Objecting to Rothamsted's UK GM Winter Wheat Application

GM FREEZE
the campaign on GM food, crops and patents

1 May 2013

Summary

Rothamsted Research has applied to extend its release consent for growing GM wheat to include an Autumn-sown crop. Rothamsted says the move addresses criticism of the ongoing Spring-sown crops in the original trial pointing out that aphids are not a major problem on UK Spring crops so the market for a GM aphid repelling Spring wheat would be tiny, and the £1.28 million investment of public money cannot be justified.

The GM Autumn-sown wheat in this application contains identical GM traits designed to produce aphid repelling pheromones.

Members of the public can object to the application by citing **Reference: 11/R8/01** and emailing gm-regulation@defra.gsi.gov.uk or writing to:

GM Team,
Department for Environment, Food and Rural Affairs
Area 3B, Nobel House
17 Smith Square
London SW1P 3JR

Deadline for objections: **17 May 2013**

Full details of the application can be found at www.gov.uk/genetically-modified-organisms-applications-and-consents.

Unlike in Spring-sown wheat, aphids can be a problem in Autumn-sown crops because they can infect the crop with Barley Yellow Dwarf Virus (BYDV, viral diseases in cereals are a problem in Winter varieties of wheat and barley). This disease can spread in the crop once growth resumes in the Spring and has the potential to cause significant yield loss. Once infected with BYDV there is no means to treat the crop, and dieback can occur around plants infected in Autumn. Aphid numbers are usually drastically reduced by cold Winter weather, although damage to the crop can occur in the Spring/Summer if the weather favours rapid aphid population growth and natural predators and parasitoids are absent or only present in low numbers.

On intensive arable farms aphids are controlled in Autumn mainly by seed treatment and spraying during.

Background

Rothamsted Research is one of the leading agricultural research institutions in the UK and has conducted GM crop trials in the past. The institute has been very supportive of GM technology for many years, including carrying out field trials for GM wheat in 1998-2001 and 2002-2005.[1]

Director of Rothamsted Research Professor Maurice Maloney has spent his entire career on GM technology. He was appointed at Rothamsted in January 2010 having previously been Chief Scientific Officer of SemBioSys Genetics Inc, a biotechnology company in Calgary, Canada he founded in 1994. He was responsible for developing strains of transgenic oilseed rape while working for Calgene.

Rothamsted has close links to the biotech industry and issued a joint press statement in Summer 2012 with the Agricultural Biotechnology Council (ABC) calling for a growth plan for agricultural biotechnology in the UK.[2]

The current GM wheat project has received over £1.28 million in public money via grants awarded by the Biotechnology and Biological Sciences Research Council (BBSRC, see table 1).

Table 1 Grants from the BBSRC contributing to the development of GM wheat to be tested at Rothamsted research

Grant reference	Title	Grant	Duration
BBS/E/C/00005010	A new generation of insect resistant GM crops: transgenic wheat synthesising the aphid alarm signal	£70,432	01/12/08 to 31/03/13
BB/G004781/1	Ditto	£732,112	01/12/2008 to 30/11/2013
BB/H017011	Design of aphid alarm signal: Design of bioactive sesquiterpene-based chemical signals with enhanced stability	£479,026	01/01/11 to 30/06/14
Total		**£1,281,500**	

Source: www.bbsrc.ac.uk/pa/grants/AdvancedSearch.aspx

In September 2011 Rothamsted was granted consent to grow a Spring-sown GM wheat variety modified to produce a pheromone that causes aphids to leave the crop and is said to attract predators and parasitoids to the crop. In March 2013 the consent was amended permitting an increase from 350 plants per square metre to 500 plants per square metre *"to allow a higher density of seeds to be planted. This is intended to take account of poor germination rates experienced in the 2012 planting"*.[3]

Why germination rates last Spring were poor in 2012 is not clear at present.

Conventional aphid control
There are three main aphid pests of wheat in the UK:

- The bird cherry-oat aphid, *Rhopalosiphum padi*
- The grain aphid, *Sitobion avenae*
- The rose grain aphid, *Metopolophium dirhodu*

Aphids harm wheat in three main ways:
- By sucking sugars from the plant, reducing the amount available for growth and filling ears
- By encouraging fungal infestation that colonise their sugary exudates
- By carrying infectious plant virus diseases, such as BYDV

The bird cherry-oat aphid and grain aphid are mainly responsible for infecting plants with BYDV in the Autumn.

