productivity of vegetation and made a comparison of the same under ecosystems. We have neither indicated that the net productivity of the desert is in any manner high nor compared it with any dry matter measurement of any ecosystem. We mentioned 'that certain living organisms (both flora and fauna) grow and thrive well in sand dunes...'. Grow and thrive should not be interpreted as thriving vegetation or faunal life in the desert. We have also mentioned that the succulent plants of the deserts have a crassulacean acid metabolism of photosynthesis, which separates CO_2 absorption and its actual fixation in time. There are also data available to show that seed densities average between 5000 and 10,000 per m^2 in the Sonoran desert, USA and up to 20,000 per m^2 in the Sahara desert. (Deserts USA Newsletter: www.desertsusa.com/du_plantsurvive.html).

2. Water is a limiting factor for life, but life forms (odd bacteria algae) have been detected under the harshest conditions.

3. Regarding Maheshwari's comments on hydrogenase, he may refer to Reysenbach, A.-L. and Shock, E., *Science*, 2002, **296**, 1077–1082.

4. However, we appreciate the closing remarks of Maheshwari that '...although the "fast-depleting freshwater resources of the planet" are a matter of concern, and one may be delighted to see the role of thermophilic microorganisms being championed for innovative biotechnology for combating water scarcity, thermophilic bacteria are no exception to the dictum that no liquid water implies no life'.

1. Pushpangadan, P., Srivastava, S., Mehrotra, R. and Kochhar, V. K., *Curr. Sci.*, 2004, **87**, 1644–1646.
2. Radhakrishna, B. P., *Curr. Sci.*, 2004, **87**, 20–22.

P. PUSHPANGADAN

National Botanical Research Institute,
Rana Pratap Marg,
Lucknow 226 001, India
e-mail: pushpangadan@satyam.net.in

Bioengineering in biological control: Prospects and progress

Agricultural systems provide adequate opportunities for studies on herbivore-induced volatile organic compounds which influence herbivore location behaviour by natural enemies, enabling sizable reduction of herbivores. The intimate interaction between plants and natural enemies is known to act as a driving force leading to the production of adequate signals affecting the behaviour of natural enemies in a positive way[1]. With increasing awareness of the role of signal molecules in insect communication, attempts at biosynthesis of these molecules are gaining increased recognition by entomologists and plant pathologists engaged in the study of insect–plant interactions. Biosynthesis of these signal molecules has led to increased understanding of the utilization of these signals in the behavioural, physiological and morphogenetic responses of insects. With nanogram samples of these messenger molecules, it has become possible to isolate components from mixtures, enabling characterization of unknown natural products. The biosynthesis and isolation of compounds have become significant as in the understanding of the role of mono- and sesquiterpenes in the attraction of natural enemies[2,3]. Prospects of bioengineering them efficiently enabling plants to produce these compounds which attract an array of natural enemies are on the increase. The primary role of natural products is to enable plants to communicate with the environment, acting as toxins or biocides against insect and other plant species, besides acting as stress signals activating plant defence. Incidentally mention may be made of transgenic plants in which the metabolic engineering of cytochrome P 450 has resulted in improved insect resistance[4].

It is now known that many compounds released after herbivore damage are common to more than one species, while others are species-specific. While the green leaf volatiles or C_6 alcohols, and phenolics such as methylsalicylate are often detected, what has become more important is an assessment of the elicitor molecules in the oral secretion of herbivores. Two well-known compounds introduced by insect feeding are β-glucosidase and volicitin, the former from the regurgitant of *Pieris brassicae* caterpillar and the latter from *Spodoptera exigua*[5,6]. Since different herbivore feeding can induce different blends of volatiles, the need for identifying the large number of yet unknown compounds in oral secretions cannot be overemphasized. Interestingly enough, β-glucosidase triggers the same volatile release as feeding by the larvae. In the case of volicitin, a fatty acid–amino acid conjugate, its potency as an elicitor of maize isolates which attract parasites, is well documented. The wounding of plant tissues also results in the triggering of the octodecenoid pathway, resulting in the release of jasmonic acid[7], which serves as a signal for the expression of a number of compounds that contribute to plant resistance, besides activation of the oxidative burst involving polyphenol oxidases. As such the volatile blend to be introduced or enhanced should be chosen to closely match the major attractants known for the natural enemy species against which control has to be initiated. The need for synchronizing the release of terpene volatiles with the presence of herbivores is important, so that when modifying existing volatile release in a crop plant, the need for a herbivore promoter also becomes relevant.

While the genes encoding the biosynthetic steps are engaging the attention of molecular biologists, manipulation of the steps involved in the communication of C_5 units in the basic pathways such as the mevalonate pathway, becomes necessary. While the pathways are well known, precursors of terpene biosynthesis are now identified as geranyl diphosphate (for monoterpenes) and farnesyl diphosphate (for sesquiterpenes). Genes encoding both have been identified, the enzyme terpene synthesis converting them with mono- and sesquiterpenes. Needless to emphasize that it is the engineering of terpene synthesis that provides numerous opportunities to alter specific composition of terpene volatiles[8]. With these new and recent developments, the feasibility of engineering crop plants to emit readily detectable burst of terpenes to signal the presence of herbivores, is more. Recent discovery of volatile terpenes of plants that attract natural enemies, with progressive technology through bioengineering, may perhaps go a long way in harmonizing the full potential of biological control.

