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Farmers' Interest in Growing GM Crops in the UK, in the Context of a Range of On-farm Coexistence Issues

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Although no GM crops currently are licensed for commercial production in the UK, as opposition to GM crops by consumers softens, this could change quickly. Although past studies have examined attitudes of UK farmers toward GM technologies in general, there has been little work on the impact of possible coexistence measures on their attitudes toward GM crop production. This could be because the UK Government has not engaged in any public dialogue on the coexistence measures that might be applied on farms. Based on a farm survey, this article examines farmers' attitudes toward GM technologies and planting intentions for three crops (maize, oilseed rape, and sugar beet) based on a GM availability scenario. The article then nuances this analysis with a review of farmer perceptions of the level of constraint associated with a suite of notional farm-level coexistence measures and issues, based on current European Commission guidelines and practice in other EU Member States.

Key words: coexistence measures, farmer attitudes, GM crops, maize, oilseed rape, sugar beet.

Introduction

Since their first introduction in 1996, genetically modified (GM) crops have generated two significant socio-economic phenomena—first, very rapid expansion of acceptance of the technologies by farmers in certain parts of the world (notably the Americas but also India and China more recently) and, second, significant public opposition to the technologies in other places, particularly the European Union (EU). This public opposition has, in large part, driven the development of the policies currently operated by EU and Member State Governments; these policies exclude most GM crops from EU agriculture and many GM products from commodity markets. As a consequence of this, there has been considerable academic and commercial interest in the drivers of consumer attitudes toward GM crops, resulting in a plethora of studies of this topic in recent years (see, for example, Hall, Moran, & Allcroft, 2006; Lusk et al., 2004; Zhang, Huang, Qiu, & Huang, 2010).

Perhaps understandably, interest in farmer attitudes (and the attitudes of other stakeholders) toward GM crops has been much more limited (Bett, Okuro Ouma, & De Groote, 2010). However, a range of social, economic, and environmental drivers of farmer attitudes toward acceptance of GM crops have been identified. Bullock and Nitsi (2001), Phillips (2003), and Qaim (2009) identified anticipated income gains as a key driver of farmer attitudes; the income gains result from lower expenditures on inputs such as pesticides, labor, machinery, and fuel. Marra and Piggott (2006) and Ervin et al. (2010), among others, note the role—as a driver of attitudes toward GM crops—of perceived non-monetary benefits, such as simplification of farming operations and greater flexibility of these operations, resulting in reduced labor requirements. It is believed that these lower labor and management requirements would increase opportunities for off-farm income-generating activities (Keelan, Thorne, Flanagan, Newman, & Mullins, 2009).

Farmer attitudes toward GM crops in countries where there is currently no GM crop production are based on their expectations of the various benefits and dis-benefits of GM acceptance. These expectations are being constantly updated by new information coming from diffuse sources, but primarily from observation of the performance of GM crops in other countries where they are currently being grown. However, these expectations are also influenced by issues relating to farmers' own social and economic environments. These more location-specific issues include the legislative environment, perception of their own competence to cope with the new GM technologies, and the attitudes of social referents and consumers (toward GM products) in the markets that they are supplying, where these attitudes are often mediated through the food-chain institutions that they supply (Flett et al., 2004; Lynne, 1995). The legislative and regulatory framework in which EU farmers have to operate to produce GM crops is framed by a number of pieces of EU legislation, but primarily the following.

- EC 9810/06 (Council of the European Union, 2006), which sets limits for maximum permitted levels (0.9%) of adventitious presence of authorized GM material in non-GM products
- EC Recommendation of 13 July 2010 (European Commission, 2010), which provides guidelines for national coexistence measures to avoid unintended presence of GM material in conventional and organic crops

Demont et al. (2009); Areal, Riesgo, and Rodríguez-Cerezo (2011); and Areal, Riesgo, Gómez-Barbero, and Rodríguez-Cerezo (2012) identify the existence of coexistence measures as a significant driver of attitudes toward acceptance of GM crops in a number of EU countries, impacting negatively on historic and likely future rates of GM acceptance.