Farmers tend to use two forms chemical controls on aphid during the Autumn in a "belt and braces" approach:

- Seed treatment using a neonicotinoids (clothianidin and imidacloprid) give protection for 6-8 weeks as the insecticide is present throughout the plant.
- Pyrethroids spayed over the crop.

Predators and parasitoids are exposed to these insecticides by either being sprayed directly (pyrethroids) or via ingesting aphids (neonicotinoids), which can reduce their numbers and affect their ability to respond to future aphid attacks.

A Winter wheat crop would normally be harvested in July/August of the following year, however Rothamsted's GM application only extends until early 2014 when the trial will be terminated, meaning no data on the quality or yield of the GM wheat will be gathered. This suggests that Rothamsted is only interested is studying how the crop deals with Autumn aphid infestations and the transmission of BYDV and/or it do not have enough money to run the trial to harvest.

The new application

The GM trait

Rothamsted Research has applied to release GM wheat seeds into the environment in Autumn 2013. The wheat variety Candenza (which is both Spring- and Autumn-sown) has been genetically modified to produce a hormonal chemical compound that acts as an alarm signal to theoretically move aphids from the crop or deter them from landing on it. This chemical, the pheromone sesquiterpene (*E*)-β-farnesene (EBF), is produced by aphids when they are being attacked by predators and parasites. This alarm pheromone causes other aphids to stop feeding and move away from the source by developing wings and flying away, walking or dropping off the plants, which reduces their chance of being eaten or parasitised. EBF is also said to repel other aphids about to infest the crop. In addition Rothamsted Research says the emission of EBF would be expected to attract predators and parasitoids (mainly wasps) to the GM crop.

The two genes involved in the production of EBF being tested in this trial ((*E*)-β-farnesene synthase (EBFS) and farnesyl diphosphate synthase (FPPS)) have been synthesised in a laboratory – they "are not found naturally" (see Part A of application section 12). The application says the genes are "similar to that found in peppermint (*Mentha × piperita*), and the enzyme encoded by the FPPS cassette has most similarity to that from cow (*Bos taurus*), but is generally ubiquitous and occurs in most organisms".

Rothamsted Research's decision to use a gene sequence for FPPS cassette that closely resembles a cow gene raises questions about the public acceptability of such a move. This is one step removed from using animal genes in crop plants which would surely trigger controversy about the morals and ethics of such an application of genetic modification.

The two genes (EBFS and FPPS) are placed in two separate constructs, both of which include genetic materials from a number of different organisms as promoters to regulate the expression of the pheromone genes, marker genes used to confirm if each plant contains the genes and other genes to ensure that the construct functions in wheat cells. Table 2 shows the origins of each part of the two constructs. The presence of two marker genes in each construct (for resistance to the antibiotic kanamycin and tolerance herbicide glufosinate ammonium) is unusual.

Table 2 Origins of genetic materials that make up the genetic constructs used for the pheromone genes in Rothamsted's GM wheat

Function	**Source organism for genetic material**
Plasmid[1] replication in *E. coli*	*Escherichia coli* bacterium
Plasmid replication in *A. tumefaciens*	*Agrobacterium tumefaciens* bacterium
Antibiotic resistance marker (Kanamycin)	*Escherichia coli* bacterium
Left and right hand borders sequences (of T-DNA)	*Agrobacterium tumefaciens* bacterium
Promoter for: constitutive expression of pheromone genes (ie, EBFS/FPPS constantly being produced throughout the plant)	Maize
Pheromone genes EBFS and FPPS	Synthetic (closely related to mint and cow)
DNA sequence to ensure EPFS/FPPS gene products (proteins) will target and interact with chloroplasts	Wheat
Terminator DNA sequence for pheromone	*Agrobacterium tumefaciens* bacterium

gene (to indicate where the gene ends)	
Glufosinate ammonium (herbicide) tolerance marker	*Streptomyces hygroscopicus* bacterium (stated to be inoperative in this construct)

1. A plasmid is a particular strand of DNA that is capable of reproducing independently of the chromosomal DNA. Plasmids are commonly circular and occur naturally mostly in bacteria.

The genetic constructs carrying the EBF producing genes were inserted into the genome of Candenza wheat using a ballistic projectile method (ie, coating tiny gold particles with the gene constructs and "shooting" them into the embryonic plant cells in the hope they will be integrated into the plants' chromosomes and genome). This method is not precise or predictable.

