Hot potato

GM potatoes in South Africa — a critical analysis

Vanessa Black

AFRICAN CENTRE for BIOSAFETY

ISBN: 978-0-620-40629-1

www.biosafetyafrica.net

Suite 3, 12 Clamart Road, Richmond 2092, Johannesburg, South Africa
Tel & Fax +27 (0) 11 482 8915

The African Centre for Biosafety (ACB) is a non profit organisation, based in Johannesburg, South Africa. It provides authoritative, credible, relevant and current information, research and policy analysis on issues pertaining to genetic engineering, biosafety and biopiracy in Africa.

Edited by Rose Williams

Design and layout by Lesley Lewis, Inkspots, Durban: inkspots@iafrica.com

Printed by Prontaprint, Durban

Acknowledgements

This publication has been made possible as a result of the generous support of Evangelisher Entwicklungsdienst (EED) and the Norwegian Agency for Development Co-operation (Norad).

Contents

Executive Summary

In 2001, the South African Agricultural Research Council (ARC) began conducting field trials with potatoes genetically modified to contain a Bt gene Cry1Ia1 (formerly BtCryV). This novel gene is intended to protect the plants and potato tubers from infestations of the Potato tuber moth (*Phthorimaea operculella*).

This research is not home grown or 'truly South African'. The ARC is part of an international consortium, which includes the Michigan State University (MSU), the International Potato Centre in Peru and gene giant, Syngenta. Syngenta has quietly been cornering the GM food potato market; lodging a stream of patents in the USA and other countries for a form of terminator (GURTS) technology **that prevents potatoes from sprouting unless they are treated with chemicals supplied by the patent owner.**[1]

The project is funded by the United States Agency for International Development (USAID), well known for its projects to promote agricultural biotechnology in developing countries.[2] Ironically, GM potatoes were abruptly withdrawn from stores in the USA due to consumer distrust.

Egypt was the original partner of choice for the project, however, after eight years of research and ostensibly at the brink of commercialisation, the Egyptian government cancelled the project because it feared that the GM potato would jeopardise its export market to the European Union. A parallel GM potato project initiated in Indonesia also did not materialise and was cancelled by the Indonesian government.

South Africa became an obvious next choice, with its lax GM regulations and pro-GM institutional framework. To date, the GM project in South Africa has enjoyed six years of field trials involving the testing of a range of GM lines primarily to assess the efficacy of the Bt gene in South Africa, with some testing of ecological impacts and gene flow.

Touted as a tool to assist small-scale and emergent black farmers, the GM potatoes are said to be only 1 or 2 years away from commercialisation.

The African Centre for Biosafety (ACB) and other groups in South Africa have vociferously opposed the field trials on Biosafety and socio-economic grounds.[3] We have pointed out that potato farmers integrate diverse and adaptable strategies to respond to climate change, disease and pest challenges. Emergent farmers often do not have access to the finance and infrastructure for this, and many cannot even access certified seed potatoes. The Bt potato is therefore unlikely to reach small-scale farmers, will cost even more than conventional seed potatoes and at best provide a 'cure' for just one of the many problems these farmers face.

The biosafety of the Bt potato is a major concern. Potatoes grow easily from tuber scraps, and can be quickly spread. Once in the environment toxins produced by the Bt genes spread in the environment adversely impacting a range of insect and soil organisms, with knock-on consequences for ecological systems. Bt crops also increase pesticide resistance in target insects potentially creating unmanageable 'super pests'. The Bt Cry1Ia1 gene hasn't been used previously in commercially released crops, so the potential health impacts of this construct are unknown. However, multiple health problems have been documented in connection with other crops modified with Bt genes including immune reactions, impacts on organ weight and function, and allergic reactions.[4] Horizontal gene transfer from GM plants to soil and stomach bacteria is of particular concern. Genes producing Bt toxin may transfer creating unwanted biological pesticide factories, but also antibiotic resistant genes could be transferred creating superbugs that cannot be treated. This GM potato includes a gene resistant to the antibiotic kanamycin, which is important in South Africa for treating drug-resistant TB.[5]

Despite GM maize, cotton and soya being commercially grown in South Africa, due to increased consumer awareness and public debate, it is highly unlikely that GM potatoes will find a way onto the South African market. One of the largest food retailers, Pick n Pay, issued a surprise media release in 2007 stating that they would not stock the GM potato until the decision-making body on GMOs could provide conclusive scientific evidence on its biosafety. **McCains, which dominates the food processing industry, has indicated that they will not use GM potatoes in South Africa**.

Ninety percent of South Africa's potato exports totalling 14 095 252 kilograms are exported within Southern Africa. Zambia and Angola are the main importers of South Africa's seed and processed potatoes. Angola has no biosafety legislation in place. Zambia has a strong anti-GM foods stance, and has already tackled the USA head-on in rejecting the USA's food aid GM maize during the 2001 food crisis. Zimbabwe, Malawi and Mozambique only accepted the GM maize on condition that it was milled prior to being distributed to make sure it could not be planted.[6] **In this context it is likely that South Africa's main African trading partners will slam the doors on a brand new GM food**.

It is easy to see that the commercialisation of the Bt potato in South Africa will not benefit Africans as widespread rejection is anticipated. Rather the benefits will accrue to the researchers involved in the project, many of them from the US, and the owners of the key GM gene (Bt Cry1Ia1) in this potato, Syngenta. Echoing past colonial practice, African soil is once again being exploited for open field trials with a risky crop that puts African biodiversity and health at risk.

The United Nations General Assembly has declared 2008 to be the International Year of the Potato. It is an opportune moment for South Africa to reject and put a stop to the Bt potato project. Scarce public resources should rather be invested in a sustainable future, by tackling the socio-economic barriers faced by emergent black farmers and investing in research and development that improves food sovereignty using traditional food crops and ecological farming methods.

Structure of booklet

In this booklet, we provide a background to potatoes, examine the South African potato industry, the Bt potato project for South Africa and include comprehensive information on:

- the origin of potatoes and international context
- growing potatoes in South Africa
- the South African potato industry
- the history of the Bt potato project funded by USAID and developed as part of the Agricultural Biotechnology Support Project (ABSP) in Egypt, Indonesia and South Africa
- the history and progress of Bt potato projects in South Africa
- and selected examples of other GM potato projects

The potato – an introduction

Potatoes belong to the Solanaceae Family of plants, commonly known as 'nightshades'. Several popular crop plants belong to this family including tomatoes, aubergines, capsicum peppers (chilli and bell) and tobacco. The Solanaceae Family are flower-bearing plants and many, including several vegetables, have parts which are poisonous. In potatoes only the tubers are edible.

History of the cultivated potato

The Andes Mountains of Peru, Bolivia, Ecuador and Colombia on the western edge of the South American continent constitute the centre of origin of the potato and home to more than 5000 varieties of potato.

Around 200 wild species of potato can be found concentrated in the Andes, but also growing as far north as the southern United States. Many of these can cross-breed with cultivated potatoes and have been used as a source of new genes to strengthen domesticated varieties. For example, the species *Solanum demissum* which is found in Mexico, another centre of potato diversity, has been an important source of resistance to late blight disease and its genes are now found in most commercial potatoes.[7]

Archaeological evidence, as well as a recent study of the genetic composition of landrace potato varieties in the Andes, suggests that the potato was first cultivated north of Lake Titicaca in Peru in South America during the pre-Columbian period up to 7000 years ago.[8] Nine species of cultivated potato exist in the world today, and all of these are found in Peru's Cordillera Blanca mountain range and the area around Lake Titicaca. *Solanum stenotomum* is believed to be the oldest cultivated species of potato but *Solanum tuberosum* is the main Andean species that has spread around the world.[9]

The Spanish writer Pedro de Cieza de León documented that the Spaniards first laid eyes on potato fields in Columbia in 1537, and it is probably the Spanish who first brought the potato to Europe.[10] Due to their high vitamin C content potatoes were carried on board ship by the Spanish and then other sailors to prevent scurvy. By the end of the 16th century potatoes were found in several European countries, where they were initially used to feed livestock. A Swiss botanist, Pierre Bahuin, was responsible for describing and naming this potato *Solanum tuberosum* in 1596. Around 1621 Britain sent potatoes to its American colonies and it is thought they arrived in Ireland around 1625. By the end of the end of the nineteenth century, the cultivation of potatoes had extended across most of Eastern Europe and the potato had become a staple crop in many cultures.[11] *Solanum tuberosum* is divided into two slightly different subspecies: subspecies *andigena*, which is adapted to the short day in the Andes, and subspecies *tuberosum*, the potato grown commercially round the world that is believed to have adapted to Europe's longer growing day.

Potatoes are a remarkable source of food. A medium sized potato contains 45% of the daily adult requirement of vitamin C, 18% of the potassium we require as well as significant amounts of iron, zinc, thiamine, niacin and vitamin B6. The potato also contains valuable supplies of such essential trace elements as manganese, chromium, selenium and molybdenum.[12]

Some historians believe that the potato literally fed the Industrial Revolution by boosting food production to such an extent that the population exploded thus freeing peasants for factory work. This was most evident in Ireland where the population swelled to 8 million (double the present day population). However, in 1845 disaster struck when the then unknown 'late blight' fungal disease (*Phytophtora infestans)* rotted the Irish potato crop in the field starting a potato famine that spread across Europe. When the famine finally ended over 4 years later 2.5 million people had starved to death in Europe, and 1 million Irish had fled Ireland to start a new life in North America. [13]

The potato arrived in Africa relatively recently. Potatoes were first grown in South Africa as early as 1830, and British and German colonists introduced potatoes in East Africa in about 1880. They were introduced in west and north Africa to feed soldiers fighting in the first World War.[14]

Potato production and consumption today

Today potatoes are the world's most widely grown tuber crop and the fourth largest food crop after rice, wheat and maize. Potatoes are grown in 148 countries, more than any other crop except maize. World potato production has increased at an average rate of 4.5 percent over the last 10 years.[15] In 2006, 315 million tons of potatoes were grown worldwide.[16] China produces the most potatoes, having grown 70 338 000 tons of potatoes in 2006, 22% of the world potato crop. Top producers after China are the Russian Federation (12% of world crop), India (7.5%), the USA (6.2%) and Ukraine (6.1%).[17]

The International Potato Centre reports that since the 1960's the area planted to potatoes in developing countries has expanded more rapidly than that of any other food crop. In 2005 the developing world's potato production reached 162 million tons, exceeding that of industrial countries for the first time.[18]

Europeans eat the most potatoes per person; on average 96 kilograms per person in 2005. Although the developing world eats less than a quarter of that consumed in Europe, consumption in developing countries has been increasing while in Europe it is slowing down. Consumption of potatoes has increased in the developing world, from less than 10 kg per capita in 1961 – 1963 to almost 22 kg in 2003.[19] In the potato's centre of origin in the Andes a person eats 50 – 60 kilograms per year, while Africans ate an average of 14.2 kilograms per person in 2005.[20]

Potatoes in South Africa

South Africa is the third largest potato grower in Africa after Egypt and Algeria, and the biggest producer in sub-Saharan Africa. Production has increased considerably in the last 16 years from 1.2 million tons in 1990 to 1 862 856 tons in 2006. During the same period the area under potato production decreased from 63 000 ha to 53 000 ha. The increase in yield per hectare, currently averaging around 30 tons per hectare, can be attributed to the increasing use of irrigation as well as improved planting material.[21]

Potatoes are a popular vegetable in South Africa. Local farmers supply most of the potatoes eaten in South Africa; an average of just over 29 kilograms per person in 2005.[22]

Potato parts and terms

The part of the potato plant that we eat is called the ***'tuber'***, which is an enlarged underground stem.
Potatoes grown for eating are called '***ware***' or '***table potatoes'.***
Potatoes are an annual plant that can naturally reproduce in two ways:

1. Seed

Potatoes bear fruit after self-pollination or pollination by insects (most often bumble bees) carrying pollen from other potato plants.[23] These fruit look similar to green cherry tomatoes, and each carries from 100 - 400 seeds from which new potato plants can grow.[24]

The seeds found in the fruit are called ***"true seed"*** or ***"botanical seed".***

The degree to which potatoes flower, cross-pollinate and produce true seed is dependent on both environmental conditions and the characteristics of particular cultivars. Some potato varieties do not produce any seeds and can only be reproduced vegetatively.

2. Vegetative propagation

Any potato variety can be grown by rooting cuttings taken from the plant or by planting whole or parts of a tuber that has ***"eyes"***: small growth nodes with buds from which new shoots will grow.

The potato tubers that are used to grow new potato plants are called ***"seed potatoes".***

Potato cultivars and uses

All commercially cultivated potatoes belong to one botanical species, *Solanum tuberosum*. However, many thousands of varieties or 'cultivars' of potato exist that differ in size, shape, colour and texture.

A farmer needs to consider a number of factors when choosing which potato cultivar to grow. Each potato growing region has a different climate, soil conditions, as well as prevalent pests and diseases. Different cultivars will do better or worse in these circumstances. In addition farmers need to consider market preferences for certain cultivars and the time it takes for the tubers to mature and be ready for sale. In the end a farmer will try to gain the biggest and best quality yield for the lowest input costs while still having a market to sell to.

In South Africa, Vanderplank, Buffelspoort, Up-to-date and BP1 have been the most popular cultivars historically – in 1995 these together comprised 91% of the potato crop. In the 1990's an effort was made to introduce new cultivars to the South African market: new foreign cultivars were imported suited to specific niche markets and the Agricultural Research Council (ARC) bred new cultivars suited to South African conditions. By 2002 the four traditional cultivars were only planted in 61% of the production area.[25]

Potato cultivars in South Africa can be divided into three groups according to the length of their growing periods:

1. Short growing period (less than 90 days). Vanderplank is the most popular cultivar in this group.
2. Medium-growing season cultivars (90 -110 days) form the bulk of potatoes grown in South Africa. BP1 and Up-to-Date are the most popular cultivars in this group and make up 77 % of the potatoes grown in the country.
3. Longer growing season cultivars (longer than 110 – 150 days) such as Hoevelder, Sackfiller, Late Harvest, Kimberley's Choice and Cedara.[26]

Cultivars also vary considerably in texture, firmness and colour when cooked. This influences consumer preference as one cultivar may be better suited to preparing a particular dish than another. Properties that are of importance include whether the potato stays firm (good for salad) or floury (good for mashing, baking), breaks apart or discolours while cooking. These properties are also important in the food processing industry as well as properties such as how the potato keeps its shape when cut (frozen chips), and how much dry matter or sugar the potato contains (French fries and crisps).

The suitability of cultivars available in South Africa to different cooking methods is outlined in the table below.

Table 1: Which cultivar to use when cooking

Cultivar	Baking & roasting	Mashing	Salad	Crisps	Canned	French fries
Astrid	•	•				
Aviva			•	•		
BP1	•				•	•
Buffelspoort	•				•	•
Calibra				•		
Caren	•		•	•		•
Columbus		•		•		•
Charlie				•		
Crebella				•		
Darius	•		•	•		•
Dawn				•		
Devlin			•			•
Erntestoltz				•		
Eryn						•
Esco			•			
Evan			•			
Fabula			•			
Fianna	•			•		•
Hermes	•					•
Hertha		•		•		•
Hoevelder	•	•		•		
Kimberly Choice						
Lady Rosetta	•	•		•		
Liseta	•	•	•			
Mondial	•	•	•			
Mnandi	•	•				
Pentland Dell	•	•		•		•

Pimpernel				•		
Ronn	•	•				
Ropedi			•	•		
Sandvelder	•	•	•	•		
Shepody	•	•				•
Spunta	•	•				
Up-to-date	•	•				•
Vanderplank			•		•	•

Key: • Cultivars most commonly used in the processing industry (Potatoes SA)

Growing potatoes

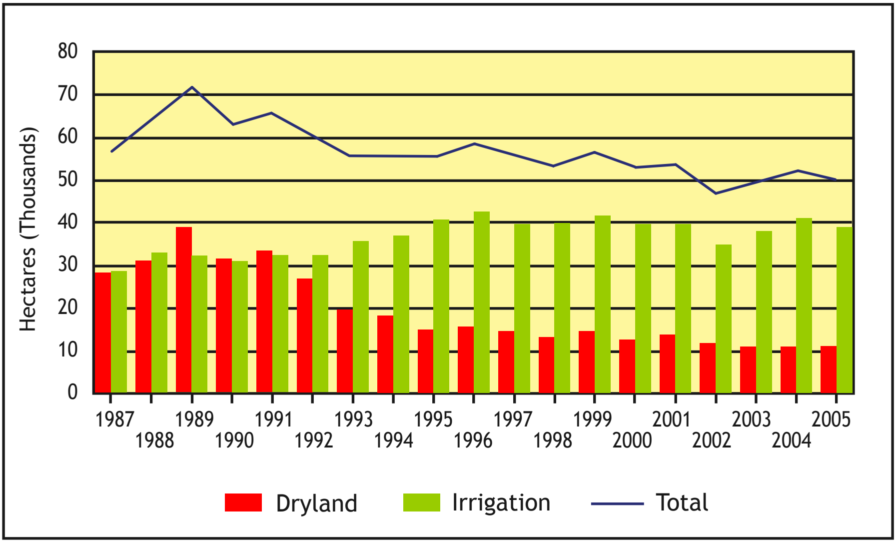
South Africa is not ideally suited to growing potatoes due to a warm climate and water scarcity, but the diversity of micro-climates and soils across the country provide an opportunity for producers to supply potatoes all year round. Tuber yields are generally lower and less stable in tropical and subtropical regions, due to both temperature and higher occurrence of pests and diseases.[27]

The potato grows best in deep soils (at least 600 mm) that are well-drained and not compacted. Poor soil aeration harms tuber development as the tubers cannot get enough oxygen. However, because the potato has a shallow and poorly developed root system, the most critical factor in growing potatoes is providing adequate and consistent water throughout the growing cycle. Water stress even for short periods can affect tuber yields; and several tuber disorders are connected to too much, too little or sporadic access to water.[28]

The bulking up of potato tubers is also affected by radiation levels, the length of days, and temperature. Potatoes yield best when temperatures are between 16 – 21 degrees Celsius.[29]

South African potato farming is dominated by commercial farmers who can compensate for water scarcity and pest and disease problems through irrigation and high use of chemical inputs. Since 1991, there has been a slight decline in the overall hectares planted with potatoes, however, the same period has also seen a marked conversion from dryland to irrigated farming and a 34% increase in tuber yields.[30]

Hectares planted – Potatoes



Source: Potatoes SA[31]

The environmental toll of potato production

The Sandveld in the Western Cape best illustrates the devastating consequences of expanding potato production under irrigation. The Sandveld only receives about 200mm of rain a year, yet it produces 15% of the total potato crop in South Africa, second only to the Limpopo region. Since 1994, the area under cultivation has extended by at least 25% through clearing away of unique fynbos and renosterveld vegetation to make way for irrigated crop 'circles'. In 2005, about 80% of all Western Cape applications to clear virgin veld for new agricultural production came from Sandveld farmers. Potato production uses on average 7000 cubic metres of water per hectare per year. In 2005, irrigation in the area was using up 35 million cubic metres of water – 3 million more than the water available in the area, leading to extreme water stress in the region and concerns that unique wetlands would be permanently damaged and that sea water would infiltrate the aquifer.[32]

Potato growing regions

South Africa's potato production area is divided into 14 distinct regions based on geographical, ecological and climatic differences.

