KEYNOTE ADDRESS

Nanobiotechnology: Bridging the gap between biology and nanoscience for sustainable agriculture

Absar Ahmad
Interdisciplinary Nanotechnology Centre
Aligarh Muslim University, Aligarh-202002
aahmad786in@gmail.com

In recent years, the synthesis of nanoparticles through biological routes has been gaining immense popularity, offering an innovative solution to the limitations and challenges associated with conventional chemical and physical synthesis methods. At the forefront of this emerging field, our research team is pioneering the use of biosynthesis, with a particular emphasis on harnessing the unique capabilities of plants and plant microorganisms. This ground-breaking approach offers a myriad of advantages, including enhanced stability, water dispersal, fluorescence, and natural protein capping, qualities that are challenging to attain through traditional chemical and physical synthesis methods. Moreover, biosynthesis is inherently sustainable and environmentally friendly, making it a promising option for applications in various fields, including agriculture.

Our research has primarily focused on the utilization of fungi and actinomycetes, plant microorganisms, for the biosynthesis of biocompatible, water-soluble, fluorescent, and protein-capped nanoparticles. These microorganisms have demonstrated their exceptional ability to reduce aqueous metal ions both intra and extra-cellularly, leading to the formation of stable metal nanoparticles. This intriguing process is enzymatic in nature, and the versatility of our approach is underscored by the diverse range of enzymes secreted by these microorganisms, such as sulphite reductase, nitrate reductase, and hydrolyzing proteins, in response to metal stress. This adaptability opens the door to economically feasible room-temperature synthesis of quantum dots, metal nanoparticles, and nanooxides, with implications that span across various industries.

One notable aspect of our research is the symbiotic connection between fungi and plants. This connection has led us to explore the potential of plant extracts containing valuable biomolecules that can not only facilitate the biotransformation of metal ions but also regulate the shape of nanoparticles. Among the plant extracts we've studied, Geranium and Lemongrass extracts have stood out, with Lemongrass extract, in particular, resulting in the large-scale synthesis of gold nanotriangles with intriguing near-infrared absorption properties. This discovery holds significant promise for the agricultural sector, offering innovative applications for improved crop management, disease detection, and soil health assessment.

Furthermore, our recent endeavours in extracting anti-cancerous drugs from endophytic fungi and their immobilization on nanosystems for drug delivery and targeted drug delivery applications are poised to make a substantial impact on the field of nanomedicine. This breakthrough not only promises to revolutionize cancer research but also has far-reaching implications in agriculture, where controlled and targeted delivery of pesticides, growth regulators, and nutrients can significantly enhance crop yields and reduce environmental impacts.

In conclusion, our research into the biosynthesis of nanoparticles, especially those that are challenging to synthesize using traditional physicochemical methods, is dedicated to developing sustainable and environmentally friendly approaches for nanoparticle production. These nanoparticles possess unique and desirable properties, making them highly relevant for a wide range of applications in agriculture, including precision farming, crop protection, and soil health assessment. We firmly believe that our findings will continue to have a profound and lasting impact on various fields, propelling us into a future where sustainable, green, and highly effective nanomaterials play a pivotal role in shaping our world.

INVITED LECTURES

Harnessing atmospheric nitrogen fixation under climate change for sustainable productivity in chickpea

Rajendra Kumar
Division of Genetics, ICAR-Indian Agricultural Research Institute, New Delhi-110012
rajendrak64@yahoo.co.in

Malnutrition, often known as hidden hunger, affects more than half of the world's population, including pregnant women and younger children in developing nations. One of the most important responsible factors for malnutrition is food insecurity which affects almost a billion people worldwide. Chickpea has been identified as one of the most economically important foods, which is a significant source of different macro and micronutrients. Protein has been identified as one of the important sources for the fulfilment of nutritional deficiencies. Nitrogen and phosphorous are crucial elements required for chickpea plant growth and development. Several *Rhizobium* species have been used in agriculture for promoting nitrogen-fixing ability in legumes. Similarly, fertilizers and VAM (vesicular-arbuscular mycorrhizae) enhance crop growth and yield. The current study presents the understanding of dissection of global chickpea germplasm for nodulation traits, the effects of the exogenous supply of *Rhizobium*, VAM and fertilizer on chickpea for the fulfilment of nutritional requirements, ARA estimates and chickpea plant growth in terms of yield and production.

