From blessing to curse? The Return of Pink Bollworm and its impacts on the livelihoods of Bt cotton farmers in Telangana, India

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Introduction

While early scientific literature on Bt (*Bacillus thuringiensis*) cotton documented its positive agronomic effects on yields, revenue and reductions in pesticide use (Qaim 2003, Sadashivappa & Qaim 2009, Choudhary & Gaur 2015, Kathage & Qaim 2012, Veettil et al. 2016), the recent return of pink bollworm (*Pectinophora gossypiella*) pests in India raises doubt in regard to the technology's longevity. Especially its long-term effects on farmers' livelihoods need critical re-investigation. Based on 42 problem-centred interviews conducted in Karimnagar District, Telangana, this study assesses the socio-economic impacts of the recent return of the pest on cotton farming households. Methodologically, it follows an explorative livelihood approach. It examines the risks that have arisen in the context of the recent crisis and discussed the farmers' strategies to cope with and adapt to this shock.

Fig. 8: Boll infected with pink bollworm (Photo: K. Najork 2018)

Bt Cotton in India

Genetically engineered (GE) seed technologies were developed in the 1990s to tackle the problem of *lepidopterans,* like bollworms, which are considered a major limiting factor in cotton production (Choudhary & Gaur 2015, Kaviraju et al. 2018). Producing endotoxins of the *Bacillus Thuringiensis* bacterium, Bt crops have lethal effects on lepidopteran insects and thus provide built-in protection against them (Khan et al. 2018).

Developed by Mahyco Monsanto Biotech Limited (MMBL), Bt cotton was the first GE crop to enter the Indian market in 2002 (Sadashivappa & Qaim 2009). The first Bt generation (Bollgard-I) has now been almost completely replaced by hybrids based on the Bollgard-II technology containing two induced Bt genes (Cry1Ac and Cry2Ab) instead of one (Cry1Ac) (Choudhary & Gaur 2015, ISAAA 2017).

With proliferating adoption rates, the area under Bt cotton has drastically increased throughout India since the GE-technology was introduced. Today, it amounts to an estimated 93% of the total Indian cotton area (Choudhary & Gaur 2015, ISAAA 2017). Hence, Bt technology plays an essential role for India's cotton sector which currently accounts for 26% of global cotton production, thereby taking the lead in the same (Statista 2020, Fand et al. 2019).

However, recent attacks of pink bollworm pests have now reignited the debate, not only about potential resistances in lepidopteran pests towards the endotoxins produced in Indian Bt cotton plants, but also about severe setbacks in regard to peasant farmers' livelihood security due to the technology's failure and the resulting collapses in yields.

Early Effects of Bt Cotton Adoption on Farmers' Livelihoods

Especially studies rooted in agricultural economics (e.g. Qaim 2003, Kathage & Qaim 2012, Sadashivappa & Qaim 2009, Veettil et al. 2016) emphasize the drastic increase in yields and the parallel decrease in pesticide usage – apparently related to Bt cotton diffusion. Bt is claimed to have strongly 'outperformed' conventional cotton (Kathage & Qaim 2012: 2, Qaim 2003, Veettil et al. 2016). Sadashivappa & Qaim (2009) assert yield advantages of up to 40%, which accordingly have led to higher profits among smallholders, up to 44% according to Morse et al. (2007), resulting in an increased standard of living (see also Kathage & Qaim 2012, Yadav et al. 2018). Thus, the technology has been praised for its contribution to 'positive economic and social development' (Kathage & Qaim 2012: 1).

Critical voices on the technology are scarce. Yet there are some studies rooted mainly in cultural anthropology, which suggest that 'the yield advantage of Bt over non Bt is not statistically significant' (Gaurav & Mishra 2012: 12), that it is unrelated to the technology but rather to different cultivars and agronomic practices, or that yields were stagnating or even falling during the last years, and that Bt cotton cultivation is paralleled by an increase in riskiness (Stone & Flachs 2015, Stone 2011, Flachs 2017).