In the UK, there has been no authorization for commercial GM crop production and, in addition, no coexistence measures have been proposed as of yet. Indeed, there has yet to be any consultation by the Government on the future nature of such measures. Because of this, studies of farmer attitudes toward GM crops in the UK are constrained by the fact that UK farmers are largely unaware of a factor that has been demonstrated in other countries to significantly and negatively impact rates of GM acceptance.

This article, therefore, reports on work that sought to explore the attitudes of UK farmers toward GM crops, informed by an understanding of the type of coexistence measures that would necessarily have to be in place at the time of UK authorization of the production of such crops. To achieve this, it has been necessary to draft a set of notional coexistence measures to form a scenario for a future regulatory framework.

As there is no guidance from the UK Government on the nature of the coexistence measures that would be implemented in the UK, a suite of measures was drawn from those currently operating in other EU states. Member States are empowered to adopt what measures they feel are appropriate, so a range of measures are practiced across the EU. By providing UK farmers with a more nuanced regulatory scenario, it was hoped to elicit attitudes that more accurately reflect likely future planting intentions. As a further step, the study explored farmer attitudes toward the coexistence measures themselves, generating data on their practicability and the likely costs associated with compliance.

Table 1. The area of maize, oilseed rape, and sugar beet grown and number of holdings growing these crops in the UK, 2010.

	Area (ha)	Holdings (numbers)
Maize	145,800	7,581
Oilseed rape	641,600	14,902
Sugar beet	118,500	4,911

Source: UK Defra (2011)

Method

Procedure

A draft questionnaire was produced using an iterative process with the six national partners in the PRICE project[1] (Germany, Spain, Portugal, Romania, the Czech Republic, and the UK). This was initially based on one successfully used by the Joint Research Centre-Institute for Prospective Technological Studies (JRC-IPTS) at Seville for maize growers in Spain in 2011. The UK questionnaire went through several design stages before a pre-pilot version was trialled with a number of local farmers and past students of the School of Agriculture, Policy, and Development at the University of Reading. The questionnaire was then revised, and slightly different versions were prepared for each of the three study crops—maize, oilseed rape, and sugar beet. The final version of the UK questionnaire was kept as similar as possible for those used in each of the study countries to allow for future cross-country comparisons.

The resulting eight-page A4-size questionnaire was sent out on November 5, 2012 with a reply-paid envelope. No official list of farm businesses was available for use by the researchers in order to draw a sample, so a list of addresses was purchased from the main UK telephone book, concentrating on areas in England where the three study crops are commonly grown. Thus, the maize questionnaire was sent out to 1,297 farm addresses in western England; the oilseed rape version was sent to 992 addresses in eastern England, as well as 742 of the sugar beet version in the same region. Two reminders were sent to maximize response rate. It should be pointed out that, in England, very few farmers grow grain maize; the vast majority grow it for ensiling for cattle feed.

Table 1 shows the area grown to maize, oilseed rape, and sugar beet in the UK in 2010 and the number of

1. *The PRICE (PRactical Implementation of Co-existence in Europe) project aimed to examine coexistence at both the farm and other regional levels across the study countries.*

Table 2. Respondent characteristics (means).

	Maize growers (N=53)	Oilseed rape growers (N=96)	Sugar beet growers (N=65)
Years in farming	35.9	36.6	37.6
Age in years	53.1	56.7	55.1
Farm income (£ per year)	31,588	24,218	26,915
Size of farm (ha)	186.5	541.2	395.2
Area grown of crop in question (ha)	24.7	112.4	47.7

holdings growing these crops. When we consider that there was a total of 228,000 agricultural holdings in the UK in 2010 (UK Department for Environment, Food, and Rural Affairs [Defra], 2011), the low total of holdings growing these crops suggests that two of the three study crops are somewhat unusual or specialty crops, with only oilseed rape as relatively commonly grown.

The survey was closed on March 31, 2013, by which time 214 clean, fully-completed responses had been received. Since the questionnaires were sent to all farms in areas where the study crops were commonly grown—rather than farms that definitely grew the study crops—it is not possible to calculate a real response rate to the survey. The total of 214 complete responses was composed of 53 maize growers, 96 oilseed rape growers, and 65 sugar beet growers.

