S. K. Satheesh awarded the American Geophysical Union's Devendra Lal Memorial Medal

Professor Devendra Lal, was a distinguished geophysicist and earlier Director of the Physical Research Laboratory. His work spanned diverse areas of the Earth and Space Sciences. He is best known for his role in founding and developing the field in which cosmic rays produced isotopes on Earth are used as tracers to investigate a wide range of Earth science problems.

The American Geophysical Union (AGU) recognizes individuals for their exceptional achievements, outstanding contributions, service to the scientific community and attainment of eminence in the field of Earth or Space Sciences. The AGU instituted a medal in honour of Prof. Devendra Lal in 2016. This medal is presented every year in recognition of outstanding Earth and/or Space sciences research by a scientist belonging to, and working in, a developing country.

The medal for the year 2017 has been awarded to Professor S. K. Satheesh, Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science (IISc), Bengaluru for his outstanding contributions to the understanding of the climate impact of atmospheric aerosols. He is a pioneer in aerosol research in India. He innovatively combined satellite data with field experiments and numerical model simulations to show that aerosols can alter the natural hydrological cycle and cloud properties. The influence of elevated aerosol layers on the onset of monsoon in India has been demonstrated by him through several aircraft field campaigns. He also recently showed that elevation of black carbon to the stratosphere has serious implications on ozone depletion. Using multistage polarization techniques, he has pioneered the design of a small satellite to measure and assess the impact of aerosols on climate. He has also devised an angular scattering instrument to study the role of aerosol mixing, which is vital for modelling studies. Satheesh collaborates with many national and international scientists, mentors, several students at IISc and is also the Chairman of the Divecha Centre for Climate Change.

MEETING REPORT

Agronomy for evergreen revolution*

The 4th International Agronomy Congress was inaugurated by M. S. Swaminathan (World Food Laureate). The Congress took note of the fact that today's agriculture is challenged by climate change, land degradation, loss of biodiversity, food and energy crisis, and population explosion. To liberate the developing world, especially South Asia and Africa, from the twin scourge of hunger and poverty, we need strategies for and greater investments in natural resource management (NRM) innovation-led, accelerated and sustainable agricultural growth, with emphasis on resource-poor smallholder farmers. It was recognized that the task of achieving zero hunger was daunting but not insurmountable, and agronomy can and has to play a major role in realizing this goal. Agronomic research, facilitated by good-quality science and tackling practical problems of farmers individually and collectively, is essential to enhance productivity and raise farmers' income. The strategies for sustainable NRM include scientific land-use planning, conservation agriculture, precision agriculture (water, nutrient and weed management), contract farming, organic farming, farming systems approach, climate smart agriculture, and strengthening collaboration and partnerships for up-scaling technologies.

All these issues were covered in the deliberations under the detailed agenda of the Congress that comprised of 4 evening lectures, 8 plenary presentations, 4 special sessions, a panel discussion, and 12 symposia with keynote addresses, lead and rapid-fire presentations. In the inaugural session, three textbooks, viz. *Climate Resilient Agronomy*, *Modern Concepts of Agronomy*, and *Weed Science and Management* were released. Besides these, special issues of the *Indian Journal of Agronomy*, *Indian Journal of Fertilisers*, *Indian Farming* and *Kheti* were also brought out. The Congress was attended by more than 1000 participants from 22 countries.

The major recommendations that emerged out of these deliberations, with implications for research, development and policy are presented below as the 'Delhi Declaration: Agronomy for Evergreen Revolution'.

(1) It was recognized that agronomy has served the world community in the past by ensuring adequate food and nutritional security. However, in view of the emerging problems, there is a need for reorienting our strategies to achieve the zero hunger challenge. This requires a paradigm shift in our research and development agenda as well as policy support.

(2) For making agronomic innovations relevant to the present needs of farmers, systems research is essential to replace traditional agronomic research. To understand the likely effects of future climate on the current and alternative management practices, cropping system models such as Agricultural Production Systems Simulator (APSIM) enable comparison of alternative cropping

*A report on the Major Recommendations of the Fourth International Agronomy Congress and Delhi Declaration 'Agronomy for Evergreen Revolution' organized under the theme 'Agronomy for Sustainable Management of Natural Resources, Environment, Energy and Livelihood Security to Achieve Zero Hunger Challenge' from 22 to 26 November 2016 by the Indian Society of Agronomy in collaboration with the Indian Council of Agricultural Research, New Delhi.

systems and quantifying their value across different metrics.