In regard to the technology's reported positive effects on pesticide usage, academic criticism is rare, too. The majority of scientific findings on the topic suggest Bt technology to be the reason for decreases in pesticide applications. Qaim (2003) found reductions of more than 60% and Veettil et al. found such reductions 'across all toxicity classes over time for both Bt and non-Bt cotton' (2016: 118). Kathage & Qaim even claim that a 'widespread adoption of Bt has led to area wide suppression of bollworm populations' (2012: 2). However, some scholars relate pesticide reductions to other factors than Bt cotton. Flachs (2017: 2) purports that a decrease in pesticide usage can only be assigned to the initial phase of Bt cotton introduction and that 'total insecticide applications had largely returned to their pre-GM levels' by 2010, when Bt adoption was ubiquitous in India.

In our study, the vast majority of interviewed farmers confirmed the positive effects of Bt cotton by affirming the technology's initial successes in regard to yield in- and pesticide decreases. They even termed the sharp early increases in yields as 'boom' (V02-I07, V02-I08) and stressed the initial improvement of their economic situation, as they were able to conduct significant long-term investments, such as building houses or buying machines, or investing in their children's education, due to increased cotton-related profits (V02-I08, V02-I1, V03-I08, V03-I10). Yet, the target pest's recent return to the central and southern zone of Indian cotton production in the season of 2017/18, is now overshadowing the technology's initially posed success story (Fand et al. 2019, Naik et al. 2018).

Fig. 2: Farmer in his Bt cotton field. (Photo: K. Najork 2018)

Pink Bollworm Causes New Risks

Late research in the field has taken up a tone of scepticism (Kranthi & Stone 2020) as the promise of built-in protection against lepidopteran pests has failed and Bt cotton apparently 'lost the battle' (Fand et al. 2019: 314). In recent studies, yield losses of up to 30% are reported (Fand et al. 2019) fuelling concerns among smallholders and other actors in the cotton industry. Thus, the question of immediate livelihood risks and thereto related coping strategies is immanent and a critical re-investigation of the technology seems requisite.

In accordance with the recent critique, in our study, the majority of interviewed farmers shared the increasing scepticism: While they described cotton yield performance as a curve starting with the above-mentioned 'boom', they claimed yields to have recently declined, accompanied by concurrent re-increases of pesticide applications (V02-I07, V02-I09). Altogether, non-Bt cotton was described as more reliable than its GE counterpart (V02-I06, V02-I12).

Concerning the late return of the target pest to Indian cotton fields, all interviewed farmers attested to have been impacted by pink bollworm infestations in their fields with yield decreases of up to 80% – despite the implementation of Bt II by all interviewees (V01-I01, V02-I02, V03-I01, V03-I09). The collapses in yields have resulted in devastating financial losses, paralleled by according effects on farmers' livelihoods. The shock's severity is underlined by a 70-year-old farmer claiming that he 'cannot remember a similar shock like this' (V02-I13).

Moreover, interviewees described the infestation as unforeseeable and emphasized the notion of surprise in its occurrence: 'I opened nearly 50 cotton bolls just to make sure that they were not affected, but unfortunately the whole field was infected by pink bollworm' (V02-I01). Similarly, another farmer mentioned this aspect of unexpected risk: Having started the construction of his house with the surplus of the early years of Bt cotton implementation, he was unable to finish the house after the return of pink bollworm, so that it still remains unfinished today (V02-I07).

Farmers' (In-)Ability to Cope and Adapt

These recent risks have led to new livelihood strategies of Bt cotton farmers: (1) Responsive short-term strategies directly applied in order to cope with the shock and (2) preventive strategies pursued to adapt to the changed conditions in the long run to avoid a recurrence of the recently experienced financial shock. These newly implemented strategies have, in turn, varying effects on farmers' livelihoods, depending on socio-economic as well as agronomic variables.

