# The Protected Site – Seven Years of Field Research with Genetically Modified Plants

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**The Protected Site is fenced, guarded and surveilled in order to protect field trials with genetically modified plants from vandalism.** (Photo: Mario Waldburger, Agroscope)

## Summary

The Protected Site – Agroscope's secure trial area on the Reckenholz (Zurich) site – was established in 2014. Since then, it has offered a unique opportunity for field research with genetically modified (GM) plants in Europe, with stringent biosafety requirements and the highest security standards, not least as regards protecting the trials from vandalism. The establishment of a Protected Site is the outcome of a broad political consensus that field trials with GM crops should also be possible under the GM moratorium prevailing in Switzerland since 2005, thereby ensuring freedom of research in the plant sciences. The aim of the Protected Site is firstly to enable basic research on individual genes or combinations of genes as well as on GM plants and their interactions with the environment, and secondly to promote application-oriented research analysing the benefits and risks of GM plants for Swiss agriculture. These research activities contribute to the acquisition of experience with and evaluations of GM plants in Switzerland. In this way, important contributions can continue to be made to assist with the differentiated assessment and rating of newly developed breeding techniques, e.g. genome editing.

**Key words:** genetically modified plants, field trial, Protected Site, plant research, moratorium.

## The Origin of the Protected Site

The first field trials with genetically modified (GM) plants were carried out in 1986 in France and the US; shortly thereafter, researchers in Belgium, the UK and Chile also embarked on GM research (James & Krattiger, 1996). A virus-resistant GM tobacco was grown commercially in China for the first time in 1992 (James & Krattiger, 1996). Two years later, the first product of a GM plant was marketed in the US – a tomato with a longer shelf-life (Flavr-Savr tomato; Martineau, 2001). Today, GM varieties (particularly of soybeans, maize, cotton and oilseed rape) are cultivated on 13 % of the world's arable acreage (ISAAA, 2019).

Then as now a world leader in plant research, Switzerland took advantage of and further developed the new plant transformation opportunities from the very start. The first field trials with GM plants in Switzerland took place in 1991 and 1992 (Malnoë *et al.*, 1994). The experimental plants – virus-resistant potatoes – were developed and studied by Agroscope on the Changins site (then, still the Swiss Federal Research Institute Changins (RAC)). Only in 2004 and after many years' struggle to obtain a deliberate-release authorisation, ETH conducted a field trial with spring wheat at the ETH research station in Lindau-Eschikon (canton of Zurich) (Schlaich *et al.*, 2006). The scientifically successful trial, which received wide media coverage, was carried out in compliance with exceptionally stringent environmental regulations (Schlaich *et al.*, 2007; Fisch, 2013).

From 2008 to 2010, further field trials with GM plants took place in Switzerland as part of the National Research Programme 'Benefits and Risks of the Deliberate Release of Genetically Modified Plants' (NRP 59; www.nfp59.ch). The resistance to powdery mildew of different University of Zurich and ETH Zurich GM wheat lines was investigated in two projects at Agroscope's Reckenholz (ZH) and Pully (VD) sites (Mascher *et al.*, 2012). A further six projects addressed biosafety questions concerning these wheat lines (Foetzki *et al.*, 2011). In the first year of the trial (2008), a majority of the trial plots on the Reckenholz site were vandalised. In Pully, smaller attacks on the trials took place in both field seasons (2009–2010). For this reason, the field studies could only be continued under guard, a very costly option (Bernauer *et al.*, 2011; Romeis *et al.*, 2013). These attacks were by no means the only ones in Europe: In France and Germany in particular, but also in England, Italy and Belgium, field trials with GM plants conducted by academic or state research institutions were repeatedly destroyed from the late 1990s on (Gómez-Galera *et al.*, 2012; Kuntz, 2012). This led to a noticeable drop in experimental activity and to a call for the protection of such trials (Atkinson & Urwin, 2008).

