GM FREEZE

Briefing on BASF's Application to Field Test Blight Resistant Potatoes in 2007/08

Blight

Late potato blight (*Phytophthora infestans)* is one of 600 pests and diseases that affect potatoes which range from bacterial wilt to cyst eel worms to late blight. The latter is probably the most economically damaging of all. Slugs are also a major pest along with wire worms, cut worm and other soil dwelling insect larvae.

Late potato blight was responsible for the 19th Century potato famines in Ireland, when thousands starved to death because potatoes were such an important part of the diet and no other food was made available. At the time, the varieties being grown had little or no resistance to blight and tubers simply rotted in the ground or in store. When the first small stocks of potatoes were imported and grown in Ireland, it is likely that the blight pathogen was not imported with them – available but susceptible varieties grew very well and the poor became highly dependent on them. So when the blight pathogen did get into Ireland and establish itself, it was able to run riot.

At present fungicides are used heavily to control late blight on main crop potatoes. However, other diseases such as stem canker, black scurf, silver scurf and black dot, also require fungicide usage. Therefore, elimination of late blight does not necessarily mean the end to fungicide use on potatoes. In 2004 nearly 1.3 million kg of fungicide were sprayed on potato crops. Data of how much was applied specifically for late blight are not available via the Pesticides Safety Directorate's web site.

Late blight is partially weather-dependent in that it likes humid and damp conditions to get established on the foliage of potatoes and if this is followed by warm weather the disease can spread very rapidly to 100% infection in less than two weeks. The effect of infestation is that the foliage dies back prematurely and the tubers go soft (lesions caused by the pathogen develop on the tuber which are damaging themselves, but they are also infected rapidly by bacteria that can cause the tuber to collapse into a stinking mess) and become completely inedible.

Use of overhead irrigation can also create conditions suitable for blight to get established. The mono-cultural way we grow potatoes in the UK also leaves our crop open to blight attack and rapid spread of the disease. This is made even worse by the fact that one variety, Maris Piper, accounts for nearly one third of all main crop potatoes grown. This variety is poorly resistant to blight but it is much loved by the potato processing industry and supermarkets because of its shape and high dry matter content which makes it great for chips and crisps. It was the first commercial variety to carry resistance to potato cyst eel worm which is also a major pest. In organic systems cyst eel worm is controlled by adopting long rotations (a minimum of five years between successive potato crops).

Blight Resistance

Over recent decades conventional potato breeders have made a lot of progress in developing resistant varieties. Late blight resistance is assessed as part of the National List trials necessary for a new variety to be placed on the National List of Varieties. NIAB Recommended List also includes a score for late blight.

Of the 120 current varieties on the National List that have been field trialed by NIAB, 24 (20%) have good resistance for both foliar blight resistance and tuber resistance. Ten score very highly for both. So it is clear that blight resistance can be achieved through conventional breeding programmes. Times have changed since Ireland in the 1840s.

Blight resistance scores in potatoes apply to foliage and tubers. A variety such as Midas may have good foliage resistance (8) but scores lower for tubers (4). Conversely, Melody has poor foliage resistance (4) but acceptable tuber resistance (7). Maris Piper is low on both counts, but the top ten have high scores for both foliage and tuber resistance (e.g. Mira and Eve Balfour).

Late blight mutates all the time. The pathogen causing late blight exists as a large population containing much genetic variation, particularly in relation to virulence against blight resistant potatoes; many strains of the pathogen currently in existence contain various combinations of virulence genes. Production of a blight–resistant potato that contains resistance genes matching one of these virulence combinations means that it will only be a relatively short time before spores of the matching pathogen strain land on the resistant potato plants and overcome them. Individual varieties may last longer because the matching virulence is not readily available – it may depend on selection of a rare mutant or of a recombinant from sexual reproduction which brings two or more rare virulence genes together and in recent decades is evolving through sexual reproduction. This means that breeders have to be one step ahead of the disease. The rate at which the blight pathogen can overcome resistance is impossible to predict. Individual varieties can last for several decades or resistance can break down in a few seasons. It is not entirely clear how resistance works in these varieties but it appears that the main mechanism is the death of cells immediately next to the one where blight infection has tried to take hold. This causes a small brown spot on the leaf but the fungus cannot spread any further and the disease symptoms die back. The genetic variation lies in coding genes in the host and pathogen that determine whether this so-called hypersensitive response is switched on or not.

So far a blight resistant variety with the processing qualities of Maris Piper has not been produced. UK breeding has concentrated on yield, processing quality and appearance rather than blight resistance.

However, Hungarian breeders have been working on blight resistance since the 1940s and produce many highly resistant varieties. The Sarvari Research Trust has taken this work forward in the UK and produced varieties highly suitable for UK conditions and extremely resistant to blight. However, they have experienced problems in getting these varieties accepted by the supermarkets and processors on grounds of appearance (too knobbly), dry matter and late maturity. The Trust has now developed varieties that mature earlier than the very late maturing parent Hungarian stock. The Sarpo varieties are performing well in UK trials and in taste tests. However, none have so far forced their way into the top 20 commercial varieties. The development of a variety with very high blight resistance which also rivals Maris Piper for processing qualities may be some way off.

