Syngenta

Switching off farmers' rights?

Syngenta
Switching off farmers' rights?

Author: Hugh Warwick, Genetics Forum
Editors: Alex Wijeratna, ActionAid; François Meienberg, Berne Declaration
Research: Dr Sue Mayer, GeneWatch UK; Valentin Küng, Küng-Biotech+Umwelt
October 2000

Contents

Executive summary 6

Introduction 7

Corporate players 8
AstraZeneca **8**
Novartis **8**

Syngenta merger 10

Corporate concentration 11

The technology 12
'Terminator' **12**
'Traitor' **12**

Global reaction 14

Patent review 16

Demands 23

Conclusions 24

References 25

Executive summary

In October 2000 AstraZeneca and Novartis merged their agribusiness interests to become Syngenta. Their aim is to become the world's first global business solely focused on agribusiness – making and selling:

- herbicides, fungicides, insecticides
- seeds.

Both AstraZeneca and Novartis have been accused in the past of working on GM crops which would enforce a continuing dependence on buying their products. The most famous are 'Terminator seeds' – seeds modified to grow plants which produce infertile seed. Farmer have always saved seed, and 1.4 billion people still rely on them as their primary seed source. 'Terminator' means farmers would have to buy new (patented) seed or chemicals which will switch off the sterility each year – at an increased and annual cost. Such a cost would be felt heavily by poor farmers in the South.

'Terminator' is just one example of a range of GM techniques known as 'Genetic Use Restriction Technologies' (GURTs). These work by controlling the traits of GM crops with the application of special chemicals. The plants' natural functions – or traits – are betrayed: hence they have been dubbed 'Traitor Technology'. It was the Canadian-based Rural Advancement Foundation International (RAFI) who first exposed the technology and coined the terms 'Terminator' and 'Traitor' in 1998/99. The research in this report builds on RAFI's earlier analysis.

After much public outcry, both AstraZeneca and Novartis made public promises that they would not commercialise the 'Terminator' patents they owned. However, investigations in this report show that research and development around 'Terminator' and 'Traitor' seeds has continued since those promises were made.

We have uncovered 11 new patents held by both companies which allow for genetic modification of staple crops which will:

- produce disease prone plants (unless treated with chemicals)
- control the fertility of crops
- control when plants flower
- control when crops sprout
- control how crops age.

Syngenta will have the single largest interest in GURTs of all the global GM companies. Out of a total of 60 GURTs patents identified to date, Syngenta own 25, or 42 per cent.

In the light of the evidence in this report, the four authors, ActionAid, Berne Declaration, GeneWatch UK and the Swedish Society for Nature Conservation have serious concerns about the potential impact Syngenta's work on 'Terminator' and 'Traitor' technologies could have on poor farmers in the South if commercialised. We encourage civil society to scrutinise 'Traitor Technology' and have issued the following demands to Syngenta and national governments:

1. that Syngenta commits not to develop any crops using 'Terminator Technology'
2. that Syngenta commits not to develop plants with weakened disease resistance and/or where the possibility of growing farm-saved seeds with the same characteristics is made dependent on the use of a chemical inducer
3. that in line with recommendations from the UN Convention on Biological Diversity (COP5), Syngenta will not conduct field trials on 'Traitor Technology' until the results of assessments of the impact of the technology are available
4. that Governments agree a global ban on 'Terminator Technology'
5. that Governments do not allow field testing of 'Traitor Technology' and assist the CBD in the assessment of its impacts.

October 2000

Introduction

The world's largest GM company has just been created. AstraZeneca and Novartis have agreed to merge their agribusiness interests to form a new company called Syngenta AG. Syngenta is the first global business solely focused on agribusiness. The multinational will be ranked number one in the world for agrochemicals (herbicides, fungicides and insecticides), number two for seed treatments and will be the third largest seed supplier – with combined sales of $7.34 billion.

Both AstraZeneca and Novartis have been researching 'Genetic Use Restriction Technologies' (GURTs), the most famous of which is 'Terminator Technology'. 'Terminator Technology' generates sterile seeds that force farmers to buy new seed or new chemicals each year. GURTs – dubbed 'Traitor Technology' – relate to the control of other plant characteristics, or traits. These traits can be switched on or off by the application of a proprietary (or company licensed) chemical.

In the context where multinationals are buying up local seed companies and dominating national seed markets in the South (eg, the corn market in Brazil where Monsanto now control 60 per cent of the market) and restricting the choice of varieties available, should the varieties of crops on the market contain a high or higher proportion of GURTs seeds, poor farmers may find they have no choice but to use GURTs seeds. This may be particularly true if they can only afford to buy seeds by accepting inducements of technical assistance or credit provided by the selling company.[0]

The uproar following revelations that GM companies were racing to genetically engineer sterility into seeds led some corporations to reconsider and declare that they would never commercialise the technology.

In 1999 Zeneca Agrochemicals said: "[The company] is not developing any system that would stop farmers growing second generation seed, nor do we have any intention of doing so."[1] The CEO of Zeneca Agrochemicals, Michael Pragnell, wrote to ActionAid stating: "Zeneca has no interest in trying to change farmers' traditional practice of saving seed and in fact we decided in 1993 not to develop and bring to market any systems which would prevent farmers from doing this. We have no intention of revising this decision". Novartis said in February 2000, that they had, "a long-standing policy that we will not use genetic use restriction technology to prevent seed germination."

But where does the merger leave these promises? These companies have said no to 'Terminator', but they have left themselves clear to develop 'Traitor', which will oblige farmers to buy chemical inducers each year. But is there evidence they are forging ahead with 'Terminator' and 'Traitor' technologies? Currently 1.4 billion people depend on farmer-saved seed as their primary seed source. Many civil society organisations (CSOs) see GURTs as a further erosion of farmers' rights. "If they can't save seed, they can't continue to adapt crops to their unique farming environments, and that spells disaster for global food security."[2] The consolidation of the seed market and reduction of choice to an increasing proporation of GURTs seeds is potentially a real threat to seed saving.

New evidence in this report suggests that both partners merging into Syngenta have been pursuing 'Terminator' and 'Traitor' on a broad front. ActionAid, Berne Declaration, GeneWatch UK and the Swedish Society for Nature Conservation have uncovered 11 patents now owned by Syngenta. These reveal GM technologies that are designed to control crucial aspects of the lifecycle of crops through the use of (often) proprietary chemicals. The characteristics are tied in with the use of chemicals that could force poor farmers in the South into chemical dependencies. Syngenta is working on:

- control of the fertility of crops
- control over when they flower
- control over when they sprout
- control over how they age and even
- control over whether their immune systems activate or not.

All these patents are GURTs. The UN recommends that GURTs not be field-tested and that there should be a moratorium on their development until their impact has been fully assessed.[3]

Corporate players

AstraZeneca Plc

15 Stanhope Gate
London W1K 1LN
United Kingdom
Telephone: +44 (0) 2073045000
Website: www.astrazeneca.com

AstraZeneca is a major pharmaceutical and agrochemical multinational that realigned as a 'Life Sciences' company. It formed in 1999 when UK-based Zeneca Group Plc merged with Astra AB, from Sweden.[4] AstraZeneca had a market capitalisation of $85 billion in 1999 and total sales of $15 billion. It was the world's third largest agrochemical company (behind Novartis and Monsanto) and the fifth largest seed company.[5]

Zeneca Agrochemicals have invested heavily in biotech research and development (R&D), which trebled to $60 million between 1997–98. Sales from this division were $2.7 billion in 1999.[6] Its pesticides are sold in 130 countries around the world.