One of the key conclusions and recommendations of NRP 59 was that field trials with GM plants are important for Switzerland as a centre of research, and that their effectuation must be enabled by ensuring that the high costs of security measures would no longer come out of research funding, but be covered by the establishment of so-called 'Protected Sites' (Bernauer *et al.*, 2011; NRP 59 Steering Committee, 2012). Consequently, the construction and operation of a protected site at Agroscope Reckenholz was provided for as research infrastructure in the Dispatch of 2013 on the Promotion of Education, Research and Innovation (ERI Dispatch), which the Swiss Federal Councils adopted in 2012. Since then, the operation of a Protected Site has been part of Agroscope's mandate, and is funded by the public sector with an annual budget of CHF 750,000.

In 2005 the Swiss electorate approved a five-year moratorium on the commercial cultivation of GM plants. Since then, the moratorium has been extended by the Swiss Parliament another three times, latterly until the end of 2021. In November 2020, the Federal Council proposed extending the moratorium by a further four years. Research, including field trials, is explicitly excluded from this moratorium, among others to allow the advantages and disadvantages of GM plants to be explored and in order to ensure freedom of research in Switzerland in the field of plant sciences.

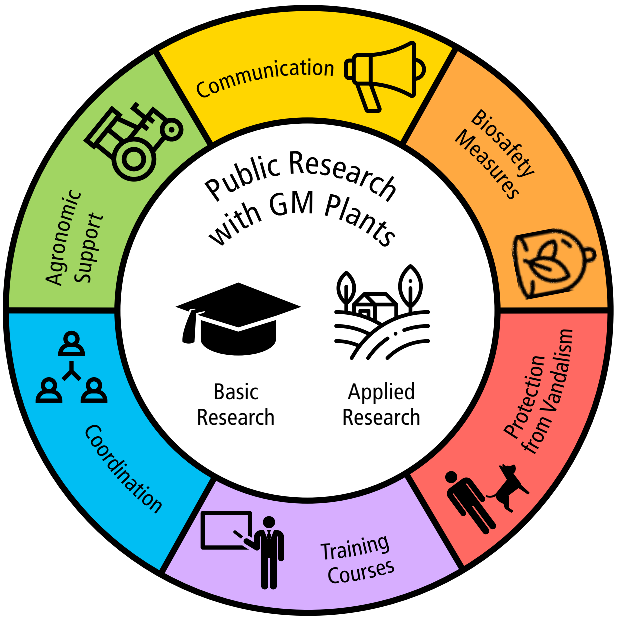


**Fig. 1 | Services provided by Agroscope as operator of the Protected Site.** (Icons: www.freepik.com and www.cleanpng.com)

## What Services Are Provided by the Protected Site?

Agroscope established the Protected Site on its experimental land on the Reckenholz site (ZH) and began operating it in March 2014. In addition to its role as operator of this trial platform, Agroscope also acts as user. As operator, Agroscope has several duties (Fig. 1): First and foremost, it ensures the protection of the trial field by means of fencing, round-the-clock guarding and surveillance and an alarm system. Management of the Protected Site also includes the provision of basic agronomic support for the field trials, e.g. tillage, sowing, fertilisation, harvest and plant-protection treatments. In addition, Agroscope is heavily involved in implementing the biosafety measures, both via compulsory training of the people working in the field trials as well as via measures in the field such as the cleaning of machinery and equipment or the laying of protective bird netting. Thanks to the field trials on the Protected Site, in collaboration with the Federal Office for the Environment FOEN and other agencies, experience can be gained in the enforcement of the legal provisions, the implementation of the enacted biosafety measures can be tested in trial practice, and unresolved questions can be answered on a scientific basis.
Technical and scientific coordination (trial planning and professional exchange between the various research groups) is also the responsibility of the operator. Moreover, Agroscope assumes an important role in communication by keeping the public informed via media releases, guided tours, and its own website (www.protectedsite.ch), in consultation and collaboration with the researchers. Consequently, the Protected Site has also developed into a point of contact for media professionals regarding genetic engineering.

