Occasional Paper Series
Vol. 6, No. 1, January 1999

Trait*or* Tech

The Terminator's Wider Implications

The quarter-century long industry campaign for intellectual property monopoly over living materials faces a decisive battle in 1999/2000. The outcome will be determined, first and foremost, by public concern and civil action. The battle theatre will shift between the European Court, the WTO TRIPS Review, South governments, and United Nations agencies such as FAO, UNCTAD, and the Biodiversity Convention. In the midst of the fray, it is important not to lose sight of industry's primary purpose - within which, intellectual property is a weapon not a goal.

Industry has two objectives: First, to secure societal acquiescence to a virtually unlimited and unregulated global patent-property culture. Second, to entrench intellectual property as a non-tariff barrier to market entry for all but the most powerful members of the corporate clique. Mega-mergers - often driven by patent and technological opportunities - are already transforming the once-diverse life industry into a handful of homogeneous club members. The club trades patent licenses and markets among themselves and excludes public and lesser-private enterprises. Independent public research is becoming extinct. Entrepreneurial small private science is being priced out of the patent poker game. But, new *negative* technologies (Trait*or* Tech) are being developed with built-in exclusivity and long-range controls. In an oligopoly, patents become marginal. The first (and arguably the worst) of the Trait*or* Tech generation are agriculture's Terminator and "Traitor" technologies (T'nT). Peculiarly, these technologies offer a case wherein banning the patents means banning the technologies. The fight against the Terminator, although it is only one element of the negative technology initiative, focuses the whole "life patenting" debate while raising the alarm over the Trait*or* Tech strategy that Terminator portends. This document describes the Trait*or*'s strategy and outlines a proposal to defeat it.

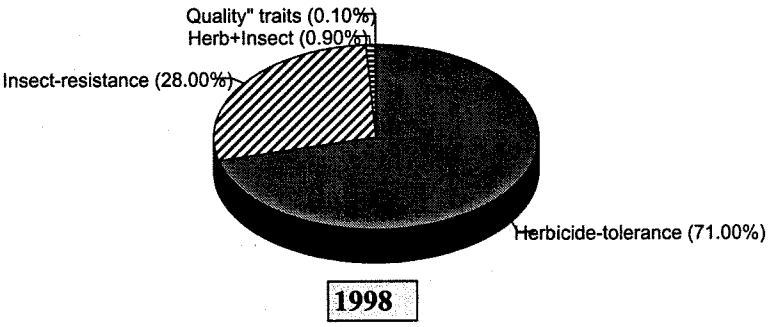
The Implications for Terminator and "Traitor" Technologies

The T'nT *Trendlines*

The Main Point: The most evident feature of Terminator Technologies is that a suicide "sequence" of exotic genes, triggered by an antibiotic, renders the seeds sterile in the next generation. The Terminator offers no agronomic advantage. Its merit is exclusively for the patent-holder who can use the technology to force farmers to re-purchase seed at the beginning of every growing season. (For a detailed background examination of the Terminator, please see RAFI Occasional Paper Series Vol 5, No. 3: *RAFI Impact: The Terminator File* August, 1998, also available at www.rafi.org.)

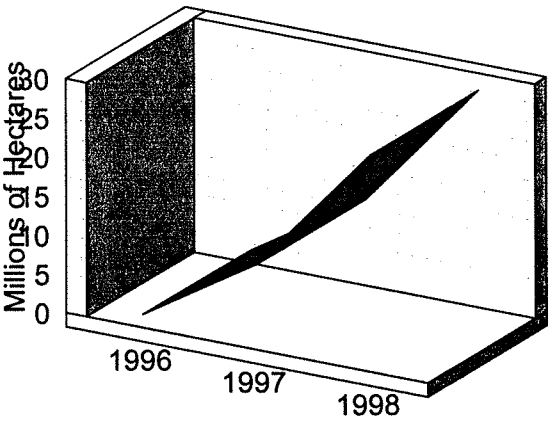
The brutish biological reality of this monopolistic strategy actually obscures the technology's more subtle (and insidious) dimensions. The two Terminator patents (the USDA/Monsanto and AstraZeneca claims) demonstrate that it is possible to switch on - or off - specific genes or, possibly, multi-gene traits - by applying an external catalyst. While using the technology to create sterility is clearly the most lucrative possibility for its owners, the same strategy could be applied to trigger other traits with other negative implications..