Incorporation of molecular techniques in ecological field studies has also shown the phenotypic effect of silencing genes. For instance, a reduction in volatile emission can also result from the effects of silencing genes affecting the attraction of natural enemies. This has been adequately demonstrated, enabling better assessment of function of a gene under field conditions[9,10]. Modifications of existing secondary pathways for defence by altering the level of expression of endogenous genes or inserting foreign genes from wild species, results in the augmentation or modification of phenolic production[11]. While information transfer between infested and uninfested plants is known, the possibility that plant roots release an elicitor that can induce the production of plant volatiles in another plant, has also been explored[12].

Identifying many more elicitors in different injured crop plants, as well as recent advances in microarray techniques could provide a more comprehensive view of gene expression patterns.

1. Dicke, M., Van Baaflen, P., Weesles, R. and Dijkman, A., *J. Chem. Ecol.*, 1993, **19**, 581–599.
2. Ananthakrishnan, T. N., *Curr. Sci.*, 1999, **77**, 33–37.
3. Ananthakrishnan, T. N., *Insects and Plant Defence Dynamics*, Science Publishers, Enfield, New Hampshire, 2002.
4. Morant, M., Bak, S., Moller, B. L. and Reichhart, D. W., *Curr. Opin. Bull.*, 2003, **14**, 151–162.
5. Mattiacci, L., Dicke, M. and Posthumus, M. A., *Proc. Natl. Acad. Sci. USA*, 1995, **6**, 2036–2040.
6. Pickett, J. A., Smiley, D. W. M. and Woodcock, C. M., *Adv. Bot. Res.*, 1999, **30**, 91–115.
7. Staswick, P. E., *Plant Physiol.*, 1992, **99**, 804–807.
8. Degenhardt, J., Gershenzon, J., Baldwin, I. T. and Kessler, A., *Curr. Opin. Biotechnol.*, 2003, **14**, 169–176.
9. Kessler, A. and Baldwin, I. T., *Science*, 2001, **291**, 2141–2144.
10. Dicke, M., Joop, L. A., van Loon and Jong, P. W., *Science*, 2004, **305**, 618–619.
11. Pickett, J. A., Wadhams, L. J. and Woodcock, C. W., *Agric. Ecosyst. Environ.*, 1997, **64**, 149–156.
12. Dicke, M. and Digkman, H., *Biochem. Syst. Ecol.*, 2001, **29**, 1075–1087.

T. N. ANANTHAKRISHNAN

Flat 6, 'Dwaraka',
22, Kamdar Nagar, Nungambakkam,
Chennai 600 034, India
e-mail: ananththrips@yahoo.com

Lymphatic filariasis eradication programme

The eight sister states in the Northeast, i.e. Assam, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalya and Sikkim, have a tropical climate with luxuriant moist and deciduous rainforest. This environmental condition is ideal for breeding mosquitoes, leading to epidemics like malaria, lymphatic filariasis (LF), Japanese encephalitis and other mosquito-borne diseases. Low socio-economic conditions, difficult terrain, limited health facilities coupled with poor surface communication specially during long monsoon periods, pose major challenges in providing health services.

LF caused by nematode parasites *Wuchereria bancrofti* and *Brugia malayi*, is one of the leading causes of permanent and long-term disability in humans. Mosquito vectors, mainly *Culex quinquefasciatus* and swamp-breeding species of *Mansonioides* transmit LF in the country. India alone accounts for 40% of global burden of this disease. About 450 million people in more than 18 states/union territories of India and belonging to about 257 districts are at risk of infection.

Assam contributes more than 94 lakh people who are at risk of filarial infection; 360,000 microfilarial carriers and 90,000 diseased persons to the national pool[1]. There is an increase of 10,000 microfilarial carriers during a period of one year. Both forms of LF (*W. bancrofti* and *B. malayi*) have been reported from Assam in earlier surveys[2]. Filarial survey conducted amongst labourers working in tea gardens and local population endorsed the earlier findings that high microfilaria and disease rates in tea labourers were recorded compared to local indigenous population[3]. However, Raina *et al.*[4] has reported a decline in *B. malayi* infection from the southern part of Assam. Regarding chemotherapeutic studies, literature retrieval revealed only one reference of drug trials against bancroftian filariasis using diethylcarbamazine (DEC) alone in a tea garden setting[5]. Thus the tea worker community is not only the main sufferer from LF, it is also responsible for transmission and propagation of filarial infection.

Most of the tea labourers whose ancestors originally migrated from high filarial endemic states like Orissa, Andhra Pradesh, Bengal, Bihar, Kerala and Uttar Pradesh during pre-independence era to work as labourers in various tea estates, are still living in densely populated labour lines within the tea gardens or in close vicinity of tea factories and remain isolated from other indigenous population. Now they are dispersing in all the possible tea-growing areas instead of living in isolation and confining themselves to the existing old tea estates, because of the fact that tea leaf plucking and processing requires skilled workers and the existing workforce in Assam is being recruited in all newly created gardens across other states. In other words, along with tea workers, LF is now reaching newer niches. Further, *Cx quinquefasciatus*, the main vector of LF, is ubiquitous.

Studies conducted in Pondicherry, Shertallai and elsewhere in the country had shown that man-days loss due to filarial fever, acute attack and chronic clinical manifestation is huge and exerts significant impact on the socio-economic condition at both state and national levels. In the tea garden set up of Assam and Tripura, where tea output is directly related to work output, man-days loss due to filarial fever, acute attack and clinical manifestation must be enormous.

Researchers have found that single annual regimen of DEC at the dose of 6 mg per kg body weight, if given as mass therapy alone or in combination with albendazole