## Field Trials on the Protected Site

Around three hectares in size, the Protected Site is subdivided into a completely netted facility (23 ares) set up for trials with GM apple trees, as well as four subplots of an average size of 60 ares which can be used for arable crops. To date, GM plants have been grown on two of these subplots every year, and a four-year crop rotation has been ensured. Keeping as close as possible to a conventional crop rotation is important for maintaining soil fertility and generating results that are relevant for practice. Furthermore, the plots must be managed in such a way as to allow the requirements for subsequent treatment of the trial plot (e.g. the monitoring of volunteer plants) stipulated in the relevant release permit to be met. This places tight constraints on the simultaneous use of all four plots for GM trials, or rather renders their simultaneous use impossible.
The number of field trials with GM plants on the Protected Site grew quickly in the beginning, and since 2017 four projects have run in parallel (Fig. 2). The field trial with genetically modified winter wheat (Fig. 2), focused on whether the use of a gene from barley for sugar transport can increase the yield potential of wheat. All other trials dealt or deal with the researching of the

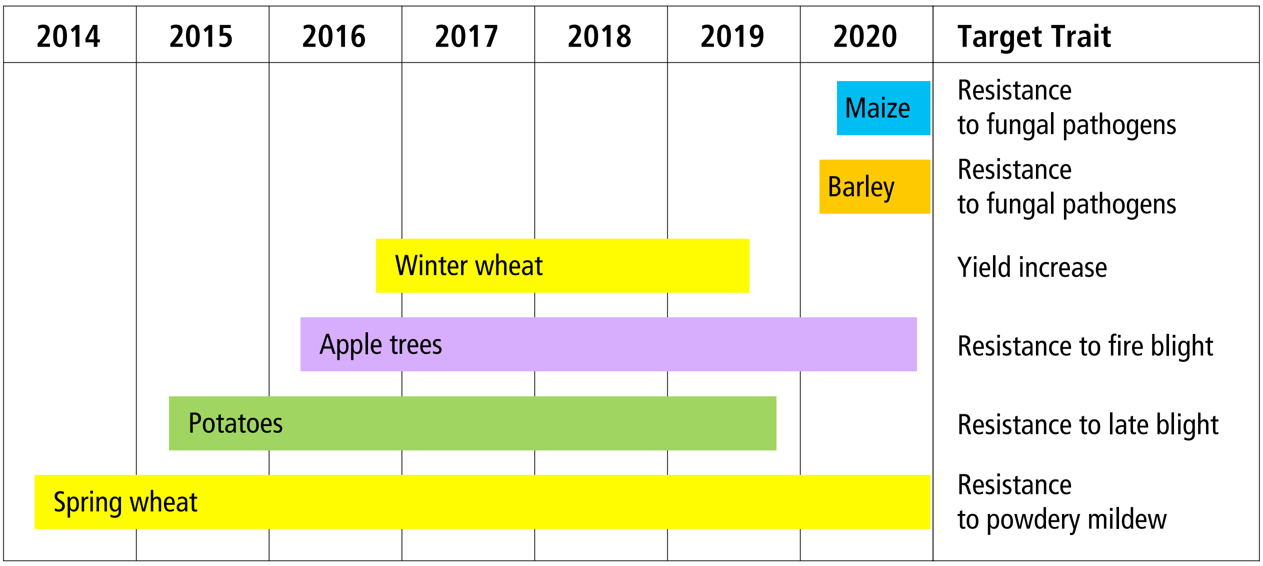


**Fig. 2 | Time period of the field trials, crop and target trait of the GM plants that have been studied on the Protected Site to date.**

