



Sensors and Sensing for Precision Agriculture (V16H1S1)

ICAR- Indian Agricultural Research Institute, New Delhi

Oct 05, 2020, 1500hrs to 2200hrs

Detail Program

Speakers	Time (IST)
Setting the Stage	
1500-1530hrs	
Welcome : Dr. Rashmi Aggarwal, Dean and Joint Director (Education), IARI	
Introduction to the Session: Session Co-ordinator Dr Rabi N Sahoo, ICAR- IARI, New Delhi	
Remarks	
Chair (Theme 1) : Prof M. Udaya Kumar, GKVK, Bengaluru	
Chair (Theme 2 & 3) : Dr Alok K Sikka, IWMI India Representative and Former DDG (NRM), ICAR, N Delhi	
Co-Chair : Dr Anil Rai, ADG (ICT) ICAR, New Delhi	
SoPs for Session and Making Proceedings:	
Rapporteurs	
Dr K K Bandyopadhyay, ICAR- IARI, New Delhi	
Dr Joydeep Mukherjee, ICAR- IARI, New Delhi	
Theme1 : High throughput Phenotyping for Precision Agriculture	1530-1700hrs
Dr C. Viswanathan, ICAR-Indian Agricultural Research Institute, India	1530-1545 hrs
Prof. Sindhuja Sankaran, Washington State University, USA	1545-1600 hrs
Panel Discussion	1600-1700 hrs
Theme 2 : IoTs for Precision Agriculture	1700-1830 hrs
Prof U B Desai, IIT Hyderabad, India	1700-1715 hrs
Prof. Prasant Mohapatra, University of California, Davis, USA	1715-1730 hrs
Panel Discussion	1730-1830 hrs
Theme 3: Sensors and Sensing for Soil and Crop Health for Precision Agriculture	1830-2100hrs
Dr Rabi N Sahoo ICAR-Indian Agricultural Research Institute, India	1830-1845 hrs
Dr. Dharmendra Saraswat, Purdue University, USA	1845-1900 hrs
Dr. Chandrashekhar Biradar, ICARDA-CGIAR Research Center, New Delhi, India	1900-1915 hrs
Prof. Rajiv Khosla Colorado State University, USA	1915-1930 hrs
Prof. Lav R. Khot, Washington State University, USA	1930-1945 hrs
Panel Discussion	1945-2030 hrs
Concluding Session	2030-2100 hrs

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Additional Panelist*	Affiliation
Dr. Chittaranjan Ray	University of Nebraska, Lincoln, USA
Dr.Narendra N. Das	NASA Jet Propulsion Laboratory, USA
Prof.Gadi V.P. Reddy	USDA-ARS-Southern Insect Management Research Unit, USA
Dr. Prameela Krishnan	Agricultural Physics, ICAR-IARI, India
Prof. Vinay K Sehgal	Agricultural Physics, ICAR-IARI, India
Dr. V K Singh	ICAR-IARI, New Delhi, India
Prof. Sekhar Muddu	IISc, Bengaluru, India
Prof. Santanu Chaudhary	IIT Jodhpur, India
Dr. Vidyadhar Mudkavi	CSIR-4PI, Bengaluru
Dr S. N. Jha	ICAR, New Delhi

*As per the organizing team's guidelines, DRDO, we can have only 20 panelists in a session. But as discussed with them, we, as host of the session, can include more panelists from participants joining as an Audience maximum up to 200. Total participants, including panelists, can be 1000. We would request you all to suggest the participants' list to make the session more interactive and fruitful.

Virtual Platform : CISCO Webex, link shared via email to all panelists

Session Co-ordinator

Dr Rabi N Sahoo, ICAR- IARI, New Delhi

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Institute Host:

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Background Note

Sensor and Sensing for Precision Agriculture

Doubling food production by 2050 for sustaining the food security in county and globe is a challenge. This increase in production must be achieved mainly by increasing crop productivity per unit area while sustaining the environment and enhanced input use efficiency. Indeed, pressure for competing land uses will likely reduce the area under food grain crops. Shrinking natural resource base (per capita availability of land and water devoted to agriculture), declining quality of resources, and environmental degradation issues will increase the threat to our ability to meet the growing population's basic needs unless we look beyond what we have with modern technologies for improving productivity. Hence, both genetic improvement approaches involving high throughput phenotyping and genomics-assisted breeding improve the innate resource use efficiency, stress tolerance, yield, and precision crop management strategies to improve resource use efficiency and reduce inputs post-harvest losses are vital issues to be taken care for a sustainably enhanced production system. Success stories of precision agriculture abroad have been encouraging to look forward and make it happen in Indian agriculture with an appropriate engineered approach.