Chart 1: Transnational Trait Control
Gov'ts too tolerant & non-resistant



This is not fear-mongering. This is market logic backed by recent experience. Twenty years ago, RAFI staff warned that pesticide manufacturers were buying into the seed industry in order to develop plant varieties that could tolerate their patented herbicides. RAFI's supposition was universally condemned by public and private scientific and political institutions. Within two years of RAFI's prediction, however, pesticide manufacturers were openly developing herbicide-tolerant plants and, by 1998, 71% of the crop lands sown to transgenic seeds contained herbicide tolerant traits. (See Chart 1.) RAFI's analysis in 1979 was based upon a realistic appraisal of the scientific opportunity proffered by the (then) barely-known set of techniques later called "biotechnology"; and, by a common sense understanding of the "natural" commercial tendency to reduce costs and maximize profit. RAFI is now applying this same analysis to Terminator Technologies.

Chart 2: Global Growth of Transgenic Crops - 1996-98



T'nT: Our conclusion is that the Terminator (suicide gene sequence) is one part of what can be most correctly described as "Traitor" technology. Biotech breeders are now focussing on the linkage between the Terminator's ability to sterilize second-generation seed with the technology's ability to promote other "Traitor" sequences in the first-generation seed. This combination is called T'nT - Terminator *plus* Traitor gene control.

The Transgenic Market: As Chart 2 shows, the total global market for transgenic varieties has exploded from virtually nothing in 1995 to almost 28 million hectares in 1998. The potential Terminator component in the rapidly-expanding transgenic seed market is no less impressive. The two Agri-Giants that claim ownership of T'nT Technology patents (Monsanto of the USA and AstraZeneca of UK/Sweden) can claim roughly 90% of the total global transgenic landscape in 1998. (See Chart 3.) By the time T'nT is commercialized (sometime between 2003 and 2006), the other dominant biotech breeders - Novartis of Switzerland, DuPont/Pioneer of the USA, and Avantis (the recently announced merger of Hoechst and Rhone-Poulenc including AgrEvo - the joint Hoechst/Schering agbiotech firm) will either have their own T'nT patents or licenses to use existing patents. It is also highly likely that at least one or two of these companies will have been acquired by one or two of the others. (Zeneca and Astra announced their $37.5 billion merger late in 1998, for example.)

T'nT Technologies as the *Launching Pad* for Bioserfdom:

The Potential Platform for Positive or Negative Genetic Traits

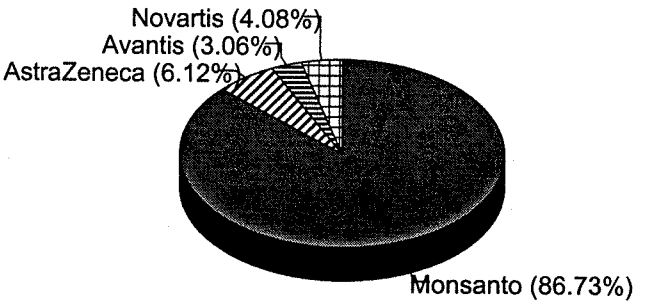
At one level, T'nT offers the opportunity to load a number of commercial characteristics onto a plant variety which the company can choose to either activate or de-activate at - or *after* - the point of sale. This turns T'nT into a *launching pad* or *platform* technology upon which proprietary traits are placed. Farmers can buy seed like they might buy a motor scooter - with or without so-called "value-added" accessories. Depending on what traits the farmer can afford - or what traits the company wants to disclose - chemical sprays or soakings can activate the purchased qualities in the "host" seed.

In fact, the Terminator is still more powerful than this scenario suggests. Economic and commercial realities point the way clearly to how the technology will evolve.

Apomixis Link: One significant factor in developing "sterile" seed is the cost of multiplying T'nT for sale. However, CIMMYT (the International Maize and Wheat Improvement Centre in Mexico) and France's ORSTOM (a public agricultural research institute) have learned how to isolate and develop apomixis in crops like maize and millet. (Please see RAFI Occasional Paper Series Vol 5, No. 1: *Terminator Trends: The Silent Spring of Farmers' Rights,* June, 1998 available at www.rafi.org as a PDF file. This document provides a discussion of apomixis.) Apomixis allows breeders to create inexpensive clones from single seeds. In theory, this could have tremendous benefit for resource-poor farmers. In practise, commercial breeders are racing to find apomixis in other major crops and to combine its ability to mass produce low-cost clones with the Terminator's suicide