Survey Representativeness

When considering the results of investigations such as those reported here, it is necessary to consider the representativeness of the survey respondents before considering the findings. This section compares key structural characteristics of the survey respondents with official national statistics. Table 2 shows some characteristics of the survey respondents and their farm businesses. The data show that not only have the respondents been in farming for a long time (the mean is between 35.9 years and 37.6 years), but also that they are, on average, just over 50 years old. Defra (UK Defra, 2013) data show that the mean age of farmers in the UK in 2010 was 59 years old, so the study farmers were marginally younger than in the general farmer population.

It is difficult to make precise comparisons between the survey farmers and the general pattern for England. However, if one compares survey maize growers with their nearest equivalent farm type (i.e., specialty dairy farms), survey oilseed rape growers with their nearest equivalent farm type (i.e., cereal farms), and survey sugar beet growers with general cropping farms, then all three groups of survey farms had farm incomes less than the national average (UK Defra, 2013).

The mean farm size of respondents' farms was considerably higher than the national average for England of commercial holdings of 129 ha (UK Defra, 2013). However, the national figures are for holdings, not businesses, and it should be appreciated that many large farm businesses consist of more than one holding.

Figures from Defra (UK Defra, 2011) show that the mean oilseed rape area per holding in the UK in 2010 was 43 ha, 24 ha for sugar beet, and 21 ha for maize. In comparison to the equivalent mean areas of these crops grown on the survey farms, it can be seen that while the maize areas were similar, the survey farms' area for oilseed rape was more than twice the UK average and about twice the area of sugar beet. However, care needs to be taken when considering these comparisons since the national figures are for holdings (not businesses) and for the UK as a whole, whereas the survey farms were in England.

Tests for non-response bias were carried out on respondents' characteristics of age of farmer, size of farm, and area of study crop. This was undertaken by examining the characteristics of the first 30% replying against those of the last 30% replying for each of the three crops. The theory is that if the 'late' responders are statistically significantly different from the 'early' responders, then there are strong grounds for suspicion that those who did not respond at all are more likely to be similar to the 'late' responders. Comparison was made for the nine measurements (three variables × three farm types), and it was found that only one comparison showed a statistically significant difference—late sugar beet respondents tended to have larger area farms than early respondents, suggesting that for sugar beet, large growers of the crop may be underestimated in terms of area of crop grown ($t=-2.18$; $P=0.035$).

To summarize, our examination of the representativeness of the survey respondents and their businesses compared with the national population found that they were slightly younger, had larger (in area) farms, had lower farm incomes, and grew much larger areas of oilseed rape and sugar beet. Testing for non-response bias revealed only one statistically significant difference,

Table 3. Some mean farm and farmer characteristics of potential adopters of the GM study crops compared with those who would not consider growing them.

Characteristics	Potential adopters	Potential rejecters	Significance of differences
Years in farming	34.1	40.6	t=3.64; P=0.0003
Age in years	53.4	58.2	t=2.85; P=0.0048
Farm income (£ per year)	89,040	66,494	t=-4.13; P=0.0001
Size of farm (ha)	500.0	262.7	t=-3.75; P=0.0002
Land rented (% of total)	33.6	34.3	t=0.13; P=0.8963
Number of farmers bordering	8.4	6.1	t=-1.92; P=0.0558
Staff numbers	4.8	2.7	t=-3.42; P=0.0008
Member of a farmers' union (%)	71.2	56.4	X^2=4.9975; P=0.0258
Member of a certification scheme (%)	74.0	54.0	X^2=9.4970; P=0.0021
Obtained a degree (%)	37.8	17.2	X^2=6.3884; P=0.0115

suggesting that large growers of sugar beet might be underrepresented.

Results

Those surveyed were asked through the questionnaire if they would consider planting GM oilseed rape/maize/ sugar beet if these were licensed by the Government for the 2015 planting year. Interestingly, considering that GM maize is grown to provide resistance to the European corn borer—a pest not yet widespread in the UK—roughly half of those growing maize said they would consider planting GM maize. Even higher rates of potential acceptance were stated by those farmers growing oilseed rape, with 62% of survey farmers responding that they would consider growing GM varieties of the crop; for the sugar beet farmers, 63% said they would consider growing GM varieties of the crop.

