Using nanotechnology to control pests: trapping fruit fly using pheromone gels

In a world where the human population is growing rapidly, the necessity for using chemicals to reduce crop damage from pests and to improve the yield increases. With many mouths to feed, it is not economically viable to practice organic farming methods on a large scale. With genetically modified crops being a controversial topic and under the scanner, scientists are constantly trying to develop new alternative solutions to keep pest infestations at bay. In most cases, the pests develop resistance to chemicals and the evolutionary arms race continues. More environment-friendly and economically viable options to tackle this problem are highly desirable in this regard.

The fruit fly *Bactrocera dorsalis* infests fruit crops like apple (*Annona squamosa*), banana (*Musa paradisiaca*), mango (*Mangifera indica*), orange (*Citrus sinensis*), peach (*Prunus persica*), plum (*Prunus domestica*) and guava (*Psidium guajava*) causing huge economic losses, particularly in the tropical countries. Each year 27% of India's mango yield is affected by fruit-fly infestation and has made a big dent in the country's economy due to ban on mango exports to USA, Japan and Australia[1]. In 2003, orchard owners in Punjab growing kinnow (*Citrus* spp.) lost 50% of their crop yield to fruit flies[2]. Several pest control methods have been tried to tackle the fruit-fly infestations, but all of them have been by and large ineffective.

The infestation cycle begins with the adult female fruit fly laying its eggs under the skin of the fruit (Figure 1). Once hatched, the larvae feed on the pulp of the fruit from within. This continues for ~9–35 days until the larvae metamorphose into the pupae. They undergo the pupa stage in the soil near the host plant and emerge as adults in 1–2 weeks, all ready to continue the infestation cycle. The affected fruits show signs of infestation in the form of small depressions on the surface (Figure 1). These infected parts become soft and pulpy and the fruits are shed prematurely even before they ripen. This not only leads to significant loss in crop yield, but also shortens the shelf-life and lowers the market price of the fruits.

A safe and inexpensive solution for tackling this problem, using pheromones in nanogels, has been found[3]. Pheromones are volatile chemical compounds secreted by a species to help it communicate with other individuals of its kind. Previously pheromones were combined with water-based gels (hydrogels), but this proved to be ineffective as the hydrogels either got evaporated due to exposure to heat and air or were washed away during monsoon. To overcome these hurdles, the authors[3] have developed a pheromone-based nanogel to attract and trap the fruit flies. Using advanced techniques based on supramolecular principles and nanotechnology, they have successfully developed a unique nanogel that is chemically, thermally and mechanically stable. This nanogel slows down the evaporation of the highly volatile pheromone methyl eugenol (ME) and protects it from the degrading effects of environmental factors like exposure to air, water and sunshine. ME is released by female fruit flies to attract the male fruit flies towards them. When tested alone, it was found that ME evaporated in less than three weeks. In contrast, the ME entrapped in nanogel was present for up to 30 weeks under ambient field conditions. Field tests were conducted in guava orchards to study the efficiency of the pheromone nanogel. In field, these nanogels demonstrated high residual activity, even during adverse weather conditions. Simple traps made from plastic bottles and containing vials of the ME nanogel (Figure 2) were suspended from the guava trees in a plot measuring 0.625 ha. This was done when the guava fruits were in the ripening stage and was continued until the fruits were harvested. The male fruit flies attracted by the ME gel entered the traps and were confined in the water column present in the lower part of the traps. The ME nanogel in the traps was found to be effective for nearly a whole month with a high efficiency rate in the first three weeks. As a result, the harvested fruits showed lesser signs of fruit-fly infestation.

The advantage of using pheromone-based nanogels is that they are easy to

Figure 1. The fruit fly (*Bactrocera dorsalis*) and a fruit-fly infested guava fruit (*Psidium guajava*). © Deepa Bhagat.

Figure 2. A fruit-fly trap with a vial containing the methyl eugenol nanogel. © Deepa Bhagat.

handle, reasonably priced and are needed in small quantities, unlike chemical pesticides which need to be repeatedly sprayed over a large area. The method is also environment-friendly, as at no time, is the nanogel in contact with the fruit. Since pheromones are species-specific, they do not harm other insect or bird species that otherwise frequent the orchards. Finally, these nanogels are neither highly volatile nor water-soluble like pheromone hydrogels and can last for a whole fruit-crop season. This study highlights the use of nanogels in the field of pest management and the scientists hope to find similar solutions to other pest infestations.