Chart 3: Transnational Trait Control

The Global Market in 1998



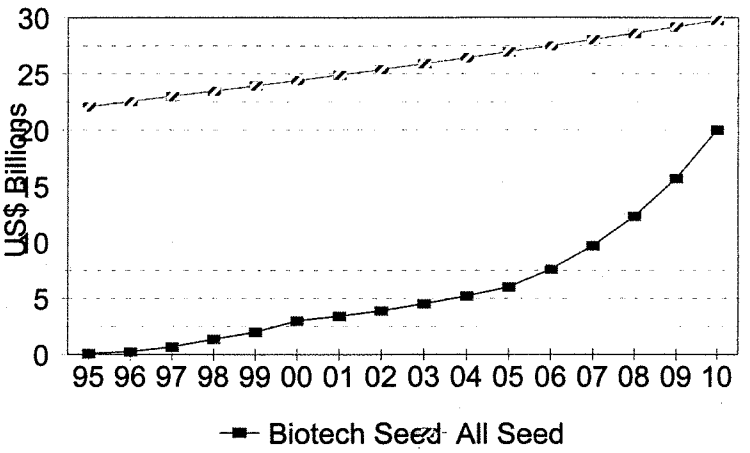
sequence. The combination will further reduce genetic diversity in agriculture and increase crop vulnerability for farm communities. The impact on the corporate bottom line, however, will be to reduce production costs in multiplying T'nT "seed".

Chemical Catalyst: TnT's owners still have a major cost hurdle. Currently, the *tetracycline* antibiotic is used to bathe the seeds and activate the sterility trait. There could be biosafety problems in planting antibiotic-contaminated seeds so extensively in the soil. Of greater concern to corporations, however, is that the high cost of the chemical process must be borne by the seller and passed onto the buyer. Once T'nT use becomes widespread and farmers have lost their traditional seed sources, the obvious strategy is to transfer the chemical from the "red ink" ledger to the "black ink" ledger by activating suicide (and other) traits via proprietary chemicals - preferably the company's own herbicides or insecticides - that can be *sold* to the farmer.

In order to accomplish this, the activation of the suicide sequence will have to be linked to the catalyzation of other traits farmers think they need. If herbicide-spraying triggers a high-yield trait or a vital disease-resistance trait, farmers might feel obliged to pay for a chemical that also happens to destroy the reproductive process of the seed. Would commercial breeders do such a thing? The straightforward economic logic is overwhelming. A cost item becomes a profit opportunity.

Chart 4: Global Biotech Market

Biotech share will exceed $20 billion



Box 1:

More Traitors - What "Cell Size" for Farmers?

It's Hard to Keep Up! Truth is Faster than Fiction

At the beginning of 1999, RAFI learned that scientists at the University of North Carolina, with funding from Novartis and AgrEvo (nowAvantis?), have developed a process that can enlarge (or, presumably reduce) plant cell size by two to four times *after* the seed has been planted. The researchers are discussing two specific uses: transforming trees planted for softwood pulp into hardwood trees suitable for furniture; and using a chemical spray to strengthen maize stalks (thus preventing "lodging" - bending to the earth under the weight of ripening grain) as the crop nears harvest.

Almost simultaneously, AgriBioTech and Kimeragen announced an exclusive deal to use Kimeragen's chimeraplasty technology on turfgrass and forage seeds. Chimeraplasts can be designed to insert selected sequences, modify existing sequences, or *de-activate* endogenous genes. Advanta is providing the "whiskers" transformation technology necessary to deliver the Chimeraplasts.

These revelation brings home a late 1998 study of DuPont by the Harvard Business School. The School suggested that the shift to "output" traits (variety traits designed for food processors or consumers) could lead to the development of crop chemical sprays targetted to a single enhanced protein in a single variety.

Traitor Traits: Secondary traits could be of two kinds: First, activating the traits through spraying could either improve the productivity of the crop or the *process-ability* of the commodity. Equally, however, spraying could protect the crop or the commodity from the activation of *negative* traits - traits that, unless halted, could render the crop unproductive for the farmer or unwelcome to the consumer. Since spraying to de-activate negative or "traitor" traits is often a greater incentive for the farmer, it will be the most attractive option for the company.