Zeneca recently described itself as:

"One of the leading companies in agricultural biotechnology. Key to the research strategy is the increasing integration of bioscience activities across agrochemicals and seeds. This integrated approach enables Zeneca to offer farmers improved crop quality and yield with better crop protection solutions."[7]

AstraZeneca has over 50 collaborations world-wide which include links with universities in Europe and the US and research institutes such as the John Innes Centre in the UK, and other companies such as Incyte and ExSeed Genetics.

A large target for AstraZeneca is the developing world where the potential for expansion is great. For example, its biggest selling product is paraquat, for which it has just opened a new factory in China.[8] Paraquat is widely used to control weeds for plantation crops such as coffee and cocoa. It is a highly toxic chemical, classified as a Class 1b poison and highly hazardous by the World Health Organisation, and it has no antidote. One teaspoon is fatal and there have been deaths caused through accidental ingestion because of its similarity to Coca Cola[9] (though now many varieties of the chemical are coloured blue.) The toxicity is also thought to build up in the soil. Sweden and Denmark have banned it, and the Federal Republic of Germany have introduced severe restrictions.[9]

Novartis AG

Lichtstrasse 35
4056 Basel
Switzerland
Telephone: +41 (0)613241111
Website: www.novartis.com

Novartis formed when Swiss agrochemical/pharmaceutical companies Ciba-Geigy and Sandoz merged in 1996. The merger was an indication of their desire to distance themselves from the uncertain chemical markets, and refocus as a 'Life Sciences' company.

With total sales of $19 billion in 1999,[10] Novartis' main areas are pharmaceuticals, nutrition and agrochemicals.[11] Pharmaceuticals account for 56 per cent of all Novartis' sales and agribusiness 24 per cent, but the divisions have been increasingly integrated through the company's development of biotechnology.

They have invested actively in GM, spending $100 million on biotechnology out of a total R&D spend of $2 billion in 1999. They have also increased their interests in genomics and bought up seed companies.[12] They recently opened a new insecticide factory in China, capable of producing 5,000 tonnes of insecticide a year.[13]

Novartis agribusiness sector had sales of $4.7billion in 1999,[14] making it the second largest after Aventis.

A report into their 1999 sales reveals why Novartis is spinning off its agrochemical interests:

"Crop Protection sales were affected by weak farming economies, strong price competition

and the difficult economic situation in Brazil, Russia and Ukraine. Herbicides came under heavy pressure in corn, and fungicides sales were impacted by strong competition…" The report goes on to say that for its seed industry, *"sales in the NAFTA region declined, with corn-seed sales suffering from price pressure and acreage reductions, and soybean sales being impacted by the increased use of farm-saved seed."*[15]

The two companies that formed Novartis had a history of scandals. Sandoz was responsible for a disaster in 1986 when 30 tons of hazardous organophosphate pesticides spilled into the Rhine river, killing fish, wildlife and plants. And Ciba-Geigy was found to have sprayed young boys in Egypt with the pesticide chlordimeform in 1976 to see how it was absorbed into their bodies. This pesticide is a suspected carcinogen.[16]

Despite its size, Novartis has remained relatively untouched by the furore over GM crops in Europe. While Monsanto was vilified, Novartis protected itself from the media. This is despite the fact that their main GM crop, Bt maize (called Event 176 or 'Maximiser'), contains a controversial antibiotic resistance marker gene.

Novartis, however, failed to escape entirely. While the European Commission finally approved Bt maize in 1997, Austria and Luxembourg quickly banned its import, and France decided to suspend authorisation for its commercial growing in December 1998.[17]

In apparent reaction to the outcry over GM crops, Novartis announced in August 2000 that they were eliminating genetically engineered ingredients from their entire worldwide line of consumer food products, including Gerber baby foods, Ovaltine, Wasa crackers, and their line of diet and health foods.[18]

But the work on GM remains unblunted. Of the 22 maize and soya varieties announced for sale by Novartis in September 2000, only a quarter are conventional. Most are GM with specific chemical tie-ins. The majority are linked to YieldGard, Liberty Link and RoundUp – pesticides licensed from other biotech corporations such as Monsanto and Aventis.[19] And in the pipeline there is a GM maize product, Acucorn, which contains a gene that builds in resistance to a particular herbicide (protoporphyrogen oxydase). These are a new line of herbicides that Novartis will launch at the same time as its Acuron crops in order to challenge Monsanto's top-selling RoundUp Ready herbicide line. Novartis hope that Acucorn will be commercially available in 2003.[20]

The merger

Syngenta
Schwarzwaldallee215
4058 Basel
Switzerland
Telephone: +41616971111
Website: www.syngenta.com

Syngenta have headquarters in Basel, Switzerland, and the company will be floated on the Swiss, London, New York and Stockholm stock exchanges. The relative share value will be for Novartis, 1:1 and for AstraZeneca, 1:40.83, ie, shareholders will receive one Syngenta share for every 40.83 AstraZeneca shares. The total market value is estimated to be $20 billion.[21]

"This new company will be the first global business to be solely focused on 'Agribusiness'. It will be the world-leader in this sector with a turnover of $7.34 billion and 23,500 employees, leading the way in insecticides, herbicides and fungicides; it will also be the third largest in seed production."[22]

About 13 per cent of the new business will be seeds and the remaining 87 per cent dedicated to crop protection.[23] The main products include the selective herbicides Bicep Magnum, Fusilade and Surpass, the non-selective herbicides Gramoxone, Touch, Amistar, Bravo, Ridomil Gold, Score and Tilt, and the insecticides Curacon, Force and Karate.

Syngenta's aims are:
- creation of the world's first Agribusiness only corporation
- creation of a unique international sales and service network
- development of market sectors with sustainable growth
- accelerated developments of progressive solutions
- achievement of leader-status in new crop protection technologies like 'input' and 'output traits'.

The merger will not be without human costs – 3,000 jobs are expected to be lost worldwide and the restructuring costs are estimated to be around $850 million.

The new management will be led by Novartis' Heinz Imhof as President and David Barnes of AstraZeneca as Vice-President, with Zeneca Agrochemicals CEO, Michael Pragnell, taking on the role of Syngenta CEO.[24]

The European Commission, acting as competition watchdog for the European Union, required that each company make a number of disinvestments before the merger was authorised. This was due to concerns about the creation or strengthening of dominant positions in certain markets. The cereal fungicides based on strobilurin and flutriafol, as well as maize herbicides sulcotrione and acetochlor, were sold as part of this deal. For example, in the herbicide protection of maize, the merger would have created a market share of up to 65 per cent in some countries, four times bigger than the nearest rival, Aventis.[25]

Syngenta will be a truly global concern. The pro forma regional turnovers for 1999 (below) indicate the spread of interests.[26]

Region	Turnover ($ millions)	Research and production sites
Europe, Africa, Middle East	2,877	40
NAFTA	2,463	18
Latin America	955	7
Asia-Pacific	1,040	21

Corporate concentration and control

Agrochemical sales of the top five companies [27]

Company	1998 Sales ($ millions)	1st Half 1999 Sales ($ millions)
Syngenta	7,049*	3,733
Aventis	4,676	2,672
Monsanto	4,032	3,069
BASF	4,139	2,333
DuPont	3,156	1,872

* Based on the agrochemical sales of AstraZeneca and Novartis for 1998

Top five plant biotech patent holders [28]

Company	Patents	% Total
Syngenta	205	9
DuPont/Pioneer	184	8
Monsanto	173	8
Aventis	55	2
Dow Agrosciences	45	2

Although these figure show 30 per cent of all plant biotech patents are held by five companies, this is, in effect, a gross underestimate. The figures do not include the patents held by institutes with exclusive licensing agreements with the corporations. The true figure is estimated to be at least 50 per cent.[29]

Since the first planting of a GM crop, the agro-chemical companies have consolidated and transformed themselves into biotechnology giants, buying local seed companies, plant-breeding and biotech companies and made alliances with shippers, processors, distributors and retailers. This vertical integration has resulted in vast control over the food chain by a handful of corporations.

