Department of Agriculture and Food

GOVERNMENT OF WESTERN AUSTRALIA

What is the Value Proposition for GM Technology in WA

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Genetic engineering is as old as the hills

The ability to decode any genome is showing that genetic material from other species is quite common in the genome of a host species

While the majority is often fragmentary and appears to have little role, some genes are considered to have key evolutionary roles

•Human genome has up to 9% of its makeup as viral genes, maize even higher – we have over 2000 virus species present in our bodies

•In humans/mouse/sheep the key genes for placental development are derived from viruses, two very important genes for brain functioning

•In insects one bacterium present in the reproductive tract exchanges DNA with its host; sea slugs do it with algae they eat.

Technology for GM

- **Technology for GM development is constantly evolving, and most countries are either doing it or have links to other countries who are.**

- **Agrobacterium is the most common vector but is often entangled with IP issues**

- **Ballistics technology is robust but takes time to clean up the effects**

- **Viral vectors are in development which are likely to be open-source-modeled license with no major commercial restrictions**

Technology for GM

- **Objections to GM often revolve around the use of markers or promoters**

- **Common markers are antibiotic resistance, herbicide tolerance - new markers have been developed**

- **PMI gene enables the plant cell to use mannose, a type of sugar, as a source of energy.**

Visible markers: A fluorescent protein marks transformed plant cells – genes that enable the plant to produce proteins that bind to toxic heavy metals,

Technology for GM

- **A number of techniques use genetic tools that act as "molecular scissors" that can cut certain genes out of the genome.**

- **Once transformed cells have been selected, scientists activate the gene encoding the scissors by an external stimulus. The scissors then cut out the marker gene and the gene for the scissors themselves**

- **Introducing silencing genes – stop genes of interest expressing - no protein/enzymes produced**

Classifications for GM

Source of genes

- **Intragenic/Cisgenic - Within genome – same species**
- **Famigenic - Species in the same family**
- **Linegenic - Species in the same lineage**
- **Transgenic - Unrelated species**
- **Xenogenic - Laboratory-designed genes**

Global GM status

- **Widespread use of many GM crops globally – 134 million ha planted**
- **Key crops are soybeans, corn, cotton and canola**
- **Major traits are herbicide tolerance and insect resistance**
- **Key growing countries are US, Brazil, Argentina, Canada**
- **Major importers of GM crops are Japan, China, Europe, Pakistan**
- **Australia has approved GM cotton (since 1996), canola, carnations for general release and they are now grown in most states where climate suits**