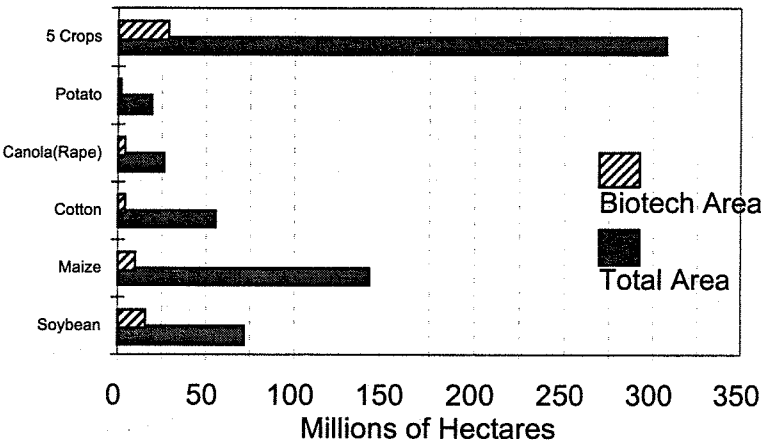
T'nT Technologies as the *Control Pad* for Agri-Food Monopoly:

The Opportunity to Exercise Market Control

Regulating the Irregular: Of course, the deliberate introduction of negative quality characteristics should be a "tough sell" in the marketplace and among regulators. But, not necessarily. First, biotech breeders can argue that the provision of beneficial transgenic sequences comes with either additional biosafety risks or with complex "side-effects" (something pharmaceutical companies are used to defending) that can be readily ameliorated with the timely spraying of their patented pesticides. Second, whether spraying activates positive genes or de-activates negative genes will not be resolved scientifically. It will be *finessed* through Madison Avenue advertising campaigns of the corporations. Thirdly- and most significantly - the Terminator *is itself* a negative or traitor trait! We are not debating what Agri-Giants *may* do. They have already done it. The USDA, Monsanto and AstraZeneca are already claiming that the invention and introduction of defective seed - "damaged goods" (as Bill Hankin of Heritage Seed Curators- Australia puts it) - is the necessary cost of offering a platform technology to farmers. If T'nT is allowed to reach the market, industry will have won! It will have overcome the seemingly insurmountable hurdle of convincing regulators and farmers that using suicide seeds is acceptable in food production. If regulators buy into that logic, the "sell" on other traitor characteristics will be no problem.

Chart 5: Transgenics Share of 5 Crops

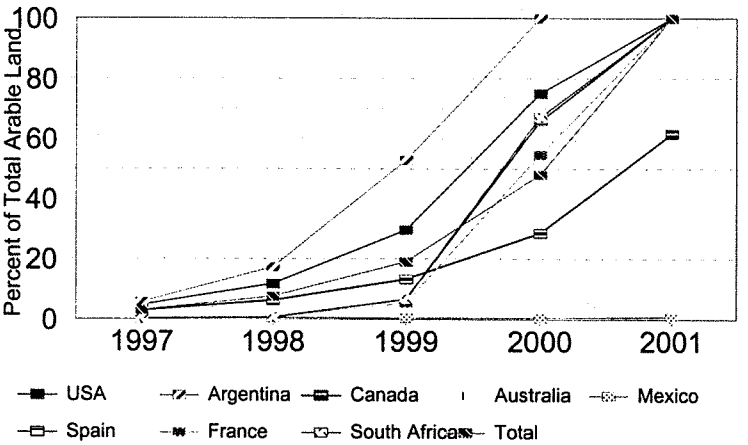
Global Coverage in 1998



Dirty Seeds: National and international seed regulations will be adjusted to encourage the spread of T'nT "seeds". This will be orchestrated in two ways: First, industry will argue (as they have already) that their seeds offer an additional level of biosafety in working with transgenic species. They will insist that T'nT increases environmental security in the global multiplication and shipment of seed stocks and utterly eliminates the threat of unwelcome genes leaking (via pollen) into other fields or forests. On this basis, Agri-Business will

Chart 6: Global Trend Pre-T'nT

Transgenics Trend in Lead Countries



describe - and government regulators will accept - T'nT as the vehicle (launchings pad) of choice for the international movement of all seeds and, especially, for the safe use of high-tech planting material.