The trial

The trial site at Rothamsted's farm will be security fenced. The applicant says that the trial will include eight 6x6 metre plots (288 square metres) planted with GM wheat events 2803R6P1 or 2812R9P1 (event 2803R6P1 contains both GM genes and 2812R9P1 the EBFS GM gene only) plus eight 6x6 metre plots of non-GM (non-transgenic) controls. Plot will be separated from each other by 10 metres (0.5 metre space, 9 metre barley, 0.5 metre space) and from the edge of the trial by 10 metres of barley (or space) plus a 3 metre pollen barrier of non-GM wheat. The applicants says the nearest cereal crop will be at least 80 metres away.

The Rothamsted application states that the two GM lines produce very different amounts of the pheromone: event 2803R6P1 is said to produce 1833ng/plant/hour and 2812R9P1 only 30ng/plant/hour – 60 times less than its counterpart. The significance of this difference in this trial site is very unclear. The application for the Autumn-sown crops merely repeats the objectives of the spring sown application, *"This is a research trial to assess any change in behaviour of aphids, their parasitiods or predators that result from the modified volatiles given off by these GM plants."*

Apart from the layout of the trial plots and buffer zones, there is no information regarding the scientific objective of the trials. It may be merely to observe behaviours of insects, or there may be an intention to compare the performance of the two GM events as well as comparing GM with the non-GM controls, or there may be another purpose.

Given the very large difference in pheromone production between the two events, some sort of comparison between the two GM events seems probable. If this is the case the proximity of the various plots in a comparatively small area (80mx80m) raises the possibility that one plot may interfere with a neighbouring plot depending on how far the pheromone will drift or be blown in the air. Although EBF pheromone is rapidly broken down in the air (11-16 minutes)[4], aphids are capable of detecting it at very low concentration,[5] and therefore even small amounts of drift could be a significant influence on aphid behaviour. This raises the question as to how the experimental layout will be able to distinguish the effects of the pheromone between plots, especially if they are adjacent to each other and only separated by a 10 metre buffer. If interplot interference occurs the justification for an elaborate outdoor trial would be lost as a more controlled greenhouse trials would provide more reliable results.

Difficulties with the trial

In the absence of any clear scientific objectives from this trial (beyond confirming that the plants produce pheromones and observing whether aphids behave in the open air as they do in the greenhouse) it is very hard to see what value the taxpayer will gain from the extension to cover an Autumn-sown crop.

This becomes an even more pertinent point when the potential market for a GM Winter wheat variety is considered. According to Nix 2013[6], the cost of insecticides used on Winter wheat amounts to 2% of expenditure on all pesticides (including growth regulators). Nix's cost for all pesticides is £173 -180/hectare, so the total cost of insecticides per hectare is just £3.46-£3.60. In addition Winter wheat seed it also treated with neonicotinoids as an additional protection against aphids carrying the Barley Yellow Dwarf Virus. The current cost of seed treatment comes in range of £10.80/hectare to £21.60/hectare depending on seed rate.

If GM wheat were to be introduced farmers would need to be convinced to abandon the current "belt and braces" approach to aphicide application in the Autumn outlined above. Assuming that an insurance spraying with pyrethroids was also abandoned, the price differential for GM wheat seed would need to be less than the cost of the saving made on aphicides, which is in the range £14.33-£25.13/hectare.

In 2005 ADAS Consulting[7] reported for Defra that a proposal to traditionally breed Barley Yellow Dwarf Virus resistance into Winter wheat was not viable because of the low cost of aphicides. At that time the total cost of seed treatment and sprays amount to 1.8% of the value of the harvested wheat crop. The same calculation in 2013 produces the same figure, so the commercial viability of the GM wheat would depend either on aphicides being banned or taxed at a sufficiently high rate. In the event of a ban on neonicotinoid seed treatments, relying on several applications of synthetic pyrethroids would reduce aphid control costs. The economic case for GM wheat remains weak compared with conventional intensive production. Any decision to use seed treatment in wheat his made before sowing and takes no account of whether aphids will be present on the crop or not. This means that seed treatment cannot form part of an integrated pest management approach with the aim of reducing overall pesticide use. Farmers relying on spraying have the option to not go ahead if crop surveys reveal no pests or the presence of beneficial insects (predators, parasitoids and pollinators), which would be harmed if spraying took place.

Growing GM wheat would have other additional costs including on-farm coexistence measures to avoid contamination, compensation funds for any contamination (currently no insurance is available for any GM cultivation in the UK) and off-farm traceability and labelling (a legal requirement).

Any premium for GM wheat seed would be rapidly eroded by the need to ensure that consumer labelling was accurate enough to provide choice. Any compensation costs borne by the farmers would quickly wipe out any saving from adopting a GM seed with just EBF genes present.

