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Field *versus* Farm in Warangal: Bt Cotton, Higher Yields, and Larger Questions

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Summary. — A longitudinal anthropological study of cotton farming in Warangal District of Andhra Pradesh, India, compares a group of villages before and after adoption of Bt cotton. It distinguishes "field-level" and "farm-level" impacts. During this five-year period yields rose by 18% overall, with greater increases among poor farmers with the least access to information. Insecticide sprayings dropped by 55%, although predation by non-target pests was rising. However shifting from the field to the historically-situated context of the farm recasts insect attacks as a symptom of larger problems in agricultural decision-making. Bt cotton's opponents have failed to recognize real benefits at the field level, while its backers have failed to recognize systemic problems that Bt cotton may exacerbate.
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1. INTRODUCTION

The movement of genetically modified crops into the developing world continues to be a matter of widespread interest and some controversy. This movement has been led by Bt cotton, which incorporates one or more insecticide-producing *Cry* genes from the soil bacterium *Bacillus thuringiensis*. India is a particularly closely-watched frontier for this crop. India is by far the world's largest cotton planter but its cotton sector is one of the world's most troubled, ranking 70th in yields and infamous for farmer suicide (Gruère, Mehta-Bhatt, & Sengupta, 2008). The most apparent problem in its fields—at least in the early 2000's when Bt cotton was approved—was predation by Lepidopteran bollworms, precisely the pests for which Bt crops were developed. Therefore the potential for a dramatic impact seemed great. India has also played a key role in the struggle over public relations and discourse (Stone, 2002b): it is an iconic site for external technological intervention in agriculture, and home to a strong NGO sector that has contested the new technological regime at every step (Herring, 2006, 2009; Scoones, 2008).

A verdict of resounding success of Bt cotton in India has been announced by many (e.g., Gonsalves, 2007). Numerous studies of field-level performance are now available, often providing measures of central tendency showing positive results: for instance, throughout India, "On average, Bt-adopting farmers realize pesticide reductions of roughly 40%, and yield advantages of 30–40%" (Sadashivappa & Qaim, 2009, p. 172). Yet these studies have several major limitations, most notably selection and cultivation biases: early adopters are not a random group, but a sample biased toward successful farmers, and Bt plots often receive extra care, making synchronic comparisons problematic. There has also been a counter-narrative of agronomic failure and farmer rejection, even including charges that the new seeds are to blame for the farmer suicides (Shiva, 2008). These publications have their own serious problems, often including dubious empirical support.

In fact, the complex set of relationships between the new technology and its users resists such simple narratives. Even when considered from a strictly economic field-level perspective, Bt cotton's impacts are "inconclusive," according to a review of India (and other developing countries) by agricultural economists (Smale, Zambrano, & Cartel, 2006, p. 195). Agronomic impacts documented to date are also quite short-term, and the complex insect ecology in Indian cotton fields has a history of resisting management solutions. But there is also a larger problem that we risk myopia in modelling Indian farm production as a laboratory well suited to isolating impacts of new factors of production on yields and profits (see Busch, Lacy, Burkhardt, & Lacy, 1991, pp. 49–52). Bt cotton is hardly a technology with no impact on cultivation practices, as claimed by some advocates (Wambugu, 1999); it may bring a plethora of changes including new requirements for field management practices, new kinds and rates of technological change, new sources of advertising and lobbying, and new insect population dynamics. These changes may impact time management, machinery use, health, and indigenous knowledge (Brookes & Barfoot, 2009; Stone, 2007a), but such broader and more indirect aspects of technological change remain little studied and poorly understood.

Within India, activists, scholars, and reporters have paid particular attention to Warangal District of Andhra Pradesh, where the debates on suicide by cotton farmers have been centered (Gruère *et al.*, 2008; Kantor, 2008; Shiva & Jafri, 1998; Stone, 2002a, 2002b). Warangal has been called "the most controversial district in India" (Herring, 2008). This paper draws on long-term ethnographic research in Warangal District to make two contributions. It first presents a panel study comparing cotton production in four villages in 2003, which was the last year before farmers began to adopt Bt seed, and 2007, the first year of virtually all Bt seed. This analysis avoids selection and cultivation biases by using comparable samples of farmers before and after adoption of Bt seed. It then develops a broader perspective on technological change in cotton cultivation, based on a distinction between the field and the farm. *Field* studies, in this usage, concern crop performance under growing conditions, key variables being inputs, ecological phenomena, yields, and profits. *Farm* here

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refers to a socio-economic management unit with such parameters as debt and income, access to labor and land and technology, social linkages with other farmers and vendors, and indigenous knowledge. Studies from this perspective can reveal longer-term and broader dynamics. The focus is on two aspects of farm-level dynamics. First is the recent historic context of cotton cultivation in Warangal: these farms are not ahistoric laboratories, but operations that were in the midst of important secular changes in technology use and market interaction when Bt cotton appeared. Second is the impact of Bt cotton on the acquisition and transmission of information. As Smale *et al.* (2009, p. xv) point out, "Biotech crops have particular implications for the transfer of knowledge and the organization of seed supply and related information, as well as the empowerment of farmers and farming communities. These are some of the issues the public demands to hear about." Indigenous knowledge and decision-making have been central concerns in this ethnographic project.