Potato growing regions of South Africa[33]

Key to regions:

1. Limpopo
2. North West
3. Gauteng
4. Mpumalanga
5. Northern Cape
6. Western Free State
7. Eastern Free State
8. KwaZulu-Natal
9. Sandveld
10. Ceres
11. South Western Cape
12. Southern Cape
13. Eastern Cape
14. North Eastern Cape

Summary of potato production in South Africa

Table 2: Summary of potato production in South Africa

	Potato Growing regions	% of Harvest in 2006	Planting time		Area under Irrigation	% of crop grown as Seed potatoes	% of table crop processed
	Limpopo	17.7	Summer	Jan-March	Y	0%	17%
			Winter	April-Aug	Y	0%	14%
	North-west	3.4	Summer	Nov-Jan	Y	28%	78%
			Winter	Aug	Y	28%	23%
	Gauteng	1.4	Summer	Dec-Feb	Y	0%	0%
			Winter	Jul-Nov	Y	0%	24%
	Mpumalanga	10	Summer	Aug-Dec	80%	10%	15%
	Kwa-Zulu Natal	7.7	Summer	Aug-Feb	78%	63%	5%
			Winter	May-Aug	100%	0%	5%
Free State	W Free State	12.1	Summer	Nov- Feb	68%	50%	12%
			Winter	Aug-Oct	Y	45%	12%
	E Free State	14.4	Summer	Aug-Dec	15%	1%	11%
	SW Free State	3.2	Summer	Dec-Jan	95%	0%	3%
			Winter	Aug-Nov	95%	0%	3%
	N Cape	4	Summer	Jan-Feb for	Y	62%	8%
			Winter	Aug	Y	62%	8%
Western Cape	Sandveld	15.1	Summer	Jan-April	99%	35%	15%
			Winter	May-Dec	99%	35%	15%
	Ceres	2.2	Summer	Oct-Dec	100%	20%	22%
	SW Cape	1	Winter	Jul-Oct	100%	0%	20%
	S Cape	1.2	Summer	Nov-Apr	100%	15%	
			Winter	May-Oct	100%	15%	
Eastern Cape	E Cape	3.2	Summer	Oct-March	100%	0%	
			Winter	Apr-Sept	100%	0%	
	NE Cape	3.5	Summer	Aug-Nov	40%	0%	
			Winter	Feb-July	40%	0%	

Main cultivars planted												
Astrid	BP1	Buffelspoort	Columbas	Darius	Eryn	Fabula	Hertha	Lady Roseta	Mondial	Pentland Dell	Platina	Up-to-date
	•											
	•	•						•		•		
		•					•	•				
	•	•										•
	•	•										•
	•								•	•		•
	•	•					•					•
•	•	•					•					•
	•					•			•			•
	•	•							•			
	•			•					•			•
				•		•			•	•		
		•		•					•		•	
				•	•				•			•
				•					•			•
	•	•	•									•
	•	•	•									•
	•	•										
•	•								•			
•	•								•			
•	•								•			
•	•								•			
	•								•			•
	•								•			•

(compiled from data from Potatoes South Africa[34])

Role players in the potato industry

Potatoes SA is an industry related body representing table and seed potato growers, the processing industry and emerging farmers. It was established to support and promote the potato industry. Potatoes SA services are funded by a levy (13 cents for table potatoes and 4.4 cents for seed potatoes)[35] included in the price of each 10 kg pocket of potatoes sold.

Potatoes SA has established various committees and forums to promote different aspects of the industry. These include Forums for Greenhouse, Exporters, Processing, Packaging, Laboratory Services and Seed potatoes. There are also committees for Seed potatoes, Emerging Farmer Development, National Potato Research and Marketing.

The Vegetable and Ornamental Plant Institute (VOPI) of the Agricultural Research Council (ARC) at Roodeplaat has the mandate to carry out research and technology transfer on potatoes.[36] This is planned in conjunction with the Research Committee of Potatoes South Africa. Potatoes South Africa then funds the approved projects according to the requirements of the ARC. ARC house the SA Potato Cultivar collection which is the gene bank for potatoes in South Africa.

The Independent Certification Council for Seed Potatoes is a Section 21 company established under the Plant Improvement Act which has overall authority to oversee the South African Seed Potato Certification Scheme. It is comprised of representatives from the Department of Agriculture, the Agricultural Research Council, a representative of the Nucleus Material Production Forum, the manager of Potato Laboratory Services, the manager of the Potato Certification Service and seed potato growers.[37]

The Potato Certification Service (PCS) is contracted by the Independent Certification Council for Seed Potatoes to manage and administer the Certification Scheme. [38]

The South African potato gene bank

The Agricultural Research Council (ARC) is mandated to keep the gene bank of potato cultivars grown in South Africa.

The South African National Potato Cultivar Collection is housed *in vitro* (in test tubes) at an ARC laboratory facility in Roodeplaat. The gene bank stores a nucleus of 'true-to-type' and disease-free material, which has been cloned through tissue culture techniques from each cultivar. Two sets of twenty plants each are kept in cold storage cabinets in separate buildings for each cultivar. Plant material is then issued to the industry for reproduction, either through tissue culture facilities or greenhouses that are accredited for mini tuber production within the Seed Certification Scheme.[39] *In vitro* material and mini-tubers may be imported into South Africa, but all seed potatoes for cultivation are produced in South Africa to prevent the introduction of new diseases into the country.

Three types of cultivar are kept in the gene bank: 'open varieties' and varieties protected by 'plant breeder rights' that are either owned by private clients or jointly owned by Potatoes South Africa (Potatoes SA) and ARC.

'Plant breeders' rights' (PBR) are a form of intellectual property rights granted to the breeder of a new variety of plant. Usually these give the plant breeder control over the propagation of the plant and any harvested part of the plant for a prescribed number of years. PBR allow the breeder to license the growing and use of the variety to another entity for a royalty fee. These rights also allow the breeder to bring a law suit against anyone who makes use of the plant without a license from the breeder.

Plant Breeders' Rights in South Africa are legislated in the Plant Breeders' Rights Act, 1976 (Act No 15 of 1976). PBR are valid for 20 – 25 years depending on the plant. The breeder is entitled to exclusive rights for a period of 5 – 8 years after which the breeder must issue licenses (enabling the charging of royalties) to other persons who want to use the plant commercially.[40]

Six 'open varieties' of commercially grown cultivars are kept in the cultivar collection namely BP1, Buffelspoort, Hertha, Pimpernel, Up-To-Date and Van der Plank.[41] 'Open varieties' are older cultivars that have been grown for so long that they no longer are protected as the intellectual property of the breeder, and thus anyone can use them without paying royalty fees to the breeder. [42]

ARC is contracted to keep cultivars in the gene bank for private clients. These are only available to the client, unless written permission is granted to issue the material to someone else. Importers of new foreign potato cultivars often obtain exclusive rights to multiply these cultivars in South Africa and register Plant Breeders Rights in South Africa. For example, the most popular table potato, Mondial, comes from the Netherlands but is registered to Rascal Seed in South Africa.

Cultivars that have been bred by the Vegetable and Ornamental Plant Institute (VOPI) at ARC-Roodeplaat are also kept in the collection. These are Aviva, Calibra, Caren, Darius, Devlin, Eryn, Esco, Hoevelder, Mnandi, Ronn, Ropedi and Sandvelder. These are protected by Plant Breeder Rights, which are jointly owned by ARC and Potatoes SA.[43] ARC and Potatoes SA have issued sub-licenses to private companies for these varieties, allowing them sole rights to market and sell seed potatoes for these varieties. These sub-licenses have been granted as part of a strategy to encourage the uptake of these new cultivars in the industry. Royalties on sales of these are ceded to ARC and Potatoes SA.[44]

Certification of 'seed' potatoes

Potato tubers that are planted to grow new plants are called 'seed potatoes'. South African potato farmers are encouraged to buy and plant 'certified' seed potatoes, rather than replanting from their own crop, to prevent the spread of potato diseases. The quality of the seed potatoes a farmer uses strongly influences the farmer's success. About 35% of production input costs go towards buying seed potatoes, and if these are diseased, not only can the crop fail, but the farmer's land can be infected with fungal and bacterial organisms that prevent further potato cultivation.[45]

South Africa's production of 'certified' seed potatoes was completely revised through the promulgation of the South African Seed Potato Certification Scheme in May 1997, under the Plant Improvement Act (Act No 53 of 1976).[46] Changes included the deregulation of the mini-tuber industry and limits to the consecutive generations of potatoes that can be certified.

A Section 21 company, the Independent Certification Council for Seed Potatoes, is the designated authority under this scheme. It in turn contracts the Potato Certification Service (PCS) to manage and administer the Certification Scheme. The PCS inspects fields and tubers to confirm that cultivars being grown are pure and that phytosanitary requirements are met before the seed potatoes are certified.[47] Uncertified potatoes may not be grown in the same field as certified crops. Typically a farmer must register the production area 21 days after planting, 2 inspections of the fields are done and then after harvesting a sample of the tubers undergo laboratory testing for bacterial and viral diseases before certification is confirmed by means of a seal and labels.[48] There are currently 5 laboratories in South Africa, which are registered with the Department of Agriculture and accredited by Potatoes South Africa. The controlling laboratory is the Coen Bezuidenhout Seed Testing Centre, at Zeekoegat near Pretoria.[49]

Seed potatoes are certified according to a double system of generations (0 – 8) and 3 quality classes (Elite, Grade 1 and Standard). Generation '0' potatoes are disease-free 'mini-tubers' that have been grown in greenhouse conditions from *in vitro* (test tube) plantlets such as those provided by the gene bank at ARC. Currently there are 8 facilities in the country producing mini-tubers and various companies import mini-tubers from around the world. *In vitro* planting material or tubers produced from in vitro plantlets in the greenhouse are also called 'nuclear seed'. In the past all *in-vitro* plantlets were supplied by ARC, but several private laboratories are now also certified to produce these since the industry was deregulated in the 1990's. The first field reproduction is generation 1. Seed potatoes may only be multiplied for 8 generations before losing certification. Potatoes that are certified as Elite or Grade 1 potatoes can be used to produce seed potatoes again in the next generation. However, if the potatoes are certified as Standard grade they may not be certified the next season. Elite grade potatoes are identified by a red sticker on the label and Grade 1 by a green sticker.[50]

Currently in South Africa there are around 200 farmers using about 10 300 hectares of land, who maintain the stringent production standards required to register as seed potato growers with the South African Seed Potato Certification Scheme.[51]

The seed certification system has helped to improve the quality of crops farmers grow. However, the scheme is also a means of controlling the seed supply and entrenching property rights (increasingly held by multinationals) and royalty fees in the agricultural system. Over time this creates unequal power relations whereby small farmers are squeezed out of the market because they do not have the capital necessary to access cultivars and inputs that that are increasingly sold at a premium. The ease with which potatoes can reproduce from portions of the plant and tubers, however, does slow corporate control of potato production. Because each farmer can save a part of their crop for a few generations before needing to buy new seed potatoes it can take several seasons to introduce new potato cultivars. Farmers generally grow potatoes on a 3-4 year rotation system with other crops such as maize and wheat. It is also can be difficult to clear an old cultivar from a field, as these will tend to re-grow.

From test tube to seed to plate

According to Potatoes SA the country is self-sufficient in potato production. However, the process by which commercially grown potatoes reach our plate is often a complex one involving many parts of the country. For example, the potato on your plate may have undergone the following process:

- One of the eight 'nucleus seed' producers in the country obtains *in vitro* material from the gene bank and multiplies this in their greenhouse to produce generation 0 mini-tubers. One of these, for example, Potato Seed Production (Pty) Ltd in Mpumalanga, is contracted to provide limited quantities of healthy planting material to the industry and therefore this farm supplies the most popular 'open' varieties.[52]

- A large-scale seed potato producer (farming on 200 or more hectares) buys mini-tubers from the laboratory in Mpumalanga and grows these out for a few generations.

- A smaller commercial seed potato grower, in KwaZulu–Natal for example, buys these seed potatoes when they have reached the 3rd generation. These are planted in the summer season and harvested in March. These seed potatoes are sold on to farmers in Limpopo for the winter planting season. The KZN farmer will re-plant a part of his crop to produce seed potatoes for the next season. This will be done for 3-4 seasons until the crop has reached the 8th generation and can therefore no longer be certified, requiring that a new set of generation 3 potatoes are bought from the larger grower.[53] The Limpopo farmers sell their crop as table potatoes at a fresh produce market.

- A trader buys potatoes at the market, and repackages these into smaller bags to sell to street traders from whom you buy a handful for supper.

This system makes optimal use of the varied climates and growing conditions in South Africa, ensuring that South Africa is one of the few countries where potatoes are grown and brought to market all year.

Potato economics in South Africa

Commercial farmers

There are approximately 900 active commercial potato farmers[54] in the country employing about 65 000 farm workers.[55]

The cost of producing potatoes commercially is high due to the many inputs required and the cost of infrastructure for irrigation. Dry land farming in the Eastern Free State costs between R22 000 – R30 000 per hectare, while the costs of irrigated potato production increase to R 54 000 – R62 000 per hectare.[56]

Small-scale and emerging farmers

'The Guide to Potato Production in SA' published by Potatoes SA in 2002 estimated that there were around 1130 emerging, small-scale farmers in South Africa, but acknowledged that statistics are not readily available. This was confirmed by Gavin Hill[57], whose seed potato company is specifically targeting emerging farmers in KwaZulu–Natal (KZN). He says that despite government promises to support and develop small-scale farmers, the Department of Agriculture has no figures on the number of emerging farmers and no database by which to contact and support these farmers. He estimates that there are up to 300 000 subsistence farmers in KZN, who have been planting potatoes for many years. Official per capita consumption figures, based on sales at the fresh produce markets, are below the national average in KZN, Limpopo and the Eastern Cape. In KZN it is only 11 kg per person per year. He reasons that this is not because people in KZN eat fewer potatoes, but rather that these provinces have greater numbers of subsistence farmers who grow and sell potatoes in their local area.

Potatoes SA allocates 10% of levy income to emerging farmer development programme projects.[58] These include providing training on potato growing, assistance with developing business plans, and accessing markets and finance. They also run a training programme in partnership with the Glen College of Agriculture, which in 2006 added a SETA accredited internship programme. Interns are expected to assist emerging farmers as part of the programme.

Potatoes SA define small-scale farmers as those who farm on less than 2 hectares of land. Farmers who have at least 2 hectares under potato cultivation with the potential to grow to at least 10 hectares, are defined as emerging commercial farmers. In practice such farmers need to have access to at least 50 hectares of arable land in order to practice the crop rotation necessary in potato farming.[59]

The Transformation* manager of Potatoes SA, Diale Mokgojwa, provided the following statistics on the number of small-scale and emerging commercial farmers in South Africa[60]:

REGION	SMALL SCALE (less than 2ha under potato cultivation)	EMERGING COMMERCIAL (2 – 10 ha under potato cultivation)
Western Cape	38	1
Eastern Cape	25	6
KwaZulu-Natal	137	2
Free State	7	1
Mpumalanga		1
Limpopo	5	3
TOTAL	212	14

Most small scale farmers sell their produce within their own local communities, while emerging commercial farmers sell locally, at the farm gate and some send produce to fresh produce markets.