By 2000, only four companies account for virtually the entire global transgenic market: Syngenta, Monsanto, Aventis and DuPont. Seventy one per cent of current GM crops are herbicide-tolerant – ie, they are genetically engineered to be resistant to a specific herbicide, most often produced by the same company.[30] Four crops – soya, maize, canola and cotton – accounted for 99 per cent of all transgenic crops planted worldwide in 1999.[31]

The concentration of power extends into agrochemicals. Between them the five largest companies, Syngenta, Aventis, Monsanto, BASF and DuPont, will account for over 70 per cent of the global pesticide market.

Vertical integration is leading to the concentration of supply into fewer hands and, inevitably, to further intensification and monoculture production for farmers. This is because industrial hybrid and GM seeds are essentially designed to work in monoculture. Monoculture farming reduces biodiversity, undermines food security and hastens the demise of indigenous knowledge and varieties. Such effects are particularly problematic in poorer areas. It is recognised that reductions in biodiversity create instability in the agricultural ecosystem and can also lead to the evolution of more aggressive pests and diseases, which are more difficult to control.[32]

The control that Syngenta will exert extends beyond the production of seed and agrochemicals. A sample of 60 patents was identified by the Rural Advancement Foundation International (RAFI) as being 'Traitor' and 'Terminator-type' technologies. Of these 25, or 42 per cent, will be held by Syngenta. This is by far the largest proportion held by any single company.[33,34] (This does not include the eleven uncovered in this report.)

The technology

'Terminator'

GM 'Terminator' plants are genetically engineered to produce sterile seed. By inserting a series of 'promoter' and 'marker' genes and gene switches, it is possible to interrupt and switch on or off the sterility of crops at the molecular level by applying chemicals to the plant. Seed can be harvested but not saved as a source for the next planting without the repeated use of a chemical inducer.

In the first original 'Terminator' patents identified in 1998, a specific chemical triggers a genetically engineered suicide mechanism. The trigger is an antibiotic (called tetracycline) applied to the seeds. The result is that the next generation of seeds is dead.

"Its declared goal is to promulgate plants that will produce self-terminating off-spring – suicide seeds," wrote Dr Steinbrecher and Pat Mooney. "'Terminator Technology' epitomizes what the genetic engineering of crops is all about and gives an insight into the driving forces behind the corporate campaign to control and own life."[35]

This may sound dramatic and anti-farmer, but not all see it this way. Harry Collins, vice president of Delta & Pine Land Company, explained: "The centuries old practice of farmer-saved seed is really a gross disadvantage to Third World farmers who inadvertently become locked into obsolete varieties because of their taking the 'easy road' and not planting newer, more productive varieties."[36]

However, the Crucible Group (which includes the International Plant Genetic Resources Institute and the Dag Hammarskjold Foundation) puts 'Terminator' into a wider context.

> *"The monopoly control afforded by 'Terminator Technology' goes far beyond patents and threatens national sovereignty. A patent is a time-limited, legal monopoly granted by a government in exchange for societal benefits. In the case of the 'Terminator', the biological monopoly is not time-limited, and is not necessarily approved by national governments."*[37]

'TerminatorTechnology' was sold initially to the world as a 'Technology Protection System', to protect the investment of the biotech companies. Then the biotech industry changed tack and started to use the 'Green Gene Defence'. This argued that 'Terminator' seeds are beneficial to the environment because they could mitigate the problem of horizontal gene transfer (when genetically engineered crops spread their genes into unengineered crops and wild populations). The theory is that the engineered traits will be prevented from generating 'accidents' and outcrossing by the 'Terminator Technology'.[38] This is a tacit admission that the potential hazard of horizontal gene transfer is real, and contradicts reassurances given when GM crops were first released into the wild. And it also ignores the risks posed by 'gene-silencing' – where intended changes unaccountably fail to work. If this were to happen with crops that were thought free from the risk of contamination and the 'Terminator Technology' failed, it could lead to the spread of the GM contamination.[39] Furthermore, if the 'Terminator' or 'Traitor' crop cross-pollinates a neighbour's crop, they may find some of their seed is sterile.

'Traitor'

The agrobiotech corporations are racing beyond 'Terminator' towards more specific crop control technologies. Controlling more sophisticated traits than just the fertility of seeds brings advantages to corporations because it leaves the farmer to grow seeds but ensures that farmers still pay to use these seeds effectively each year. This is where 'Traitor' come to the fore. 'Traitor Technology' is considered more subtle than 'Terminator' because it is controlling more sophisticated traits than just the sterility of seeds. The authors of this report believe that it is potentially just as insidious and threatening to the interests of poor farmers in the South.

The full scope of trait control has been emerging since 1999. Researchers found that corporations were working to control genetic traits in plants with external chemical catalysts, or promoters, to show (or 'express') the desired trait. This means that a crop's basic functions can be regulated and induced by the external application of chemicals. So, for example, the moment when (or even if) a plant flowers, its yield or its fertility can all be controlled by the application of chemicals. Or, if the right chemical were not applied, the plant could become highly susceptible to disease [see p17, Novartis US 6,091,004].

These traits are all covered by the patents examined below.

"The ultimate goal appears not to be to force farmers to buy [new] corporate seed every year but to force farmers to pay for [the effective use of] their seed every year – capturing enormous cost savings for the company and rendering the commercial merit of aggressive new plant breeding methods. Farmers are becoming trapped in a pattern of biological controls that lead inevitably to bioserfdom."[40]

These GM crops have been described as 'junky' plants because they are chemically dependent. The farmer will get the option of buying seeds with various 'add-ons' that can be activated at the point of sale – for a price. The chemical switch used to activate the feature, or inactivate a negative trait, will be a proprietary chemical. This ties the farmer to the corporation.

The socio-economic implications are serious. 'Traitor Technology' could counteract the aims of international agreements such as the UN's FAO International Undertaking on Plant Genetic Resources which provide farmers with the right to save or conserve seed. International and national political decisions which safeguard rights (eg, national intellectual property rights laws which confirm farmers' rights to save seed without paying license fees) could be overcome by corporations. Farmers' rights and privileges could be compromised to such an extent that farmers may not be able to buy crops with fully-operational immune systems.

Global reaction

The world was outraged by 'Terminator Technology' and condemnation came from governments, CSOs and development agencies.

