Identifying GM crops for cultivation in the EU through a Delphi forecasting exercise

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Abstract:

This paper reports the design and implementation of a Delphi forecasting exercise carried out to identify crop traits that could feasibly be introduced to the advantage of European arable farmers, and for the general benefit of members of the public in EU member states.

An expert stakeholder panel was recruited, and in the first round of the consultation, asked for opinions regarding a number of scenarios concerning the availability of GM events, and also scenarios that envisage novel crops developed using advanced technology that is not classified as GM. In a second round of consultation, panel members were asked to comment anonymously on opinions elicited in the first phase.

Preliminary results indicate that crops with input traits most likely to become available in EU before 2025 are HTIR maize, HT sugarbeet and HT soybean; these crops are already widely adopted outside Europe. The crops with output traits most likely to become available are winter-sown varieties of rape with reduced saturated fats, spring varieties of which are already available outside EU (notably Canadian Canola).

Keywords: Forecasting, genetic modification, herbicide tolerance, insect resistance

JEL codes: B4, O3, Q1

1. Introduction

Genetically modified (GM) crops have delivered substantial economic benefits for farmers, both small and large scale, as well as environmental benefits, in the limited number of countries where cultivation has been permitted (James, 2014). With one exception, i.e. Bt maize, there is no GM crop currently permitted for cultivation in the European Union (EU) and the area under production remains small, and largely confined to Spain and Portugal. There being slight prospect of approval for cultivation of other GM crops, there is little incentive for biotech crop developers, the great majority of whom are commercially focused, to develop crop trait combinations that are specifically targeted at agronomic conditions in the EU.

Stein and Rodriguez-Cerezo (2009) identified a pipeline of new GM crops of potential interest for EU arable farming awaiting field trials, and the USDA Animal and Plant Health Inspection Service (APHIS) continues to publish a list of successful petitions for unregulated release into the environment in the USA of GM crops; the 117th such petition, for a potato with blight-resistance and other properties, was approved in September 2015 (APHIS, 2015).

A working group was established by the European Commission in 2007 to evaluate whether certain new techniques constitute techniques of genetic modification and, if so, whether the resulting organisms fall within the scope of the EU GMO legislation. Lusser and Davies (2013) reported the findings of the working group, and assessed worldwide attitudes to six new plant breeding technologies (NPBTs). Crops resulting from some of the NPBTs cannot be distinguished from conventionally bred crops. Lusser and Davies considered that a global discussion of the regulation of such crops appears to be indispensable to avoid disruption of trade in the future. Hartung and Schiemann (2014) compared some of the NPBTs defined by the EU expert group with classical breeding techniques and conventional transgenic plants, and noted that plants developed by NPBTs are often indistinguishable from classically bred plants and are not expected to possess higher risks for health and the environment.

The work was carried out by the University of Reading within the EU-funded AMIGA Project (www.amigaproject.eu) and involved a survey of expert GM stakeholders from various relevant sectors. In this paper, we report some preliminary results from this work.

2. Design of the Delphi study

The so-called Delphi technique was largely developed by Dalkey and Helmer (1963) at the RAND corporation in the USA in the 1950s and has become a well-used and accepted method for allowing expert opinion to help predict the future. As Hsu and Sandford (2007) say, it makes 'sense of consensus' in that is uses well-informed individuals to express their insights and experience on future change or developments.

The Delphi technique is an anonymous method for consensus building using questionnaires to collect opinions and data from a panel of experts. The key characteristic of a Delphi process is that the data gathering has both the elements of 'iteration' and 'feedback'. Subject anonymity in the process is seen as an important benefit of the process which reduces the effects of dominant individuals in a group setting (Dalkey, 1972). The first round of the investigation involves the sending out of a structured open-ended questionnaire to a panel of experts. In the next round (or iteration), the panel is sent a second questionnaire which contains both their original answers (or feedback) and a summary of those of the other panel members. Further iterations are sometimes carried out.

While the Delphi technique has been widely used in other applications, it has not been much used in the area of agriculture. Nevertheless, Fearne (1986) used the Delphi technique to forecast agricultural policy decisions in the EU, Menrad et al (1999) used it to examine future trends in biotechnology in the EU, as did Cunha and Swinbank (2009) when exploring what had prompted the European Commission to reform the Common Agricultural Policy in 1992, 1999 and 2003. More recently, Stebler et al (2015) used a Delphi panel to identify, and weight, the prioritisation of zoonotic diseases in Switzerland.

