

using linear elliptic equations, and topological invariants in Yang-Mills nonabelian gauge theories which are nonlinear elliptic equations, the importance of the index theorems can be realized, which essentially relate the analytic index with the topological index of elliptic complex over manifolds.

The proof of the APS was presented by B. L. Sharma (Allahabad). L. Rodino (Torino) discussed asymptotic expansion of the heat equation for quasi-elliptic operators, while P. Panarese (Bologna) found asymptotics of the L^2 -unbounded operators on a class of non-compact Riemannian manifolds. R. Sharma (New Haven) gave a talk on contact Riemannian manifolds. H. Pedersen (Odense) presented his group's work on hyper-complex manifolds. That quantum-state space may be Weyl-Kahler was proposed by S. C. Tiwari (IONP). S. Pattanayak's (Bhubaneswar) talk was on the Toeplitz operators.

R. D. Carmichael (Wake Forest) reviewed generalization of the Hardy H functions, and H-J Glaeske (Jena) presented a survey on the convolution structure of Hermite transforms, M. W. Wong (York) on localization operators on the Weyl-Heisenberg group, M. Nagase (Osaka) on Garding's inequality, P. K. Jain (Delhi) on imbeddings of Sobolev spaces and several contributions on these topics were included in the session on analysis. Colombeau's generalized functions were the focus of attention in the review by M. Oberguggenberger (Innsbruck), and J. Schmeelk (Virginia Commonwealth) introduced Stieltjes transforms in the study of these functions. Microlocal filtering with orthonormal wavelets was discussed by R. Ashino (Osaka Kyoiku).

Modern trends relating to computers in mathematics and application-oriented research was reflected in the opening remarks of H. P. Dikshit (M. P. Bhoj Open Univ.). Most of the papers presented by Indian institutions were on

the applied mathematics, however there were good contributions on geometry and analysis too. Patodi's teacher S. N. Lal and class-mate I. K. Khanna shared their reminiscences with the audience during the inaugural function. Convener of the conference R. S. Pathak and the sponsoring agencies NBHM, CSIR and UGC/BHU deserve appreciation for conceiving and making this event possible. It was intriguing that in spite of the key role of geometry and topology in the current fundamental physics, there was no presence of physicists in this conference. Perhaps it would be a rewarding exercise to organize a conference on APS and Physics exclusively.

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MEETING REPORT

Biotechnology of plant protection: Application and technology development: A report*

A national symposium on 'Biotechnology of Plant Protection: Application and Technology Development' was organized by the Mycology and Plant Pathology group of the Centre of Advanced Study in Botany, Banaras Hindu University. The 3-day long deliberation centred around eight major themes: (1) Genetic engineering and plant protection; (2) Biochemical and molecular approaches to plant defence mechanism and immunization; (3) Plant pathogens: ecology, biology and epidemiology; (4) Molecular identification and detection of plant pathogens and diseases; (5) Biotechnology and biocontrol:

new options; (6) Forest/post-harvest technology; (7) Plant protection and emerging technologies; and (8) Biotechnology: Basic and applied aspects.

The opening lectures were delivered by Anupam Varma (IARI, New Delhi), Paul Bridge (University of London, UK), A. N. Mukhopadhyay (Assam Agriculture University) and B. L. Jalali (Haryana Agricultural University). Varma elaborated upon the emerging trends in biotechnology of plant protection, Bridge highlighted the use of 'molecular markers' in understanding the epidemiology of fungal plant pathogens, and Mukhopadhyay dealt with the role of biotechnology in management of plant diseases in agriculture, especially within the framework of integrated disease management system. Jalali discussed the role of molecular biology in plant disease management in the next millennium. Rakesh Tuli (NBRI,

Lucknow) deliberated upon the commercial release of genetically engineering plants for durable pest management and the need for studying variations in insect populations, spontaneous frequency of native resistance genes, type of dominance, migration and mating behaviour of insects and computer simulation of population dynamics-based knowledge strategies for the lasting release of transgenic plants. Sunil Mukherjee (IARI, New Delhi) gave an account of molecular characterization of UIMYMV genome and viral replicase with emphasis on possible use of *Rep*-DNA to induce viral resistance. K. Narayanan (Project Directorate of Biological Control, Bangalore) highlighted the impact of molecular biology and genetic engineering aspect of insect viruses with emphasis on their efficient utilization in pest management. D. V. Amla (NBRI, Lucknow) delivered a lecture on