So after producing a GM Spring wheat variety with no obvious agronomic need, Rothamsted has now come up with a GM Winter wheat with no obvious market unless the current aphicides are banned or become much more expensive or cease to provide adequate aphid control. Conventional selective breeding of BYDV resistant wheat varieties has not taken place due to the low cost of aphicides,[8] and the same fate could await GM aphid repelling Winter wheat.

Non-GM alternatives to aphid control

In contrast agroecology offers a number of approaches to controlling aphids in Winter wheat crops without GM or insecticides including:

- Longer rotations between wheat crops to prevent "green bridges" from following crops permitting aphids becoming established very soon after sowing of the Winter crop. The current practice of planting a second wheat crop is very open to aphid infestation via volunteers from the previous crop. It is therefore inherently unsustainable and cannot be classed as good agronomy.
- Delayed sowing (a week's delay can reduce BYDV by half by reducing aphid infestation).
- Good control of volunteer cereals in stubble by minimum cultivation.
- Provision of habitats for predators in the form of wildflower rich field margins and beetle banks across fields. Ground beetles (C*arabidae*), rove beetles (*Staphilinidae*), spiders (especially money spiders *Linyphiidae*) are all active predators in Autumn, as are parasitoids wasps.[9] On-farm habitat creation has the added benefit of providing habitats for birds, mammals and pollinating insects, as well as enhancing the landscape.
- Planting mixed variety seed lots with an intrinsically larger gene pool can reduce disease incidence and impact.

Traditional breeding of BYDV resistant varieties, used in combination with agroecological methods, offers a balanced approach to aphid control without the problems of persuading the market to accept GM and the associated costs of developing and growing GM varieties. Such an approach provides many other benefits, such as habitats for pollinators, other insects, mammals, birds and amphibians, landscape features and increased soil carbon.

Grounds for objecting to the application

There many reasons the release of GM wheat should not take place. GM Freeze is calling on Defra to refuse the application.

Using genes with animal origins

Until now commercial GM crops entering the market have avoided using animal genes in their GM constructs. It would have been highly controversial if Rothamsted Research had opted to use the gene from a cow directly as the physical, albeit slightly altered, base for the construct instead a synthetic copy. The use of synthesised genes in this way therefore needs to be very carefully considered given there are, by Rothamsted Research's own admission, other options open to them. The decision to allow the use of synthetic animal genes should not be left to politicians, regulators and scientists but be based on the outcome of a public consultation. The application should be rejected to allow such a debate to take place without any deadline imposed.

No market for the final product

GM wheat was trialled extensively around the world, including in the UK, until the early part of the last decade when widespread market rejection of GM in cereals by farmers and consumers became obvious. Monsanto abandoned GM wheat research in the EU in 2004,[10] and more recently sources in Canada[11] and Australia[12] report significant opposition to restarting GM wheat development in both countries. UK retailers have maintained a strict policy against GM ingredients in food since 1998, and there is no sign this will change. Using GM wheat to feed livestock would be a disaster because the presence of GM in EU feed wheat would cause huge disruption and costs for the grain trade to ensure that milling wheat (for food) remained GM-free. The strong likelihood is that the EU market will reject GM wheat for the foreseeable future, so the public expenditure on the proposed trial at Rothamsted cannot be justified, especially in the present crisis in public finances.

Premature move to field testing

The scientific paper on *Arabidopsis thaliana* suggests that the genetic modification of wheat to produce the EBF pheromone could be more complex than implied by the applicant and that there is room to doubt whether the GM wheat will have the desired effect on aphids. For instance aphids have been shown to become habituated to EBF quite quickly and ignore the signal and stay on the GM plant.[13] The impact on predators of parasitoids arriving at a pheromone-emitting crop with no aphids present has also not been addressed. The question of where displaced aphids end up is significant, especially if they move onto a neighbouring non-GM crop. The proposed GM field trial is therefore premature, and future research to address these uncertainties should be carried out in the first instance with non-GM plants naturally producing EBF. Such research should also include options for using EBF without the use of genetic modification, as described above.

