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When Naive Presumptions Prompt Hasty Judgments:

On the Benefits and Problems of Genetic Engineering

Towards a Rational Dialogue on GMOs: Only Evidence Matters!

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Summary

The public has a poor understanding of and inadequate access to accurate information about farming practices, food production and agricultural biotechnology. This means that it is relatively easy to generate citizen rejection and opposition to biotechnology on ethical grounds when amplified by the distortion of evidence. In this paper, two examples are used to illustrate this relating to inaccurate claims that all GMO derived seeds are sterile and that patents on GMOs restrict farmers long-standing traditional rights to save and re-use seeds. The inaccurate and distorted reporting of science and evidence relating to GMOs on the internet has serious consequences for academic research and the public/private knowledge concerning the risk/benefit assessment of GMO culture for human or animal consumption. While scientific data, evidence and facts have now accumulated from decades of research and more than 20 years of commercial cultivation, a challenge remains relating to how to make the general public more aware of this information. This paper presents some suggestions for improving public access to more balanced information and a more 'rational dialogue on GMOs'.

1. From a knowledge society to a belief society

It is generally accepted that the development of genetic modification techniques and genetically modified organisms (GMOs) has improved our knowledge of natural processes and has the potential to deliver considerable agricultural, industrial or socio-economical changes which affect human society at large. However, to help ensure consumer health, confidence in products and protection of the environment, some form of regulation is required.

Unfortunately, the general public has poor understanding and inadequate access to accurate information about farming practices, food production and agricultural biotechnology. This can be made worse when amplified by distorted and inaccurate reporting of evidence and the history of genetically modified (GM) crop development represents a case history of this. Many anti-scientific, false tropes such as *"GMOs cause cancer, colony collapse disorder of bees, suicides of Indian farmers, effects on non-target organisms, sterile seeds…"* can be easily found on the internet. Similarly, stories relating to patenting of crop genes and how this may place restrictions on plant breeders and farmers by seed companies, destruction of scientific research like GM crop trials, harassment of researchers studying GMOs, harassment of farmers growing GM crops, and the development of 'parallel or pseudo-science' by anti GMO technology activists are also commonplace. There has also been politically-motivated distortion of scientific evidence by some governments, non governmental organizations (NGOs) and some parts of the media[1].

The widespread reporting and dissemination of inaccurate and distorted information through the internet has serious consequences for academic research both in developing and developed countries and for public/private knowledge relating to the risk/benefit assessment of GM crop cultivation. Pseudo-scientific facts have been created/manipulated by some 'scientists' and their communication amplified by journalists and anti-GMOs NGOs (commonly via the internet). For example, a simple sentence such as '*some GM plants are tolerant to insects'* is inaccurate although a statement such as '*some GM plants are tolerant to some (not all) insects'* is scientifically correct and more accurate. For many journalists it is not important whether their statements are correct or accurate. Today convictions and views have become

[1] Ricroch, A., M. Guillaume-Hofnung, & M. Kuntz (2018). The ethical concerns about transgenic crops. Biochemical Journal 475 (4) 803-811. doi: 10.1042/BCJ20170794

forms of 'evidence' to many. Thus, pre-conceived views have become the new form of evidence ('pre-thought ('*pré-pensé'* as cited by Riocreux))[2]. What matters is not the definition of the word but the consensus of views about it. As such, we observe irrational beliefs and have moved from a knowledge society to a belief society. This extends to the challenging of peer-reviewed scientific data. To illustrate this, I present below two examples relating to this: firstly information/mis-information about the development and adoption of sterile crop seeds through GM techniques and secondly, how patenting of GM techniques imposes restrictions on the activities of plant breeders and farmers.

