alone. Extrapolation of the data indicated that about 0.1 million people may be suffering from arsenical skin lesions in North 24-Parganas alone[2]. Studies conducted by UNICEF and Jadavpur University showed that 14 districts in Bihar, 11 districts in Uttar Pradesh, two each in Assam and Chattisgarh and one in Jharkhand display large-scale arsenic contamination[3].

Almost in every home in the northern district of Bangladesh, there is a child or an adult suffering from a mysterious disease. Many have died and the villagers have lost count of the casualties, most of them small children[1]. The symptoms are frightening: watery eyes, chronic indigestion, colds and stomach cramps in the early stages and swollen limbs with bleeding gangrene-like wounds in severe cases. This silent killer is arsenic which has contaminated the drinking water of many villages in northern Bangladesh.

Phytoremediation, the use of plants to help clean up toxic waste sites, is not only a growing science but also a growth industry[4]. Researchers have created an engineered *Arabidopsis* plant that safely takes up the toxic arsenic element, and hope to use it to restore soils that are too contaminated for human use[5]. Once arsenic is concentrated in the leaves or stems of plants, the plants can be harvested cheaply and incinerated safely. Genetically engineered, deep-rooted perennial trees are well suited to remove arsenic from soil. So far no plant which is capable of absorbing the arsenic from deep soil has been designed and proved effective outside the laboratory. Plants (trees) carrying the genes for detoxification of mercury present in polluted soil have been developed and it has been proved that these plants absorb mercury from the soil and vaporize it effectively to the atmosphere in non-toxic forms[5]. People are using the engineered Indian mustard plants (*Brassica juncea*) to clean up selenium deposits in California's Central Valley[6]. Drinking water throughout the North Indian region has been contaminated by soils polluted naturally and by spills and drainage from factories. There is an urgent need to develop and apply phytoremediation technology using genetically engineered plants to decontaminate the polluted soils and water bodies in India. This will be effective in bringing new resources and technology to solve environmental problems, and in India human resource expertize in biotechnology is not lacking.

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NEWS

MEETING REPORT

Emerging technologies in resistance dynamics in insect–plant interactions*

Inaugurating the meeting on Resistance Dynamics, the Vice-Chancellor of the University of Madras, S. P. Thyagarajan outlined the various strides made in the field of biotechnology and opined that genomics and genomic medicine form the interface between environmental risks and environmental protective factors. He mentioned that proteomics and functional genomics find relevance in every field of science. He also indicated that emerging fields of science such as nanosciences and nanotechnology are reliable tools in the diagnosis of ailments. K. V. Peter (Vice-Chancellor, Kerala Agricultural University, Thrissur) in his keynote address dwelt on the beneficial aspects of insects to man, as also the chemical inputs involved in the resistance of crop plants against insects. S. Natesh (Department of Biotechnology, New Delhi) in his special address discussed the economic, ecological and ethological perspectives of insects and commented that the loss of yield in crops by insects should be viewed seriously. He said that transgenics should be a part of IPM technology and efforts should be made to convert biotechnology into economic wealth.

Introducing the theme of the discussion meeting, T. N. Ananthakrishnan said that insect-resistant cultivars provide a substantial or sound approach to crops with constitutive resistance possessing genetically inherited traits and induced resistance occurring when the defence system of a plant is stimulated by external physical or chemical stimuli. The effects of insect-resistant cultivars are cumulative; the longer the insect-resistant plant genes are employed, greater the benefits with decreasing amounts of wild germplasm available for using many crop plant species. It becomes all the more necessary for better preservation of existing global plant crop germplasm collection. Interdisciplinary research between entomologists and plant breeders would certainly augment diversity, enabling collection of new genetic materials that can be incorporated into diverse crop plants. Additional types of insect resistance genes sources such as *Bt* genes, lectins, proteinase and amylase inhibitors have

*A report on the VI Discussion Meet on Resistance Dynamics held on 2 December 2005 at COSTED, Chennai.

come into use and such transgenes, when expressed, impart high insect mortality. Efforts are also being made to combine conventional and transgenes to result in more stable resistance. The use of DNA markers to select insect-resistant plants using RFLP has enabled better assessment of the role of insect resistance genes in crops such as rice, wheat, pulses, etc. Many opportunities for interdisciplinary research to identify and develop new sources of resistance are emerging with the cooperative effects of biochemists, entomologists, geneticists, molecular biologists and plant breeders.