Secondly, corporations will point to the threat posed by traditional open-pollinated seeds in *polluting* T'nT fields. "Volunteer" seed (unplanted or drift seed) from adjacent fields will be seen as contaminants in T'nT fields that reduce the value of the harvest where the T'nT crop contains marketable "output" (or processing) traits. It might also be argued that open-pollinated contaminants could distort precision-farming readings (Please see RAFI Communique (March/April 1997) *Bioserfdom: Technology, Intellectual Property and the Erosion of Farmers' Rights in the Industrialized World* for a discussion of precision-farming.) attract or carry pests and diseases for which T'nT "seeds" are unprotected; or, mix with T'nT related chemicals in untested ways that could further damage the eco-system; etc. Building on the popular assumption that farmers are destroying nature, T'nT will be described as the responsible "green" solution to an age-old problem.

The Next Bio/Chemical Frontier: For pesticide patent-holders, the opportunities just keep on coming. By augmenting their herbicides, Agri-Giants can extend the lifetime of their current patents - or acquire supplementary patents for pesticides already accepted by regulators. As companies work to perfect T'nT technology, they will also attempt to transform (or, at least, repackage) their agri-chemical business into a "catalytic promoter" business with an array of biological/chemical sprays and coatings. While modified pesticides will continue to be part of the package, they may be joined by microbiological materials and the entire package will be wrapped in the environmentally-friendly image of the catalytic promoter.

Box 2:

Damaged Goods

The modern history of Defective Technologies

Is it really possible to convince consumers and regulators to accept - even embrace - defective technologies? Remember the Betamax video recording system? Universally acknowledged to be superior to the VCR technology we now all use, the beta system didn't have the market clout (and the patent savy) needed to survive. As a result, the world is using an inferior technology even though a better system is available.

Then there's the 'Windows-versus-Mac' case. There is no disputing that Macs are technologically superior, user-friendlier, and vastly less prone to viruses and failure. Despite this, governments and consumers have overwhelmingly opted for PC/Windows technology and Bill Gates has become the richest man in the world selling a defective product. The cost? Y2K - a PC/Windows problem that will add billions to taxpayer and consumer bills in 1999/2000. T'nT is agriculture's Y2K.

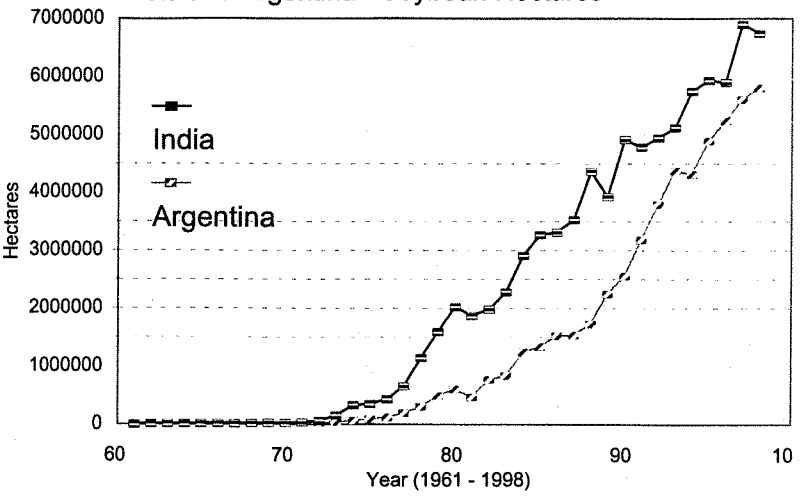
Time line: Because the proprietary holder of any trait can be assured that the trait can't be re-used and that sales will be repeated season after season, the Terminator will become the launching pad of choice for every commercial biotech breeder the moment it comes to market. Within 2-3 years of its introduction, all of the land area sown to transgenic crops will be Terminator fields. RAFI estimates that by 2010 - and very likely as soon as 2006 - the great majority of the world's non-subsistence farmland will be sown to T'nT "seed" - unless the technology is banned. In less than ten years, twelve thousand years of farmer-saved seed and community plant breeding could wither to an end.

Industry analysts record that the 1998 global market for transgenic seed reached $1.35 billion from no sales at all as recently as 1995. The same analysts project sales in excess of $6 billion for transgenic seed by 2005 and

this could rise to $20 billion by 2010. The current global market for commercial seed is approximately $23 billion. RAFI predicts that the overall shape of the industry will change considerably in the coming decade. The role and market for seed growers and seed cleaners and conditioners will be transformed while the dominance of those who control germplasm will increase. The overall size of the commercial seed industry may grow at only 2% per annum but the biotech breeders' share could climb to 80% or more of total industry turnover. By 2010, this will all be attached to T'nT technologies. Charts 4 and 5 help tell the story.