Technological developments in sensors, remote sensing at different platforms, geospatial sciences, and ICTs have a special advantage in generating state-of-the art informatics - capturing the variability, vulnerability, and dynamism of agricultural system through spatiotemporal monitoring crop, soil, and micro-environment for precision agriculture. Next-generation phenomics, the study of plant growth, performance, and composition, utilizes new technologies involving different sensors, sensing platforms, and big data analytics to characterize plant responses to the environment better and describe the growth environment itself better. This information would enable us to provide valuable scientific insights into the factors contributing to the low productivity, which would form the essential ingredients to evolve the effective strategies for precision agriculture to enhance it.

Opportunities for Precision Agriculture in Indian Agriculture are optimal keeping in view the recent initiatives of different national-level programs in agriculture such as Doubling Farmers Income by 2022, Pradhan Mantri Fasal Bima Yojana, Soil Health Card, more crop per drop, National Agricultural Market, Digital India, Digital Agriculture, and many more. Some of the scopes of Intelligent Indian Agriculture may be building a digital nervous system for precision farming by small-scale farmers with virtual joint management for order-made/market in production for the customer, optimizing inputs /resources, and accelerated breeding with recent technologies of sensing and data analytics.

The Vaibhav Summit 2020 of India's Government allows identifying technology/knowledge gap & futuristic areas of research India and developing a framework for systematic and objective-driven collaboration between international academia with Indian roots and our national luminaries for paving the way for the country's advancement in academics and scientific research. In the session on 'Sensors and Sensing for Precision Agriculture' under the Horizontal Precision agriculture schedule during Oct 05, 2020, illustrious experts from Indian diaspora and India would deliberate on the state of the art technologies, research, and development in the field of sensor and remote sensing technologies, and their analytics for precision agriculture. Besides exploring specific areas for collaboration to view strength, complementarity, and research gaps under the identified three themes and proposing developing a working paper as excellence in collaboration with global partners through focused collaboration in research and development and capacity building.

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Brief Biography of the Chairs and Speakers

Dr. M. Udaya Kumar

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Chair of the Session (Theme 1)

Prof Udayakumar Makarla obtained BSc from Andhra University, MSc (Agriculture) from Moscow, and PhD (1971) from Academy of Sciences, USSR while working under the supervision of Professor US Nasirov. He joined the University of Agricultural Sciences, Bangalore (1973), worked there as Professor and Head of the Department of Crop Physiology (1983-), and Head, Division of Plant Sciences (1998). He was Visiting Professor at Wageningen Agriculture University, Netherlands.

He made notable researches in crop physiology covering areas: photosynthesis, crop water use efficiency, plant molecular biology and transgenic research. He developed and standardized several conceptual ideas and contributed significantly to crop research in India. He independently established a national facility for stable isotope analysis to quantify crop water use efficiency, transpiration and established modern laboratories for drought physiology, molecular biology and transgenic testing. He created an active school on drought research with conceptual frame work, integrating germplasm characterization for drought traits and adapting molecular approaches to introgress adaptive mechanism. He has over 140 research publications to his credit. He also guided over 25 PhD students.

Prof. Udayakumar played a key role to develop the Crop Physiology Department, University of Agricultural Sciences, into an advanced Research Centre in the area of abiotic stress responses of plants. He also developed a strong school on drought research from molecular mechanisms to canopy responses. Under his leadership, a national facility on stable isotopes for biological studies, sponsored by DST, was established. He served in various national committees of DST, ICAR and DBT. He implemented several Indo-Australian and Indo-US programmes.

Professor Udaya Kumar received several awards, notably: Best Teacher Award by ICAR (1997), Meritorious Invention Award by NRDC (1985), Rotary Gold Medal (1994), and ITC Best Scientist Award (1998). He was elected Fellow of the National Academy of Agricultural Sciences, New Delhi, Indian Academy of Sciences, Bangalore and National Academy of Sciences (India), Allahabad and received Omprakash Bhasin Award 2019, life time achievement award, Indian Society of Plant Physiology.