plants' disease resistance. In the GM spring wheat project, the aim is to amass further findings on how powdery-mildew resistance genes function and could be combined. The effect of broad-spectrum, exceptionally long-lasting disease resistance from wheat is being tested in GM barley and maize. The aim of these three studies is a better understanding of the varied interactions of plants and pathogens, which will contribute to basic research on crop disease resistance. In the netted facility, cisgenic[1] apple trees with fire-blight resistance originating from a wild apple tree were being studied in order to pursue basic questions on the effectiveness of the inserted resistance, as well as any possible unintended effects thereof. Somewhat more application-oriented, or already closer to a commercial product, are the cisgenic potato lines whose resistance to the potato late blight pathogen was improved (see box and Fig. 3).

## Challenges of Field Trials with GM Plants

GM plants fall under the Gene Technology Act (GTA), and their release is governed by the Release Ordinance (RO). Field trials with GM plants are subject to authorisation, and the relevant application must be submitted to the Federal Office for the Environment (FOEN) (Fig. 4). Such an application is extensive (usually around 80 pages long) and requires specialist knowledge in the fields of biology (especially molecular biology, botany and ecology) and agronomy (plant production and breeding), as well as basic legal knowledge. With the 2004 wheat field trial, ETH researcher and project leader Christof Sautter laid valuable groundwork via the first field release application under the Release Ordinance (RO) that came into force in 1999, which then served as a template for the three NRP 59 applications. Despite the increasing number of examples, drafting a new application still demands around 5 to 6 months of a research associate's time.

Compared to field trials without GM plants, therefore, considerable preparatory work must be invested in the drafting of a release application. The authorisation requirement has two further consequences: firstly, experience has shown that it takes 6 to 7 months after submission of the application to obtain an approval decision, and so this is the soonest that the field trial can start. During this period, the FOEN checks the completeness

[1] Only genes from the same or a crossable species were transferred to cisgenic plants by means of genetic engineering techniques. These genes could also have been introduced by conventional cross-breeding. Cisgenesis, i.e. the production of cisgenic plants, is one of the so-called new plant-breeding techniques.

### Field Trial on the Protected Site with Cisgenic Late Blight-Resistant Potatoes

**From 2015 to 2019, a field trial with cisgenic[1] potatoes was conducted on the Protected Site. The cisgenic potatoes carry up to three resistance genes from wild potato species against the potato late blight pathogen (*Phytophthora infestans*). A combination of several resistance genes conferred complete resistance throughout all the years of the trial, confirming the results of similar field trials in The Netherlands and Belgium (Haesaert *et al.*, 2015; Haverkort *et al.*, 2016). Whereas Swiss commercial potato crops require 7–8 plant-protection treatments on average to protect them from the aggressive potato late blight pathogen (SCNAT, 2018), the cisgenic lines showed no disease symptoms whatever in these trials, even without plant protection (Fig. 3). Since a combination of several resistance genes is difficult for the pathogen to overcome, these plants could be grown without the application of plant-protection products, thus simultaneously massively reducing yield losses and plant-protection product use in potato production.**


Fig. 3 | **Field trial with cisgenic potato plants on the Protected Site. Fungicide treatments were forgone for the entire trial. Left of centre in the photo is a row of the variety 'Atlantic' heavily infected with late blight. To the right of this there is a row with cisgenic Atlantic which is completely resistant thanks to its two resistance genes from wild potatoes, *Rpi-vnt1* and *Rpi-sto1*.** (Photo: Susanne Brunner, Agroscope)

of the application and publishes the notification of receipt of the application in the Federal Gazette, at which point the time limits for statements from three further federal expert committees, two federal commissions, one cantonal agency and the public begin to run. After expiry of the deadline, the FOEN checks all statements received and any applications for party status[2], carries out a final assessment and drafts the decision with the potential rulings (Fig. 4). A delay of just a few weeks in these processes can mean missing the sowing or planting time, entailing a wait until the following year.
Also relevant for the preparation of an experimental release is the fact that in the approval process particularly affected persons are granted party status, i.e. these persons can object to the trial and to the decision of the FOEN. To date, party status rights have been asserted for three trials. In all three instances the approval process was significantly delayed, so that in all cases the trials could only begin one field season later than planned.
Despite the uncertainty of whether and when a release trial will be authorised, researchers should ideally start the processes of applying for a release permit, obtaining

