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Stealth Seeds: Bioproperty, Biosafety, Biopolitics

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ABSTRACT *Transgenic seeds in both India (*Bt *cotton) and Brazil (glyphosate-resistant soybeans) spread widely and rapidly through farming communities outside the reach of biosafety or bioproperty institutions. Stealth transgenics are saved, cross-bred, repackaged, sold, exchanged and planted in an anarchic agrarian capitalism that defies surveillance and control of firms and states. The outcome is more pro-poor than alternative modes of diffusion, but undermines a growing consensus in the international development community on appropriate bio-safety and intellectual property institutions for biotechnology. Second, stealth procurement of biotechnology divides nominally pro-poor political coalitions, driven by a great ideational divide on uncertainties and risks of transgenics. The ability of seeds to move underground through stealth strategies of farmers undermines widely-assumed bio-safety-regime capability. Likewise, property in biotechnology appears less monopolistic and powerful, more relational and contingent. Stealth practices of farmers in pursuit of transgenics contrary to wishes of firms, states and many NGOs suggest a different model of the farmer than that often encountered in both developmentalist and anti-'GMO' discourse: more active, creative and autonomous, less hapless and supine. Resultant incapacity of social institutions to secure interests of firms and states in biotechnology renders more likely eventual development of controls from genetic engineering – the 'terminator technology' of political dramaturgy.*

I. Monsanto, Terminators, and the Mud

In July 2003, before a meeting in Palakkad district, south India, to memorialise the peasant leader Keraleeyan, agrarian activists told me and each other of threats from 'the terminator'. I explained to colleagues that the 'Monsanto/terminator/suicide-seed' narrative about *Bt* cotton tests was a product of a Canadian web site, NGOs and instrumental political dramaturgy, not reality. Politely, no one corrected me. At the meeting, a prominent public intellectual – P. A. Vasudevan – said that the current stage of historic agrarian struggles for which Kerala is justifiably well-known is only for 'the mud'; world agriculture will be controlled by Monsanto and Cargill, through biotechnology. Popular forces had learned how to struggle against and defeat the

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landlords, their *goondas* and police, but they did not know how to fight globalisation.[1] The emergence of a new farmer organisation in a district already intensively organised reflects his analysis: the *Deshiya Karshaka Samrakshana Samithi* (National Agriculturalist Protection Committee, DKKS) was formed to protect farmers from globalisation, one prominent manifestation of which was Monsanto and its terminator technology (DKSS, 2003: 2).

In this diagnosis, the DKSS joined a loose national movement linking external threats to agriculture to multinational corporations and biotechnology. Monsanto was (falsely) attributed ownership of a patent on terminator technology, and (more falsely) of unleashing this bio-cultural abomination on India through field trials of *Bt* cotton. Terminator technology would in theory permit engineering of plants that could not produce viable seeds, generating a biological dependence of farmers on firms beyond that of commercial arrangements.[2] Traditional practices of 'self-organising' agriculture would be replaced by dependency and cash nexus. This construction – linking multinational capital and globalisation to the cultural abomination of 'suicide seeds' – created a powerful political narrative. Paired with Dow Chemicals, which 'brought us Bhopal and Vietnam', Monsanto was said to be planning to 'unleash genetic catastrophes' (Asian Social Forum, 2003). Terminator imaginary persisted in Indian public discourse around biotechnology, demonstrating great power, pervasive reach and persistence in the face of disconfirming evidence. Biopolitics centered on this ideational construction cleaved coalitions seeking social justice and betterment of farmers.

Suicides by debt-ridden farmers – most notably in Warangal district, Andhra Pradesh – were linked explicitly by activists to globalisation of agriculture and new seed technologies.[3] Dependence of farmers on hybrid seeds of multinationals – rhetorically branded 'seeds of death' or 'suicide seeds' – linked field trials of transgenic cotton in l998 to the opening wedge of terminator technology in India. *Seeds of Suicide* was 'dedicated to the farmers of India who committed suicide' (Shiva et al., 2000). Chapter one of Vandana Shiva's *Biopiracy: The Plunder of Nature and Knowledge* is entitled: 'Piracy through patents'. Dr Shiva's over-riding concern with biotechnology is 'the control of agriculture by multinational corporations' (Shiva, 1997: 91). Activists burning field crops of *Bt* cotton trials called their movement 'Operation Cremate Monsanto'. Terminator seeds were specifically banned by the government of India in 1998 in response, but the movement continued (Herring, 2005).

Monsanto's representative in India publicly refuted charges of suicide seeds: 'Since the so-called terminator gene does not exist today in any plant in any country in the world, the question of its involvement in the field trials currently on in India does not arise' (Dow Jones Agnet, 20 November, 1998). The Chairman of Mahyco, Monsanto's Indian business partner, BR Barwale emphasised that the seeds being tested had been approved by the Department of Biotechnology for trials and have 'nothing to do with the so-called terminator genes'. Monsanto's marketing director for India argued that the farmers' suicides had nothing at all to do with Monsanto's *Bt* seeds (which were not even on the market), but ironically might have been prevented by its technology (Mistry, 1998). With transgenic cotton, he said, farmers would have had less debt from pesticide purchase and less crop loss to bollworms – less poverty, fewer suicides. More obviously, since the hybrid transgenics under

testing had been back-crossed into local cultivars, there were at least six generations of *Bt* cottons in India at time of the field tests: a clear indication that no terminator genes were in the cotton (Gosh, 2001: 11). If anti-*Bt*, pro-farmer organisers were interested, a countervailing discourse was readily available, and in high profile.[4]

That transgenics arrived in India through Monsanto yoked biotechnology to multinational capital. Had *Bt* cotton come through the Indian private or public sector – as is now unfolding with both Chinese and Indian varieties – biopolitics would have taken a different turn. But in the event, the technology was inseparable from the property, from multinational capital and from pressures on agriculture from globalisation.

II. Transgenic Cotton in India: From Robin Hood to Cottage Industry

The vicissitudes of cotton farming in India are extreme. Yields are among the lowest in the world, the area under cotton the highest (James, 2002). A bitter irony in the farmer suicides is that insecticides unable to protect crops – either because of insect resistance or dilution and adulteration – were sufficiently strong to kill farmers ruined by debts incurred to purchase pesticides. Sharad Joshi, leader of India's largest farmer organisation, *Shetkari Sanghatana*, illustrated the crisis through a single tragedy: 'It [2001] was a year of miseries for the cotton growers of Maharashtra. Neelkanth Mankar, a cotton grower in Yavatmal district, unable to face creditors, committed suicide'.

But in the neighbouring state of Gujarat, Joshi (2001) noted:

> Through a lucky stroke a nondescript seed company managed to play Robin Hood and smuggle into Gujarat one line of anti-bollworm gene. For three years nobody noticed the difference and then came the massive bollworm rampage of 2001.

There was no way to distinguish transgenic lint or seeds from their appearance, but fields indicated the difference:

> Gujarat saw all its traditional hybrid cotton crop standing devastated, side-by-side the Bt-gene crops standing resplendent in their glorious bounty. The Government was upset and ordered destruction and burning of the bountiful crop.[5]

Neither the 'Cremate Monsanto' movement nor the government bio-safety regulators had noticed the transgenic cotton. Monsanto's partner Mahyco did, and complained to the Genetic Engineering Approval Committee in Delhi. The seeds had been sold as Navbharat 151. They were originally detected in Gandhinagar district of Gujarat in six locations. Press reports typically said that the extent of coverage was over '10,000 hectares' [or sometimes '10,000 acres'] in extent; this number was used in parliament, and has crept into academic accounts. Both suspiciously parallel estimates are groundless. Precisely because these were underground seeds, no one knows exactly the extent or location of plantings. The GEAC investigated during the last week of September, and found Mahyco's charges to be true. The cotton

contained the Cry1Ac gene in the construct of Monsanto. The head of Navbharat, Dr D.B. Desai, was summoned to Delhi for the 9 October meeting of GEAC to explain evident violation of biosafety regulations: no transgenic crop could be planted without officially sanctioned tests and final approval by the GEAC. Dr Desai did not appear; his counsel argued that Navbharat did not know there was a *Bt* gene in its seeds. It was sold as a hybrid registered by the government of Gujarat. On 12 October the GEAC met again and ordered the Gujarat government to act. Here regulation encountered the light-switch problem: a switch is thrown but it is not connected to anything. Gujarat state had not set up a biosafety committee, as all states were mandated to do; the GEAC itself has no police powers.[6] A case was registered against Dr Desai for violation of the environmental protection act (l986; Rules, l989) that regulates transgenic organisms.

The GEAC ordered not only burning of the crop, as the farmers' organisation notably scorned in their resistance ('we will burn with our crops in our fields'), but also mandated (1) a public warning in regional newspapers; (2) retrieval and destruction of seeds from farmers' houses and ginning mills; (3) collection of lint, which was to be stored in steel containers and transported to the Central Institute of Cotton Research in Nagpur for testing; (4) procurement of all yet-to-be harvested crops from farmers; (5) uprooting and burning of the standing crop; and (6) measures to sanitise the fields.