Risk of outcrossing

Rothamsted Research makes a number of proposals to reduce the risk of the GM wheat outcrossing to neighbouring commercial wheat crops or other experimental crops on their land. Rothamsted Research states, *"Wheat is a self-pollinating crop with very low rates of crosspollination with other wheat plants."* However Rothamsted also states that wheat does outcross to other wheat plants at a rate *"usually less than 1%"*, but add, *"Under certain growing conditions individual genotypes may have outcrossing rates of up to 4-5%."*

If outcrossing caused a detectable GM presence in neighbouring non-GM wheat, the crop would need to be labelled as GM under EU Regulation1830/2003, and without exception if the contamination level was over 0.9%. An organic crop would lose its certification if any contamination occurred. GM presence may also affect the market and price received for the contaminated crop due to current retail policies on GM ingredients, many of which require that no GM is present. Any

GM contamination of wheat has the potential to cause considerable economic harm throughout the food web.

In 2002 and 2003 Canadian researchers tracked outcrossing from a blue-grained variety of wheat, finding cross-pollination occurred at low levels (0.01%) up to 190 metres away in 2002 and up to 2.75km away in 2003.[14] Another study found outcrossing in commercial scale crops at distances of up to 200 feet (66 yards).[15] Most gene flow occurred within 100 feet of the pollen source, with rates of 7.5% at distances of less than one foot. The highest rate of outcrossing at 200 feet was 0.25%. Higher rates at greater distances were recorded in commercial scale trials compared to smaller experimental plots because the pollen sources were greater. These studies show that outcrossing rates vary between varieties of wheat, which is explained by slightly differing floral structures[16] and differences in male fertility. Semi-dwarf wheat varieties are more likely to outcross.[17] Current isolation distances for certified wheat seed production of 30 feet[18] would not be adequate to prevent GM contamination.

New research published in 2011 found that GM wheat varieties were more likely to outcross than the non-GM comparators[19]:

> *"Although the overall outcrossing rate in the first experiment was only 3.4%, Bobwhite GM lines containing the Pm3b transgene were six times more likely than non-GM control lines to produce outcrossed offspring. There was additional variation in outcrossing rate among the four GM-lines, presumably due to the different transgene insertion events."*

The authors put this difference down to "*more or less prolonged flowering time and stigma exposition among GM lines due to more or less reduced male fertility",* but offered no explanation as to the cause of these differences or whether they were due to the GM events, which can to induce changes in the recipient plants.[20]

The enhanced outcrossing of GM wheat varieties in this trial took place at short distances within fields and would be more likely to give rise to contamination problems if there was seed contamination or if volunteer GM wheat plants germinated in a non-GM crop.

Rothamsted Research presents no data on the outcrossing potential of Cadenza in different environmental conditions, so its true potential for outcrossing is not known. According to the GM wheat application there is a small risk that the GM wheat could outcross to relatives in the grass family, which in the UK are noted as being from the genus of *Elytrigia* and *Elymus*. Attention should be on two species in the genus *Elytrigia – Elytrigia repens* (common couch) and *Elymus caninus* (bearded couch). The former is already an extremely troublesome weed in cereal and other arable crops, as well as in many other crops and gardens, so the application should be refused to remove the chance of outcrossing occurring. A chance crossing between the GM wheat and a couch plant would result in glufosinate ammonium resistance developing in couch as a consequence of the presence of the marker gene and potentially an increased fitness due to reduced aphid attack (if the trait is performing according to design).

Before the UK trials of GM oilseed rape began it was stated that cross-pollination between the crop and the common arable weed charlock (*Sinapsis arvensis)* was impossible under field conditions. Yet during the Farm Scale Evaluations from 2000-2003 such a cross did occur[21]. This demonstrated that rare events do occur under natural conditions. The creation of a population of glufosinate ammonium resistant couch could cause serious agronomic problems for farmers in the long term and lead to an increased use of herbicides to control it.

Environmental Impacts

The applicant states, *"The survivability of these plants in unmanaged systems may be affected by their ability to modify the behaviour of aphids and their parasitoids or predators."* (Part A paragraph 16)

The GM wheat might change aphid behaviour by diverting aphids in greater numbers onto neighbouring non-GM crops. This could result in use of aphicides on the non-GM crop when none would have been required otherwise because critical aphid population levels that would cause economic harm would not have been reached. The applicants have not addressed the issue of the impact of aphid displacement onto neighbouring farms, which could make BYDV infection worse.

Predators and parasitoids may be drawn to the GM crop believing the presence of EBF signifies the presence of prey. This may divert them from non-GM crops where there is a significant aphid population in need of control and result in more harm to the crop than may have been caused otherwise. This type of effect may impact more on organic cereal farmers who rely on natural predators and parasitoids to keep aphids under control, but any farmer who chooses not to use GM wheat would be at risk.