[2] 'Party status' means participation in legal or administrative proceedings. Administrative procedural law stipulates that party status presupposes both the capacity to be a party to legal proceedings (legal capacity) and a legitimate interest in the proceedings. It is determined on a case-by-case basis. Interests worthy of protection in connection with field trials with GM plants are e.g. not suffering any health or financial damage, or environmental damage to one's real property.

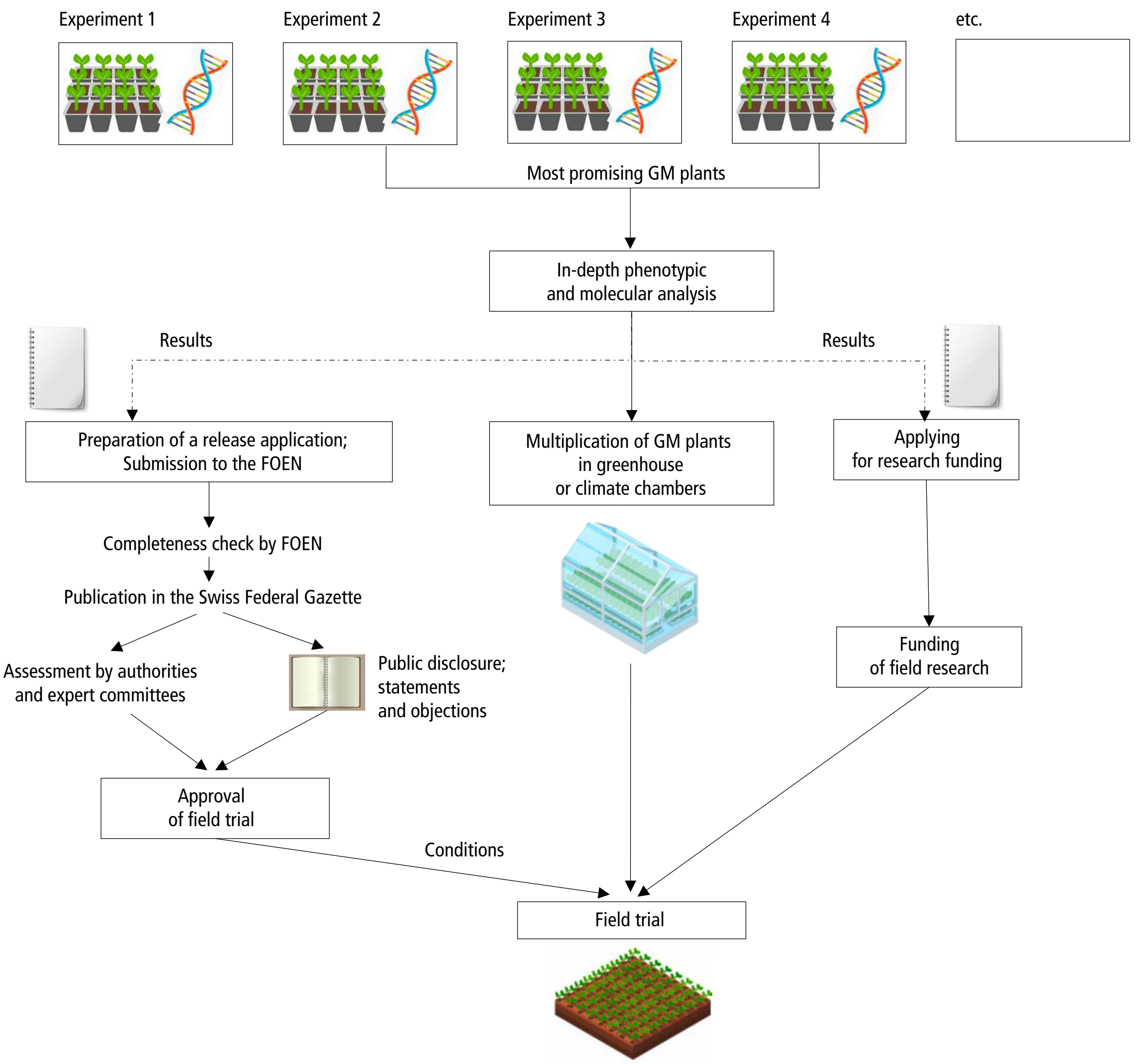


**Fig. 4 | Essential preliminary work for conducting a field trial with GM plants (FOEN: Federal Office for the Environment).**
(Icons: www.freepik.com, designed by Macrovector)

funding and multiplying the GM plants in parallel, in order not to lose time (Fig. 4). In a typical research project, this is usually hardly feasible, however.

If a release authorisation is granted after the application is examined, it is always subject to conditions, the aim of which is to minimise the likelihood of GM plants being disseminated outside of the trial field, or even entering the food chain. Depending on the trial, these mandated measures demand negligible-to-substantial compromises in the scientific studies. With the GM apple trees, for example, flowering, or more precisely, pollen dispersal had to be prevented. Although individual apples may be produced by removing the anthers and then hand-pollinating the blossoms with non-GM pollen, it is not possible to collect fruit yield data under these conditions.

Switzerland is unusual in that it prohibits field trials with GM plants carrying an antibiotic resistance marker (ARM)[3] if the antibiotic in question is used in human or veterinary medicine. As a result, many GM plants are excluded from field trials in Switzerland. Accordingly, international cooperation in this area is significantly restricted for Swiss researchers. To date, there have been at least three projects where researchers had to abandon the submission of a release application for the Protected Site owing to these constraints.