These orders were not carried out, marking an unambiguous political victory for farmers over regulators. Appropriately enough, Gujarat's decision to do nothing to enforce the order was announced in Delhi by the Union Minister for Textiles, Kashiram Rana immediately after a meeting with the Chief Minister of Gujarat, Narendra Modi. Delhi has a deep national interest in cotton production. Textile Minister Rana could see nothing wrong with the controversial seeds; he reasoned that since the *Bt* seeds reduced pesticide use and were favoured by farmers, opposition must be coming from the pesticide lobby. Gujarat state's Minister of Agriculture, Purshottam Rutala, made the same argument: who other than the pesticide lobby had an interest in depriving farmers of a beneficial technology? The consensus, across state and national governments, and eventually the GEAC itself, articulated by Secretary of the Department of Biotechnology Manju Sharma, was that the 'interests of farmers' would not be harmed. Union Agriculture Minister Ajit Singh said delay in approval of the *Bt* seeds would be 'inexcusable', given the damage bollworms were doing to Indian cotton. The consequence was that farmers would continue to grow, save and breed transgenic cottons despite clear evidence of violation of India's environmental protection laws and biosafety procedures.[7]

Failure of the GEAC order indicated that the biosafety regime was out of the hands of regulatory authorities and scientists in 2001 and in the hands of politicians and organised farmers. The central government provided little political support for the hard line originally adopted by the GEAC. Regulation in a federal political system necessitates balancing central and provincial powers. Agriculture is constitutionally a state subject in India; Gujarat's position was clear. Likewise, the government of the neighbouring state, Maharashtra, was actively pressing for immediate approval of transgenic cotton; Maharashtra is the geographic base of the *Shetkari Sanghatana*. The Maharashtra Minister of Agriculture Rohidas Patil announced on 11 December 2001 in the State Legislative Council that the state

would make *Bt* cotton seeds available to farmers from 1 January onwards – three months before the Genetic Engineering Approval Committee in Delhi approved the technology.[8] On 25 March 2002, farmer representatives led by Sharad Joshi – a member of the *Kisan* [agriculturalist] *Coordination Committee* (KCC) – threatened to launch a civil-disobedience movement if *Bt* cotton were not approved by Delhi. KCC representatives from cotton-growing states across India – Gujarat, Maharashtra, Punjab and Andhra Pradesh – rallied for immediate approval, and threatened to cultivate transgenic varieties whether or not the government approved.[9] The following day, 26 March, the GEAC approved three varieties of the Mahyco–Monsanto *Bt* cotton, making India the 16th nation in the world to certify a genetically engineered plant for commercialisation, albeit provisionally and in the face of fierce opposition.

Though the officially sanctioned varieties – Bollgard-MECH 12, 162 and 184 – are much more expensive than other hybrid seeds, they sold well and the technology has been licensed to other seed firms. But competition from the stealth seeds and their progeny has been vigorous. On 16 August 2004, Union Agriculture Minister Sharad Pawar stated in parliament that the underground seed market was flourishing and alarming. No one knows how many 'Robin Hoods' – in the construction of Sharad Joshi – are active in rural India, but it is clear that a cottage industry of transgenic pocket breeding has grown up around descendants of the original Navbharat 151 seeds.

There is a rough sequence to this evolution. After Navbharat 151 was banned in 2001, it became scarce, though not impossible to find; farmers sought out its parent lines for breeding.[10] Some saved their seeds after ginning and sold or exchanged or replanted the F2 generation of Navbharat 151, which was no longer available legally in the market. There is deep irony in this spread of the vigorous offspring of the 'suicide seeds'. These seeds are called 'loose seeds', straight from the ginning mill, unpackaged and unbranded.[11] They may express less *Bt* endotoxin, but, according to farmers in Gujarat, offer reasonable protection at a very low price.[12]

Nevertheless, many farmers worry about hybrid vigour in cotton and distrust F2 seeds. Given the high cost of official seeds and the scarcity of the very effective NB151, farmers themselves began breeding new transgenic hybrid varieties. They use Navbharat 151 seeds for the male contribution and a local variety especially well-suited to their agronomic conditions as female. From this process, a new Gujarati word has been hybridised: 'Navbharat variants'. There are un-counted branded and packaged *Bt* variants in circulation: Luxmi, Kavach, Viraat, Sarathi, Vaman, Agni, Rakshak, Maharakshak, Kranti, the generic Kurnool *Bt* and simply '151' playing on the original Navbharat 151 variety, among many others. These locally back-crossed hybrids made by farmers are sold by local merchants, who sometimes guarantee the seeds, to distinguish them from the many spurious seeds claiming *Bt* status in the market. To indicate transgenic character semi-covertly, some variants have printed 'BesT Cotton Seed' on the package. There are as well farmer-to-farmer transactions of modified and crossed transgenic seeds with no name.[13] The decision matrix of farmers facing this volatile seed market is complex, as there is great agronomic and cost variation, but farmers in Gujarat have largely naturalised stealth *Bt* as part of their time-tested decision matrix (Roy et al., 2007).

The tension between official seeds and stealth seeds is dynamic, in continuous flux as seed firms jockey for position and new varieties are approved – or de-certified for certain areas, as were two MMBL varieties in Andhra Pradesh in 2005. When the GEAC refused approval for Mahyco–Monsanto's new variety MECH-915 for growing in north India, an advertisement soon appeared in a prominent Hindi daily advertising farmer-grown transgenic seeds available by calling the cell phone of one Piyush Patel. Sonu Jain, relating the story in the Indian Express (Delhi) of 20 April 2002, quotes Patel as saying 'If I live in Gujarat and go to Shimla, I will not die, so the same way these seeds developed in Gujarat will grow'. Patel's *Bt* seeds sold at Rs 555 per packet of 500 grams, less than a third the officially approved Mahyco–Monsanto seeds' price. By June of 2005, I found that the range of locally-hybridised transgenic cotton cultivars in Gujarat sold for Rs 250–700 per packet (roughly enough to plant one acre); F2 transgenic seeds were selling for Rs 10 for the same weight packet. Jayaraman (2004) cites 'industry sources' as estimating that more than half of the transgenic cotton in India comes from unapproved varieties; my discussions with Gujarati seed producers suggest a much higher figure for that state. Data from Navbharat Seeds (personal communication, October 2005) indicate that on an all-India basis, about 34 per cent of the cotton seed packets sold are transgenic, of which 9 per cent are legal and 25 per cent stealth. Yet these estimates apply only to packaged and branded stealth seeds, not to loose seeds. The ratio is highest in the North Zone (Punjab, Haryana, Rajasthan): 107,000 packets of legal transgenic seeds to 1,170,000 illegal packets, together accounting for about a third of cotton acreage.

Dr R. P. Sharma of the GEAC believes this to be a temporary phenomenon: farmers will eventually choose *Bt* cultivars from trusted seed companies and abandon the stealth transgenics: the current state of affairs simply reflects the fact that 'scarcity breeds corruption' (personal communication, New Delhi, 27 June 2005). Scarcity was induced by banning the extremely effective Navbharat 151.

Where did stealth *Bt* originate? Standard accounts have emphasised Gujarat and the Robin Hood construction of Sharad Joshi, but the seeds were available in other locations as well. In early November, 2001, 460 acres of seed farms were found to be producing transgenic cotton in the Kurnool and Mahabubnagar districts of Andhra Pradesh. Chairman of the GEAC A. M. Gokhale claimed that Navbharat was selling transgenic cotton under brand names of *Vijay, Digvijay* and *Jay* in the state. It was widely believed that other stands of parent seeds were growing in the Punjab and Maharashtra.[14] As the matter is *sub judice*, it is difficult to come to definitive answers. Dr N. P. Mehta, the breeder who developed NB 151, has stressed serendipity: his breeding strategy was directed toward early flowering for a crop rotation with sugar cane in Surat; one of his scouts came across an unusually bollworm-resistant cultivar, which proved vigorous upon crossing, producing NB 151 (personal communication, Ahmedabad, 20 June 2005; see also Mehta, 2005). Both Mahyco–Monsanto Biotech Limited and the GEAC believe that the transgene was appropriated from MMBL stock, possibly from the field trials mandated by the GEAC. No definitive answer is now possible; sequestering of *Bt* technology in either the regulatory or property sense has not proved administratively or politically feasible.

Farmers in Gujarat have embraced the agrarian anarcho-capitalism of stealth seeds. This outcome is not in the interest of seekers of innovator rents through

state protection of intellectual property – in this case both Monsanto and Navbharat. The long development costs and time, mandated by a biosafety regime that is becoming global, are estimated to be about US$8 million for MMBL; these costs put official seeds at a price disadvantage. In Indian law, there is no restriction on farmer-to-farmer exchange of seeds. Farmer-generated transgenic hybrids that I have seen reference on the package the Indian Seed Act of l966, Section 24, which protects this right explicitly. Lacking capacity to use patent protection on intellectual property, Mahyco–Monsanto favours strict regulation. In these circumstances, regulatory restriction of official seed varieties confers property-like rights unavailable through patents. If only its seeds are legal, licensing of the technology confers short-term monopoly rents on MMBL. Advocates for Navbharat accuse the GEAC of exactly this: market-rigging through biosafety regulation creates de facto bioproperty rights.

Bt cottons have been in the field too short a time for definitive assessment of either biological or economic success across so varied an agro-ecology as India; results vary with seasonal variations of pests, weather and local agronomics (Rao, 2004b). More systematic data are being compiled, much of it rejected by opponents for being tainted by Mahyco–Monsanto sponsorship, and none long-term enough for robust conclusions.[15] But unless one thinks farmers irrational, there is strong evidence of *Bt* technology's effects in India being similar to those in China, where both the Monsanto and public sector versions of *Bt* cotton have been adopted rapidly by small farmers (James, 2002; Pray et al., 2002). Farmers have done this for higher yields, less pesticide application against bollworms, and higher profits.

