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Cotton Exchange Building, 2nd Floor, Cotton Green, Mumbai - 400 033
Phone: 3006 3400 Fax: 2370 0337 Email: cai@caionline.in
www.caionline.in

Forty Years of Cotton Crop Protection in India

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Dr. Sandhya Kranthi, Ph.D, Entomology, IARI, New Delhi, is the Head I/c, Crop Protection Division at the Central Institute for Cotton Research (CICR) Nagpur, She has more than 25 years of experience in cotton crop protection.

GUEST COLUMN

Dr. Sandhya Kranthi
Head (i/c), Division of Crop Protection, CICR

The decade of Bt cotton (2002 to 2012)

Until the introduction of Bt cotton, production and multiplication of cotton seeds was largely produced by Government institutions and state agricultural universities. Public sector cotton seeds were popular especially in India and the seed price was just 1/10th of the input costs. Also varietal seeds that could be used year after year were popular. Bt cotton hybrid seeds were introduced in 2002 primarily for bollworm control. Inputs required for cotton production, including seed, were met by private seed companies of the country who rose to the occasion and benefitted financially from this move. Subsequently, a significant leap in cotton production was recorded. During 2001 India produced about 158 lakh bales, which increased to 243 lakh bales in 2004 and 345 lakh bales by 2011. However, it is interesting to note that the yield increase by 2004 was mainly due to the IPM/IRM strategies, new insecticides, new hybrids, and new area in Gujarat, in addition to 5.4% area under Bt cotton. The area under non-Bt straight varieties was about 55.0% in 2004 and non-Bt hybrids at 38.0%. Introduction of 2 gene product in the form of Bollgard II was being contemplated, during this part of the decade. At around the same time lateral flow immunodiagnostic kits were developed at CICR. The spurious Bt seed market had also proliferated as the cost of authentic single gene Bt was steep (Rs.1350 per packet of 450g). but with the help of the Bt detection kits developed at CICR, coupled with a reduction in the seed prices to about Rs.800, the spurious seed market was restricted.

In 2005, the Indian Government recognised CICR as the Bt Referral lab and judicial seed samples referred to this National Institute were tested for the presence or absence of Cry toxin gene. During the later part of this decade about one-third of India's production was derived from the state which has one-fourth of the cotton area. Clearly, apart from the contribution of Bt cotton, the increase in yield was due to other major changes in the decade. Perceptible changes included, implementation of IPM and IRM on a large scale by the Ministry of Agriculture and

ICAR, the introduction of some excellent cotton hybrids, increase in cotton area in Gujarat from 15 lakh ha to 26 lakh ha, increase in check dams and drip irrigation systems, increase in hybrid cotton area from 40% to 90% and introduction of 6-7 new effective insecticide molecules for bollworm control and sucking pest management. Crediting BT cotton alone with spectacular yield increases in cotton as is believed may not be true after all.

It was also the period when the government invested in the Technology Mission on Cotton where the focus of research was on the production of tangible, measurable outputs.

Importantly, networking of cotton groups was strengthened in the area of strategic research. Molecular approaches were adopted to resolve issues of pest diversity, insecticide resistance mechanisms and in studies on Cry toxin expression. Basic studies on the role of endosymbionts in cotton insect pests and endophytes on the cotton plant were initiated.

Researchers carefully studied the impact of Bt cotton and Indian cotton production was often taken up in case studies. Farmers adopted the Bt cotton technology whole heartedly in many countries, as in India, where the technology was introduced. Development of Bt detection kits, their IPR protection and smooth commercialisation and successful management of mealybug outbreaks in addition to management of endemic outbreaks of minor pests like the mirid bug on cotton were landmark achievements of the period.

Bt-cotton in India 2002-2010

Bt-cotton technology (Bollgard from Monsanto) was first approved in 2002 by the GEAC for commercial cultivation in Central and South Indian cotton–growing zones in the form of three hybrids (MECH-12, MECH-162, and MECH-184). Subsequently, the GEAC approved RCH-2 (Rasi seeds) in 2004, for cultivation in the Central and Southern zones. In 2005, another 16 hybrids were approved. The total reached to 20 Bt hybrids, with 6 for North, 12 for Central and 9 for South India. Realising the potential of the technology, several Indian seed companies acquired sub-licenses of the technology to acquire the rights to incorporate the cry1Ac gene into their own hybrids. In the year 2005, Bollgard II hybrids were introduced in the market and seed companies ensured that the single gene product, Bollgard carrying Cry1Ac was phased out of the market, primarily due to IPR issues. By 2010 Bollgard II hybrids dominated the market. It was also the year that pink bollworm incidence and damage was being reported by farmers of Gujarat and Maharashtra.