## Conclusions and Prospects

To date, six multiyear field trials with GM plants have been or are being conducted on the Protected Site. So far, all trials have run undisturbed, and have successfully generated new basic knowledge as well as new findings for agricultural application. As intended, the Protected Site supports the researchers in the implementation of the biosafety regulations and in the coordination and communication of their experiments. All in all, the Protected Site provides the research community with a functioning platform which reliably enables field research whilst keeping the public informed in a transparent manner and providing straightforward access for interested parties or the media – very much in the spirit of a window into GM plant research.

In the years ahead, field research with GM plants will be influenced by whether and how the moratorium on cultivating GM plants in Switzerland, which expires at the end of 2021, is extended. Although field research continues to remain possible if there is an extension, application-oriented research would be less attractive owing to the lack of prospects. Today, a whole range of new methods, most notably the genome-editing techniques (e.g. CRISPR/Cas), are available for plant breeding. Both in Switzerland and the EU, all of the plants produced with these techniques are currently subject to gene technology legislation. The national and international scientific community is calling for differentiation of these tools, since they can be applied in an exceptionally wide variety of ways, from transgenic use to nature-identical mutation breeding. At least 140 market-oriented crops are currently being developed at international level by means of genome editing (Menz *et al.*, 2020). Today, plants which were modified via these techniques without incorporating foreign genetic information are not classified as GMOs in many countries, and we can expect the approval of such varieties to increase dramatically in these markets. Nowadays, genome-editing techniques are an integral part of both basic and applied research, and are also helping to boost knowledge in crop research. Consequently, genome-edited plants will also be researched on the Protected Site in the near future. ■

[3] Selection markers are used during the production of GM plants. They confer a characteristic to the cells that allows researchers to efficiently select the fraction of the cells which actually carry the genes to be introduced. Afterwards, these markers no longer serve a function. Most often, a resistance to antibiotics or a tolerance to herbicides is used.

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