Pest management for *Bt* cotton: Need for conservation biological control

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There has been rapid cultivation of transgenic cotton hybrids with myriad genes of *Bacillus thruringiensis* (*Bt*) singly, (*Cry 1Ac* – Mon 531 event and *Cry 1Ac* – event 1), and in combinations through stacking (*Cry 1Ac* and *Cry 2Ab* – Mon 15985 event) and fusion (*Cry 1Ac Cry 1Ab* – GFM event) in India. The area, number of hybrids and number of companies dealing with *Bt* cotton have risen from 0.038 mha, three and one in 2002 to 5.5 mha, 134 and 24 during 2007–08 respectively. The total change in cultivation profile is evident with the *Bt* hybrids constituting 58% of the country's 9.5 mha cotton area during 2007–08. The increased production and productivity of 270 lakh bales and 503 kg ha^{-1}, respectively, during 2006–07 over the pre-*Bt* benchmark year of 2001 when the area, production and productivity levels of the country were 8.6 mha, 158 lakh bales and 309 kg ha^{-1} respectively, signify the notable contribution of *Bt* hybrids in India.

Cotton hybrids expressing various endotoxins of *B. thruringiensis*, per se fitting into genetic or host-plant resistance and biological tools of integrated pest management (IPM) have given a new dimension and impetus to the IPM philosophy that aims to reduce the massive reliance on insecticides for pest management on the conventional or non-*Bt* cotton. Being a target technology for saving yield loss due to bollworms, *Bt* cotton would still succumb to yield loss due to the 'block' of sap feeders (jassids, aphids, thrips, whiteflies, mealy bugs, mirids and stainers) spread throughout the growing season, right from seedling emergence to harvest, that out-number the complex of bollworms on the crop. With the biotic potential of sucking pests being high, they are a potential threat to *Bt* cotton. Although the emergence of sucking pests is often fielded as an argument against the use of *Bt* crops, the opposite is true. *Bt* crop is effective against bollworms and the broad-spectrum insecticides to control them are no longer being used. Other insects, both harmful and beneficial, which were also once suppressed by these insecticides, are now seen increasing in their abundance.

Farmers are known to apply insecticides, irrespective of whether they have any potential to reduce the yields. This brings forward the first insecticide application of the season and reduces the number of natural control agents in the fields. This is the first step in the seasonal pesticide treadmill that results in the build-up of insecticide resistance within and between crop cycles in target insect pests, and also induce secondary outbreaks. Under field situations, aphids, jassids, thrips and whiteflies, in particular are seen as 'predator fodder' and as such have an important role to play as attractants to the ladybirds, lacewings, predatory bugs and spiders. Many of the predators have similar life systems as those of sap feeders and therefore compete for the same resources, viz. space and food, resulting in a situation unusual for heavy outbreaks of more than one type of insects on the crop. In general, low densities of all types of sucking pests are likely to be found at any time. The dominant species will be the one best favoured by the local source of infestation, the characteristics of a given crop stand and its management (variety, sowing date, pesticide and fertilizer regime, irrigation pattern, etc.), the spectrum of natural enemies, and the weather characteristics (rainfall, humidity, maximum and minimum temperatures, etc.) of a given season. The factors that influence insect build-up under man's control are many and dominant over the climatic forces that are largely natural.