Potatoes SA has a very active education programme to encourage farmers to only use certified seed potatoes, and believe that the majority of small-scale farmers are now buying certified seed. Farmers are taught how to identify certified seed (the bag must be sealed and labelled indicating the generation and growers details) and the benefits of using this. Mr Mokgojwa as well as Mr Hill[61] blame 'unscrupulous dealers' for selling uncertified seed to the farmers on the poor premise that it is cheaper or falsely claiming that ordinary potatoes are seed potatoes. However, researchers involved in a socio-economic study of small and emerging farmers have identified more fundamental problems hampering small-scale farmers' access to seed potatoes. Many farmers cannot afford to buy potatoes or can only buy small quantities at a time. These constraints also prevent farmers from planning ahead.

* Transformation refers to the inclusion and empowerment of black farmers in the industry, who were prevented from owning land and participating in commercial farming before 1994 through apartheid legislation.

The seed potato industry works on an order system where orders must be placed some time in advance of planting season. As a result, stock may be depleted when emerging farmers are ready to buy, forcing them to make do with what is left on an open market, which may not be certified or cultivars that are appropriate for their area.[62] An employee at Potato Seed Production, one of the main suppliers of seed potatoes for popular cultivars, confirmed that small-scale farmers tend to buy small amounts of seed potatoes; usually directly from the farm and generally not more than a bakkie load (small utility vehicle) at a time.[63]

Small-scale farmers are most concerned about yields, and therefore prefer cultivars that will do well in tough conditions with little inputs. Cultivars such as BP1, Astrid and Mnandi are popular for this reason. Consumers tend to want potatoes that look white and wash well. Where farmers use cultivars that are not ideally matched with consumer preferances the farmer will be able to sell the crop, but not at a premium.[64]

Potatoes SA[65] have identified the following as the main problems faced by emerging commercial potato farmers:

◊ The main barrier to entry is the high cost of infrastructure required to scale up operations

◊ Potatoes are a high value crop with high input costs. Most farmers do not have the capital to fund this and as a result they cut corners during the production season. The result of this is that they do not achieve the expected yields.

◊ Small scale production is not economically viable and most farmers do not cooperate to achieve the economies of scale. There is a lot of social facilitation that needs to be done to overcome this barrier.

◊ Financial institutions are not willing to finance operations that are not economically viable (farm needs to have more than 35 ha potatoes and 50 – 100 ha of other crops on a four to five year rotational plan)

◊ Lack of people and business skills to properly manage an enterprise, resulting in a lack of trust that causes many enterprises to collapse.

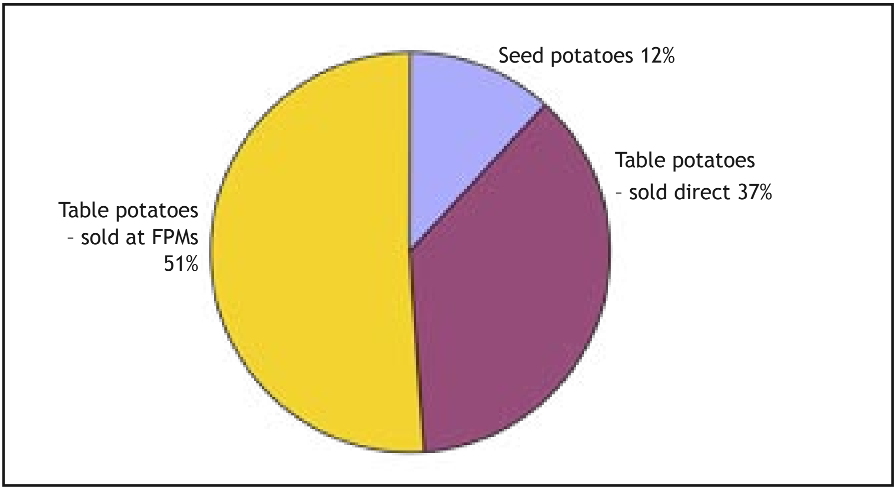
Domestic potato trade

The 2002 agricultural census calculated that R1598 million in gross farming income was derived from potatoes in South Africa.[66] Potatoes SA report that 1.9 million bags of potatoes were grown in 2007, earning R3 billion for producers. Potatoes contribute about 33% to the value of the major vegetables market and comprise 5% of total agricultural production in South Africa.[67]

South African consumers spend around R9.5 billion on potatoes and potato products annually.[68] The table potato crop is distributed in the market either through direct sales (on farm, to food retailers and processors, and export) or through fresh produce markets (FPMs). There are 22 fresh produce markets around the country.

The Johannesburg and Pretoria fresh produce markets accounted for 44% of the total sold in 2005, with purchases in Cape Town and Durban accounting for 11% each[69]. Gauteng currently consumes about 684 000 tons of potatoes a year.[70] Informal traders buy 40% of the potatoes sold at fresh produce markets.

South African potato harvest in 2005



Compiled from Potatoes SA data[71]

Potato retailers

Major South African food retail chains were contacted for information on their procurement of potatoes. Only Pick n Pay[72] and Woolworths[73] responded. Pick n Pay sold R 106 million worth of fresh potatoes in 2006.

Both of these retailers rely on partially centralised buying systems to ensure that potatoes are procured at a good price. Pick n Pay makes use of a semi-national supplier that procures and pre-packs the potatoes for four distribution centres. The supplier sources potatoes in the region of the distribution centre, preferably from commercial farmers through a pre-ordering system that secures supplies. Woolworths also has a central buying system but buy potatoes in the region they supply to. No emerging farmers supply Woolworths but they hope this will change through a mentoring programme to improve the quality of potatoes grown by emerging farmers.

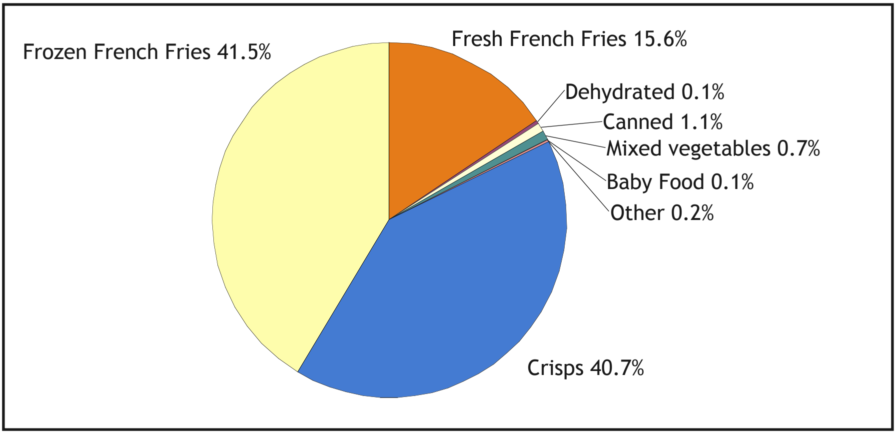
Pick n Pay note that consumers in the Western Cape and KZN have preferences for particular cultivars which the retailer tries to accommodate. Woolworths prefer BP13, BP1, and Mondial because they are good all purpose potatoes, but also procure Fianna for baking. Their customers prefer all purpose potatoes that are white and round.

Pick n Pay cite extreme weather conditions such as extreme heat or excessive rain or cold as the main reasons for a shortage in supply of potatoes. This is especially a problem from February to April when the combination of heat and rain limits the shelf life of potatoes. The main problem Woolworths experience is the sprouting and greening of potatoes.

The processing industry

Processing forms a significant part of the potato industry. In 2005 the potato processing industry used about 18% of the potato crop. Most of this is used for frozen and fresh French fries and crisps. (See graph below). The processing industry grew by over 100% between 1991 to 1995.[74]

2005: Potatoes processed (316 831 ton)



Source: Potatoes SA[75]

The potato processing industry in South Africa is dominated by the Canadian multinational food processing company, McCains. McCains entered the South African market in 2000 when it bought the French Fry and vegetable production facilities of Irvin and Johnson (I&J), a subsidiary of Anglovaal Industries. The deal included three plants, making McCains an instant market leader in frozen potato products.[76] One of these was a French fry and potato flake plant in Delmas, which the company is in the process of expanding.[77] In 2001 the company acquired Heinz Frozen Foods.[78]

McCains procure potatoes through direct contracts with growers for specific cultivars based on its own market and sales assessments. Currently 1% of the potatoes processed by McCains comes from emerging farmers through grower contracts. However, the company has an active programme to expand the supply from emerging farmers through providing financial support, training and coaching to small growers.[79] The company has also started a potato seed project in Lichtenburg in the North-west Province, which it hopes to hand over to black farmers by 2012. Most of the 10 000 tons of potatoes supplied from the area will come from black farmers by 2008.[80]

Although most of the products that McCains manufactures in South Africa are sold in the country, McCains does occasionally export products to Australia, New Zealand and Argentina depending on demand and the exchange rate. [81]

Imports and exports

Globally South Africa has a very small share of the potato market. It is ranked as the 31st largest potato producer, supplying 0,5 % of the world's total production.[82] In 2007 South Africa exported 13 million bags (130 000 tons) of potatoes and imported 30 000 tons of frozen French fries.[83] South Africa produces 14% of the total African crop.

Nevertheless South Africa is an important role player in the southern African potato market. Due to high transport costs the bulk of South Africa's potato exports are sent to neighbouring countries: Botswana, Lesotho, Mozambique, Namibia, Swaziland and Zimbabwe. Angola, Mauritius, Reunion and the Seychelles are the largest importers of South African potatoes outside of the southern African Customs Union. The greatest quantity of frozen potato exports are to Angola and Zambia.[84] Shoprite Checkers also export potatoes through their stores in Southern Africa. The bulk of seed potato exports go to the Ivory Coast, Kenya, Malawi, Zambia and Zimbabwe.[85]

Sea and air exports of fresh potatoes from South Africa per continent in kilograms[86]

Year	Africa	Americas	Central Europe	F/East & Asia	M/East & Mediterranean	Grand Total
2006	15 921 755	-	1 000	116 388	47 750	16 086 893
2007	14 095 252	301	1 000	943 358	117 629	15 157 540

Potatoes SA has established the South African Potatoes Export Forum to generally promote export quality, service and markets for South African potatoes while ensuring good relations between exporters and growers.

Potato pests, diseases and weeds in South Africa

Potato plants and tubers are attacked by a wide range of pests and diseases. There are many factors influencing the occurrence of pathogenic and pest organisms including cultivar selection, farming practices during and after the growing season, irrigation, regional climate, seasonal weather conditions and harvesting and storage methods. This requires that farmers are vigilant, have adaptable mitigation strategies and "use integrated plant health strategies that integrate several techniques for improving plant health, based on a view of the potato crop as an agricultural ecosystem".[87] Most economically important diseases are carried on soil and tubers. Late and Early blight, nematodes, scab, and leaf miner have been mentioned as the most problematic afflictions, however, it is difficult to find statistics on the overall economic and yield impacts of different pests and diseases on the annual potato crop. Wet areas such as KwaZulu-Natal (KZN) are particularly affected by blight, whereas Potato tuber moth is not much of a problem in KZN.[88] Potato farmers rely on a large arsenal of chemicals to control organisms afflicting potatoes as well the weeds that compete for nutrients and water. Weeds like nut grass grow into potato tubers, but also host a range of plant diseases and pests.

At least 19 herbicides are available to potato farmers in South Africa. These must be carefully selected according to the type of weed that is targeted and the growth stage of the crop. Several herbicides will damage the potato plants if applied at the wrong time, and some can only be used on certain potato cultivars.[89]

Key potato pests and diseases are described below.

Viruses

Nine significant potato viruses are found in South Africa. The impacts of these infections vary considerably depending on when the plants are infected, growing conditions, the weather, the particular strain and the cultivar's resistance to viruses. The most serious viruses in terms of crop losses in South Africa, which are monitored by the potato certification scheme are potato leaf roll virus, potato virus Y and tomato spotted wilt virus.[90]

Most potato viruses spread from infected tubers remaining in the soil, from seed tubers or by being passed on by insects that puncture the plant tissue, especially aphids. Potato virus Y is spread from host plants, which also include peppers, tomatoes and tobacco, via 25 species of aphids soon after coming in contact with infected plants. Potato leafroll virus is spread from potato and tomato plants by 10 species of aphids, which carry the virus throughout their lives once infected. Tomato spotted wilt virus can also affect tomato, tobacco and peas and is spread by thrips when they reach the adult stage. [91]

Most viruses, except for tomato spotted wilt virus, have no visible impact on tubers and therefore these need to be tested to ensure they are virus free. [92]

Bacterial diseases

Several bacterial diseases occur, which generally cause wilting or rotting of plants and rotting of tubers in the soil or in storage. The most important of these are Bacterial wilt (brown rot), and *Erwinia* species causing Soft rot, Black leg and *Erwinia* wilt. These bacteria spread from infected plants and soils. Soft rot bacteria can also survive in rivers and dams. Once soils become infected with Bacterial wilt, potatoes should no longer be grown there. Common scab is another bacterial disease found in SA which causes rough patches on the tubers. Although this doesn't affect yield and short term storage, it causes losses through downgrading of the potatoes in the market. This can transfer from soil and most other root crops.[93]

Fungal diseases

Several fungal diseases infect potato plants in South Africa. Often these are spread through infected plants and spores which can remain in the soil for long periods. The most problematic fungal diseases in South Africa are *Fusarium* wilt and dry rot fungi, stem end rot, gangrene, silver scurf, black dot, black scurf and late blight.[94]

Fusarium occur in all soils where potatoes are grown and can infect the root sand stems directly or through lesions made by other organisms. [95]

Late blight causes dark mildew patches on leaves and stems resulting in collapse of the plant. The spores are rapidly spread by wind and moisture from diseased to healthy plants. The fungus can also survive for long periods on infected tubers causing the disease to spread via seed or tubers from previous years remaining in the soil. [96]

Round lesions on leaves and sunken lesions on tubers during storage are an indication of Early blight. This is the most common potato disease in South Africa occurring in moist and hot conditions. The fungus attacks all Solanaceous plants spreading from infected plant material, including remains in soil, to plants and damaged tubers. [97]

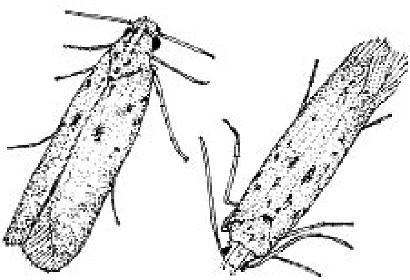
Insect pests

Over 100 types of insects attack potatoes. Aphids, lady birds, leaf miners, white fly, mites, thrips and various caterpillars including bollworm, cut worm and potato tuber moth attack the plants. Potato tuber moth, black maize beetle, cut worms, potato snout beetle, and millipedes attack the tubers. Registered insecticides target 9 of the 100 insect species that can attack potatoes in South Africa.[98]

Potato tuber moth *Phthorimaea operculella* (Zeller)

The Potato tuber moth originated in the Andes along with the potato. By 1895 it was already established in the Cape. Today it is present in all provinces, but creates a problem in the summer potato crop in warm areas with low rainfall. Areas that are most heavily impacted include the Kouebokkeveld and Sandveld regions.[99]

The adult moth[100]



The adult insect is a silvery-grey moth about 1cm long with tiny dark specks on the wings. The moths are most active at dusk, continuing through the night, but hide in the plants during the day. [101]

Each female moth can lay up to 250 oval eggs, which are laid singly on the underside of potato leaves, on exposed tubers or the soil under plants. These change from a white colour to yellow and then black before the 1-2 mm long caterpillars hatch.[102] These larvae are greyish with a green or pink tinged abdomen and a dark head, and grow in 4 stages to a length of about 12mm. The caterpillars pupate among dead potato leaves or sand just below the soil surface, or on stored potato tubers, spinning silky cocoons that are camouflaged with soil particles and debris. [103]

The life cycle of the insect is affected by temperature. In warm summer weather a complete generation can span as little as 3 – 4 weeks: eggs hatch in 4 – 14 days, larvae mature in 14 – 24 days, pupae hatch after 6 – 9 days, and adult females begin to lay eggs after 2 – 4 days. Up to 5 generations can breed in a single summer, but the life cycle may take up to 5 months in cold weather. [104]

The Potato tuber moth attacks several plants from the Solanaceae family including potato, tobacco, tomato and egg plant.

In potatoes both leaves and tubers are affected. The larvae mine the flesh of the leaves or leaf stems creating transparent blisters in the leaves as they eat, which can eventually destroy the plant. Most serious crop damage, however, occurs to the tubers before harvesting but especially in storage. As leaves become scarce late in the season larvae move down to eat the tubers by moving through cracks in the soil or attacking tubers that are exposed on the soil surface. Potatoes which bear tubers close to soil surface are more easily infested e.g. the Astrid cultivar. [105]

Larvae enter the tubers through the 'eyes' and mine narrow tunnels throughout the tuber. Mounds of frass (droppings) outside the tunnels indicate that the tubers are infested. Tunnels created by tuber moth can promote further fungal and bacterial infections. [106]

Preventing tuber moth damage

Currently farmers rely heavily on chemicals to kill the moth's natural predators. Twenty three insecticides are registered in South Africa against tuber moth in the field. These are generally applied weekly in combination with fungicides. No chemicals are specifically registered to control the tuber moth in storage. [107]

Chemicals need to be used carefully and rotated between types to prevent the moths from developing resistance. It is interesting to note that once an insect develops resistance to a particular chemical it is likely that it will have resistance to other chemicals that work in the same way. In general the insecticides registered in SA can be divided into 3 main groups[108] (although there are exceptions):

◊ Carbamates and organophosphates interact with the insect's AchE enzyme.