"If the owners of technology, such as big companies, used it to victimize people through methods such as promotion of 'terminator genes', the state should intervene and not leave the task to the market mechanism."
Maurice Strong, former Secretary General, UNCED[41]

"For example, in India where there are nearly 100 million operations holdings, denial of plant-back rights or the use of the terminator mechanism will be disastrous from the socio-economic and biodiversity points of view, since over 80 per cent of farmers plant their own farm-saved seeds."
MS Swaminathan, former chair of the UN Food and Agriculture Organisation's (FAO) Council.[42]

"We are against ['Terminator']. We are happy to see that in the end some of the main multinationals which have been involved in implementing these terminator genes have decided to backtrack."
Jaques Diouf, FAO Director General.[43]

"The agricultural seed industry must disavow use of the 'Terminator Technology' to produce seed sterility… The possible consequences, if farmers who are unaware of the characteristics of 'Terminator' seed purchase it and attempt to reuse it, are certainly negative and may outweigh any social benefits of protecting innovation."
Professor Gordon Conway, President, Rockefeller Foundation.[44]

The Consultative Group on International Agricultural Research (CGIAR) recommended in 1998 that its 16 research institutes ban the use of 'TerminatorTechnology' in their crop-improvement programmes.

"The International Agricultural Research Centres, supported by the CGIAR system, which are engaged in breeding new crop varieties for resource-poor farmers, will not incorporate into their breeding materials any genetic systems designed to prevent seed germination."[45]

Criticism also came from governments. Panama, India, Ghana and Uganda have all announced their intention to oppose 'Terminator Technology'.

And the UK Government, through the Department for International Development, stated that they have given an undertaking "not to develop, test or use breeding material which incorporates genetic systems designed to prevent seed germination."[46]

One of the most intense debates so far over GURTs – or 'Traitor Technology' – was at the Fifth Conference of the Parties (COP5) to the UN Convention on Biological Diversity (CBD) held in Nairobi in June 2000. The UN's final text on GURTs recommends:

"…that, in the current absence of reliable data on genetic use restriction technologies without which there is an inadequate basis on which to assess their potential risks, and in accordance with the precautionary approach, products incorporating such technologies should not be approved by Parties for field testing until appropriate, authorized and strictly controlled scientific assessments with regard to, inter alia, *their ecological and socio-economic impacts and any adverse effects for biological diversity, food security and human health have been carried out in a transparent manner and the conditions for their safe and beneficial use validated. In order to enhance the capacity of all countries to address these issues, Parties should widely disseminate information on scientific assessments, including through the clearing-house mechanism, and share their expertise in this regard."*[47]

Many Southern governments called for tougher action. The African Group called on all Parties to:

"…immediately ban the 'Terminator Technology' from respective national territories and thus, from the whole of Africa, as intolerable politically, economically and ethically and in terms of safety of plant life, and in the future, be constantly on the look out for unacceptable products of biotechnology."[48]

Monsanto's CEO, Robert Shapiro, met the criticism with the pledge that they were "not to commercialize gene protection systems that render seed sterile." It had, erroneously, been reported that Monsanto did not own any 'Terminator Technology' patents – that its only involvement was through its failed attempt to purchase Delta & Pine Land Company. In fact, Monsanto does have such a system, patent WO97/44465 – 'Method for Controlling Seed Germination Using Soybean ACYL COA Oxidase Sequences.'[49]

AstraZeneca has said they will not commercialise systems which prevent seed saving, and Novartis claimed they were not pursuing systems which prevented seed germination. But at no stage, despite the protests, were any patents or patent applications actually withdrawn.

The corporations gave the impression that 'Terminator' was terminated and lulled many into a false sense of security. But this was never the case. The industry has carried on with its research full steam ahead.

"We've continued right on with work on the 'Technology Protection System'. We never really slowed down. We're on target, moving ahead to commercialize it. We never really backed off." Harry Collins, Delta & Pine Land Seed Company, January 2000.[50]

It has since been revealed that the US Department of Agriculture (USDA) has received two new 'Terminator' patents and has been testing the technology in laboratory conditions. So far experimental 'Terminator' tobacco plants have been grown at the USDA lab in Lubbock, Texas. There is every intention to commercialise the technique.[51]

A USDA spokesperson, Willard Phelps, said the goal of the USDA's new technology is "to increase the value of propriety seed owned by US seed companies and to open up new markets in Second and Third World countries."[52]

A US company, ExSeed Genetics, which AstraZeneca has a 20 per cent stake in, also has a 'Terminator-type' patent. The patent (WO9907211 'Controlled germination using inducible phytate gene') states that the inducible traits are "useful to a seed company because it maintains germplasm security by rendering the seed incapable of being reproduced for breeding purposes" and it "prevents farmer saved seed by rendering the seed incapable of being reproduced for future years."

But 'Terminator' and 'Traitor' are not just in the US. At least one 'Traitor' technique has been tested in the UK to date. Potatoes with an alcohol-sensitive switch mechanism to control when the potato sprouts was field-tested at Zeneca's Jealotts Hill research station in Berkshire between May and November 1999, and repeated this year. These experiments were undertaken without the knowledge of the scientific advisors to the UN COP5 meeting in Nairobi.

Given that there has been no let up in research into GURTs, will industry resist commercialisation? And in the light of dizzying corporate mergers and takeovers, do their previous pledges mean anything? Monsanto, AstraZeneca and Novartis have all now merged.[53] Do their promises still stand?

Patent review

'Terminator-like' and 'Traitor' patents issued to AstraZeneca and Novartis in the last two years (to June 2000).[54,55]

Company	Patent Number	Title	Date Issued
AstraZeneca	WO9906578	Genetic method for controlling sprouting	11 February 1999
AstraZeneca	WO9929881	A method for increasing plant yield and controlling flowering behaviour	17 June 1999
AstraZeneca	WO9942958	Hybrid seed production	26 August 1999
Novartis	US 6,018,105	Promoters of plant protoporhyringen oxidase genes	25 January 2000
Novartis	US 6,018,104	Nucleic acid promoter fragment isolated from a plant tryptophan synthase alpha subunit (trpA) gene	25 January 2000
AstraZeneca	WO0009708	Novel DNA constructs comprising protease encoding sequences used in cells for disruption of cell function, controlling senescence, and modification of stored protein	24 February 2000
AstraZeneca	WO0009704	Gene switch	24 February 2000
Novartis	US 6,031,153	Method for protecting plants	29 February 2000
Novartis	US 6,057,490	Method for selecting disease resistant mutant plants	2 May 2000
Novartis	US 6,091,004	Gene encoding a protein invovled in the signal transduction cascade leading to systemic acquired resistance in plants	18 July 2000
Novartis	US 6,107,544	Method for breeding disease resistance into plants	22 August 2000
ExSeed Genetics, (Zeneca has stake in ExSeed Genetics)	WO9907211*	Controlled germination using inducible phytate gene[56]	18 February 1999
Novartis	US 5,880,333*[57]	Control of gene expression in plants by receptor mediated transactivation in the presence of a chemical ligand	9 March 1999

* Patents uncovered by RAFI[58]

The following is a selected reveiw of the latest GURTs patents.

Zeneca Ltd Patent WO99/42958

Publication date: 26 August 1999
Title: Hybrid Seed Production.[59]

Abstract

Methods of preparing hybrid seed are described. One such method comprises interplanting a male parent plant which is male fertile and homozygous recessive female sterile and a female parent plant which is homozygous recessive male sterile and female fertile, allowing cross-pollination and obtaining the seed produced therefrom. The genomic material of each parent plant may also have integrated therein a gene construct comprising a promoter sequence responsive to the presence or absence of an exogenous chemical inducer, optionally operably linked to one or more enhancer or intron sequences, operably linked to a gene which fully restores the fertility of each parent plant, the gene being expressed by the application to the plant of an external chemical inducer thereby allowing each parent to self-pollinate.

Analysis

Zeneca's stated purpose in developing the 'invention' described in this patent is to improve the production of hybrid varieties of GM crops. "…The present invention relates to the molecular control of sterility in crop plant. Such male and female sterility in plants can be used in the preparation of hybrid seed from crops which are naturally self pollinating."