Baseline monitoring of susceptibility in insect pests was recognised as an important area of resistance research. In addition, funded programmes on the monitoring of changes in baseline susceptibilities to Cry toxins and new insecticides were initiated. Careful monitoring of changes in the pest and natural enemy fauna in fields was also carried out. Links within the cotton fraternity were strengthened through the All India Coordinated Research Improvement Project on cotton. Outbreaks of insect pests were closely monitored and managed. Strategies to manage pest outbreaks were funded by the Technology Mission. An advisory service was launched in 9 languages using voice mail message services. Taking into consideration the biotic and abiotic factors that were likely to influence cotton, advisory service was provided to registered cotton farmers in all the cotton growing states under the E kapas project of the TMC.

Cotton pest management underwent a radical change after 2000 all over the world. Novel eco-friendly insecticides that were highly effective on bollworms, *H. armigera* and other bollworms were introduced. Chemicals such as spinosad, indoxacarb, emamectin benzoate, novaluron and lufenuron ensured effective control of H.armigera while being less toxic to beneficial insects in the cotton ecosystem. The new molecules not only belonged to radically different chemical groups hitherto unknown, but were also required to be used atmilligram level per hectare. Interestingly, *H. armigera* infestation reduced significantly in cotton ecosystems from 2000. Reports of bollworm outbreaks became rare. It is not clear whether it was the introduction of Bt-cotton or the change in insecticide use pattern in Asia, notably the decrease in pyrethroids, coupled with increase in the new chemistries which impose fitness problems in residual surviving populations, which caused the change, but H.armigera populations rarely exceeded economic threshold levels in Asia, particularly in majority of the cotton growing regions of India. This period also coincided with the introduction and widespread use of chloronicotinyls and growth regulator diafenthiuron These new generation insecticides

Incidence of mealy bugs (Phenacoccus solenopsis) on cotton plant

Nymph of mired bug (Campylomma livida) feeding on cotton leaf

were selectively more effective on the sucking pests and less toxic to beneficial insects as compared to all the conventional insecticides thus aiding sustainable pest management.

After the introduction of Bt-cotton, following its widespread cultivation, associated with a consequent reduction of insecticide sprays, especially during flowering and boll formation phase, some minor pests (*Spodoptera litura*, mealy bugs, mirid bugs, thrips, jassids, weevils, etc), which are not susceptible to Cry1Ac, showed resurgence in many parts of the world. In India, the year 2007 recorded mealy bugs as a major biotic stress on cotton, including Bt cotton. Smart protection practices such as spot application of insecticides together with minimal interventions helped promote the efficacy of biological control agents thus putting an end to the mealybug epidemic on cotton in the country.

Magnified image of adult of thrips (Thrips tabaci) on cotton leaf

Pest management beyond Bt (2010-2017)

Cotton productivity from 2011 declined and fluctuated between 350-400 kg/ha. Several dramatic changes in cultivation practises were brought about to break the yield barrier in cotton despite 95% of the area being cultivated by Bollgard II. Alternative approaches based on scientific research and deductive logical reasoning were developed. Short duration Bt varieties with the single gene were being reintroduced in place of single gene Bt hybrids that were withdrawn in 2010. High density planting system was introduced for the first time in the country. The concept of cultivating compact short duration varieties/ hybrids was promoted to facilitate mechanical picking. Cultivation of desi cotton was re-introduced in areas where Bt cotton did not perform as desired. Identification of varieties suitable for surgical cotton was initiated. Research on mechanisation for picking of seed cotton was initiated. It was also the period when inefficacy of Bt against the target pest, the pink bollworm was reported for the first time in pockets of Gujarat, Maharashtra, Madhya Pradesh, Telangana, Andhra Pradesh and Karnataka. Whitefly outbreak was reported in North India in the year 2015. Delayed sowing, inadvertent promotion of susceptible Bt hybrids, indiscriminate use of insecticides singly and as mixtures were the reasons that caused this outbreak. Strategies on timely sowing of tolerant Bt hybrids was emphasised

Leaf curl virus damaged cotton plant

to curtail the whitefly and leaf curl viral disease. Use of insecticides early in the season and use of insecticide mixtures was discouraged. Smart thinking led to the correct placement of effective insecticide molecules in the crop window. For PBW management, cultivation of short duration BT hybrids, use of pheromones for mass trapping, mating disruption and monitoring was promoted. Avoidance of certain insecticides that made the crop attractive for pink bollworm incidence and damage was recommended.

The E-kapas project reached out with timely advisories to a large number of registered cotton farmers across the country in the vernacular language and the state agricultural universities had an important role in this programme spearheaded by CICR. The concept of refuge in bag, backed by scientific data generated through networking partners with external funding, was implemented by the Government as a result of which the Bt cotton farmer would have no choice in the planting of the refuge.

The benefits of RIB may be limited to delaying resistance, marginally, in *H. armigera* alone. Preliminary research on novel gadgets to determine the nutrient status of the plant or probable biotic stress was initiated. By and large, this was the golden period for cotton research and development in the country. Currently cotton pest management is acknowledged, based on scientific learning and reasoning, as an amalgamation of production and protection practises involving intelligent use of seed, soil, nutrients, pesticides and mechanisation.

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(The views expressed in this column are of the author and not that of Cotton Association of India)