Chart 7: Pursuing the Cinderella Crop

India and Argentina - Soybean Hectares



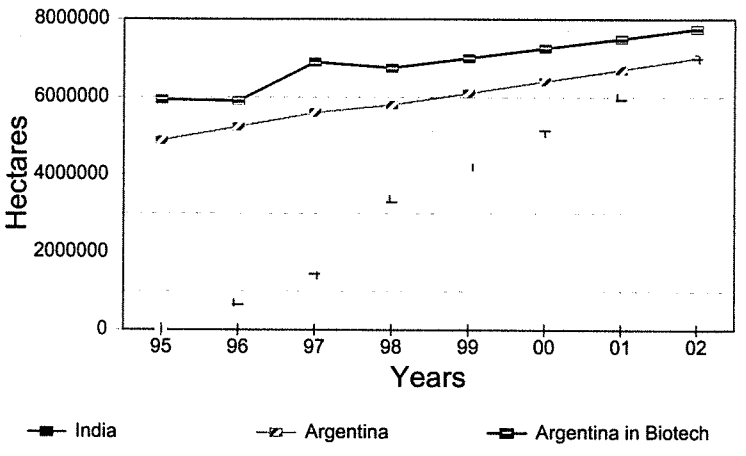
To date, the market for transgenic seed has been effectively limited to five crops (soybeans, maize, cotton, potatoes and the "canola" type of rapeseed) in eight countries. Nevertheless, transgenic varieties have boomed to control, for example, more than half the soybean hectares in the USA and Argentina. It is expected that China, Former USSR and much of Eastern Europe will grow to become major users of transgenic seed in the next two years. It is also possible that a number of Latin American states - most notably Brazil - will adopt transgenic crops in the near future. Wherever transgenics go, T'nT is sure to follow.

RAFI estimates that the boom market for biotech breeders will shift from the North to the South (and East) by 2001-2002. T'nT "seeds" will probably come on stream 2-4 years afterward and will quickly conquer the transgenic areas. Chart 6 indicates the trendline for the countries currently accepting transgenic crops. (Note that France may decide to reject transgenic crops or defer its decision to the EU.)

Whether South or North, the trajectory for market acceptance of transgenic crops appears to be similar. Large farmers, whether in Argentina, South Africa, Australia or the USA, adopt the biotech vanities quickly. It remains to be seen whether these varieties withstand field conditions but the early indications are that large commercial growers will at least try out the new seeds as soon as they become available. Unless there is a crop disaster (a distinct possibility), RAFI projects the trendline in Chart 6 for the eight countries that have already accepted transgenic crops.

Chart 8: On a Crash Course?

India & Argentina - Soybean Trendline



Since the Seventies, for example, Argentina and India have both moved into soybeans at almost identical rates and enjoy almost identical areas of crop production. More than half of Argentina's soybean crop is now under transgenic varieties and that percentage is predicted to

increase to well over 80% in 2-3 years. Were India to follow the same pattern - first into transgenics and then (inevitably) into T'nT, the impact on poor farmers in India could be traumatic. Charts 7 and 8 describe the current and projected scenario for soybean in the two countries.

T'nT Technologies *Fall-Out*:

The Implications for Farm and National Food Security

Farm Security: T'nT will directly impact the well-being of non-subsistence farmers in several ways. First, it will immediately multiply the seed costs of farmers who do not routinely buy hybrid or other specialist seeds (where seed-saving is unusual for agronomic reasons). These are costs incurred at the front-end of the growing season when farmers can least afford additional expenses. Not only will farmers have to purchase seed four or more times more often than in the past, but the seeds themselves will be 2-3 times more expensive than open-pollinated seeds at every purchase. The share of seeds in overall farm costs could rise from the current norm of about 3% of production costs to 12-16%. Second, it will inevitably tie farmers to the purchase of certain chemicals whose costs will also rise as farmers find themselves locked into a production mode they no longer control. Thirdly, as corporations exercise their patent monopolies over T'nT systems, farmers will have to accept licensing and marketing arrangements that will determine their input sources and their output customers. As the biotech industry moves to develop processing traits alongside its input traits, vertical mergers will transform the agri-food system into a handful of powerful international enterprises controlling all aspects of production and processing. With this monopoly, the farmers share of the food economy will decline still further.

