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## **The Birth and Death of Traditional Knowledge: Paradoxical Effects of Biotechnology in India**

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Whereas previous chapters have emphasized interactions between biotechnology and environment, this chapter takes up the relationship between biotechnology and traditional knowledge. In particular I will consider the nature and resilience of traditional agricultural knowledge, as crop genetic modification – arguably the most powerful and controversial technology ever to enter the agricultural sector – moves into developing countries. How this technology may affect traditional knowledge and practice is poorly understood. Some argue that genetically modified (GM) crops are particularly suited to developing countries because they offer self-contained solutions ‘in the seed’ that can be adopted without farmers having to adjust or even to understand (Wambugu, 1999); others warn that the new technology threatens to undermine traditional knowledge (Harwick, 2000, p53; Simms, 1999).

The concern over these issues is nowhere as keen as in India, where GM cotton has been spreading rapidly. I have been conducting ethnographic field studies among Indian cotton farmers since before this cotton was released, and it has become increasingly clear that an examination of the interplay between traditional agricultural knowledge and GM cotton can yield important insights into each. This chapter shows that, just as agri-biotechnology is hardly the monolith that industry and green critics agree it is (even as they disagree on whether it is monolithically beneficial or sinister (Stone, 2002c)), its impacts on traditional agricultural knowledge are diverse and even paradoxical. I here present two case studies on Indian cotton growers. The cases share a spectacular rapid spread of GM cotton, but I will argue that they are sharply, perhaps even diametrically, opposed regarding their implications for traditional knowledge.

The first case, set in Andhra Pradesh, is a study in the disruption of traditional agricultural knowledge. Contrary to industry claims that the rapid adoption reflects farmer experimentation and evaluation, the farmers here have faced such wild variability in the seed system that they have all but given up on experimentation, and

now show a striking degree of faddism in seed choices. Contrary to activists' claims, this 'deskilling' predated the GM seeds (although now the GM seeds appear to be exacerbating the problem).

The second case, set in Gujarat, lacks the ethnographic depth of the first, but it offers an intriguing contrast. Here the spread of GM cotton has been dominated by illicit seeds, leading to widespread flouting of seed laws aimed at protecting both the environment and the farmer; but there are signs of success both in cotton production and also the 'reskilling' of farmers.

## **BT COTTON IN INDIA**

Crop genetic engineering is being led into the developing world mainly via *Bt* cotton. *Bt* is *Bacillus thuringiensis*, a soil bacterium that produces crystalline proteins that damage the digestive systems of certain lepidopteran insects. This order comprises butterflies and moths, including several moths that are severe cotton pests in their caterpillar stage (generally known as bollworms). The genes expressing the insecticidal proteins are known as CRY genes. All commercial *Bt* cottons in India contain the same genetic construct, developed by Monsanto, containing the Cry 1A(c) gene. (For further background on genetic modification of plants see Stone, 2002a).

India is one of the most closely watched arenas where GM crops have been introduced. Indeed there are few places where the stakes are higher, given the vast potential market of 700 million farmers as well as the energetic and highly sceptical NGO sector. India officially approved its first *Bt* cotton seed for the 2002 season;<sup>1</sup> three seeds were released, produced by MMB Ltd., a collaboration between Mahyco (the Indian firm providing hybrid cotton seed) and its partner and partial owner, Monsanto (the St. Louis-based biotechnology firm providing the gene construct). In the following years, several other cotton seed companies licensed the *Bt* construct for their cotton seeds. As Table 17.1 shows, the number of *Bt* seeds on the market has climbed, and the overall sales have climbed dramatically, from 72,000 packs in 2002 to 3 million in 2005.

In some localities, such as Warangal District of Andhra Pradesh, the surge in sales was much sharper than these national trends. Warangal is a pivotal cotton-growing area; cotton cultivation here has been problematic in recent years, and indeed has been implicated in hundreds of suicides (Reddy and Rao, 1998; Stone, 2002b). What my recent survey of Warangal seed vendors shows is remarkable: from 2003 to 2005, the market share held by *Bt* hybrids climbed from 1 per cent to 20 per cent to 62 per cent (since this does not count the under-the-counter *Bt* sales discussed below, the actual figure is somewhat higher). In some villages 90 per cent of the seed choices in 2005 were for *Bt* seeds, including 83 per cent for a single brand. Even before this sales extravaganza, Monsanto had claimed *Bt* cotton to be the 'fastest adopted new product in the history of agriculture' (Dinham, 2001), but the rush to *Bt* cotton for the 2005 season in Warangal was a veritable craze.

**Table 17.1** Bt seeds on market and sales in India

	Seeds on market	Sales (1000s)
2002	3	72
2003	3	230
2004	4	1300
2005	20	3000

## INDIA COTTON AND IOWA CORN

What leads to such rapid spread of a new technology? Innovation–diffusion theory has much to say on the topic; this field began with a study of seed adoption by farmers and has emphasized agricultural innovation ever since (Rogers, 2003). Ryan and Gross's (1943) study of adoption of hybrid maize focused on how Iowa farmers evaluated the new seeds and acted on the evaluations. The study showed adoptions following the s-curve that results from plotting a normal curve distribution cumulatively. The s-curve was later shown in adoptions of tetracycline and various other innovations (Coleman et al, 1966; Rogers, 2003). Ryan and Gross, and later researchers, recognized stages in the farmer's adoption process: *initial knowledge* (farmer learns of innovation); *persuasion* (farmer forms attitude towards innovation); *decision* (farmer evaluates innovation); *implementation* (farmer adopts innovation); *confirmation* (farmer evaluates performance of innovation).<sup>2</sup>

Buried deep in the paradigm for innovation–diffusion research was the assumption that the 'innovation' is somehow a better mousetrap: hybrid corn gave greater yields, and tetracycline had fewer side effects. Such relative advantages were what was confirmed in the 'Decision' phase, either through conducting one's own trials or by vicariously accessing information on 'trial by others' (Rogers, 2003, p177). Those who recognized the relative advantage and adopted early were termed 'innovators' or 'winners'; those who did not were 'laggards' or 'losers'. For farmers, the mainstay of this process – the route to being a winner – was the planting of a small experimental plot to trial the new technology.

Yet innovation–adoption research has increasingly come to recognize social processes that override or replace empirical evaluations. Some diffusion research now stresses perceived advantages of innovations, and documents cases where local cultural practices and beliefs exert control over which innovations are adopted. In some cases, medical innovations (like water boiling in disease-ridden villages) that were not only 'better mousetraps', but potentially matters of life and death, were rejected on cultural grounds (Rogers, 2003). Comparative studies of contraceptive use in both Korea and Thailand showed that whole villages adopted one form of contraceptive even if it offered no particular advantage over methods used by other villages (Entwhistle et al, 1996; Rogers and Kincaid, 1981). A more relevant recent example is the Perales et al (2005) study of maize diversity in Chiapas, Mexico: neighbouring Maya communities used distinct landraces of maize, not for reasons of

agronomic performance but because of the channelling of information within social networks.

In India, prominent explanations of the spread of *Bt* cotton have wielded the original functionalist dogma of innovation adoption theory, citing farmer assessments of relative advantage and acumen:

*we should leave the choice of selecting modern agricultural technologies to the wisdom of Indian farmers*

(pro-industry agricultural leader P. Chengal Reddy, quoted in Pinstруп-Anderson and Schioler, 2001, p108)

*we need to 'let the farmers finally decide on the usefulness of Bt cotton. Farmers are wise enough to adopt anything good and discard things that do not work'*

(Andhra Pradesh Agriculture Minister, quoted in Venkateswarlu, 2002).

Monsanto and others have explicitly invoked the dogma of assessment based on small-scale experimentation:

*Like the adoption of any new technology, people planted it on smaller acres initially, but the ever-increasing Bollgard plantings demonstrate that the Indian farmer is willing to embrace a technology that delivers consistent benefits in terms of reduced pesticide use and increased income. Clearly the steadily increasing Bollgard acres being planted by increasing numbers of Indian farmers bears testimony to the success of this technology and the benefit that farmers derive for it.*

(Monsanto Director of Corporate Affairs for India, Ranjana Smetacek)<sup>3</sup>

The faith in farmer experimentation echoed through Western critiques of biotech opponents, which cited seed experimentation as a key to 'historically producing' better crops and better incomes' (Herring, 2006).

My own research has been in a tradition that is very attentive to traditional knowledge and practice, and I have seen seed experimentation and farmer assessments of crops up close. Yet from the outset, I saw disquieting patterns in Warangal farmers' approach to cotton seeds. First, was a striking localization of seed choices: the seed that was the favourite in one village might find no market whatsoever a few villages away, and neither farmers, dealers nor agricultural officials could offer any agronomic explanation for the patterns. Second, was that these local favourites were surprisingly ephemeral: the seeds that farmers were swearing by when I began interviews in 2000 had almost all dropped from favour by 2005, when I began the study reported below. Finally, there was a rather alarming tendency for farmers to rely on uncritical emulation in making seed choices: farmers who could justify seed choices on assessment of relative advantage were greatly outnumbered by those who simply stated they had planted what their neighbours had planted. The contention here is that this behaviour had crucial implications for traditional agricultural knowledge; that there is a theoretical basis for explaining it; and that it is vital to understanding the dramatic history of *Bt* cotton adoption.

## AGRICULTURAL SKILLING AND DESKILLING

Let us think more carefully about what shapes farmer decision making. It is first important to note that farmer beliefs and practices are not as simple or static as they are often conceived. The farmer must manage a system involving intricate fits between environment, markets, seeds and other agricultural technologies, cultivation tactics, and cultural institutions for mobilizing work and other resources (e.g. Dove, 2000; Lansing, 1993; Stone et al, 1990). *Farmers do not simply acquire information* on a seed or other technology, but rather learn how practices and technologies perform together under variable conditions. Average yield under controlled conditions is only a small component of farm management. Moreover, since many of these factors change through time, so does the farmer's management acumen. This broader and dynamic concept of learning is what we can term *skilling* (Stone, 2004).

But skilling is susceptible to obstruction (see Bentley, 1989, 1993; Stone, 2004; Ziegenhorn, 2000). In her history of maize breeding in the US, Fitzgerald (1993) argued that adoption of hybrids led to 'deskilling' as American farmers turned into passive customers of seed firms. Hybrid crops may offer yield advantages, but the seeds produced by hybrids normally are not planted because they exhibit varying degrees of yield depression. Within a few years of the spread of hybrids, corn farmers who had previously been developing landraces and collaborating with public sector breeders were told, 'You may not know which strain to order. Just order FUNK'S HYBRID CORN. We will supply you with the hybrid best adapted to your locality' (Funk Bros. 1936 Seed Catalog, quoted in Fitzgerald, 1993, p339). This claim of deskilling alludes to the process described in Braverman's (1974) *Labour and Monopoly Capital*, in which capitalism degraded the role of labourers by separating mental from manual work.<sup>4</sup> To Braverman, the process was particularly apropos of factories, where it led to replacement of skilled workers, who were more expensive and less controllable, by machines and less-skilled workers.<sup>5</sup>

Fitzgerald did not probe the nature of agricultural deskilling thoroughly, but I have elsewhere argued (Stone, 2004, 2007) that agricultural deskilling differs from Braverman's process in three key respects. First, agricultural practice is more dynamic than factory work: most farmers are constantly skilling on new technologies, markets, and social conditions. Farming does not consist of mechanical application of knowledge or the making of binary decisions (e.g. adopt vs. don't adopt); the role of each technology in the performance must constantly be in play. Therefore *agricultural deskilling is not the displacement of a static set of skills, but rather the disruption of an ongoing process of skilling*.