1.1. Example 1: The belief that GMO crop seeds are sterile

On 3 March 1998, the United States Patent and Trademark Office (USPTO) issued patent number US 5,723,765A 'Control of plant gene expression' granting Delta & Pine Land Co. the exclusive right to license a new technology entitled 'Control of plant gene expression' (iinventors: Melvin John Oliver, Jerry Edwin Quisenberry, Norma Lee Glover Trolinder, Don Lee Keim)[3]. This trait was named Genetic Use Restriction Technologies (GURT). The GURT

[2] Riocreux, I. (2016). La Langue des médias. Destruction du langage et fabrication du consentement. Ed. L'Artilleur/Toucan. 334 pages

[3] 'Control of plant gene expression' patent **(**Inventors: Melvin John Oliver, Jerry Edwin Quisenberry, Norma Lee Glover Trolinder, Don Lee Keim). Abstract. A method for making a genetically modified plant comprising regenerating a whole plant from a plant cell that has been transfected with DNA sequences comprising a first gene whose expression results in an altered plant phenotype linked to a transiently active promoter, the gene and promoter being separated by a blocking sequence flanked on either side by specific excision sequences, a second gene that encodes a recombinase specific for the specific excision sequences linked to a repressible promoter, and a third gene that encodes the repressor specific for the repressible promoter. Also a method for making a genetically modified hybrid plant by hybridizing a first plant regenerated from a plant cell that has been transfected with DNA sequences comprising a first gene whose expression results in an altered plant phenotype linked to a transiently active promoter, the gene and promoter being separated by a blocking sequence flanked on either side by specific excision sequences to a second plant regenerated from a second plant cell that has been transfected with DNA sequences comprising a second gene that encodes a recombinase specific for the specific excision sequences linked to a promoter that is active during seed germination, and growing a hybrid plant from the hybrid seed. Plant cells, plant tissues, plant seed and whole plants containing the above DNA sequences are also claimed.

technologies are the product of genetic techniques and enable plants to produce sterile seeds (V-GURTs)[4] or to de-activate a desirable trait in the second (next) generation (T-GURTs)[5].

This technology provided the scope to develop sterile biotech plants and therefore raised concerns that farmers, especially small ones in developing countries who are less financially able to buy new seeds every year will be adversely affected by the development and use of this technology because it potentially prevents farmers from saving and re-using seed. This GURT technology has been called "terminator" seed technology by the anti-GMO organization RAFI, Rural Advancement Foundation International, or "suicide seeds" by the organization that RAFI later became: the ETC group. Although this patent was published in 1998, its use was subsequently banned under a *de facto* moratorium in 2000 by the Parties to the Convention of Biological Diversity (CPD) in the Fifth Conference of the Parties (COP5)[6] and re-affirmed in 2006. Although no company has ever commercialized a biotech trait that resulted in sterile seeds using this technology, either before the 2000 moratorium or subsequently, these technologies remain among the most controversial, are perceived as a tool to force farmers to depend on large, multi-national corporations' for seeds and are perceived to be (incorrectly) widely in use in biotech seed.

It is, however, interesting to note that this GURT technology offers the potential to prevent transgene flow from one plant to another and therefore can help prevent the passing of undesirable traits from one plant to another – this could be valuable, for example, in the case of cost-effective, field-scale production of plants genetically modified to produce pharmaceuticals or other bioproducts[7]. Nevertheless, the anti-GMO campaigning against "terminator" genes (V-GURTs), based on false stories and information means that many

[4] Van Acker, R. C., A. R. Szumgalski & L. F. Friessen (2007). The Potential Benefits, Risks and Costs of Genetic Use Restriction Technologies. Revue canadienne de phytotechnie, 2007, 87(4): 753-762. https://doi.org/10.4141/CJPS06033

[5] Lombardo, L. (2014). Genetic use restriction technologies: a review. Plant Biotechnology Journal 12(8) 995-1005. doi: 10.1111/pbi.12242

[6] Decision V/5: 'Agricultural Biological Diversity: Review of Phase I of The Programme of Work and Adoption of a Multi-Year Work Programme' https://www.cbd.int/decision/cop/default.shtml?id=7147.

[7] Sang, Y., Millwood, R.J. & C. Jr. Neal Stewart (2013). Gene use restriction technologies for transgenic plant bioconfinement. Plant Biotechnol J. 11(6):649-58. doi: 10.1111/pbi.12084

people erroneously believe that all GMOs produce sterile seeds and therefore the potential beneficial (for society) application of this technology has not taken place.

1.2. Example 2: Intellectual property protection of plant innovation. Patenting of GMOs and restrictions for breeders and farmers

Many people object on ethical grounds to the principle of patenting living objects, or parts of living objects such as genes and therefore oppose the application of biotechnology.

This does, however, affect the principles by which new (improved) crop seeds are developed and innovators rewarded via the granting of intellectual property rights for seed/variety development. It also affects the conditions under which farmers can save their own seed for re-use (known as 'farm saved seed', FSS).