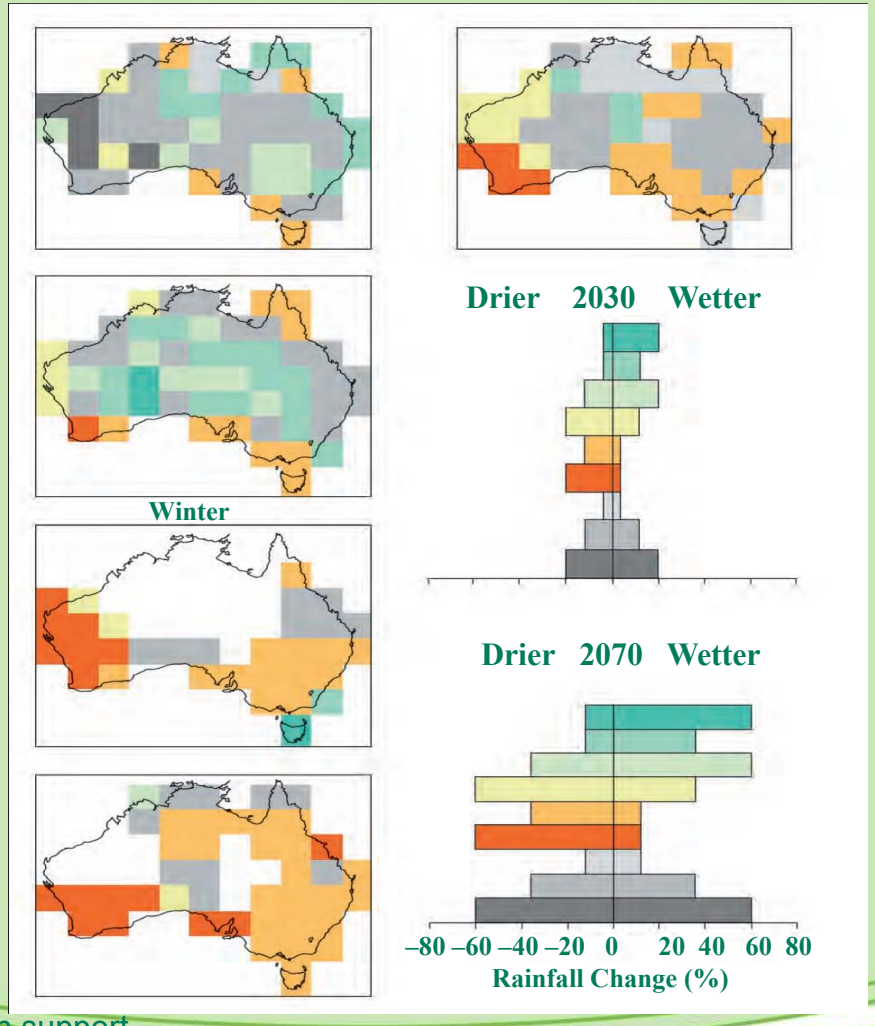
Environmental/economic/social challenges

Targets for GM technology - where is the value?

- **Climate change – drought, heat stress, cold tolerance**
- **Effects of excess nutrient outflow on air and water**
- **Resource base degradation – salinity, acidity**
- **Declining rates productivity gain in major crops**
- **Constant loss of production from pests**
- **Quality challenges**
- **Health – heart disease, colon cancer, vitamin deficiency**
- **Better Incomes for farmers/countries**

Climate Change - Australia

Ranges of average seasonal and annual rainfall change (%) for around 2030 and 2070 relative to 1990. The coloured bars show ranges of change for areas with corresponding colours in the maps. Ranges are not given for areas with seasonally low rainfall because percentage changes in rainfall cannot be as reliably calculated or applied in such regions.



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CSIRO Climate Change Research Program with support from the Australian Greenhouse Office.

Climate challenges

- **GM crops for tolerance to drought and heat stress are under development**
- **Can't provide absolute protection but do lift yields when rainfall is lower than average**

- **Monsanto, BASF, Syngenta, CSIRO, ACPFG, China?**
- **Main crop is corn, but canola under consideration.**

