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Viewpoint

Communicating the risks of genetically modified organisms: lessons learnt from an Irish field of cisgenic potatoes

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As plant scientists we are all too familiar with the generic commentary that is often associated with the development or use of genetically modified organisms (GMOs) in agricultural systems, but through fact-driven communication, constructive engagement can be achieved. The EU-funded 'AMIGA' project, one element of which involved assessing the impact of a GM potato (previously engineered for late blight resistance using cisgenics) with field trials in Ireland, provides a valuable case study in how this can come about. The experiences detailed highlight important lessons learnt relating to the presentation of scientific evidence in a non-scientific format and the necessity for greater integration of biological and social sciences to support the participation of biological researchers in public engagement exercises.

Potato 'late blight' disease caused by the oomycete *Phytophthora infestans* remains the single greatest biotic stressor of global potato production, responsible for ~€1bn in annual damage to the EU potato sector alone (Haverkort *et al.*, 2008). In the absence of resistant varieties that meet consumer demands on taste and appearance, growers are wholly dependent on fungicide applications to preserve yields. In Ireland alone, this typically equates to >10 sprays per crop (Dowley *et al.*, 2008), which has a significant financial and environmental impact.

Sources of genetic resistance to late blight disease do exist in wild potato species (Vleeshouwers *et al.*, 2011), but the introgression of this resistance into commercial varieties through conventional breeding practices is time consuming due to the complexity of the potato genome (Potato Genome Sequencing Consortium, 2011). It typically takes ~12 years to breed a new potato variety, but the introduction of wild germplasm can extend this to >40 years. Such an extended period of development occurred with the varieties Bionica and Toluca, which contain the late blight resistance gene *Rpi-blb2* transferred from the wild species *Solanum bulbocastanum* (Haverkort *et al.*, 2016).

Field evaluation of GM potatoes in Ireland

Cisgenics is a relatively novel breeding technique that describes the genetic modification of a plant with a native gene, together with its promoter and terminator, from a sexually compatible plant (Schouten *et al.*, 2006). Through cisgenics, novel potato lines can be engineered in a matter of months, highlighting the potential of cisgenics to (i) accelerate the potato breeding process and (ii) address a trait deficit, such as susceptibility to late blight, in commercial varieties without compromising through genetic segregation the elite processing/quality traits the variety already possesses (Haverkort *et al.*, 2009, 2016).

In 2011, the EU-funded 'AMIGA' project commenced with the goal of assessing and monitoring the impact of GM crops on agro-ecosystems (Arpaia *et al.*, 2014). Included in AMIGA was a cisgenically modified potato line, previously developed through the Dutch DuRPh programme, which displayed a strong late blight resistant phenotype due to the presence of *Rpi-vnt1.1* from *Solanum venturii* (Haverkort *et al.*, 2016). As partners in AMIGA, we assessed the impact of this cisgenic GM potato line on specific parameters of soil biodiversity (versus its non-cisgenic comparator) across three years of field experimentation (Ortiz *et al.*, 2016) in Ireland. Meanwhile, a spatio-temporal analysis completed on both the Irish and duplicated Dutch field sites validated integrated management strategies to support the durability of *Rpi-vnt1.1*-mediated resistance (Kessel *et al.*, 2018).

The Irish component of the AMIGA study was the first field evaluation of GM potatoes in Ireland and only the second GMO field licence authorized by the Irish Environmental Protection Agency (see http://www.epa.ie/licensing/gmo/release/fieldtrial/). Predictably, the initial announcement of the study generated significant media and stakeholder interest, with one commentator describing it as the 'perfect' news item: using a GM potato to tackle late blight in the same country that was devastated by the 1840s potato famine.

Communications strategy and practice

Based on previous experiences within the EU (Gómez-Galera *et al.*, 2012), scrutiny from the media and public was foreseeable. After internal discussions within Teagasc and among partners of the AMIGA project, we designed a communication strategy based on three core actions. (i) Accessibility—we would respond to all requests for information and where logistically possible participate in all events to which we were invited, irrespective of potential/perceived organizer bias. (ii) Transparency—we would explain the objectives and context of our research with all stakeholders in a manner that was both objective and humble in its delivery. (iii) Engagement—we would commit to building trust with all stakeholders through empathy and respect. In parallel, we committed to countering inconsistent ideologies and commentary with scientific fact. Our priority throughout was to listen to and acknowledge all concerns, respect each opinion and deliver science in a non-scientific idiom so that audiences fully understood the biological processes involved.

From 2012 to 2016 we actively participated in 94 events (Fig. 1), across online and traditional media platforms, and through a range of live forums. The demographic of participants ranged from knowledgeable experts to consumers who openly admitted their awareness of the issues was minimal, but had clear opinions on what they wanted to see happen. As anticipated some audiences were initially argumentative while we also received multiple emails/letters highlighting the retrograde nature of our research, which was too often accompanied with personal insults.