Opponents continue to proclaim 'the disaster wrought by *Bt* cotton in India'.[16] This construction is empirically groundless but strategically partisan. Opponents somehow fail to distinguish *Bt* technology from specific cultivars. The reason that there are between 200 and 300 cultivars of cotton grown in India is that cultivars have specific agronomic characteristics: no single variety will do well in all places in all seasons. Farmers know this; many who claim to represent them do not.

There exists no credible evidence of the 'failure' of *Bt* cotton technology in India. There is great variation in performance of cotton cultivars, both *Bt* and non-*Bt*. Reasons for variance are not always discernable, either by farmers or researchers, since there are many unmeasured variables in complex interactions – local climate, soil chemistry, pest variance, water timing, nutrients. Second, spurious seeds are pervasive: some varieties sold as *Bt* are not; some farmers honestly but mistakenly believe their *Bt* crop has failed. Third, there are demands for financial compensation from Mahyco–Monsanto and the government for *Bt* crop failure; there is material incentive to claim poor results. Fourth, the MMLB varieties are clearly not the best germplasm for insertion of the *Bt* gene: many farmers seem to prefer Navbharat and other varieties, legal and illegal. New firms are vigorously entering the market as licensees of MMLB's technology, but with different cultivars. Finally, and most important, none of the claims of failure compare two isogenic varieties, one with and one without the *Bt* gene, to assure control of varietal characteristics (Naik et al., 2005). Rather, all disadvantageous variance across over time and space – which will be extreme in India – is attributed to the *Bt* gene, constructing a biological absurdity. The *Bt* gene codes for a single protein, the Cry1Ac; there is no reason for

production of that protein – lethal to *Lepidoptera* – to cause staples to shorten or leaves to wilt.[17]

Perhaps the most careful controlled study to date is of MECH-162 (Bambawale et al., 2004) – compared to the isogenic *non-Bt* MECH 162 and a conventional hybrid. This study used a participatory field trial to test meaningfully paired varieties with and without integrated pest management. Consistent with other studies, *Bt* plants required half the sprayings of other plants, experienced less bollworm infestation, and, somewhat surprisingly, reduced attacks of sucking pests and two natural enemies of cotton. With integrated pest management, the *Bt* variety recorded a yield of 7.1 q/ha and a net return of Rs 10,507/ha. Damage to fruiting bodies was much less with *Bt* plants, which would account for the premium some *Bt* farmers receive for their lint in the market. The authors concluded: '*Bt* Mech-162 used in an IPM mode resulted in highest yields and economic gains to the farmers; pesticide consumption was also reduced' (Bambawale et al., 2004: 1633). *Bt* technology and improved agro-ecological practices each contributed to superior outcomes in this controlled study.

Indian farmers are experimenting widely with *Bt* cottons, both official and unofficial; both categories are multiplying rapidly. Neither duped nor passive puppets of multinational monopolists, cotton farmers continue the endless struggle of agriculture against insects, with a new tool. Their techniques continue traditions of seed saving, seed exchange, and seed experimentation (Gupta and Chandak, 2005; Roy et al., forthcoming). But then what of the elaborate bio-safety regime that is to prevent genetic anarchy? A commission on bio-safety regulations headed by eminent agricultural scientist M. S. Swaminathan concluded in under-stated officialese: 'Public regard and satisfaction for the regulatory systems currently in place are, to say the least, low' (Bagla, 2004). Dr Swaminathan himself was quoted in *Nature Biotechnology* (2004, 22: 1334): 'illegal proliferation of GM varieties must cease or else the bio-safety regulations will be rendered meaningless'. Yet A. K. Dixit, Director of Agriculture for Gujarat, said: 'It is impossible to control something at this large a scale. When we go to the fields, we become targets for trying to take away a beneficial technology from farmers' (Seed Quest, 2003a).

III. Representing Farmers: Biopolitics and Credibility

Coalitions for the poor are difficult to conjure, harder to create and sustain. The experience of a single farmer, little noted at the time, proved diagnostic of the representational problems of the suicide-seed coalition.

In the beginning of Operation Cremate Monsanto in l998, the *Karnataka Rajya Raitha Sangha* (KRRS) organised the burning of *Bt* cotton crops on two test plots in Raichur and Bellary districts of Karnataka state. The KRRS is a farmer organisation specifically dedicated to protecting Indian farmers – and India – from globalisation, personified by Monsanto (Herring, 2005; Omvedt, 2005). Cremated test plots received international attention; failure to cremate a third trial plot as planned, in Adur village, Haveri *taluq*, went virtually unnoticed. Yet this episode proved diagnostic of difficulties facing any coalition that seeks to be both pro-poor and anti-transgenic. The farmer who owned the plot, *Shri* Shankarikoppa Mahalingappa, was a member of the KRRS, but was unconvinced by its leadership.

He stressed in a conversation with me that he could not depend on the movement's explanation of the new technology, but had to see for himself. He asked for and received police protection for his test crop. *Shri* Mahalingappa had sequestered 100 seeds from biosafety trials on his land; he planted them and found germination by 95 of the 100 'suicide seeds'. The terminator construction dissolved before the organic empiricism of a farmer concerned about pesticide costs and farm income. Shankarikoppa Mahalingappa concluded that 'terminator' talk was 'just propaganda'.[18]

Mahalingappa's dissent illustrated not only the political problem of cultural distance of movement elites from farmers, but also a different view of science. His epistemology was inductive and grounded rather than deductive and derivative. Against the notion that farmers were duped by corporate propaganda, he said: 'no one's word can be taken; you have to see for yourself... farmers must be convinced personally that a crop is beneficial; only the farmers can decide'. His perspective is simply prudent farm management. Mahalingappa now buys Bollgard MECH-162 and finds it profitable despite high seed cost; he spends less on chemicals and gets higher yields because of reduced bollworm damage. Why does he not use the cheaper stealth seeds so popular in Gujarat? He trusts the quality of the official seeds and does not trust the F2 generation of hybrids. The additional cost of seeds is more than compensated by additional revenue: 'it makes money for me'. And what of bio-safety? 'The genes cannot be taken back', but he is not worried about any bad effects, because he's seen none. The foliage seems not to harm insects other than bollworms, nor mammals; he could perceive no threat from the new seeds.

How could there be such a disjuncture between farmer experience and the position of public intellectuals and NGOs that claim to represent the farmer? In a typical press account of Operation Cremate Monsanto:

> 'Farmers,' it is said, led by Prof. Nanjundaswamy of the Karnataka Rajya Raitha Sangha, attacked the Monsanto seed farm near Malaldguda in Raichur district and destroyed the cotton crop in order to protect Indian farmers from the dreaded Terminator Gene. The campaign was repeated in Bellary district and other 'farmers' in Andhra Pradesh did the same thing. Speaking in the name of all of them, Prof. Nanjundaswamy has vowed to repeat it in Maharashtra and Punjab.[19]

This press report notes the ambiguity in characterising 'farmers' active against transgenics. It is now clear that the technology was spreading, not terminating, because farmers were finding ways to obtain illegal seeds and eventually ways to breed transgenic hybrids themselves.

Despite persistent reports of catastrophic failure, and movements to de-certify Mahyco–Monsanto varieties (successful in Andhra Pradesh in 2005), demand for official seeds continues to grow, at times exceeding supply, even at prices triple or more those of other hybrids. Sales of the MMBL Bollgard seeds increased six-fold in 2004–05 over the previous year. Moreover, 21 varieties produced by Indian firms that had sublicensed the *Bt* technology had been approved for planting as of June 2005. Approvals of new *Bt* cultivars continue to come from the GEAC, including the

Bollgard II technology. Farmers continue to scramble for *Bt* seeds but are price-conscious, often opting for stealth seeds over official seeds.[20]

Yet 'the failure of *Bt* cotton' – in an agronomic and economic sense – continues to fill press reports. Refusal to believe that farmers might have some valid experience on which to base a preference for transgenics is diagnostic of representational problems in rural movements headed by metropolitan elites. This epistemological fundamentalism – privileging international public intellectuals over farmers' intelligence – creates a wedge in possible coalitions for the poor.[21] If one grants that Indian farmers and seed firms might be commercially rational, the continuing spread of the Cry1Ac technology must indicate biological and micro-economic success. When I presented this argument to activists against biotechnology in Palakkad district, the response was that farmers had been duped or coerced, falling into the trap of the monopolist Monsanto. Vandana Shiva et al. wrote in the conclusion to their 1999 article in the prominent Indian social-science journal *Economic and Political Weekly* that 'the promotion of genetic engineering by corporations like Monsanto can only be based on dictatorial, distorted and coercive methods'.