A comparison of 10 various farm and farmer characteristics of the stated potential adopters and non-adopters of the three GM versions of the study crops (see Table 3) reveals eight statistically significant differences. To summarize, the potential adopters had fewer years in farming, were younger, had a higher annual farm income, larger farms, more staff numbers, were more likely to be a member of a Farmers' Union or Certification Body, and were more likely to have a degree than the potential rejecters of growing GM crops. The first seven of these comparisons were significant at the 0.1% level or lower. These findings are consistent with other work concerning the diffusion of innovations in agriculture and other industries (see, for example, Jones [1963] and Rogers [1983]).

Respondents who indicated they would not plant GM versions of the study crops if they were licensed by the Government for the 2015 planting year were given a series of 11 reasons that might have led to them to this viewpoint. Against each of these possible reasons, they could state whether they 'completely disagreed,' 'somewhat disagreed,' were 'neutral,' 'somewhat agreed,' or 'completely agreed.' Table 4 shows the proportions of respondents who 'somewhat' or 'completely' agreed with the various possible reasons given.

From Table 4, one broad theme emerges: stated non-adopters were more negative about growing oilseed rape and sugar beet than maize growers, possibly because they were aware of GM maize being grown in Spain and Portugal. Table 4 also shows that there were some potential reasons for our respondents not wanting to plant GM crops that were not seen as important or decision-forming. Less than 15% 'somewhat' and 'completely' agreed with the following statements: 'I think the GM crop would be difficult to sell;' 'it is associated with complicated management;' 'it would cause conflict with my neighbors;' and 'the seed would be too expensive and difficult to buy.'

Table 4 also shows that perhaps the most important reasons for not wanting to grow GM crops by our group of 'rejecting GM' farmers was that they were already growing the study crops under specific standards that forbid GM crops (such as organic standards). This reason was given by 23% of the maize growers, 40% of the oilseed rape growers, and 33% of those growing sugar beet. A relatively high proportion (over 16%) of the non-adopters agreed with the statement that 'I don't believe in these new kinds of crops.' Other important reasons given for not wanting to plant GM crops were 'I have more faith in the use of insecticides to combat pests and diseases' and 'I don't think there would be an increase in economic returns.'

When the responses of those who said they would plant GM crops (if allowed) were examined, it was found that the largest mean area per farm that might be

Table 4. Proportion (%) 'somewhat' and 'completely' agreeing with the following reasons why stated non-adopters reject growing GM crops.

	Maize growers (N=26)	Oilseed rape growers (N=35)	Sugar beet growers (N=24)
I do not think there would be an increase in yields.	15.4	14.3	8.3
I do not think there would be an increase in economic returns.	7.6	20.0	25.0
I do not believe in these new kinds of crops.	19.2	31.4	16.6
I prefer not to change my type of crop.	3.8	22.8	20.8
I think GM maize / oilseed rape / sugar beet would be difficult to sell.	3.8	5.7	12.5
I have more faith in the use of insecticides to combat pests and diseases.	11.5	17.1	20.8
A majority in society is opposed to it.	7.6	8.6	12.5
It is associated with complicated management (e.g., coexistence rules like refuge areas, etc.).	7.6	2.8	4.2
I cultivate the crop under specific standards that forbid GM (i.e., organic).	23.1	40.0	33.3
It would cause conflict with my neighbors.	0	14.3	4.2
The seed would be too expensive and difficult to buy.	7.6	11.4	12.5

Table 5. The expected mean changes in price, yield, and profit stated by potential adopters of planting GM maize, oilseed rape, and sugar beet.

	Change in		
Growers of	Sale price (£/t)	Yield (t/ha)	Profit (£/ha)
Maize	-0.07	+2.23	+15.00
Oilseed rape	+1.89	+0.42	+44.91
Sugar beet	+1.68	+2.51	+30.49

planted was 69.8 ha for those growing oilseed rape. The equivalent stated mean planting area was 28.2 ha for those growing maize and 29.4 ha for those growing sugar beet.