Second, agricultural skilling is partly a social process that relies on farmers observing, discussing, and often participating in each other's operations. When technology passes between farmers, information usually does too (Brush, 1993, 1997; Cleveland and Soferi, 2002; Richards, 1989; Siffitoe, 2000). Other farms increase the amount of payoff information available, and other farmers participate in the process of interpreting it. Agro-ecological skill may become embedded in cultural concepts (Brodt, 2001; Thrupp, 1989) and even in institutions that individuals may not fully

understand (Lansing, 1993; Netting, 1974). Factory workers may learn some aspects of their jobs from fellow workers, but this plays a much smaller role in their training, and they are not responsible for overall production strategy like the farmer. *Agricultural deskilling results from the disruption of processes of social learning that are uniquely instrumental in farm production.*

Finally, unlike industrial workers, farmers still need the skills that are degraded. That slaughterhouse workers do not know a sirloin from a fillet, or that McDonalds staff lack culinary skills, is no problem; in the slaughterhouse the process of turning an animal into discrete food products has been compartmentalized, and in the fast food outlet the process of cooking has been automated so that workers would have no use for the displaced skills. In contrast, farmers still have to make decisions about the use of technologies, even if they have not been able properly to 'skill on' them. There is a crucial difference between an industrial situation in which skill has no place, and an agricultural situation in which skill is needed but cannot be acquired. *Agricultural deskilling is not simply farm tasks being automated; it is the degradation of the farmer's ability to perform.*

I have also identified three common impediments to agricultural skilling: unrecognizability (uncertainty about what technology is being used or trialled), inconsistency (high temporal, spatial, or situational variability in performance), and excessive rates of technological change (Stone, 2004).

But there is another stream of research that provides crucial concepts for understanding the advent of agro-ecological maladaptation. Cultural–evolutionary theorists working in the tradition of Boyd and Richerson's (1985) *Culture and the Evolutionary Process* distinguish between environmental (or individual) learning, which is based on evaluations of payoffs from various practices, and social learning, in which adoption decisions are based on teaching or imitation (Boyd and Richerson, 1985, p40; Henrich, 2001).<sup>6</sup> The central feature of social learning are processes whereby individuals are emulated according to 'biases'. Examples are *prestige bias* (emulating another farmer on the basis of prestige rather than that farmer's actual success with the trait being copied) and *conformist bias* (adopting a practice when it has been adopted by many others).<sup>7</sup> Work in this tradition shows how payoff assessments may not be the prime driver of innovation adoption. We should expect reliance on 'pure social learning' when environmental learning is costly and/or inaccurate (McElreath, 2004; Richerson and Boyd, 2005, pp113–114).

This distinction between environmental and social learning is useful in building a formal body of theory, but from an ethnographic standpoint it is a bit contrived because the two forms of learning contribute to each other to varying degrees. Even a direct environmental observation made on one's own crop ('Brahma cotton yielded 6 quintals/acre for me last year ...') is likely to be interpreted or contextualized through a form of social learning ('... which was much more than my neighbour said he got with the same seed'). Even a classic case of conformist adoption ('I am planting Brahma because my neighbours are ...') assumes at least an indirect environmental basis ('... and they wouldn't all be planting it unless someone had an indication it would do well'). It is this variation within the realm of social learning

that is crucial. It is not social learning per se that may spread maladaptive beliefs and practices (Richerson and Boyd, 2005, p166); it is social learning with relatively little grounding in environmental learning. When the flow of environmental payoff information is disrupted or rendered inaccurate or expensive, social learning may run largely on transmission biases and other factors weakly connected to payoff evaluations.

There, alongside the functionalist orthodoxy of innovation adoption that has been used to explain the spread of *Bt* cotton in India, is a theoretical basis for understanding how processes of farmer assessment of environmental payoffs (the basis of *skilling*) may be impeded and replaced by social learning. Whereas social learning may certainly be adaptive – the farmers being emulated may be running their operations adaptively – it also may not be adaptive, as the Warangal case shows.

## SEEDS IN WARANGAL: ADOPTION AS DISRUPTED SKILLING

Warangal farmers (Figure 17.1) have a long history of small-scale cultivation of non-hybrid cotton; for many years they grew Old World cotton without external inputs and with scant pest problems, using it mainly for local cloth production. In the early 1970s, breeders in Gujarat developed the world's first hybrid cottons, using the New World species *Gossypium hirsutum*. These cottons are highly susceptible to southern India's impressive assortment of diseases and severe pests, which include several bollworms (which eat the fruit containing the lint and seeds) and also sucking pests (which feed on the plant's sap). Pest outbreaks are highly variable in time and space, making this a singularly challenging environment for *hirsutum* cultivation. Thus, these cottons spread along with an armory of pesticide sprays, which cause as many problems as they solve. The spread occurred in the early 1990s, when the combination of strong prices, trade liberalization, and government campaigns led many farmers to take up commercial cotton.<sup>8</sup> Today, India is the only area in the world where cotton production is based on hybrids. In Warangal, the movement into commercial hybrid *hirsutum* production was led by Andhra immigrants from Guntur District and other coastal areas with a tradition of commercial cotton cultivation.

This shallow history of skilling on hybrid cotton surely plays some role in the problems described below, yet it is easy to overestimate its importance. Depth of experience with a crop is hardly an overriding determinant of the skilling process; the literature abounds in examples of successful adoption and successful integration of new crops. The Nigerian Kofyar provide an example, becoming expert commercial yam farmers as they moved into a new area from a homeland where they had grown no yams at all (Stone, 1996). It is not so much the relative newness of commercial *hirsutum* cotton cultivation that has impacted the skilling process, as it is the nature of the seed market.



**Figure 17.1** Maps of India showing location of Andhra Pradesh and Gujarat and Warangal District showing census villages

In Warangal, the market not only offers hybrids that must be repurchased each season, but an extensive, rapidly changing and often deceptive roster of seeds. There are over 800 input shops in the district, including at least one in virtually every village of any size. Warangal City has around 190 shops, including several dozen concentrated around Station Road (Figure 17.2). A 2005 survey of 37 input vendors in Warangal City gives a snapshot of the market for 2003–2005.<sup>9</sup> These vendors collectively sold 125 different cotton brands from 61 companies during this three-year period; the total number of cottons sold in the district is over 200. The number available at any given time was smaller since seed products come and go rapidly. Of the 78 seeds sold by our sample vendors in 2005, only 24 had been around since 2003.

Farmers must also deal with several levels of deceptiveness in seed products. On one hand, there is often variation among packs of a single seed product. Causes of variation range from lax controls over the hybrid production to the corrupt practice of packaging different seeds as a single brand. Every year sees new cases of severely flawed seeds on the market. Flawed or mislabelled products, known as 'spurious seed', are a bane not just for farmers but for vendors, who have on occasion been closed down for selling a seed that turned out to be spurious. At the same time, the seeds sold under different brand names may be identical: it is widely known that cotton parent lines have been appropriated from state agricultural universities and research institutes by cotton seed companies, which then market the hybrid offspring under different names. Bunny cotton (a local favourite in recent years, as shown below) is





Left: Station Road in Warangal City, a concentration of several dozen shops selling seeds, fertilizer and pesticide. Right: A Station Road vendor with a pack of Mahyco *Bt* cotton and some of his other cotton seeds

**Figure 17.2** *Seed vendors*

known to be identical to four other seeds on the market, according to a local cotton expert. (Ziegenhorn (2000) gives a surprisingly parallel account of the systemic deception in the American maize market.) Government seed inspection is largely ineffective. In Warangal City, a single inspector visits under half of the seed vendors, taking a few samples that are then tested for physical purity and germination rate but not for the important question of whether the seed is what the box claims. When substandard seed is found, the dealer is charged a fine of Rs.500 – around \$12, slightly more than the cost of a single box of seed.

The ‘anarcho-capitalism’ (Herring, 2007) of this cotton seed sector, with its large, unstable and deceptive array of seeds, is clearly incompatible with the processes of experimentation and evaluation. External sources of seed information, rather than mitigating the impediments to skilling, exacerbate the problem. Government-sponsored extension is virtually non-existent. Local Telugu-language publications provide agricultural information, but the reliability varies, and advertisements often masquerade as objective information. Newspapers may also dramatize seed scandals to boost readership, for example the recent case of a cotton seed company that got into a dispute with a local daily paper. Despite the lack of evidence of any problems with their seeds, there were enough damning articles published to put them out of business. But the most common source of information on cotton seed is corporate promotion. Cotton seed advertising is seemingly ubiquitous in Warangal: signs hang from trees, walls are painted, flyers are distributed and pitches blare from company vehicles. Only cotton is so heavily promoted; rice seed, which is selected more on the basis of environmental learning, and which is overwhelmingly non-hybrid, is rarely

advertised. Assessing the impact advertising has on seed choice is beyond the scope of this chapter, but even if advertisements rarely influence particular seed elections, the ubiquity of low-credibility noise contributes to farmers' general indifference to analysis of seed performance.

The plight of Warangal cotton cultivators, then, goes well beyond Fitzgerald's description of the deskilling caused by adoption of hybrid maize. They face a frenzied turnover in the seed market (which they encourage with their penchant for new products), deceptiveness in seed brands, unpredictable ecological events such as pest and disease outbreaks, secular changes in insect ecology, and a highly noisy and unreliable information environment. These factors make seed evaluation costly and inaccurate, and suggest that environmental learning should be scant. This situation should provide a marked contrast to the various studies showing rational, and often highly strategic, seed selection practices where farmers know what they are planting and where technological change is gradual.

Therefore the fast food and slaughterhouse workers that are such notable contemporary examples of industrial deskilling (Schlosser, 2001) turn out to be poor models for agricultural deskilling. A better metaphor would be a chef whose job is to continuously develop new dishes in a kitchen where someone keeps changing the labels on the ingredients, and the stove and oven will not hold a constant temperature. With this in mind, let us examine how seed adoptions are patterned against this backdrop of deskilling in Warangal.

## **DESKILLING AND COTTON CRAZES**

This analysis of seed choice is based on extensive interviews conducted in nine periods of fieldwork between 2000 and 2006 and three household agricultural censuses conducted between 2003 and 2005.<sup>10</sup> Table 17.1 shows the villages studied and the numbers of cotton-planting households represented in these surveys (actual sample sizes were considerably larger; for example 26 per cent of the households censused in 2004 planted no cotton that year). The 2003 and 2004 surveys elicited detailed household social and economic information along with agricultural decision making; the 2005 survey was more focused on agricultural decision making and seed choice. Surveys were mostly conducted between July and October, allowing for the collection of seed choice data for the census year and the preceding year, but input–output information only for the preceding year (cotton seed is usually planted in late June and harvested October until March). In the following analysis, data on the 2002 seed choices and yields come from the 2003 census and data on the 2003 seed choices and yields come from the 2004 census. Data on the 2004 seed choices come from both the 2004 and 2005 censuses (only the non-repeat interviews added in 2005). Data on 2005 seed choices come from the 2005 census. Figure 17.1 shows the location of the sample villages, and further information on the criteria for village selection appears in the appendix.