If biological and economic failure constitute one strand of resistance to a technology many farmers find beneficial, a second strand is nationalism: biotechnology is unacceptable for its foreign origin and implications for neo-colonial control. Responding to a BBC story that portrayed the farmers of Gujarat as clever pirates of Monsanto's intellectual property – as implied by Sharad Joshi's Robin Hood characterisation – the Research Foundation for Science Technology and Environment (headed by Vandana Shiva) rebutted:

> This rumour about piracy is initiated by Monsanto whose *Bt* cotton has totally failed throughout the length and breadth of the country and to divert attention of the public and policy makers from the failure of its genetically engineered seeds, Monsanto is trying to focus on the outstanding success as unjust and illegal of an indigenously bred cotton variety.[22]

'Indigenously bred', perhaps, but equally transgenic – with the Monsanto Cry1Ac gene.[23] Charges of genetic pollution and the saving construction of indigenous breeding provide an exit from the *cul de sac* of the suicide-seed narrative. Just as the 'Monsanto terminator' construction came from a website in Canada, the revisionist response of anti-transgenic forces bears a striking resemblance to Canadian websites defending Percy Schmeiser. The construction of Canada's most famous biopirate – in Monsanto's view – or victim of biological pollution – in the opposition's view – deploys the defence of gene flow. Mr Schmeiser's defence in the case he lost repeatedly, finally in the Supreme Court of Canada in June of 2004, is that he did not illegally appropriate intellectual property for transgenic canola seed production on his farm, but suffered pollution of his fields by Monsanto's plants.[24] The revisionist reconstruction of RFSTE valorises Gujarati farmers' 'indigenous' breeding, but the major trait responsible for success – resistance to bollworms through the Cry1Ac endotoxin – is reconstructed as incidental and accidental, a result of biological pollution from Monsanto.

The *Bt* controversy began with a nationalist (and Gandhian) theme of resisting foreign threats to India (Herring, 2005). Attacks on Monsanto continue, but *Bt*

technology itself has been naturalized. Leader of the farmer organisation *Khedut Samaj* in Gujarat, Bipin Desai, charged that the 'failing' – and foreign – *Bt* technology has been approved by the government, but the successful home-grown *Bt* variety (Navbharat 151), has not. Vice President of the organisation, Labshankar Upadhyay, added: 'The BJP talked about *Swadeshi* [self-reliance]. But it promotes a foreign company at the cost of an Indian firm. And we [farmers] stand to lose'. The RFSTE construction enables a nationalist and populist attack on the biosafety regime: Delhi officially allowed the import and testing of, and then certified, a foreign incarnation of *Bt* technology, but filed a court case against an indigenous plant breeder. The stealth seeds are held to be legitimate in a way the government seeds – which are much more expensive – are not (Mehta, 2005: 77–84, 108–15, 137–9).

Stealth seeds were decisive in turning Indian farmers into a pressure group for transgenic cotton. Farmers encountered transgenics through the mediation of rumour, misinformation, and contradictory official signals (Parmar and Vishvanathan, 2003). The suicide-seed narrative was dramaturgically engaging; but external political intermediation loses power over time unless both framing and objectives resonate with a threshold level of farmers' experience. The micro-economic and biological success of *Bt* technology outweighed the more indirect, distal and hypothetical arguments about foreign control and dangerous genes: oppositional discourse outran agricultural interests. Framing is bounded, ultimately, by interests, even if loosely at any particular time.

The triumphalism of the industry relies on the success and acceptance of *Bt* technology, but may be premature. For all the romanticisation of local knowledges and the village *Volk*, it is not clear that sons of the soil always know best (Herring, 2000). Farmers adopted insecticides not after considering the science and social externalities, but rather from an interest calculation: to protect their crops. Farmers understand the dead-end nature of the pesticide alternative to *Bt* cotton; they are little concerned about biosafety. Uncertainties are externalised to society as a whole, and projected onto an elusive 'biosafety regime'.

IV. Stealth Soy in Brazil

India's *Bt* cotton story suggests rethinking core assumptions in the standard narrative of seeds and states in developmentalist biotechnology. Is India an aberrant case?

Brazil parallels India's experience in three ways: first, the developmental state supported biotechnology. Looking outward to competition in the international economy, Brasília pressed for indigenous and collaborative development of biotechnology. In both nations, support for transgenics from the centre was challenged in the periphery, by forces in civil society. Second, despite considerable political conflict around the bio-safety regime, regulations were rendered irrelevant by the capacity of farmers to find and breed transgenic seeds underground. Third, Monsanto provided a symbolic target and rallying point for opposition at the same time that farmers were finding ways to avoid Monsanto's property claims. Rather than monopoly power, Monsanto encountered not only competition from stealth seeds, but the same difficulty in policing underground seeds faced by the regulatory

state. Intellectual property rights fiercely debated in political and policy circles proved illusory when seeds went underground.

Brazil's economy depends on agricultural exports, of which soy is a major component. As competing nations approved transgenic soy much sooner, Brazilian farmers faced cost disadvantages vis-à-vis farmers in Argentina and the United States – the other two of the top three soy exporters.[25] But global imperatives were contradictory in the case of soy. Global market segmentation created a niche for 'GMO-free' soy when opposition to transgenics surfaced in Europe and Japan after 1997; the cost-of-production disadvantage Brazilian farmers faced might be off-set by the premium for 'GMO-free' soy (Paarlberg, 2001: 67) – if exports could be reliably segregated and certified.

Introduction of transgenic crops to Brazil proceeded in what David Hathaway (2002) called 'a vacuum in the exercise of authority'. The state was divided against itself. The political struggle for legitimacy to rule on transgenics engaged different levels of the court system, divisions within the federal government and disputes between the states and Brasília.

Brazil's Biosafety Law was passed by the National Congress in 1994 and issued in January 1995. It granted authority over genetically-engineered organisms – both pharmaceutical and agricultural – to a National Technical Biosafety Commission (CTNBio), consisting of academics, a broad range of government ministries – from Health to Agriculture to Education to External Affairs and representatives of industry and civil society. CTNBio was to be the federal agency responsible for the development and implementation of biosafety policies, ethical codes, and evaluation of risk and environmental threat. Brazil's 1990 Consumer Defense Code mandates labelling of all products to inform consumers of characteristics they have a right to know about. Transgenics are also regulated by the Industrial Property Code of 1996, which explicitly responded to new requirements of WTO's Trade-Related Aspects of Intellectual Property Rights (TRIPS), granting legal protection to inventions related to pharmaceuticals, food processes, and biotechnology.[26]

CNTBio approved commercial release of three varieties of Monsanto's Round-Up Ready (RR) soybeans in September 1998; the representative on the Commission from the Institute for Consumer Defense (IDEC) resigned in protest. Both Greenpeace and IDEC filed legal appeals; in 1999, an injunction (*ação cautelar*) was issued by a federal judge, Antonio Prudente. Commercial cultivation of RR soybeans was legally banned, on grounds that they had not been adequately tested for human health and environmental impacts. More fundamentally, the authority of CTNBio was challenged by a suit in 2000, seeking an injunction against decisions on transgenic-crop releases before the government formulated rules for assessing biosafety. A third decision, issued 14 February 2002 in response to a suit brought by the federal Public Ministry, suspended all further field tests of 'biopesticide' transgenics until Brazil's pesticide legislation is enforced. These decisions combined to produce a 'judicial moratorium' on the commercial release of transgenic crops in Brazil.[27]

Opposition to regularisation of transgenic soy was led by Greenpeace Brazil and IDEC, later joined by a section of the Ministry of Environment – the Brazilian Institute for the Environment and Renewable Natural Resources (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* or IBAMA) – and the umbrella *Campanha Por um Brasil Livre de Transgênicos*.[28] As in India, opposition

targeted corporate globalisation, and Monsanto in particular. At a 'People's Tribunal' – a functional equivalent of the *Beej Panchayat* of India – Monsanto was convicted of producing seeds sold to Argentina in 1995, subsequently smuggled into Brazil, that 'endangered the environment, biodiversity, human health, the country's agricultural genetic wealth, and the Brazilian economy'.[29]

The federal government held that uncertainty was discouraging private investment in biotechnology, both foreign and domestic, as well as development within the sophisticated public sector. In July of 2000, six senior cabinet members of then-President Cardoso's government (including those for environment and health) signed a 'manifesto' supporting both transgenic crops and the authority of the federal CTNBio. Brazil's National Academy of Science as well as the Brazilian Genetics Society expressed approval of transgenic crops (Poddar, 2004: 30). In December of 2000, legislation granted CTNBio more robust authority to circumvent appeals against its legal competence.

Much of the legal manoeuvring in elite circles was irrelevant to what was growing in the ground. A report issued in 2002 by Liberal Party parliamentary Deputy Ronaldo Vasconcellos exposed widespread planting of glyphosate-resistant soy in Brazil despite the legal ban (Osava, 2002). Seeds had been smuggled from Argentina, and perhaps other neighbours, since at least 1997, and were being reproduced and re-crossed by Brazilian farmers. According to his report, transgenic seeds accounted for up to two-thirds of the crop of Rio Grande do Sul – Brazil's southernmost state; there was evidence as well of seeds' spreading north.[30] Vasconcellos was suspicious of his own numbers and underscored the political consequences of stealth seeds for biotechnology data. He suggested that disseminating exaggerated figures had a political rationale: to present transgenic soy as a *situación de facto (fait accompli*), seemingly irreversible. Indeed, some opponents saw stealth seeds generally as a 'contamination strategy'.[31] As in Gujarat, the actual area planted to underground seeds in Brazil was unknown. Officially, Rio Grande do Sul maintained its own anti-transgenic policy, and stopped most federally authorised field trials in the state. The state government claimed incapacity to halt widespread smuggling from Argentina – though by this time most seeds seem to have been indigenously produced.