Box 3:

BioSafety

There are no standards if there are no choices

Of what use is the BioSafety protocol (possibly to be adopted in Cartagena in February, 1999) if the only options available to farmers are transgenic T'nT seeds sold by a half-dozen agri-giants? As the public sector loses its independent capacity for innovation it is also losing its ability to monitor technologies they don't understand. Over time, the irresistible force of corporate greed will overwhelm the highly-movable object of government policy and regulation. There is no BioSafety without capacity. The new rait*or* Tech will be rationalized into acceptability.

Can the famous small biotech "start-up" companies keep the TNEs honest in such a fast-changing technological environment? Not if the industry's 1998 experience holds true in 1999. The number of biotech IPOs (Initial Public Offerings) fell to 12 during 1998 from 22 in 1997. IPO proceeds plummeted to $417 million from $750 million. During 1998, in Europe alone, there were more than $66 billion in mergers in the Life Industry. The competition is evaporating.

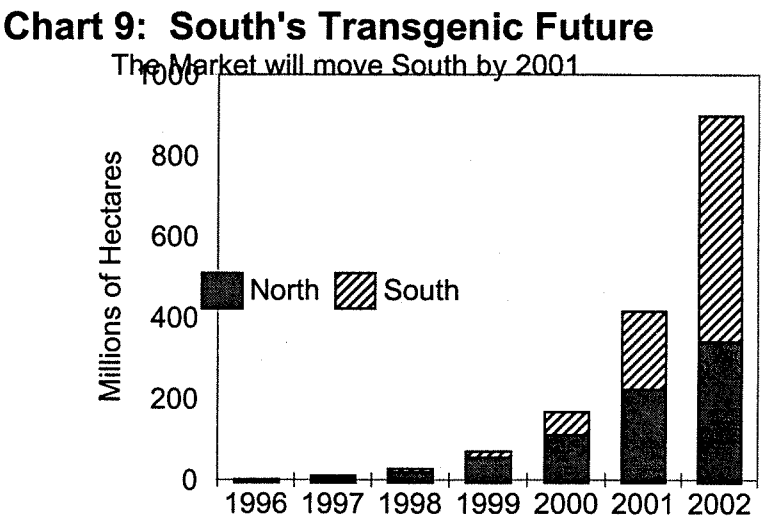
3

ood Security: These economic pressures will also afflict subsistence farmers as they are forced into using TnT. Direct pressure will come from multiple sources: First, as has happened from time-to-time in countries ranging from Indonesia and Philippines to Zimbabwe, some governments, in the mistaken belief that they are strengthening urban food security and/or export markets - will legislate the use of T'nT as a requirement to market or for access to credit, irrigation, or other services. Secondly, commercial and even non-commercial creditors (such as micro-credit institutions) have shown that they are prepared to pressure farmers to adopt

specific technologies as a pre-requisite to loans. Thirdly (as Australia's Bill Hankin has suggested), millions of tenant and sharecropper farms may also be pressured by their landlords to adopt T'nT on the assumption that this is the best means of maximizing profitability. Finally, of course, marketing tactics could also lure some desperate farmers to embrace the technology in the hopes of transcending an immediate crisis. Within a handful of years after the adoption of TnT, resource-poor farmers will no longer have traditional seeds to return to. By FAO's estimate (the Leipzig State of the World Report on Plant Genetic Resources) 1.4 billion poor people depend upon farm-saved seed and community plant breeding for their food security. These are the people most at risk.

Food Aid Security: The plight of the poor could be harmed further by well-intentioned food aid and seed-aid programmes that inadvertently spread T'nT Technologies. It is not unusual for destitute farmers who have lost their own seed supply through some disaster to attempt to plant food aid "grain" as seed. Food aid shipments coming from Mediterranean or sub-tropical climates in OECD countries - or coming via the purchase of "grain" in neighbouring tropical countries - has a reasonable chance to yield a harvest. If, however, the food aid shipments include T'nT "seed" , the crisis for farmers could double when nothing grows.

Seed Security: The full import of the spread of T'nT to its declared priority target - Third World farmers - is difficult to exaggerate. First and foremost, as poor farmers are driven away from seed-saving and plant breeding, agricultural biodiversity - including our genetic choices for future needs - will collapse and field genetic erosion will accelerate from its current level of 2% per annum to rates that could all-but-eliminate *in situ* diversity. Of equal importance, since the half-dozen Agri-Giants that will dominate the seed supply will not be breeding for resource-poor farmlands, millions of subsistence farms will be driven to extinction and hundreds of millions of poor people will join the rural landless or the urban migrants.