During 2020-21**,** an association panel consisting of 300 genotypes containing 224 desi and 76 Kabuli types, based on the observations recorded for nodulation traits extracted from the pool of chickpea global core germplasm plus other genotypes consisting of ≈ 2000 was constituted and multi-locational experiments were accomplished. The association analysis was done by using Core Hunter 3 program also analyzed descriptive statistics, PCA, and Agglomerative Hierarchical Clustering of accessions and a multi-location / multi-environment trials of the association panel were conducted in 6 environments comprising of 5 field grown trials at IARI, New Delhi – 2 sets (with & without fertilizer), IARI-Regional Station, PUSA, Samastipur, Bihar; SHUATS, Naini, Prayagraj, UP and RPCAU campus, Vaishali, Bihar and another sub set comprising of 20 genotypes in earthen pots. The twenty genotypes (9 having extremely lower number of nodules, 9 genotypes having extremely higher number of nodules along with two checks Desi and Kabuli) were selected from association panel were grown in triplicates following RBD under 6 environments / treatments (control, NPK, VAM, Rhizobium, VAM + NPK, Rhizobium + NPK) in 360 earthen pots for assessing response of chickpea genotypes and phenotypic data was recorded. The Acetylene Reductase Activity for all these 20 genotypes was conducted in order to estimate the Nitrogenase activity with the help of GCMS (Gas chromatography mass spectrophotometry) technique to estimate the nitrogen fixation potential of root nodules. The maximum values of Nitrogenase ($\eta mole C_2 H_4/\eta/g/1000$) for control, VAM and rhizobium were recorded in BG -3022 (674.12), ICC-9085 (139.28) and ICC-2083 (827.02) respectively.

In order to facilitate molecular screening/genotyping of the association panel, around ~25 EST-SSR primers with product size range (~150-250) were designed and ~260 polymorphic markers have been selected from public domain. Software STAR- Statistical Tool for Agricultural Research and Plant Breeding Tools developed by IRRI- Quantitative Genetics and Biometrics cluster was used for ANOVA. The seven SNP IDs from the sequenced data were identified followed by their validation through another population set.

Use of microbial pesticides for sustainable agriculture: Current scenario, regulatory requirements and commercialization

H.B. Singh
Department of Biotechnology, GLA University, Mathura-201301
hbs@rediffmail.com

Most cultivated plants are prone to many diseases caused by fungi, bacteria, viruses, phytoplasma and nematodes. Out of several diseases reported on plants, soil-borne diseases caused by fungi cause considerable loss in productivity and quality of the produce. Biopesticides based on living microbes and their bioactive compounds have been promoted as replacements for synthetic pesticides for control of plant diseases. However, lack of efficacy, inconsistent field performance, low shelf life and strict regulatory requirements by CIBRC has generally relegated them to niche products. Significant increases in market penetration have been made, but microbial pesticides still only make up a small percentage of disease control products.

Thirty four microbes have been included in the schedule to the Insecticide Act 1968 for production of microbial based biopesticides. While working with some important antagonistic microbes (*Trichoderma., Pseudomonas* and *Bacillus* spp.), we have documented the biocontrol ability of these organisms at field level as well as up to the extent of commercialization. We have started promoting the usage of biopesticide formulations as a component of integrated farming practices with involving farmers of eastern Uttar Pradesh in order to produce pesticide residue free crop.

The research on biocontrol agents (BCAs) can be fruitful only when we commercialize and register the product based on superior strains. Biopesticide registration require data on technical and formulation related information such as biological characteristics, pathogenic contaminants, other microbial contaminants, bioefficacy, toxicity, container compatibility and shelf life etc. To achieve this, certain norms specified by Central Insecticides Board are to be followed. Till date, about 970 microbial based biopesticides products are registered with CIBRC (http://cibrc.nic.in/bpr.doc) under section 9(3B) and 9(3) of the Insecticides Act, 1968 Government of India). During the presentation emphasis will be given on organic cultivation of crops using microbial pesticides in order to increase the farmers income and also to provide pesticide residue free quality produce for the community.

Deciphering the mechanism of delayed banana streak MY virus infection in diploid banana progenitor *Musa balbisiana*

Virendra Kumar Baranwal, Susheel Kumar Sharma and Nitika Gupta
Division of Plant Pathology, ICAR-Indian Agricultural Research Institute
New Delhi-110012, India
vbaranwal2001@yahoo.com