◊ Pyrethroids affect the insect's sodium channel. These are contact or stomach pesticides so must be applied when moths or small larvae are active before they begin mining into the leaves. These also work better at cooler temperatures

◊ Growth regulators affect the moulting process.

During the past ten years new chemicals have been registered for use against the tuber moth, e.g. a pyrrole, an oxadiazine, benzoylureas and spinosad. However, these are much more expensive.[109]

Two parasitoids, *Copidosoma koehleri* and *Apanteles subandinus*, have been imported and successfully released in South Africa. These parasitise 80 – 90% of larvae in unsprayed fields in most seasons. However, when moth infestations are high due to warm and dry weather the 20% of tuber moths that remain can still cause damage.[110] A virus that is lethal to tuber moth is also being investigated at Roodeplaat.

There are several less damaging methods for controlling tuber moth, but these require farmers to adapt and use a number of strategies together, which are given below:[111]

In the field

- Natural enemies of the potato tuber moth include several beetles such as the lady beetle, venomous sackspiders, orb-web spiders, and cryptic spiders and wasps.
- Choosing cultivars for traits that limit opportunities for infestation helps, e.g. early maturity allows the tubers to develop before moth numbers increase later in the season and cultivars that form tubers deeper in the soil are less accessible to larvae.
- If the tubers form less than 10cm below the soil surface the soil should be mounded around the plants to increase depth.
- Select fields for potatoes where the soil is not prone to cracking easily as it dries.
- Provide adequate water. The larvae don't like rain and overhead irrigation. Consistent watering also prevents soils from drying out and cracking.
- Harvested potatoes shouldn't be left in fields overnight where they can be reached by larvae, nor should pulled potato vines be used to cover tubers against the sun as larvae may move from leaves to tubers.
- Provide alternative Solanaceae as host plants to attract the tuber moth away from the potatoes.
- Rotate Solanaceae crops so that they are not planted in the same fields or near to the previous season's crop, which would provide fresh food for waiting eggs and pupae.

In storage

- Storage below 10 degrees Celsius prevents damage to the tubers by keeping any eggs or larvae in the tubers inactive.
- The CIP recommend using repellent plants such as eucalyptus or lantana in storage.

GM potatoes in South Africa

Two projects for the development of genetically modified (GM) potatoes have been initiated in South Africa. Both projects are attempting to engineer resistance to the Potato tuber moth and related insects through the insertion of genes derived from the bacteria *Bacillus thuringiensis* (Bt). These projects are run by A: First Potato Dynamics (FPD) Holdings and B: the Agricultural Research Council (ARC) and are detailed on pages 38 and 39.

The following table indicates successful applications to the Department of Agriculture for the importation, export and trial release of transgenic potato material.

Table 3: Permits issued to date by the Department of Agriculture for the release of GM potatoes in South Africa[112]

Year	Month	Permit type	Applicant	Description
2000	March	Import & Contained use	ARC-012	Imported from USA for Laboratory & greenhouse trial
	Sept	Extension	ARC-012	Extension of import permit
2001	July	Import & Field trial	FPD-004	28 glass tubes imported from Israel for field trails
	Aug	Field trial	FPD-005	150 RSA tubers for field trial
	Sept	Field trial & amendment to field trial permit	ARC-014	800 tubers
2002	May	Amendment to field trial	FPD-007	2500 tubers from USA for field trial
	June	Import	FPD- 008	7 clones imported from Israel
2003	April	Import	ARC-019	Import of 10 plantlets from USA, line G3
	June	Field trial (fast track permit)	ARC-023	2640 seed tubers from RSA G2 & G3 lines
2004		Field trial	ARC-024	6827 Bt seed tubers from RSA
2005	July	Export	CSIR-002	30 kg of Spunta G2 & G3 exported to Scotland for contained use
2006	June	Export	ARC-035	80g of G2 Spunta for contained use in the USA
	June	Field trial	ARC-034	3414 Spunta G2 Bt tubers
	June	Field trial	ARC-033	1750 Mnandi mini tubers
2007		Contained use	ARC-OVI	Spunta G2

A. First Potato Dynamics (FPD) Holdings

First Potato Dynamics (FPD) Holdings is a private company that has the agency in South Africa for two major Dutch Breeding Houses, namely Agrico and Meijer, and also imports from Israel and New Zealand. Historically FPD focused on supplying potatoes for the processing industry but are now strengthening their market share in the table potato industry as well as supplying mini-tubers and G2 potato seed. [113]

Permit authorisations published by the Department of Agriculture show that FPD were the first entity to obtain permission to conduct field trials with genetically modified potatoes in South Africa during 2001 and 2002 (See Table 3: Permits issued to date by the Department of Agriculture for the release of GM potatoes in South Africa). However, the Landbouweekblad had already published a story about the success of FPD's field trials with transgenic tuber moth resistant potatoes in September 2000.[114] According to the article both the plants and tubers of Desiree, Lady Rosetta, O' Maya and Shepody cultivars containing Bt genes successfully withstood tuber moth attack, and the company hoped to commercialise within two years. However according to Lefras Olivier, from the potato propagation division of FPD, the Bt potato project was "put on ice" because of the intricacies of dealing with various multinationals over the patent rights vested in the potatoes and because the time wasn't right in the context of potato industry politics. He nevertheless believes that biotech potatoes are the lesser of two evils when compared to the chemicals used in the potato industry and therefore their Bt potatoes are still on the cards.[115]

FPD's partners in the Bt potato project included the Centre for Potato Research in Hot Climates Ltd, a private company based in the northern Negev in Israel that works together with the Ben-Gurion University and a few private companies in Israel, South Africa, UK, and USA. Their aim is to develop new potato varieties and technologies for hot climates. They developed the Bt potato together with another Israeli company, Vitality Biotechnologies Ltd located in Tirat Hacarmal.[116]

B. The Agricultural Research Council (ARC) Bt potato project

The second transgenic potato project in South Africa is being managed by the Vegetable and Ornamental Plant Institute (VOPI) at ARC on behalf of an international consortium.

Key role-players

The Michigan State University (MSU)

The MSU has been the main proponent of the Bt Potato project from its inception and remains the international project coordinator. The Bt potato project leader, Dr David S Douches, heads the Potato Breeding and Genetics Programme under their

Department of Crop and Soil Sciences. The mission of this programme is to deliver improved potato varieties; to develop varieties that result in reduced pesticide use and promote sustainable farming, and to explore ways to enhance nutritional value of potatoes. [117]

Initially the Bt potato project was managed by the Department of Crop and Soil Sciences, but due to the complexity of legal and other aspects management was later transferred to the Institute of International Agriculture.[118]

The Institute of International Agriculture (IIA) provides an inter-departmental focal point for programs focusing on international study, development and activities in the areas of food, agriculture and natural resources. It provides a home to many of MSU's externally funded international development projects. Dr Johan Brink is the director of Biotechnology Programs at the institute which focuses on GM cassava through the Southern Africa Biotechnology Project, provision of technical assistance in Southern Africa and Asia on a needs basis, support to a biosafety coordinator in Uganda promoting biotechnology as well as the Bt potato project.

Agricultural Biotechnology Support Project (ABSP)

The ABSP is a USAID funded programme that generally promotes the adoption and development of agricultural biotechnology in developing countries through various capacity-building and technology transfer initiatives.

The first phase of the project, ABSP 1, ran under the management of the Institute of International Agriculture at the Michigan State University (MSU) from 1991 – 2003. The main goal of this phase was 'to mutually enhance U.S. and developing country institutional capacity for the use and management of biotechnology research to develop environmentally-compatible, improved germplasm.' This was achieved through specific objectives relating to insect and virus resistance and the 'transfer of scientific knowledge and techniques to developing countries through postdoctoral fellowships'.[119] The MSU worked in partnership with various developing country institutions including the Agricultural Genetic Engineering Research Institute (AGERI) and the Horticultural Research Institute (HRI) in Egypt; the International Potato Centre (CIP) in Peru, the Centre for Food Crops Research (CRIFC) in Indonesia and later ARC-VOPI in South Africa. [120]

ABSPII is being managed by Cornell University and is implemented by an extensive consortium comprising American research institutions as well as many international private, 'non-government' and academic institutions. The University of Cape Town is listed as a consortium partner. ABSP II is working in Bangladesh, India, Indonesia, the Philippines, Mali and Uganda.[121] The focus of this phase is to build capacity in the policy environment for the use, management, and commercialization of agricultural biotechnology in developing countries. This includes developing 'product commercialisation packages' and building farmer and consumer awareness of the benefits of biotechnology.

International Potato Centre (CIP)

The International Potato Centre, based outside of Lima in Peru, seeks to reduce poverty, and achieve food security and sustainable urban and rural livelihoods in developing countries. It does this through convening research and partnership programmes and assisting with access to new technologies in relation to potato, sweet potato, and other root and tuber crops, as well as on the improved management of natural resources in the Andes and other mountain areas. [122]

CIP is a member of the Alliance of the 15 centres of the Consultative Group on International Agricultural Research (CGIAR) and so receives its principal funding from the 58 governments, private foundations and international and regional organizations that constitute CGIAR.

Agricultural Research Council (ARC) – Vegetable and Ornamental Plant Institute (VOPI)

The ARC has a long history of agricultural research in South Africa. However, it was established in its current form as the principal 'public' agricultural research institution in South Africa under the Agricultural Research Act 86 of 1990 (as amended). The Act sets out the objectives of the ARC as "conducting of research, development and technology transfer in order to promote agriculture and industry; contribute to better quality of life; and facilitate/ensure natural resource conservation". A key focus is the development and dissemination of new technology, and competitive commercialisation of research results to make the agricultural sector more sustainable. ARC is also tasked with rendering services to the Department of Agriculture. ARC's functions are carried out through 10 research institutes, with access to research farms throughout the country. [123]

ARC has a keen interest in biotechnology and conducts biotechnology research in several of its units in addition to the Biotechnology Division of VOPI (ARC-VOPI), including the Grain Crops Institute (ARC-GCI); the Institute for Tropical and Subtropical crops; the Animal Improvement Institute (ARC-AII); Infruitec-Nietvoorbij

(ARC- Infruitec-Nietvoorbij) and the Small Grain Institute (ARC-SGI). ARC has also played an influential role in promoting biotechnology in Africa. In 1995 UNESCO's Biotechnology Action Council established a Biotechnology Education and Training Centre (BETCEN) for Africa at ARC-VOPI in Roodeplaat, where a large number of African scientists have been trained.[124]

ARC-VOPI was established in 1949 when the main research farm at Roodeplaat was bought. A unit of VOPI focusing on Fynbos has also been established in Stellenbosch. The mission of ARC-VOPI is to "do innovative, needs-driven, environment friendly research, technology development and technology transfer on potatoes, vegetables (hydroponic production as well as indigenous vegetables) and indigenous flowers".[125] **Research is aimed at both the commercial and developing agricultural sector. Several commercially grown potato and vegetable cultivars have been developed by VOPI.**

Agricultural Genetic Engineering Research Institute (AGERI)

AGERI was established jointly in 1989 by the Egyptian government and the United Nations Development Program within the Agricultural Research Centre (ARC) of the Ministry of Agriculture & Land Reclamation (MOALR) in the Arab Republic of Egypt. In general AGERI promotes Egyptian capacity in biotechnology by providing laboratories and opportunities for the development of biotechnologists and biotechnology projects.

Garst Seed Company (formerly ICI Seeds)

Garst was founded in 1930 and is now based in Slater, Iowa. The company built an early reputation on maize hybrid seeds. Today it sells a variety of transgenic and high yielding maize, soybean, sorghum, alfalfa and sunflower products. Garst is affiliated to and backed by Syngenta's resources and research. [126]

ICI was one of 17 multinational companies implicated in the infamous Tala Valley in KwaZulu-Natal where vegetable farmers faced crop losses and mutations following herbicide drift from other agricultural activities. Affected farmers filed a Supreme Court action against the 17 companies to stop the manufacture and sale of all hormone herbicides in the country. The court rejected the application, ruling that the action should have been brought against the herbicide users and not the distributors and manufacturers. Furthermore the court penalised the farmers by ordering that they pay the massive legal costs incurred by the chemical companies estimated at that time to have been around R750 000.[127]

Syngenta

Syngenta emerged as the first multinational company focusing exclusively on agribusiness from the merger of the agrochemical and seed businesses of Novartis (Switzerland) and the agrochemical and biotech businesses of AstraZeneca (UK) in November 2000.

These companies had grown out of a long process of corporate growths and mergers. Notably Novartis was established in the mid 90's through one of the largest corporate mergers in history between Sandoz and Ciba-Geigy. AstraZeneca formed through merging Astra AB (Sweden) and Zeneca Group (UK), while Zeneca was established in 1993 after Imperial Chemical Industries (ICI) demerged its three main businesses (including ICI Seeds).

Today Syngenta prides itself as being a world leader in "crop protection" through its combination of biotechnology and agrochemical products and is the third largest company in the commercial seeds market. Syngenta is represented in over 90 countries and sales in 2006 were approximately US$8.1 billion.[128]

Syngenta's precursor companies had a long history in agricultural products beginning with pesticides in the 1930s, expanding into seed companies in the 1970s and biotechnology in the 1980s.[129]

This history includes the production of highly toxic agricultural chemicals such as DDT and other organophophates. Syngenta continues to defend the production and sale of dangerous agri-chemicals, the most notable of these being Paraquat, which is mostly used in developing countries, and the non-selective herbicide Atrazine, which causes cancer and birth defects.[130]

Ciba-Geigy and Sandoz began research on engineering insect resistant crops using Bt toxin in the 1980s, which resulted in Bt Maximiser/Knockout insect resistant maize. The USA approved commercial growing of this in 1995 and it continues to be one of Syngenta's most important brands.[131] Syngenta achieved global notoriety in 2007 by contaminating US exports to Europe and elsewhere, with its unapproved GM maize, Bt 10.[132]

While Syngenta's bread and butter products focus on input traits for commodity crops they have made much public mileage out of new generation GM crops that supposedly introduce traits that benefit consumers, but especially the world's poor. Syngenta's so-called 'Golden Rice' project to enhance the Vitamin A content of the rice is an example.

Behind the scenes Syngenta has been pursuing the most controversial of biotechnologies: Gene Use Restriction Technology (GURT) known commonly as Terminator or Traitor technology. GURT creates either sterile seeds or controls particular plant characteristics. For example fruit ripening, flower or sprout-timing is controlled through applying a proprietry chemical.[133]

In South Africa Syngenta was given commercial approval to sell its GM maize, Bt 11, in 2003. GA21 was approved for commercial import for food, feed and processing as well as field trials. Syngenta has applied for commodity clearance of other GM maize varieties Bt176 and MIR604 but these are on hold pending the results of a Department of Trade and Industry study into price distortions in the maize market. Significantly, in 2007 South Africa's Executive Council on GMOs refused Syngenta's application for commodity clearance of GM maize event 3272. This maize is modified to produce two new proteins suited to ethanol production. Several varieties of its GM cotton (VIP and herbicide tolerant) have also been field tested in South Africa.[134]

Syngenta invests heavily in international lobbying to push its agribusiness agenda. It has contributed substantially to lobbying and funding political candidates in the USA. Its precursor Novartis entered a five-year US$25 million research alliance with Berkley University in California allowing Syngenta rights to a third of license on new innovations and seats on the committee allocating research funding.

It also participates in a number of influential trade organisations such as CropLife International and the World Business Council for Sustainable Development. The most controversial is Syngenta's participation, through the Syngenta Foundation for Sustainable Development, in the governing body of the Consultative Group on the International Agriculture Research Centres (CGIAR). The CGIAR links international agriculture research centres and seed banks "To achieve sustainable food security and reduce poverty in developing countries through scientific research and research-related activities in the fields of agriculture, forestry, fisheries, policy, and environment".[135] Unlike other participating private foundations, Syngenta is the only one which is directly involved in seed and agrochemical businesses. Through its position on the CGIAR, the Syngenta Foundation will most certainly push its pro-corporate and pro-GM agenda.[136]

Bt Potato – history and vested interests

The ARC Bt potato project has a long history linked to a number of international institutions. The project began in Michigan (USA) and Egypt, where it reached a stalemate prior to commercialisation. South Africa subsequently received the project as a 'hand-me-down' as the interests vested in the project pursued their goal to have a GM crop potato commercialised.