Engaging with the argument

In response we set about objectively dissecting the arguments and specific points made, supporting our responses with clear biological or organizational facts. For communications by letter or email we ensured that the appropriate source material was included to support our commentary, including original research. While this had a positive impact, based on follow-on communications with respondents, the face-to-face forums presented the single most important opportunity for engagement.

Irrespective of audience size, positively framing participant's attention through contextualization in the opening engagements was critical (Box 1). By highlighting a popular food (Box 1C) that people could easily relate to, we were able to succinctly explain (i) why omnipresent late blight infection (Box 1A) made the research so important in light of the need for >10 sprays (Box 1B) per potato crop, and (ii) that we were not working covertly with the ag-biotech industry to commercialize a GM potato.

As a result, from our experiences, audience sentiment moved from a somewhat antagonistic perspective of 'we must stop this GM work' to a more positive engagement process, i.e. 'we didn't know potatoes received so many sprays' and 'what are the alternatives to spraying?' By impartially describing the options (conventional, organic, GM), we refrained from biasing one regime over another. We factually presented the advantages/disadvantages of each system from the context of both the consumer and the farmer. Significantly, our aim was not to convince participants that only one system should be considered and all others rejected out of hand. On the contrary, our aim was to empower people to come to their own conclusions based on sound, scientifically based reasoning explained in a non-scientific format.

Actively encouraging participants to freely ask questions was important and while presentations were tailored with each specific audience in mind, we quickly learnt to expect the unexpected question or comment (e.g. What is blight? I thought

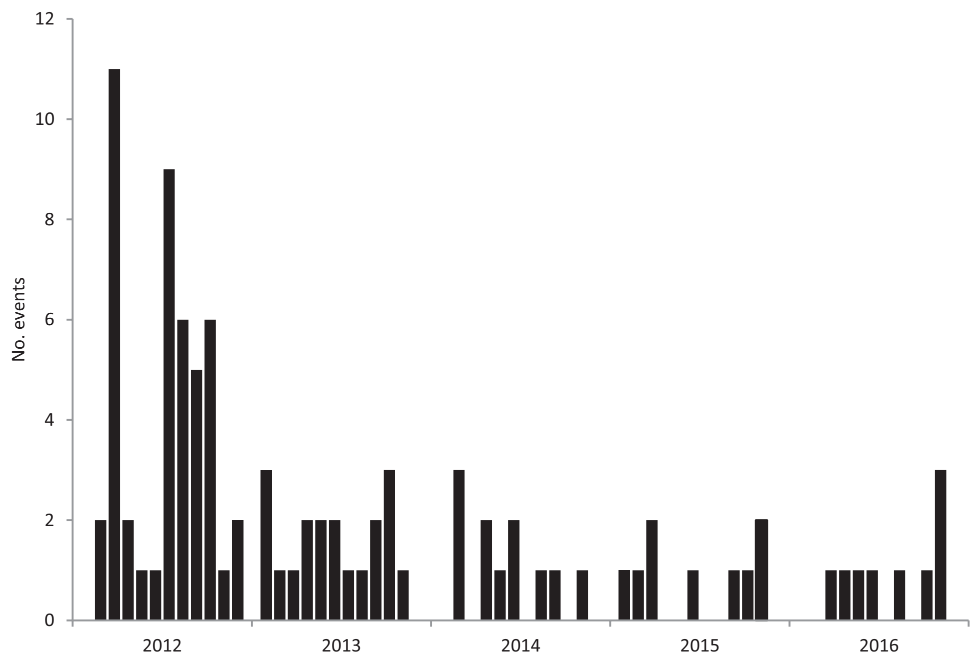
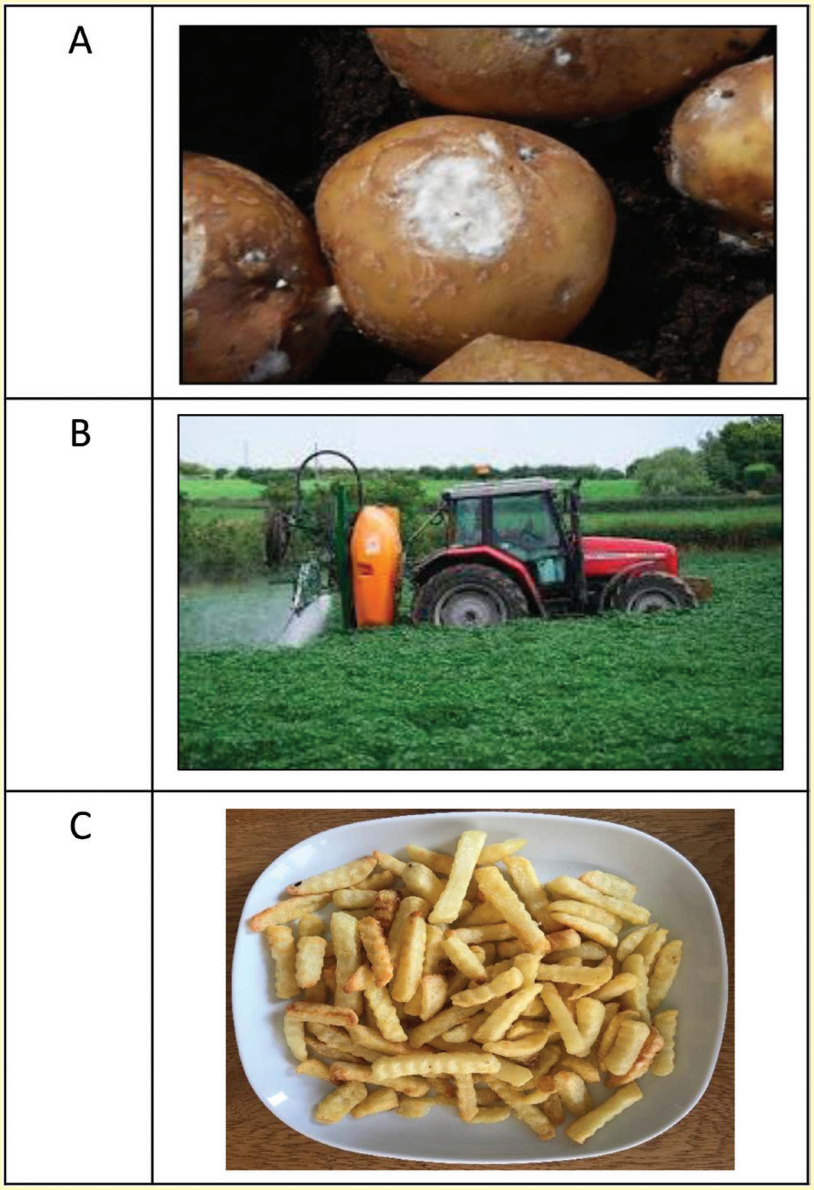