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Dr Alok K Sikka

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Chair of the Session (Theme 2 & 3)

Dr Alok K. Sikka is with International Water Management Institute, Delhi Office as IWMI Representative-India since April, 2016. Prior to joining IWMI, he served as Deputy Director General (Natural Resource Management), Indian Council of Agricultural Research (ICAR) and Technical Expert (Watershed Development) (in the rank of Additional Secretary to Govt. of India), National Rainfed Area Authority (NRAA), Planning Commission, Government of India, New Delhi. He was Director of ICAR Research Complex for Eastern Region, Patna and Basin Coordinator for Indo-Gangetic Basin under the CGIAR Challenge Program on Water and Food from 2002-2007.

He is Ph. D. in Civil and Environmental Engineering with specialization in Hydrology and Water Resources Engineering from Utah State University, Logan, Utah. Besides working with ICAR for many years at Indian Institute of Soil & Water Conservation, Dehradun and its Research Centres, he was with National Institute of Hydrology, Roorkee; visiting Professor at University of Arizona, Tucson; and Faculty at the Oregon State University, Corvallis, USA. He has more than 251 publications and is recipient of many national awards including Fellow of National Academy of Agricultural Sciences.

He has a rich and diverse experience of over 38 years in research, institutional and policy issues, teaching, training, extension and consultancy in the areas of natural resource management, soil & water conservation, watershed management, water harvesting, hydrologic modelling, water management, drought management, climate change, water productivity and farming systems.

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Dr. Anil Rai

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Co-Chair of the Session

Dr. Anil Rai is presently working as ADG-ICT and Head, Centre of Agricultural Bioinformatics at Indian Agricultural Statistics Research Institute (IASRI), New Delhi. He is the Coordinator, Network Project on Agricultural Bioinformatics and Computational Biology. His major areas of research includes development of models/methodologies/ procedures/tools for analysis of biological/omics data. Modeling and analysis of plant phenomics data, applications of geo-informatics/ spatial models/ statistics in agricultural surveys, Survey Sampling and policy research.

His major contributions includes establishment of "Advanced Supercomputing Hub for OMIC Knowledge in Agriculture" (ASHOKA)- the first State-of-Art supercomputing hub for Indian Agriculture Research at IASRI, New Delhi, National Agricultural Bioinformatics Grid (NABG) in ICAR, Department of Agriculture Research and Education, Government of India, New Delhi and Centre for Agricultural Bioinformatics (CABin) at IASRI development of Genome Sequence Submission Portal following international standards. Developed methodology of integrated survey for estimation of harvest and post-harvest losses of 45 agricultural commodities at all India level, statistical methodology for Prioritization of Rainfed area in the country for agricultural production, methodology of India Protection Quotient for urban as well as rural India at household level from Income Expenditure surveys. Widely travelled abroad and acted as Consultant to many national and international organizations.

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Dr C. Viswanathan

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Speaker of Theme 1 : High throughput plant phenotyping for Precision Agriculture

Dr. Viswanathan Chinnusamy is Principal Scientist & Head, Division of Plant Physiology at Indian Agricultural Research Institute, New Delhi. He has 24 years of teaching and research experience in the area of physiology and molecular biology of abiotic stress tolerance of plants. His lab uses functional genomics and precision phenotyping for functional validation of genes, genetic engineering and genome editing of plants for enhancing abiotic stress tolerance of crops. He contributed to the discovery “Inducer of CBF Expression 1 (ICE1)” pathway of cold tolerance in Arabidopsis, which led to its use for engineering abiotic stress tolerance in diverse crops. His contributions to the elucidation of the “ABA signalling pathway” paved novel ways of improving crop yield under abiotic stresses using orthogonal receptors and novel chemical mimics of ABA, in addition to genetic engineering approaches. He has contributed to decipher miRNA biogenesis pathway and its role in stress tolerance. Further, his lab has identified promoters, genes and traits for improvement of abiotic stress tolerance of crops. He has contributed to the establishment of Nanaji Deshmukh Plant Phenomics Centre (NDPPC) at IARI, New Delhi in 2017, and initiated of a new course on Advances in Plant Phenomics for M.Sc. & Ph.D. students. NDPPC has recoded over 4 million image data, and identified donors and QTLs for NUE and WUE in rice and wheat using phenomics. He is currently coordinating National Agricultural Higher Education Project on Centre for Advanced Agricultural Science and Technology at IARI for enhancing genomics skills of faculty and students.