- **In Australia testing is on sugar cane, wheat and barley**

Nutrient loss/efficiency

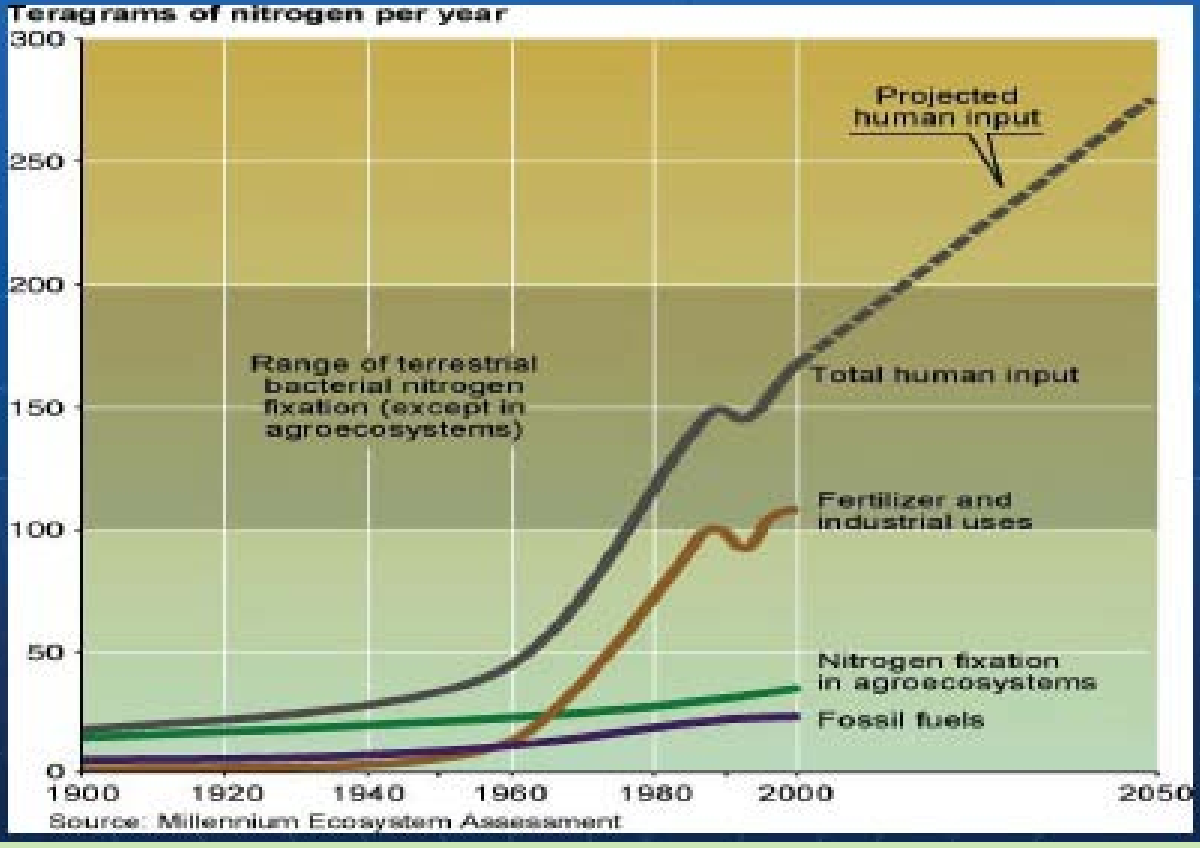
- **Major non-legume crops rely heavily on nitrogen fertiliser**
- **Requires fossil carbon for production, and side effect is nitrous oxide emissions – major greenhouse gas**
- **Nitrous oxide now implicated as a ozone depleting chemical**
- **"If we could reduce nitrogen-related emissions in agriculture by 50% in the top six crops," Eric Rey, the president and CEO of Davis-based Arcadia Biosciences says, "the effect on greenhouse-gas levels would be the same as if you took all the cars in the United States, the United Kingdom, and Germany off the road forever."**

Nutrient loss/efficiency

- **Genes for nitrogen efficiency now a key GM target in maize, wheat, canola**
- **In Australia testing is on sugarcane, wheat and barley**
- **In rice experimental testing shows same yield for one third reduction in N fertiliser**

- **Phytase gene modification reduces phosphorus binding - increases efficiency of P use by livestock**
- **Less P in effluent from intensive animal industry**
- **Experimental in maize**

Perturbation of the Nitrogen Cycle



Resource base degradation

- **Globally salinity is a major cause of land degradation causing significant loss of productive land**
- **Rising sea levels a driver for rice with inundation of delta regions**
- **While no species commercialised testing for ability to grow in saline conditions now a target for rice, wheat and barley**
- **In Australia wheat and barley are main crops under test.**