**Table 17.2** *Village summary (households surveyed)*

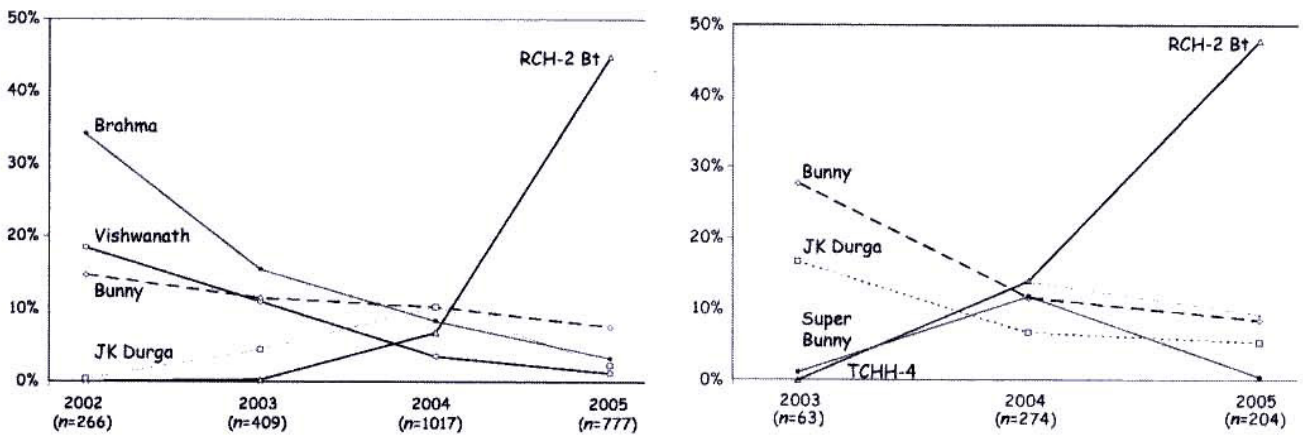
<i>Year of census</i>	<i>2003</i>	<i>2004</i>	<i>2004–2005</i>	<i>2005</i>
<i>Crop year</i>	<i>2002</i>	<i>2003</i>	<i>2004</i>	<i>2005</i>
Bandarupally			38	38
Gudeppad	62	150	90	68
Kalleda	41	37	34	27
Oorugonda			58	62
Pangidepally			66	68
Pathipalli		71	81	54
Ravuru	44	31	63	71
Tekumatla		89	81	67
<b>Total</b>	<b>147</b>	<b>378</b>	<b>511</b>	<b>455</b>

Sampling frames were derived from the government's 1996 Multi-Purpose Household Survey, which lists all households in the district along with socioeconomic variables including land ownership. Stratified random samples were drawn in each village to ensure representation of farmers differing in wealth and connectivity to information networks. From ethnography it seemed clear that larger landowners tended to be more 'cosmopolitan' (to use the term from classic innovation-diffusion studies), and better connected to non-local information sources, and this was confirmed by the census.<sup>11</sup> As research was initiated in each village, households were ranked on land ownership and divided into terciles (landless households were excluded since they rarely plant cotton). Terciles were randomized and sampled equally; since this analysis looks at clustering in seed choices, this randomization is essential. For subsequent-year censuses, farmers were re-censused when possible, and other households were added using the same randomizing strategy. Further information on sampling procedures is in the appendix.

The survey was designed to reveal variation in agricultural decision making across space and time, and to collect social-organizational, spatial-organizational, economic, educational and ethnic effects on this variability (only a small portion of which appears in this analysis). It was not explicitly designed to allow characterization of Warangal District, and several distinctive sectors of the district were not studied.

The farmer interviews recorded *seed choices*, defined as a farmer having bought a type of seed, whether it was one box or more, and whether or not it was the only seed type the farmer bought that year. The numbers of seed choices, which are given in Figure 17.3, tend to be somewhat higher than the numbers of cotton-planting households because many households plant more than one seed. The seed choices are expressed as percentages,<sup>12</sup> and the top choices are plotted for the years for which data are available.

Figure 17.3 shows the top selling seeds in the sample villages combined, based on the seed choice data. The highlight is the precipitous rise of one seed: Rasi Seed's RCH2-Bt. The first *Bt* cottons marketed in Warangal were not particularly popular, not simply because of the *Bt* trait but because it had been put into unpopular Mahyco hybrids. RCH2 (a seed that, according to open secret, was produced from parent



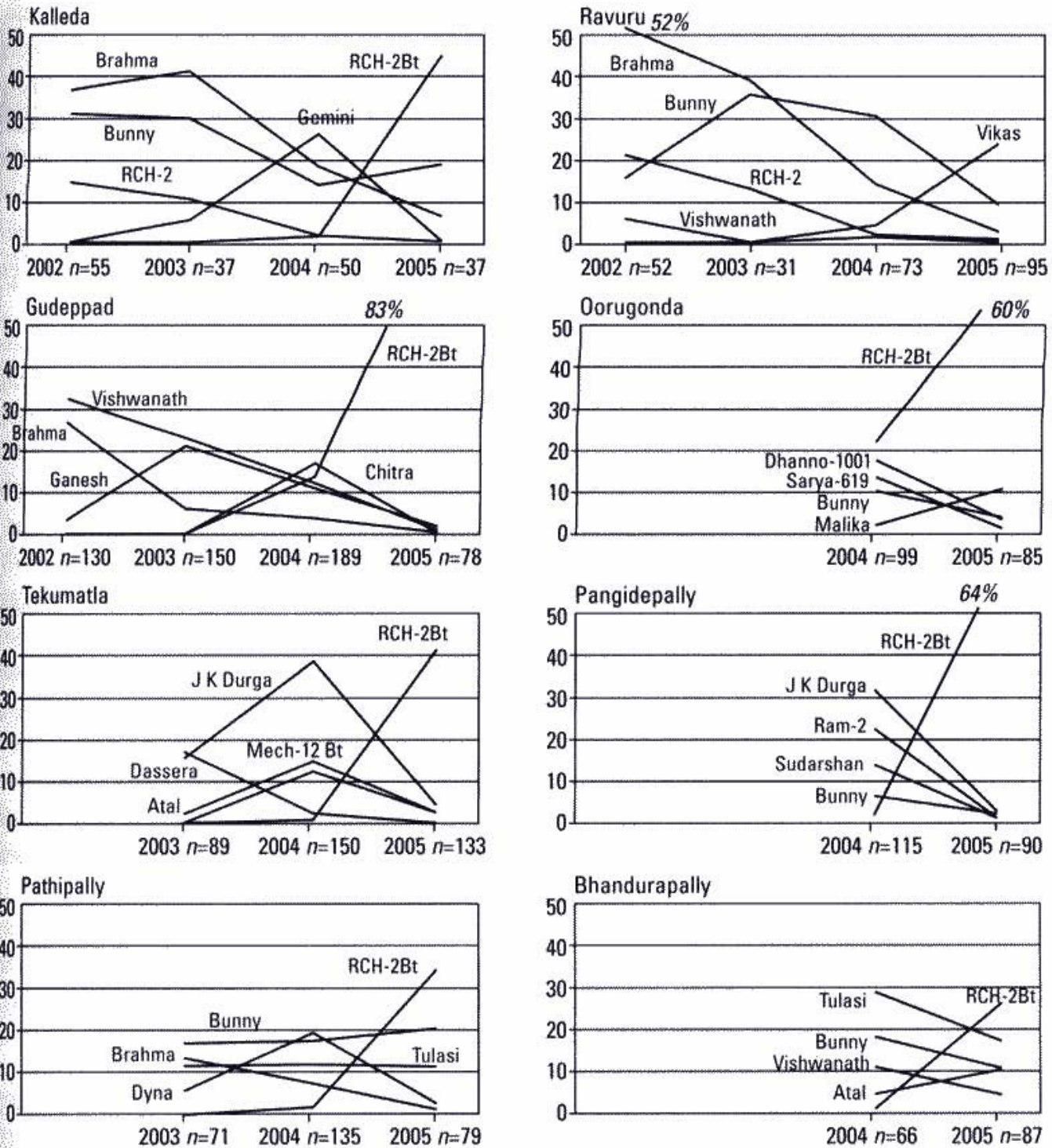
The left graph is based on seed choices as reported in farmer surveys; the right is based on percentages of total sales reported in the survey of Warangal City seed vendors. The census villages reflect some of the local favouritism described in the text; for instance, Brahma happened to be a local favourite in several villages in 2002–2003.

**Figure 17.3** All village charts: Trends in the most popular five cotton seeds

lines appropriated from a state-run research centre) was a fairly popular hybrid in many parts of the district. The *Bt* version appeared on the market in 2004, and in 2005 it achieved sudden wild popularity in much of the district, accounting for 45 per cent of the 777 seed choices in the sample. When the other *Bt* seeds are included, *Bt* seeds account for 54 per cent of all seed choices. Figure 17.3 shows that the take-off of RCH2-Bt reported by the sampled farmers is mirrored in the seed vendor survey.

But what is particularly interesting are the striking local variations in adoption patterns. Figure 17.4 shows village-specific patterns in seed choices for the eight villages. Almost all villages show the sharp climb in RCH2-Bt adoptions, but a closer inspection shows a pattern of abrupt and ephemeral seed crazes preceding the *Bt* craze. In Gudeppad, for instance, Brahma and Ganesh were strong local favourites in 2003 but had virtually disappeared by 2005; Chitra went from being negligible, to town favourite, back to negligible. In Kalleda, Brahma was a runaway favourite in 2003 before dropping sharply, as Gemini became the town favourite – for one year only. In Ravuru, Brahma was the runaway 2002 favourite, but had dropped to virtually nil by 2005; Bunny, the strong favourite in 2004, lost its popularity to Vikas in 2005. In Tekumatla, the 2003 favourite Dassera dropped precipitously in 2004, when JK Durga rose to almost 40 per cent of cotton choices before crashing to 4 per cent. In Pathipally there was a steady market for Brahma and Bunny, but it also had a craze, with Dyna rising to town favourite in 2004 before dropping to almost nil.

Moreover, the crazes tended to be highly localized, with the notable exception of RCH2-Bt. As Figure 17.4 shows, Kalleda and neighbouring Ravuru shared the Brahma and Bunny crazes, but Kalleda's 2004 Chitra craze did not touch Ravuru. Chitra was the top seed in Guddepad in 2004, but was negligible in neighbouring Oorugonda. JK Durga, the runaway favourite in Tekumatla in 2004, was also the top seller in neighbouring Pangidepally, but Pangidepally's other 2004 favorites – Mahalaxmi, Sudarshan and Bunny – were negligible in Tekumatla. Pathipally's 2004



For each village, the most popular five cotton seeds over the past 3–4 years (depending on data availability) are graphed. The Y-axis shows the percentage of all the village’s yearly seed choices each seed accounted for. Each pair of graphs shows villages that are very close.

**Figure 17.4** Village specific trends

favourite, Dyna, was negligible in neighbouring Bhandurapally in 2004 (although Tulasi was popular in both villages).