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Dr. Sindhuja Sankaran

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Speaker of Theme 1 : High throughput plant phenotyping for Precision Agriculture

Topic : Advancements in sensing and data mining techniques for crop phenotyping to support crop improvement programs

A researcher in agricultural automation engineering, **Dr. Sankaran** engages in sensing data-driven discoveries that transform how we study the interaction between crops, genetics and environment to produce sustainable food, fiber and fuels. Based at Washington State University in Pullman, Washington, Sankaran's work focuses on advanced sensor technologies that detect and measure phenotypes—the physical expression of genes—in crops, supporting plant breeding, crop plant research, and precision agriculture. She utilizes opto-electronic, biological, and chemical sensors for non-invasive, rapid and continuous monitoring of plant responses to environmental stress, helping create a faster and better understanding of how our food crops react to a changing environment. Over the past six years, she has developed new tools to evaluate traits including crop vigor, stress tolerance, and seed size and quality across multiple crop breeding programs. She is a member of the American Society of Agricultural and Biological Engineers, the National Association of Plant Breeders, the North American Plant Phenotyping Network, and the International Society of Precision Agriculture.

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Prof U B Desai

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Speaker of the Theme 2: IoTs for Precision Agriculture

Prof. Uday B. Desai is Prof. Emeritus at IIT Hyderabad at present and was the Founding Director of IIT Hyderabad from June 2009 to June 2019. For nearly five years he served as the mentor Director for IIIT Chittoor, Sri City, IIT Bhilai. He is also Honorary Professor Woosong University, South Korea. He also serves as a Strategic Consultant for TSDSI (Telecom Standards Development Society of India). He is an academic advisor to several institution in India. He is B.tech, from IIT Kanpur, the M.S. from the State University of New York, Buffalo, and the Ph.D. degree from The Johns Hopkins University, Baltimore, U.S.A., in 1979, all in Electrical Engineering.

After Serving in the School of Electrical Engineering and Computer Science Department at Washington State University, Pullman, WA, U.S.A. during 1979-1987, he joined as Professor in the Electrical Engineering Department at the Indian Institute of Technology - Bombay till 2009. He has held Visiting Associate Professor's position at Arizona State University, Purdue University, and Stanford University. He was a visiting Professor at EPFL, Lausanne also the Director of HP-IITM R and D Lab. at IIT-Madras.

His research interests are in wireless communication, wireless sensor networks, cyber physical systems, Internet of Things and AI. Dr. Desai has graduated 25 Ph.D. students, and over 100 Masters students with Thesis option. He is the author/coauthor of nearly 300 peered reviewed papers in international journals and international conferences.

Dr. Desai received the outstanding many awards and fellowships. He is a Fellow of INSA (Indian National Science Academy), Indian National Academy of Engineering (INAE) and The Institution of Electronic & Telecommunication Engineers (IETE). He is a member and chairs of many central governmental committees and several governing councils of leading academic institutions.

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Professor Prasant Mohapatra

Vice Chancellor for Research
Distinguished Professor of Computer Science
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Speaker of the Theme 2: IoTs for Precision Agriculture

Dr. Prasant Mohapatra is serving as the Vice Chancellor for Research at University of California, Davis. He is also a Distinguished Professor in the Department of Computer Science and served as the Dean and Vice-Provost of Graduate Studies at University of California, Davis during 2016-18. He served as an Associate Chancellor during 2014-16, and the Interim Vice-Provost and CIO of UC Davis during 2013-14. He was the Department Chair of Computer Science during 2007-13, and held the Tim Bucher Family Endowed Chair Professorship during that period.

In the past, Dr. Mohapatra has been on the faculty at Iowa State University and Michigan State University. He has also held Visiting Scientist positions at Intel Corporation, Panasonic Technologies, Institute of Infocomm Research (I2R), Singapore, and National ICT Australia (NICTA). He has been a Visiting Professor at the University of Padova, Italy and Yonsei University, and KAIST, South Korea. D. Mohapatra was the Editor-in-Chief of the IEEE Transactions on Mobile Computing. He has served on the editorial board of the IEEE Transactions on Computers, IEEE Transactions on Mobile Computing, IEEE Transaction on Parallel and Distributed Systems, ACM WINET, and Ad Hoc Networks.