Understanding of aphids and their predators/parasitoids reactions to the EBF produced by GM wheat is very limited, and the design of the experiment proposed for Autumn 2013 does not address these issues or any other possible environmental impacts, including with regard to trial design. Nor is there any mention in the application of any potential impact on soil-dwelling organisms caused by the release of the pheromone (eg, via the roots) or of any other genetic changes of the wheat. One of the breakdown products of EBF is said to be acetone (part A paragraph 19), which may well impact soil organisms in the root area of the plant and change the composition of the soil.

In addition these plants possess the ability to tolerate glufosinate ammonium-based herbicides, which would increase their survivability in environments where these herbicides are the only ones used. There is also a possibility that in the future the presence of the glufosinate ammonium tolerance gene could be used as an agronomic trait in a commercial variety to make it attractive to farmers wishing to control weeds in cereal crops. The results of the UK's Farm Scale Evaluations clearly showed that GM herbicide tolerant Spring and Winter oilseed rape with tolerance to glufosinate ammonium had a significant impact on the flowering plant species in arable fields compared to the current herbicide regime used on conventional crops. This would also have a significant impact on numbers of arable weeds and insects, which forms a vital food resource for farmland wildlife and would harm many species.[22] Furthermore the development of a dependence on glufosinate ammonium for weed control in cereals could lead to the development of weed resistance in major arable weeds leading to an escalation in herbicide usage and costs, as has happened in Roundup Ready crops in the US and South America.[23 and 24]

There is an overwhelming case for further studies to be conducted using non-GM plants to enable the possible interactions to be studied. Such studies may also produce information on non-GM options for using EBF.

Food safety
Although the applicant states that none of the GM crop will enter the food chain, food safety should be taken into consideration in assessing the application. Firstly human error or unforeseeable events may lead to the accidental inclusion of the GM wheat in the food or feed chains, either directly or indirectly through contamination of non-GM wheat crops via outcrossing or seed mingling. Second there would be no point in permitting a crop that would eventually be refused approval for commercial growing because it is unsafe to eat. There are a number of concerns including:

a) The presence of Antibiotic Resistant Marker genes (ARMs)
The GM wheat contains two copies of a kanamycin resistance gene used as genetic markers. The EU phased out markers for antibiotic resistance because they may have *"adverse effects on human health and the environment".* (EU Directive 2001/18 Article 4.3) Phasing out on test sites was due to take place by December 2008.

In 2007 the European Medicines Agency[25] commented on the use of kanamycin resistant genes in GM crops, expressing concern that the aminoglycosides group of antibiotics, which includes kanamycin, could become more important in the future if antibiotic resistance to other groups of antibiotics increases. The Agency pointed out that kanamycin is currently used to treat bacterial infections, including tuberculosis, in cases where other antibiotics fail due to the development resistance in the pathogens. Kanamycin is in clinical use.

There is a clear risk that the kanamycin gene from the GM wheat could transfer horizontally into harmful bacteria rendering the pathogenic microorganisms resistant to this group of antibiotics and reducing the options for successful antibiotic treatment of serious illnesses and infections. The risk for horizontal gene transfer is greatly enhanced due to the extensive presence of bacterial sequence homologies and the origin of replication sequences, as also acknowledged by the applicant.

The use of the kanamycin resistance gene in the GM wheat is unnecessary for the purposes of the trial. The presence of the kanamycin resistant gene would present a major barrier to the GM wheat obtaining an EU marketing approval, if it ever progresses to that point, since there is widespread concern among EU Member States.

b) Impacts from the genetic modification events

The applicant states:

- *"We have not analysed the position or the structure of the insertion nor sequenced the flanking genomic DNA."* (part A paragraph 14)
- *"We have not specifically investigated genetic or phenotypic stability of these lines."* (Part A paragraph 17)
- *"There appears to be no published toxicity or allergenicity data for EBF but at the levels expected to be generated by these plants and because they will not enter the food or feed chains, we consider the potential toxic or harmful effects to be negligible."* (Part A paragraph 19)

Despite the substantial lack of data the applicant is happy to pronounce the GM wheat safe for human consumption. This opinion is also partly based on the expressed assumption that the GM wheat or its traits or its genetic modifications will under no circumstances end up in the food and feed chains.