Agricultural economist Matin Qaim got a different glimpse of this cotton faddism in his survey of 375 Indian cotton growers. He found that after the 2002 season, over half the farmers who had adopted *Bt* cotton subsequently ‘disadopted’ it. Then, ‘[i]nterestingly, a remarkable share of the disadopters re-adopted *Bt* technology after a break of one or two years’ (Qaim 2005, p1321). But to Qaim, the patterns ‘clearly

demonstrate that genetically modified crop adoption and disadoption are not irreversible decisions for farmers; they are part of a normal learning process' (ibid.). However, as argued above, 'normal' learning (better termed skilling) is an environmental-social process, and it is difficult to imagine what environmental assessments would lead farmers to such short-term, localized cotton seed crazes. None of the interviewed seed vendors were aware of any agro-ecological rationale, and the farmers too were consistently unable to justify the seed crazes on the basis of seed traits. The paired villages in each case have the same soils, microclimate and access to input markets.

There are some conditions under which abrupt adoption of new seeds may have a definite agro-ecological basis. For instance, disease is a major problem for pearl millet growers, and Rajasthani farmers adopt each new disease-resistant seed variety quickly (Tripp and Pal, 2000; Tripp, pers. comm.). The faddism contributes to the chronic cycle of breeders adjusting plants to pathogens and pathogens adjusting to plants, but farmer decision making is responding to agronomic problems and has a basis in environmental learning. No such agro-ecological advantage is evident in the Warangal seed crazes, and certainly none that would explain neighbouring villages exhibiting such different patterns. The growers themselves offer no agro-ecological justification for the faddism. In fact, not one of the 12 Gemini planters I interviewed in Kalleda attributed their adoption of Gemini to specific traits (beyond the ubiquitous anticipation of good yield), and none knew much about Gemini's specifications. Only two of the 12 farmers mentioned first-hand knowledge of Gemini's performance (both had seen a field of Gemini the year before). Indeed, the farmers were generally agnostic on qualities of the seeds (the only specific trait that farmers regularly evaluate in cotton in the boll size, discussed below).

## **NOVICE AND EXPERIMENTAL PLANTING**

Small-scale experimentation and evaluation are used in many cases by Indian farmers as a basis for seed selection (e.g. Gupta, 1998, p197), but the Warangal seed crazes seem irreconcilable with this practice. We can investigate this empirically by isolating cases of 'novice planting' – defined as the planting of a type of seed for the first time – since the Warangal surveys include information on how many times each seed type had been planted previously. I have used data on 2003 plantings for this, avoiding the surge in plantings of new *Bt* seeds, which would have caused unusually high rates of novice plantings. In the 2003 season (as recorded in the 2004 census), among cotton-planting households a median of two acres were planted to cotton (mean = 2.86; *sd* = 1.97; *n* = 231). Within this sample of households, 55 per cent planted one seed type, 26 per cent planted two, and 19 per cent planted three or more, for a total of 410 seed choices. Of these seed choices, 59.3 per cent were novice plantings.

But are these novice cotton plantings actually tests of new seeds on small plots, as claimed by innovation-adoption orthodoxy and by Monsanto? We can answer this first by considering that the total area planted to cotton by our sample in 2003 was

**Table 17.3** *Planting sizes: Counts and column percentages*

<i>Acres planted to the seed</i>	<i>Times seed planted before</i>			<i>N</i>
	<i>0</i>	<i>1-2</i>	<i>3+</i>	
<1	6 (2%)	1 (1%)	2 (3%)	9 (2%)
1-1.9	146 (60%)	49 (61%)	44 (55%)	239 (59%)
2-2.9	65 (27%)	21 (26%)	24 (30%)	110 (27%)
3-3.9	17 (7%)	4 (5%)	7 (9%)	28 (7%)
4-4.9	5 (2%)	5 (6%)	3 (4%)	13 (3%)
5+	4 (2%)	0	0	4 (1%)
	<b>243</b>	<b>80</b>	<b>80</b>	<b>403</b>

663 acres, of which novice plantings comprised 390 acres, or 58.9 per cent. This is very close to the percentage of fields that were novice plantings, showing that overall novice plantings are the same size as experienced plantings. But given the importance of experimentation to the larger theoretical issues at stake here, including innovation adoption, the spread of *Bt* cotton and agricultural deskilling, we need to look more closely at small-plot cultivation. We must first ask what constitutes a small experimental plot, and given the median household cotton acreage of two acres, it seems clear that a small experimental plot would have to be under an acre. Commercial cotton seed is sold in 'acre packs' with enough to seed one acre; less than 1 per cent of the cotton purchased in my surveys consisted of 'loose seed'. This packaging makes experimentation slightly inconvenient, but hardly prevents it; farmers can (and occasionally do) split packs to plant sub-acre plots.

Table 17.3 breaks down the sizes of plantings by the farmer's experience with the seed. Note that only 9 of 403 plantings, or 2.2 per cent, were what we would consider small experimental plots. Most plantings were between one and three acres, regardless of the farmer's experience with the seed, and farmers were just about as likely to buy multiple boxes of a novice seed as of a seed they had experience with. Perhaps the most salient finding regarding experimental planting is that when a farmer planted a seed for the first time, 98 per cent of the time it was on one acre or more, and 37 per cent of the time it was on two or more acres, in an area where the median area planted to cotton was only two acres. This lack of small experimental planting characterizes small and large cotton farmers alike.

Interviews provided consistent evidence that Warangal cotton farmers' propensity is for trying new seeds on the market, rather than trying seeds on experimental scales with a view to picking one for long-term adoption. A frequent response when farmers were asked why a particular seed was chosen was that it was new in the market – meaning that no experimental information whatsoever was available. This attraction to new seeds exacerbates the turnover of seeds in the market, as seed firms sometimes take seeds that have fallen out of favour, rename them and relaunch marketing initiatives.

The absence of seed evaluation is further confirmed by farmer knowledge of key seed traits. Farmers in the 2004 survey were asked if, for the cotton type they planted

**Table 17.4** *Knowledge*

	<i>Boll size</i>	<i>Water requirement</i>	<i>Time to maturity</i>	<i>Insect resistance</i>
No	17%	45%	29%	38%
Yes	83%	55%	71%	62%
N	520	519	518	516

the most of that year, they knew what to expect in the cotton's (1) boll size, (2) water requirements, (3) time to maturity, and (4) resistance to any crop pests. Despite the fact that farmers are understandably reluctant to admit to knowing little about the seeds they were planting, substantial numbers plead ignorance, as shown in Table 17.4.

Even taken at face value some of these figures are striking; water requirement is a basic cotton trait that under normal conditions would be a prime criterion for seed selection. The only trait for which few farmers confessed ignorance was boll size; large boll size is one trait that Warangal farmers consistently claim to value most highly.<sup>13</sup> However, given the crazes that dominate cotton plantings, it is not surprising that there is confusion on even this trait. For instance, of the farmers in the sample who planted RCH2-Bt in 2005, 83 per cent claimed to know what boll size to expect (interviews were conducted before bolls were mature). Boll size is frequently discussed and routinely divided into small, medium and large; according to producer, the RCH2-Bt boll is 4.5–5 grams, which is medium-sized. However, of these 280 farmers, only 44 per cent identified the size as medium; 30 per cent and 27 per cent thought the boll was large or small. There were also interesting indications that expectations were forming on a village-specific basis.<sup>14</sup>

In sum we have seen that:

- Warangal cotton farmers face an extensive, ever-changing and often deceptive roster of seeds;
- many of the key determinants of a good crop are unpredictable (germination; reliability of seed; insect and disease outbreaks) and there is wide intra-brand variability;
- villages show sharp ephemeral fads lacking agro-ecological rationale;
- most of all cotton plantings are novice and non-experimental;
- as a result, very little environmental learning can occur.

The question of what actually does drive seed choices therefore becomes quite important, not only to an understanding of the spread of *Bt* cotton, but also to a more general understanding of agricultural deskilling. Let us first look ethnographically at the actual drivers of cotton choice in Warangal District, and then consider it as a problem in theory.



## ETHNOGRAPHY OF COTTON CRAZES

Given the obstacles to skilling in cotton cultivation, it should not be surprising that various forms of social learning are instrumental in decision making; what is surprising is the loose standard for accepting social information or choosing models to emulate. For illustration, let us consider two of the 2004 crazes shown above: Gemini in Kalleda and Chitra in Gudeppad.

Extensive interviews with 2004 Gemini planters in Kalleda revealed a set of primarily social explanations that do not trace back to any agro-ecological rationale. Gemini cotton seed was introduced in 2003, by a newly formed company of the same name (it is likely to be a seed previously marketed under a different name, although this cannot be confirmed). Its marketing strategy capitalized on the farmer penchant for untried seeds, and on local connections in Kalleda; the principal owner is from a nearby village. Many Kalleda farmers buy their seeds from a Warangal shop owned by Sampath Rao (pseudonym), a member of a large and influential Kalleda-area family that has traditionally had a paternal relationship with many small farmers in the area. As the sole distributor of Gemini in Warangal, Sampath got a high profit margin on this seed, and recommended it strongly to his customers. The company owner was also an affine of the mandal president, who recommended the seed. Gemini also ran a marketing campaign in Kalleda before the 2004 cotton season, with farmers who made advance purchases of Gemini seed getting scratch cards for prizes. The only hint of environmental learning was that one of the 2003 Gemini planters was a *pedda rytu* ('big farmer'); he apparently got a good yield, although no better than the yields farmers obtained from various other seeds. Interviews with 2004 Gemini planters turned up virtually no knowledge of traits of the seed; the most common rationale for adopting was that 'other farmers around here were planting it'. By 2005, Gemini had virtually disappeared from Kalleda fields.<sup>15</sup>

Gudeppad's 2004 craze was driven by emulation by a single local farmer and by marketing. Chitra was introduced in 2003 by Nath Seeds. A Nath marketer who grew up in Gudeppad used his local knowledge to recruit Nagaraju Reddy (pseudonym) for demonstration plots. Nagaraju Reddy was a *pedda rytu*, and an attentive farmer whose crops often outpaced others in the area. In 2003 the marketer gave Nagaraju a free box of Chitra, and when it did well, transported many of the area's farmers to see it. Because they liked the look of his field, or simply because Nagaraju was planting it – again, environmental and social learning do not cleave neatly – Chitra became the most popular seed in Gudeppad the next year. Of the 25 Gudeppad Chitra planters who reported a primary factor in their adoption, 16 (64 per cent) cited Nagaraju by name. None of the Chitra planters interviewed could specify what they had seen in Nagaraju's field, beyond 'good yield'.

Nagaraju actually planted five different brands in 2003. He reported that one brand yielded around 10 quintals/acre; three yielded around 14 quintals/acre, and Chitra yielded around 15 quintals/acre. Such a small difference in yield would hardly have been visible to visiting farmers. What set Chitra apart from Nagaraju's other



Visible behind them are a few of the many hybrid seeds available at the shop. The man in the middle is paying Rs.1600 a pack for RCH2-Bt (four times the cost of conventional seed). When asked why he had chosen RCH2-Bt, he said it was what other farmers were buying.

**Figure 17.5** *Buying Bt: Farmers buying cotton seeds at a shop in Warangal*

brands was that it was new, and that it was being touted by the Nath marketer. Chitra then virtually disappeared from the village in 2005.