Fig. 1. Number of events participated in through the Irish component of the AMIGA project (2012–2016). Events included engagement with stakeholders, the public, and policymakers across online platforms, traditional print, radio, and TV formats, and through debates, public forums, discussion groups, workshops, and open days.

Box 1. Imagery used to frame discussions

By using high impact images that highlighted the problem (A) and the current remedy (B) required to sustain popular, everyday foods (C), it was possible to succinctly contextualize and frame discussions with stakeholders and consumers.



blight was only around in famine times? How many of your family died in the famine?). While atypical from a scientific perspective, each question was answered with a level of respect that acknowledged the desire of the participant to ask the question in the first place. Again, we learnt that this made a significant contribution to building trust with audiences, who became appreciative and supportive of our efforts to engage and communicate our research goals. After presenting datasets on the agronomic and environmental performance of the cisgenic potato line (Fig. 2; Kessel *et al.*, 2018), participants openly acknowledged the positive role this specific GM crop could potentially have in potato production. Yet too regularly, subsequent contributions from participants concluded 'it was still too risky' or 'the risk is still too high'.

Explaining what is a risk

In response, it was clear that we needed to explain what is a risk and clarify the principles of risk assessment relative to people's daily lives. By definition, risk is a function of hazard×exposure, such that in the absence of a potential exposure event or a defined hazard, the risk is zero. In contrast, if both hazard and exposure are considered high, so too is the risk (high×high=high). But what exactly does 'too risky' mean and, more importantly,

