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Arms race: *Bt* cotton vs bollworm

Bt cotton – cotton that is genetically engineered to produce insecticides – has for many years kept in check the voracious appetite of a certain larvae that has a particularly sweet-tooth for cotton: The pink bollworm larvae.

Indeed, the cultivation of *Bt* cotton has led to significant decreases in toxic pesticides and insecticidal sprays, thus hugely benefitting farmers. In fact, such has been the profitability of *Bt* cotton that India today has become the largest exporter, and the second largest producer of cotton. *Bt* cotton therefore has been a boon to the Indian farmer, who once could only stare helplessly as hordes of one inch long bollworms devoured their produce.

Unfortunately, today, after about a decade since *Bt* cotton was first introduced in Indian farms, the pink bollworm has evolved to become resistant to the toxins exuded by the *Bt* cotton: The bollworm has become a pest once again.

The toxins exuded by the *Bt* cotton plants are known to kill the bollworm via two complementary modes. Either the toxins compromise the cell membrane by forming pores; or the toxins induce apoptosis – programmed cell death. Studies today, however, report that in many countries across the world, the bollworm populations have fixed beneficial mutations that allow them to survive the siege of toxins exuded by the *Bt* cotton. What makes matters worse is that in some bollworm populations, the genes that conferred resistance to toxins, have now become homozygous dominant. This is bad news. Why? Because had the genes been recessive, then they could be silenced by introducing sterile bollworms in the afflicted area which would disrupt the native populations of bollworm.

Furthermore, studies show that in India, especially in Maharashtra, the *Bt* cotton, which had been genetically engineered to produce two different kinds of toxins, have now become ill effective to curb the depredations of the bollworm because the bollworm has become resistant to both these toxins. The evolutionary one-upmanship between *Bt* cotton – or for that matter humans – and the one inch long bollworm larvae has therefore taken a new turn in the 21st century. So, given the development of these recent evolutionary defences in the bollworm arsenal, how do we rein them in again, and counter their threat?

A Review Article, **page 1483**, endeavours to answer this question by delineating several pest management practices – such as the usage of complementary crop varieties; the development of the agronomic refuge technology; and also the controlled introduction of the natural predators of the pests into the farmlands.

Weaver ants: Nature's tailors

Today, biopolymers – polymers extracted from plants, animals, and even microorganisms – are being used extensively in several different fields. And why not? They are biodegradable, carbon neutral, and even sustainable. Examples of such biopolymers include mulberry silk, spider silk, polyhydroxybutyrate, polyactic acid, zein, etc. The list indeed is endless.

In recent years, one other biopolymer has entranced researchers world over. This biopolymer is particularly abundant in the forests of India: A silk fibre secreted by the indefatigable workhorses of nature – the weaver ants.

The weaver ants use this fibre to craft airborne nests dangling from the canopy, many feet above ground. Verily, this engineering feat is no mean task, and of all the ant species, the construction of the weaver's nest is by far the most complex.

First, chains of worker ants identify, snip, and bring together a cluster of young leaves. Once the leaves are in close proximity, the workers – by using their mandibles – scoop up the larvae from the queen's chamber and shuttle them to their new home. Simultaneously, during this careful transfer of their progeny, the workers squeeze the larvae, ever so gently, between their mandibles. Stimulated by this measured squeeze, the larvae secrete fine silk fibre that is used as a glue by the workers to weld the leaves firmly. Thus, the ants hold the larvae between their mandibles, and then move around the edges of the leaves, smearing the leaves with this glue. This to and fro motion between leaves is repeated until the leaves stick firmly, after which the remaining larvae are shuttled into their new homes. The labour of the weaver ants, however, does not cease; they quickly move to other leaves and continue to build and weave using the silk of larvae as mortar.

A Research Communication, **page 1545**, studies this silk of the 'weaver', and unveils some hidden properties. The silk, for example, is resistant to chemicals, and also boasts of a structure at the nano scale that is far more uniform than artificially made electro-spun fibres. Such properties of the fibre, this study notes, could make it a particularly useful substance to culture tissues; to synthesize drug delivery vehicles; and also to engineer functional prosthetic limbs.

Grassroots innovations in India

When one thinks of informal economy – daily wage labourers, farmers, fruit vendors, etc. – one assumes that the people employed in this sector are a burden on a country's economy because (i) they do not contribute to the country's GDP, and (ii) their income cannot be taxed. In fact, the informal sector is also known as the 'grey economy' because the monetary exchanges cannot be governed. The poorest sections of society eke out a living in this sector. One would therefore not be naive to assume that the people employed in the informal sector – considering their illiteracy and poverty – would not have the intellectual capacity to 'innovate,' to engineer patentable technologies. Nothing, however, can be further from the truth.

Indeed, if one were to stroll through the villages, one would realize that some of these 'informal workers' have engineered ingenious technological solutions to alleviate their woes. Bamboo processing machines; pesticide sprayers which double up as a bicycles; specially engineered pulleys which have a stopper and a lever arrangement that ensures one-way movement of the rope and bucket; check dams with a series of circular structures; sugarcane bud chippers that can separate more than 300 buds per hour – all are testament to the creativity of the informal worker. And it is particularly heartening to note that India is the first country to integrate this innovative potential of the informal sector with the formal sector by both, providing millions of dollars of funding to the inventors (helping many to become entrepreneurs), and protecting their intellectual rights by patenting their innovations.

A General Article, **page 1476**, delineates several governmental and non-governmental initiatives, and delves deep into the genesis of the support system for the 'informal sector' innovation in India.

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