Table 5 summarizes the responses of those who said they would consider planting the three study crops in terms of their expectations of changes in sale price, yield, and profit from growing the GM version of these crops.

For growers of maize, while they would expect a very slight decrease in the sale price, they believe that growing GM maize would result in an increase in yield of 2.23 t/ha and a concomitant increase in profit of £15.00/ha. Sugar beet growers thought that, on average, growing GM versions would result in an increase in the sale price of £1.68/t and a yield increase of 2.51 t/ha, with an increase in profit of £30.49/ha. However, the greatest benefits were anticipated by growers of oilseed rape, who anticipated around a £45/ha increase in profit.

An important objective of the study reported here was to explore farmers' views on state regulation of GM crop production, i.e., the burden of various measures to assure coexistence between GM and conventional crops. Before questioning the farmers who said they might plant GM crops, the following statement about regulating GM crop production was presented to them.

> To ensure the feasibility of producing both GM crops and non-GM crops concurrently in Europe, the European Commission has developed guidelines for use both at the farm level and elsewhere in the food chain, the so-called coexistence guidelines. These guidelines contain measures to be taken by farmers in order to avoid unintended contamination of non-GM products, both in the field and during harvest. Each EU Member State has freedom to translate this framework to national legislation. In the UK, there is no legislation at this time, but discussions are under way. Any national legislation that is agreed will have an impact on practices on your farm. In the rest of this survey, we want to gain some insights into how the different measures under discussion would affect you and which of these you would recommend for implementation.
>
> Imagine that, in the UK, legislation is introduced that requires a range of measures to be taken alongside GM production, which might include

- informing your neighbors about your GM cultivation,
- providing information about your GM cultivation via a public register,

Table 6. The perceived burden to potential adopters of GM crops of some possible coexistence measures in terms of ease of implementation.[a]

Coexistence measures	Maize growers	Oilseed rape growers	Sugar beet growers
Five-year record keeping of seed purchases and product sales	1.6	1.4	1.7
Asking your neighbors about their plans to cultivate maize /oilseed rape / sugar beet	2.5	2.8	2.7
Cleaning the drill after sowing GM seeds	2.4	1.9	2.5
Planting a 12-row buffer zone	3.1	3.2	3.3
Planning the sowing of your maize /oilseed rape /sugar beet in such a way so it doesn't coincide with neighbors' planting (4 weeks difference in April and 2 weeks in May)	3.9	4.0	4.2

[a] *Mean rankings on a scale where 1=easy to implement and 5=very high burden*

Table 7. The perceived burden to potential adopters of GM crops of some possible coexistence measures in terms of labor requirements and the approximate cost of implementing the measure.

	Extra labor time needed (minutes/year)			Approximate cost of measures (£/ha)		
	Maize	Oilseed rape	Sugar beet	Maize	Oilseed rape	Sugar beet
Record keeping	38.7	62.6	42.8	4.5	25.8	5.7
Asking neighbors	94.3	188.1	119.4	5.8	47.5	13.1
Cleaning drill	50.0	53.5	72.8	3.2	10.8	10.9
Planting 12-row buffer	126.6	230.4	188.8	19.1	39.0	28.1
Sowing date planning	70.0	115.6	137.7	18.6	18.6	84.3

- GM growers being liable for economic losses caused to neighboring non-GM farmers,
- an isolation distance of 75m between a GM crop and the same conventional crop (whether on your farm or a neighbor's), or
- the need for approval to grow GM crops from the Government and your neighbor.

After the presentation of the above statement, a table was provided of five different possible measures to assure coexistence between GM and conventional crops. Respondents were asked to rank what they perceived the overall burden of these measures would be to them and their business, i.e., what extra time would be needed to carry out the measure and what they estimated would be the approximate cost of carrying out the measure, including their labor and office costs.

The five possible coexistence measures presented are of two basic types—two administrative activities and three practical or farm-management activities. Table 6 summarizes the respondents' mean estimates of the general level of burden associated with adopting these coexistence measures on a scale of 1-5, where 1 signifies 'easy to implement' and 5 indicates a 'very high burden.' Table 6 shows that there was a high degree of conformity on the perceived burdens of each measure between the three groups of growers of the study crops.