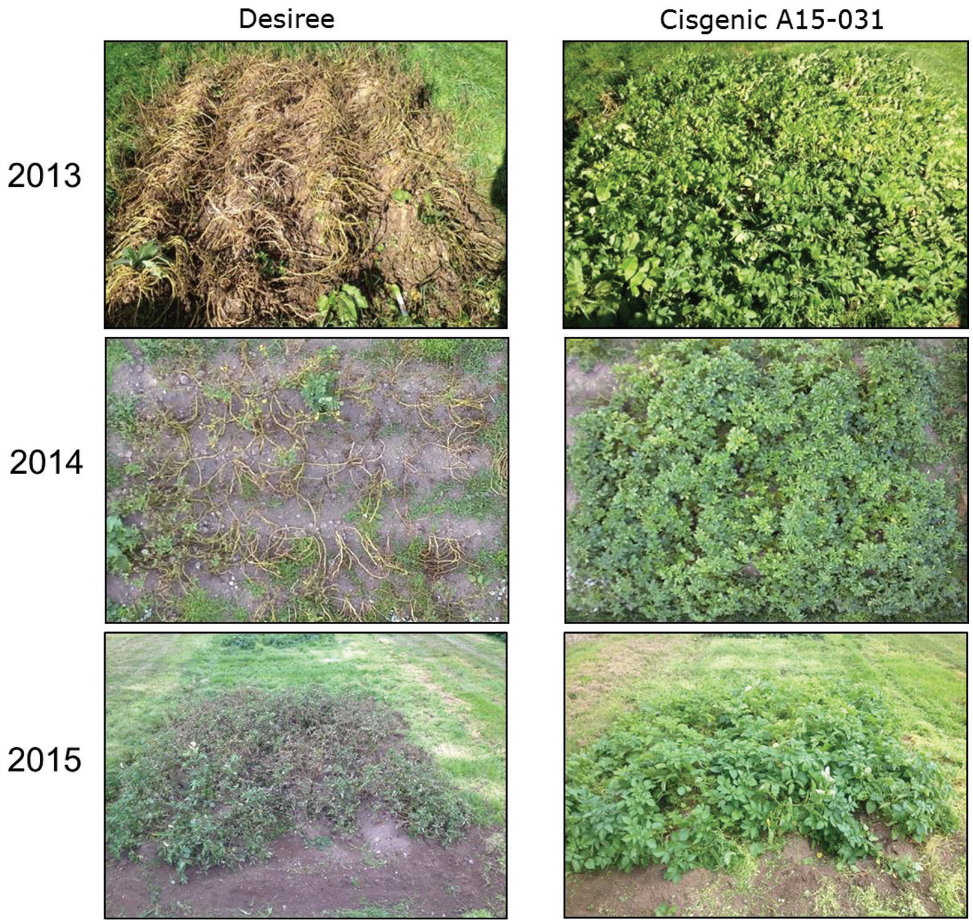


Fig. 2. Agronomic performance of GM potato line A15-031 (right) relative to its equivalent comparator non-GM variety Desiree (left) in the absence of any fungicide treatments. Field assessments were conducted in 2013, 2014, and 2015 at a licensed field location in Carlow, Ireland. A15-031 was cisgenically engineered at Wageningen University through the DuRPh programme (Haverkort *et al.*, 2016).

how can the non-equivalence of multiple, diverse 'high' risks be explained? To improve audience comprehension of risk assessment we described simple examples to delineate between three scenarios, each categorized as being high risk. For example, walking on an icy road (scenario 1), eating undercooked chicken (scenario 2), swimming in a sea infested with sharks (scenario 3). All three scenarios can be labelled high risk because both the hazard (ice, food poisoning, and sharks for scenario 1, 2, and 3, respectively) and the exposure (on top of the ice, eating the chicken, and swimming beside sharks) are rated high in each scenario. However, by explaining that the occurrence of a risk does not equate to the size of a risk (e.g. the risk of rain), it was possible to re-frame the 'risk' of the work we were doing through the AMIGA study and the perceived 'risk' of growing potatoes that reduced the environmental footprint of potato production by >95% (Kessel *et al.*, 2018).

Perspectives

Over the 4 years of the project, we engaged with >5000 participants through public/stakeholder events, which were time consuming and challenging, yet highly rewarding. Events ranged from open days with >1000 participants to public meetings, conferences, or workshops with several hundred attendees through to smaller community groups with typically <50 attendees. Comparing our approach from start to finish, it is clear we made mistakes from which several lessons were learnt. If we were to start again we would ensure dialog exercises were completed in order to gain a quantitative metric on the impact of our initiatives. Critically, we would seek input and guidance from social scientists prior to the commencement of any public discourse—an important message to be heeded in an age when the merit of biological and environmental science is too easily questioned.

It is challenging to stand in front of a public audience and discuss a subject that has polarized opinion for too long. However, in the context of our exchanges we learnt that the goal must not be to persuade audiences that one crop management system is superior to another. On the contrary, participants should be encouraged to draw their own conclusions based on a position of information, grounded in sound science that from their perspective is easily understood. Communicating evidence in an open, impartial and humble manner is critical to demonstrating trustworthiness and, as recently argued, admitting uncertainty to an audience is acceptable and helps build empathy and credibility (Spiegelhalter, 2017).

Based on our experiences, it is possible and worthwhile to communicate the issues of certain GM crops across a diverse range of audiences. In light of the challenges we face as a society, the role of scientific advancement has never been as important as it is now, but in the absence of impactful communication and communicators, unfortunately the potential benefits of scientific progress will not be fully realized in an age when we need them the most.

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