Dr. Mohapatra received his doctoral degree from Penn State University in 1993, and received an Outstanding Engineering Alumni Award in 2008. He is also the recipient of Distinguished Alumnus Award from the National Institute of Technology, Rourkela, India. Dr. Mohapatra received an Outstanding Research Faculty Award from the College of Engineering at the University of California, Davis. He received the HP Labs Innovation awards in 2011, 2012, and 2013. He is a Fellow of the IEEE and a Fellow of AAAS.

Dr. Mohapatra's research interests are in the areas of wireless networks, mobile communications, cybersecurity, and Internet protocols. He has published more than 350 papers in reputed conferences and journals on these topics. Dr. Mohapatra's research has been funded through grants totaling about 15 million US dollars from the National Science Foundation, US Department of Defense, US Army Research Labs, Intel Corporation, Siemens, Panasonic Technologies, Hewlett Packard, Raytheon, ARM Research, and EMC Corporation.

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Dr Rabi N Sahoo

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Speaker of Theme 3: Sensors and Sensing for Soil and Crop Health for Precision Agriculture

Rabi N Sahoo, working as Principal Scientist with Indian Agricultural Research Institute, Indian Council of Agricultural Research, New Delhi has 20 +years of experience in research, teaching and capacity building in the field of Remote Sensing. He has rich experience in generating and mobilizing resources to lead different multidisciplinary and multi-institutional collaborative remote sensing research programs through different external funded projects total amounting to INR 105 crores over last 20 years.

He is a researcher on hyperspectral remote sensing from ground, aerial and satellite platforms and its applications in agriculture which includes quantitative assessment of soil attributes for fertility and quality assessment, biotic and abiotic stress monitoring of crops for assessing crop conditions for precision agriculture and modeling for site specific nutrient requirement, sensor based high throughput plant phenotyping in control and field conditions and drone remote sensing. At present Dr Sahoo as National co-coordinator leading Network program on Imaging Spectroscopy and Applications (NISA) of DST having 37 research institutes as partners. He has been member of working group of Dept. of Science & Technology (DST) on Hyperspectral remote sensing, task force of NITI Aayog on drone remote sensing for crop insurance and Science team member of joint campaign of ISRO-JPL-NASA -Air borne hyperspectral remote sensing (AVIRIS-NG) in India.

He has been instrumental in developing state of the art Nanaji Deshmukh Plant Phenomics Centre, IARI. His team has conducted several training programs on remote sensing and GIS benefitting more than 500 researchers. Published more than 230 publications having 110 research papers in refereed journals to his credit. Currently leading proposed ICAR Network program on Precision Agriculture.

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Dr. Dharmendra Saraswat

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Speaker of Theme 3: Sensors and Sensing for Soil and Crop Health for Precision Agriculture

Title of Talk : Unmanned Aerial Sensing (UAS) for Weeds and Plant Disease Sensing

Dr. Dharmendra Saraswat is an Associate Professor in the department of Agricultural and Biological Engineering at Purdue University, USA. His research involves novel applications of information, communication, and sensing technologies (ICSTs) for improved management of plant production (field and nursery crops) and natural resources, spatial and temporal modeling for watersheds, and development of efficient and smarter algorithms for managing and visualizing field-sensor based farm data. Dr. Saraswat's overall research and extension efforts have been well recognized both nationally and internationally. He has received several awards including Outstanding Engineering Teacher (Purdue, Fall 2019), Purdue Seed for Success Award (2018), American Society of Agricultural and Biological Engineers (ASABE) Standards Award (2018), ASABE Educational Aids Blue Ribbon Award (one in 2017, one in 2015 and two in 2013), American Society of Horticultural Sciences (ASHS) Outstanding App Award (2016), Southern Region-American Society of Horticultural Sciences Blue Ribbon Extension Communication Award (2016 and 2012), Fellow of Indian Society of Agricultural Engineers (2014), John W. White Outstanding Extension State Faculty Award (2014), Excellence in Remote Sensing and Precision Agriculture from National Association of County Agricultural Agents(2013), ASABE superior paper award (2012), Early career award and Innovation award (2011) from the University of Arkansas.