One coping strategy adopted by almost all interviewees was to take loans in order to buffer their financial losses resulting from the collapses in cotton yields (V01-I10, V02-I06, V02-I07, V02-I13, V02-I14, V03-I05, V03-I06). The formal bank system was generally preferred since informal sources, such as money lenders or commission agents, demanded higher interest rates. The access to this system was, however, restricted to land-owning farmers or those who were able to provide another kind of deposit, for example gold or jewellery (V01-I10, V02-I06, V02-I08, V02-I13). Farmers who did not own any land, had to revert to the above-mentioned informal sources (V02-I13, V02-I14, V03-I05, V03-I06).

As a result, the coping strategy of taking loans varied in success depending on the socio-economic preconditions of the respective farmer. Farmers with less financial capital were disproportionately affected when trying to overcome their financial crisis than those farmers who were economically better off by default. This inequality became manifest as some resource-poor farmers got into debt traps as they were not able to pay off their loans (for example V02-I14). As last resort to cope with the incurred losses, several interviewed farmers had to sell some of their land (V02-I14, V03-I05, V03-I07, V03-I10).

A rather long-term adaptive strategy implemented by some farmers was to grow a second season on their cotton fields. Growing a second crop, which was usually maize, was possible due to the significantly shortened crop cycle of Bt cotton. This was stated as the major benefit of Bt cotton, as the second crop resulted in additional household income and served as balance, especially in times of crisis (V02-I13, V02-I11, V03-I09).

This privilege was, however, limited to those farmers with sufficient access to irrigation facilities (V2-I10, V2-I14). Insufficient water supply, on the contrary, either impeded the bowery altogether, or exposed the crop to new risks. One interviewee described that, after having lost his first crop (Bt cotton) to pink bollworm, he also lost his second crop (maize) due to a lack of water supply (V2-I13). Hence, instead of balancing his losses, his second crop indebted him even further. As a consequence, economically weaker farmers were again hit unequally hard by the shock due to their impeded access to irrigation facilities.

A general strategy, independent of the crisis and yet related thereto, was the non-compliance of refuge requirements. Refuge crops (or refugia) consisting of non-Bt crops are required to surround each Bt cotton field in a ratio of 95:5 (Bt:non-Bt) in order to lower the target pest's evolutionary pressure and thus prolong the effectivity of the technology (Carrière et al. 2005, Flachs 2017, ISAAA 2017, Kranthi 2015). The strategy not to grow a refugia was implemented by all respondents. As the realization of this requirement would entail economic disadvantages for farmers, all interviewees reported to follow the alternative strategy of non-compliance (V02-I06, V02-I07, V02-I08, V02-I12). Despite the fact that farmers follow what has to be acknowledged as a comprehensible livelihood strategy to enhance their economic well-being in the short term, they jeopardize their livelihood systems as a whole in the long run. As the ISAAA (2017) states, this mismanagement erodes the technology's resistance to pink bollworm and threatens the longevity of the technology.

Conclusion

Our findings show the altered impacts of Bt cotton implementation over time. While positive agronomic effects of the technology were confirmed for the initial years of Bt cotton diffusion, a durability of the technology's early successes must be negated.

The return of the lepidopteran target pest, pink bollworm, witnessed by all interviewed farmers, must be interpreted as alarm signal for the failure of Bt technology. The in-built pest resistance promised by seed companies is no longer reliable. As a result of this recent breakdown, farmers faced severe financial losses due to collapses in cotton yields. Forced to react to these new risks, farmers implemented responsive coping strategies in consequence. While these have proved beneficial for *some* farmers in balancing financial losses, it meant a deepening of crisis for others. At that, already poorer, and more vulnerable farmers are affected disproportionately severe as they fail to revert to promising adaptive strategies, such as the growing of a second season. Additionally, the general strategy of non-compliance with refugia requirements not only jeopardizes the longevity of Bt technology itself, but corrodes the foundations of Bt cotton farmers' agricultural livelihood systems. By pursuing livelihood strategies oriented toward short-term economic profits, farmers put the socio-ecological sustainability of their own biotechnology-driven livelihoods at stake.

Since the proper implementation of refuge crops requires high investments by farmers which often cannot be met, the responsibilities of political officials as well as seed companies must be emphasized in this regard. They cannot simply pass the buck to farmers when it comes to prolonging the technology's longevity and spurn own responsibilities.

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