During the next decade, what crop-trait combinations from elsewhere will be made commercially available in EU, or developed specifically for Europe, that could offer potential benefits to EU agriculture and/or society at large, should the policy environment become permissive enough to allow their cultivation? For the present work, crop traits were identified providing potential benefits in terms of:

- herbicide-tolerance (HT)
- insect-resistant (IR)
- frost-tolerance
- combating the effects of pests and pathogens
- improving bread-making properties of wheat
- enhancing nutritional properties of oilseeds
- other traits, such as bruise-resistance, of value in the food chain.

3. Method

To carry out the Delphi study, a panel of 26 experts was recruited representing stakeholders with various professional roles in crop research and development, arable farming, crop protection and farm management. The recruitment was made from a large database of participants in recent UK and European technical meetings and research activities, and included a small representation of experts from outside Europe.

An explanatory letter and a one page sheet for recording consultees' estimates and opinions on availability of GM crops for areas in the EU were sent out to 212 people electronically. This initial list was drawn up in four ways: from lists of attendees at conferences on GM crops; authors of appropriate papers in the journal AgBioForum; authors of papers referred to in relevant papers in AgBioForum; and people the present authors knew to have knowledge and interest in GM crops. Some 43% of the initial list were academics, 20% were from independent research institutes, 20% were government officials and 17% from a commercial background. Approximately 24% were located in North America, 68% in Europe and the remaining 8% in the rest of the world.

A reminder e-mail was sent after 30 days and a total of 51 replies were received: 26 were sufficiently complete for the respondents to be retained as the panel. Of these: 10 were academic; 9 were from a commercial background; 4 were from a research institute; and 3 were government officials.

The GM crops that we consulted on were divided into two groups:

- Ten GM crops with input traits conferring advantages to the farmer:

winter oilseed rape (OSR) – HT**; potato -** IR; **potato -** pathogen tolerant; **wheat -** drought tolerant; **wheat -** frost tolerant; **barley -** frost tolerant**; sugarbeet -** HT; **soybean** - HT; **maize** - drought tolerant; **maize** – HT and IR.

- Seven GM crops with output traits, modifying the characteristics of the harvested product:

wheat - with improved bread making properties; **wheat** - with higher dietary fibre; **wheat** - with reduced levels of protein linked to celiac disease; **soybean** - with improved nutritional profile; **OSR** - producing Omega 3 oils as a dietary supplement; **OSR** - with a lower saturated fat content; **potato** - with resistance to bruising.

Respondents were asked for their opinion as to whether these crops would be available before 2025. A 6 point Likert scale was used, from 0 'not likely' to 5 'very likely'. They were also asked their opinion on the likely effect of the crops on farmers' costs and yields as compared with conventional 2015 crops (not be discussed in this paper).

4. Results

The mean estimates of the panel of experts on likely availability of the 'new' crops being available before 2025 are shown for input traits in Table 1 and for output traits in Table 2.

It can be seen from Table 1 that the crop/trait the panel overall thought most likely to become available before 2025 was maize (herbicide tolerant and insect resistant) with a mean rank score of 2.7 followed by soybean (herbicide tolerant) with a score of 2.4, and sugarbeet (herbicide tolerant) with a score of 2.4.

Table 1 also reveals that the crop/trait the panel overall thought was least likely to become available before 2025 was wheat (frost tolerant) and barley (frost tolerant), both with mean scores of 0.9. The next least likely crop/traits ranked by the panel as being available by 2025 were potato (insect resistant) and wheat (drought tolerant) both with mean scores of 1.4.

It can be seen from Table 2 that the crops/traits the panel overall thought most likely to become available before 2025 were OSR (with a lower saturated fat content) and OSR (producing Omega 3 oils as a dietary supplement) both with a mean score of 2.1.

Table 2 also shows that the crops/traits the panel overall thought were least likely to become available before 2025 were wheat (with reduced levels of protein linked to celiac disease) and wheat (with higher dietary fibre) both with a mean score of 1.1.

5. Discussion

The study reported here does not attempt to rank GM crops in terms of potential economic or public health benefits. It aimed simply to reveal expectations about a number of specific crop traits, and to do even that without attempting to assess any benefits arising from combining or 'stacking' of traits in any one crop, with the exception of herbicide-tolerant insect-resistant (HTIR) maize.