The illegal-immigrant seeds themselves had not necessarily been purchased through legal channels. Monsanto was refused patent protection for Round-Up Ready (RR) soybeans in Argentina in 1995. Argentina's largest seed firm, NIDERA, purchased a former Monsanto partner, Asgrow Argentina, and thus acquired RR seeds, which were sold to farmers without technology fees. In 1999, president of the National Seed Institute (INASE) of Argentina, Adelaida Harries, estimated that '25–30 per cent of the soybean and wheat crops are sown with illegal seed, which farmers sell to their neighbours'.[32] Nor could Monsanto count on enhanced chemical sales as their technology spread: Round-Up (glyphosate) was out of patent and 20 companies competed with Monsanto for sales (Paarlberg, 2001: 71–2). Opponents of transgenics in Rio Grande do Sul argued that control of the international border was a federal matter; the fault lay in Brasília – which favoured biotechnology. Other states – Santa Catarina, Mato Grosso do Sul, and Pará – passed state laws giving their newly-created State Biosafety Commissions control over transgenics in anticipation of federal deregulation (Hathaway, 2002). As in India, federalism made for a disjointed and indeterminate regulatory environment.

In January 2001, approximately 1200 Brazilian farmers mobilised by the Landless Workers Movement (MST) stormed a Monsanto biotechnology plant in Rio Grande do Sul in protest against genetically modified food (Reuters, 2001). This protest strategically coincided with the World Social Forum that had convened in Porto Alegre, countering the World Economic Forum simultaneously underway in Davos, Switzerland. Aided by anti-globalisation protesters, farmers uprooted genetically engineered corn and soybeans at the experimental station and wrote on walls: 'The seed of death' and 'Monsanto is the end of farmers!' A local MST leader, Solet Campolete, explained, 'these seeds trick farmers and create dependency on seeds produced by a big multinational'.[33]

Though discursive framing of social movements paralleled that of India, there was also interest-driven opposition: stealth soy was a threat to Brazilian exports. Federations of agriculture in Mato Grosso do Sul – the country's leading soy-producing state – and Paraná demanded action against transgenic soy. Paraná began interdicting plantings in 17 areas and ultimately attempted to blockade seeds by declaring the state a 'GMO-free zone'. Paraná had been conducting negotiations to export non-transgenic soy to China (*Actualización,* 24 March 2003, Issue 8). Both states' federations cited preferences of the European Union and Japan for 'GMO-free' food. The Paraná federation of agriculture's Technical Commission on Grains warned of 'an enormous loss of revenues' because the national system is unable to certify 'reliable separation' of transgenic soy (Osava, 2002).

Opponents of Monsanto, globalisation and transgenics expected support from the federal level when the Workers' Party (*Partido dos Trabalhadores* or PT) government took office on 1 January 2003. The party promulgated an anti-globalisation agenda and endorsed the precautionary principle in environmental policy. Yet, on 25 September, a Presidential Decree (MP131) authorised the planting and harvesting of transgenic soy for one year (Conroy, 2003) – a de facto amnesty. Permission was extended in 2004 for one year. Farmers were allowed to plant transgenic seeds saved from the last harvest, but not to sell them (Osavo, 2004; *Actualización*, 25 September 2003, Issue 3). In October 2004, permission for growing transgenics in the 2005 season was granted as well, subject to registration.[34]

The government had first sought to limit transgenic soy to one state, Rio Grande do Sul. When Governor Requião of the neighbouring state of Paraná declared both his state and Brazil's main grain port, Paranaguá, as GM-free zones, officials began stopping soy trucks at the border and turning away those that tested positive for glyphosate-resistant soy. This practice directly contradicted the presidential decree; it also created a problem of international jurisdiction, as countries such as Paraguay that permit transgenic soy found their shipments delayed or seized. On 11 December 2003, Brazil's Supreme Court unanimously ruled suspension of Paraná's law, while delaying a final ruling on constitutionality (Reuters, 2003). The Liberal Front Party had brought the case, arguing that the state legislature had overstepped its jurisdiction. The perhaps unstable outcome is that there can legally be no 'GM-free zone' in Brazil (Seed Quest, 2003b). On 26 March, another presidential provisional measure (later converted to Law 10688/03) established rules for the commercialisation of the 2002–03 soy crop, including transgenic soy. This measure gave amnesty to farmers who had illegally planted transgenic soy when the ban was in place. There

are no official statistics, but estimates run up to 90 per cent of soy in Rio Grande do Sul as transgenic (Neto, 2003; *Actualización*, 5 December 2003, Issue 6).

Significant sectors of civil society objected to post-facto regularisation of stealth seeds in an economy that both consumes and exports soybeans and products on a large scale. The Campaign for a Transgenic-Free Brazil went so far as to brand President Lula – whom they saw as a proponent of the precautionary principle before his election – as a 'crusader' for transgenics ('*un cruzado pro de-GM*', *Actualización*, 24 March 2003, Issue 8). As in India, farmers' organisations were divided; spread and replication of seeds underground clearly demonstrates desirability to many farmers. Some deputies in the Workers' Party (PT) supported what opponents – specifically Paulo Pimenta – called the agenda of big landlords and soya producers of Rio Grande Do Sul. Whether poor farmers opposed or supported transgenics is not established, but there is anecdotal evidence that small farmers have bought into the technology, which should in theory be scale-neutral.[35]

The national state is divided as well. The Agriculture Ministry has supported liberalisation of transgenics; the Environment Ministry, increasingly marginalised, has opposed it (*Actualización*, 18 December 2003, Issue 5). A new bio-security law was proposed in October, 2003; in February of 2004, the amended draft bill was approved by the Chamber of Deputies. Delays and compromises reflected differences in the ruling coalition, particularly conflict between the minister of agriculture, Roberto Rodrigues and Marina Silva, minister of environment, who has opposed de-regulation in the absence of further studies (Neto, 2003; Hochstetler, 2004: 17–9). Agricultural interests recognized these deep divisions and were reluctant to plant transgenic soy, fearing actions by courts, the environment minister and state governments might prevent their marketing.[36]

Why were these seeds spreading? Urbashi Poddar (2004: 31) summarises advantages perceived by Brazilian farmers:

> . . . producers are able to control weeds with less tillage and limit their herbicide applications to just one spray over the top of the plants rather than adhering to a more expensive sequence of pre-emergent and post-emergent sprays . . . used with conventional soybeans. . . . The Brazilian Association of Seed Producers estimates that farmers save approximately 20 per cent on their fertiliser costs using the genetically modified crop, 'which also taxes their land less' —And with higher yields. In justifying use of illegal technology, some farmers responded that the seeds 'serve as an instrument of economic leverage against the subsidy regime upheld by the United States and other . . . industrialized nations'.

Public distrust of transgenics targets opaque concentration of information in unaccountable hands. Though public institutions are being crafted to permit trials and supervise biosafety procedures, much research is under private auspices. Brazil, like India and China, has significant public sector resources for biotechnology. Paarlberg (2001: 70) notes that Brazil's intellectual property protections have encouraged not only foreign investment but also scientific entrepreneurs. Brazil's public sector research organisation, EMBRAPA, has announced a new transgenic soy resistant to Imidazolinone-based herbicides, similar to Monsanto's RR soy resistant to herbicides of the glyphosate family. Testing for commercial release will

take time, and imidazolineone is more expensive than glyphosate; nevertheless, the assumption of multinational monopoly of biotechnology is unsustainable. Such outcomes of public science undermine critiques of biotechnology that assume a high-technology monopoly of bioproperty (Reuters, 2004b). Paarlberg notes that plant breeders at EMBRAPA have developed local varieties of soybean, maize, and cotton best suited to Brazilian conditions, and have used Brazil's new IP system to establish ownership of this valuable collection of improved germplasm. These scientists see strengthening of research capacity of universities and public institutes as an antidote to monopoly by multinational firms.[37]

The future of stealth seeds in Brazil remains in legal limbo. Farmers who grow them are in theory required by the federal government to sign an agreement to comply with terms for growing transgenic soy: but there are interpretive disputes as to what compliance means, and how it can be enforced. Moreover, Monsanto claims intellectual property in the germplasm and continues to press its property claims, against uneven resistance by Brazil and its neighbors.[38]

How widespread are stealth seeds beyond Brazil and India? Anecdotal evidence is prolific, hard evidence scarce. Pray and Naseem (2007) note that 'a recent survey of scientists in Latin America by ISNAR indicates . . . that government scientists were using patented techniques extensively without knowing they were patented in some cases or not caring about it in others'. Qaim and de Janvry (2002) find that if 'black market' seeds for *Bt* cotton in Argentina were included in the calculus, most benefits of the technology would end up in farmers' pockets, not Monsanto's. Pray and Naseem also note that though China has patent laws, plant breeders' rights, and trademarks – in theory protecting both Monsanto and public sector *Bt* cotton varieties, and has stringent biosafety regulations – 'most of the *Bt* cottonseed that farmers planted was produced by farmers or small seed companies and government research institutes who did not apply for bio-safety committee approvals or pay royalties to the owners of varieties or genes'.[39] *Bt* rice has reportedly appeared in the market in China, without bio-safety clearance. Bolivia and Paraguay have had the Brazil-Argentine experience with underground soy; Paraguay has explicitly acknowledged the fact. Finally *Bt* cotton and *Bt* corn have reportedly appeared in Brazil.