Banana streak MY virus (BSMYV) is one of the most widely prevalent badnaviruses associated with streak disease in *Musa* species. Its infection and symptom development varies across the banana genotypes. The present study, for the first time reports successful agroinfection of BSMYV in diploid banana progenitor *Musa balbisiana* cv. Bhimkol (BB) which was earlier considered resistant. Agroinfection of Bhimkol banana showed delayed infection 280 days post-BSMYV agroinoculation. Transcriptome analysis to decipher the mechanisms of delayed BSMYV infection was carried out. *De novo* assembly of transcriptome generated 101,961 unigenes with a mean length of 1310 base pairs (bp). Out of the total coding sequence (CDS), 48,797 CDS were annotated against the non-redundant protein database. A total of 3174 differentially expressed genes (DEGs) were identified, of which 1138 up-regulated and 2036 down-regulated genes were observed in comparison between mock inoculated (BB_Mock) and delayed infected (BB_Symptomatic) Bhimkol banana. Heatmap with hierarchical clustering of top 50 significantly differentially expressed genes showed four different clusters. Based on fold changes, and adjusted p-value, twelve selected DEGs were validated using quantitative-PCR (qPCR). Selected DEGs were associated with regulation of plant hormone, host defense system and host machinery hijack. The present study also revealed a complex cross talk between Ca^{2+} dependent Ras, macromolecules localization and auxin responsive genes to regulate primary metabolite production that possibly hinder the spread of virus across the cell leading to the delayed establishment of BSMYV infection in Bhimkol banana. To the best of our knowledge, this is first report on elucidation of delayed infection of BSMYV in diploid *M. balbisiana* (BB) through comprehensive transcriptome.

Feeding the 10 billion by 2050: A Genomics perspective

Manoj Prasad
Professor, Dept. of Genetics, University of Delhi South Campus, New Delhi
Scientist VII (on Lien) & JC Bose Fellow, DBT-NIPGR, New Delhi
Adjunct Professor; Department of Plant Sciences, University of Hyderabad, Hyderabad
manoj_prasad@nipgr.ac.in

Human population is racing towards 10 billion by the year 2050 and ensuring the basic needs of the growing population is going to be a challenging task. Climate change, decrease in total arable land, and reduction in yields due to biotic and abiotic factors pose a significant threat to agriculture. High temperature-induced crop failures are prominent nowadays in major staples, including rice, wheat, and maize; however, crops such as foxtail millet (*Setaria italica*) are resilient to temperature stress. We have identified a total of 113 heat shock protein (HSP) encoding genes in foxtail millet and a novel sHSP of foxtail millet, SisHSP21.9 was characterized for its role in conferring tolerance to high-temperature stress. SisHSP21.9 is a panicoid-specific gene, which is highly upregulated during high-temperature in leaves, and the protein is localized in the chloroplast. Its expression is directly regulated by the heat shock factor, SiHSFA2e, during temperature stress. Further, overexpression of SiHSP21.9 in rice enhanced the survival of transgenics during high-temperature stress (>80% survival frequency), and the transgenic lines showed improved plant architecture and overall grain yield. Compared to WT plants, transgenic lines maintained optimal photosynthesis rates with higher photosystem efficiencies at high temperatures, and this is conferred through protecting the components of photosystems, chlorophyll-binding proteins, and chloroplast-localized functional proteins by SisHSP21.9. Prolonged high-temperature stress showed minimal damage to chloroplast proteins resulting in comparatively lower yield loss (35-37%) in transgenic lines. Altogether, the study suggests that SisHSP21.9 is a potential candidate for designing thermotolerant crops for climate-resilient agriculture.

Fish pond based integrated farming system model: A technological boon for waterlogged sodic soils

Chhedi Lal Verma, S.K. Singh, Sanjay Arora, A.K. Singh, T. Damodaran, V.K. Mishra, C.S. Singh, Arjun Singh
ICAR CSSRI Regional Research Station, Lucknow 226002

Introduction of the large networks of unlined canals without due consideration to drainage has led wide spread waterlogging, salinity and sodicity over the globe. India is having vast networks of canals and suffering with severe waterlogging and salt accumulation in the root zone. Sharda Sahayak in UP; Tungabhardra in Karnataka; Indira Gandhi Nahar Pariyojana (IGNP), in Rajasthan and Madhya Pradesh; and Mahi and Ukai command area in Gujarat are having substantial waterlogged and salt-affected. Continuous seepage from the canals causes steep rise in water tables and causes water-logging, salinity, sodicity, formation of marshy lands and decreased biodiversity. Salinization of 0.37 M ha area in Sharda shayak Canal Command of U.P. within a span of three decades and 0.18 M ha area in the Indira Gandhi Nahar Priyojana, Rajasthan within few years of introduction of canal have resulted a great loss of agricultural productivity and economy of irrigation projects. If preventive/ ameliorative attempts are not taken the salt-affected areas is bound to increase from 6.74 to 16.2 M ha by 2050. Technologies for reclamation and management of salt-affected soils namely gypsum technology, subsurface drainage, salt tolerant crop varieties, guidelines for use of poor quality waters and rehabilitation of salty land through forestry specie are quite successful. Reclamation of waterlogged saline soils with the provision of improved subsurface drainage had been quite successful but there was no technology available for reclamation of waterlogged sodic soils located in large canal commands. Fish Pond Based Integrated Farming System Model was developed recently for reclamation of waterlogged sodic soils. Within a period of two years cropping can be diversified to intensive vegetable production and intensive fish stocking. Farmers' income could be increased to several folds with minimum payback period of one to two years. Initial investment of Rs. 5.0 to 6.0 lakh would transform two hectares of land to FPBIFS Models with raised bed and pond ratio of 1:1. About 0.15 M ha of area in U.P. is suffering with twin problems of waterlogging and sodicity. FPBIFS model is a technological boon for horizontal expansion of agricultural lands and unprecedented increase in crop productivity and income.