An ethnography of the 2005 RCH2-Bt craze is harder to construct. The surge to 45 per cent of seed choices at the district level is unprecedented, but at the village level the surges are not such a dramatic departure from past crazes (Guddepad being the notable exception). The difference was that instead of each village having a craze for its own favourite, in 2005 most villages had a craze for the same seed; the crazes were synchronized. This may result partly from the history of *Bt* seeds. The Mahyco hybrids that were the first *Bt* seeds sold (in 2002) were unpopular in Warangal, and moreover they were 'old' seeds (on the market for over ten years) in an area where farmers were compulsive buyers of new seeds. Following reports of a poor year in 2004 (resulting mostly from problems unrelated to the *Bt* trait), these Mahyco seeds were banned in Andhra Pradesh; also in 2005, '*Bt*' versions of 16 seeds appeared on the market, including several popular seeds (of which RCH2 was only one). None of the Warangal vendors or farmers could offer an agro-ecological rationale for sales to take off for this particular seed (as compared to Mallika-Bt, for instance, another popular seed in Warangal), and it is difficult to explain the RCH2-Bt craze as the

result of superior performance in the previous year (as shown in the following section). Controlled experiments by Kranthi et al (2005) show that the CRY gene does not express particularly well in this germplasm. What several farmers did tell me was that they chose RCH2-Bt because it seemed to be the seed most others were buying; there was, in effect, a 'buzz' about it on Station Road, and conformist bias was clearly in operation (Figure 17.5).

## **EFFECTS OF BT COTTON ON COTTON CULTIVATION IN WARANGAL**

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Several commentators have warned that the introduction of *Bt* cotton would lead to deskilling of Indian farmers (Harwick, 2000; Simms, 1999). I have analysed what 'deskilling' actually means in agriculture, and showed how and why it has occurred in the Warangal cotton sector. Clearly this deskilling has occurred prior to, and independent of, *Bt* cotton. However, this does not mean that the spread of *Bt* cotton has not affected the problems with skilling. I would point to three ways in which *Bt* cotton has exacerbated the deskilling.

The first is that with *Bt* cotton has come a sharp increase in the amount of public media and discourse (Yamaguchi et al, 2003). The media have been highly contradictory, with biotechnology proponents and opponents alike producing deceptive media. As Herring (2007) put it, 'Farmers in India faced transgenics through the mediation of rumour, NGO's, public intellectuals, contradictory official signals'. It is difficult to isolate the effects of these new flows of information on seed choices, but it has sharply increased the noise level.

The second has been the introduction into farm management of a new variable that is poorly understood by farmers and dealers alike. There is, for instance, considerable confusion over whether the *Bt* technology works the same regardless of the seed into which it is bred. Company representatives have assured farmers and dealers that the *Bt* works the same in all hybrids, but a detailed study by Kranthi et al (2005) showed considerable differences among hybrids. The Kranthi et al study also showed sharp declines of expression of CRY proteins – and of mortality of the worst cotton pest – beginning 90 days after sowing, well before the bollworm threat has passed.

Third is the exacerbation of the already problematic rate of technological change. On top of the high rate of turnover in the cotton seed market, there are now numerous *Bt* versions of seeds appearing. Moreover, there are already new *Bt* genes in the pipeline (GEAC, 2006; Jayaraman, 2005), so that the already groaning shelves of input vendors may soon have multiple *Bt* variants of conventional seeds. More troublesome yet, as regards the skilling process, is the appearance of under-the-counter *Bt* seeds. These seeds, referred to locally as 'zerobill' seeds because the vendor sells them illegally without any bill of sale, represent a worsening not only of the rapid rate of change, but of inconsistency and unrecognizability as well, since the

buyer normally has no idea of where the seeds came from or whether the same seed will be available in the future.

From the perspective of traditional agricultural knowledge, this *Bt* technology is decidedly not merely 'in the seed'. The key problem on Warangal cotton farms may have long predated *Bt* cotton, but *Bt* cotton has rapidly become an exacerbating factor.

## **NAVBHARAT 151 IN GUJARAT: BT COTTON AND RESKILLING**

Coeval with these developments in Warangal, a different story has unfolded across the country in Gujarat. While there has been no comparable study of skilling and deskilling (and I have only conducted very brief fieldwork there), there are intriguing suggestions that *Bt* cotton has had the paradoxical effect of getting farmers more involved in the processes of experimentation, evaluation and even breeding. The agent of this change was a cotton hybrid by the name of Navbharat 151.

Navbharat is an Ahmedabad-based seed company headed by the respected breeder D. B. Desai, and 151 was a hybrid cotton seed it began selling in 2000. At that time, transgenic cottons were being tested in India, but none had yet been approved by the Genetic Engineering Approvals Committee (GEAC); Navbharat had not licensed the *Bt* technology from Monsanto and there was no reason to suspect that this seed was transgenic. The hybrid sold well but attracted no unusual attention. Then 2001 brought a particularly severe wave of bollworm outbreaks, to which fields of Navbharat 151 seemed impervious, leading to raised eyebrows, PCR testing discovery of the Cry 1A(c) gene, 'corporate fury' (Jayaraman, 2001), government demands that the illicit crops be destroyed (this did not happen), and criminal charges against Desai and his colleagues. Ironically, it was not intellectual property theft that brought the Navbharat officials to the dock; genes were not patentable at the time. The infraction was against the Environmental Protection Act, because 151 was a transgenic seed not approved by the GEAC. Desai claims he had sought no approval because he had not known his cotton was transgenic, and as soon as he found out he tried to license the technology from Monsanto (Monsanto's refusal, Desai later pointed out, cost both them and Navbharat a lot of money). The criminal proceedings have languished, but the company was promptly banned from selling any of its own cotton hybrids.<sup>16</sup>

Soon after the 151 affair – and partly because of it, according to some observers – the GEAC approved the three Mahyco-Monsanto *Bt* cotton seeds. Thus, for the 2002 cotton season, the illicit *Bt* seeds were expected to be replaced by the authorized MMB seeds in Gujarat's shops and fields. But this did not happen for several reasons. There was the issue of seed quality. The Mahyco hybrids one had to buy to get the *Bt* were out of favour and water-intensive. On the other hand, word had spread that with Navbharat 151 the breeders had hit the jackpot: in the fields of Gujarat, this

hybrid was a highly productive, long-season cotton with excellent resistance to bollworms. There was also the issue of seed cost: the approved *Bt* seeds cost Rs1600 (around \$35), as compared to the normal price of Rs400 per acre-box. As farmers began to search for cheaper *Bt* seeds, one source appeared right below their noses: 151's F2 seeds, which exhibited very little yield depression, and some farmers began to replant them. Some ginning mills began to offer seeds back to the farmer for a small price after separating the lint, and farmers who had previously sold their cotton crop to a trader began to sell directly to the gin.

But the booming demand for the now-banned Navbharat 151 seeds was also met in other ways. The bulk of the seed production for 151 had been farmed out to Kurnool District of Andhra Pradesh – an area intentionally well outside of the target sale area, to reduce ‘leakage’ – but a number of Gujarat farmers had been enlisted to produce 151. The banning of 151 late in the 2001 season left these contract farmers with fields full of Navbharat 151 seeds that the company could not buy from them. Precisely what happened to these seeds will never be known, but the uses included being kept for 2002 planting by the contract growers, being sold as brown-bagged seed and being sold to cotton seed companies to be packaged as branded seeds and sold the next spring. The seeds clearly became quite mobile; many of the Kurnool contract farmers were immigrants from Guntur District (discussed above as innovators in commercial agriculture), and seeds appear to have readily found their way into Guntur. They apparently also flowed back to Gujarat where demand would be especially keen the next year.

We now know that before long, *Bt* seeds were not only being replanted but also were luring farmers and others into the breeding game. Indeed, it is now well documented (Gupta and Chandak, 2005; Jayaraman, 2004; Roy et al, 2007) that these orphan seeds became the basis for an thriving cottage industry of *Bt* cotton breeding (illegal, because none of the seeds were approved by GEAC). Some of the breeding was being carried out by those with technical training (such as graduate students at Gujarat Agricultural University (Gupta and Chandak, 2005, p218)), but much was being done by farmers. Rather remarkably, some farmers were even maintaining inbred lines and producing their own hybrids. The Gujarat cotton fields turned into what Anil Gupta (a leader in studying and promoting farmer innovation) termed ‘the greatest participatory farmer plant-breeding mela [carnival] in history’ (quoted in Herring, 2007).

By 2003, Gujarat shops were awash with illicit *Bt* seeds, many with coy names alluding to the technology (‘**BesT** Cotton’) or to Desai’s original product (‘Kapas-151’), or underscoring that they were first generation hybrids (‘Kavach F-1’). For brand after brand, PCR testing at the Central Institute of Cotton Research confirmed the presence of the Cry 1A(c) gene (Kulkarni, 2003). In 2004, industry’s claims that over half of all the GM cotton growing in India was from unapproved seeds (Jayaraman, 2004, p1333) were generally regarded as realistic. By the 2005 season, Navbharat’s own surveys indicated 80 per cent of the cotton growing in Gujarat to be from illicit *Bt* seeds. (Unconfirmed word on the street was that the percentage was just as high in Guntur, Andhra Pradesh, where many of the Kurnool-grown seeds had ended up.)

Measuring the actual performance of the illegal *Bt* cottons has been fraught with difficulty,<sup>17</sup> but anecdotal evidence (e.g. Shah, 2005) indicates that the illicit *Bt* cottons performed particularly well. This would be consistent with the state-wide figures: the data from the Gujarat State Department of Agriculture show a rise in yield from 1.2 quintals/ha. in 2000 to 4.7 quintals/ha in 2003.

Although no ethnography of agricultural practice is available for Gujarati farmers, it seems clear that a large number of farmers here are more actively involved in seed experimentation and payoff assessments. Some of this involvement would have predated the arrival of illicit *Bt* seeds; the seed repertoire here already included indigenous non-hybrid (replantable) cotton (*G. herbaceum* according to Kranthi, 2005; *G. arboreum* according to Morse et al, 2005). But with farmer-bred varieties, the farmer is obviously better able and more inclined to assess performance, and when these seeds are sold to other farmers, there is more information to be passed along with the seeds. In addition, this seed is often provided in loose form (rather than the 'acre packs' that dominate Warangal purchases), which facilitates small-plot experimentation.<sup>18</sup> These differences in seed systems, and especially the farmer breeding of *Bt* seeds, should greatly reduce the problems with inconsistency, unrecognizability and accelerated technological change, and it is therefore not surprising that a recent investigation into agricultural decision making there has shown a much greater degree of control than I have shown in Warangal (Roy et al, 2007).

The intent here is not to depict *Bt* cotton, at least in purloined form, as having led to an across-the-board mitigation of agricultural deskilling among Gujarati cotton farmers. The fact is that most of the illicit *Bt* seeds that have appeared since the demise/liberation of Navbharat cotton were still packaged hybrids, sold by fly-by-night companies. Surely for many farmers, the problems of unrecognizability have worsened. Yet for other farmers – and there is presently no basis for saying how many, except that the number clearly is significant – the tortured history of *Bt* technology in Gujarat has been instrumental in them becoming reinvolved in experimentation, assessment and even developing their own seeds. Where this has occurred, likely impacts would include increased consistency and recognizability and a slowed rate of technological change. Given the foregoing discussion, we would have to count this as a step towards reskilling.