Egypt

The project began as part of the Agricultural Biotechnology Support Project (ABSP)[137]. Initially Egypt was the focus of the programme and in 1992 the ABSP entered into a cooperative research agreement with Agricultural Genetic Engineering Research Institute (AGERI) [USAID/CAIRO/AGR/A, co-operative Agreement No. 263-0152 A-00-3036-00[138]] with the aim of producing potatoes, maize, cucurbits and tomatoes that were resistant to pests. According to the ABSP website Egypt was the first choice as a partner because "The Egyptian government ... is receptive, to changing Egyptian policies to foster biotechnology entrepreneurship. USAID also has a well-established office in Cairo dedicated to three objectives: technology generation, technology transfer, and policy reform. The office is in the unique position of being able to provide funding to country projects directly." Further it quotes Judith Chambers, a former ABSP project officer who later joined Monsanto, "A really good research infrastructure already existed in Egypt ... a state-of-the-art functional lab and many people who had been trained in the United States." [139]

The Bt potato project fell under a broader ABSP programme to 'develop and manage resistance to the Potato tuber moth'. Their first goal was to insert an insect resistant gene into the potato genome. The MSU team identified a codon modified Bt gene, CryV (now termed Cry1Ia1) owned by Garst Seed Company (formerly ICI Seeds) for use in the transformation. A material transfer agreement (license to use the gene) was secured with Garst in October 1994 allowing the MSU to use the gene and share it with collaborators in Egypt and Indonesia.[140]

According to Dr David Douches, Professor of Crop and Soil Sciences at MSU, who continues to head the project, "The first step was to make sure that the gene worked. It required us to make vector constructs that allowed us to make the transformation. We had to improve the system so that we could screen a large number of plants. We now have a genotype-independent system that allows us to transform any type of potato." The MSU tested the efficacy of the gene against the Tobacco hornworm (*Manduca sexta*), as no tuber moths occur there, in field trials at the Montcalm potato farm in Michigan between 1993 and 1996 (http://www.iia.msu.edu/absp/egypt-ptm.html).

At the same time Egyptian scientists at AGERI were working on their own tuber moth resistant potatoes using locally developed Bt genes. This resulted in additional field trials of potatoes using CryIa(c) and CryV var. kurstaki delta-endotoxin genes.

The ABSP played an important role in promoting the adoption of GM technology within partner countries. A key component of this was a capacity building programme with governments and scientists. Egyptian scientists attended an 8-week biosafety internship programme at MSU in 1993, an IPR and patent internship programme at Stanford in 1993, and an IPR workshop in Washington DC in 1994. ABSP also brought Prof. John Barton from the Stanford University Law School to Cairo to present a workshop on Intellectual Property Rights, Patents & Licensing, which was attended by over 100 participants from various public and private sector institutions.[141] Key AGERI scientists who were instrumental in drafting the new Biosafety regulations in Egypt were recipients of this training. Ongoing legal assistance was provided through the consultancy of Prof. Barton to assist with designing model legislation and addressing intellectual property rights issues that came up in projects.

Prior to the ABSP's interventions, foodstuffs and pharmaceutical compounds could not be patented under Egyptian law, so that they could benefit society. The ABSP's strategy of 'capacity building' succeeded in reforming patent and biosafety policy in favour of the biotechnology industry. In 1995, new Biosafety legislation was promulgated by the Ministry of Agriculture and Land Reclamation, (MALR) by two Ministerial decrees (nos. 85 and 136) and an Egyptian National Biosafety Committee was established. Procedures for commercializing GMOs were established in 1998 by a Ministerial decree no. 1648.[142]

In 1996 the MSU/AGERI team began transformation of Spunta potatoes – a fresh market cultivar grown in Egypt, and by 1997 the MSU sent first and second generation tubers to Egypt for testing. The 1997 Bt potato tests were the first GM field trials approved in Egypt. Field testing was carried out at two locations from 1997 to 2001:

- ◊ Small-scale trials were carried out in Giza at AGERI's newly developed containment facilities, also supported by ABSP.
- ◊ Larger trials continued at the regional office of the CIP in Kafr-el-Zyat in the Nile River Delta potato production region in Egypt.

According to the MSU, the Centro Internacional de la Papa (CIP) / International Potato Centre was a key partner, bringing field expertise and relationships with the commercial potato sector to the team.[143] They also conducted laboratory tests on the Bt potato's impact on the larval development of 2 Andean tuber moth species.

By 1998, the Bt Spunta potatoes had undergone 4 years of what were considered to be successful field trials and 2 years of storage trials using the traditional Egyptian Nawalla storage system. The potato team began drawing up detailed plans for commercialisation in Egypt and partners for further trials were identified in Indonesia and South Africa.

In 2001, the ABSP project received a blow when after 8 years of research, the government of Egypt decided not to continue with the process to commercialize Bt potatoes. Reasons given for the failure to commercialise in Egypt included public resistance to field trials and commercialization plans expressed in media articles,[144] sensitivity from the processing industry as well as the government's concern that the Egyptian export market of potatoes and other agricultural commodities to the European Union (EU) would be affected because of European resistance to GM foods.

Indonesia

The ABSP began a parallel process to promote biotechnology in Indonesia beginning in 1992. This also involved capacity building exchanges and the Bt potato project and another USA backed insect resistant maize project provided the push to develop biosafety guidelines so that field trials could begin. National Biosafety Guidelines were passed by Ministerial Decree in 1997. Assistance provided by ABSP also led to the formation of IPR and technology transfer offices in Indonesia. This process to open Indonesia up to GM companies led to the eventual approval of GM cotton in 2000. [145]

Efforts to take the Bt potato project further in Indonesia were unsuccessful: the public sector partner lost interest in taking the project into field trial stage due to resource constraints, and early attempts to partner with a private potato business failed due to concerns about the reaction of the chip manufacturing industry. [146]

The Bt potato kit

The GM potatoes that are currently being researched derive from the following donor organisms[147]:

The genes used in the potato are:

- BtCry1Ia1 (formerly called BtCryV) gene was isolated from the *Bacillus thuringiensis kurstaki* bacteria by researchers in Europe, to confer resistance to the insect the Potato tuber moth (*Phthorimaea operculella*). This gene is regulated by a CaMV 35S promoter (from the Cauliflower mosaic virus) and the bacterial nos terminator.

  Research shows that this gene impacts on both lepidopteran and coleopteran insects.

- The NptII gene is derived from Tn5 in *Escherichia coli (E. coli)*. Tn5 is a transposon that moves rapidly around bacterial chromosomes and plasmids leaving copies of itself as it moves. The Tn5 contains a gene which provides resistance to the antibiotic kanamycin (also called neomycin), which is used as a selectable marker to identify the successfully transformed DNA in the laboratory. The elements that allow mobility in Tn5 have been removed from the cloned nptII. This gene is regulated by a bacterial nos promoter and bacterial nos terminator.

Method used to transform the potato DNA

Agrobacterium tumefaciens was used as the vector (invades the potato with the new genes) to transform the potato DNA – it is called an *Agrobacterium* Ti plasmid.

The potato cultivars that have been transformed for testing in South Africa are:

- the Spunta cultivar. The Michigan State University (MSU) obtained permission from the licensed breeders (J. Oldenburger, Assem, Holland) to use these in their breeding programme.

The Spunta cultivar is a long oval-shaped table potato with slightly powdery, dark cream flesh that is suitable for boiling and roasting. Spunta is mildly susceptible to *Fusarium* dry rot and *Fusarium* wilt. It has a medium length growing period.

- the Mnandi cultivar, developed by ARC. It has very high field resistance to early and late blight, but is moderately susceptible to *Fusarium* dry rot. It is a an oval shape with pale yellow flesh and a fine, floury texture. It is not suitable for processing and doesn't keep well if exposed to heat and water stress while growing. It has a medium to long growing period of roughly 110 days. Non-GM Mnandi is grown by low-input farmers in KZN and the Eastern Cape, and ARC has been testing its suitability in Angola, Mozambique, Zambia and Zimbabwe.
- According to the MSU the commonly grown South African variety BP1 has been successfully transformed[148] and Darius will also be transformed, while the Ranger Russet, Jacqueline Lee, Atlantic and Lady Rosetta varieties have been transformed for use in the USA and Mexico[149].

South Africa

In December 1999, a Materials Transfer Agreement was signed between ARC-VOPI and the MSU to transfer 12 transgenic Bt potato lines in the form of tissue culture plantlets to South Africa for greenhouse and field evaluations.[150] Authorisation was granted in 2000 for the 2001 growing season.

With the failure of the projects in Egypt and Indonesia the MSU turned all its attention to South Africa as the last avenue for commercializing the Bt potato, and in 2001 the research project with ARC-VOPI was expanded. To make the project more palatable, the project has been specifically marketed in South Africa as a development project to assist small-scale and emerging potato framers.

The ABSP did not have to expend much energy in paving the way for the Bt potato project in South Africa. Nevertheless a '*Southern Africa Regional Biosafety Program Workshop*' on regional biosafety needs and opportunities was held in South Africa in March 2001.[151]

Field trial research began at ARC in 2001. The following table summarises the research activities carried out by ARC on the Bt potato.

Table 4: Bt potato summary of research activities reported to the Executive Council

Year	Permit #	Activities
2001/2 Year 1	17/3(4/01/123) 17/3(4/01/130) 17/3/1-ARC-01/014	2001 ARC received 6 GM potato lines (Spunta -6av3, Spunta-G2, Spunta-G3, L235-4, Spunta-S1, Spunta-S4) in vitro from MSU & multiplied in greenhouses to produce mini-tubers. First field trials with mini-tubers planted in October 2001 & storage trial with left-over mini-tubers in Gauteng (Roodeplaat). Testing for: • efficacy of gene against tuber moth in field & storage trials • preliminary gene flow studies – Spunta G2 tested, low fertility found • studied soil micro-organisms & nutrient cycling, impact on non-target species & microbial diversity
2002/3 Year 2	17/3(4/02/189) 17/3/1-ARC-02/020	Trials with Bt lines 6-a3, G2, G3, L235, S1, S4 compared to Spunta & BP1. Field trials in Gauteng (Roodeplaat) & Western Cape (Ceres) with tubers from previous year's trial. Storage trials at Roodeplaat in diffuse light store extended from previous year. Winter 2003 mini-tubers planted in greenhouse at Roodeplaat for next season. 30 000 tuber moths released at Roodeplaat. Left over material destroyed by deep freezing Testing for: • efficacy of gene against tuber moth in field & storage trials. Claim protection from moth for 8 months in storage, but tubers still attacked by mealy bug, red spider mite. • checked for virus incidence: PVY, PVX. PVS, PLRV

2003/4 Year 3	17/3(4/03/068)	Trials with Bt Spunta G2 & G3, compared to Spunta, BP1, Mnandi. Planted as well as storage trials in Gauteng (Roodeplaat), W Cape (Ceres- Koue bokkeveld), & KZN (Kokstad). Ceres & Kokstad planted from potatoes saved from previous year trials. Roodeplaat used mini-tubers. Mini-tuber production at Roodeplaat for next season trials (Sept 2004) 20 000 tuber moths released at Roodeplaat. Testing for: • efficacy of gene against tuber moth in field & storage trials • checked for virus incidence: PVY, PVX. PVS, PLRV – no difference in GM found • effect of parasitism in cages of potato leaf-miner emerging from GM & non-GM leaves – no impact found • impact on non-target species especially other arthropods through pitfall and sweep net traps • tuber moth survival on alternative host plant leaves in laboratory bioassays tests only
2004/5 2005/6	17/3(4/04/108)	Trials with Bt Spunta G2 & G3, compared to Spunta & BP1. Planted in Gauteng (Roodeplaat), Western Cape (Ceres – Koue Bokkeveld), Eastern Cape (Patensie), eastern Free State (Bethlehem/Petrus Steyn dryland) & KZN (Kokstad dryland & irrigated). In 2005 expanded to Limpopo (Dendron) Storage trials in 2004 at Roodeplaat, Ceres, Kokstad

2004/5 2005/6	17/3(4/04/108)	Testing for: • efficacy of gene against tuber moth in field (Roodeplaat, Ceres, Kokstad, Dendron, Petrus Steyn, Patensie) & storage trials • preliminary gene flow studies by collecting true seed produced and monitoring volunteer potatoes growing after trial Spunta G2 tested, low fertility found • Ecological tests (Roodeplaat, Ceres, Petrus Steyn) including: – Soil sampling for arthropods, soil mites & nematodes – variety of traps, sweep nets & visual observation of impact on non-target organisms – analysis of tuber moth eggs & pupae placed in fields for evaluation of parasitism – leaves affected by potato leafminer collected to monitor parasitism of this pest – testing of glandular trichome (sticky hairs on potato) effects on tuber moth parasite, C.koehleri • Lab tests of impact of gene on target & non-target species Planned to conduct: • Food and feed safety analyses • Tissue samples to test for gene stability • Analysis of nutritional composition & toxicity at ARC-Animal Nutritional & Animal products institute, ARC-Onderstepoort Veterinary Institute & CSIR Bio/Chemtek. • In glasshouse crossing of GM with other cultivars to test gene stability in producing true potato seed

Current Status

The African Centre for Biosafety has engaged in several years of correspondence with members of the ARC project team. In addition, in 2004, ACB (Mariam Mayet), together with Biowatch South Africa (Elfrieda Pschorn-Strauss), Glen Ashton and William Stafford, submitted an objection to the decision-making authority on GMO applications (the Executive Council) in response to the application by ARC for continued field trials with the GM potato. This objection called for an immediate halt to further field trials with the potato, given these were unlikely to provide the additional data needed concerning gene flow or ecological and feed safety of the new GM potato varieties. The objection also noted that socio-economic impacts of the project had not been addressed at all, and that previous trials had failed to abide with permit conditions.[152]

The Executive Council approved the trials prompting further objection from the ACB in March 2006, again calling for the experiments to be stopped. This detailed response provided further evidence that important issues concerning transgenic instability, horizontal gene transfer, antibiotic resistance gene markers, soil microbial diversity, problems with the use of the CaMV, and toxicity to non-target insects were not being addressed by ARC. Furthermore it noted that "the construction and release of a transgenic plant into the environment only to benefit storage of the crop is illogical. The benefit of these transgenic potatoes is outweighed by the enormity of the risks."[153] Despite the fact that 43 individuals and 24 organisations supported the objection the permit was granted.

Since then no further information has been made public. The ACB has made numerous requests to ARC throughout 2007 for information and progress reports of studies on the socio-economic impacts on farmers, food safety assessments and impacts on non-target organisms in the environment, as well as the date an application for commercialisation can be expected. According to the MSU International Institute of Agriculture's website the MSU and VOPI are busy compiling a regulatory dossier in preparation for commercialisation of the Spunta G2 line. This data collection includes a socio-economic survey, allergenicity and toxicity assessments, evaluation of outcrossing and weediness potential, and the effect on non-target insects.[154] ARC was unwilling to provide any further information citing the confidential nature of the project, until such time as the application for general commercial release is submitted to the Executive Council (from whom the public can access information using the Public Access to Information Act). "We are not entitled to discuss client funded projects to any one not directly involved in the research, before the results are published publicly due to IP (intellectual property) issues involved".[155]

Food and feed safety

Food safety is a major concern. This Bt Cry gene hasn't been used previously in commercially released crops. Furthermore, commercialisation of crops in developing countries is usually based on safety and other regulatory data generated through prior commercialisation in the USA. This case is unusual in that this data will be generated in South Africa.

A small-scale animal feeding trial using Spunta G2 and G3 lines obtained from AGERI was previously undertaken as part of a M.Sc. thesis published in 2004. The study found that "feed ingested DNA is partially resistant to the mechanical, chemical and enzymatic activities in broiler chicken gastrointestinal tracts, is not completely degraded and can pass the gut epithelium and enter some organs of broiler chickens". However, the scientists were unable to find modified constructs from GM potato in their tissue samples. They also noted that although they had not found any specific problems with rats and chickens fed on the GM potatoes the potential risks of unknown toxins from the GM potatoes and their ability to affect reproductive function, mutagenicity or carcinogenicity cannot be confirmed by short-term experiments[156].

ARC reported that food and feed safety data would be compiled by ARC-Animal Nutritional & Animal Products Institute, ARC-Onderstepoort Veterinary Institute & CSIR Bio/Chemtek. In 2006, ARC confirmed[157] that preparatory trials were being conducted with rats to establish how much standard (non-GM) potato could be included in a rat's diet before it becomes detrimental to them, and the point at which the feed becomes unacceptable to the rats, in preparation for scientifically acceptable GM potato feeding trials. The Bt potato feeding trials would include feeding the test animals pure protein, as well as whole food studies with rats being fed potatoes as part of their diet. ARC developed a method for the production of cooked and uncooked freeze dried potato powder to enable testing.[158] In 2006 the MSU listed the Tshwane University of Technology as a partner in toxicology studies.[159] ARC's 2007 Annual Report states that ARC-OVI Toxicology Laboratory have, in collaboration with ARC-API and ARC-ROODEPLAAT, been involved in animal toxicity testing of the GM potato to determine its safety for human consumption.

Health concerns

The nptII marker gene

Antibiotic resistance marker genes allow cells to survive applications of an antibiotic in order to test which ones have been genetically modified. The GM potato contains the nptII gene as selection marker. This provides resistance to the antibiotic kanamycin, but also neomycin, paromomycin, ribostamycin, butirosin, gentamicin B and geneticin (G418).[160]

The European Union (EU) has taken a decision to phase out the use of antibiotic markers due to the ability of bacteria plasmids to assimilate genes, and thus the potential for antibiotic resistance to be transferred to stomach or harmful bacteria. (Directive 2001/18/EC Article 4). However, the consequences of kanamycin resistance are debated. The European Food Safety Authority has argued that there is little reason for concern due to the limited use of kanamycin in human and veterinary medicine and because kanamycin resistant bacteria are found commonly in nature.[161] Others disagree. Kanamycin resistant bacteria can easily develop cross-resistance to antibiotics from the same family: aminoglycoside antibiotics.[162] In South Africa another aminoglycoside, amikacin, is frequently used to treat pneumonia and septicaemia. More importantly kanamycin is listed in the WHO Essential Medicines Library as a drug reserved for treating multi-drug resistant tuberculosis[163], and is used for this purpose in South Africa.[164] This form of TB is a growing problem world-wide and has already had a devastating impact in South Africa. Increasing the opportunities for kanamycin resistance should therefore be avoided.