Productivity ceiling

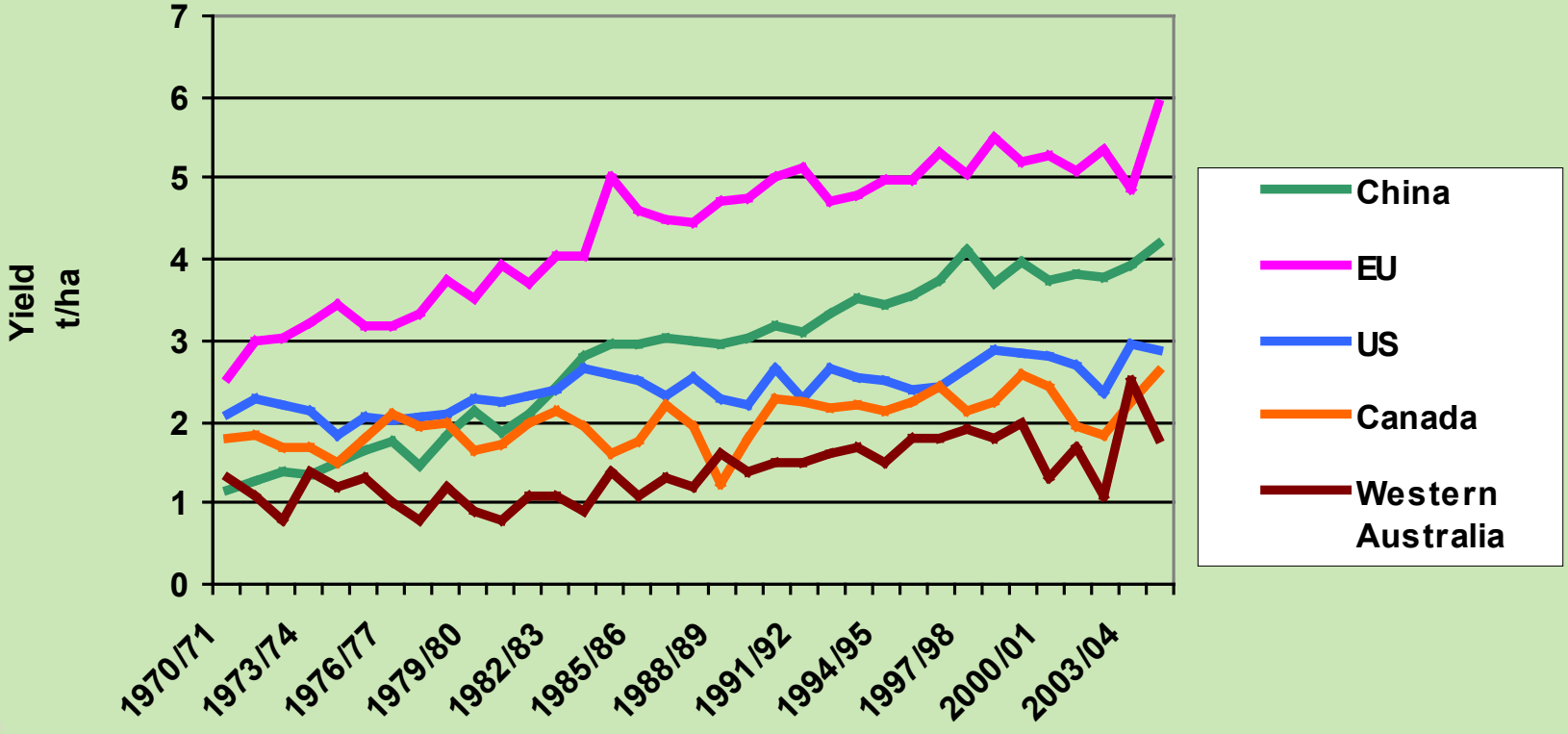
- **9 billion people by 2045 – 10 billion by 2100, on less land more urbanised – can we feed the world?**

- **Globally many crops have plateaued in yield - main gains from Green revolution are now diminishing**

- **Corn has maintained productivity rise and this is at least in part due to GM application**

- **GM technology for improved hybrid development now underway in canola in Australia – 10% achieved – further 10% target.**

Wheat yields for selected countries - 1970-2005



Since 2000 ave rate. yield gain US wheat = 3kg/ha/year
Cf ave. rate yield gain in corn = 20kg/ha/year

Production loss from pests (disease, insects, weeds)