Under what conditions will the phenomenon of stealth seeds emerge? Underground seeds have appeared in democratic and authoritarian systems, federal and centralized, strong and weak states. Generalization is unwarranted. Certainly some common factors contribute: monopoly prices of official transgenic seeds – enabled by bio-safety regulations more than market power; structural power of agriculture as a sector and local power of farmers as political actors; permeable bureaucracies; regulatory confusion and delay; weak institutions. These conditions, though widespread, tend to disappear in biotechnology discourse – both developmentalist and oppositional – that reifies seed and state.

V. Reification of Seed and State

The ability of seeds to go underground through farmer stealth strategies undermines surveillance of states and firms assumed in two divergent discourses: opponents of genetic engineering fear monopolisation of property rights, proponents assume

bio-safety regimes that can control nature and farmers – a Panopticonic state enforcing global protocols. Neither discourse is proving robust on the ground. Surveillance of nature is no mean task, either macro or nano.[40] Strong interests are at work. Farmers pursue stealth seeds because the technology is affordable and divisible; the genetic roulette they enable has not been a powerful deterrent.

Stealth seeds inject a new dimension of dissention into potential coalitions for the poor: farmers seek them out, NGOs seek to stop the technology. Brazil's PT government has been split, as have representatives of farmers and NGOs. In India, the loss of credibility entailed in the Monstanto-terminator-suicide-seeds campaign divided farmers' movements and reduced the political capability of NGOs supporting farmers' rights and environmental protection. Contested science drives different segments of the active body politic in opposite directions. Indeed, a defining characteristic of bio-politics is the ambiguity of interests. Interests in transgenics must be processed through a complex cognitive screen in which much that needs to be known is not known: the great ideational divide follows neither class nor North–South lines (Herring, 2007). Intellectual property rights are reified as a force against the farmer – as if patents were somehow self-enforcing. Opponents fear the same reifications of bio-property that techno-optimists posit as preconditions for progress. 'Monopoly' by seed firms dominates the argument against transgenics even as stealth strategies defy property claims in the fields. Farmer-bred 'Robin-Hood' *Bt* seeds may be spreading faster than officially sanctioned seeds from 'monopolist' Monsanto, as they are cheaper, and often give better results (Roy et al., 2007). Farmers in Brazil and India pursued benefits of transgenic crops for reasons not credible, or even comprehensible, to their nominal allies in politics and NGOs.

Property rights in landscapes – in macro-nature – evince a long history of conflict between states and local communities, easier to claim in international treaties than in forests and fields (Herring, 2002). Stealth seeds underscore the dependence of property rights in micro-nature on close monitoring mediated by high technology. In both Brazil and India, in different crops, technology developed by Monsanto was appropriated, redeployed and developed by small-scale entrepreneurs and farmers themselves, unmindful of TRIPS negotiators or NGO petitions. In India, Delhi could not know that the cotton plants that survived the bollworm infestation of 2001 were transgenic and illegal prior to genetic testing.[41] Commercial interests diligently provided the knowledge state actors lacked; 'seeing like a state' may be more astigmatic than seeing like a firm. Navbharat's successful *Bt* cotton violated no property rights, but clearly expressed the Monsanto *Cry1Ac* gene. In Brazil's transgenic soy, it is clear where the seeds originated, but it is less clear that Monsanto has a valid property claim after generations of field-level modification of varieties by farmers and seed firms operating independently of Monsanto. Bioproperty claims, like property claims generally, are relational; they mean what actors can make them mean. Ironically, the popular and successful Navbharat 151 seeds were banned – and their germplasm went underground – not because of Monsanto's property claim but because they had evaded bio-safety procedures. In effect, as angry farmers and seed producers in Gujarat protested, to the extent Mahyco–Monsanto had privileged market position and extracted rents from farmers, it was a function not of market power but restriction of alternatives by bio-safety regulators.

Whatever else the genomics revolution may bring, it will certainly bring higher levels of surveillance. Surveillance has real costs, and certainly developmental opportunity costs; good policy rests on analysis that is currently absent. The analytics are missing partly because of inevitably incomplete science at the knowledge frontier: there are known unknowns and unknown unknowns. Because the transgenic genie is out of the bottle, the cost and consequences of bio-safety regimes need attention.

VI. The Goldilocks Paradox: Getting Regulation 'Just Right'

To be normatively acceptable, development policy must argue for priorities at the margin: what are opportunity costs of an extra dollar spent on bio-safety regimes? How do benefits compare to alternative uses of that same dollar? The answer depends on how one conceptualises benefits, how one couches alternatives, the normative position one takes on uncertainty and risk, and the projections one makes from an inevitably incomplete science. Figure 1 sketches the analytics of this problem. The first question in Figure 1 is: what additional risk is introduced by

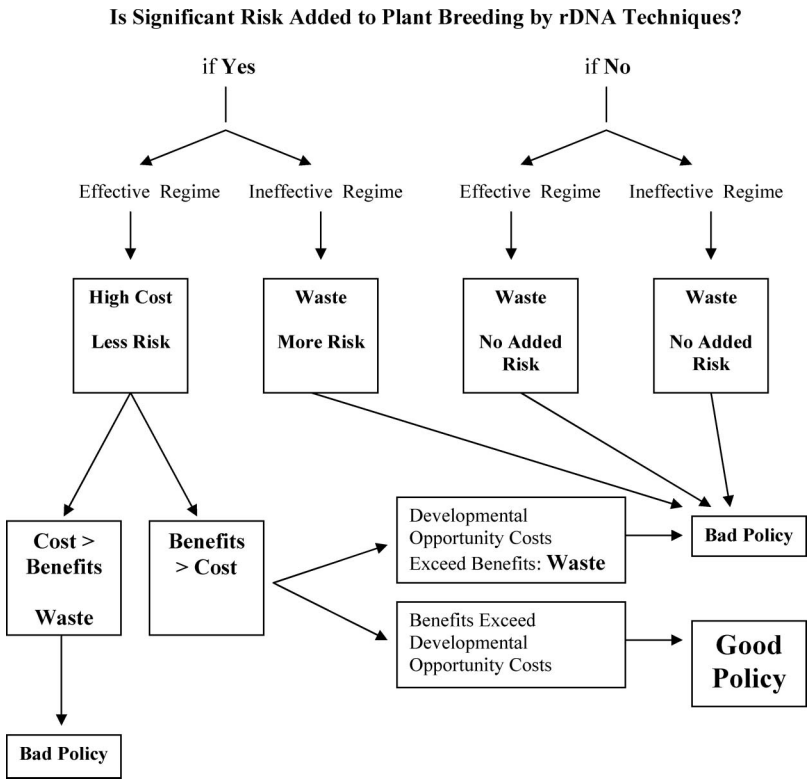

Figure 1. Biosafety regime scenarios and social costs.
Source: Ronald J. Herring, Cornell University

recombinant-DNA technology compared to conventional breeding techniques? Answers in the literature vary from zero to a lot. Gene flow is pervasive in plants; all transfers of genetic materials through any form of breeding constitute some risk, however remote. There may be little if any *incremental* risk in genetic engineering. Moreover, invasive species allow whole genomes to flow through ecologies; these risks may dwarf the risk of single-gene flow, especially since not all transgene flow will improve the fitness of receptive plants: most crosses and mutations are less, not more fit. Yet, control of invasive species seldom receives the level of rhetorical or financial support given to regulation of transgenics, despite enormous costs (Herring, 2007).

If there is no incremental risk in rDNA techniques of plant breeding compared to alternatives, all expenditures – human capital, administrative time, institution building, money – will be wasted, whether the biosafety regime is effective or ineffective. The analogy might be to buying insurance against spells cast by enemies. Alternatively, let us assume that there *is* additional risk – the dominant position. It then matters whether the biosafety regime is effective or ineffective. If institutions are ineffective, incurred costs will go for naught: transgenes will spread and the outcome is again waste. An analogy might be the very expensive 'war on drugs' periodically claimed by American administrations. Third, consider the situation where there *is* additional risk, and the biosafety regime is effective. Here analysis faces a new challenge: should the additional costs be incurred? Who should pay? If costs exceed benefits, and the biosafety regime is nevertheless established and nurtured, there is again waste. If benefits exceed costs, a second level of analysis becomes necessary: if the opportunity costs of the effective regime exceed the costs of the regime, we again are in the world of waste. It is *only* if benefits of a biosafety regime clearly exceeded the value of alternative uses of resources that the policy would be justifiable in developmental terms.

It is hard to avoid the conclusion from the outcomes in Figure 1 that justifiable developmental policy promoting genetic engineering would be restricted to extremely important objectives, or restricted to deployments with very low risk. For low-income countries, opportunity costs are large: microbiologists, lab space, research protocols, administrative time, money. Establishing a matrix of priorities would demand far more science than currently available. By this logic, provitamin A 'Golden Rice' is in a different category from the herbicide-resistant grass for golf courses – recently shown to experience gene flow over very long distances in the US.[42] A developmental calculus between fewer blind children and fewer weeds on golf courses might seem a simple one; but defenders of transgenic grass argue that weeds will be suppressed on golf courses whether we like it or not, and typically with much more dangerous chemicals than glyphosate, thereby justifying RR grass.