It is visualized today that crop plants could be bred for more induced resistance through adding genes which provide such resistance into crop genomes, where they have not occurred in nature. Breeding programmes for crops could select plants that exhibit high levels of induced resistance against herbivores. Further prospects for using genetically engineered crops are exciting, because the resistance traits can be fused to promoters so that they can be made to express only following an attack. Plant breeders and molecular biologists could plan to switch to induced resistance, since at the molecular level such traits increase variability. Inducing plant defences with elicitors and with transformed plants that induce novel genes for induced resistance, prospects for an effective means of pest control are promising.

K. S. Mohan (Monsanto Research Center, Bangalore) indicated that resistance development is a complex phenomenon involved with several genetic and environmental factors. Key among them are natural frequencies of resistance alleles, dominance of the trait, mating and migratory behaviour of moths, natural mortality factors, susceptibility to insecticides, fitness cost for single/multiple resistance mechanisms, feeding habits and extent of availability of host crops and biology of pests. Many of these parameters can be invoked into the Hardy–Weinberg equilibrium for determining the frequency of resistance alleles in the population. A model of resistance development has been proposed by researchers. In general, such models can help us understand (i) interaction among the parameters, (ii) prioritize the parameters based on weightage to resistant development; (iii) pinpoint critical future research areas. Laboratory-generated data on the parameters need to be fed into the model with utmost caution because of lack of complete knowledge on how these parameters interact in nature. Any extrapolation of laboratory-data model to field situation needs to be realistic.

Speaking on the genetic engineering of terpenoid pathways in crop plants for better resistance and enhancing parasitoid activity, R. S. Annadurai (Vittal Mallya Research Foundation, Bangalore) suggested that agricultural biotechnology has opened up many novel ways of managing pests. Manipulation of the response dynamics of crops seems to be a reliable biotech strategy in order to harness the full potential of biological control in modern agriculture. Volatile organic emissions with characteristic blends are often released by crop plants due to insect feeding. These volatiles have a tendency to attract parasitoids and predators towards the grazing species, offering relief to plants that are under attack. Oral secretions from feeding insect species have been known to trigger volatile release. Majority of volatile compounds released after herbivore damage are monoterpenes and sesquiterpenes, which are released only after insect injury and not due to mechanical injury. Composition of insect-injured volatile blends is influenced by factors such as the type of injury, herbivore species, developmental stages of the herbivore and nature of the elicitor molecule in herbivore saliva. Agricultural systems are aimed at reducing chemical pest control. Therefore, inputs should employ strategies to lure herbivore natural enemies. Several signalling pathways, including jasmonic acid, salicylic acid, ethylene and hydrogen peroxide orchestrate the induction of defences. A self-defending crop plant could mean many things in terms of environmental safety, safer food and better productivity, he said.

Highlighting the role of biotechnology for enhancing host–plant resistance to insect pests, S. Mohan Kumar (Tamil Nadu Agricultural University, Coimbatore) opined that host–plant resistance is the most important tool in pest management, which reduces pest abundance through antixenosis, antibiosis and tolerance. Natural plant defence mechanisms have economical and ecological benefits. A better understanding of the mechanisms and genes involved in resistance would allow insect resistance breeding programmes. There is clearly an urgent need to present molecular biologists, crop breeders and plant protection scientists across the world with the large selection of genes conferring biotic stress resistance in acceptable agronomic backgrounds, together with the tools and knowledge to effectively manipulate these genes. This would involve both transgenic and DNA marker technologies together with the knowledge of resistance mechanism and their interactions with the environment. It will lead to the development of crop cultivars with durable resistance to insect pests. Through this approach, insect-resistant transgenic lines to manage many insect pests were developed with *Cry* genes of *Bt*, protease inhibitors, alpha amylase inhibitors and plant lectins.