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'Development of transgenics of grain legumes for improved resistance to insect pests'. R. P. Thakur (ICRISAT, Patancheru) spoke about the application of marker-assisted back crossing to transfer all downy mildew resistance quantitative trait loci (QTLS) to a common genetic background and discussed in general about the pathogen variability and QTLs for downy mildew resistance in pearl millet. The prospects of biotechnological application of microbes for protecting plants through alleviation of environmental stress effects were covered by Aruna Mishra (Utkal University). The current status of biotechnological approaches to crop protection in *Phytophthora* foot rot disease management was presented by Y. R. Sarma (Indian Institute of Spices Research, Calicut). N. Ramon (University of Madras) discussed the role of mycorrhizae in biocontrol of plant pathogens and mechanism of disease control. A. R. Podile (Hyderabad University) dealt with the current status of the role of chitinolysis by biocontrol agents and the prospects of improving their efficiency. H. S. Chaube (G. B. Pant University of Agriculture and Technology, Pantnagar) discussed the impact of soil and plant factors in population dynamics, PGPA and biocontrol potential of *Pseudomonas fluorescens*. Delivering the Young Scientist special lecture, S. S. Sandhu (R. D. University, Jabalpur) talked on the molecular biology of entomopathogenic fungi for control of insect pests. The 'biocontrol' session was followed by poster sessions. The evening session had two invited lectures under the theme 'Biotechnology: Basic and applied aspects', which were presented by M. S. Manocha (Brock University, Canada) and Z. K. Khan (CDRI, Lucknow).

On 26 February, during two concurrent sessions the lectures delivered were on the themes 'Biochemical and molecular approach to plant defence mechanisms and immunization against pests' and 'Molecular identification and detection of plant pathogens and diseases'. These lectures focused attention on pathogenesis-related (PR) proteins in plants induced by various pathogens and their molecular signals, management of rice and sugarcane by selection of transgenic system(s) and PR-proteins, biochemical and molecular basis of hypersensitive response during pearl millet downy mildew host-pathogen

interaction, technology development of antiviral agents using viral resistance-inducing proteins in host plants, significance of putative resistance determining gene(s) in developing viable strategies for disease, identification and utilization of resistance gene(s) against spot blotch of wheat, use of different molecular detection techniques in the identification of plant pathogens based on species/strain-specific DNA probes, identification and classification of phytoplasmas using molecular tools, molecular aspects of mollicute interaction with insect and plant, utility of immunological techniques for early detection of fungal plant pathogens, molecular biology of rice tungro viruses from India and its application in disease diagnosis and control, and molecular strategies in developing transgenic plants utilizing various viral genes in rice. The invited lectures were followed by oral and poster presentations ranging from transgenic plants for pest resistance to mechanism of resistance to biological disease management and the molecular mechanism(s) of microbe-microbe interactions. During the evening session on the theme 'Plant protection and emerging technologies', three invited lectures were delivered. These lectures drew attention to application of genetic engineering for management of virus and virus-like pathogens infecting citrus, importance of natural products of microbial origin in developing resistance in crop plants, role of siderophore-producing microorganisms in the biocontrol of important crop diseases, and molecular biology of sub-family *Bigaminiviridae* and disease management strategies with special reference to cotton leaf curl virus.

A special plenary/round table discussion on the theme 'Plant protection in the next millennium' organized by B. L. Jalali, had M. N. Khare, H. N. Verma, A. K. Sarbhoy, V. K. Gupta, P. Bridge and R. P. Thakur on the panel. In the beginning the panelists presented their ideas on plant protection in the next millennium. This was followed by opinions expressed by a large number of distinguished delegates concerning: (1) Seed health as measure for plant protection; (2) diagnosis and plant pathological clinics for disease management; (3) modern taxonomy employing molecular techniques; (4) application of informa-

tion technology in plant pathology to bridge the communication gap; (5) human resource development in the new areas like molecular plant pathology, cloning of genes for resistance to produce transgenics; (6) development of commercial biological control and IPM for disease management; and (7) exploration and patenting of micro-organisms for plant disease control. It was felt that these aspects need more emphasis in this millennium.

On 27 February, there were four major sessions run concurrently. The 'forest/post-harvest technology session' comprised two keynote and three invited lectures. The deliberations were on ectomycorrhizae and their biocontrol potential, management strategies of apple scab by disease forecasting, post-harvest/forest plant pathological problems; protection of tree seedlings against soil-borne fungal pathogens by ectomycorrhizal (EM) fungi, seed quality control as disease-free seeds plant quarantine system, and application of biotechnology in forestry with a case study of sandal wood.

A concurrent session on 'Plant pathogens: ecology, biology and epidemiology' had a keynote address by U. P. Singh, who presented a detailed account of losses to farmers by powdery mildew of pea and also the various facets of the disease with emphasis on measures control. This was followed by lectures on the potential of indigenous VAM isolates on growth and development of tomato in Zambia, ascospore germination in *Sclerotinia sclerotiorum* and its pathogenesis in cruciferous hosts, and management of insect pests on cotton crop by mycopesticides.