Not only are benefits socially disputed, but it is even in principle difficult to calculate risks (Thies and Devare, 2007). *Bt* gene flow from cotton is unlikely to pose great risk. Test trials on *Bt* cotton found that there was no incremental risk: *Bt* plants showed the same characteristics as existing cottons in food and feed, except for the *Cry1Ac* protein, which disappears in pressed oils and seems to be harmful only to *Lepidoptera*. There was no evidence of damage to field ecology. Are these tests adequate? Could data from comparable regions of China or the US have been used to ascertain risk, by-passing field trials in India? Or, are even more fine-grained tests

necessary, as agro-ecologies vary continuously rather than clumping into blunt categories?

There is also risk of resistance to the endotoxin developing in *Lepidoptera* – a threat to a public good deployed for decades by organic farmers who use *Bt* foliar sprays to control insects. *Refugia* are proposed for slowing the development of resistance of insects to *Bt* toxin. These *refugia* are costly for small farmers and often are evaded. Is this a dangerous outcome? Every agro-ecology is somewhat different. Mahyco presented to regulators the argument that there may actually be no problem with resistance development at all, as the bollworms will always have natural *refugia* in a great variety of non-cotton plants; there are about 157 hosts for bollworms in India. This argument, while biologically plausible, failed because 'uproar about the terminator' made authorities cautious.[43]

Capital in biotechnology complains that there is too much regulation – even though regulations favour corporate deep pockets over small firms, and thus reinforce technological hierarchy.[44] Environmentalists typically argue that there is too little. By what metric would one recognize the Goldilocks standard of 'just right': not too much, not too little?

Consider the cost of vetting *Bt* cotton in India. Though critics complained that bio-safety testing was done in private and supervised by Mahyco–Monsanto, there were 12 agricultural universities involved in the studies, eight Central Research Institutes, the Indian Council for Agricultural Research, the Indian Council for Medical Research, four Central Ministries and departments of agriculture in six states.[45]

From discussions with Monsanto beginning in 1993, an application by Mahyco to import seed was made on 10 March 1994; a permit was received 3 October 1995. Mahyco imported Bollgard seed in l996. Imported germplasm was backcrossed into Indian varieties. During this period there were greenhouse and laboratory trials; these and later trials were mandated by the Review Committee on Genetic Manipulation [RCGM] of the Department of Biotechnology. There was only one limited field trial at one location. In l997–98, a gene-flow study was conducted in limited field trials at five locations. In the same period, toxicological studies were conducted at ITRC in Lucknow. In 1998–99 field and experimental trials were allowed by the RCGM at 40 locations to test allergenicity and toxicity. Regulation in India is based on 'incremental risk' – that is, risk added by the transgenic that is not present in the isogenic variety of the same plant.[46] For this trial, careful controls matching varieties are critical. These were the trials targeted by Operation Cremate Monsanto and from which the dissident farmer Mahalingappa conducted his own test of the terminator hypothesis. All safety data were submitted to the RCGM; the uprooting and burning protests induced authorities to request more trials. In l999 multi-location trials replicated contained-research trials, at 11 locations. Procedures at this point reflected social turmoil; more caution was applied. It was only in 2000 that the RCGM recommended to the Genetic Engineering Approval Committee of the Ministry of Environment large-scale contained field trials, which entailed seed production for testing. At this point Navbharat transgenic seeds had been in fields for at least one year and were spreading to new acreage, but no regulatory authorities knew it.

Turmoil surrounding court cases and popular resistance caused the GEAC to ask for more field trials under auspices of the Indian Council for Agricultural Research;

these trials were planted late and thus tainted in the eyes of NGO opponents, as peak bollworm infestation was avoided. Consequently, in 2001, a second year of field trials was ordered by the GEAC under the supervision of the ICAR. Before these results could be vetted, the Robin Hood seeds appeared in Gujarat, noticeable only because a bollworm rampage had wiped out other varieties. In 2002, field-trial results were submitted to the GEAC, which subsequently, in March 2002, approved three *Bt* hybrids for commercialisation. This decision was widely and correctly interpreted as a *fait accompli*.

Is this level of social expenditure justified by results? What was lost in these procedures? For every year of delay, some level of unnecessary pesticide application reduced farmers' incomes and contaminated soils, waters, and skins, with an unknown costs in poisonings and loss of fauna. The opportunity costs for Mahyco may have been high: presumably this time and effort could have gone into finding better hybrids than the original three, which were not the best available. Mahyco holds its cash costs to be approximately $8 million for development and testing of three transgenic varieties. The same transgene had been present in cotton in other countries for years, with no known ill-effects. Navbharat bypassed biosafety procedures and created a *Bt* hybrid with early flowering characteristics well suited to Gujarati conditions; if Bollgard varieties are safe, so too, presumably, is Navbharat 151 and its numerous variants/descendents – but the former are legal, the latter are not.

One future consequence of the stealth-seed phenomenon is predictable: real terminator technology. Social institutions will not deal with stealth seeds very well, as they do not deal with any high-value product that is movable across permeable state space: software, pornography, information, drugs, arms. Ajit Singh, Minister of Agriculture at the time of the *Bt* discovery, said: 'see that we cannot even regulate adulterated food; how will we regulate seeds?'[47] Gene-use restriction technologies (GURT) will become the only feasible assurance of restricting gene flow where there is risk and the only way to enforce property claims under many conditions. The biological remedy is arguably more effective than the institutional remedy[48] – if it can be made to work in the field. Yet this conclusion illustrates again the power of discourse to shape and filter interest. Terminator technology was sidelined because of biopolitics. Is terminator technology acceptable as social policy? The clear answer has been no.

Disputes about material interests are demonstrably subject to conciliation, bargaining and compromise – familiar terrain for the political economy of interests. Deals can be struck. Disputes about the nature of the natural, and consequent risks of the unnatural, take on a different politics, dependent on expertise that is asymmetrically distributed, both locally – on the ground within movements – and globally. Biopolitics is less susceptible of ordinary bargaining solutions, but it is an inescapable politics spawned by the genomics revolution.

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Notes

1. On historical uniqueness of agrarian struggles in Kerala, Herring (2003). The Monsanto-terminator story circulated even in India's premier journal of the social sciences, the *Economic and Political Weekly*: Shiva et al. (1999), Sahai (1999).
2. On conjunction between globalisation and terminator technology, Suman Sahai, leader of Gene Campaign, wrote (1999: 84), 'Trials of a genetically altered cotton variety (*Bt* cotton) conducted by the American company Monsanto have provided the trigger because Monsanto also happens to own the terminator technology'. See also Bharathan (2000), Parmar and Vishvanathan (2003). RAFI International 2000 seems to be the origin of the phraseaology in their 'Suicide seeds on the fast track'. On terminator discourse, Gold (2003).
3. Stone (2002), Shiva et al. (2000: 64–110), Srinand Jha (2001). On debt as a cause of suicides, Centre for Environmental Studies Warangal (1998), Department of Agriculture and Cooperation (1998). Government of Karnataka (2002) concluded that debt and agrarian crisis were implicated, but many suicides were tragically personal in nature.
4. How much leaders knew about the truth of the discourse is uncertain. Vandana Shiva et al. wrote in l999 of the seeds: 'they are in an ecological sense terminator, which terminates biodiversity . . .' Shiva et al. (2000: 98) wrote: 'Freedom from the second cotton colonisation needs to be based on liberation through the seed. . . . The freedom of the seeds [is] simultaneously a resistance against monopolies . . . like Monsanto . . . The seeds of suicide need to be replaced by the seeds of prosperity'.
5. Joshi (2001), Greenpeace India (2001), Jayaraman (2001), Mathew (2001), Sahai (2002), Shaik (2001), Mehta (2005: 60–79, 130–6), Visvanathan and Parmar (2002), Scoones (2003), Omvedt (2005). These sources are complemented by discussion with Mr Raju Barwale, Managing Director of Mahyco, 28 May 2004 and Dr D. B. Desai of Navbharat and *Bt*-cotton farmers, Gujarat June 2005.
6. 'Cultivation of *Bt* cotton using Navbharat seeds', Government of India, *Rajya Sabha* Unstarred Question No 205 to be answered on 01.03.2002 by Minister for Environment and Forests, Shri T. R. Baalu; author's interviews, New Delhi, June 2002; Ahmedabad, 2005.
7. Interviews in Delhi and Ahmedabad, 2002, 2005; Gene Campaign (2005, Part II: 72 *et passim*).
8. Patil told the Council that this outcome was assured by the Agriculture Secretary in Delhi, a result of successful lobbying by the state government. The question was raised by N P Hirani, a legislator who is also Administrator of the State Cotton-Growers Association. The *Indian Express* (11 December 2001).
9. Herring (2005); also *Indian Express* (Mumbai/Nagpur edition, 13 November 2001; Delhi edition, 25 March 2002), *Financial Express* (3 April 2002), Gene Campaign (2005, Part II: 101, 109 *et passim*).
10. Yamaguchi (2004, Chapter 4), found that farmers with relatives in Andhra Pradesh were more successful in obtaining NB 151 seeds after they were discovered and banned. The text's account was confirmed by conversations with seed producers in Gujarat (June 2005).
11. The English is sometimes used in rural Gujarat to designate what farmers also call *lodhavela biyaran* ('ginned seeds') to designate non-branded F2 *Bt* cotton seeds.
12. I have heard farmers insist that F2s outperform official seeds. Though contrary to conventional wisdom, it is possible that variable agronomic conditions favor variance in phenotypic characteristics other than those for which the hybrid was chosen. See Roy et al. (forthcoming), on farmer logics of seed choice.
13. Personal communication, 16 October 2004; also Seed Quest (2003a), *Indian Express* (28 May 2003), Jayaraman (2004), *The Hindu* (4 November 2004).
14. Minister for Environment and Forests, Shri T. R. Baalu, 'Restriction of production and sale of *Bt* Cotton', Government of India, *Rajya Sabha* Unstarred Question No 206 to be answered on 01.03.2002; Gene Campaign (Part II: 102–3); interview with Ajit Singh, former Minister of Agriculture, New Delhi, 22 June 2005.
15. For positive agronomic results in Gujarat, see Roy et al. (forthcoming), Morse et al. (2005). Mahyco–Monsanto's own data for the first year of legal production of their MECH varieties on 55,000 farms