In crops like cotton, rice, maize, tomato, tobacco, potato, rapeseed, etc. promising results were realized. Transgenic crops, however, may succumb to a threat of resistance development to the toxins because insect populations are able to acquire resistance after repeated exposure to *Bt* toxins. The diamondback moth is notable as the only pest to evolve high levels of resistance in the field as a result of repeated use of *Bt* formulations. Altered toxin binding, reducing the affinity of *Bt* toxin for the brush border membrane of midgut epithelium, has been identified as a primary mechanism of resistance. An effective insect resistance management programme must consider numerous factors, including characteristics of the product, target-pest biology, the pest complex and crop system. The lack of response on field resistance even after eight years after the introduction of transgenic crops provides an opportunity for us to preserve *Bt* and other novel insect-resistant crops.

S. Uthamasamy (Tamil Nadu Agricultural University), speaking on the dynamics of transgenic *Bt*-cotton in the management of the bollworm, indicated that *Bt*-cotton contained the gene *Cry1Ac*, which provides resistance to cotton bollworm *Helicoverpa armigera*. One of the expectations was that expression of the *Bt* protein would be consistent throughout the growth of the crop and consequently, control of the target pests would be provided almost the full season. The *Cry1Ac* gene is driven by a promoter which gives constitutive expression in all tissues in the plant, although there are significant differences between plant structures in the level of *Bt* protein production.

Some secondary plant products, such as phenolics and orthoquinones produced or increased by plants during periods of physiological stress or physical damage

altered the efficacy of *Bt* crystal proteins against noctuidae larvae, he observed. The expression of toxicity varied with plant parts, leaves expressing higher toxicity than the reproductive tissue, viz. squares and bolls in Indian hybrid; toxicity of *Bt* gradually increased from 50 to 90 days after sowing and decreased when the plant aged (120 and 150 days after sowing). Further study also indicated that the toxicity of *Bt*-cotton varied in different geographical populations of *H. armigera* in South India and such variations in susceptibility to *Bt*-cotton may lead to development of resistance in it.

Renee Borges (Indian Institute of Science, Bangalore) talking on the implications of host plant resistance argued that inducible defences have arisen because they are costly and are hence deployed when required. However, other benefits of induced defences such as reduction of negative effects on predators and parasites, also need to be considered. The recent elucidation of inducible jasmonic acid and salicylic acid pathways in plants has brought in their wake considerable expectation that they can be successfully employed in agriculture. Application of methyl jasmonate to above or underground plant parts has been shown to elicit the induced defence pathways in a localized or systemic fashion and to mimic the response to natural plant wounding by herbivore attacks. This might be considered a boon to the agricultural sector and an example of a natural pesticide. The acquisition of induced resistance costs may be expressed as reduced number of flowers or number of fruits set or a longer period of fruit ripening, which might be critical in areas where fruit development is also sensitive to climatic conditions. Whole genome expression profiling using microarray technology has provided a means for examining the crosstalk between the various stages of plant defence from the perception of attack by herbivores or pathogens to the downstream components of the defence cascade. Such profiling, coupled with cleverly designed experiments, is needed to understand the true implication of a fixed versus plastic response. The jasmonic acid pathway has effects beyond that of just elevating resistance. An interaction model should also include feedback from the plant strategy onto the herbivores as well as the third trophic level consisting of parasitoids. These findings are especially required in this age of technology when disease resistance genes of varied origin and of varied position in the signal transduction cascade can be transferred into plants to create transgenic lines.