The possible coexistence measure seen as least burdensome to potential adopters of GM crops—with a mean score of from 1.4 to 1.7—was the 'five-year record keeping of seed purchases and product sales.' 'Cleaning the (seed) drill after sowing GM seeds' was seen as slightly more burdensome, with a score of between 1.9 to 2.5, followed by 'asking your neighbors about their plans to cultivate maize/oilseed rape/sugar beet,' with scores ranging from 2.5 to 2.8. 'Planting a 12-row buffer zone' was seen as the second-most burdensome potential coexistence measure (scores ranging from 3.1 to 3.3). However, the most burdensome of the five potential GM coexistence measures—with a score for the three study crop growers of 3.9 for maize, 4.0 for oilseed rape, and 4.2 for sugar beet—was 'planning the sowing of your crop in such a way so it doesn't coincide with your neighbor's planting (4 weeks difference in April and 2 weeks in May).' Thus, it can be concluded that most of the likely adopters of GM crops rated three out of the five potential coexistence measures as 'somewhat' or 'highly' burdensome.

In Table 7, respondents' answers to the questions about how much time they estimated would be needed to achieve each of the five postulated GM coexistence measures are listed by study crop, as well as their estimate of the approximate cost of each measure to their farm operation, including labor and office costs. While it can be seen that there is considerable variation between crops, some generalizations can be made.

Taking the stated extra labor time needed per year to comply with each of the postulated coexistence measures and accounting for variations between the three study groups, Table 7 shows that 'five-year record keeping of seed purchases and product sales' was regarded as the least burdensome of the possible measures, resulting in just 63 minutes of extra labor time per year. Next, 'cleaning the drill after sowing GM seeds' would require an additional 50 to 73 minutes per year to achieve compliance. 'Asking neighbors about their plans to cultivate the crops' was seen as the next most time-consuming coexistence measure, requiring an estimated 94 to 188 additional minutes per year.

The most burdensome of the possible measures, in terms of additional labor time, was seen as 'planting a 12-row buffer zone,' which was estimated to take between 126 and 230 minutes per year; planning crop sowing so it wouldn't coincide with neighbors' planting was thought to be less time consuming, at between 70 and 138 minutes per year. It can also be seen that respondents growing oilseed rape estimated that the various measures would be more time consuming than those growing sugar beet. Those growing maize had the lowest time estimates.

Table 7 also shows the respondents' estimates of the costs of complying with the five possible coexistence measures. Again, as with their labor time estimates discussed above, those growing oilseed rape had, in general terms, higher estimates than those growing sugar beet who, in turn, had higher estimates than those growing maize. Record keeping and cleaning the drill were seen as the least costly measures to implement, with estimates ranging from £3.2 to £25.8 per hectare. 'Planting a 12-row buffer zone' and 'planning sowing the crop not to coincide with neighbors' planting' were seen by growers of all three study crops as the most costly measures, with estimates ranging from £18.6 to £84.3 per hectare.

Those surveyed were asked whether they would change their production plan for the study crops because of a conflict with a neighbor. Around 70% of those growing maize said they would, as would 69% of those growing oilseed rape, whereas only 56% of those growing sugar beet would change their production plan. The farmers were then asked whether they would be concerned about possible problems with the unintended presence of their GM crop in the produce of the non-GM neighbors. Just over 59% of the maize growers said they would be concerned, compared with 72% of those growing oilseed rape and 53% of the sugar beet growers.

Next, the farmers were asked whether they would be concerned about problems with beekeepers because they were growing GM crops; 59% of the maize growers and 67% of the oilseed rape growers said they would be concerned, but only 38% of the sugar beet growers indicated such a concern. Again, as with the two other questions about their attitudes toward coexisting with their neighbors, those respondents growing sugar beet proved to be the least concerned about possible consequences outside the borders of their farms, possibly because sugar beet is grown on large-sized farms in intensive arable areas of the country. In addition, the responding sugar-beet growers are the most experienced of the three types of farmer, on average.

