moisture stress through compensation and source–sink adaptation respectively, is a boon for higher output without any attendant remedial measures. With so many positive feedbacks of the system components, reexamination and reorientation of strategies for the ecosystem are the priorities in case of cotton farming. Ecosystem management incorporating off-cum-growing season habitat management through synchronization of soil, water, nutrient-oriented production practices, at farm and community levels, to enhance and fortify an unconditional balance among system variables, would result in sustainable qualities of a total system. The simple cultural practices under the growers' control, viz. timely crop termination resulting in closed seasons, compulsory crop rotations, sustenance of soil health through organic manure, proper field sanitation, adoption of cropping systems inclusive of crops with barrier, trap, indicator and refuge functions, careful selection of quality seeds of robust genotypes and timely (early) sowing form the foundation for management of the ecosystem. The approach of alternative and artificial system management using synthetic products should come in handy only to avoid the risk of greater financial loss at times of outbreak. The applied components of pest management on the crop using botanical, biological, behavioural or insecticidal methods should be based on the status of crop growth and development, that reflects the combined effects of innate and managed edaphic, micro and macroclimatic growing conditions, as against the pest numbers and damage levels as action thresholds. Such an approach not only accounts for the genetic response of the cultivar against insect pests, but also for the subtle role played by the native natural enemies in turn maximizing the built-in pest reduction features of an ecosystem.

The pursuit for ecosystem management through understanding of the dynamic variables of crops, pests, natural enemies, inputs, costs, returns and quality, with optimization approach through an interactive information system, would lead to powerful and long-term solutions for the ever-changing pest problems. Research programmes networked across crops and farms of a geographical region with multi-tasking objectives utilizing specialists and generalists of multidisciplines would lay a strong foundation for problem-solving. The stability of ecosystems depends on sustained efforts to find ways to modulate the system parameters to remain at equilibrium most of the time. When growth and development of cotton genotypes are the inclusive manifestations of edaphic, environmental (biotic and abiotic) and management factors, is it not appropriate to address the pest problems through plant health-based ecosystem management measures of production and protection? Management of sucking pests and bollworms based on crop symptoms and fruit retention levels respectively, is required for precision in cotton protection apart from the approach of integrated farming systems of cotton production incorporating decision-support systems.

S. VENNILA

Division of Crop Protection,
Central Institute for Cotton Research,
Post Bag No. 2,
Shankarnagar (PO),
Nagpur 440 010, India
e-mail: svennila96@gmail.com

An environment friendly cheap method to reduce coastal malaria in India

Malaria is one of the serious scourges inflicted upon humanity. It causes human mortality and morbidity along with great financial loss. Every year about 300 million people are estimated to be affected and a further 2400 million (about 40%) of the world's population threatened by the disease[1]. Malaria is endemic in India and active transmission has been reported from many areas. Bulk of the cases is found in the flood plains of northern India and coastal plains of the east and west coasts. The epidemiological situation in India in 2005 is as follows[2]: Population in malaria affected areas, 1044.7 million; number of reported deaths due to malaria, 963 persons; number of reported malaria cases, 1,817,093; *Plasmodium falciparum* percentage, 44.3 and established malaria vectors, *Anopheles dirus*, *An. minimus*, *An. philippinensis*, *An. culicifacies*, *An. stephensi* and *An. annularis*.

Bacillus thuringiensis is a Gram-positive, rod-shaped, spore-forming bacterium with mosquitocidal properties[3]. *B. thuringiensis* belongs to the *Bacillus cereus* complex that also includes *B. cereus*, *B. anthracis* and *B. mycoides*. In 1975–76, a WHO-sponsored project in Israel examined mosquitoes for the presence of pathogens as part of the development of biocontrol strategy against malaria vectors. During this survey, a new *B. thuringiensis* strain was discovered with high toxicity to mosquito larvae[4]. It was later characterized and designated[5] as *B. t.* var. *israelensis*, serotype H14. The rapid development of *B.t.i.* products for mosquito control resulted from the reported toxicity of synthetic insecticides in human and non-target organisms and development of resistance due to over exploitation. It has been noticed that when conditions for bacterial growth are not optimal, like many other bacteria, *B.t.i.* also forms spores. *B.t.i.* H-14 serotype dormant stage products contain spores and parasporal crystals. The parasporal crystal contains four major proteins – Cyt 1A (27.3 kDa), Cry 4A (128 kDa), Cry 4B (134 kDa) and Cry 11A (72 kDa) – in three different inclusion types assembled into a spherical parasporal body held together by a lamellar envelope[6]. Among these proteins, Cry 4 protein toxin is Dipteran-specific. All proteins are toxic to mosquitoes; however there appears to be a synergistic interaction between the Cyt1Aa and the Cry4 and Cry11 proteins, resulting in high toxicity to mosquito larvae.

