Relevance of modern technologies to Indian agriculture

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The five-point programme suggested by Swaminathan and Kesavan to 'End hunger, achieve food security and improved nutrition and promote sustainable agriculture' (UN Sustainable Development Goals (SDGs)) is unexceptional[1]. One understands the need for providing adequate calories, end protein hunger, overcome micronutrient deficiencies, access to clean drinking water and attention to imparting nutrition literacy to the community. However, it is surprising that the authors summarily dismiss genetic engineering technology as not sustainable based on a superficial analysis. The fact remains that introduction of *Bt*-cotton transformed this country from a cotton-importing destination to that of a cotton-exporting nation. One needs to analyse the reasons for its diminishing efficacy and ensure sustainability. The US National Academy of Sciences, Engineering and Medicine has produced a 420-page document on GM crops (Genetically engineered crops: experiences and prospects, The National Academies Press, Washington, DC, USA, 2016, doi: 10.17226/23395) after extensive consultations by a 20-member committee representing almost every branch of science and society. Among other findings, it has found that '*Bt* in maize and cotton from 1996 to 2015 contributed to a reduction in the gap between actual yield and potential yield under circumstances in which targeted pests caused substantial damage to non-GE varieties and synthetic chemicals could not provide practical control'. It goes on to state that 'The emergence of secondary pests and resistant pink boll worm in India is a typical example of the non-implementation of the refuge strategy. This has not happened in the US, since the high dose/refuge strategy is implemented'. Should we not be advocating use of appropriate cotton variety for a given soil, proper assessment of pest density, use of refuge strategy and ensure high *Bt* expression in the plant to delay resistance development? Should we not be implementing a package of integrated pest management using *Bt*-cotton to sustain long-term benefits, suggested by experts all along. Use of spurious seeds would only defeat the whole purpose. Genes are now available to combat infestation by minor pests transmitted by white fly, and their introduction can only happen if there is an incentive to pursue this line of research and field trials are permitted. A greater challenge is to have *Bt*-cotton varieties than hybrids, so that the farmers can reuse the seeds. While all other countries grow *Bt*-cotton varieties, India is the only country growing *Bt*-cotton hybrids. Although cotton yield is less in varieties than hybrids, this is more than compensated for by the fact that varieties lend themselves to be densely packed per acre compared to hybrids, the latter occupying more space per plant. While cotton varieties are short-duration crops, the farmers grow *Bt* hybrids longer to improve yield, but lend the plant susceptible to the secondary pests even with Bollgard (BG-2). Earlier, the institutions concerned messed up with the development of cotton varieties by allowing the Monsanto hybrid contamination. Only now, the Central Institute for Cotton Research, Nagpur, is talking about releasing both *Bt* and non-*Bt*-cotton varieties in a year or two. This emphasizes the fact that apart from commitment to generate the cotton varieties, there needs to be vigorous extension activity to advice the farmers regarding technology and help them to follow the protocols to reap the benefits. Left alone, most farmers would only spray more pesticides to control the pests without leaving any space for refuge and in the process create resistance even to BG-3. The story of *Bt*-brinjal is sad and comical. While its commercialization is still under embargo in India, Bangladesh has benefited by using the same clone and data generated in India to commercialize the crop with great success. The cultivation has been extended to 5000 farmers, despite efforts by activists to provide a negative story. I am sure *Bt*-brinjal would have crossed over to Kolkata! The story was the same with *Bt*-cotton. Farmers started cultivating clandestine *Bt*-cotton seeds in view of its pest resistance and higher yields, despite threat by the Government that such crops would be burnt down. The Government had no alternative, but to legalize cultivation of *Bt*-cotton! I guess history would repeat itself. GM banana with fortified beta-carotene and iron content that can save millions of children from vitamin-A deficiency, blindness and anaemia can become a reality. This technology was obtained from Queensland University, Australia, with the blessings of the Prime Minister himself. GM mustard can provide newer hybrids as never before, if permitted to move forward to make a dent in the huge edible oil import bill of the country. It is unfortunate that even a trial of the mustard DMH-11 is being prevented on the basis that it is a backdoor entry for herbicide-tolerant gene introduction. Actually, it will only facilitate newer hybrid generation, which has not been easy in a self-pollinating crop. The use of herbicide is only for selection purposes and not for application in the farmer's field.

I do see a silver lining in the editorial by Swaminthan and Kesavan[1]. The statement 'Among the various technologies based on predominance of natural evolutionary mechanisms, the induced mutation breeding using X-rays and gamma rays as well as an alkylating agent, ethyl methanesulphonate (EMS), is clearly the most sustainable from ecological, social and economic points of view', is welcome. I expect that based on this statement, gene editing using CRISPR-Cas would be acceptable, since it involves mutating the existing genes more precisely than the methods being adopted. The technology does not involve mobilizing genes from the outside. This technology, especially for application to agriculture is moving by leaps and bounds and I do hope our regulatory system would be ready to facilitate exploitation of modern technologies to ensure food and nutrition security to the burgeoning population. Agricultural scientists in India have demonstrated that they can move ahead with the newer technologies without the involvement of MNCs. The fact remains that they are depressed with the present situation. When do we see genuine support for technology? At this stage, one is not asking for commercialization of GM crops, but an opportunity for fair, comparative trials in the field. It is unfortunate that this is not happening because of powerful interests against the technology.

Large-scale analysis of data from authenticated reports covering a period of over 15 years has discounted engineered concerns on the health safety of millions of human and cattle consuming GM-corn or soybean across the globe. The unending debate has gone on for too long and use of newer technologies to sustain food and nutrition security can only happen through a political decision. While the debate for and against rages on, India continues to occupy the 131st position in human development index and 154th rank in healthcare access and quality index among 190 countries. GM technology or gene editing are not magic bullets, but powerful technologies that can make a difference, if applied on a case-by-case basis, followed by sound extension activity to help the farmer. When would the government wake up and take a bold step to move forward?

1. Swaminathan, M. S. and Kesavan, P. C., *Curr. Sci.*, 2018, **114**(8), 1585–1586.

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