CaMV 35S promoter (from the Cauliflower mosaic virus)

The modified BtCry1Ia1 gene is 'turned on' or made active in the DNA by the CaMV 35S promoter from the Cauliflower mosaic virus. This promoter can also function in bacteria, so if the transgene is integrated into bacterial DNA it will carry a functioning 'on switch'. The only human study ever conducted with GM food found that in 3 out of 7 volunteers, genes from the herbicide tolerant GM soy being studied, transferred from the soy to bacteria in the gut. Further investigation found that the bacteria had become herbicide tolerant indicating that the CaMV promoter was functioning. Should this happen with these GM potatoes the gene producing Bt toxin could be switched on so that gut bacteria start producing this toxin resulting in unpredictable impacts ranging from low level toxicity to life threatening allergic reactions.[165]

Biosafety issues

Current studies being conducted by the ARC include impact on non-target organisms. The progress of these studies has not been reported on. ACB has, through its objections, noted that the proposed design of ecological tests to assess the impact on non-target organisms was not adequate. Furthermore, Bt toxin is released into the soil from Bt crops where it can remain for up to 234 days, and populations of earthworms and beneficial parasites have been shown to decrease in fields where Bt crops are grown.[166] The ARC has not indicated how the impact of a Bt potato crop on soil microbiology will be assessed, if at all.

The long term impacts of permanently engineering a pesticide into a plant are also not being addressed. The Bt potato project leader, Dr Douches, notes in a paper that the potato pest that the Bt potato targets in the USA, the Colorado Potato Beetle "has shown the ability to adapt to many insecticides over the past half-century. Currently, it is reported to be resistant to 37 insecticides worldwide, including organophosphates, carbamates, organochlorines, pyrethroids, and hydrogen cyanide.[167] Similarly Potato tuber moth resistance to pesticides has been proven in countries outside of South Africa, indicating the same potential in South Africa, and farmers are warned that different types of insecticides must be used alternately and only when necessary to prevent resistance from developing.[168] It is therefore likely that the uncontrollable but permanent release of the Bt toxin into the environment through GM potato plants will result in the Tuber moth developing resistance to Bt toxin over time, with implications for organic farmers using *Bacillus thuringiensis* as an organic pest remedy in a variety of Solanaceous crops.

Eicher et al[169] estimate that the process for collating regulatory data and technology negotiations will take until 2010. They also cite concerns about liability, especially in relation to the trans-boundary movement of Bt potatoes into neighbouring countries that do not have biosafety regulatory policies and systems in place, as a key reason that commercialisation of the Bt potato in South Africa has been delayed.

The ease with which potatoes can be vegetatively reproduced is of concern to many. One of South Africa's largest retailers, Pick n Pay, issued a surprise media release in April 2007, to the effect that it would not stock the GM potato until the council could provide conclusive scientific evidence on the biosafety of the product.* Upon

---

* Solgado, I. 23 April 2007. **Retailers enter battle for high ground in GM foods**. Business Report.

further investigation their Regulatory Affairs Manager expressed concern that Pick n Pay cannot control the source of potatoes received from their suppliers and that they were concerned that GM potatoes may be entering the supply chain. Pick n Pay has written to their suppliers to say that they will not accept any GM potatoes. Pick n Pay's position is confirmed in correspondence stating, "GM potatoes have yet to undergo registration through the Department of Agriculture or complete the necessary safety trials. For this reason, at this stage, Pick n Pay would not stock them. Once the GM potatoes have undergone the necessary processes and received approval from the Department of Agriculture to be grown in South Africa, a decision will be made whether or not we will stock them, but only if they are clearly and transparently labelled".*

Socio-economic studies

Despite the continuing reference to the benefits the Bt potato will bring to emerging and resource-poor farmers, very little evidence of this has so far been provided by the project team.

The MSU International Institute of Agriculture's website emphasises investigations that are being made into the socio-economic benefits of the Bt potato. It also mentions that a South African project team was assembled to conduct a socio-economic survey of the impact of the Bt potato on smallholder commercial farmers, subsistence farmers, large scale commercial farmers and seed producers in order to address the requirements for the Regulatory dossier. In 2006, ARC completed a report in collaboration with the Human Sciences Research Council (HSRC) titled "Smallholder potato production activities in South Africa: a socio-economic and technical assessment of five cases in three provinces". This document is currently being withheld from the public, and will only be released when the application to commercialise the Bt potato is submitted. In four of the five areas that were studied, communities rely extensively on government grants, such as pensions or child support grants, and struggled to afford any agricultural inputs.[170]

The economic impact of introducing a new GM food crop in South Africa has not been investigated. In addition to Pick n Pay rejecting GM potatoes, McCains have also confirmed in writing that they will not buy GM potatoes for use in their processed

* Badenhorst, S. 20 November 2007. Manager Regulatory Affairs. Pick n Pay. Personal communication.

potato products or use Spunta and Mnandi cultivars.[171] Reasons for this were not given, however, McCains was the first company in the USA to reject the GM potatoes commercialised there because of consumer distrust.[172]

Over 90 % of South Africa's potato exports are to other countries in Africa, especially southern Africa. Zambia and Angola are major importers of South African seed and processed potato products, and South Africa's neighbours import fresh potatoes.[173] There has been substantial controversy surrounding GM foods in Southern Africa. Zambia has been the leader in rejecting GM food aid, with countries like Zimbabwe insisting that GM grains are milled before being brought into the country. Angola has no biosafety legislation in place.[174] African trading partners are likely to reject a new GM food crop, especially one which can grow so easily, impacting severely on South Africa's potato export market.

Who benefits?

It is unclear what Intellectual Property Rights (IPR) rights the MSU, AGERI and VOPI will have, should the potatoes be commercialised.

Ownership of Cry1Ia1 gene has been transferred to Syngenta Company through a series of corporate take-overs. Reports on the Bt potato project refer to the Cry gene obtained from ICI Seeds and then Zeneca. The gene was originally licensed to ICI Seeds, which became GARST seed company, which then entered into an agreement with Zeneca (Berkshire, UK), which then merged with Novartis to become Syngenta.

The Cry1la1, formally called CryV, falls under USA patent 6780408 assigned to Syngenta Participations AG (Schwaarzwaldallee, CH) on the 24th August 2004, for a wide range of Bt Cry genes.[175] The MSU has negotiated with Syngenta to obtain a license to commercialize the Spunta G2 Bt line in South Africa. Syngenta is willing to grant the license provided the South African government grants full regulatory approval. [176]

At the beginning of the project a patent on the CaMV 35S promoter was still pending in the USA, but was subsequently granted to Monsanto adding further complexity to the intellectual and consequent commercial rights to this potato.

No information has been shared on how the profits from the sale of the Bt potato will be distributed between all the partners who have contributed to the project, and what, if any benefits will be returned to the country through the ARC. The product is likely to be delivered through the systems already in place to grow and distribute certified seed potatoes, where royalties will be collected as they are currently with cultivars protected by Plant Breeder Rights.

The project costs

The project partners have not been willing to disclose how much the development of the Bt potato has cost thus far. It is also not clear to what extent the South African tax payer has been footing the bill in support of ARC's involvement in the project, given that ARC is a parastatal.

The USAID has continued to support the "testing and rollout strategy" for the Bt potato in South Africa[177] and ARC-VOPI list the USAID, the MSU and Harvest Plus as main clients.

The MSU reported in their progress report on the first phase of the ABSP (1991 – 2001) that additional funding support was received from USAID desks as follows: $1.6 million from USAID/Jakarta, $7.0 million from USAID/Egypt and $400,000 from USAID/Africa Bureau[178]. Small contributions were also received from Monsanto, Garst Seed Company and the Rockefeller Foundation. This contributed to the general strategy to promote biotechnology through learning exchanges, training workshops, creating national biosafety legislation, the construction of containment facilities and the Bt potato projects. What portion of this funding was allocated specifically to the development of the Bt potato is not shared.

Eischer *et al* (2006) estimate that more than US$ 3 million of donor funding has been poured into the 12 years of research on this project between 1993–2005.

GM potatoes in select countries

USA

Monsanto's NewLeaf potato, the only commercialised GM potato, was grown in the USA and Canada from 1995 -2001. The NewLeaf line of products were primarily modified with a gene from *Bacillus thuringiensis* subsp. *tenebrionis*, which creates the Cry3A protein rendering the potatoes resistant to Colorado potato beetle. These potatoes also carried the NPTII antibiotic resistance marker.[179] By 1999, having captured 5% of the potato seed market, the NewLeaf potato was dealt a blow when McCains announced it would not use GM crops in any of its products due to consumer distrust of GM potatoes.[180] Soon after crisp manufacturers, Proctor & Gamble (making Pringles chips) and Frito-Lay, requested that farmers not supply them with GM potatoes.[181] Finally in 2000, the fast-food giant McDonald's Corp. told it's french-fry chip suppliers to stop using the GM potato. Companies like J.R. Simplot Co., a major maker of French fries, instructed its farmers to stop growing NewLeaf potatoes and the NewLeaf market crumbled. Denying any influence from the market, Monsanto announced that it would withdraw GM potatoes after the 2001 growing season, in order to focus its research and marketing funds on four far bigger markets for genetically modified seed: canola, cotton, maize and wheat.[182]

Latin America

In Latin America there have been several projects to push forward with GM potatoes in the centre of origin of the crop, drawing wide-spread protest from farmers in the region.

In January 2007, a coalition of 34 farming organisations in Peru, launched an international protest campaign against Syngenta for continuing to pursue a type of terminator technology that would prevent potato tubers from sprouting unless a proprietary chemical is applied to the tubers. The coalition argue that Syngenta's continued pursuit of terminator potato patents in Europe, Brazil, Canada, China, Egypt and Poland, in addition to those already granted in Australia and Russia, show Syngenta's interest in commercialising the terminator potato, thereby putting the survival and culture of Andean peoples at risk.[183]

In mid-2007, a media report was published on the International Potato Centre (CIP) website, announcing that CIP scientists had developed Peru's first GM potato: named

Revolucion and modified with a Bt gene.[184] This prompted an open letter of protest from RALLT (the Network for a GE free Latin America) signed by 100 organisations.[185] On 7 July 2007, the CIP director, Pamela Anderson, issued a statement in response denying that the CIP has any intention of releasing GM potatoes in the Andes. CIP blamed a journalist for misinterpreting information presented on a training course. She admitted that the CIP developed a Bt potato resistant to tuber moth prior to 2002 as part of a research project designed to develop scientific capacity to work with these new biotechnologies. However, the CIP Board took a decision in April 2006 that the CIP will not disseminate GM potatoes in the Andean zone, which includes the countries of Peru, Bolivia, Ecuador, Colombia, Venezuela, Argentina and Chile.[186]

In the same week the government of the Cusco region in the Peruvian Andes banned the growing of any GM potatoes in the region to protect the potato diversity inherited by people in the region.[187]

The World Bank has also had a hand in paving the way for GM products. The World Bank and International Centre for Tropical Agriculture (CIAT) have applied for a GEF grant beginning in 2007 under the guise of building biosafety capacity, targeting Brazil, Colombia, Costa Rica, Mexico, and Peru. The project objectives include harmonising biosafety regulation in the region and building "awareness on biosafety for communicators, opinion-makers and the general public"[188]; a tried and tested strategy, in the same vain as the ABSP, to pave the way for the multinational biotech industry's products and undermine local objection to GMOs. Furthermore the project specifically sets out to facilitate the "deployment" of GM crops (using these as 'models' for environmental risk assessment and management) in the centres of origin for these crops. This will inevitably contaminate the biodiversity of these food crops, destroying the food, culture and agriculture systems that have been developed in the region over several thousand years and undermining food sovereignty in the region.[189]

Germany: BASF's Amflora potato

There are several projects in Europe field trialling GM potatoes with insect resistance and other traits. The most advanced of these is a project by the chemical corporation BASF for the 'Amflora' potato, aimed to benefit industrial processing using starch. Normally a potato produces two types of starch:

- 70 – 80 % is amylopectin. This starch is water soluble and sticky. It is very useful in the food, paper, and chemical industries as paste, glue, or as a lubricant.
- The rest is amylose starch.[190]

Because it is difficult and costly to separate the two types of starch for processing, the 'Amflora' potato has been modified with an additional gene that interferes with the gene that produces the enzyme that is responsible for amylase starch. Without this enzyme the bonding dextrose sugars all go in one direction resulting in amlopectin.[191] As a result 98% of the starch produced by the potato is the more useful amylopectin. This modification benefits industrial processes which use potato starch as the useful amylopectin doesn't have to be separated from the amylase starch. The GM starch potato also contains the antibiotic resistance marker nptII.

BASF has completed field trials and are now awaiting approval for commercial release. Although Amflora has been created for industrial applications, the application is for food and feed because it is difficult to control potatoes in the market and some residues of starch processing are fed to animals. Little experience exists about the effects of inhibiting a normal plant process, both in the plant itself as well as how a drastically changed composition will impact on other organisms.

Cautious European Union ministers could not reach the qualified majority (72.3 % of votes) required to approve the application in July 2007, so the decision now rests with the European Commission. BASF are confident that the Commission will give the go ahead early enough in 2008 to proceed with commercial plantings in the 2008 growing season, thus ushering in the first approval for commercial growing of a GM food in the European Union since 1998.[192]

In the meantime BASF have already announced new field trials with two other GM potatoes. One is another cultivar with modified starch and the other contains genes from wild potatoes found in South America resistant to phytophthora 'late blight' fungus.

Conclusion

> *"The goal is not to produce magic bullets or miracle potatoes – needs and conditions are too varied for that."*
>
> CIP on pest management

It is clear from the long history of the GM potato project that it is part of the USAID's agenda to foist GM foods on the developing world and in so doing open up new markets for American biotechnology interests. In particular, the Michigan State University, leader of the Bt potato project, will have through this project, spearheaded the commercialisation of a new GM food crop with partners in a developing country, bringing funding and new research opportunities and building capacity.

Despite the veil of secrecy surrounding the project, in particular the withheld socio-economic studies on the small-scale and emerging potato farmer sector, other accessible research indicates that this GM technology is unlikely to provide long lasting benefits to resource poor and small-scale farmers. Farming potatoes requires constant adaptation to environmental circumstances. Regional climatic patterns, changing weather, access to suitable cultivars and farming methods all impact on the growing cycle and the saleability of potatoes in the market place. Small-scale farmers are constrained by an inability to access resources to pre-empt and adapt to this variability. Providing a single and costly remedy for one amongst a myriad of problems will not alleviate the challenges they face.

Many emerging farmers do not have the land resources or capital to access the infrastructure, inputs and certified seed that makes commercial potato farming profitable. Farmers already struggle to pay for certified seed of open varieties, let alone licensed cultivars. GM seed is typically sold at double the price of hybrid seed in South Africa, which will render this technology inaccessible to them.

Insects quickly develop resistance to chemicals. As the Bt potato project leader, Dr Douches, has noted, the Colorado potato beetle has been able to adapt to the many insecticides applied in the past half century and is currently resistant to 37 insecticides worldwide.[193] Similarly potato farmers in South Africa are warned that it is necessary to vary the types of chemicals used and to use chemicals judiciously to prevent tuber moths from developing resistance. Based on this experience, it seems to make no sense to create a plant that will continuously emit a single pesticidal toxin into the environment from all its parts in an uncontrollable dosage, as resistance is bound to develop. Furthermore studies in China and the Makhathini Flats in South Africa[194] that have analysed the impact of growing Bt cotton for a period of 5 or more years have found that secondary pests proliferate once the target insect has been removed by the Bt toxin, typically requiring renewed applications of chemical pesticides. Furthermore, the majority of small-scale and emerging potato farmers identified by Potatoes SA, and who have a long acknowledged history of potato farming, reside in KwaZulu-Natal where the Potato tuber moth is not a major potato problem.[195]

Even though ARC is contracted and presumably paid by the GM potato consortium, the involvement of this parastatal in addressing the Tuber moth problem, which on average only accounts for 2% or less[196] of the input costs of growing potatoes, is squandering limited public resources. This funding could be spent on addressing a variety of more fundamental problems experienced by resource-poor and subsistence farmers, rather than furthering the agendas of USA researchers and multinational companies.