Although the above features were similar in the pre-*Bt* period, biological controls were expected to play only a minor role within the context of IPM, if they could function despite chemical applications. If the biological control agents were unable to function in crops receiving insecticide applications, they were considered ineffective. It is to be stressed that the goal of the IPM on conventional cotton is to minimize the massive reliance on insecticides in crop-production systems to restore the lost pride of the natural ecosystems, including the native natural enemy abundance. Therefore, even with the constraints associated with augmentative biological control in terms of mass production, shelf-life, slow action and quality control, bio-intensive pest management was enforced. However, with *Bt* cotton at the centre stage, efforts to develop pest-control systems based on conservation biological control need utmost focus given the reduced insecticide use, changing pest scenario and re-establishing native natural control agents. An attempt to document the taxonomic diversity of arthropods of the current cotton ecosystems inclusive of *Bt* and non-*Bt* has indicated re-establishing native predators from different groups, viz. Chrysopidae (*Chrysoperla* sp. (*carnea*-group)) of Neuroptera; Lygaeidae (*Geocoris ochropterus* (Fieber)), and Miridae (*Deraeocoris* sp.) of Hemiptera, Coccinellidae (*Cheilomenes sexmaculata* (F.), *Brumoides suturalis* (F.) and *Scymnus castaneus* Sicaid) of Coleoptera, Syrphidae (*Ischiodon scutellaris* (Fabricius) and *Dideopsis aegrota* (Fabricius)) of Diptera and spiders from different families, viz. Araneidae, Clubiondae, Lycosidae, Oxyopidae and Salticidae of Arachnidae. These diverse groups of predators have greater potential to offer natural control of emerging sucking insects. Apart from increasing diversity, report of maximum abundance of coccinellids, chrysopids and syrphids on *Bt* over non-*Bt* cultivars, and IPM over insecticide-treated plots is available[1]. Given the current scenario, conservation of native natural entomophages at the forefront supported with strategic use of biopesticides and reduced use of synthetic insecticides without sacrificing crop yields and profitability, should be the agenda for overall pest management of the cotton production system. Transgenic crops through biotechnology, natural control of pests through biodiversity component of natural enemies, enhancement of natural enemy effectiveness through biosignalling for evergreen revolution[2], strategies to lure herbivore natural enemies[3] and need for 'Integrated Biodiversity Management'[4] have been the realm of recent research trends in pest management. However, the emphatic field research-cum-application relating to the natural enemy fauna awaits success. Therefore, it is not rational that the hitherto higher insecticide use against bollworms can be substituted by a fewer sprays against sucking pests, a trend that is seemingly capturing the fancy of researchers and farmers alike, currently. Like the use of insecticides requiring strategies for insecticide resistance management (IRM), *Bt* cotton cultivation has already elicited demand for *Bt* resistance management (BRM) for the target insect pests. IRM or BRM on any crop for polyphagous pest(s) although essential, is a limited and unidirectional approach with the strategies positioning the artificial interventions spatially and horizontally (refugia) or temporally (insecticide against late season bollworm) and vertically (stacking of genes).

The efforts and infrastructure to monitor the phenomena and in turn develop strategies would outweigh the designing of cropping systems to promote natural and renewable forces that keep the pests within acceptable bounds. Under Indian conditions, natural enemy-based pest management is still to become a reality due to the lack of systems perspective in crop management and mismatch between the needs and mandate towards addressing pest management issues on a fast track. In the context of changing pest problems due to changing cultivation pattern of cotton, protection practices and changing climate, prospects are high to exploit the simultaneously emerging natural regulators. This requires quick attention into determining the effects and efficacy, and mechanism of association besides formulation of conservation and enhancement methods for harnessing benefits in a cheaper and organic way. Inter-plant system using an alternative crop and spray of supplementary food for attraction and detainment of predators as potential components of IPM recommended in Australian cotton provide clues of possible success[5,6]. Under Indian conditions, the significantly increased activity of coccinellids, *C. sexmaculatus* and *Coccinella* sp. on cotton with cowpea as an intercrop in the irrigated south zone[7], and random planting of maize at a rate of 10% of cotton encouraging the predators of sucking pests[8], reported on conventional cotton, can form a recommendation along with transgenic cotton sucking-pest management. Meanwhile, immediate transitions and openings that permit strategic change towards conservation require the documentation of taxonomic diversity, abundance and their importance, strengthening of the information base through collation of historical records cum traditional knowledge, preparation of crop/production system/regional summaries and building of natural enemy-based IPM advisory system using conservation biological control. In addition, identification, characterization and economic evaluation of conservation practices in a cropping system mode, and addressing the critical areas such as formulation of specific policies for promotion of conservation bio-control, coordination of government policy on pesticides and other agricultural matters affecting biological control, developing strong leadership for conservation programmes with adequate resources and quality control, and effective execution, monitoring and evaluation are the need of the hour. The realm of conservation biological control needs immediate attention in *Bt* cotton pest management. An active approach to acknowledge the role of native natural enemies and promotion of their effectiveness through landscape ecology is the need of the hour, before embarking on recommending curative measures for sucking-pest management in the rapidly expanding area of *Bt* cotton.

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Himalayan seismic disaster management

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India is known for its high level of seismicity. A number of large-magnitude earthquakes (magnitude more than 8.0) have occurred in the country during the last few years[1–3].

The Geological Survey of India (GSI), after three years of field work, has reported that the probability of occurrence of a destructive earthquake of magnitude more than 7.5 in various districts of Uttarakhand is in the range 0.83–0.98. These probabilistic values, for a geological event such as an earthquake, could be taken as almost a certainty. Bapat[4] has discussed this observation. In addition, a number of researchers[5–7] have observed the possibility of occurrence of a strong earthquake in NW Himalayas. Most of these predictive observations, inferences and conclusions are based on seismic, tectonic and statistical analysis. All these efforts make it clear that a big jolt is imminent. Some efforts are being made to refine the observations. However, according to Freund[8] it should be realized that earthquake prediction is possible with the help of the non-seismic, non-geologic and non-geodetic approach. He has discussed electrical, magnetic, electromagnetic and atmospheric measurements for finding a reliable earthquake precursor or precursory situation. At present, the overall situation is that the NW part of the Himalayas in