Results show that from the field perspective, the first five years of Bt use in Warangal have brought moderate success in battling an insidious bollworm problem, including increased yields and sharp declines in insecticide use. In recent years, however, crop predation by non-target insects has emerged as a severe problem. From the farm-level view, the outcome is more complex. Using a history of cotton farmers' articulation with agricultural technologies, this paper maintains that the bollworms were only a symptom of a larger problem: a fraught relationship with technology that has had serious negative effects on agricultural decision-making. Field-level gains have been real, but overemphasized; a technology that mitigates an immediate problem in the field may exacerbate the underlying condition that produced the problem in the first place.

2. RESEARCH ON BT COTTON IN INDIA

Field-level studies of Bt cotton in India now number in the dozens and reviews of this literature are provided by Smale *et al.* (2006) and Smale *et al.* (2009). Smale *et al.* (2006, p. 195, 2009, p. 21) find the results in India to be "inconclusive," citing heterogeneity in physical, social, and economic environments.[1] The clear majority of studies by economists do reveal advantages in cotton yield, and often in pesticide usage, for Bt cotton, but there are several reasons for agreeing that the results to date are inconclusive.

One issue is that measures of central tendency obscure the enormous variability across time and space (Qaim, Subramanian, Naik, & Zilberman, 2006; Smale *et al.*, 2006). Consider the major cotton-producing states (Gruère *et al.*, 2008 especially Fig. 9): yields in Gujarat have surged from below the national average before Bt cotton to leading the country by 2005, while yields in Madhya Pradesh have decreased since Bt arrived.[2] Within sub-state units such as the district or mandal, villages vary greatly in prosperity, access to information, and other factors affecting use of new technologies, which may help explain cases like Maharashtra where studies show a "complex, confusing picture of farmers' spraying behaviour and a startling degree of variability in their cotton output" (Bennett, Kambhampati, Morse, & Ismael, 2006; Glover, 2009, p. 16). It is doubtful that there is any such thing as a "typical cotton growing village" (Subramanian & Qaim, 2009, p. 256) in India.

Research to date has also been overwhelmingly focused on brief periods. India first approved Bt cotton in 2002 and most studies focus on the small populations of early adopters that year and the next: Bennett, Ismael, Kambhampati, and Morse (2004), Bennett *et al.* (2006), Qaim *et al.* (2006), and Orphal (2005) cover 2002–03, while Naik, Qaim, Subramanian, and Zilberman (2005) and Morse, Bennett, and Ismael (2007) cover 2003.[3] Only Sadashivappa and Qaim (2009) present panel data spanning five years, aggregating results from four states. Moreover, none of these studies contextualize the study years in important secular trends in cotton cultivation.

Another persistent problem has been selection bias. Early adopters are known to be a sample biased towards successful farmers (Crost, Shankar, Bennett, & Morse, 2007). Morse *et al.* (2007, Table 3) found Bt-adopters on average to own 58% more land and 75% more non-land assets; Sadashivappa and Qaim (2009, p. 175) found Bt adopters to own up to 36% more land. Lalitha *et al.* (2009, Table 7.6) found Bt-adopters to be not only richer in land, but better educated and more diversified. Morse *et al.* (2007) showed Bt-adopters to be more effective farmers by comparing the *non*-Bt fields of adopters (i.e., farmers who planted both types) with the fields of non-adopters; they found the adopters' conventional fields produced 29–43% more than the other conventional fields. Research to date has very rarely controlled for this bias, and many studies fail to even specify how their samples were drawn (e.g., Barwale, Gadwal, Zehr, & Zehr, 2004; Sahai & Rahman, 2003). The problem is key because almost all studies have focused on the years immediately following the introduction of Bt cotton, when yield differences mainly reflect the agricultural prowess of a biased group of early adopters (and also reflect how this group happened to fare their first time trying a new technology). Crost *et al.* (2007, p. 34) found that in "cross-sectional analysis of the type used in most of the previous studies on Bt cotton, more than half of the observed yield effects would be due to self-selection effects."[4] Two studies have attempted to control for selection bias by comparing Bt and conventional yields for farmers who planted both. Morse *et al.* (2007) found Bt fields in Maharashtra to outyield conventional fields by 43% in 2002 and 27% in 2003; Sadashivappa and Qaim (2009) found Bt yield advantages of 24–58% in a 4-state sample.

A related problem is bias in cultivation practices: prior to the institution of price caps in some states in 2006, Bt seeds cost four times as much as conventional seeds, and would have been planted in the fields with best irrigation and then benefited from unusual care and expense. This accords with the fact that adopters spent *more* on bollworm sprays for their Bt plots than for their conventional plots (Morse *et al.*, 2007, Table 4). In Warangal I have seen many cases of farmers lavishing extra resources and attention on their Bt fields.

Smale *et al.* (2006) also point out that a very small number of scholars have written almost all of the peer-reviewed literature on Bt cotton. Some may also be further discomfited by the fact that several of the studies showing superior field performance by Bt cotton were sponsored by Monsanto (Sheridan, 2009), used data collected by Monsanto's partner, Mahyco (Bennett *et al.*, 2006; Qaim & Zilberman, 2003), or were authored by employees of Mahyco (Barwale *et al.*, 2004).

Much of the literature from NGO's, which routinely reports problems with Bt cotton cultivation, is more problematic yet. The most noted studies finding Bt cotton to have performed poorly in Andhra Pradesh were sponsored by a Hyderabad-based NGO that has campaigned against the technology (Qayum & Sakkhari, 2004, 2005).[5] The most prolific contributor to India's anti-GMO literature has been Vandana Shiva, who has raised useful questions about the political economy of Bt cotton (Shiva, 2005; Shiva & Jafri, 1998) but whose organization has also produced dubious empirical studies of Bt cotton (e.g., Jalees, 2008) and poorly supported charges of the cotton causing suicide

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