Potatoes tubers can easily grow into new plants, and once planted volunteer potatoes keep re-growing in fields, making it difficult to monitor and control where potatoes are grown. Although a large proportion of farmers do buy certified seed potatoes, many farmers continue to share potato seed, especially in resource poor communities. This not only presents problems for the technology's patent holders in terms of collecting technology fees on the product, but also has liability implications for South Africa in terms of cross-boundary movement of the potatoes to neighbouring countries where these are not approved. South Africa is the main supplier of table and seed potatoes in southern Africa. It is inevitable that once these potatoes are commercialised they will end up contaminating the fields of our trading partners. In 2001, a furore developed in southern Africa around GM food aid funded by USAID, when Zambia confronted the USA head-on by rejecting its GM maize despite the food crisis in the region. Zimbabwe, Malawi and Mozambique accepted the GM maize only on condition that it was milled prior to being distributed to make sure it could not be planted. Zambia and Angola are the main importers of South Africa's seed and processed potatoes. Angola has no biosafety legislation in place. It is likely in this context that South Africa's main trading partners in Southern Africa will reject this new GM food crop.

McCain's, which dominates the potato processing industry in South Africa, has said it will not use GM potatoes. The retail giant, Pick n Pay, issued a media statement in 2007 to say that it will not buy GM potatoes from its suppliers until the South African GMO Council could provide conclusive scientific evidence on the biosafety of the product and had given it full regulatory approval. Pick n Pay has also launched a large organic growers project sending a strong message to farmers that GM potatoes do not make sound business sense.

Since the 1990's, the commercial potato farming and processing sector has rallied resources to improve profitability; including investing in infrastructure, tightening up the seed certification system and introducing new cultivars. Given that 2 large food companies have already raised concerns and the southern African export market is likely to reject GM potatoes, it remains to be seen whether the South African potato industry is willing to risk this investment for a GM potato gamble. Emerging and small-scale farmers, the supposed beneficiaries of the technology, will only be further burdened and marginalised by the increased cost of GM seed and constraints on their rights to save potatoes as seed for the next crop. Certainly, South African consumers have not been consulted as to whether they feel comfortable with the prospect of yet another important staple food being genetically modified to contain novel genes and in this case, genes that have not been used in any of the GM products on the market today. The GM potato presents economic, health and biodiversity risks. South Africans have cause to celebrate 2008 as the year of the GM-free potato, rather than pandering to multinational biotechnology interests.

References

1 International Institute for Environment and Development (IIED). 12 January 2007. **'Insulted' Andean farmers pick GM potato fight with multinational Syngenta.** http://www.iied.org/mediaroom/releases/070110syngenta.html (accessed 30th January 2008).

2 GRAIN. 2005. USAID: Making the world hungry for GM crops. http://www.grain.org/briefings/?id=191

3 Ashton, G., Baker, G., Mayet, M., Pschorn-Strauss, E., Stafford, W. 2004. **Objections to application for a permit for additional trials with insect resistant Bt Cry V Genetically Modified Potatoes (*Solanum tuberosum* L. Variety 'Spunta' G2 and G3), as applied for by Dr G. Thompson, Director Plant Protection and Biotechnology, South African Agricultural Research Council, dated 24 May 2004**. African Centre for Biosafety. http://www.biosafetyafrica.net/portal/DOCS/objection_bt_potato_g2_g3.pdf and African Centre for Biosafety. (2006). **Additional comments and objections to continued trials of GM potatoes**. http://www.biosafetyafrica.net/portal/DOCS/GMPotatoesObjection.pdf

4 Smith J.M. 2007. **Genetic roulette. The documented health risks of genetically engineered foods**. Fairfield: Yes! Books.

5 Bamber, Dr S. 26 January 2008. Centre for the Aids Programme of Research in SA (Caprisa) UKZN. Personal communication.

6 Moola, S. and Munnik, V. 2007. **GMOs in Africa: food and agriculture**. ACB Biosafety, Biopiracy and Biopolitics Series 4.

7 Ochoa, C. From Agriculture to Culture: Universal Gift. Graves, C. (ed). **The potato, treasure of the Andes.** http://www.cipotato.org/publications/books/potato_treasure_andes_online/21_universal_gift.asp

8 International Potato Centre. (CIP). CIP Press room. Media Releases. **Origin of the potato centred in Peru**. http://www.cipotato.org/pressroom/press_releases_detail.asp?cod=17 (accessed 10 September 2007).

9 Ochoa, C. From Agriculture to Culture: Universal Gift. Graves, C. (ed). **The potato, treasure of the Andes.** http://www.cipotato.org/publications/books/potato_treasure_andes_online/21_universal_gift.asp

10 Ochoa, C. From Agriculture to Culture: Universal Gift. Graves, C. (ed). **The potato, treasure of the Andes.** http://www.cipotato.org/publications/books/potato_treasure_andes_online/21_universal_gift.asp

11 Ochoa, C. From Agriculture to Culture: Universal Gift. Graves, C. (ed). **The potato, treasure of the Andes.** http://www.cipotato.org/publications/books/potato_treasure_andes_online/21_universal_gift.asp

12 CIP. CIP press room: Facts and Figures. http://www.cipotato.org/pressroom/facts_figures/let_them_eat_potatoes.asp (accessed 6 February 2008).

13 Rhoades, R. From Agriculture to Culture: A fantastic voyage. Graves, C. (ed). **The potato, treasure of the Andes. From agriculture to culture**. C.Graves. Lima, Peru: International Potato Center (CIP) 2001. http://www.cipotato.org/publications/books/potato_treasure_andes_online/23_fantastic_voyage.asp

14 Rhoades, R. From Agriculture to Culture: A fantastic voyage. Graves, C. (ed). **The potato, treasure of the Andes. From agriculture to culture**. C.Graves. Lima, Peru: International Potato Center (CIP) (2001), http://www.cipotato.org/publications/books/potato_treasure_andes_online/23_fantastic_voyage.asp

15 CIP. **CIP Potato facts: growth in production accelerates**. http://www.cipotato.org/potato/facts/growth.asp (accessed 10 September 2007).

16 FAO. 2007. UN International year of the potato. http://www.potato2008.org/en/aboutiyp/index.html (accessed 20 January 2008).

17 FAO. 2007. UN International year of the potato. Potato world. http://www.potato2008.org/en/world/index.html

18 FAO. 2007. UN International year of the potato. http://www.potato2008.org/en/world/index.html (accessed 20 January 2008).

19 FAO. 2007. UN International year of the potato. http://www.potato2008.org/en/aboutiyp/index.html (accessed 20 January 2008).

20 FAO. 2007. UN International year of the potato. **Potato world**. http://www.potato2008.org/en/world/index.html (accessed 20 January 2008).

21 FAO. 2007. UN International year of the potato. **Potato world** http://www.potato2008.org/en/world/index.html (accessed 20 January 2008).

22 FAO. 2007. UN International year of the potato. **Potato world** http://www.potato2008.org/en/world/index.html (accessed 20 January 2008).

23 Department of Horticulture, College of Agricultural and Environmental Sciences. University of Georgia. **The potato**. http://www.uga.edu/vegetable/potato.html (accessed 6 January 2008).

24 CIP. **Potato: true potato seed**. http://www.cipotato.org/potato/tps/overview.asp (accessed 6 January 2008).

25 Niederwiesser, J.G. (Ed). 2003. **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute.

26 National Department of Agriculture. Directorate Agricultural Information Services. 2003. **Potato Profile**. http://www.nda.agric.za/docs/Potatobrochure/potato.htm (accessed 17 September 2007).

27 Steyn, P.J. 2003. The origin and growth stages of the potato plant. Niederwiesser, J.G. (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute.

28 Du Plessis, H.F. and Steyn, J.M. 2003. Soil, water and irrigation requirements. Niederwiesser, J.G. (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute.

29 Steyn, P.J. 2003. The origin and growth stages of the potato plant. Niederwiesser, J.G. (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute.

30 Theron, D.J. 2003. The South African potato Industry in perspective. Niederwiesser, J.G. (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute.

31 Potatoes South Africa. SA Potato Production. http://www.potatoes.co.za/home.asp?pid=121 (accessed 24 September 2007).

32 Yeld, J. 24 November 2005. The Cape Argus p. 5. http://www.iol.co.za/general/news/newsprint.php?art_id=vn20051124124945247C56

33 Potatoes SA. Production. http://www.potatoes.co.za/home.asp?pid=81 (accessed 11 February 2007).

34 Potatoes South Africa. **Production regions**. http://www.potatoes.co.za/home.asp?pid=81. (accessed 24 September 2007).

35 Du Toit, L. Potatoes South Africa. Personal communication on 29 January 2008.

36 Potatoes SA. **Research**. http://www.potatoes.co.za/home.asp?pid=45 (accessed 11 February 2007).

37 Potatoes South Africa. http://www.potatoes.co.za/home.asp?pid=161 (Accessed 24 September 2007).

38 Potatoes South Africa. http://www.potatoes.co.za/home.asp?pid=161 (Accessed 24 September 2007).

39 Agricultural Research Council. Downloaded from http://www.arc.agric.za/home.asp?pid=424&toolid=2&itemid=2319 (accessed 24 September 2007).

40 National Department of Agriculture, South Africa. http://www.nda.agric.za/docs/geneticresources/variety_control.htm (accessed 29 January 2008).

41 Thiart, S. 29 January 2008. Laboratory manager of the in vitro genebank at ARC-Roodeplaat. Personal communication.

42 Thiart, S. 2006. **Where do our potatoes come from?** Article published on http://www.arc.agric.za/home.asp?pid=424&toolid=2&itemid=2319 (accessed 24 September 2007).

43 Thiart, S. 2006. **Where do our potatoes come from?** Article published on http://www.arc.agric.za/home.asp?pid=424&toolid=2&itemid=2319 (accessed 24 September 2007).

44 Vorster, I. 23 January, 2008. Agricultural Research Council, Roodeplaat. Personal communication.

45 Pieterse, B.J. and Theron, D.J. Seed potato quality. Niederwiesser, J.G. (Ed). 2003. **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute.

46 Potatoes SA. Seed potato certification scheme. http://www.potatoes.co.za/home.asp?pid=161

47 Potatoes SA. Seed potato certification scheme. http://www.potatoes.co.za/home.asp?pid=161

48 Bryant, W. 19 September 2007. Farmer growing seed potatoes on 40 ha in KZN. Personal communication.

49 Potatoes SA. Seed potatoes: laboratory services. http://www.potatoes.co.za/home.asp?pid=159. (accessed 19 September 2007).

50 Potatoes SA. Seed potato certification scheme. http://www.potatoes.co.za/home.asp?pid=161 (accessed 19 September 2007).

51 Potatoes SA. Seed potato certification. http://www.potatoes.co.za/home.asp?pid=179 (accessed 19 September 2007).

52 Potatoes SA. http://www.potatoes.co.za/home.asp?pid=189 (accessed 19 September 2007).

53 Bryant, W. 19 September 2007. Farmer growing seed potatoes on 40 ha in KZN. Personal communication.

54 Van Zyl, P. 31 January 2008. Manager Industry Information, Potatoes South Africa. Personal communication.

55 National Department of Agriculture. Directorate Agricultural Information Services. 2003. **Potato profile**. http://www.nda.agric.za/docs/Potatobrochure/potato.htm (accessed 17 September 2007).

56 Booyens, E. 18 December, 2007. Marketing Manager, Potatoes SA. Personal communication.

57 Hill, G. 23 January 2008. Director of Potatoes Africa (growing certified seed potatoes in KZN). Personal communication.

58 Potatoes SA. 2007. Transformation. http://www.potatoes.co.za/home.asp?pid=47 (accessed 11 February 2007).

59 Potatoes SA. http://www.potatoes.co.za/home.asp?pid=643 (accessed 26 January 2008).

60 Mokgojwa, D. 23 January 2008. Transformation manager, Potatoes South Africa. Personal communication.

61 Hill, G. 23 January 2008. Potatoes Africa seed potato company. Personal communication.

62 Vorster, I. 23 January 2008. Agricultural Research Council, Roodeplaat. Personal communication.

63 Meyer, J.B. 20 February 2008. Potato Seed Production. Personal communication.

64 Hill, G. 23 January 2008. Potatoes Africa seed potato company. Personal communication.

65 Mokgojwa, D. 23 January 2008. Transformation manager, Potatoes South Africa. Personal communication.

66 Statistics South Africa. (2002). **Census of commercial agriculture 2002**. http://www.statssa.gov.za/publications/Report-11-02-01/Corrected Report-11-02-01.pdf (accessed 20 January 2008).

67 Van Zyl, P. 31 January 2008. Manager Industry Information, Potatoes South Africa. Personal communication.

68 Kabini, V. 19 January 2008. **Two thousand and ate: the potato year**. City Press online. http://www.news24.com/City_Press/Features/0,,186-1696_2254854,00.html (accessed 20 January 2008).

69 Potatoes SA. Volumes sold on FPMs in 2005. http://www.potatoes.co.za/home.asp?pid=121 (accessed 11 February 2007).

70 Kabini, V. 19 January 2008. Two thousand and ate: the potato year. City Press online. http://www.news24.com/City_Press/Features/0,,186-1696_2254854,00.html (accessed 20 January 2008).

71 Potatoes SA 2005. SA potato production: production year. http://www.potatoes.co.za/home.asp?pid=121 (accessed 11 February 2007).

72 Lourens, L. 26 July 2007. Buyer: potatoes, Pick n Pay. Personal communication.

73 Pienaar, K. 11 July 2007. Technologist Vegetables, Woolworths. Personal communication.

74 Potatoes SA. Processing industry. http://www.potatoes.co.za/home.asp?pid=43 (accessed 11 February 2007).

75 Potatoes SA. 2005. Processed potatoes.. http://www.potatoes.co.za/home.asp?pid=121 (accessed 11 February 2007).

76 Quick Frozen Foods International. 1 July 2000. **McCains enters South Africa with I&J buy**. http://www.allbusiness.com/wholesale-trade/merchant-wholesalers-nondurable/620974-1.html (accessed 9 January 2008).

77 Hill, L. 7 December 2006. **McCains Foods to expand SA plant**. Engineering News. http://www.engineeringnews.co.za/article.php?a_id=99090 (accessed 5 July 2007).

78 Competition Tribunal Republic of South Africa. 2001. Case 17/AM/Mar01. http://www.comptrib.co.za/%5Ccomptrib%5Ccomptribdocs%5C116%5C17AMMAR01.pdf (accessed 8 January 2008).

79 Bekker, J. 4 February 2008. Potato seed specialist/agronomist, McCains. Personal communication.

80 Quick Frozen Foods International. 1 April 2007. **McCains foods building 69 million dollar plant to expand frozen market in South Africa**. http://goliath.ecnext.com/coms2/gi_0199-6533892/McCain-foods-building-69-million.html

81 Bekker, J. 4 February 2008. Potato seed specialist/agronomist, McCains. Personal communication.

82 National Department of Agriculture. Directorate Agricultural Information Services. 2003. **Potato profile**. http://www.nda.agric.za/docs/Potatobrochure/potato.htm (accessed 17 September 2007).

83 Van Zyl, P. 31 January 2008. Manager Industry Information, Potatoes South Africa. Personal communication.

84 CIP and Niederwiesser, J.G. (Ed). 2003. **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute.

85 Booyens, EJ. 20 January 2007. Manager: Market Development and Product Promotion, Potatoes SA. Personal communication.

86 Perishable Plant Export Control Board. 2008. Information supplied in response to Public Access to Information application.

87 Theron, D.J.and Mienie, N.J.J. 2003. An Integrated Approach to Pest Management. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute. (pp. 109-117).

88 Hill, G. 23 January 2008. Director of Potatoes Africa, growing certified seed potatoes in KZN and Bryant, W. 19 September 2007. Farmer growing seed potatoes on 40 ha in KZN. Personal communications.

89 Du Plessis, H.F.and Prinsloo, K.P. 2003. Weed Control. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 95-102).

90 Thompson, G.J. and Strydom H.D. 2003. Occurence and control of viral diseases. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 121-128).

91 Thompson, G.J. and Strydom H.D. 2003. Occurence and control of viral diseases. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 121-128).

92 Thompson, G.J. and Strydom H.D. 2003. Occurence and control of viral diseases. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute. (pp 121-128).

93 Gouws, R., Theron, D.J.and Mienie, N.J.J. 2003. Occurrence and control of bacterial diseases. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 109-117).

94 Denner, F.D.N., Theron, D.J.and Millard, C.P. 2003. Ocurrence and control of fungal diseases. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 109-117).

95 Denner, F.D.N., Theron, D.J.and Millard, C.P. 2003. Ocurrence and control of fungal diseases. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 135-152).

96 Denner, F.D.N., Theron, D.J.and Millard, C.P. 2003. Ocurrence and control of fungal diseases. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 135-152).

97 Denner, F.D.N., Theron, D.J.and Millard, C.P. 2003. Occurrence and control of fungal diseases. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 153-163).

98 Le Roux, S.M., Steyn P.J. and Visser, D. 2003. Occurrence and control of pests. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 153-170).

99 Le Roux, S.M., Steyn P.J. and Visser, D. 2003. Occurrence and control of pests. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 153-170).

100 Foot, M. 1998. Hortfact: Potato tuber moth cycle. Horticulture and Food Research Institute of New Zealand. http://www.hortnet.co.nz/publications/hortfacts/hf401015.htm (accessed 13 September 2007).

101 Foot, M. 1998. Hortfact: Potato tuber moth cycle. Horticulture and Food Research Institute of New Zealand. http://www.hortnet.co.nz/publications/hortfacts/hf401015.htm (accessed 13 September 2007).

102 Le Roux, S.M., Steyn P.J. and Visser, D. 2003. Occurrence and control of pests. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 155-157).