In a session exclusively devoted to oral presentations, 10 papers were presented. These were on variability in *Rhizoctonia solani* responsible for sheath blight of rice, detection of plant diseases using an innovative technique of Photoacoustic Spectroscopy (PAS), characterization of variability in *Fusarium oxysporum* f. sp. *pisi* from Himachal Pradesh using RAPD analysis, PCR-RFLP analysis of IGS region of *Fusarium oxysporum* f. sp. *ciceris*, molecular techniques for identification of citrus greening disease, development of transgenic strains of entomopathogenic fungus *Nomuraea rileyi* for bio-management of tobacco caterpillar (*Spodoptera litura*), effect of biopesti-

cides on head mould pathogens and the role of seed and nutrient quality of sorghum, molecular analyses of antifungal antibiotics by *Bacillus thuringiensis* (*Bt*) and other species based on primer synthesis specific to *zmaR*, application of siderophoregenic fluorescent pseudomonads and their application to increase (18–20%) the yield of groundnuts.

The best paper award was presented to B. R. Sarosh (University of Mysore). The best oral presentation award was given jointly to A. Chakraborty (BARC, Trombay) and Amita Singh (G. B. Pant University of Agriculture and Technology, Pantnagar). The best poster award was presented jointly to S. Kim (Institute of Agricultural Research, South

Korea) and S. R. Khandelwal (North Maharashtra University, Jalgaon).

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COMMENTARY

Future challenges in food grain production in India

R. R. Daniel

The overall performance in food grain production in post-independent India, spurred by the Green Revolution, is worthy of the highest admiration. Notwithstanding, the trends in grain (rice, wheat, coarse cereals and pulses) production over the last decade portend a wide variety of major challenges and compulsions to meet the accelerating demands in about 20–30 years. Yet there is no clear expression of governmental action for a long-term strategy and integrated action plan to match the severity of the unprecedented challenges and the exploitation of emerging technologies. The purpose of the present note is to bring together these challenges to highlight how important it is to understand and surmount them in order to increase our future grain production.

Food grain production

India's food grain production has an impressive record of growth from a mere 50 million tonnes (mt) in 1950 (population: 360 million) to 200 mt in 2000 AD (population: 1 billion). This growth, kick started by the Green Revolution, lost its momentum during the 1980s. In retrospect we have learnt that the energy-intensive Green Revolution relying primarily on a few high yielding crop varieties is unsustainable and that it has polluted and exhausted the soil–water system. During the 1990s, in spite of good monsoons year after year, the growth rate of grain production halt-

ingly rose by 1.7% per year compared to 2.6–3.5% during 1960–1980 (ref. 1) while the population grew at 1.9% (ref. 2). Further, a worrying factor is that over the last four years, the annual production is hovering close to 200 mt only. These days we rightly take pride that we are self-sufficient in grain production. But we must not forget that hidden in this statement is the fact that it is at the cost of the hunger of 350 million of our people in poverty.

Agriculture and national development

An important factor closely linked to grain production in India is that 70% of our vast but economically weak population is dependent on agriculture. It is therefore evident that if we are to elevate their standard of living, it can only be through productive agriculture augmented by non-farm employment and human development. Thus genuine self-sufficiency in food grain production and poverty alleviation are intrinsically linked. Sustainable national prosperity will be jeopardized if the farm sector does not receive its due priority from the government.

The challenges

Population

Currently, our population is one billion and we are growing at the rate of 1.9%

per year. For the year 2025, the UN Medium Projection is 1.392 billion. It is clear that, in future, the grain demands will depend strongly on how well we control population growth.

Grain land

Land is a fixed resource. The gross cropped area in India is 191 million hectares (m.ha) and the net cultivated grain area is only 124 m.ha². Although over the last 10 years the cultivated grainland area has hardly increased, it is widely believed that it may shrink in future due to soil erosion, urbanization and human settlements, commercial agriculture, laying new highways and rural road networks and migration of farm labour in search of employment. The high population density, rural poverty and scant pasture land for the 450 million heads of livestock² also bring pressure on the land and forests. Furthermore, it is important to note that the per capita arable land available in India dipped from 0.36 ha in 1960 to 0.2 ha in 1990 and is forecast by Population Action International Report 1995 to decrease alarmingly further to 0.12 ha. For comparison a Western type diet including pasture land requires 0.5 ha per capita³.

Soil degradation

The Green Revolution has degraded the soil–water system and depleted the soil