Emerging constructs from environmental and climate change on agriculture and food security

Sanat Kumar Saha
Agricultural, Energy and Environmental Scientist
Professor Emeritus Kalinga Institute of Industrial Technology (KIIT), Deemed University, Bhubaneswar
Hon. Visiting Professor, Rani Rashmoni Green University (RRGU)
Government of West Bengal, Tarakeswar

Addressing the citizens on 10th December, 2022, our Hon'ble President of India has appealed to treat nature and bio-diversity with dignity and respect. Over past few years, the world has suffered from high number of disasters caused by climate change and unusual weather patterns. We must respect our nature, flora and fauna, bio-diversity and ecology as our fundamental duty incorporated under Article 51A (g)of the Constitution. India's population is the highest in the world by crossing about 1.428 billion in 2023, as against China's 1.425 billion. It's a stupendous task for India to ensure good health, food security, malnutrition, education, shelter and environment. While the challenges are towering, there are numerous achievements that gives us the reassurance that we are progressing on the right direction. However, what can make us pace faster towards the right direction to enable India position in food and agricultural sustainability.

According to Food and Agricultural Organisation (FAO) of United Nation " All people, at all time , have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preference for an active and healthy life". Currently, food security has undergone considerable changes by attaining over 350 million tonnes. However, there are undernourished people in India.

There is a need for second green revolution in India, which should focus on increasing crop yield in eastern and north-eastern states, assured irrigation, rural electricity , renewable sources of energy (like solar, wind, hydro etc.) on sustainable basis, drought prone varieties of crops as well as tackling of climate change, use of bio-technology, rain water harvesting & water shed development, reclamation and management of degraded / wasteland for Agricultural use , focus on organic farming, bio-fertilizer, integrated nutrient supply, use of nano fertilizers (nitrogenous and phosphatic), use of drone for agricultural use, natural resources and environmental management etc.

Role of pulse crops in combating global warming

P.S. Deshmukh
Former Head, Division of Plant Physiology, IARI, New Delhi -110012
Write2psd@gmail.com

The United Nations has declared this year as International Year of Millets and 2016 was International Year of Pulses. The question comes in the mind of the common person: Why this and what's needed ? As both the groups of crops are primitive crops and habituated and were primarily grown for millions of years in the tropics and subtropical regions in general. When the country became independent there was an acute shortage of food grains, specifically cereal crops like wheat and rice. So the emphasis has been laid on increasing the production of these crops by planners and managers. Through the introduction of the green revolution during 1960 onwards both cereal crops were extensively grown in collaboration with the United States. During the next 15 years our production has significantly increased but at the cost of areas under the variety of pulses and millet crops. As the time passed there were realisations by mid-eighties that acute shortages of both pulses and oilseed crops resulted in an increase in diseases due to deficiencies of essential nutrients in the common masses. In addition, both cereal crops require a high amount of water and nutrients. This resulted in decrease in water table and increase in salinity in the region which caused serious attention of planners again.

In IARI during 1998 it was thought to introduce various pulse crops to varied moisture and temperature stress and look for more tolerant varieties with physiological traits which can be used later by breeders to release them extensively in the various regions of the country. On the basis of our studies for next 15 years it has been concluded that growing of pulse crops between cereal crops is essential to maintain both water table and increase the soil fertility to the satisfactory levels and also increased production of both pulse and cereal crops. The levels of salinity were also reduced significantly. Due to better supply of pulses, the ration systems of the country resulted in better intake of proteins by common masses thereby reducing the nutrient deficiencies. It is also thought that pulses being dicot crops with root systems penetrating in the deeper layers of soil better utilise water and show temperature tolerance as compared to cereal crops. We emphasise more popularisation of pulses in the country along with millets to combat climate change, which has been realised significantly in our subcontinent.