Summary, Discussion, and Conclusions

This investigation of farmers' interest in growing GM maize, oilseed rape, and sugar beet crops in the UK in the context of a range of on-farm coexistence measures was carried out in 2012/13 via a postal survey of farmers. By the end of March 2013, 214 clean, fully completed responses were received, processed, and entered into an electronic database.

The survey farmers were somewhat younger than the national population and their farm incomes were below the national average for their farm types, but they had larger (in area) farms. Testing for non-response bias revealed only one statistically significant difference, an implication that large current growers of sugar beet might be under-represented.

When those surveyed were asked whether they might consider growing GM oilseed rape/maize/sugar beet if it was licensed by the Government for the 2015 planting year, around half those currently growing maize said they would consider it, as did 62% of those growing oilseed rape and 63% of those growing sugar beet. The figures for oilseed rape are very similar to those intentions found by Areal et al. (2011).

The potential adopters of GM crops had significantly fewer years in farming, tended to be younger, had a higher annual farm income, larger farms, more staff numbers, and were more likely to be a member of a Farmers' Union or Certification Body and to have a university degree than those who said they would not grow GM crops. This finding is consistent with past studies of adoption of other innovations, such as by Rogers (1983) and Jones (1963).

Those survey farmers who did not envision adopting GM crops had several reasons for this decision, including that they were worried about whether the GM crop would be 'difficult to sell,' that it would be 'associated with complicated management,' and that the 'seed would be too expensive and difficult to buy.'

Looking at those who said they would plant GM crops (if allowed in the future), it was found that oilseed rape growers indicated that they might plant 70 ha of the crop, while maize growers might plant 28 ha, and sugar beet growers 29 ha. Growing GM oilseed rape was seen as having the greatest potential for increasing profit, followed by growing GM sugar beet and then GM maize. As a result, if these stated areas were 'raised' to the national level, up to 247,000 ha of GM oilseed rape (38% of all plantings in 2010) might be grown, plus 83,000 ha of GM maize (57% of plantings in 2010) and 45,000 ha of GM sugar beet (38% of plantings in 2010).

The possible coexistence measure that was seen as least burdensome to the potential adopters was keeping records of seed purchases and product sales for five years. The most burdensome measure was seen as planning crop sowing in such a way that would not coincide with a neighbor's planting. However, in terms of their increased labor time, respondents thought that planting a 12-row buffer zone was the most burdensome, and this was also seen as the most costly of the five possible measures to carry out. Taken over all three crops, and using the above raised estimates of GM planted areas, this last coexistence measure alone might add as much as £12M to the production costs in the UK. Summed together, the costs of the five coexistence measures would increase national production costs for the three crops by £44M.

The survey farmers who stated they would adopt GM crops if allowed were asked a series of questions about their attitudes toward interacting with their neighbors who were growing conventional crops. The majority showed concern about potential problems of coexisting with neighbors, but sugar beet growers were much less concerned than those growing oilseed rape or maize.

As Areal et al. (2011) pointed out, few studies have investigated farmers' attitudes towards adoption of GM crops. However, those that have investigated this topic have found that net income gains were important and that non-pecuniary benefits such as flexibility in crop management were also felt important by farmers (Bullock & Nitisi, 2001; Ervin et al., 2010; Marra & Piggott, 2006).

Finally, it could be argued that asking farmers how they might react in the future to a change in policy is a hypothetical exercise, and that they might not actually do what they claim. However, Tranter, Costa, Knapp, Little, and Sottomayor (2004) reviewed examples of intentions surveys in agriculture worldwide and discussed problems in carrying out such surveys and interpreting the results. They concluded that providing that the questionnaire was piloted and well-designed and the sample was relatively large, the results are liable to be accurate. Thus, it can be argued that the results presented above can be regarded as a reliable estimate of how UK farmers would act if GM crops were allowed to be grown in the future.

As a postscript, it should be pointed out that two recent high-level reports have concluded that the expansion of GM crop growing in Europe would be beneficial to all concerned across the food chain (European Academies Science Advisory Council [EASAC], 2013). The UK Council for Science and Technology (2014) agreed with this, especially for the UK's particular position.

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