In order to produce pure hybrid seed, it is essential that cross-pollination only occurs between the two parent varieties and that self-pollination or pollination by the same variety does not take place. This system ensures that happens by generating male sterility in one variety and female sterility in another.

Zeneca's approach differs from existing GM systems for producing pure hybrid seed in its use of a female sterile variety in addition to male sterility. Until now, only male sterile varieties have been used and any unwanted seed produced by self-pollination has been removed by physical or genetic means.

Since each has been genetically modified to be either male or female sterile, they cannot reproduce unless their sterility is reversed. This is achieved by applying a chemical that switches on a gene in the plant that restores its fertility. The chemicals which Zeneca proposes using for this purpose include alcohol and 'herbicide safeners' such as its own patented 'dicloramid'.

Zeneca's new system for producing high purity hybrid seed – which it suggests could be applied to wheat, rice, maize, barley, soybean, sunflower, cotton, sugar beet, lettuce, oilseed rape and tomato – comes at a cost to the farmer. Although the hybrid seed they buy will be fully fertile, a proportion of the seed produced by the resulting crop will be sterile. This proportion depends on the method of genetic engineering used. When the sterility system is targeted at the pollen and egg, most of the harvested seed will be sterile. If it is targeted at the structures that make the pollen and egg, there will be less sterile seed. In either case, however, if farmers keep some of the harvested seed for resowing, they will be gambling on the proportion that will actually germinate and grow. In effect, therefore, farmers will be forced into buying new seeds each season if they want to guarantee maximum fertility of the seeds they plant– good news for the seed producer.

Comment: 'Another Terminator'

This is a 'Terminator-type' technology. The end result is that a proportion of the seeds are sterile, 25 per cent or 50 per cent depending on the technique used. This will prevent farmers being able to rely on saved seed – exactly the same intention as the original 'Terminator'. Sterility options are deliberately engineered into these seeds.

Zeneca Ltd Patent WO09929881

Publication date: 17 June 1999

Title: A method for increasing plant yield and controlling flowering behaviour.[60]

Abstract

The present invention describes a method of increasing plant yield. Also described are DNA constructs comprising DNA sequences coding for proteins involved in sucrose transport, metabolism and uptake operably linked to controllable promoter regions and plants transformed with said constructs. More particularly a method for the controlled production of said proteins resulting in an alteration in plant growth characteristics, flowering time and in yield is described.

Analysis

In this patent, Zeneca explain how they will use their chemical switch system (the alcohol sensitive alcA/AlcR system) together with genes which target expression in certain tissues or organs such as the fruit, seed or leaf. This means that traits, such as flowering and yield, can be controlled by the application of a chemical. In this instance the chemical is ethanol.

> *"We have unexpectedly found that the controlled expression of an invertase gene using the alcA/AlcR switch promoter system leads to an increase in plant height, an increase in leaf size and to an increase in up to 10 per cent in the fresh weight of a plant and accelerates the time at which the plants flower ie the plants flower early."*

The patent states that the invention could be applied to crops such as *'field crops, cereals, fruit and vegetables such as: canola, sunflower, tobacco, sugar beet, cotton, soya, maize, wheat,* *barley, rice, sorghum, tomatoes, mangoes, peaches, apples, pears, strawberries, bananas, melons, potatoes, carrot, lettuce, cabbage and onion, trees such as eucalyptus and polar trees and cut flowers and ornamentals.'*

The patent notes that it may be particularly useful for improving the uniformity of bananas.

Comment: 'Controlling spring time'

There is the potential that this technology could be used to squeeze an extra harvest into the year by controlling flowering. In an attempt to maintain strict control over the production of a crop, the flowering times will be synchronised. The control of this trait removes the crop even further from the ecosystem and into the factory. For example, insects that depend on some variety in the flowering times of crops to gather nectar will have their options reduced. As has been seen with the widespread use of insecticides, whatever affects the insects also affects the rest of the food chain. So spring might be co-ordinated, but it may also be silent.

Zeneca Ltd Patent WO 0009708

Publication date: 24 February 2000

Title: Novel DNA constructs comprising protease encoding sequences used in cells for disruption of cell function, controlling senescence, and modification of stored protein.[61]

Abstract

An isolated DNA construct comprising: a) a first DNAsequence comprising either an inducible promoter sequence responsive to the presence or absence of an exogenous inducer or a developmental gene promoter capable of initiating gene expression in a selected tissue or at a selected stage of development of an organism; b) a second DNA sequence comprising a DNAsequence coding for a protease enzyme operably linked and under the control of the promoter sequence specified at (a); whereby the presence or absence of the exogenous inducer or the activation of the developmental gene promoter specified at (a) results in expression of said protease enzyme. These constructs are preferably rendered reversible by the presence of further elements. They can be used in plant or mammalian cells for disruption of cell function, controlling senescence and modifying the metabolism of stored proteins.

Analysis

Zeneca describes the use of chemical switches to control the process of cell maturation, ageing and dying in both plant and mammalian cells: *"The present invention relates to DNAconstructs, for use in transformations of plant and mammalian cells. In particular, the present invention relates to a DNAconstruct which enables cell function to be disrupted and, optionally, for the disruption of cell function to be reversed".*

The patent describes how chemicals could be used to delay ageing in plants and, in particular, its use in preventing pre-harvest sprouting and delaying seed maturation.

The patent considers the invention could be applied to any plant which can be genetically modified and refers specifically to: canola, sunflower, tobacco, sugar beet, cotton, cereals such as wheat, barley, rice, maize and sorghum, fruit such as tomatoes, mangoes, peaches, apples, pears, strawberries, bananas, and melons and vegetables such as carrot, lettuce, cabbage and onion.

Comment: 'Controlling ageing'

Whilst the stated intention is to produce animal feed and foods where nutritional quality is maintained, rather than reduced, as occurs as seed or fruit ages and germinates, it also means that the seeds may have to be treated before they can be planted if they are to germinate properly. Thus the farmer is tied into a seed/chemical relationship with the corporation.

Novartis Finance Corporation Patent: US 6,091,004

Publication date: 18 July 2000

Title: Gene encoding a protein involved in the signal transduction cascade leading to systemic acquired resistance in plants.[62]

Abstract

The invention concerns the location and characterization of a gene (designated NIM1) that is a key component of the SAR pathway and that in connection with chemical and biological inducers *enables induction of SAR gene expression and broad spectrum disease resistance in plants. The invention further concerns transformation vectors and processes for overexpressing the NIM1 gene in plants. The transgenic plants thus created have broad spectrum disease resistance.*

Analysis

This patent involves an isolated DNA molecule (NIM1 gene) that encodes a NIM1 protein involved in the signal transduction cascade leading to systemic acquired resistance (SAR) in plants. The SAR signal transduction pathway is critical for maintaining plant health. SAR is a particularly important aspect of plant disease responses because it gives resistance against a broad spectrum of infectious agents, including viruses, bacteria, and fungi. When the SAR pathway is blocked, plants become more susceptible to pathogens that cause disease, and they also become susceptible to some infectious agents that normally would not cause disease.

The main claim of the patent is a GM plant with increased SAR gene expression and enhanced disease resistance.

But the patent also relates to plants which are defective in their normal response to pathogen infection because they do not express genes associated with SAR and are highly vulnerable to disease.