This ignores the fact that there is no information on any impacts caused by the genetic modification of the two GM wheat events, for instance the effect on the gene expression of the wheat's own genes. Wheat is known to cause intolerance problems in many people (in the UK 25,000 people suffer from Coeliac disease, gluten intolerance, BMA 1990), some with serious health consequences, such as wheat-dependent exercise-induced anaphylaxis. As wheat can have a significant health impact on a minority of people any potential changes to the composition, expression or shape of normal proteins arising from the GM events should be investigated before further development is permitted.

c) Unpredicted effects

The applicant states, *"Except for the emission of EBF, all aspects of the phenotype of events 2803R6P1 and 2812R9P1 including morphology, pollination and seed-set **appear** to be identical to nontransgenic control wheat plants."* (Part A paragraph 16)

This statement (and the statement of paragraph 19) is pure assumption and ignores the body of scientific evidence regarding the presence of unpredicted effects due to the genetic modification of a plant.

For example it is well recognised that the introduction of genes and genetic sequences via genetic modification commonly leads to mutations in the plant, in particular when using particle bombardment. It is also widely recognised that the interaction between the introduced genes or with the plant's own genes can give rise to unpredicted effects of both qualitative and quantitative nature, including antagonistic, additive or synergistic effects. Neither these effects nor their consequences can be predicted from the gene sequence introduced into the plant.

d) No data on toxicology and allergenicity

The applicant states, "*Some seeds from the GM and control plots will be conditioned, threshed and stored in appropriate GM seed stores."* (part A paragraph 33)

In addition to the statements in paragraph 19, this clearly indicates that part of the first GM crop will be harvested and stored, and therefore human errors could result in accidental contamination of non-GM seeds.

The applicant also states that no wheat from the trial site will be consumed, although experience from other countries confirms that contamination of food and seed from GM test sites does occur. For instance in the US experimental test crops have led to unapproved GM traits entering the food chain, including Bayer's LL601 GM long grain rice[26] found in 2006 as a contaminant in non-GM exports from the US to many countries around the world. This led to import bans, very significant financial losses for the US rice industry and a series of court actions.[27] The contamination was not detected in commercial rice crops until five years after the experimental trials were completed in 2001.

Similarities between the LL601 case and the GM wheat trials proposed by Rothamsted Research are obvious. The lack of any food safety data or risk assessment of the GM wheat could cause similar problems if contamination occurred or if any GM seed were to contaminate non-GM wheat seed lots eventually were used for commercial production.

Non-GM alternatives to control aphids

Agroecology combines natural pest control and good agronomy, which can be complimented by traditional plant breeding and non-GM application of aphid sex hormones.

Predators and Parasites

There are many alternative approaches to managing aphid populations on cereal crops that do not involve the use of aphicides or genetic modification. Indeed some have been developed and trialled at Rothamsted Research.[28]

The key practices in Autumn-sown crops are long rotations, good field hygience to prevent "green bridges" and maintaining high levels of predators and parasitic wasps, which attack aphids in arable field margins and encourage them to move into the middle of fields.

Recently published research by the Home Grown Cereals Authority found that Winter wheat yield has not continued to rise annually, as would be expected from the testing of new varieties in field trials, partly because of the adoption of very short rotations including "second wheats", which carry clear yield penalties.[29]

Another essential step is to provide a diverse habitat rich in pollen and nectar near fields as a continuous supply of food and shelter for predators and parasitoids when no aphids are present on the crops. Predators of aphids include ladybird adults and larvae, hoverfly larvae, lacewing larvae, spiders, ground beetles and rove beetles. Parasitoids of aphids are mainly small parasitic wasps that lay eggs in aphids and the developing larvae use them as a source of nutriment. Common aphid parasitoids can parasitize up to 500 aphids in a season,[30] and individual ladybirds have been shown to feed on up to 33 aphids per day.[31] Beetles, spiders and parasitoids are the most significant controls on aphid numbers in the Autumn.

Research has shown that creating a complex landscape can increase the numbers of parasitoids by providing sources of nectar for adults to feed on before laying their eggs in aphids, but this type of mixed habitat and arable field may also provide over-Wintering sites for cereal aphids.[32]

The Defra-supported SAPPIO LINK project 0915, CSA 5462 investigated several aspects of aphid biological control and management. As well as providing suitable habitat for predators and parasitoids to survive when there are no cereal aphids, the project also trialled the use of pheromones to attract parasitoids to the cereal field.[33] Data from a controlled experiment in Winter wheat showed the potential for effective aphid control using populations of predators and parasitoids,[34] *"Aphid populations were 18% higher at reduced densities of ground-dwelling predators, 70% higher when flying predators and parasitoids were removed, and 172% higher on the removal of both enemy groups."*

Rothamsted's GM wheat depends on the reaction of predators and parasitoids to the alarm pheromone. Without suitable habitat they may not be present in sufficient numbers to deal with aphids in and around the crop. As it is possible to control aphids using natural predators and parasitoids alone, it is very unclear what additional benefit the GM trait would bring that cannot be achieved using the methods outlined above alone.