103 Foot, M. 1998. Hortfact: Potato tuber moth cycle. Horticulture and Food Research Institute of New Zealand. http://www.hortnet.co.nz/publications/hortfacts/hf401015.htm (accessed 13 September 2007).

104 Le Roux, S.M., Steyn P.J. and Visser, D. 2003. Occurrence and control of pests. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 155-157).

105 Le Roux, S.M., Steyn P.J. and Visser, D. 2003. Occurrence and control of pests. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute. (pp. 155-157).

106 Foot, M. 1998. Hortfact: Potato tuber moth cycle. Horticulture and Food Research Institute of New Zealand. http://www.hortnet.co.nz/publications/hortfacts/hf401015.htm (accessed 13 September 2007).

107 Le Roux, S.M., Steyn P.J. and Visser, D. 2003. Occurrence and control of pests. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 155-157).

108 Le Roux, S.M., Steyn P.J. and Visser, D. 2003. Occurrence and control of pests. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 170-171).

109 Mkize, N. 2005. **Tuber moth insecticide resistance investigated**. http://www.potatoes.co.za/home.asp?pid=219 (accessed 28 January 2008).

110 Le Roux, S.M., Steyn P.J. and Visser, D. 2003. Occurrence and control of pests. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 170-171).

111 Le Roux, S.M., Steyn P.J. and Visser, D. 2003. Occurrence and control of pests. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute. (pp. 156-157).

112 National Department of Agriculture: Genetic Resources. **GMO Permits issued**. http://www.nda.agric.za/docs/geneticresources/forms_pdf.htm (accessed 16 September 2007).

113 First Potato Dynamics. http://www.fpd.co.za/ (accessed 16 September 2007).

114 Loch, H. 22 September 2000. **Motbestande aartappel toon groot beloft**. Landbouweekblad. Pp. 36 – 38, 40.

115 Lefras Olivier. 27 September 2007. Personal communication.

116 The Centre for Potato Research in Hot Climates. http://www.potato-hot.com/about.htm (accessed 26 September 2007).

117 MSU potato breeding and genetics. http://www.msu.edu/~douchesd/index.html and MSU Institute of International Agriculture http://www.iia.msu.edu/index.html (accessed 6 July 2007).

118 ABSP. Egypt and the potato tuber moth. http://www.iia.msu.edu/absp/egypt-ptm.html (accessed 6 July 2007).

119 ABSP. **History of ABSP**. http://www.iia.msu.edu/absp/background.html (accessed 6 July 2007).

120 ABSP. Research projects. http://www.iia.msu.edu/absp/research.html (accessed 6 July 2007).

121 Cornell University International Programs. (2006). **ABSP II**. http://www.absp2.cornell.edu/ (accessed 26 September 2007).

122 International Potato Centre. (CIP). http://www.cipotato.org/cip/about.asp (accessed 6 July 2007).

123 Agricultural Research Council. **What we do**. http://www.arc.agric.za/home.asp?pid=283 (accessed 26 September 2007).

124 Moola, S and Munnik, V. 2007. **GMOs in Africa: food and agriculture**. ACB Biosafety, Biopiracy and Biopolitics Series 4.

125 ARC Vegetable and Ornamental Plant Institute. **Introduction**. http://www.arc.agric.za/home.asp?pid=424 (accessed 26 September 2007).

126 Garst Seed Company. http://www.garstseed.com/GarstClient/AboutGarst/AboutGarst.aspx (accessed 26 September 2007).

127 African Centre for Biosafety. 2007. **Objections made to the application by Syngenta SeedCo for field trials in respect of GM Maize events GA 21 and Bt 11 x GA 21**. http://www.biosafetyafrica.net/portal/images/ACB/objectionssyngentaseptember2007.pdf (accessed 20 January 2008).

128 Syngenta. http://www.syngenta.com/en/index.aspx. (accessed 20 January 2008).

129 Syngenta. **About Syngenta: Syngenta company history**. http://www.syngenta.com/en/about_syngenta/timeline.aspx (acessed 20 January 2008).

130 Pesticide Action Network North America. **PANNA corporate profile: Syngenta**. http://www.panna.org/resources/%252Fcaia/corpProfilesSyngenta (accessed 19 January 2008).

131 Corporate Watch. 2003. **Biotech Briefings: Syngenta** http://archive.corporatewatch.org/genetics/commercialisation/syngenta.htm (accessed 5th January 2008).

132 See GM Contamination Register at http://www.gmcontaminationregister.org

133 Corporate Watch. 2003. **Biotech Briefings: Syngenta** http://archive.corporatewatch.org/genetics/commercialisation/syngenta.htm (accessed 5th January 2008).

134 Williams, R. 2007. **Interrogating GMO decision-making**. ACB Biosafety, Biopiracy and Biopolitics Series: 1

135 CGIAR. See http://www.cgiar.org/who/index.html. (accessed 20 January 2008).

136 ETC Group. 2005. **Syngenta-the genome giant?** *Communiqué*, Issue # 86. www.etcgroup.org (accessed 20 January 2008).

137 ABSP. **Research projects: development and management of resistance to tuber moth**. http://www.iia.msu.edu/absp/potato_00.html (accessed 21 June 2007),

138 El Sanhoty, R.M.E. 2004. **Quality control for foods produced by genetic engineering.** M.Sc. Berlin.

139 ABSP. **Egypt and the potato tuber moth**. http://www.iia.msu.edu/absp/egypt-ptm.html (accessed 6 July 2007).

140 Eicher, KE. Maredia K, Sithole-Niang I. 2006. **Crop biotechnology and the African farmer**. Food Policy 31 (2006) 504 – 527. http://www.biw.kuleuven.be/aee/clo/euwab_files/Eicher2006.pdf (accessed 18 October 2007).

141 ABSP. 2001. ABSP Indicators and achievements 1991–2001. www.iia.msu.edu/absp/reports//absp-indicatorsfinal.doc (accessed 31 October 2007).

142 Dr Bahieldin, A. **Biotechnology and the production of plants resistant to droughts and plagues, Egyptian prospects**. AGERI. http://www2.mre.gov.br/aspa/semiarido/data/ahmed_bahieldin.htm (accessed 31 October 2007).

143 Pathak, B. 2002. **The process of biotechnology development and dissemination in developing countries: experience of US Aid's Agricultural biotechnology program**. Paper presented at 6th International ICABR Conference, Italy.

144 USDA. 2006. **GAIN Report FS6029**. http://www.stat-usa.gov/agworld.nsf/505c55d16b88351a852567010058449b/aa536f2aad0280458525720500 56dea7/$FILE/SF6026.PDF (accessed 18 October 2007).

145 Pathak, B. 2002. **The process of biotechnology development and dissemination in developing countries: experience of USAID's Agricultural biotechnology program**. Paper presented at 6th International ICABR Conference, Italy.

146 Pathak, B. 2002. **The process of biotechnology development and dissemination in developing countries: experience of USAID's Agricultural biotechnology program**. Paper presented at 6th International ICABR Conference, Italy.

147 Michigan State University, Institute of International Agriculture. **Bt potato project in South Africa**. http://www.iia.msu.edu/project_potato.html (accessed 14 September 2007).

148 Douches, D., Bt Potato project team. 2006. **Commercialisation of potato tuber moth resistant potatoes in South Africa: introduction**. Presentation to World Potato Congress August 2006. http://www.potatofoundation.com/WPC_2006/Presentations/MondayAugust21/David-Douches.pdf (accessed 20 January 2008).

149 MSU and Michigan Potato Industry Commission. 2005. **Michigan potato research report**. http://www.msu.edu/~longch/2005%20MPIC%20Research%20Report.pdf (accessed 6 June 2007).

150 http://www.iia.msu.edu/absp/potato_00.html

151 ABSP. 2001. **ABSP Indicators and achievements 1991-2001**. www.iia.msu.edu/absp/reports//absp-indicatorsfinal.doc (accessed 31 October 2007).

152 Ashton, G., Baker, G., Mayet, M., Pschorn-Strauss, E., Stafford, W. 2004. **Objections to application for a permit for additional trials with insect resistant Bt Cry V Genetically Modified Potatoes (*Solanum tuberosum* L. variety 'Spunta' G2 and G3), as applied for by Dr G. Thompson, Director Plant Protection and Biotechnology, South African Agricultural Research Council, dated 24 May 2004**. African Centre for Biosafety. http://www.biosafetyafrica.net/portal/DOCS/objection_bt_potato_g2_g3.pdf. (Accessed 20 January 2008).

153 African Centre for Biosafety. 2006. **Additional comments and objections to continued trials of GM potatoes**. http://www.biosafetyafrica.net/portal/DOCS/GMPotatoesObjection.pdf (accessed 20 January 2008).

154 Michigan State University, Institute of International Agriculture. **Bt potato project in South Africa**. http://www.iia.msu.edu/project_potato.html (accessed 14 September 2007).

155 De Ronde, K. 21 September 2007. ARC-VOPI: Biotechnology Division. Personal communication.

156 El Sanhoty, R.M.E. 2004. **Quality control for foods produced by genetic engineering.** M.Sc. Berlin.

157 Bothma, G. 7 September 2006. ARC-VOPI: Biotechnology Division. Personal communication with Mariam Mayet.

158 Agricultural Research Council. 2006. **Annual Report 2005/6**.

159 Douches, D., Bt Potato project team. 2006. **Commercialisation of potato tuber moth resistant potatoes in South Africa: introduction**. Presentation to World Potato Congress August 2006. http://www.potatofoundation.com/WPC_2006/Presentations/MondayAugust21/David-Douches.pdf (accessed 20th January 2008).

160 European Food Safety Authority. **Statement of the Scientific Panel on GMOs on the safe use of nptII in genetically modified plants**. March 2007. http://www.efsa.europa.eu/EFSA/Statement/gmo_statement_nptII_,0.pdf (accessed 20 January 2008).

161 European Food Safety Authority. **Statement of the Scientific Panel on GMOs on the safe use of nptII in genetically modified plants**. March 2007. http://www.efsa.europa.eu/EFSA/Statement/gmo_statement_nptII_,0.pdf (Accessed 20 January 2008)

162 Smith J.M. 2007. **Genetic roulette. The documented health risks of genetically engineered foods**. Fairfield: Yes! Books (p. 133).

163 WHO Essential medicines library. **Medicine uses: Kanamycin**. http://mednet3.who.int/EMLib/DiseaseTreatments/MedicineDetails.aspx?MedIDName=364@kanamycin (accessed 20 January 2008).

164 Bamber, Dr S. 26 January 2008. Centre for the Aids Programme of Research in SA (Caprisa) UKZN. Personal communication.

165 Smith J.M. 2007. **Genetic roulette. The documented health risks of genetically engineered foods**. Fairfield: Yes! Books (pp. 129 – 137).

166 Ashton, G., Baker, G., Mayet, M., Pschorn-Strauss, E., Stafford, W. 2004. **Objections to application for a permit for additional trials with insect resistant Bt Cry V Genetically Modified Potatoes (*Solanum tuberosum* L. variety 'Spunta' G2 and G3), as applied for by Dr G. Thompson, Director Plant Protection and Biotechnology, South African Agricultural Research Council, dated 24 May 2004**. African Centre for Biosafety. http://www.biosafetyafrica.net/portal/DOCS/objection_bt_potato_g2_g3.pdf and African Centre for Biosafety. 2006. **Additional comments and objections to continued trials of GM potatoes**. http://www.biosafetyafrica.net/portal/DOCS/GMPotatoesObjection.pdf

167 D.S. Douches *et.al*. 2002. **Development of *Bt-cry5* insect resistant Potato Lines 'Spunta-G2' and 'Spunta-G3'**. HORTSCIENCE 37(7):1103-1107.

168 Le Roux, S.M., Steyn P.J. and Visser, D. 2003. Occurrence and control of pests. In J.G. Niederwiesser (Ed). **Guide to potato production in South Africa**. ARC-Roodeplaat Vegetable and Ornamental Plant Institute (pp. 156, 170-171).

169 Eicher, KE. Maredia K, Sithole-Niang I. 2006. **Crop biotechnology and the African farmer**. Food Policy 31: 504 – 527. http://www.biw.kuleuven.be/aee/clo/euwab_files/Eicher2006.pdf (accessed 18 October 2007).

170 Hart, T.G.B. 14 September 2007. Human Sciences Research Council. Department of Urban, Rural and Economic Development. Personal communication.

171 Bekker, J. 4 February 2008. Potato seed specialist/agronomist, McCains. Personal communication.

172 Farmers Weekly. 3 December 1999. **McCain blows cool on GM potatoes**. http://www.gene.ch/genet/2000/Jan/msg00018.html (accessed 30 January 2008).

173 Perishable Plant Export Control Board. 2008. Information supplied in response to Public Access to Information application.

174 Moola, S and Munnik, V. 2007. **GMOs in Africa: food and agriculture**. ACB Biosafety, Biopiracy and Biopolitics Series 4.

175 USA Patent and Trademark Office. Patent full-text and image database. **USA Patent 6780408**. http://patft1.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=6780408.PN.&OS=PN/6780408&RS=PN/6780408 (accessed 3 December 2007).

176 Eicher, KE. Maredia K, Sithole-Niang I. 2006. **Crop biotechnology and the African farmer**. Food Policy 31: 504 – 527. http://www.biw.kuleuven.be/aee/clo/euwab_files/Eicher2006.pdf (accessed 18 October 2007).

177 USDA (2006). **GAIN Report FS6029**. http://www.stat-usa.gov/agworld.nsf/505c55d16b88351a852567010058449b/aa536f2aad028045852572050056dea7/$FILE/SF6026.PDF (accessed 18 October 2007).

178 ABSP. 2001. **ABSP Indicators and Achievements 1991-2001**. www.iia.msu.edu/absp/reports//absp-indicatorsfinal.doc (accessed 31October 2007).

179 Agbios database. **GM potatoes**. http://www.agbios.com/dbase.php?action=ShowProd&data=ATBT04-6%2C+ATBT04-27%2C+ATBT04-30%2C+ATBT04-31%2C+ATBT04-36%2C+SPBT02-5%2C+SPBT02-7 (accessed 20 January 2008).

180 Farmers Weekly. 3 December 1999. **McCain blows cool on GM potatoes**. http://www.gene.ch/genet/2000/Jan/msg00018.html (accessed 30 January 2008).

181 Kilman, S. 28 April 2000. **Monsanto's biotech spud is being pulled from the fryer at fast-food chain**. Wall Street Journal. http://www.gene.ch/genet/2000/May/msg00013.html (accessed 30 January 2008).

182 Kilman, S. 22 March 2001. Monsanto's genetically modified potatoes find slim market, despite repelling bugs. Wall Street Journal. http://www.mindfully.org/GE/Monsanto-Dumps-Potatoe.htm (accessed 30 January 2008).

183 International Institute for Environment and Development (IIED). 12 January 2007. **'Insulted' Andean farmers pick GM potato fight with multinational Syngenta.** http://www.iied.org/mediaroom/releases/070110syngenta.html (accessed 30 January 2008).

184 Environment News Service. 19 July 2007. http://www.gmwatch.org/archive2.asp?arcid=8124 (accessed 20 January 2008).

185 Bravo, E. 23 July 2007. Answer of the International Potato Centre in relation with a GE potato. Personal communication.

186 International Potato Centre. 2007. http://www.cipotato.org/pressroom/press_releases_detail.asp?cod=41 (accessed 16 July 2007).

187 Nature. 18 July 2007. http://www.nature.com/news/2007/070716/full/070716-5.html (accessed 30 January 2008).

188 GEF World Bank. 2006. **Project executive summary: Latin America: multi-country capacity-building in biosafety**. http://www.thegef.org/Documents/Council_Documents/GEF_C28/documents/268905-3-06ExecutiveSummary.pdf (accessed 30 January 2008).

189 See a statement detailing concerns issued by ACB, the ETC Group, GRAIN and Red por una América Latina Libre de Trasngénicos. **Groups in Africa, Latin America condemn World Bank biosafety projects**. http://www.etcgroup.org/en/materials/publications.html?pub_id=536 (accessed 30 January 2008).

190 GMO Compass. **GM crops: potatoes**. http://www.gmo-compass.org/eng/grocery_shopping/crops/023.genetically_modified_potato.html (accessed 20 January 2008).

191 Fletcher, A. 2006. Food Navigator. http://www.agbios.com/static/news/NEWSID_8048.php. (accessed 27 September 2007).

192 GMO Compass. 2007. **EU expects approval of Amflora within weeks**. http://www.gmo-compass.org/eng/news/310.basf_expects_eu_approval_amflora_within_weeks.html (accessed 20 January 2008).

193 D.S. Douches *et al* 2002. **Development of *Bt-cry5* insect resistant potato lines 'Spunta-G2' and 'Spunta-G3'**. HORTSCIENCE 37(7):1103–1107. 2002.

194 Patel, R., Schnurr, M and Witt, H. 2006. **Technology, representation & cotton in the Makhathini Flats, South Africa**. Review of African Political Economy-Vol. 33: 497-513. http://www.roape.org/cgi-bin/roape/show/10908.html

195 Mokgojwa, D. 23 January 2008. Transformation manager, Potatoes South Africa. Personal communication.

196 Mokgojwa, D. 23 January 2008. Transformation manager, Potatoes South Africa. Personal communication.