Discussing the ecological risks of genetically engineered crops, H. C. Sharma (ICRISAT, Hyderabad) said that genetic engineering of crops to confer resistance to insect pests offers an environment-friendly method of crop protection. Impressive results have been obtained with the expression of *Bt* and other toxin genes for insect control in several crops, and over 60 million hectares are currently planted with transgenic crops. However, development and deployment of transgenic crops need to address issues related to their impact on the environment and the risks, including (i) risks for animal and human health (toxicity and food quality, safety, production of allergens, and development of resistance to antibiotics); (ii) risks for agriculture (development of resistance and evolution on new insect biotypes, development of super weeds, possible alternation of nutritional values, performance limitations and insect sensitivity, increased susceptibility to non-target pests, and loss of biodiversity); (iii) risks for the environment (persistence of gene or transgene products in the environment, effects on non-target organisms, increased use of chemicals, and unpredictable gene expression); (iv) risk of horizontal gene transfer (genetic pollution through transgene or promoter dispersion, transfer of foreign gene to microorganisms by recombination–transcaptidation, complementation, etc.); (v) interactions among different genetically engineered organisms; (vi) social and ethical issues, and (vii) unanticipated consequences. There is need for a more responsible public debate on the environmental impact of transgenic crops and better presentation and the benefits of growing transgenic crops for pest management for a rational deployment of genetically transferred plant for sustainable crop reduction.

Speaking on the 'Decade of insect-resistant transgenic crops', T. M. Manjunath (former Director, Monsanto Research Center) said that the year 1996 heralded a new era in insect pest management, as three insect-resistant transgenic crops, incorporated with modified genes that produce insecticidal proteins derived from the soil bacterium *Bacillus thuringiensis*, have received due recognition. India entered the transgenic world in March 2002, with the regulatory approval of *Bt*-cotton containing *Cry1Ac* for the control of cotton bollworm. The area planted with *Bt*-cotton in India was 29,415 ha in 2002, 86,240 ha in 2003, 5,30,800 ha in 2004 and about 12,00,000 ha in 2005. The benefits from insect-resistant transgenic crops included significant increase in crop yields owing to effective control of target pests, drastic reduction in the application of chemical insecticides, conservation of biological control agents as well as other beneficial organisms and considerable increase in net profit to farmers. The technology has not caused any untoward incidence with regard to environmental safety and pest resistance. The year 2005, he observed, marks the beginning of the first decade of large-scale cultivation of transgenic crops in multiple countries. A critical analysis was made on safety assessment, risk management, global adoption, environmental and economical benefits, and their role in integrated pest management, future prospects as well as some of the challenges faced.

Prasanth Jacob (Institute of Forest Genetics and Tree Breeding, Coimbatore), speaking on the possibility of using insect resistance in forest trees, indicated that research on the potential of host tree resistance and its effective utilization in forests to raise phenologically superior trees is gaining momentum, particularly with reference to teak and poplars. In addition to variation in the levels of primary and secondary chemicals, variation in leaf surface cuticular properties of teak clones in imparting resistance to the teak defoliator and skeletonizer has been evident. The study of biochemical basis of resistance and its influence on the natural enemies may prove to be of greater importance to wood plants. Resistance to insects is one of the basic objectives in tree improvement programmes carried out by tree breeders and geneticists.

K. P. Sanjayan (G. S. Gill Research Institute, Chennai) indicated that resistance induction in plants is a novel strategy to combat insect attack. He discussed the *Lycopersicon esculentum*-herbivore system as a useful model in studying plant response to insect attack in view of its having five inducible proteins in the foliage, viz. two major proteinase inhibitors and three oxidative enzymes – polyphenol oxidase, peroxidase and lipoxygenase. The rapidity, duration and spatial extent of induction of a given phytochemical determine what organisms are affected by the chemi-

cal, requiring mapping of the response temporally and spatially. In this effort, the results were interpreted in terms of spatial induction, variability and persistence of induction responses through different damage treatments.

S. Chelliah (formerly of the Tamil Nadu Agricultural University), in his closing remarks mentioned that modern research in biotechnology should be convincing to farmers, whose acceptability of the research is vital. He traced the origin of 'Ponni' variety of rice and how it got accepted by the farmers in particular and the public in general. The need for farmers' education in regard to various aspects of pest monitoring and pest management is equally important, he observed.

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MEETING REPORT

International Symposium and IABMS Annual Conference 2005*

There is increasing appreciation about the relevance of the holistic system of medicine. This has augmented scientific interest in medicinal plants and herbal products. India has a vast reservoir of medicinal plants and a long tradition of using herbal products for healthcare. It is therefore important to secure a better understanding of medicinal plants and herbal products in the treatment of diseases and in enabling healthier life.