show an all-India average reduction in pesticide use per acre of 65–70 per cent, worth Rs 920 to the average farmer, an increase in yields of 3.22 quintals per acre and an increase in income of Rs 7520 per acre (unpublished data). The smallest benefits were reported in Andhra Pradesh (Rs 5930), where much of the 'failure of *Bt* cotton' literature originates. Bambawale et al. (2004) in an independent assessment of MECH-162 find positive results. Qaim and Zilberman (2003) created a stir for projecting atypically positive *Bt* cotton results from India.

16. *The Hindu* (14 December 1998). Compare Rediff.com (2001), Srinand Jha (2001). Even the serious journal *Frontline* carries similar stories: Krishnakumar (2004) confidently analyzed 'the disaster wrought by *Bt* cotton'. For useful commentary, Rao (2004). Claims of failure began with field trials: Shiva et al. (1999). Reports of *Bt* failures on a few farms even merited Parliamentary discussion. Responding to insistence of an MP from Gujarat, a central team of scientists was sent to investigate MECH-162; the team found normal agronomic variance. Madhusudan Mistry, MP, Lok Sabha, letter to Dr Murli Manohar Joshi, Ministry of Science and Technology, 18 October 2003; answered in Parliament 8 December 2003 by Mom Raj Singh, Under Secretary, NO.RS.9/6/2003-S&T.
17. The cultivar MECH-184, for example, needs early watering to develop; otherwise, it wilts. Bambawale et al. (2004) reported unpublished data showing superior performance of even this demanding variety, a finding consistent with Roy et al. (forthcoming). Though Stone (2004) argues that biotechnology is especially 'de-skilling', conventional hybrids often require new knowledge and techniques.
18. Interview with Mahalingappa, 7 June 2004. Madsen (2001: 3733–42), Birasal (l998), Visvanathan and Parmar (2002: 2714–24).
19. *The Hindu* (14 December 1998). Similar accounts appear in the *Deccan Herald* (1998, Bangalore edition).
20. Interviews, MMBL, GEAC, cotton-seed producers.
21. Meera Nanda 2003 argues that anti-Enlightenment epistemological relativism, manifest in 'alternative' sciences, is instrumentally deployed by the *Hindutva* right as well as by public intellectuals claiming the mantle of the left.
22. Press release of 20 June 2003, New Delhi. Signatories of the petition range ideologically from the *All-India Bhartiya Kisan Sangh*, a BJP affiliate, to the *All India Kisan Sabha*, a Communist Party of India affiliate.
23. Sanat Mehta (2005: 60–76); interviews with Dr D. B. Desai and the breeder of Navbharat 151, Dr N. P. Mehta in Ahmedabad, June 2005.
24. Conversations of author with Percy Schmeiser, 27–28 January 2004. For a brief history, Federal Court of Appeal Ruling 4 September 2002, http://decisions.fct-cf.gc.ca/fct/2002/2002fca309.html accessed 5 May 2004.
25. Paarlberg (2001: 67–92), Poddar (2004: 24–52), the text also relies on various issues of *Actualización: Un boletín de noticias & análisis mensuales de la Campaña Por Un Brasil Libre de transgênicos* (hereafter *Actualización*).
26. Niiler (1999), Buckly (2000), Paarlberg (2001: 73–4), Hathaway (2002), Fontes (2003).
27. Ironically, the state of Rio Grande do Sul banned cultivation of all transgenic crops effective January 1 2000 (Niiler 1999: 848). On early decisions, Hathaway (2002), Fontes (2003).
28. Sources for this section include *Actualización*; Niiler (1999), Maria Jose Sampaio, personal communications, 2003, 2004.
29. Osava (2004), Associação Nacional de Biossegurança (2001).
30. Estimates of planted area, here and later, are based on extrapolation from area harvested backward to seeds sold; non-transgenic seeds sold were sufficient to plant only about 40 per cent of the state's area (Bensen, 2001). Saved seeds, transgenic and otherwise, are not counted by this technique. See also Nuffield Council (2004: 3.57–3.61).
31. 'En resumo, no había ningún otro objetivo para esta decisión de ahora sino reforzar la estrategia de situación de facto de los pro-OGMs'. *Actualización*, 25 September 2003, Issue 3.
32. INASE opposed 'brown bag' seeds that carry 'no guarantee of quality and identity . . . and royalties are not paid . . .' The state's interests are engaged because no taxes are collected on underground sales. 'Illegal GM-crop trading in Brazil and Argentina': http://www.gene.ch/genet/1999/Oct/msg00008.html
33. Ironically, the seeds were produced by local farmers, not Monsanto (Poddar 2004: 32); http://www.organicconsumers.org/monsanto/brazilprotest.cfm

34. Numerical estimates of farmers who have registered to plant transgenic soy vary so much that reporting is premature; there is both compliance and evasion (Ewing, 2003).
35. The mayor of Chapada, Rio Grande do Sul, Carlos Alzenir Catto, was quoted as saying that '98 per cent' of the farmers in his area, including small farmers, were registered to plant transgenic soy: 'Here, people don't have any fear of signing up because they know they are planting a product that is not bad for health or the environment, because they can spray less agrochemicals on the crops . . .' (Ewing, 2003).
36. Lewis (2004), Reuters (2004).
37. Paarlberg (2001: 70). Leila Macedo Oda, president of the NGO ANBio (National Biosafety Association) draws a parallel the 'market reserve' in computing in the 1980s. By forbidding import of computers, the Brazilian government hoped to favor the local computer industry, but lack of competition only made Brazil lag behind other countries. Computers were then smuggled much as farmers now smuggle seeds (Neto, 2003: 1257–8).
38. The Agriculture Department of Paraná cordoned fields near the town of Pato Branco when crops tested positive for transgenic soy. The crop was ruled illegal because the owner had not signed an agreement to observe new rules for transgenic cultivation. Only 464 farmers had signed the agreement – itself contradicted by a state law, later overruled, banning transgenics. Many farmers refused to sign because the agreement failed to reflect modifications made by Congress to the biosafety bill. The agreement requires that farmers pay royalties on illicitly produced seeds; the new bill rejects this liability (Ewing, 2003; American Soybean Association Weekly Update, Archives, 19 January 2004; Clendenning, 2004).
39. Salazar et al. (2000), Pray and Schimellpfenning (2001), Pray and Naseem (forthcoming), Jayaraman (2004). Luisa Massarani reported on 2 December 2005, on SciDev.Net, an accusation by the state deputy Frei Sérgio Antônio Görgen of transgenic corn being sold in Rio Grande do Sul. Greenpeace announced in mid April 2005 findings of a German laboratory of *Bt* genes in rice seed in markets near Wuhan (*New Agriculturalist Online*, 5 May 2005, http://www.new-agri.co.uk/05-3/newsbr.html#nb7).
40. The parallel to James Scott's *Seeing Like a State* (l998) is clear; Scott's high modernist state needs legibility of its terrain, but finds it hard to attain. The Panopticon is posited, but illusive.
41. There are now much simpler *Bt* detection kits developed in India, costing about Rs 50 (1$US) per kit.
42. Andrew Pollack (2004) reports on a study (forthcoming in Proceedings of the National Academy of Sciences) of transgenic bentgrass created by Monsanto and Scott for golf courses for weed management. Gene flow extended as far as 12 miles, which was unexpected. The US Forest Service is quoted as saying that the grass 'has the potential to adversely impact all 175 national forests and grasslands'.
43. Interview with Mr Raju Barwale, 28 May 2004. MMBL was required to provide seed for the refuge – in a packet of 450 grams of *Bt* seed, 120 grams of non-*Bt* isogenic seed is supplied by the firm for *refugia* planting, along with instructions. The firm is expected to do resistance studies. Cited sources for this section are supplemented by interviews in Delhi, July 2001, June 2002, June 2005. Also Department of Biotechnology (l996).
44. For an argument that approval is excessively slow for biotech in India, see CII (2001).
45. Sources for this section include conversations with Mahyco officials, officers of the Department of Biotechnology, NGO activists and Department of Biotechnology (2002), Scoones (2003), Bagla (2004).
46. Transgenics are governed by the Environmental Protection Act of 1986, Rules of l989, and specifically Notification No GSR 1037 E dated 5 December l989.
47. Interview, New Delhi, 21 June 2005.
48. By analogy, a forestry official in Bangladesh once told me: 'Tigers are the best forest guards – utterly incorruptible'.

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