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Profitable, but not for all

Genetically modified cotton has limited advantages, but creates also new problems

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India has impressed the world by its remarkable 8% annual growth of national economy in the past decade. But despite economic growth –mainly in the industrial and services sector – are poverty and hunger still widespread in the country. The Indian Government is aware of the problem and has as one of the first ones recognized the 'Human Right to Food'. It further promotes agricultural growth as a means to reduce hunger.

To increase agricultural growth most Indian politicians are strongly supporting the use of biotechnology and genetic modification (GM) and have high expectations regarding their potential contribution. These high expectations are partly fuelled by the experiences with genetically modified cotton, which is being grown in India since 2002. The introduction of GM cotton varieties has indeed contributed to higher average yields, but the benefits for poor farmers and the sustainability of the technology are in doubt.

India's economy is largely dependent on agriculture with ca. 17 % of the Gross Domestic Product coming from agriculture, forestry and fishing and the agricultural sector employing more than half of the population. With an average land holding size of 1.06 hectare and 88 % of the land holdings less than 2 hectares, Indian farmers are typically small and resource poor, most of them earning hardly enough to cover their basic needs. According to the World Bank around one third of India's 1.1 billion population is considered food-insecure. The majority of these hungry and poor people live in rural areas with a livelihood dedicated to crop production.

Major crops by crop area are cereals (mainly rice and wheat), pulses and oilseeds. Cotton occupies only about 5 % of the agricultural area. But when regarding crop production by value, cotton is included in the top 5 crops after rice, wheat, sugarcane and vegetables and therefore plays an important role in the agricultural economy.

In 2002 the first approval for commercial cultivation was granted to 3 genetically modified cotton hybrids. All 3 varieties contained Bt-genes from Monsanto and were developed in cooperation with the Indian seed company MAYHCO.

Bt is the abbreviation for *Bacillus thuringiensis*, a soil bacterium which produces a protein highly toxic to certain insects, among them the main cotton pest: the cotton bollworm. As spray formulation the Bt toxin has been used in plant protection since several decades. But by means of genetic

transformation it is possible today to incorporate Bt genes into cotton plants (or other plants), enabling the plants to produce the Bt toxin and thereby to effectively protect themselves against bollworm attacks. In conventional cotton production farmers regularly apply various insecticides against cotton bollworms.

In the years after the introduction of the first Bt cotton in India up to today, not only the number of approved Bt varieties has increased explosively in India but also the area planted to Bt cotton. Apparently farmers were impressed and excited about the effect of Bt varieties against bollworms and the good performance of the new cotton varieties. The spreading of Bt varieties was further enhanced by a very active marketing strategy of the Indian seed sellers. It is estimated that since 2009 almost 90% of the total cotton area in India has been planted to Bt cotton.

The more than 600 approved Bt cotton varieties in India are, with only one exception, all high yielding hybrid varieties. Their good performance is the result of a combination of two characteristics: (1) due to their conventionally bred germplasm they have a high yield potential and (2) the genetic transfer of Bt genes conveys a sort of in built crop protection against cotton bollworms. To realize the high yield potential of these new varieties, however, farmers have to heavily invest in fertilizer, insecticides against other pests than cotton bollworms, seeds and usually irrigation.

If there is any crop in India that has registered phenomenal growth during the last 7-8 years – it is cotton. Cotton production has nearly doubled from about 15 Mio bales in 2002 to about 29 Mio bales in 2009 (1 bale are 170 kg). The increase in production was mainly due to an increase in cotton yield from ca. 300 kg/ha to more than 500 kg/ha and can be attributed to the introduction of the high yielding new Bt hybrid varieties and a subsequent intensification of the cotton production. The increase in cotton production has made India a cotton exporter since 2006 and the second largest cotton producer in the world after China.

Despite the fast adoption of Bt cotton in India, there is a vigorous controversy among researchers about the economic benefits of Bt cotton for different groups of farmers. Compilations of various studies demonstrate that farmers using the new Bt cotton varieties used in average less pesticides and had in average higher yields and net returns compared to other cotton farmers. But it is also clear that there are many farmers who do not realize the expected economic benefits for several reasons. Bt cotton growing (with the presently available Bt varieties) involves high input costs. While Bt cotton growing can be very profitable in irrigated areas and for knowledgeable and resource strong farmers, it is a very risky investment in rainfed areas. Two thirds of the cotton areas in India are rainfed and for farmers in these areas, for resource-poor farmers or farmers who are not knowledgeable about the proper agricultural procedures for growing Bt cotton, Bt cotton can be a disastrous investment. Valuable alternatives for these groups of farmers could be varieties adapted to their needs – for example drought resistant open pollinating varieties – or the use of Integrated Pest Management (IPM) practices.