Intellectual property protection of plant innovation does, however, vary from country to country, reflecting differences on culture and politics[8].

In the European Union (EU)

In the EU, biotechnological innovations such as, for example a gene or cell can be patented if the innovation is new, has an inventive step and an industrial applicability. However, varieties that may contain such patented innovations are themselves not patentable.

Whilst plant varieties are not patentable, intellectual property protection associated with development of new crop varieties is provided via what is known as Plant Breeders' Rights, as defined by the 1991 Act of the UPOV convention[9]. This convention provides protection of plant varieties so that plant breeders can obtain a return on investment but at the same time allows 'Breeders Rights' access to use new seed varieties for further research and the development of new and better seed varieties. It also permits farmers to save their seeds.

[8] Le Buanec, B. & A. Ricroch (2014). Intellectual Property Protection of Plant Innovation. In: Ricroch A., Chopra S., Fleischer S. (Editors). Plant Biotechnology - Experience and Future Prospects. Publisher: Springer international. ISBN 978-3-319-06892-3

[9] Council Regulation (EC) N0 2100/94 of 27 July 1994 on Community plant variety rights. The International Union for the Protection of New Varieties of Plants (UPOV) is an intergovernmental organization with headquarters in Geneva (Switzerland).

EU regulation 2100/94 sets out a list of crops for which farm-saved seed is allowed and established a system for collecting fees from farmers using FSS in EU Member States (*e.g.* for wheat in France, Portugal, Spain, and UK).

In the EU, transgenic (GM) plants may therefore contain a patented event (that conveys a trait like resistance to a common pest of a crop) and therefore falls within the scope of the patent protection, even when available in more than one crop variety. However, because varieties are not patentable themselves in the EU, the Plant Breeders Right system is the main way in which the developers of GM crop trait innovators are rewarded (together with the granting of licenses to plant breeders to use their patented traits in varieties) in the EU. For farmers, using crop varieties containing GM traits, they pay for new (GM) innovations via the (higher) price of seed containing a biotech trait that alternative varieties that do not contain this trait.

In the USA and Canada

In North America, the way in which crop biotech innovations are protected differs from the way in which it works in the EU. Here it is possible to patent plant varieties with more limited 'Breeder Rights' exemptions and scope to not allow the farm saving of seed. This means that plant breeders commonly apply for patent protection of crop varieties and farmers wishing to use seed containing GM traits pay for access to these innovations via a combination of higher prices for the seed (relative to seeds not containing the traits) and/or a fixed per hectare access fee related to the area planted to the GM seed. Such access fees are commonly paid as part of plant breeder-farmer contracts in which farmers also agree to not save the seed for re-use. This contractual obligation to forego rights to FSS relating to GM seed has provided anti GM crop activist groups with an opportunity to portray the developers of GM seed as exploiting farmers by taking away their 'long standing rights' to save and re-use seed, as typified by the legal case in Canada in which the GM crop developer and seed company Monsanto (now Bayer) took legal action against a Canadian canola farmer (Percy Schmeiser) for patent infringement because he saved and re-used GM canola seeds. It was portrayed as a "David against Goliath" case of big-agribusiness versus small farmer legal case in which a small farmer was being sued for inadvertently re-using saved seed on his farm that contained some seeds that contained a GM trait subject to a re-use ban. The Canadian Court rulings relating to this case clearly showed that Schmesier's claims of innocent re-use of conventional seed that inadvertently contained GM trait carrying seed from seed blown onto

his farm, were false (the Courts concluded that the farmer deliberately used Monsanto's seeds[10]). Yet despite these Court rulings in favour of Monsanto, many in the media and citizens still believe the original incorrect stories about the case and believe that farmers could face penalties for patent infringement if some GM-trait containing seeds were found to have inadvertently grown in their fields.

2. Towards a more rational dialogue on GMOs. Some possible solutions for discourse and discussion

The frequent reporting of false and inaccurate stories on the internet about GMOs has serious consequences for academic research and public/private knowledge concerning the risk/benefit assessment of GMO cultivation for human or animal consumption. (This conundrum is exacerbated by the increasing appearance of reports in the scientific literature of 'advocacy research', which intentionally reaches false conclusions, and is often published in unscrupulous, 'predatory' pseudo-scientific journals.) While scientific data, evidence and facts have now accumulated from decades of research and more than 20 years of commercial cultivation, a challenge remains relating to how to make the general public more aware of this information.