## **CONCLUSIONS**

Traditional agricultural knowledge, reconceived here as dynamic management skill, is a subject so diverse, complex, changing and poorly understood that it can be used in contradictory ways. Thus it has been demeaned by development agencies and input industries, admired by social scientists and romanticized by activists. But today in India, the arrival of GM cotton forces us to take a fresh analytic look at traditional agricultural knowledge, and to be prepared for findings that differ from past orthodoxies.

Industry's extolling of the traditional wisdom and experimentation behind *Bt* cotton adoption is disingenuous coming from the same parties that have disdained 'traditional' practices that eschewed external inputs. This sudden self-serving appreciation for traditional wisdom accords with Michael Dove's observation that the concept of indigenous knowledge, like other concepts in rural development, has succumbed over time to appropriation by the interests it initially opposed (Dove, 2000, p216). More importantly, this perspective on the skilling process is, in the case of *Bt*-cotton-loving Warangal, empirically inaccurate. Agricultural knowledge, or *skill* as it has been defined here, is dynamically generated and its development turns out to be vulnerable to inconsistency, unrecognizability and overly rapid rates of change in environmental payoffs. The cotton seed sector in Warangal was beset with all of these problems well before *Bt* cotton arrived on the scene. The central problems have stemmed from the reliance on hybrid cottons here. Hybrid seed technology per se does not necessarily produce agricultural deskilling; in fact, early hybrid maize production in the US was accomplished by close collaboration between farmers and breeders (Fitzgerald, 1993, p335). However, hybrids do open the door to deskilling by introducing their own form of inconsistency (viz., between the F1 and F2 generations), allowing unrecognizability (even US farmers may not know what they are getting (Ziegenhorn, 2000)), and encouraging accelerated technological change. These problems have become particularly acute in the anarcho-capitalism of the seed systems in Warangal.

Therefore, while 2005 was a remarkable year for GM cotton, there is a surprising cultural context to the widespread adoption here. This dramatic case of adoption of an innovation does not reflect experimentation and assessment as much as the dynamics of socially driven crazes arising in the virtual absence of environmental learning. The *Bt* seeds did not cause, but have contributed to, the continuation of deskilling here.

Across the country in Gujarat, cotton farmers have prospered, due largely to an accidental(?) skirting of a regulatory apparatus designed in part to protect the farmer. Ambiguous results from a few studies notwithstanding, the cotton boom in Gujarat is surely due in large part to illicit *Bt* cotton. We cannot parse the extent to which this success is attributable to an act of breeding by D. B. Desai, or to the poorly understood changes in the seed system attending the banning of Desai's creation. But there are clear indications that this most modern of agricultural technologies has led to the reinvolvement of farmers in cotton experimentation and even breeding, and thereby resuscitating processes that generate traditional agricultural knowledge.

## **REFERENCES**

- Arunachalam, V. (2004) 'Promotion of *Bt* cotton in India', *Current Science*, vol 86, no 11 p1470, [www.ias.ac.in/currsci/jun102004/1470.pdf](http://www.ias.ac.in/currsci/jun102004/1470.pdf)
- Bambawale, O. M., A. Singh, O. P. Sharma, B. B. Bhosle, R. C. Lavekar, A. Dhandapani, V. Kanwar, R. K. Tanwar, K. S. Rathod, N. R. Patange and V. M. Pawar (2004) 'Performance of

- Bt cotton (MECH162) under integrated pest management in farmers' participatory field trial in Nanded district', Central India, *Current Science*, vol 86, no 12, pp1628–1633
- BBC (2005a) 'Monsanto fined \$1.5m for bribery', *BBC News*, 7 January, <http://news.bbc.co.uk/2/hi/business/4153635.stm>
- BBC (2005b) 'Monsanto's sales double in India', *International news online* at [http://news.bbc.co.uk/2/hi/south\\_asia/4223284.stm](http://news.bbc.co.uk/2/hi/south_asia/4223284.stm), 7 September
- Beal, G., E. M. Rogers and J. M. Bohlen (1957) 'Validity of the concept of stages in the adoption process', *Rural Sociology*, vol 22, pp166–168
- Bentley, J. W. (1989) 'What farmers don't know can't help them: The strengths and weaknesses of indigenous technical knowledge in Honduras', *Agriculture and Human Values*, vol 6, no 3, pp25–31
- Bentley, J. W. (1993) 'What farmers don't know', *Ceres*, vol 26, no 141, pp42–45
- Besley, T. and A. Case (1993) 'Modeling technology adoption in developing countries', *American Economic Review*, vol 83, pp96–402
- Boyd, R. and P. J. Richerson (1985) *Culture and the Evolutionary Process*, University of Chicago Press, Chicago
- Braverman, H. (1974) *Labour and Monopoly Capital: The Degradation of Work in the Twentieth Century*, Monthly Review Press, New York
- Brodt, S. B. (2001) 'A systems perspective on the conservation and erosion of indigenous agricultural knowledge in Central India', *Human Ecology*, vol 29, pp99–120
- Brokensha, D. D., D. M. Warren and O. Werner (eds) (1980) 'Indigenous knowledge systems and development', University Press of America, Inc, Washington, DC
- Brosius, J. P., G. W. Lovelace and G. G. Marten (1989) 'Ethnoecology: An approach to understanding traditional agricultural knowledge', in G. G. Marten (ed) *Traditional Agriculture in Southeast Asia. A Human Ecology Perspective*, pp187–198, Westview, Boulder, London
- Brush, S. B. (1993) 'Indigenous knowledge of biological resources and intellectual property rights: The role of anthropology', *American Anthropologist*, vol 95, pp653–686
- Brush, S. B. (1997) 'Comment on Cleveland and Murray', *Current Anthropology*, vol 38, pp497–498
- Brush, S. B. (2005) 'Protecting traditional agricultural knowledge', *Washington University Journal of Law and Policy*, vol 17, pp59–109
- Brush, S. B. and D. Stabinsky (eds) (1995) *Valuing Local Knowledge: Indigenous People and Intellectual Property Rights*, Island Press, Washington, DC
- Center for Sustainable Agriculture (2005) *The Story of Bt. Cotton in Andhra Pradesh: Erratic Processes and Results*, Secunderabad, A.P., India
- Chambers, R. A., A. Pacey and L. A. Thrupp (eds) (1989) 'Farmer first: Farmer innovation and agricultural research', Intermediate Technology Publications, London
- Chibnik, M. (1981) 'The evolution of cultural rules', *Journal of Anthropological Research*, vol 37, no 3, pp256–268
- Cleveland, D. A. and D. Soleri (eds) (2002) *Farmers, Scientists and Plant Breeding: Integrating Knowledge and Practice*, CAB International, Oxon, UK
- Coleman, J. S. S. et al (1966) *Medical Innovation: A Diffusion Study*, BobbsMerrill, New York
- Conklin, H. C. (1954) 'An ethnoecological approach to shifting agriculture', *Transactions of the New York Academy of Sciences*, vol 17, pp133–142
- Conway, G. (1997) *The Doubly Green Revolution*, Penguin, Harmondsworth
- Council for Biotechnology Information (CBI) (2005) 'Bt cotton creates three times the earnings for Indian farmer', [www.whybiotech.com/index.asp?id=4515](http://www.whybiotech.com/index.asp?id=4515) 15 December
- Deccan Chronicle (2003a) 'Bt cotton yields low, farmers suffer losses', Hyderabad, India, 4



- March, p8
- Deccan Chronicle* (2003b) 'Farmers ape neighbors, pay price', 6 June
- Dekimpe, M. G., P. M. Parker and M. Sarvary (1998) 'Staged estimation of international diffusion models: An application to global cellular telephone adoption', *Technological Forecasting and Social Change*, vol 57, pp105–132
- Dewalt, B. R. (1994) 'Using indigenous knowledge to improve agriculture and natural resource management', *Human Organization*, vol 53, pp123–131
- Dinham, B. (2001) 'GM cotton – farming by formula? Biotechnology and development', *Biotechnology and Development Monitor*, vol 44, pp7–9, [www.biotech-monitor.nl/4403.htm](http://www.biotech-monitor.nl/4403.htm)
- Dove, M. R. (2000) 'The life-cycle of indigenous knowledge, and the case of natural rubber production', in R. Ellen et al (eds) *Indigenous Environmental Knowledge and Its Transformations*, pp213–251, Routledge, London
- Entwhistle, B., R. D. Rindfuss, D. K. Guilkey, A. Chamrathirong, S. R. Curran and Y. Sawangdee (1996) 'Community and contraceptive choice in rural Thailand: A case study of Nang Rong', *Demography*, vol 33, pp1–11
- Financial Express* (2005) 'Angry Andhra uproots Monsanto', 4 June, [www.financialexpress.com/fe\\_full\\_story.php?content\\_id=92868](http://www.financialexpress.com/fe_full_story.php?content_id=92868)
- Fischer, A. J., A. J. Arnold and M. Gibbs (1996) 'Information and the speed of innovation adoption', *American Journal of Agricultural Economics*, vol 78, pp1073–1081
- Fitzgerald, D. (1993) 'Farmers deskilled: Hybrid corn and farmers' work', *Technology and Culture*, vol 34, pp324–343
- Genetic Engineering Approval Committee Of India* (GEAC) (2006) 'Decisions taken in the 67th meeting of the Genetic Engineering Approval Committee', held on 22 May, [www.envfor.nic.in/divisions/csurv/geac/geac-67.pdf](http://www.envfor.nic.in/divisions/csurv/geac/geac-67.pdf)
- Gladwell, M. (2000) *The Tipping Point: How Little Things Can Make a Big Difference*, Little, Brown, New York
- Gupta, A. (1998) *Postcolonial Developments: Agriculture in the Making of Modern India*, Duke University Press, Durham
- Gupta, A. K. and V. Chandak (2005) 'Agricultural biotechnology in India: Ethics, business and politics', *International Journal of Biotechnology*, vol 7, nos 1/2/3, pp212–227
- Harwick, H. (2000) 'Guilty as charged', *Ecologist*, vol 30, no 7, pp52–53
- Henrich, J. (2001) 'Cultural transmission and the diffusion of innovations: Adoption dynamics indicate that biased cultural transmission is the predominate force in behavioral change', *American Anthropologist*, vol 103, pp992–1013
- Herring, R. J. (2005a) 'Miracle seeds, suicide seeds, and the poor: GMOs, NGOs, farmers, and the state', in M. Katzenstein and R. Ray (eds) *Social Movements and Poverty in India*, Oxford University Press, New Delhi
- Herring, R. J. (2005b) 'Is there a case for growing cotton in India?', Paper presented at the workshop on Indian Cotton: Biology and Utility, Meanings and Histories, Cornell University, 29–30 April, 2005
- Herring, R. J. (2007) 'Stealth seeds: Biosafety, bioproperty, biopolitics', *Journal of Development Studies*, vol 43, no 1, pp130–157
- Hindu, The* (2002) 'Let farmers decide on Bt. cotton', Hyderabad, 10 May, [www.hinduonnet.com/thehindu/2002/05/11/stories/2002051101640400.htm](http://www.hinduonnet.com/thehindu/2002/05/11/stories/2002051101640400.htm)
- Hindu, The* (2005) 'Monsanto clarifies on GM Crops', Hyderabad, 17 March, [www.hindu.com/2005/03/17/stories/2005031701790900.htm](http://www.hindu.com/2005/03/17/stories/2005031701790900.htm)
- Hobart, M. (ed) (1993) *An Anthropological Critique of Development: The Growth of Ignorance*, Routledge, London