Conventional plant breeding
EBF occurs naturally in plants as well as being produced by aphids as a warning signal. According to the GM wheat application trace amounts are even produced by wild type wheat. (Part A paragraph 19) This opens the possibility that this trait could be bred conventionally into modern varieties of wheat using advanced techniques, such as Marker Assisted Selection, provided the necessary research was undertaken to avoid impacts of other parts of the agroecosystem or on neighbouring crops. The problem of aphid habituation would also persist if EBF was bred into wheat using traditional techniques.

Selective plant breeding using MAS could introduce BYDV resistance into Winter wheat. However, as indicated above, previous attempts to start such a programme have been thwarted by the cheapness of aphicides used on Winter wheat, which made it economically unviable.

Manufactured pheromones
EBF breaks down rapidly in the air, but aphid sex hormones have been successfully deployed to attract aphid predators and parasitoids into infested crops in previous research, includiny by Rothamsted.[35] Such an approach could be used in conjunction with the existing monitoring and early warning system for high aphid populations (currently operated by the Home Grown Cereal Authority[36]).

Companion Planting
Rothamsted Research has already indentified peppermint as a plant that naturally produces EBF pheromone. One technique often used in agroecological farming systems is companion planting (eg, growing a second crop alongside the main crop to produce chemical signals that push pest away from the crop). Indeed Rothamsted Research has pioneered this technique, in collaboration with colleague in Africa, to develop the push-pull technique for dealing with maize pests.[37]

Want to object?
See our action at www.gmfreeze.org to send an objection directly to Defra.

If you wish to make a more detailed objection, feel free to include any of the points below in addition to your own:

- The costs current control methods for aphids on Winter wheat are so low that a GM variety would have to be sold at a loss in order to compete with non-GM varieties. It is therefore highly questionable whether the trial is a justifiable use of taxpayers' money when agroecological solutions exist and bring many additional benefits.
- The scientific justification for the extended trial in Autumn has not been made, and this should be made public before a final decision is made on the application.
- The observation of aphid and predator/parasitoid behaviour said to be the aim of the project could be made in a greenhouse in a controlled experiment conducted at the same time of year. It is unclear whether the proximity of the replicates could result in interference between plots in light winds.
- There should be a broad public consultation on the use of synthetic copies animal genes in crop plants before any further research is permitted.

- There is currently no market for GM wheat in the UK, EU or elsewhere.
- More research is needed into whether the continuous production of EBF in general, and by wheat in particular, will be effective in controlling cereal aphids in the long term due to habituation. Such research can and should be carried out with non-GM plants naturally producing EBF, such as peppermint.
- The GM wheat may be substantially different from its non-GM parent due to the impacts of the genetic modification, for instance there could be altered allergenicity and toxicity. There would be no point in trialling a crop that could late prove to be unsafe. The applicant admits having no basic data about any genetic changes arising from the GM events or any toxicity or allergenicity data of the chemicals to be produced by the wheat plant.
- The presence of the marker genes for resistance to kanamycin brings an unacceptable risk that the gene may horizontally transfer to pathogenic bacterium thereby rendering the antibiotic ineffective against some diseases. The application should be rejected for this alone in line with EU law.
- There is no proper environmental impact assessment of the potential direct, indirect or long-term impact of the aphid alarm pheromone on target and non-target organisms or on the environment, including in the soil.
- The impacts of the aphid pheromone EBF on prey and predator behaviour are not fully addressed by the experimental design or monitoring, including what happens to displaced aphids.
- The glufosinate ammonium tolerant marker gene could, at any stage, be used as an agronomic trait in a commercial variety to allow this herbicide to be used on a growing crop to kill off weeds. This would increase the risk of indirect harm to non-target species and potentially lead to the development of resistant weeds, which would require more herbicides to control them and with that an increase on the toxic burden on the environment.
- Alternative agroecological approaches to controlling aphids have not been fully explored despite showing considerable potential.
- Any unspent funds from the £1.28 million of public money allocated to the GM wheat should be used to research agroecological solutions to aphid control on cereals, and no further money should be wasted on developing and testing false solutions.

Please send a copy of your objection to your MP and ask her/him to question Defra directly. You can find your MP and contact details at www.writetothem.com. Thank you for taking this important action.

Notes

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