Comment: 'Immuno-deficient plants'

The aim of the technology in this patent is the creation of a transgenic plant with enhanced disease resistance. This trait is linked to an external promoter chemical, thus tying the farmer into a relationship with the chemical/seed company. But it also covers the potential to develop immuno-repressed plants that, without the correct inducer chemical applied to the seeds, will be hugely susceptible to disease.

Novartis AG Patent: US 6,031,153

Publication date: 29 February 2000.
Title: Method for protecting plants.[63]

Abstract

The present invention concerns a method of protecting plants from pathogen attack through synergistic disease resistance attained by applying a conventional microbicide to immunomodulated plants. Immunomodulated plants are those in which SAR is activated and are therefore referred to as 'SAR-on' plants. Immunomodulated plants may be provided in at least three different ways: by applying to plants a chemical inducer of SAR such as BTH, INA, or SA; through a selective breeding program based on constitutive expression of SAR genes and/or a disease-resistant phenotype; or by transforming plants with one or more SAR genes such as a functional form of the NIM1 gene. By concurrently applying a microbicide to an immunomodulated plant, disease resistance is unexpectedly synergistically enhanced; ie, the level of disease resistance is greater than the expected additive levels of disease resistance.

Analysis

This patent covers a method of protecting a plant against disease through synergistic disease-resistance attained by applying a microbicide to a plant which has had its immune system adjusted (immunomodulated).

An immunomodulated plant is in an activated state to protect itself against disease, this provides a certain level of disease resistance in a plant. Similarly, application of a microbicide to a plant provides a certain level of disease resistance. The expected result of combining immunomodulation with microbicide application would be a level of control reflecting the additive levels of control provided by the individual methods. However, by applying a microbicide to an immunomodulated plant, the disease resistance is unexpectedly enhanced; ie the level of disease resistance is greater than the expected additive levels of disease resistance. This is a synergistic effect.

While the immunomodulation confers disease resistance through activated SAR and the microbicide also works to protect the plant, the effect of both controls running concurrently is greater than expected.

However, the claims of the patent cover not only functional NIM1 genes that promote SAR, but also altered forms of it that are able to block the SAR activation and hence deactivate the immune response.

The patent claims the application and the effect of 28 different substances, mainly fungicides.

The following crops are listed as principal targets for the patent: barley, cucumber, tobacco, rice, chilli, wheat, banana, and tomato.

But in the 'background of the invention' the list of crops is more extensive:

"Examples of target crops for the areas of indication disclosed herein comprise, without limitation, the following species of plants: cereals (maize, wheat, barley, rye, oats, rice, sorghum and related crops), beet (sugar beet and fodder beet), stone fruit and soft fruit (apples, pears, plums, peaches, almonds, cherries, strawberries, raspberries and blackberries), leguminous plants (beans, lentils, peas, soybeans), oil plants (rape, mustard, poppy, olives, sunflowers, coconut, castor oil plants, cocoa beans, groundnuts), cucumber plants (marrows, cucumber, melons), fibre plants (cotton, flax, hemp, jute), citrus fruit (oranges, lemons, grapefruit, mandarins), vegetables (spinach, lettuce, asparagus, cabbages, carrots, onions, tomatoes, potatoes, paprika), lauraceae (avocados, cinnamon, camphor), or plants such as tobacco, nuts, coffee, sugar cane, tea, vines, hops, bananas and natural rubber plants, as well as ornamentals (flowers, shrubs, broad-leaved trees and evergreens, such as conifers). This list does not represent any limitation."

Comment

The patent protects two very different types of application, although only the application of point (1) is explicitly claimed in the patents:

1 Disease resistance is maximally enhanced in an immunomodulated (SAR-activated) plant when concurrently applying a microbicide to this immunomodulated plant.

2 The patent also describes the use of an immunodeficient plant which is defective in expressing the SAR system. SAR-activating genes, linked to an inducible promoter, can be transformed into the plant by genetic engineering. Without external induction the plant would be highly disease susceptible.

Mutants have been isolated that are blocked by SAR signalling. These mutants can be selected by conventional breeding or genetically engineered by transformation (gene replacement).

Such mutants mentioned in the patent can be the starting point for modelling a desired plant with an inducible disease resistance; inducible by a chemical substance sold by the producer of the crop variety. The consequences of the commercial application of strategy of point (2) could be far-reaching. The ability to germinate healthy plants out of such a variety according to point (2) is very limited because the plant's ability to protect itself against pathogens has to be activated first by applying an external chemical inducer.

That means that a plant that is untreated during vegetation period or that is grown out of a non-treated seed will be susceptible to disease and could not protect itself against plant pathogens.

A possible commercial use can be deduced by the following from the patent indicating that seed coating can be used in connection with the necessary induction of plant disease resistance to get healthy plants.

"In order to treat seed, the microbicide can also be applied to the seeds (coating), either by impregnating the tubers or grains with a liquid formulation of the microbicide, or by coating them with an already combined wet or dry formulation. In addition, in special cases, other methods of application to plants are possible, for example treatment directed at the buds or the fruit trusses."

Under the title 'background to the invention' the authors of the patent write:

"Crop plants are particularly vulnerable (to diseases) because they are usually grown as genetically-uniform monocultures; when disease strikes, losses can be severe. However, most plants have their own innate mechanisms of defence against pathogenic organisms. Natural variation for resistance to plant pathogens has been identified by plant breeders and pathologists and bred into many crop plants. These natural disease resistance genes often provide high levels of resistance to or immunity against pathogens".

Disease-resistance mechanisms which were lost during a long period of conventional breeding without selecting for disease resistance have been brought back into crops using genetic engineering – but now owned by a private company.

Novartis Finance Corporation Patent: US 6,107,544

(1 of 2; see p20, US 6,057,490)
Publication date: 22 August 2000.
Title: Method for breeding disease resistance into plants.[64]

Abstract

Methods are provided for selecting parental plants exhibiting disease resistance and for using these plants in breeding programs. In one method of the invention, constitutive immunity (CIM) mutants are screened for either resistance to a pathogen of interest or for the expression of systemic acquired resistance (SAR) genes. Such mutants having the desired traits or expressing the desired genes are then used in breeding programs. Parent plants can also be selected based on the constitutive expression of SAR genes. These mutants are phenotypically normal yet exhibit a significant level of disease resistance. Also disclosed are lesion-simulating-disease (LSD) mutants having a lesion mimic phenotype that also express SAR genes and exhibit disease resistance. Further disclosed are non-inducible immunity (NIM) mutants that do not express SAR genes, even when induced by a pathogen. Methods of use for these mutants are also disclosed.

Novartis Finance Corporation Patent: US 6,057,490

(2 of 2; see p19, US 6,107,544)
Publication date: 2 May 2000.
Title: Method for selecting disease resistant mutant plants.[65]

Abstract

Methods are provided for selecting parental plants exhibiting disease resistance and for using these plants in breeding programs. In one method of the invention, constitutive immunity (CIM) mutants are screened for either resistance to a pathogen of interest or for the expression of systemic acquired resistance (SAR) genes. Such mutants having the desired traits or expressing the desired genes are then used in breeding programs. Parent plants can also be selected based on the constitutive expression of SAR genes. These mutants are phenotypically normal yet exhibit a significant level of disease resistance. Also disclosed are lesion-simulating-disease (LSD) mutants having a lesion mimic phenotype that also express SAR genes and exhibit disease resistance. Further disclosed are non-inducible immunity (NIM) mutants that do not express SAR genes, even when induced by a pathogen. Methods of use for these mutants are also disclosed.