Research under EU funded Blight MOP project[1] looked at various other approaches to reducing blight. These include multi variety trials in which growing small blocks of each variety were shown to slow the start of infestation. However this does not lend itself to industrial scale production where uniformity of tuber is most important. Other agronomic approaches have so far not yielded major breakthroughs although accurate blight forecasting can help to reduce the use of prophylactic fungicide treatments.

Cross pollination

It is important to note that if a non-GM potato flower was cross-pollinated by GM potato pollen the tuber of the non-GM variety would still be non-GM. Only the seed would contain GM material.

Not all potato varieties flower and produce pollen. Some drop their flowers before fertilization. Others produce fruit (berries) but without viable seeds. Some produce fully fertile seed in their berries from which it is possible to grow new plants (Desiree being the best example from the

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[1] http://www.ncl.ac.uk/tcoa/producers/research/blightmop/

commercially popular varieties). Pollination is by insects including bumble bees, hover flies and pollen beetles (probably the most important). Long distance cross-pollination events have been found to occur. Potatoes do not cross with close relatives very easily and there is no evidence to date that this has occurred in the field. Two relatives, black nightshade and woody nightshade grow in farmland and are common. The potential for rare cross pollination events in the field cannot be ruled out. The discovery of GM charlock (an oilseed rape relative) following in the FSE trials provided some evidence that rare and improbable pollination events can and do occur. Their long term significance is very hard to judge without more knowledge of the likelihood of such events taking place.

Distances for potato to potato cross-pollination events of up to 1km have been recorded in which pollen beetles were believed to be the vector. See a comprehensive review at:

http://www.soilassociation.org/web/sa/saweb.nsf/b0062cf005bc02c180256a6b003d987f/e502ce130dc0df3d802571cd004eb285!OpenDocument&Highlight=2,emberlin

BASF GM Potatoes

The only details we have are contained in the application to DEFRA to trial late blight resistant GM varieties in Derbyshire and Cambridge in 2007 and 2008. 45,000 plants/ plot would be grown on 8 plots of around 1 hectare (2.43 acres) – two of which will be in Borrowash, Derbyshire, and 6 on NIAB trial grounds in South Cambridgeshire. Up to 500 plants will be GM per site in year one and up to 2000 in year two. The GM varieties will be grown alongside their non-GM parental lines and other non-GM varieties for comparisons for blight resistance, quality and volunteer control. The trial will also look at the impact of the GM varieties on insects associated with the crop. Part of the trial will be inoculated with British borne pathotypes of blight. It is extremely unlikely that this will impact on the overall occurrence of blight in the areas concerned because in normal years there are massive numbers of spores on the move anyway.

See http://www.defra.gov.uk/environment/gm/regulation/applications/06-r42-01.htm

BASF previously applied to hold the trials in Eire and eventually pulled out after conditions were placed on consent granted by the Irish EPA see http://www.gmfreeireland.org/press/GMFI26.pdf

The application is to test three GM varieties (no parentage is given in the application) which have been modified to resist late blight using two resistance genes from potatoes (*Rpi-blb1* and *Rpi-blb2).* Other genes used in the construct are the *ahas* gene which confers resistance to imidazolinone weedkillers (a gene from Thale Cress). The promoter gene comes from potato and the bacterium *A. tumefaciens*.

BASF's application reports that the three GM varieties to be used in the trials exhibit different rates of flowering and setting seeds.

Two varieties produce abundant flowers and the other is middling. One variety (P880) frequently sets berries although no information on the viability of the seeds is given. The other two exhibit rare or infrequent berry formation (P698 and P835 respectively). No information on the viability or longevity of seeds is provided. BASF dismiss any possibility of gene transfer via pollen.

Groundkeepers

At every harvest of potatoes, a number of small tubers (some not much bigger than a pea) fail to be harvested and remain in the soil. Occasionally bigger tubers also escape the harvesting equipment.

These can survive in the soil until the following year when they sprout to produce plants and, if left, to grow new tubers. In the case of GM potato these new tubers would also be GM. Control of these volunteer potatoes or ground keepers is either by herbicide or mechanical hoeing or digging. If left, groundkeepers can persist for up to seven years. This may be much longer if they grow and reproduce in some seasons, for example, when the surrounding crop is also a dicotyledon (broadleaf) so that only monocot herbicides are used. The problem with groundkeepers can be more chronic with organic production where dicot herbicides are never used. Thus, future non GM crops of potatoes could be contaminated if grown on the same land. BASF say that they are quickly killed by frosts. However, this depends on winters producing hard enough frosts to penetrate the soil deeply enough to reach unharvested tubers. Climate change appears to be producing warm winters and an increased rate of tuber survival. There is no doubt that naturally bred potatoes produce groundkeepers in the year following despite winter frosts

An additional problem is the disposal of old potatoes which may not have been sold. These can form small feral pollutions which could become a source of GM contamination in time although they only persist for any time in cultivated areas.