(3) The Green Revolution of the 1960s involved seed-based technology with proper agronomic management. However, considering the level of natural resource degradation, food and nutritional insecurity, the Evergreen Revolution must be based on farming system commodities. Meeting the goal of sustainable food security necessitates development of alternative cropping based on the natural endowments of different regions and needs of the local communities. Integrated farming system comprising crops, horticulture, livestock, fisheries, and other secondary activities has great potential for increasing farm income by 3–4 times in irrigated regions. Farming systems are highly location-, household-, resource- and management-specific. Appropriate statistical methodology, tools and sustainable farming system indicators need to be developed. Technical support, access to credit and markets, and risk management are essential for promotion of integrated farming. There are several success stories in this regard, which must be replicated for wider impacts.

(4) Agricultural diversification and value addition can substantially increase farm incomes. There should be development of value chains and linkages of farmers with markets. This requires more investment, access to post-harvest technology and quality raw material. Enhancing productivity, risk management and promotion of value chains also require addressing the issues of last-mile delivery of services through horizontal and vertical linkages with different institutions. Diversification should be technology- and market-driven. Digital technologies and modelling are valuable tools in these efforts. Value-tagging to ecosystem services has to be taken into account in the overall assessment of system productivity and economics.

(5) Agriculture contributes to greenhouse gas (GHG) emissions, which have great implication for climate change impacts. The projected impacts of climate change on agriculture pose a serious threat for future food security. Climate-smart agriculture is key to sustainable agriculture, providing resilience to farmers and reducing GHG emissions. Agronomic practices, such as conservation agriculture focusing on reduced tillage, legume-based diversified cropping system, and recycling of crop residues that lead to reduction in carbon footprint and increase in carbon sequestration *in situ* should therefore be promoted. Towards mitigation strategy for climate change, the technology of direct-seeded rice holds promise in saving of scarce water resources and reducing cost of production. Landscape-modelling, regional weather forecasting and decision support systems have to be promoted. Climate-resilient technology modules and climate-resilient village models have been developed by ICAR-NICRA (National Innovation in Climate Resilient Agriculture), and the stage has come to bring them onto larger platforms. The revision and updating of the contingency plans should be given high priority.

(6) Using strong research-based strategic planning, conservation agriculture (CA) systems need to be promoted in all major production systems, particularly rainfed and hill ecologies where soil loss is predominant. It should be integrated as a core component of national agricultural development plans for sustainable intensification in all major cropping systems. Since CA is a herbicide-based practice, management of weed seed banks needs more emphasis over other weed control practices. CA has produced several success stories, but adoption by farmers is slow. Site-specific refinement is needed, which should be done with the involvement of farmers. A multi-stakeholder CA platform should be established at the national and regional level (like rice–wheat consortium) to serve as a knowledge repository, monitoring and evaluation centre, and policy think-tank.

(7) Integrated in-season drought management system, with components of agro-advisories, drought-tolerant cultivars, efficient rainwater management and strategic use of water with efficient delivery systems, is essential for enhancing the resilience of rainfed/dryland farmers.

(8) Agronomists and plant breeders should work together to develop new plant types and assess stable yielding genotypes with climate-smart traits. The NRM requires technologies for appropriate soil management, integrated water management and farming systems for the identified promising genotypes to perform in diverse environments.

(9) Satellite imagery, if available at low cost, can leapfrog the application of precision nutrient management strategies in smallholder systems. Concerted efforts are needed to integrate near real-time imagery with nutrient management approaches to provide in-season flexibility to achieve productivity and profitability under climate change scenario.

(10) Awareness on water-saving technologies with the aim of getting ‘more crop per drop’ has to be promoted. Use of wastewater in a safe manner for shrubs and timbers, either straight or in conjunctive use with blue water, is a promising way of sustainable agricultural production. Techniques for the use of modern irrigation systems, including subsurface drip irrigation system, need to be perfected. Low-cost wastewater treatment technology, which is energy-efficient, should be further evaluated and popularized.

(11) For hill ecosystem, effective conservation (for soil, water and biodiversity) technologies focusing on integrated farming system through participatory and convergence approaches need to be promoted for food and nutritional security, and livelihood improvement of small and marginal farmers. To promote organic farming in hill ecosystem, emphasis should be given for assessing effective microbial consortia for efficient biomass recycling for sustaining soil health.

(12) Adoption level of reclamation process of problem soils (i.e. sodic, saline, acid) is slow due to non-availability and costly amendments. Location-specific, problem-based innovative technologies such as land configuration, stress-tolerant genotypes, furrow liming with reduced dose, seed pelleting/coating, and use of nanoparticles need to be introduced for exploring sustainability and better adoption.

(13) Coastal ecosystem is vulnerable to climate change and needs to be protected. Therefore, to conserve coastal ecosystem and improve the livelihood of coastal farmers, integrated farming system with special emphasis on agroforestry and fish farming needs immediate attention.

(14) Evidence-based agronomy, and meta-data sharing and analysis is a new area for collaboration and development of necessary expertise to meet the zero hunger challenge. There is a need to share and publish quality datasets, and train young scientists and students in data stewardship, systematic reviews and meta-analysis.