Of the input traits on which the panel gave opinions, the highest 'scoring' crops were HTIR maize, HT soybean and HT sugarbeet; all these crops are already widely adopted outside Europe (James, 2014). Other strong scoring crops were HT winter OSR and pathogen tolerant (blight resistant) potato; HT winter OSR is not available at the time of writing, and pathogen-tolerant potato was not available for any commercial cultivation until it was approved for unregulated release in USA in September 2015 (APHIS, 2015).

Of the output traits, the highest scores were for winter OSR with dietary Omega 3 oils and with low saturated fat content; Canola (spring variety of OSR) with high monounsaturated fatty acid (MUFA) has long been available (Kris-Etherton et al, 1999) and the health benefits are well-attested (Astrup et al, 2011).

Uncertainty related to regulatory acceptance of all genetically altered crops overshadows the prospect for introduction of output crop traits with real benefits for consumers. Strenuous efforts are being made within EU to achieve consensus on the regulatory environment. A press release from the European Commission (2015) summarised the present situation:

‘Two different consultancies evaluated the existing GMO legislation between 2009 and 2011 focusing on GMO cultivation and GM food and feed aspects. … Stakeholders and competent authorities expressed support for the main objectives of the legislation, such as protecting health and the environment as well as creating an internal market which remains consistent with the needs of society. The evaluation reports also confirmed that many recent actions of the Commission were on the right track.

However, some adjustments were deemed necessary to better implement the existing legislation, for example:

- the authorisation system could be more efficient
- GMO cultivation would benefit from more flexibility
- Risk assessment process would benefit from further harmonisation.

Following evaluation recommendations, the Commission has launched following actions:

- A proposal for increased flexibility on GMO cultivation
- Technical information on the socio-economic implications of GMO cultivation
- Reviewing and transforming the risk assessment guidelines for food and feed and environmental release into legal documents approved by EU countries
- Reinforcing of the environmental monitoring
- Harmonised sampling and testing for low level presence in food
- Assessing of new plant breeding techniques
- Stepping up communication on GMO issues.’

The press release omits direct mention of management of coexistence of GM and conventional crops, and the topic of coexistence was not specifically included in our Delphi study, but experts agree that decisions within EU as to coexistence issues will have a major impact on availability in Europe of novel traits introduced elsewhere (Messéan et al 2006; Beckmann et al 2006; Demont and Devos 2008; Devos et al 2009; Messéan et al 2009).

In the longer term, all forms of crop development are benefitting from genome sequencing and the associated acceleration of introduction of beneficial crop traits; for example, a consortium collaborated to sequence the potato genome (Potato Genome Sequencing Consortium 2011), and a number of genome editing tools have been developed (Urnov et al, 2010; Belhaj et al, 2013; Joung and Sander, 2013). A formal European Commission decision on which NPBTs, if any, are to be defined as GM is likely before the end of 2015, according to a Special Report from EurActiv (2015).

6. Conclusion

The study discussed here has confirmed, and to some extent quantified, the likelihood of forthcoming benefits for consumers as well as farmers from a selection of crop traits developed as a result of investment in crop breeding, and based on detailed understanding of crop genetics. If the EU can agree an arrangement to permit cultivation of some, at least, of the crops developed using new plant breeding technologies, economic and other benefits will become available to EU citizens, and especially to arable farmers.

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Tables

Table 1. Experts' views on various GM crops with input traits being available before 2025

Crops	Mean 'scores'[1]
Winter oilseed rape - herbicide tolerant	2.2
Potato - insect resistant	1.4
Potato - pathogen tolerant	2.2
Wheat - drought tolerant	1.4
Wheat - frost tolerant	0.9
Barley - frost tolerant	0.9
Soybean - herbicide tolerant	2.4
Sugarbeet - herbicide tolerant	2.4
Maize - drought tolerant	2.1
Maize - herbicide tolerant and insect resistant	2.7

[1] where 0 = 'not likely' and 5 = 'very likely'.

Table 2. Experts' views on various GM crops with output traits becoming available before 2025

Crops	Mean 'scores'
Wheat - with improved bread-making properties	1.2
Wheat - with higher dietary fibre	1.1
Wheat - with reduced levels of protein linked to celiac disease	1.1
Soybean - with improved nutritional profile	1.8
Oilseed rape - producing Omega 3 oils as a dietary supplement	2.1
Oilseed rape - with a lower saturated fat content	2.1
Potato - with resistance to bruising	1.6

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