Analysis

The claims of these two patents can be divided in three parts:

1. The patent concerns methods for breeding disease resistance into plants. The method involves selecting disease lesion mimic mutants based on either resistance to a pathogen of interest or on the expression of systemic acquired resistance (SAR) genes.
2. It also involves the identification of proteins believed to be part of a common defensive systemic response of plants to infection by pathogens. Associated with the onset of SAR is the expression of pathogenesis-related (PR) proteins. Some of which have a role in providing systemic acquired resistance to the plant. PR proteins have been found in many plant species and are believed to be a common defensive systemic response of plants to infection by pathogens.
3. The patent also concerns plants that *do not express systemic acquired resistance genes*, even when induced by a pathogen. Such non-inducible immunity mutants, which have a universal disease susceptible phenotype, have utility for use in disease and pathogenesis testing and fungicide screening programs.

   "The present invention further relates to nontransgenic mutants that are defective in their normal response to pathogen infection in that they do not express genes associated with systemic acquired resistance.

   (…)

   Non-inducible mutants develop severe disease symptoms under these circumstances, whereas non-mutants are induced by the chemical compound to systemic acquired resistance."

These plants would, therefore, be highly susceptible to disease.

The source of the genetic material and mutants claimed in the patent is broad.

"Disease resistant mutants have been reported in a variety of plants including but not limited to maize, tomato, wheat, Arabidopsis, oats, tobacco, sunflower, cucumber, etc. Accordingly, the invention can be used in breeding any plant in which disease resistant mutants can be found or induced through mutagenesis, …"

and

"As SAR and SAR gene expression is a phenomenon ubiquitous to plants in general, NIM mutants can be generated from any plant species."

Comment

The patent emphasises using the invention to select parental plants exhibiting disease resistance and using these plants in breeding programs. But the patent also claims the protection and the use of non-immunity mutants. They stress their use for disease and pathogenesis testing and fungicide-screening programs.

However, such mutants can be the starting point for plant breeding programs, where the disease resistance genes are artificially introduced by genetic engineering and where these genes are coupled to inducible promoters. The plant's resistance to diseases has to be induced by chemical substances, sold by the same company. Without the inducing substance the plant would be highly susceptible to diseases.

The following aspects should also be considered. There are parts in the text of patents US 6,107,544 and US 6,057,490, which contain keywords associated with 'Terminator-like Technology'. For example:

"In one embodiment of the invention the transgene causing cell death (eg the CIM1-derived gene in antisense) is expressed under a pollen specific promoter to cause male sterility in the female parent, whereas the pollinator carries a construct in antisense to the pollen specific construct (ie antisense-to-antisense), which is fused to the chemically regulatable PR-1a promoter. Thus, in the F1 hybrid plant population, treatment with the chemical inducer of the PR-1a promoter will activate the pollinator-line derived gene and block the expression of the mother parent-derived gene allowing normal flowering of the F1 hybrid. In an analogous fashion, lines can be created that are female sterile (by utilizing a promoter that is expressed in gynaecium tissue only)."

These parts of the patent show that certain genes coding for disease resistance mechanisms can also be used for 'Terminator-type' applications. This is not unexpected as this technology can be used in the production of hybrid seeds. Future patents using genes coding for disease resistance combined with pollination specific promoters or other promoter coupled to male or female specific gene expression, such as here, should be watched carefully.

Demands

In the light of the evidence in this report, the four authors, ActionAid, Berne Declaration, GeneWatch UK and the Swedish Society for Nature Conservation have serious concerns about the potential impact Syngenta's work on 'Terminator' and 'Traitor' technologies could have on poor farmers in the South if commercialised. We encourage civil society to scrutinise 'Traitor Technology' and have issued the following demands to Syngenta and national governments:

1. that Syngenta commits not to develop any crops using 'Terminator Technology'
2. that Syngenta commits not to develop plants with weakened disease resistance and/or where the possibility of growing farm-saved seeds with the same characteristics is made dependent on the use of a chemical inducer
3. that in line with recommendations from the the UN Conference on Biological Diversity (COP5), Syngenta will not conduct field trials on 'Traitor Technology' until the results of assessments of the impact of the technology are available
4. that Governments agree a global ban on 'Terminator Technology'
5. that Governments do not allow field testing of 'Traitor Technology' and assist the CBD in the assessment of its impacts.

Conclusions

There has been no slow down on research into GURTs. It is also clear that the distinction between 'Terminator' and 'Traitor' is less clear. Much of the 'Traitor' work is not about creating sterile or 'suicide' seeds but about injecting control mechanisms into the crops that bind the farmer to the corporation. But the end result – that farmers are unable to plant saved seed successfully – is the same.

These technologies could continue the transformation of global agriculture. And due to the vertical integration of the biotechnology and agrochemical industry, the control over the food chain is tightening – moving from farmers' into corporate hands. Corporate domination of national seed markets in the South is reducing the number of seed varieties available from which farmers can choose. As companies increase the proportion of GURTs seeds in the available pool, farmers could find that there are fewer and fewer other options available. Credit and other inducements can help GURTs seeds look like a more attractive option for poor farmers. The impact of the finanacial dependency on the seed/chemical company that these seeds bring for such farmers may be realised too late.

This report has uncovered patents with alarming potential. The patents that talk of creating plants with higher resistance to disease also claim the rights for plants that have a severely compromised immune system. If this technology was commercialised, farmers would have to buy proprietary chemicals simply to activate the immune system. This would tie the farmer into a dependent relationship where each year they would need to return to the agrochemical supplier to 'activate' seed.

The issue of farm-saved seed was identified by Novartis as one of the reasons for spinning off its seed and agrochemical divisions.[66] Novartis was not achieving the sales it wanted because farmers insisted on saving seed. This is the clearest indication of the corporation's desire to circumvent the age-old practice of saving seed. While this is becoming rarer in the developed world, at least 1.4 billion people rely on farm-saved seed worldwide.