Some suggestions for addressing this challenge are presented below.

2.1. Solution 1: Develop a more active approach

Better training of students in ethics: aiming to improve the development of critical thinking and the art of arguing

Students need (i) to learn how to write a scientific article according to a scientific approach and according to ethical rules, (ii) to learn how to communicate the scientific evidence, and (iii) to practice debating of ideas (in-class debate).

[10] http://www.ielrc.org/content/a0503.pdf

Promote integrity in research publication

Regarding professional ethics, it is interesting to note that in relation to reasons for retractions of articles and papers in peer reviewed journals[11], 76% of retractions in 2016 in one journal were due to scientific misconduct[12]. In another study[13] from 2012, 67.4% of total retractions were also attributed to misconduct. While retraction procedures differ by journal, there are common ethical practices made by the Committee on Publication Ethics (COPE), established in 1997 by a small group of medical journal editors in the UK that now has 12,694 members worldwide[14]. Membership of COPE is open to all editors of academic journals and several major publishers have signed up to it. However, many editors/journals are not COPE members. There is a need for more journals and editors to sign up to uphold these ethical practices and better demonstrate the application of integrity and transparency before accepting papers for publication. Every scientific article should undergo a critical assessment to consistent standards before being accepted for publication. However advocacy research, published in either legitimate peer-reviewed journals (in this case journals retract the paper containing false results) or in 'predatory' pseudo-scientific journals (in the latter case, they are never retracted, of course).

Improve knowledge and application of good scientific practice

[11] Bik, E.M., Fang, F.C., Kullas, A.L., Davis, R.J. & A. Casadevall (2018). *Analysis and correction of inappropriate image duplication: the molecular and cellular biology experience*. Molecular and cellular biology, 38 (20) pp.e00309–18

[12] Moylan, E.C. & M.K. Kowalczuk (2016). Why articles are retracted: a retrospective cross-sectional study of retraction notices at BioMed Central. BMJ open, 6 (11) p.e012047

[13] Fang, F.C., Steen, R.G. & A. Casadevall (2012). Misconduct accounts for the majority of retracted scientific publications. Proceedings of the National Academy of Sciences, 109 (42), 17028–17033

[14] https://publicationethics.org/

Malinovsky *et al.* (2000)[15] discusses the tools for assessing the scientific value of a study[16]. The application of consistent criteria for assessment of the quality of papers is needed. Critical evaluation should ask such questions as; Is the question clearly addressed? Is the method adapted to the objectives? Is the population studied clearly identified? Is the control population clearly identified? Is the sample size suitable? Are the analyzed variables clearly identified? Is the choice of variables adapted to the objectives? Is the duration of follow-up sufficient? Are statistical methods appropriate? Are the results presented in a clear, detailed and objective manner? Are the conclusions validated? Is the impact of the article important?

2.2. Solution 2: Improve reporting of distortion and manipulation of scientific evidence

Distortion of scientific evidence by policy makers

For example, we, researchers of public research in France, undertook a detailed analysis of the so-called "scientific" arguments put forward by the previous French government to "justify" its ban on growing maize varieties containing the one GM trait approved for commercial planting in the EU in 2012[17]. Genuine scientific documents, including those from the European Food Safety Authority (EFSA), were misinterpreted. Other important and relevant scientific articles that did not support the arguments put forward by the government were also ignored[18]. Some scientific authors cited by the French government document also testified

[15] Malinovsky J.M., Pain L., Juvin P., Langeron O., Riou B. & C. Martin (2000). Aide à la lecture d'un article scientifique. Comité des référentiels cliniques de la société française d'anesthésie et de réanimation. Ann Fr Asesth Réanim, 19, 209-16

[16] Laurent, C., Baudry J., M. Berriet-Solliec, M. Kirsch, D. Perraud, B. Tinel, A. Trouvé, N. Allsopp, P. Bonnafous, F. Burel, M. J. Carneiro, C. Giraud, F. Matose & A. Ricroch (2009). Pourquoi s'intéresser à la notion d' « Evidence-Based Policy » ? Revue Tiers monde, 4, 853-873