- Jayaraman, K. S. (2001) 'Illicit GM cotton sparks corporate fury', *Nature*, vol 413, p555
- Jayaraman, K. S. (2004) 'Illegal seeds overtake India's cotton field', *Nature Biotechnology*, vol 22, pp1333–1334
- Jayaraman, K. S. (2005) 'Monsanto's bollgard potentially compromised in India', *Nature Biotechnology*, vol 23, no 11, p1326
- Johnson, A. (1972) 'Individuality and experimentation in traditional agriculture', *Human Ecology*, vol 1, no 2, pp149–159
- Kranthi, K. R. (2005) 'Bollworm resistance to Bt cotton in India Kranthi', *Nature Biotechnology*, vol 23, pp1476–1477
- Kranthi, K. R., S. Naidu, C. S. Dhawad, A. Tatwawadi, K. Mate, E. Patil, A. A. Bharose, G. T. Behere, R. M. Wadaskar and S. Kranthi (2005) 'Temporal and intra-plant variability of CryIAC expression in Bt-Cotton and its influence on the survival of the cotton bollworm, *Helicoverpa armigera* (Hübner) (Noctuidae: Lepidoptera)', *Current Science*, vol 89, no 2, pp291–298
- Krishnakumar, A. (2003) 'Controversy: A lesson from the field', *Frontline*, vol 20, no 12, [www.flonnet.com/fl2011/stories/20030606005912300.htm](http://www.flonnet.com/fl2011/stories/20030606005912300.htm)
- Krishnakumar, A. (2004) 'Biotechnology: Claims and controversies', *Frontline*, vol 21, no 12, [www.flonnet.com/fl2112/stories/20040618002609400.htm](http://www.flonnet.com/fl2112/stories/20040618002609400.htm)
- Kulkarni, N. (2003) 'Spurious Bt cottonseeds: Is it the right way?' *Biospectrum India*, 12 November, <http://biospectrumindia.com/content/news/203111201.asp>
- Lansing, J. S. (1993) 'Emergent properties of Balinese water temples', *American Anthropologist*, vol 95, pp97–114
- Mahyco Monsanto (2002) 'Farmers earn extra income of about Rs 7000/acre with Bt cotton', Press release
- Mahyco Monsanto (2004) 'Nationwide survey by AC Nielsen ORGMARG underscores benefits of bollgard cotton', Press release
- Marglin, S. A. (1996) 'Farmers, seedsmen, and scientists: Systems of agriculture and systems of knowledge', in F. Apffel-Marglin and S. A. Marglin (eds) *Decolonizing Knowledge: From Development to Dialogue*, pp185–248, Clarendon Press, Oxford
- McElreath, R. (2004) 'Social learning and the maintenance of cultural variation: An evolutionary model and data from East Africa', *American Anthropologist*, vol 106, pp308–321
- MONSANTOINDIA.COM (2003) News, [www.monsantoindia.com/monsanto/layout/news/2003/newsjul\\_2003.asp](http://www.monsantoindia.com/monsanto/layout/news/2003/newsjul_2003.asp), visited 31 Dec. 2005
- Morse, S., R. Bennett and Y. Ishmael (2005) 'Comparing the performance of official and unofficial genetically modified cotton in India', *AgBioForum*, vol 8, pp1–6
- Netting, R. McC (1974) 'The system nobody knows: Village irrigation in the Swiss Alps', in T. Downing and M. Gibson (eds) *Irrigation's Impact on Society*, pp67–75, University of Arizona Press, Tucson
- Orphal, J. (2005) 'Comparative analysis of the economics of Bt and non-Bt cotton production', Pesticide Policy Project, Special Publication Series 8. Institute of Economics in Horticulture, University of Hannover, Hannover, Germany and FAO, Rome
- Padma, T. V. (2003) 'Report on success of GE cotton sows confusion', *Asia Times Online*, 20 February, [www.atimes.com/atimes/South\\_Asia/EB20Df02.html](http://www.atimes.com/atimes/South_Asia/EB20Df02.html)
- Pemsl, D., H. Waibel and A. P. Gutierrez (2005) 'Why do some Bt cotton farmers in China continue to use high levels of pesticides?', *International Journal of Agricultural Sustainability*, vol 3, no 1, pp44–56
- Perales, H. R., B. F. Benz and S. B. Brush (2005) 'Maize diversity and ethnolinguistic diversity in Chiapas, Mexico', *Proceedings of the National Academy of Sciences*, vol 102, no 3, pp949–954

- Perales H. R., S. B. Brush and C. O. Qualset (1998) 'Agronomic and economic competitiveness of maize landraces and in situ conservation in Mexico', in M. Smale (ed) *Farmers, Gene Banks and Crop Breeding: Economic Analyses of Diversity in Wheat, Maize, and Rice*, pp109–125, Kluwer Academic, Boston
- Perkins, R. and E. Neumayer (2005) 'The international diffusion of new technologies: A multitechnology analysis of latecomer advantage and global economic integration', *Annals of the Association of American Geographers*, vol 95, pp789–808
- Pinstrup-Anderson, P. and E. Schioler (2001) *Seeds of Contention: World Hunger and the Global Controversy over GM Crops*, Johns Hopkins University Press, Baltimore
- Prasad, C. S. (1999) 'Suicide deaths and quality of Indian cotton: Perspectives from history and technology and Khadi Movement', *Economic and Political Weekly*, vol 34, no 5, pp12–21
- Qaim, M. (2005) 'Agricultural biotechnology adoption in developing countries', *American Journal of Agricultural Economics*, vol 87, no 5, pp1317–1324
- Qaim, M. and D. Zilberman (2003) 'Yield effects of genetically modified crops in developing countries', *Science*, vol 299, pp900–902
- Qayum, M. A. and K. Sakkhari (2003) 'Did Bt cotton save farmers in Warangal?, A Season Long Impact Study of Bt Cotton – Kharif 2002 in Warangal District of Andhra Pradesh', Deccan Development Society, Hyderabad, India
- Reddy, A. S. and B. V. Rao (eds) (1998) 'The gathering agrarian crisis: Farmers' suicides in Warangal District (A.P.) India', Unpublished report, *Centre for Environmental Studies*, Hanamkonda, A.P., [www.artsci.wustl.edu/~stone/suicide.html](http://www.artsci.wustl.edu/~stone/suicide.html)
- Richards, P. (1989) 'Agriculture as performance', in R. Chambers, A. Pacey and L. A. Thrupp (eds) *Farmer First: Farmer Innovation and Agricultural Research*, pp39–51, Intermediate Technology Publications, London
- Richards, P. (1995) 'Farmer knowledge and plant genetic resource management', in J. M. M. Engels (ed) *In Situ Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture in Developing Countries, Proceedings of DSE/ATSAF/IPGRI workshop*, DSE, Feldafing, Bonn–Roettgen, Germany and IPGRI, Rome
- Richards, P. (1997) 'Toward an African Green Revolution? An anthropology of rice research in Sierra Leone', in A. Endre Nyerges (ed) *The Ecology of Practice: Studies of Food Crop Production in Sub-Saharan West Africa*, pp201–252, Gordon and Breach, Amsterdam
- Richerson, P. J. and R. Boyd (2005) *Not By Genes Alone: How Culture Transformed Human Evolution*, University of Chicago Press, Chicago and London
- Richerson, P. J. et al (2004) 'Micro-societies as evolving cultures: Linking cultural evolutionary theory and empirical research', Unpublished research proposal submitted to National Science Foundation
- Rogers, E. M. (1988) 'The intellectual foundation and history of the agricultural extension model', *Knowledge*, vol 9, pp492–510
- Rogers, E. M. (2003) *Diffusion of Innovations*, 5th edn, Free Press, New York
- Rogers, E. M. and D. L. Kincaid (1981) *Communication Networks: Toward a New Paradigm for Research*, Free Press, New York
- Roy, D. et al (2007) 'Naturalizing transgenics: Loose seeds, official seeds, and risk in the decision matrix of Gujarati cotton farmers', *Journal of Development Studies*, vol 43, no 1, pp158–178
- Ryan, B. and N. C. Gross (1943) 'The diffusion of hybrid seed corn in two Iowa communities', *Rural Sociology*, vol 8, pp15–24
- Sahai, S. and S. Rehman (2003) 'Performance of Bt cotton: Data from first commercial crop', *Economic and Political Weekly*, 26 June [www.epw.org.in/showArticles.php?root=2003&leaf=07&filename=6073&filetype=html](http://www.epw.org.in/showArticles.php?root=2003&leaf=07&filename=6073&filetype=html)

- Sahai, S. and S. Rehman (2004) 'Bt-cotton, 2003–2004: Fields swamped with illegal variants', *Economic and Political Weekly*, 26 June, [www.epw.org.in/showArticles.php?root=2004&leaf=06&filename=7344&filetype=html](http://www.epw.org.in/showArticles.php?root=2004&leaf=06&filename=7344&filetype=html)
- Schlusser, E. (2001) *Fast Food Nation: The Dark Side of the American Meal*, Houghton Mifflin, New York
- Scoones, I. (2003) 'Regulatory manoeuvres: The Bt cotton controversy in India', Working Paper 197, Institute of Development Studies, Sussex, UK
- Scoones, I. and J. Thompson (eds) (1994) *Beyond Farmer First: Rural Peoples Knowledge, Agricultural Research and Extension Practice*, Intermediate Technology Publications, London
- Shah, E. (2005) 'Local and global elites join hands: Development and diffusion of Bt cotton technology in Gujarat', *Economic and Political Weekly*, 22 October
- Shantharam, S. (2004) 'Bt cotton is a winner', *Biospectrum*, 10 August, <http://biospectrumindia.com/content/search/showarticle.asp?arid=60548>
- Shantharam, S. (2005) 'The Brouhaha about Bt-cotton in India!' *AgBioWorld*, 2 May, [www.agbioworld.org/newsletter\\_wm/index.php?caseid=archive&newsid=2358](http://www.agbioworld.org/newsletter_wm/index.php?caseid=archive&newsid=2358)
- Sillitoe, P. (1998) 'The development of indigenous knowledge: A new applied anthropology', *Current Anthropology*, vol 39, pp223–252
- Sillitoe, P. (ed) (2000) 'Indigenous knowledge development in Bangladesh', Intermediate Technology, London
- Simms, A. (1999) 'Selling suicide – farming, false promises and genetic engineering in developing countries', *Christian Aid Report*, [www.christianaid.org.uk/indepth/9905suic/suicide1.htm](http://www.christianaid.org.uk/indepth/9905suic/suicide1.htm)
- Soleri, D. and D. A. Cleveland (2001) 'Farmers' genetic perceptions regarding their crop populations: An example with maize in the central valleys of Oaxaca, Mexico', *Economic Botany*, vol 55, no 1, pp106–128
- Soleri, D. and D. A. Cleveland (2005) 'Scenarios as a tool for eliciting and understanding farmers?', *Biological Knowledge, Field Methods*, vol 17, pp283–301
- Srinivasan, S. (2004) 'Monsanto's BT cotton seed sales soar in India', *AgBios*, [www.agbios.com/main.php?action=ShowNewsItem&id=5827](http://www.agbios.com/main.php?action=ShowNewsItem&id=5827)
- Stone, G. D. (1996) *Settlement Ecology: the Social and Spatial Organization of Kofyar Agriculture*, University of Arizona Press, Tucson, AZ
- Stone, G. D. (2002a) 'Crop biotechnology background', Online enhancement to Stone 2002c, [www.journals.uchicago.edu/CA/journal/issues/v43n4/024005/024005.html](http://www.journals.uchicago.edu/CA/journal/issues/v43n4/024005/024005.html)
- Stone, G. D. (2002b) 'Biotechnology and suicide in India', *Anthropology News*, vol 43, no 5, p5
- Stone, G. D. (2002c) 'Both sides now: Fallacies in the genetic-modification wars, implications for developing countries, and anthropological perspectives', *Current Anthropology*, vol 43, no 4, pp611–630
- Stone, G. D. (2004) 'Biotechnology and the political ecology of information in India', *Human Organization*, vol 63, pp127–140
- Stone, G. D. (2007) 'Agricultural deskilling and the spread of genetically modified cotton in Warangal', *Current Anthropology*, vol 48, no 1, pp67–103
- Stone, G. D., R. McC. Netting and M. P. Stone (1990) 'Seasonality, labor scheduling and agricultural intensification in the Nigerian Savanna', *American Anthropologist*, vol 92, pp7–24
- Takada, H., and D. Jain (1991) 'Cross-national analysis of diffusion of consumer durable goods in Pacific Rim countries', *Journal of Marketing*, vol 55, pp48–54
- Talwar, A. (2005) 'Farmers turn to other farmers', *Deccan Chronicle*, 4 July