For the above-mentioned reasons, S.N. Pradhan Centre for Neurosciences, Calcutta University (CU) had organized a symposium. Participants came from all over India and abroad.

Debjani Guha (S. N. Pradhan Centre for Neurosciences, CU) in her welcome address stated that considering the huge natural resources in India, development of modern medicines from plant sources is essential. Potential therapeutic components can be developed from these resources by collaborating in the field of herbal research. Besides herbal drugs, there is widespread use of botanicals as medicinal products in developing countries. Such products are becoming a part of the integrated healthcare systems in industrialized nations.

Dhrubajyoti Chattopadhyaya (CU) in his keynote address stated that India, with its vast traditional knowledge base of herbal usage for medicinal and other purposes, is ideally posed to enter the world market in a positive manner.

In the plenary session, Uma Roy (CU) speaking on 'Psychopharmacological profile of psychometric and indigenous drugs with special reference to their antiagressive properties', stated that drug control of violence has been the subject of great interest due to recent advances in psychopharmacological aspects of violence and aggressive behaviour. Since acceptable parameters of neuropharmacological screening are yet to be determined, several experimental schedules have keen adopted to evaluate the efficacy of psychoactive psychopharmacological agents, including herbal medicines on different animal models of aggression.

In another plenary talk, A. K. Singh (DRDO, Delhi) spoke on 'Radiotracers in drug development'. Nuclear medicine is a frontline diagnostic imaging modality available at the tertiary level of healthcare system. Apart from direct functional imaging of body functions, quantitation makes it possible to obtain dynamic parametric information not possible by any other non-invasive system. Nuclear medicine imaging is based on complexation of a chemical (or a drug) with a suitable radioactive element which is then called a radiopharmaceutical. However, the only stringent requirement of radiopharmaceuticals (chemicals or drugs), he stated, is that radioactivity should not dissociate *in vivo* from the parent chemical and that the biological/chemical activity of the radiopharmaceutical should not be significantly different from the present compounds.

Debjani Guha (S. N. Pradhan Centre for Neurosciences, CU) spoke on 'Stress hypertension and effect of tea'. She described in detail the study of the effect of black tea extracts on stress and hypertension in both animals and humans.

A. Subramoniam (Tropical Botanical Garden and Research Institute, Palode), spoke on 'Promising plants in the development of new life-saving drugs for viral and fungal diseases'. According to the speaker, in the absence of satisfactory drugs against most of the viral diseases, ethno-medical folklore medicinal plants used in India, for the treatment of viral diseases, appear to be promising for development of safe and effective drugs. He described in detail recent studies carried out in his institute that have brought to light the potent *in vitro* antiviral activity of active fractions from *Ocimum sanctum* leaf and *Rhinacanthus communis* leaf against herpes simplex virus, measles virus, coxsackie virus and polio virus.

In the oral section, Rimi Hazra (Emory University, Atlanta, USA) spoke on studies on two herbal plants, *Acorus calamus* and *Moringa oleifera*, on behaviour, brain monoamines, etc. exposed to hypobaric hypoxia. Her talk included assessment of the influence of these medicinal plants on hypobaric hypoxia by behavioural, electroencephalographic study and brain monoamines estimation.

E. Murugan (University of Madras, Chennai) spoke on isolation, structural characterization of new flavonoids from *Allium cepa* and their biochemical activity. The structures of compounds established by extensive use of UV–Vis, IT–IR, FT–NMR and ESI–MS techniques were depicted in detail by the speaker.

The poster session included topics on 'phenolic group content of plants', development of databases for the fruits available at Kodaikanal, antimicrobial activity of selected medicinal plants, etc.

A workshop on modern techniques in neuroscience research was also organized within the seminar entitled 'Dr Sarada Subramanyam Workshop'. The items that were demonstrated included stereotoxic localization and histochemical identification of different brain areas, biochemical and molecular techniques for neurological disease diagnosis and behavioural studies in humans and animals.

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