The sustainability of crop protection through Bt genes is also in question. With nearly all cotton today in India being Bt varieties, cotton bollworms are exposed to an enormous selection pressure and it is now confirmed that cotton bollworms in India are developing resistance against the initial single gene Bt toxin. This means that farmers have started to spray again against cotton bollworms or have changed to newer, so-called double Bt varieties, which include 2 different Bt toxin genes. The selective targeting of the Bt varieties against the primary cotton pest cotton bollworm seems also to have opened a niche for secondary pests to multiply. Both, the emergence of resistant bollworms and the increase of secondary pests, are expected to reduce the economic and environmental benefits of crop protection through Bt gene transfer. A more sustainable approach to crop protection would be the use of Integrated Pest Management (IPM), a strategy that focuses on long-term prevention of pest damage. In IPM a wide array of crop production practices are used to sustainably reduce pest incidence and to secure yield, including the use of resistant varieties, biocontrol and the judicious application of pesticides.

What about the effects of Bt cotton on agro-biodiversity? Unlike during the green revolution, when seeds of a few popular rice varieties were distributed under massive support of the public sector with the result of a great genetic uniformity, there is today an enormous varietal diversity among the Bt cotton hybrids. Some scientists even speculate that due to the great demand for Bt varieties and the seed companies gathering all their genetic material to develop new varieties, genetic diversity of cotton varieties today might even be higher than before.

But the triumphal adoption of Bt cotton hybrids has led to a drastic shift from the use of traditional, open pollinating, so-called ‘Desi’ varieties, to Bt hybrids. This tendency has already started before the Bt varieties, but was accelerated considerably by the new Bt hybrids. Some Indian scientist call this shift alarming and warn about the risk of extinction of many traditional Desi varieties through the expansion of hybrid varieties and also through habitat degradation.

Another question concerns the coexistence of Bt cotton and GM-free cotton. The Indian cotton market does not distinguish between Bt and non-Bt cotton. Neither do the main Indian cotton export markets China and Pakistan. As the vast majority of cotton farmers grow Bt cotton anyway, coexistence is not an issue for them. No coexistence rules are formulated in India and there are consequently no rules about liability for contamination of non-Bt fields or cotton products. Awareness about the importance of coexistence rules, however, is growing in the public sector, because India is one of the largest suppliers to the growing global market of organic cotton for Europe, USA and Japan, where organic cotton commands premium prices. Organic non-Bt cotton production in India is usually assured by involving all cotton famers in one area in a non-Bt cotton project, providing non-Bt seeds and having a buy-back policy and an own marketing system of the produce.

A similar concern is food safety and consumers' choice. The increase in cotton production has brought a shift from using traditional oils like groundnut oil for cooking to the cheaper cotton seed oil, which now of course is Bt cotton seed oil. Bt cotton seed oil has no approval for human consumption in India and has not undergone a biosafety assessment. Also Bt cotton linters are used f. e. as thickening agents or stabilizers in food industry without approval and biosafety assessment. Labelling of GM foods in India is not mandatory. Consumers do therefore not have a choice regarding their intake of Bt cotton seed oil or linters.

Has Bt cotton improved food security? Some of the underlying constraints threatening India's food security are low productivity in food as well as in other crop production and poverty of large parts of the population. The introduction of Bt cotton and simultaneous intensification of cotton production has led to an increase of average cotton yields. Whether this has reduced poverty and increased access to food, especially in the rainfed cotton areas, is however doubtful. Farm incomes from Bt cotton are very variable. Knowledgeable farmers in irrigated areas will typically have economic advantages of growing the high yielding Bt hybrids. But in the poorer rainfed areas, where 2/3 of the cotton farmers live, growing the potentially high yielding Bt cotton is economically very risky. Reports about deteriorating soil conditions as a consequence of intensive Bt cotton cultivation in irrigated areas also give cause for serious concerns regarding the sustainability of the intensified production and its impact on long term food security.

Bt technology is certainly useful in some farming situations. The technology is, however, only a tool to convey protection against some target insects. It does not protect the crop against all pests and – very importantly – it does not reduce the dependency of 2/3 of all Indian cotton farmers on rainfall. As a long-term perspective for sustainable cotton production, especially for resource-poor farmers and rainfed areas, a more holistic approach would be desirable.

This approach should include a range of measures including the following: Drought resistant, adapted non-hybrid varieties (with/without Bt) should be developed, helping resource poor farmers to achieve a more stable yield and income. IPM (with Bt/non-Bt varieties) should be used to lower pest incidence levels and to reduce problems with resistance development and secondary pests. Alternatives to Bt cotton should be explored, for example organic cotton or crop diversification. The agricultural extension service should be strengthened, as information of farmers on new technologies is essential for good results and this information should not come from agribusiness. A functioning extension service is also important for IPM, which is a long-term strategy based on knowledge and education. Finally, access to low-rate credits needs to be improved to make small farmers less dependant on agricultural input dealers.

Literature

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