[17] Kuntz, M., Davison, J. & A. Ricroch (2013). What the French ban of Bt MON810 maize means for science-based risk assessment. Nature Biotechnology 31, 498–500

[18] Ricroch, A., Bergé, J. B., & M. Kuntz (2009). Is the German Suspension Of MON810 Maize Cultivation Scientifically Justified? Transgenic research. 23 June 2009. pp 12 DOI:10.1007/s11248-009-9297-5
and Kuntz, M., Davison, J. & A. Ricroch (2013). What the French ban of Bt MON810 maize means for science-based risk assessment. Nature Biotechnology 31, 498–500

that their findings were mis-represented by the government. In the interests of maintaining **ethical values,** we bought this unethical behavior to the attention of a wider audience through publication of this critique of the French government's decision in the journal *Nature Biotechnology.* Risk assessment and risk management must be kept separate to ensure the independence of researchers and the credibility of policies.

Distortion of scientific evidence by (social) media

Scientists often have difficulty obtaining a right of reply to articles in the media and correction of distorted scientific information on the internet is difficult to rectify. Science and scientific reasoning are commonly challenged today and we increasingly observe actions to prohibit thinking and thought, which is dangerous and feeds extremism. Today information is itself less important to the way in which it is communicated. Kuntz[19] defined current 'postmodernism' as an ideology whose aim is to deconstruct values: '*Implicitly, postmodernism considers that scientists cannot be trusted, and that their research must be subject to a democratic process – a 'participative democracy''*.

There are several reasons for this public mistrust of scientists: the effective deregulation of information and wide exposure to social media. The information market has been deregulated, allowing previously marginalized or ostracized ideas to spread more widely (such as the idea that all seeds containing GMOs are sterile, or that vaccines and 5G broadband networks are unsafe). Also, the general level of scientific knowledge among journalists and politicians is poor, and a hunger for "click-bait" among the latter. As a result, there are increasingly irrational reactions from (ill-informed) citizens. This is dangerous for science and for constructive dialogue. If dialogue becomes impossible, it is damaging for all parties. As Kuntz [20] cited '*Obviously, scientists should also listen to lay persons. True democratization of science means that anyone should get a chance to study science or at least to have a decent scientific culture to make informed choices*.' Journalists and anti-GMO NGOs have a good grasp of communication techniques largely based on the fact that most citizens do not differentiate between risk and danger. Thus, science can prove the existence of a risk but

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[19] Kuntz M. (2016). Scientists Should Oppose the Drive of Postmodern Ideology. Trends in Biotechnology. DOI: https://doi.org/10.1016/j.tibtech.2016.08.008

[20] Kuntz M. (2017). Science and Postmodernism: From Right-Thinking to Soft-Despotism. Trends in Biotechnology. DOI: https://doi.org/10.1016/j.tibtech.2017.02.006

cannot show that no risk at all is possible. NGOs tirelessly and intentionally use this to their advantage to amplify fear and mistrust of new technology like GMOs.

In addition, more action is needed to combat fake news. Some initiatives already exist to recognize, through awards, journalists who have written evidence-based articles (e.g., the initiative of the Academy of Agriculture of France since 2018[21]). More of this type of initiative is needed.

2.3. Solution 3: Better develop ways to combat the lazy acceptance of stories or conspiracy type theories and stories

It is important to encourage people not to accept as true anything they hear about a subject without validation and confirmation. This should include consideration of who has provided the message and in what form.

Although most citizens have a predominantly positive view of science and scientists, science is seen by some as a tool that is manipulated by businesses for self interest. Some journalists and anti-GMO NGOs commonly accuse scientists who speak or write positively about GMO applications and uses of acting on behalf of the (private) biotechnology sector, an accusation that closes the door to any possible objection, accompanied by a sort of intimidation. This aims to discredit the information provided by scientists and makes it easier to encourage citizens to lazily accept the conspiracy and/or negative and inaccurate views expressed by anti-GMO activists. If people were better equipped to question the nature of messages and information, its origins and sources, this will contribute to improved understanding.

Overall, we constantly need to produce evidence-based content to fight fake news and ensure that pupils and students do not forget that reflection and criticism are two key ways in which science can be defended, against obscurantism, for freedom.

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[21] https://www.academie-agriculture.fr/prix-medailles/prix-info-scientifique-destination-public