1. http://www.icar.org.in/en/node/1385 (accessed on 12 December 2013).
2. http://articles.timesofindia.indiatimes.com/2003-09-02/chandigarh/27196440_1_fruit-fly-horticulture-farmers (accessed on 12 December 2013).
3. Bhagat, D., Samanta, S. K. and Bhattacharya, S., *Sci. Rep.*, 2013, **3**, DOI: 10.1038/srep01294.

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MEETING REPORT

A step towards prevention of food losses*

A wholesome food is incomplete without requisite quantities of major nutrients (carbohydrates, protein and fats) and micronutrients (minerals, vitamins and phyto-chemicals). While fruits, vegetables and milk are the main source of minerals, vitamin and phyto-chemicals, the poultry and animal products like eggs and meat are the source of certain essential amino acids and proteins. Unlike cereals and pulses, all these are highly perishable food commodities.

After attaining self-sufficiency in food crops production by the 8th Five-Year Plan period, the focus of scientists and planners shifted to horticulture, which is essential for nutritional security. During the 9th–11th Five-Year Plans, horticulture took long strides placing India on the global map as the second largest producer of fruits and vegetables in the world. India harvested 223.089 million tonnes (mt) of horticultural produce from 20.876 m ha of land during 2011. The major crops contributing to this are fruits and vegetables (approx. 204 mt from 14.314 m ha area). Today horticulture accounts for 30% of India's agricultural GDP from 8.5% of cropped area. India is the largest producer of milk in the world with 127.9 mt of production in 2012 and globally is the fourth biggest egg producer. Paradoxically, 45.6% of children in this country are malnourished showing varying degrees of micronutrients deficiency. Over 33% of women have below normal BMI and one-fourth of the world's hungry live in India.

While the nation is debating on Food Security Bill and its economic feasibility, in its backyard millions of tonnes of fruits and vegetables are being dumped into dustbins. It is a nation which affords to lose around 30% of fresh fruits and vegetables after harvest and still be contented. Quantity wise this is more than the total production of fruits and vegetables in many smaller countries in the world. The FAO put the global food losses and wastages during 2012 at 30–40%. According to the FAO report, food losses are more in low-income countries and the food wastages are more in high and middle-income countries. In developing countries more than 40% of the food losses occur at post-harvest and processing levels, whereas in industrialized countries, more than 40% of food wastages occur at retail and consumer levels. In horticultural commodities, there are five stages at which post-harvest losses occur – production/harvest, post-harvest handling and storage, processing, distribution and consumption. Post-harvest losses represent a waste of resources used in production such as land, water, energy and inputs. Though a recent report of the Indian Council of Agricultural Research (ICAR), based on a country-wide survey, showed post-harvest losses in fruits and vegetables in the 5.77–18.05% range, it represented only quantitative loss, while with qualitative loss it is much more as seen in other research project reports from various other institutes/agencies.

As a mechanism for periodic and systematic collection of data on post-harvest losses is not in place, like in other countries, the planners and developmental agencies are unable to measure the impact of implementation of various schemes meant for the prevention of post-harvest losses in food crops in general and perishable crops in particular. N. K. Krishna Kumar (ICAR) and U. Venkateshwarulu (Ministry of Food Processing Industries) took stock of this situation in a recently concluded national workshop and planned a future strategy to document both the quantitative and qualitative losses in these perishables through their respective All-India Coordinated Research Programmes and make it available for researchers and planners.

Besides fruits and vegetables, dairy, meat and pountry products are the core items for food and nutritional security. Because these are highly perishable items, their production, post-harvest handling and trade affects the common population directly by influencing inflation. In the past also, several attempts were made to assess the extent of post-harvest/post-production losses in many crops and commodities to formulate strategies for minimization of losses and the information generated thereon was made use of too; but over a period of time it was considered to be obsolete due to various reasons. To keep pace with the advances in technology, there was a desire to revisit the issues and conduct a repeat study on assessment of post-harvest losses of major horticultural crops, animal and fishery products in India.

The workshop was inaugurated by S. Ayyappan (ICAR). Ninety participants, including several Directors of the ICAR institutes, project coordinators of All-India Coordinated Research Projects, Heads of Division, scientists and representatives from Mango Growers' Asso-

*A report on the National Workshop on 'Repeat Study on Assessment of Post-Harvest Losses of Major Horticultural Crops, Animal and Fishery Products in India' held at NASC Complex, New Delhi on 29 August 2013.