- Thrupp, L. A. (1989) 'Legitimizing local knowledge: From displacement to empowerment for third world people', *Agriculture and Human Values*, vol 6, pp13–24
- Thrupp, L. A. (1990) 'Inappropriate incentives for pesticide use: Credit requirements for agrochemicals in developing countries', *Agriculture and Human Values*, vol 7, pp62–69
- Times of India* (2005) 'Monsanto's cotton has deficiencies: study', 4 June, <http://timesofindia.indiatimes.com/articleshow/1132562.cms>
- Tripp, R (2006) *Self-Sufficient Agriculture: Labour and Knowledge in Small Scale Farming*, Earthscan, London
- Tripp, R. and S. Pal (2000) 'Information and agricultural input markets: Pearl millet seed in Rajasthan', *Journal of International Development*, vol 12, pp133–144
- Tripp, R. and S. Pal (2001) 'The private delivery of public crop varieties: Rice in Andhra Pradesh', *World Development*, vol 29, no 1, pp103–117
- Tripp, R., M. Wijeratne and V. Hiroshini Piyadasa (2005) 'What should we expect from farmer field schools? A Sri Lanka case study', *World Development*, vol 33, pp1705–1720
- Vandeman, A. M. (1995) 'Management in a bottle: Pesticides and the deskilling of agriculture', *Review of Radical Political Economics*, vol 27, no 3, pp49–55
- Venkateswarlu, B. (2002) 'India gives nod for bollgard cotton', Information Systems for Biotechnology (ISB), *News Report*, May, [www.isb.vt.edu/news/2002/artspdf/may0204.pdf](http://www.isb.vt.edu/news/2002/artspdf/may0204.pdf) accessed 3 February, 2004
- Wambugu, F. (1999) 'Why Africa needs agricultural biotech', *Nature*, vol 400, pp15–16
- Warren, M. D., L. J. Slikkerveer and D. Brokensha (eds) (1995) 'The cultural dimension of development: Indigenous knowledge systems', Intermediate Technology Publications, London
- Yamaguchi, T., C. K. Harris and L. M. Busch (2003) 'Agrifood biotechnology discourse in India', *Science, Technology, and Society*, vol 8, pp47–72
- Ziegenhorn, R. (2000) 'The commodification of hybrid corn: What farmers know', in A. Haugerud, M. P. Stone and P. D. Little (eds) *Commodities and Globalization: Anthropological Approaches*, pp135–150, Rowman & Littlefield, Lanham, MD

## **APPENDIX 1: SAMPLING STRATEGY**

Kalleda and Ravuru-thanda are within 15km of each other in Parvathagiri mandal. These villages have very similar soils, roads, markets, input vendors and proximity to Warangal, but differ markedly in socioeconomic profile. Kalleda has a mixed population, with virtually all local castes present, and a high degree of economic stratification. Ravuru-thanda is a largely tribal (Banjara, or 'Lambadi') village. Literacy is low and most residents are poor, and there is much less economic stratification than in Kalleda. Gudeppad is located in an area of 'black cotton soil' in Atmakur mandal, where commitment to cotton cultivation is, on average, the highest in Warangal District.

In the 2004 survey, the villages of Tekumatla and Pathipally were added. In Bandanagaram virtually no cotton is planted, and it is excluded from this analysis. Tekumatla and Pathipally are medium-sized villages in Chityal and Mulugu mandals, respectively.

In the 2005 survey, the villages of Oorugonda, Pangidepally and Bhandurapally were added; these are villages neighbouring Gudeppad, Tekumatla and Pathipally, respectively. Social and ecological conditions are in all three cases quite similar to the neighbouring village; they were included to expand the sample size and to provide information on the spatial extent of seed crazes (not analysed here).

As noted in the body of the article, samples in all villages were randomized. One aim of the 2004 census was to update (and also verify the accuracy of) the 2003 data. Therefore, in the re-censused villages, census takers were given lists of the 2003 randomly selected households. However, to achieve the same sample sizes knowing that some farmers would be unavailable, a randomized list of other farmers in the village was provided for 'fill-ins', and the census takers added names from the top of this list as needed. For the three villages added in 2004, the same sampling strategy was used as in the original four villages.

The 2005 census added villages and also expanded sample sizes within each village (except for Pathipally). Again, all available previously censused households were interviewed, and additional households were added randomly.

The survey was designed to reveal variation in agricultural decision making across space and time, and to collect social-organizational, spatial-organizational, economic, educational and ethnic effects on this variability (only a small portion of which appears in this analysis). It was not explicitly designed to allow characterization of Warangal District, and several distinctive sectors of the district were not studied.

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## NOTES

- 1 The cotton season straddles two calendar years: it is planted in June–July and then harvested from October to March. To make the discussion less cumbersome, I refer to cotton seasons by the year the crop was planted and most of the work occurs.
- 2 See Rogers (2003) pp168–218 for a summary; see Ryan and Gross (1943) and Beal et al (1957) for variations on the stage schemes.
- 3 Email to G. D. Stone, 14 November, 2005; the same point has appeared in print numerous times (e.g. Srinivasan, 2004; *Hindu*, 2002, 2005).
- 4 Adam Smith and Karl Marx described the same process, albeit with somewhat different terminology (Marglin, 1996, pp194–195).
- 5 Vandeman (1995) argues that pesticides commodified farm pest management in a destructive and self-perpetuating cycle: the less the farmer knows about insect ecology, the more insecticide is used (Thrupp, 1990; Vandeman, 1995), producing intractable problems of environmental contamination and pesticide resistance.
- 6 This is a brief distillation of a large and nuanced body of theory. What I am summarizing as ‘environmental (individual) learning’ is a sketch of what Boyd and Richerson (1985, pp95–97) call ‘guided variation’ and Henrich (2001) calls ‘the environmental learning model’.
- 7 This differs from the diffusion–innovation theorists’ parallel concept of critical mass, which refers to the point at which further diffusion is self-sustaining. Critical mass is based on actual payoffs for adoption, and it mainly applies to interactive technologies like phones and faxes where the value increases as more people adopt. In contrast, conformist bias is identified by evolutionary theorists as a purely social phenomenon.
- 8 Public sector breeders have released a few open-pollinated varieties but they have convinced only a tiny percentage of the farmers to grow them.
- 9 A survey of Warangal input vendors was conducted in June 2005. Since no complete list of vendors is available, we developed a list of vendors by reconnaissance of the Station Road area, adding any others that appeared in interviews with farmers, vendors or officials. Thirty-seven shops provided cotton sales data for 2003–2005: five were new and only provided data for 2005, 18 provided data for 2004–2005 (some had only opened in 2004, others would not or could not provide accurate data for 2003), and 14 provided data for 2003–2005. Therefore the data cannot be used to compare overall sales, but should provide a fair reflection of market shares by product.
- 10 All censuses were designed and tested in collaboration with economist Dr A. Sudarshan Reddy of the Centre for Environmental Studies, Hanamkonda and formerly of CKM College, Hanamkonda. The 2003 census also benefitted from input by Robert Tripp of ODI, London.
- 11 The 2004 census collected information on acreage owned, which corresponded to acreages reported in the Multi-Purpose Household Survey moderately well. It also contained four variables reflecting the farmer’s information connectivity: radio listening, newspaper reading, TV watching and, in particular, watching the ‘Annadata’ agricultural-extension TV programme were rated on a scale of never–sometimes–frequently. These were combined into a composite score of information connectivity (Low–Medium–High), which shows a clear correlation with land ownership ( $p < .001$ ):

**Information connectivity**

	L	M	H
<b>Acres owned</b>			
Small (<2)	121	11	8
Med (2–4.5)	92	10	23
Large (5+)	85	28	38
	298	49	69

An analysis of the extent to which access to external information sources affects participation in cotton crazes would be interesting, but lies outside the scope of this chapter.

- 12 This is similar to market share, but not exactly the same because it does not allow for farmers buying more than one box.
- 13 Plants with large bolls do not necessarily give high yield, as the number of bolls produced is variable. Large bolls may lead to marginally lower costs for harvesting labour, but they also maximize the economic losses due to bollworm attack (Jalapathi Rao, pers. comm. 2005).
- 14 In Pathipally, a plurality expected large bolls but in neighbouring Bandarupally most expected small bolls; in Kalleda, a majority expected small bolls but in neighbouring Ravuru most expected large.
- 15 In 2005, in a group interview, I asked why no one planted Gemini again. One farmer mentioned that the bolls were too small, but others had no specific reasons; several said they simply wanted to try something new.
- 16 The story has been related in various fora recently, most colourfully by Herring (2007).
- 17 For instance, Gupta and Chandak (2005) presented data from a survey of 363 farmers in 75 unnamed villages, administered by graduate students in breeding/genetics. While the results show slightly higher mean yields for MMB *Bt* cotton over Navbharat 151, the differences do not appear statistically significant, and anyway the comparison seems to span two years (Navbharat 151 was only sold through 2001; MMB *Bt* seeds were first sold in 2002). Morse et al (2005) failed to find higher yields for illicit *Bt* cotton than legal seeds, but the study was problematic; it appears to have taken all farmer responses at face value regardless of the illegal nature of the seeds they were being interviewed about, and it appears to have recorded only harvests through December, thus missing the late season harvest which is a strength for some illicit seeds. Despite these limitations in published research, the field success of the illicit *Bt* seeds is validated by the Gujarat Agriculture Department's estimates that cotton yields in the state have more than quadrupled over the past four years, during which time illicit 151 descendant seeds have spread to 60–80 per cent of the state's cotton area (Shah, 2005).
- 18 The finding from Morse et al's (2005) questionnaire-based study that only 0.6 per cent of farmers planted more than one kind of seed is dubious. The detailed interviews in Warangal indicated that 45 per cent of farmers were growing more than one seed in 2003, and this is in an area where there has been very little of the loose seed that facilitates sub-acre experimental plantings (Stone, 2007).