GM seed above a specified threshold, either 0.5% or 0.9% depending on circumstances. We have said before that it will be difficult, but by no means impossible, to manage oilseed rape volunteers so as to be certain of keeping the presence of GM below such a threshold in a field that has recently grown a GM crop of oilseed rape. We are now examining fields to estimate the percentage presence of GM in soil, crop and yield, and to find which factors of the environment, genetics and agronomy can be manipulated so that impurities remain below a threshold.

Figure 1 Section of field (9 x 9 m) following glyphosate spray showing clumped arrangement of surviving oilseed rape individuals (symbols) and dead, dense weed vegetation (shading).

Detection and estimation Detecting presence, or estimating percentage presence, faces difficulties of sampling and diagnostics. Many samples need to be taken from a range of locations in a field in order to 'capture' the distribution in space of the GM and non-GM populations. Volunteers are likely to be highly clumped (aggregated), especially if they came from GM plants which themselves arose as impurities in an otherwise non-GM field. In an example in Fig. 1, volunteers tolerant to the herbicide glyphosate were identified because they survived when glyphosate was sprayed on the field. They probably arose as impurities in non-GM seed sown the previous year. Most of the individuals were arranged in two clumps, each possibly originating from seed shed by single GM plants at the previous year's harvest. Statistical methods exist to account for such clumpiness, but the more clumped the distribution, the more samples have to be taken and processed to estimate the percentage impurity.

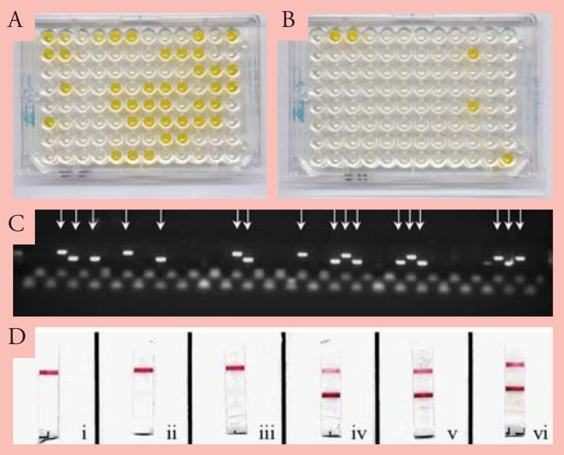
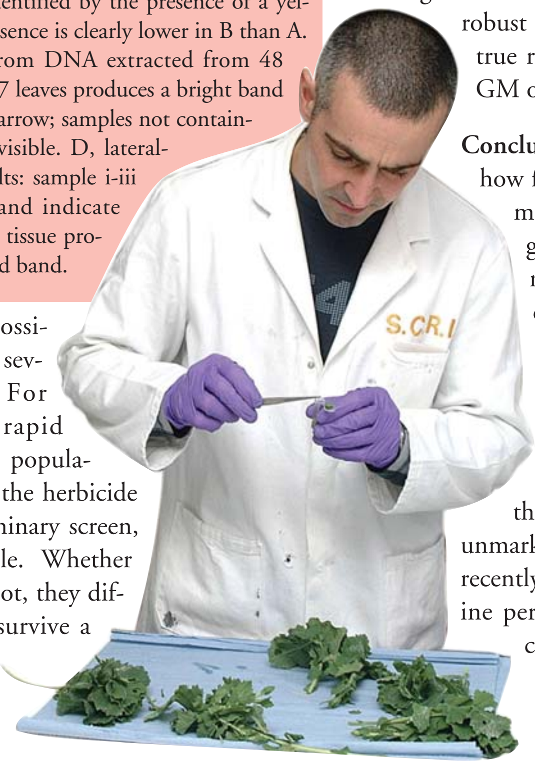


Figure 2 Examples of detection methods for GM herbicide tolerance in oilseed rape. A and B show ELISA results for leaf tissue, 96 leaf samples having been tested in each plate, GM individuals identified by the presence of a yellow colour; note GM presence is clearly lower in B than A. C shows PCR results from DNA extracted from 48 leaves; GM presence in 17 leaves produces a bright band and is indicated with an arrow; samples not containing GM material are invisible. D, lateral-flow (dip-stick) test results: sample i-iii showing a single red band indicate absence of GMHT; GM tissue produces a second (lower) red band.

Detection is usually possible by one or other of several techniques. For herbicide tolerance, rapid screening of very large populations by spraying with the herbicide can be used as a preliminary screen, but is not always reliable. Whether the plants are GM or not, they differ in their ability to survive a spray, depending on the developmental stage of the plant. So some GM volunteers might die in response to spray, thereby lowering true GM levels, or non-GM volunteers might survive. SCRI also uses a range of "off the shelf" and "in-house" techniques to test leaf or seed samples for the presence of the transgene itself (the DNA) or the protein it produces. For detecting GM glufosinate ammonium tolerance, proprietary antibody methods such as the lateral flow "dip stick" test or ELISA (Enzyme Linked Immunosorbant Assay) are used routinely, as are in-house PCR (Polymerase Chain Reaction) tests for the presence of the transgene (Fig. 2). Even molecular methods sometimes have potentially large error frequencies. Plant material grown in the field can vary markedly in its biochemistry to a degree that might confound the reliability of PCR in detecting a transgene. SCRI is undertaking tests to identify the most robust techniques that are capable of providing true rates of the occurrence and persistence of GM oilseed rape.



Conclusions Attempts to understand why and how feral and volunteer plants persist is telling much about plant population dynamics generally. The agronomic questions referred to above can be answered, but we do not yet know whether it will be practicable to switch between GM and non-GM cropping in the same field. To reiterate, the presence of GM herbicide-tolerant plants does not appear to affect the ecological safety of the field, but their presence in a later crop may make it unmarketable as GM-free. The programme has recently won new funding from Defra to examine persistence, specifically at sites where GM crops were trialled in the UK.