References

0 Wilkinson, J and Castelli, P, *The internalization of Brazil's seed industry*, ActionAid Brazil, September 2000, p65.
1 Letter from Dr DA Evans of Astra Agrochemicals to CAMBIA, Australia, 24 February, 1999.
2 Novartis Corporate Profile, PANAP 2000 (in press).
3 COP5 cops out. RAFI News Release, 20 June 2000. www.biodiv.org/Decisions/COP5/html/COP-5-Dec-05-e.htm
4 AstraZeneca's website – www.astrazeneca.com
5 Isabel McCrea & Dr Sue Mayer. *AstraZeneca and its genetic research: feeding the world or fuelling public hunger?* ActionAid 1999. p15.
6 Business wire, July 26, 2000.
7 Zeneca Annual Report and Accounts 1995.
8 *Lords of Poison: The Pesticide Cartel. Seedling*, June 2000. p18.
9 Barabara Dinham, 1999: *Zeneca: the impact on food security. Hungry for Power*: U K Food Group, London. p71.
10 www.novartis.com
11 Reuters, July 26 2000. Full Text – EU ruling on AstraZeneca, Novartis deal.
12 Novartis Corporate Profile, PANAP 2000 (in press).
13 *Lords of Poison: The Pesticide Cartel. Seedling*, June 2000. p18.
14 www.syngenta.com
15 http://www.info.novartis.com/investors/sales1999.htm
16 Novartis Corporate Profile, PANAP 2000 (in press).
17 A SEED Europe, Novartis report in Corporate Genomics series, 1999. p5.
18 *Bursting the Biotech Bubble. BioDemocracy News* #29 (Sept. 2000).
19 Cropchoice, 9 September 2000.
20 *Agrow* No 323, 26/02/99, p.21, quoted in PANAP, Novartis Corporate Profile (in press).
21 http://news6.thdo.bbc.co.uk/hi/english/business/newsid%5F546000/546147.stm
22 1 December, 1999. Letter to shareholders of Novartis from Dr Daniel Vasella, CEO.
23 1 December, 1999. Information supplied to Novartis shareholders.
24 *Ibid*.
25 Reuters, July 26 2000. Full Text – EU ruling on AstraZeneca, Novartis deal.
26 www.syngenta.com
27 *Lords of Poison: The Pesticide Cartel. Seedling*, June 2000.
28 *Ibid*.
29 *Ibid*.
30 Isabel McCrea, Dr Sue Mayer. *AstraZeneca and its genetic research: feeding the world or fuelling public hunger?* ActionAid 1999. p9.
31 *Lords of Poison: The Pesticide Cartel. Seedling*, June 2000. p25.
32 RA Ennos, *The influence of agriculture on genetic biodiversity*, BCPC, 1997 (referred to in *Hungry for Power, The impact of transnational corporations on food security* UK Food Group, March 1999.) p68.
33 RAFI, 30 January 1999. *Traitor Technology, The Terminator's Wider Implications*.
34 RAFI, 12 May 2000. *Terminator Two Years Later: RAFI Update on Terminator/Traitor Technology*.
35 Steinbrecher, R. & Mooney, P. *Terminator Technology, The Threat to World Food Security. The Ecologist*, Vol.28, No. 5, September/October 1998. p12.
36 Dr Harry Collins, D&PL Co, Vice-President. Taken from *New Technologies and Modernizing Agriculture*, an unpublished paper distributed at June 1998 FAO meeting.
37 *Seeding Solutions*, volume 1, published by IDRC, IPGRI and Dag Hammarskjold Foundation, 2000.
38 RAFI, 12 May 2000. *Terminator Two Years Later: RAFI Update on Terminator/Traitor Technology*.
39 Steinbrecher, R. & Mooney, P. *Terminator Technolgy, The Threat to World Food Security. The Ecologist*, Vol.28, No. 5, September/October 1998.pp276-279
40 RAFI, 30 January 1999. *Traitor Technology, The Terminator's Wider Implications*.
41 Statement made in India, April 7, 1999. RAFI, 12 May 2000. *Terminator Two Years Later: RAFI Update on Terminator/Traitor Technology*.
42 Swaminathan, M.S., *Farmers' Rights and Plant Genetic Resources, Biotechnology and Development Monitor*, No. 36, 1998, p6–9. RAFI, 12 May 2000. *Terminator Two Years Later: RAFI Update on Terminator/Traitor Technology*.
43 Reuters Interview with FAO – GMOs could help war on hunger, 8 February 2000. p6. RAFI, 12 May 2000. *Terminator Two Years Later: RAFI Update on Terminator/Traitor Technology*.
44 Speech to the Monsanto Board of Directors, 24 June 1999. RAFI, 12 May 2000. *Terminator Two Years Later: RAFI Update on Terminator/Traitor Technology*.
45 Fax sent to ActionAid, 6 September 2000.
46 *Genetically Modified Organisms and developing countries*, DFID Background Briefing. May 1999.
47 *COP5 cops out*. RAFI News Release, 20 June 2000. www.biodiv.org/Decisions/COP5/html/COP-5-Dec-05-e.htm
48 *Ibid*.
49 RAFI, 12 May 2000. *Terminator Two Years Later: RAFI Update on Terminator/Traitor Technology*.
50 Collins, quoted in: *Terminator Technology Not Terminated* Agra/Industrial Biotechnology Legal Letter, January 2000, Vol. 1, No. 1, p4. (reference taken from, *Terminator Two Years Later: RAFI Update on Terminator/Traitor Technology*. 12 May 2000.)

51 *News of the Week, Science*, Vol 289 pp 709–710. 4 August 2000.
52 *Seeding Solutions*, volume 1, published by IDRC, IPGRI and Dag Hammarskjold Foundation, 2000.
53 Monsanto announced in December 1999 that it was to merge with drug giant Pharmica & Upjohn to create a new company, Pharmacia.
54 Searches conducted using Derwent Biotechnology Abstracts.
55 RAFI, 12 May 2000. *Terminator Two Years Later: RAFI Update on Terminator/Traitor Technology*. p2.
56 http://l2.espacenet.com/dips/abstract?LG=en&CY=ec&DB=EPD&PNP=WO9907211&PN=WO9907211 &FTDB=WO1
57 http://www.patents.ibm.com/details?&pn=US05880333__&s_bsum=1#bsum
58 RAFI, 12 May 2000. *Terminator Two Years Later: RAFI Update on Terminator/Traitor Technology*.
59 http://l2.espacenet.com/dips/abstract?LG=en&CY=ep&DB=EPD&PNP=WO9942598&PN=WO9942598&FTDB= WO1
http://l2.espacenet.com/dips/claims?LG=en&CY=ep&DB=EPD&PNP=WO9942598&PN=WO9942598&FTDB=WO1
http://l2.espacenet.com/dips/desc?LG=en&CY=ep&DB=EPD&PNP=WO9942598&PN=WO9942598&FTDB=WO1
60 http://l2.espacenet.com/dips/abstract?LG=en&CY=ep&DB=EPD&PNP=WO9929881&PN=WO992988 1&FTDB=WO1
http://l2.espacenet.com/dips/claims?LG=en&CY=ep&DB=EPD&PNP=WO9929881&PN=WO9929881&FTDB=WO1
http://l2.espacenet.com/dips/desc?LG=en&CY=ep&DB=EPD&PNP=WO9929881&PN=WO9929881&FTDB=WO1
61 http://l2.espacenet.com/dips/abstract?LG=en&CY=ec&DB=EPD&PNP=WO0009708&PN=WO0009708 &FTDB=WO1
http://l2.espacenet.com/dips/claims?LG=en&CY=ec&DB=EPD&PNP=WO0009708&PN=WO0009708&FTDB=WO1
http://l2.espacenet.com/dips/desc?LG=en&CY=ec&DB=EPD&PNP=WO0009708&PN=WO0009708&FTDB=WO1
62 http://www.patents.ibm.com/details?&pn=US06091004__&s_bsum=1#bs um
63 http://www.patents.ibm.com/details?&pn=US06031153__&s_bsum=1#bsum
64 http://www.patents.ibm.com/details?pn=US06107544__
65 http://www.patents.ibm.com/details?pn=US06057490__
66 http://www.info.novartis.com/investors/sales1999.htm

Berne Declaration
Quellenstr. 25
P.O. Box
CH-8031 Zürich
Switzerland
Telephone: +41 1 277 70 00
Facsimile: +41 1 277 70 01
Email: info@evb.ch
Website: http://www.evb.ch

Swedish Society for Nature Conservation
Box 4625
SE-116 91 Stockholm
Sweden
Telephone: +46 8 702 65 00
Facsimile: +46 8 702 08 55
Email: info@snf.se
Website: http://english.snf.se

GeneWatch UK
The Mill House
Manchester Road
Tideswell
Buxton
Derbyshire SK17 8LN
Telephone: +44 (0) 1298 871898
Facsimile: +44 (0) 1298 872531
Website: http://www.genewatch.org

ActionAid
Hamlyn House
Macdonald Road
London N19 5PG
Telephone: +44 (0) 20 7281 4101
Facsimile: +44 (0) 20 7281 5146
Website: http://www.actionaid.org