

to experimental, potentially curative treatments for their children.

However, the Council for Responsible Genetics (CRG; Cambridge, MA) cites the case of leukemia in the gene-therapy clinical trial in Paris as reason for declaring a moratorium on all gene-therapy and gene-transfer trials. "We sympathize with the families who are going through this crisis and who were offered false

hopes by the medical community," says Sujatha Byravan, director of CRG. However, CRG notes, there is "insufficient ability" for targeting vectors being used in such procedures, and they can disrupt genes and upset cellular regulatory functions. The council also calls for "open distribution" of data describing adverse effects associated with such trials.

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## Poor crop management plagues *Bt* cotton experiment in India

Scientists in India are trying to figure out the ramifications of the growth of scores of illegal, untested, genetically modified varieties of cotton alongside legal varieties. Combined with a bad monsoon and the government's failure to educate farmers and regulate effectively, this is clouding an objective assessment of the first-year performance of GM cotton—a situation that could hinder future progress of the technology in India.

Farmers in five Indian states are cultivating Monsanto's (St. Louis, MO) *Bt* cotton on over 100,000 acres after India's Genetic Engineering Approval Committee (GEAC) gave the go-ahead in March to three hybrids developed by the company (*Nat. Biotechnol.* 20, 415, 2002). The seeds carry the *Bacillus thuringiensis* (*Bt*) gene and produce a natural pesticide lethal to the bollworm, a scourge of cotton fields worldwide. Farmers have bought *Bt* cottonseed at four times the price of traditional varieties in the hope it will bring them better returns.

Both the government and Mahyco-Monsanto Biotech India Ltd. (Mumbai)—the joint venture between Monsanto and Maharashtra Hybrid Company that sold the seeds—claim the crop is doing well. "The truth is that we have very positive feedback on Bollgard (*Bt* cotton) from farmers in all the cotton-growing states in the Centre and the South," Ranjana Smetacek, Monsanto's spokesperson, told *Nature Biotechnology*. "The agriculture ministry is happy, the evaluation committee is happy, and I can show you excellent photos [of the *Bt* fields] I have received," added Department of Biotechnology secretary Manju Sharma.

However, reports from non-government organizations (NGOs) suggest the crop is failing. Officials in Andhra Pradesh say that *Bt* cotton in the state is underperforming, and Gujarati newspapers have reported that there has been heavy bollworm infestation of *Bt* cotton, which was also found susceptible to leaf-curl virus and root-rot disease, and



Goskonda Chandra Reddy, who planted Monsanto-Mahyco's *Bt* cotton instead of rice, says bollworm attack is much less in the field than in the non-*Bt* variety he planted in the borders as refugia.

that in Madhya Pradesh, *Bt* cotton suffered greater damage due to drought than traditional varieties grown there.

One of the problems, according to both government sources and NGOs, is that local farmers are not meeting the many technical specifications—such as for refugia management and planting conditions—for *Bt* cotton, a relatively high-maintenance crop. Cotton farmers with very small land holdings, for instance, have found it impossible to set aside land for refugia, and only 40% of the total area of cotton is irrigated—which is causing problems this year because of a delayed monsoon. Prasantha Kumar Ghosh, a former advisor in the Department of Biotechnology, says *Bt* cotton is facing problems this season because of poor rains. "*Bt* cotton is input intensive, and our trials have clearly shown this."

Suman Sahai, convener of Gene Campaign, a Delhi-based NGO, and a visiting professor at the University of Heidelberg, blames the government and scientific community for failing to educate farmers about dangers of not following proper procedure. "We have consistently argued that any new technology must be

introduced only after farmers and consumers have complete information on all its aspects so that they can make an informed choice." Sahai says the government has still not placed in the public domain data generated by trials of *Bt* cotton in India. Devinder Sharma, anti-GM campaigner and director of the Forum for Biotechnology and Food Security (FBFS) in New Delhi, agrees. "The GEAC is solely responsible for hastily pushing the untested technology," says Sharma.

To make matters worse, several thousand acres—even in areas such as Punjab and Haryana where *Bt* cotton has yet to be approved—have been sown with second and third generations of a Monsanto knockoff known as Navbharat 151, according to Sahai. Last year, these seeds were covertly sold by the Navbharat Seeds Company and planted by Gujarati farmers on over 10,000 acres (*Nat. Biotechnol.* 19, 1090, 2001). Illegal *Bt* seeds (that the government failed to destroy) from last year's harvest in Gujarat have been flooding the market at one-tenth to one-half the price of legal seeds. First-generation seeds do not have the same vigor as the originals, and subsequent generations have even worse quality and yield.

The presence of so many varieties of *Bt* cotton "is making a public mockery of India's ability to regulate and direct the use of this new and controversial technology," says Sahai. "The government must recognize the chaos it has created and take corrective steps."

"The large quantity of untested and unauthorized *Bt* hybrid seeds are likely to cause losses, and farmers are likely to lose faith in *Bt* cotton, which would damage this useful technology," says Arvind Kapur, managing director of Numhens Proagro, which is getting ready to seek government approval for its GM mustard. However, A.S.N. Reddy, a senior official at Proagro, believes there is no need to panic. "In about two years the situation will stabilize," he said. "Once farmers realize the fake *Bt*-cotton varieties they use are no good, they will turn to the genuine ones."

Meanwhile, Mihir Shah, director of the Baba Amte Centre for People's Empowerment, and Debashish Banerji of the Samaj Pragati Sahyog (Nature and Society Cooperative), based in Madhya Pradesh, say: "This is obviously not a technology meant for the poor, dryland small farmers of India." Whether or not this is true will be determined from a full analysis by the Ministry of Agriculture at the end of the year, after the main harvesting season, which begins this month.

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