(15) Efficient scaling of delivery of new technologies to the farmers is essential for achieving the desired impact.

Innovation-led, business-allied, service-centric, foresight-based, multi-linear technology delivery and adoption models should replace or complement the existing public sector-led extension systems. However, skill development and confidence-building among stakeholders is required to achieve the last mile delivery.

(16) Besides food security, nutritional security is an essential element in the zero hunger goal. Producing nutrient-rich crops (food and fruit crops) and vegetables would go a long way in the sustainable diversification and intensification of cropping systems. Promotion of cultivation of pulses and leguminous vegetables through creation of 'pulse villages' supported by 'pulse Panchayats' is an important step. Agronomists have also to identify under-utilized crops that are rich in nutrients and niches in the cropping systems where they could be introduced. Additionally, use of protected agriculture with hydroponics, aeroponics, vertical farming, etc. in the urban and peri-urban areas would help in providing nutritious food.

(17) There are serious gaps in understanding the skill needs of the agricultural sector. Therefore, a mission mode approach is needed to identify and prioritize the skill needs, and institutionalize these in imparting knowledge to the youth. Agriculture needs quality youth, but the current AR4D (Agricultural Research for Development) agenda is an incremental innovation and not attractive to them. Therefore, there is need for transformational innovation through transdisciplinary and trans-stakeholder approaches at different levels, i.e. redesigning agricultural education system for entrepreneurship, and not just for research and extension. Vocational training, inclusion of agronomic education in school curriculum, especially on climate-smart, organic farming and farming system-based farmers' participatory approach for technology generation, transfer and adoption are needed to ensure faster growth in agriculture.

(18) In order to promote the development of farmers-led skills as well as protect their rights, it is necessary to recognize and further promote these innovations. It is also desirable to blend the farmers' innovations with modern scientific knowledge and properly upscale them for the benefit of the farming community.

(19) Farmers' income can be doubled by adoption of integrated approach involving new aboitic and biotic stress-tolerant genotypes, low-cost, efficient, water harvesting technology, timely inputs and credit support, nutrient scheduling on the basis of soil health card, and smart mechanization of agricultural practices. Therefore, large-scale demonstrations on integrated approaches involving farmers are necessary to achieve this target.

(20) A standing committee was constituted for holding the dialogue for the next International Agronomy Congress in a country other than India in order to make it a global event.

To realize the above goals, we the agronomists of India and elsewhere hereby adopt the Delhi Declaration and resolve to work together with all stakeholders for sustainable management of natural resources, environment, energy and livelihood security, to achieve the zero hunger challenge.

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MEETING REPORT

Challenges and knowledge gaps in ecological sciences*

As a science, the subject of ecology is relatively young, although India's ecological concerns are rooted deep in our civilization as evidenced in Vedic literature. In the modern context, the subject has grown enormously and many potential areas have been identified. However, there are still a number of challenges and knowledge gaps. A symposium was organized to address these issues which was attended by about 250 delegates from all over the country. Inaugurating the symposium, Manju Sharma (National Academy of Sciences, India (NASI), Allahabad) highlighted the need for linking ecological sciences with appropriate policies for societal benefits. She stressed upon the need for ecologically viable scientific solutions to rejuvenate our rivers, and emphasized that rejuvenation of the Ganga is possible only through multifarious approaches interfacing domains of science. She also highlighted the innovative initiatives taken by NASI under Ganga research programme. Archana Thakur (UGC, New Delhi) shared her views on the emergent need and relevance of innovative ecological research in science and social realms. The symposium witnessed 8 technical sessions, including a plenary lecture, 4 keynote lectures, 12 invited talks, 11 oral and over 100 poster presentations.

In the plenary lecture, Rup Lal (University of Delhi) explained the significance of metagenomics to address microbial perspectives in ecology. He reiterated that the boom in sequencing technologies and advances in the development of high-throughput tools/techniques based on nucleic acids/proteins have substantially up-scaled the studies enhancing our understanding of molecular microbial ecology. He also shared his experiences with the human microbiome project and advocated that the composition of the human microbiome is intricately linked with human health and diseased states. T. K. Adhya (KIIT University, Bhubaneswar) furthered the ecological role of plant–microbe interactions. In addition to rhizosphere and phyllosphere, the microenvironments of plant include endorhiza (root), anthosphere (flower), spermosphere (seeds) and carposphere (fruit). Manipulation of these microenvironments reduces the incidence of plant diseases, chemical inputs, emission of greenhouse gases (GHGs) and enhances agricultural production. Using the coastal wetlands of Chilka Lake, he demonstrated the dynamics of colonization pattern for root-associated microbiome, wherein each root niche plays a selective

*A report on National Symposium on 'Issues and Challenges in Ecological Sciences' held on 23–25 February 2017 at the Department of Botany, Banaras Hindu University, Varanasi.