- **Biotic stresses poses significant and increasing threat – estimated that 25% of global plant production/storage is lost to pests.**
- **Global use of GM technology for disease, insect and weed management is extensive – Bt genes, herbicide tolerance in maize, cotton and soybeans**
- **New genes include chitinase for disease resistance, new herbicide tolerance genes.**
- **Target crops are rice, cotton, maize, soybeans, potato, vegetables such as tomato/peppers/aubergine (China), cabbage, cauliflower/okra (India), papaya, plums**
- **Testing in Australia for bananas, pineapple**
- **GM HT lupins developed in 1990s at CLIMA**

Quality challenges

- **A more affluent world is demanding better quality for either human consumption or industrial uses**

- **GM traits under development include superior bread making of European wheats, reduced levels of mycotoxins in grains**

- **Other targets include more stable frying oils in soybean and cotton, amylopectin enhancement in potatoes**

- **High lysine corn, longer shelf life tomatoes targets in China**

Human health targets

- **Heart disease and colon cancer key killers of affluent societies, vitamin/mineral deficiencies in developing regions**

- **Amending food with nutritional factors to reduce cost**

- **GM traits under development include B glucan and high amylose resistant starch wheat varieties - CSIRO**

- **CSIRO developed canola plants that produce DHA, a healthy omega-3 oil component normally only available from fish sources. An important first step towards improving human nutrition reducing pressure on declining fish resources worldwide.**

- **Golden rice to be released to farmers in 2012, rice with 3x higher iron content (UniMelb)**

Better incomes for farmers

- **Prof W Wilson (NDSU) calculated that in US a drought tolerance trait in corn and/or soybeans (~ 6 years away) will result in a 60c/bushel (A$22/tonne) opportunity cost for wheat production on the same land.**

- **The market will need to pay another A$22/tonne for wheat to match the returns from corn or soy with this trait.**

- **New traits, such as second generation HT GM soybeans, will push the opportunity cost out to near $US1.50/bushel (A$55/tonne).**

- **For WA the premium for non-GM triazine tolerant canola to match the increased yields from non-hybrid RR canola is approximately $100/t, and $150/t for next generation hybrid RR canola– market currently pays $50/t**

Better incomes for farmers - Bt example

- **Publicly funded researchers from the University of Göttingen in Germany and the University of Warwick, UK, have found that cultivation of insect-resistant GM cotton has lead to large gains for hired female labour.**

- **Cotton production relies heavily on manual labour, which is predominantly carried out by female hired workers in rural India,**

- **Wages increased by up to 55% employment rates also went up. For the total Bt cotton area in India this would translate to about 400 million additional days of employment.**

- **Gain for all farmers across the whole cotton acreage in India in 2008 is about $US 1 billion US. The majority of this value (60 per cent) is gained by Indians living below the poverty line.**

GM technology in animal area

- **Chinese researchers have cows which produce human milk components**

- **Able to create cows that produced milk containing a human protein called lysozyme - is an antimicrobial protein naturally found in large quantities in human breast milk.**

- **They created cows that produce another protein from human milk called lactoferrin, which helps to boost the numbers of immune cells in babies.**

GM technology in animal area

- **Mosquitoes have been developed through GM to be male sterile**

- **Produced in large numbers to mate with females and so produce less offspring**

- **Current control methods, including bed nets and insecticides, have proved unsuccessful in controlling the dengue fever. In addition, a vaccine has not yet been developed, and is unlikely to be available for at least 10 years.**

- **Aim to reduce dengue fever outbreaks – successful control in experiment in Caribbean**

- **Principle should be adaptable for fruit flies**

- **Lower cost and safer than irradiation**

Who controls the genes

- **GM technology and genes introduced are managed via patents with a defined lifespan**

- **In 2011 changes are coming to Roundup Ready soybean production in Canada, with the expiry of the original Roundup Ready soybean technology patent. These changes culminate in 2013, which allows farmers to plant original Roundup Ready soybeans from saved seed. Patent expires 2014 in US and approx. 2017 in Australia.**

- **Monsanto have indicated that growers will not have to return seed once the patent expires and fees associated with using the technology will no longer apply. Seed companies will be free to develop varieties from the original RR types.**