Researchers in Peru have discovered a low-cost, eco-friendly weapon in the fight against malaria. Palmira Ventosilla (The Instituto de Medicina Tropical 'Alexander Von Humboldt', Lima) has developed a method for biological control of mosquitoes. In Peru, during the field evaluation of dormant spore forming *B.t.i.* H-14 serotype strain against mosquito larvae, *B.t.i.* were grown within fresh coconuts. At first fresh coconuts were taken and a cotton swab doused with *B.t.i.* dropped through a hole drilled in the coconut shell. The hole was plugged with cotton and sealed with candle wax. The hard-shell of the coconut protects the *B.t.i.* during incubation, while the coconut milk containing amino acids and carbohydrates provides the essential nutrition for the growth and reproduction of bacteria. After the coconuts had fermented for two or three days, they were broken open and thrown into a mosquito larvae-infested pond. Along with their regular diet of algae, the mosquito larvae ate the bacteria. The *B.t.i.* killed the larvae by destroying their stomach lining. It has also been reported from several studies that *B.t.i.* is an environment-friendly, naturally occurring bacterium which is harmless to humans and livestock.

There are several procedures to control mosquitoes by chemical, mechanical, genetical or biological means. Biological control of mosquito larvae by the application of natural animal products is one of the important techniques, which is cheap, easy-to-use and environment friendly. The above model can effectively be used to control coastal malaria in India and other countries where coconuts are easily available. It involves minimum expertise and is highly cost effective.

1. Sharma, V. P., *Indian J. Med. Res*., 1999, **75**, 1127–1140.
2. WHO, SEARO Report, India, 2007.
3. Das, P. K. and Amalraj, D. D., *Indian J. Med. Res.*, 1997, **106**, 174–197.
4. Goldberg, L. H. and Margalit, J., *Mosq. News*, 1977, **37**, 355–358.
5. Barjac, H. D., *Acad. Sci.*, 1978, **286**, 797–800.
6. Ibarra, J. E. and Federici, B. A., *J. Bacteriol.*, 1986, **165**, 527–533.

ANUPAM GHOSH

Department of Zoology,
Bankura Christian College,
Bankura 722 101, India
e-mail: anupamghosh75@yahoo.co.in

Farmers struggle for irrigation water in India's semi-arid region

Water is one among the greatest looming commodities of the 21st century. The conflict between the growing human population and the planet's unchanging supply of freshwater has already started and may get worse by the year[1]. Falling water tables are now common in India and also in China, Mexico, Thailand, USA, northern Africa, and the Middle East. Experts believe that water scarcity can become a security threat in the future[1]. Furthermore, there are 260 transboundary rivers worldwide posing potential conflicts over water and the use of water in one country can have an impact on another.

During January 2008, I visited Alawa village (population nearly 1000) in Jhalawar District, Rajasthan to study scarcity of irrigation water. Armed with diesel engines, farmers were seen aggressively pumping water from two check dams located in the Ahu River – a tributary of Kali Sindh, which originates in the northern slopes of the Vindhya in Madhya Pradesh. Check dams are small barriers built across the direction of water flow on shallow rivers to harvest water[2]. The water entrapped by the dam is primarily used for irrigation. Despite attempts over two decades by the farmers to persuade the local government to build check dams in the Ahu River, their efforts had failed. However, in 2006, the farmers convinced a local non-profit agency (Sadguru Foundation) on their desperate need for irrigation water. Subsequently, with the support of the Government of Rajasthan and matching funds from the Tata Trusts (Sir Ratan Tata Trust and Sir Dorabji Tata Trust), the foundation built two check dams, namely Alawa-I (length 179.55 m, height 2.97 m) and Alawa-II (length 249.35 m, height 2.47 m) at the cost of 75 and 82 lakh rupees respectively. As a result, the irrigation area around Alawa village increased by 500 acres, mainly due to the availability of 25 mcft of water stored by the two dams, ultimately benefiting 107 households (650 people). Farmers from neighbouring villages then started to compete for the same water source. I was astonished to witness farmers placing hoses for 3–6 km to transport water from the river (Figure 1 *a*). The intense competition for irrigation water resulted in draining even the last drop and some farmers even dug wells in the dried up Ahu River in pursuit of water (Figure 1 *b*). This shows the farmers' desperate need for irrigation water, especially in the semi-arid regions of Jhalawar District, which is one among the poorest and least developed districts in India.

Intrigued by the irrigation water saga, I participated in a village meeting of farmers to discuss options to solve the ongoing crisis. I was awestruck when the farmers came up with the following five major strategies to mitigate the water crisis: (i) source for low water consuming crops, (ii) set up regulations to restrict the use of water by farmers from adjoining villages, (iii) set up a committee to minimize irrigation water wastage, (iv) reduce the usage of private diesel engines and replace them with electrified lift irrigation system managed by the village cooperative, and (v) discuss with civil engineers how to increase the height of check dams to boost water storage. It showed how rural farmers could handle water crisis wisely using their invaluable knowledge of natural resources management in a scientific way. In fact, the farmers' strategic plan to deal with water crisis in Alawa village coincides with the recent comprehensive scientific assessment on water management in agriculture compiled by the International Water Management Institute, that calls for radical changes in the way the world produces food and manages the environment[3].

Later, I had a discussion with Sunita Chaudhary, the lead civil engineer who was involved in the construction of over 300 such check dams across western India. According to her, it would be possible to slightly increase the height of check dams without drowning nearby farms and damaging the river bank. She reiterated that numerous villages across western India face similar water shortages for irrigation, and building more check dams