The erosion of *in situ* genetic diversity will be accompanied by a dramatic narrowing of the genetic base of those T'nT varieties offered to surviving farmers. These genetically-identical clones (remember apomixis) will exacerbate harvest vulnerability. Incidents of crop failures and genetic wipe-outs will increase. Rather than strengthening food security, food insecurity will afflict more hungry people.

Public gene banks may not be particularly disrupted but they will increasingly find themselves servicing the interests of the few remaining corporate breeders who will patent the genetic traits they discover in the banks and prevent others from accessing the same material. Non-profit *ex situ* seed collections may also be compromised. As has happened in the past with national lists (of acceptable plant varieties) and the European Common Catalogue, pressure maybe exerted to prevent nongovernmental seed libraries and other seed-saving initiatives from maintaining, exchanging, and growing non T'nT seed.

Sovereignty: T'nT Technologies mean the surrendering of farmer and national sovereignty over food security. The seed - the first link in the food chain - will be surrendered to the monopoly control of a few corporations that will determine what genetic qualities countries will be able to grow; under what costs and conditions; and how (or if) positive and negative traits will be triggered by external agents. The creation of such a level of

dependency related to such a basic human need is unprecedented.

Summary

Terminator and Trait*or* Technologies

T'nT Technologies *Launch Pad*:

- T'nT will be combined with Apomixis technology to mass produce inexpensive, sterile clones.
- Terminator will be adapted to switch on (and off) other single-gene (or, possibly, multi-gene) traits such as herbicide tolerance, insect resistance, and yield or processing properties.
- Ultimately, Terminator "seeds" will be armed with a diverse payload of proprietary genes/traits that can be switched on or off by the corporation at the point of sale depending on the farmers' ability to pay or the seller's market interest.
- Currently, the *tetracycline* antibiotic activates the "suicide sequence" in Terminator. In future, however, traits will be activated/de-activated by other chemicals - such as through herbicide spraying at a critical juncture in the plant growth cycle - leading to costly and potentially hazardous chemical dependencies.
- The farmer's incentive to "voluntarily" buy chemical sprays could be "positive" - to activate genetic sequences favouring yield or processing qualities; or "negative" - to de-activate non-beneficial "side-effect" genes linked to traits that would otherwise damage the crop.
- In either case, the frontier between "positive" and "negative" measures will reside purely in the mind (and marketing campaign) of the corporation. The effect will be to transfer the chemical costs of activating/de-activating genetic traits from the company to the farmer - while still increasing the market for proprietary chemicals.
- Unless it is banned, the Terminator will spread wherever transgenic crops are introduced and will become the *launch pad* technology carrying all transgenic traits as soon as it is commercialized.

T'nT Technologies *Control Pad*:

- Terminator patents will be widely licensed (and used) by any breeder having proprietary traits.
- The specialized nature of some transgenic traits will lead regulators to describe Terminator as an "additional layer" of BioSafety that will transmorphize (in policy terms) as "consumer protection".
- As breeding advances increasingly come from companies with proprietary/ transgenic traits, conventional breeding initiatives (and markets) will wither until Terminator usage becomes the standard for progress and safety.
- Second generation Terminator patents will (if necessary) be licensed to a limited oligopoly of dominant enterprises trading markets and traits.
- Governments will regulate against open-pollinated ("save-able") seed which will be seen as "dirty" seed capable of polluting neighbouring fields and undermining processing qualities .

T'nT Technologies *Fall-Out*:

- A major escalation in crop production costs (seeds and chemicals).
- A further marginalization (and elimination) of millions of small farms unable to bear the burden of higher costs and unable to obtain seeds suited to their high-stress growing environments.
- Bioserfdom - the remaining farmers will become renters of proprietary germplasm obliged to buy, grow, and sell under contract to the corporate food oligopoly.
- A vast and rapid decline in agricultural genetic diversity in the centres of origin of the world's most important food crops.
- More crop failures brought on by genetic uniformity and technology vulnerability.
- Increases in food prices with patent/technology monopolies and a new wave of mega-mergers between agricultural input corporations and food processing enterprises.
- Escalating international dependency, food insecurity, and hunger.