Effectiveness of the Blight Resistance Genes

BASF's application does not indicate whether the two blight resistance genes they have inserted confer resistance to the foliage, tubers or both. It is therefore difficult to judge how effective the blight resistance will prove to be in commercial growing. The only way to find out is to grow them commercially and monitor them closely. Resistance could be broken down rapidly or it could last for years as in some conventional blight resistance potato varieties. The speed of breakdown will largely depend on the virulence of the new strains of blight in overcoming the plants resistance.

The attractiveness of GM blight resistant potatoes (assuming durable resistance can be genetically modified into conventional varieties) is that they might be produced more quickly than conventional breeding. So, for example, the blight resistant Maris Piper could be available in a few years but it would take longer to get full GMO approval and National Listing before it could be commercially grown. However, potato varieties are effectively F1 hybrids – the breeder crosses two desirable varieties and harvests the tubers of the hybrid – with vegetative reproduction from then on it is a relatively quick process to build up stocks of a desirable cross – quicker than breeding crops that do not have vegetative reproduction available

Uses of GM Potatoes

BASF do not say what the GM trial potatoes will eventually be used for if they gain commercial approval and DEFRA were also unable to help. In the absence of any information it is probably wise to assume that they are intended for human consumption rather than to produce industrial starch.

This brings in the question of food safety. There are at least two examples where experimental GM potatoes produced entirely unpredicted outcomes in the parent. The first was a potato modified to have low levels of the NAD-malic enzyme. This modification had the surprising effect of increasing the potatoes starch content - an outcome the research team was unable to explain[2]. The second example comes from Germany when an attempt to introduce a yeast gene to increase starch content had the opposite effect and several unexpected compounds were formed by the disruption caused to the metabolism[3]. Research on GM potatoes[4] modified to produce an insect toxin was published in 1999. This research suggested a link between feeding GM potatoes

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[2] BBSRC Business, Jan 1998. "Making crops make more starch" p6-7
[3] Gura, T. 2000 Reaping the plant gene harvest Science 287 412-414
[4] Ewan, S.W.B. & Pusztai, A. (1999) Effect of diets containing genetically modified potatoes expressing *Galanthus nivalis* lectin on rat small intestine. The Lancet 354: 1353-1354.

and damage to the immune system and growth rates of rats. This research provoked much scientific controversy[5] at the time but no follow up research has ever been carried out.

BASF do not provide any evidence to show they have looked for such unexpected events in their GM potatoes or safety data. However it should be noted that it is intended that the GM crop be destroyed at the end of each trial Expert analysis of the GM construct and surrounding DNA may produce other issues of concern.

How Can We Object

There seem to be a number of grounds of objection to BASF's GM potatoes trials:

1. There is no demand for GM potatoes now or in the immediate future and therefore the trials represent an unnecessary risk to the environment and the integrity of the GM-free potato supplies in the UK.
2. There is no need to use GM for blight resistance because good numbers of blight resistant potatoes are already available in the UK and more are on the way via the Sarpo breeding lines and other programmes.
3. There is a risk the pollen could be transferred by insects to crops in the vicinity and the GM seeds resulting could germinate to contaminate future non GM crops.
4. GM ground keepers could persist in the field for a number of years, certainly into a subsequent potato crop in the rotation.
5. Small GM tubers could be transferred by machinery or even wild mammals off field to re-establish feral populations.
6. BASF provide no evidence that unexpected side effects of the GM insertion have taken place, or that they have any data on the safety of the GM potatoes.

Deadline 19th October

If the trial goes ahead Defra can place conditions on the release consent which would reduce the risk of any GM materials escaping or gene flow taking place.

The conditions could include:

- No other potatoes should be grown on the farm for the duration of the experiment
- All potatoes in the trial should be destroyed on site regardless of whether they are GM or not.
- A prohibition on future potato crops on the same land for 10 years.
- A requirement to monitor and control ground keepers for 8 years.
- A requirement to remove flowers prior to pollination.
- A separation distance of 1.5 km between the trial and the nearest non-GM potato crop including allotments or gardens.
- Fencing to prevent wild mammals entering the site.

If you wish to object the application reference number to quote is 06/R42/01

Either in writing to the GMO Scientific Assessment and Crop Co-existence Team, Department for Environment, Food and Rural Affairs, Zone 4/E6, Ashdown House, 123 Victoria Street, London, SW1E 6DE, stating the application reference number.
or to this email address gm-regulation@defra.gsi.gov.uk

GM Freeze October 2006

[5] Review of data on possible toxicity of GM potatoes. The Royal Society: London. 17th May 1999.