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Dr. Chandrashekhar BIRADAR

Research Team Leader (Digital Augmentation) and Head of
Geoinformatics

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Speaker of Theme 3: Sensors and Sensing for Soil and Crop Health for Precision Agriculture

Title : Digital Augmentation for Accelerating Sustainable Agroecosystems and Future Smart Foods

Dr. Chandrashekhar Biradar is a **Principal Scientist and Research Team Leader**; also Head of Geoinformatics and Research Data Management Units, at the International Center for Agricultural Research in Dry Areas (ICARDA) -CGIAR Research Center. His core expertise focuses on the Digital Agriculture and citizens' science/local intelligence for complex system research for accelerating sustainable agroecosystems and conscious living. Dr. Biradar has multi-disciplinary educational backgrounds with a BSc in Forestry/Agricultural sciences, MSc in Genetic Engineering, and Ph.D. in Environmental Science and Space Applications for Biodiversity conservation from IIRS, ISRO, and the University of Pune, then Postdoctoral fellows in Earth Observation at IWMI and the University of New Hampshire, USA. He pioneered multi-disciplinary digital approaches for quantification of agri-food systems, climate change, water/land productivity mapping, land degradation assessment, multi-layer farming, and data-driven sustainable intensification. He developed the world's first satellite sensor-based rainfed production systems including irrigated and agropastoral systems. His current research focuses on digital augmentation for revitalizing balanced agroecosystems, digitization of agricultural landscapes, excellence in inclusive agroecosystems. Dr. Biradar has authored and co-authored over 210 publications including 125 peer-review journal articles and 25 books/book chapters. He has received numerous awards and honors, including Best Team Initiative, Young Scientist, and Outstanding Scientist Awards. He has led several innovative data-driven digital agricultural use-cases, deep learning tools and also pioneered biodiversity gardening for transforming urban landscapes, food forests, and rural livelihoods to enhance vital food systems, support crop diversification, biodiversity conservation, and prospecting at several scales and contexts.

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Dr. Rajiv Khosla

Robert E. Gardner Award Professor of Precision Agriculture
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Speaker of Theme 3: Sensors and Sensing for Soil and Crop Health for Precision Agriculture

Title : Scale Independent Precision Agriculture

Prof. Dr. Raj Khosla of Colorado State University is a globally recognized authority on Precision Agriculture. He has been engaged in precision agriculture since inception and has made significant contributions in the development and spread of Precision Agriculture worldwide. He is the Founder and Past-President of the International Society of Precision Agriculture. Most recently, he served as the member of National Academy of Science Executive Committee on Science Breakthrough 2030. In 2017, his research was recognized with the "Werner L. Nelson Award for Diagnosis of Yield-Limiting Factors Award" by the American Society of Agronomy. Previously, he has been recognized as the "Precision Ag Educator of the Year 2015" by the US agricultural industry. In 2012, Dr. Khosla was named the Jefferson Science Fellow by the National Academy of Sciences and was appointed as the Senior Science Advisor on Food Security to the U.S. Department of State. In 2011, he was inducted by NASA to the US "Presidential Advisory Board on Positioning, Navigation and Timing" to work on the US space based GPS policy.

Prof. Khosla is the Fellow of American Society of Agronomy; Fellow of Soil Science Society of America; Fellow of Soil and Water Conservation Society and Honorary Life Fellow of International Society of Precision Agriculture.

His main research focus has been on "Management of in-field soil and crop spatial variability using innovative technologies (such as GPS, GIS, and Remote-sensing) for variable rate precision nutrient management, particularly Nitrogen. He has generated many discoveries in precision agriculture, most widely recognized among them is the innovative technique of quantifying variability of spatially diverse soils using satellite based remote-sensing to create management zones, which is currently being used by farmers in Colorado, across US and in other countries around the world. He currently has projects in multiple countries and is championing efforts to enhance crop input use efficiency, productivity, profitability, and sustainability of large and small scale agricultural production systems. He has co-authored over 200 publications (book chapters, refereed journal articles, extension articles, proceedings, bulletins, reports, popular press articles, digital media, and others). He has been invited globally to over 30 countries.

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Dr LAV R. KHOT

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Prof. Lov R Khot is majorly involved in research and extension program on “Sensing and automation technologies for site specific and precision management of production agriculture”. Special emphasis is towards integration of

- Remote sensing (Unmanned and manned aerial systems)
- Ground-based crop sensing
- Decision support systems and information delivery technologies
- Precise applications of various production inputs
- Agricultural machinery and processes • Data-based modelling