Think locally act globally with reference to ethnomedicinal plants of India towards miraculous sustainable approach for health security and Green Technologies in agriculture

Nawal Kishore Dubey
Centre of Advanced Study in Botany, Banaras Hindu University, Varanasi-221005, India
nkdubeybhu@gmail.com

India is a mega- biodiversity rich country and has varied climatic zones comprising approximately 17000-18000 species of flowering plants of which 6000-7000 are estimated to have medicinal usage in folk practices. In India, around 25,000 effective plant-based formulations are used in traditional and folk medicine and the country enjoys an important position in the global pharmaceuticals sector. From ancient times, people are known to use the traditional medicinal plant *Materia medica* and their bioactive compounds for health care purposes. Basically, the medical formulations are developed from different plant parts or their synthetic analogs together with their folklore systems. According to World Health Organization report, more than 80 per cent of world's population depend on plant based medicines for their health care needs . The traditionally used medicinal plants have a large range of therapeutic properties, inhibiting growth of pathogens or kill them without causing toxicity to the host cells Due to immense use of allopathic and synthetic antimicrobial drugs, microbes have developed resistance to different antibiotics Herbal extracts and preparation from medicinal plants had come across its journey from the very beginning of the 20th century. Recently, scientists are focusing to develop modern medicines based on the purified active ingredients through modern chemical and biological technologies. Traditionally used medicinal plants are still recognised as common practice for cure of different diseases. Their disease curing ability is attributed to presence of different phytochemicals including alkaloids, flavonoids, and terpenoids. Traditional knowledge offers the source of new drugs developments from plants. Due to recent developments in gene technologies, many biotechnologically rich but biodiversity poor countries are involved in the act of biopiracy by illegally patenting the traditional knowledge of other countries. Hence, there is urgent need of bioprospection of traditionally used medicinal plants in order to have sovereign right on biodiversity.

In addition to this, the interest in plant products has increased exponentially especially the phytotherapeutic supplements (nutraceuticals) and cosmetics over the past decade. Apart from direct clinical use, these plants and their products are also utilized for agriculture in pest control in biodiversity-rich countries like India, China, Sri Lanka, Brazil, and Africa. In addition, exploration of phyto-chemicals so as to formulate some novel plant based green pesticides for the management of agricultural pests is currently gaining momentum in the agriculture sector also In view of post application side effects such as pest resistance, residual toxicity, non – biodegradable nature, ozone layer depleting effects, disruption of ecological balance and interference with the reproduction of non-target species, most of the synthetic chemicals (often called as grey chemicals or xenobiotics) used as pesticides have their own limitations. Plant based formulations are chiefly biodegradable and are recognized as better sustainable and eco-friendly alternatives of synthetic pesticides in food security. The most attractive aspect of using such plant chemicals in agricultural pests management is their mode of action as semiochemical or behaviour altering inhibiting the growth and metabolism of pests without killing them. Such growth regulatory approach in pest control is being more accepted currently

Every nation has sovereign right over its biodiversity which is frequently violated by the act of biopiracy or gene robbing. There are many examples of exploitation of traditionally used medicinal plants by the biotechnologically rich but biodiversity poor countries. *Pentadiplandra brazzeana* from tropical Africa, *Vinca rosea* from Madagascar, *Curcuma longa*, *Azadirachta indica* and *Withania somnifera* from India are some classical examples of biopiracy. Due to recent developments in gene technologies, many biotechnologically rich but biodiversity poor countries are involved in the act of biopiracy by illegally patenting the traditional knowledge of other countries.Hence, bioprospection would help the native countries in legal exploitation of the bioresources by preventing the act of biopiracy. Hence, bioprospection is a burning issue for biodiversity-rich countries like India, China, and tropical African nations to document their bioresources as well as to identify their useful plants, related phytochemicals and genes controlling them.

Hepatoprotective diets from nutrified crops

A.K. Gaur
Professor, Molecular Biology and Genetic Engineering, College of Basic Sciences and Humanities, GBPANT University of Agriculture and Technology, Pantnagar-263145, Udham Singh Nagar, Uttarakhand, India

Expression analysis of various putative functions and functional genomics are enhancing knowledge base to understand the genesis of bioactive molecules. Consequently, combinatorial compounds are also being derived. Bioactivities, high thoroughput screenings and chemical libraries tools and techniques are accessible. Metabolomics/ Metabonomics/Chemonomics of higher plants like Ashwagandha (Indian Ginseng), Chikory, Cholai, Kutki, Kutoo (Buck Wheat), Sama (wild rice), Malaria buti, Ginger, Ratanjyoti, Guggal, Sataver, Arjun, Sena, Neem, Kerala, Haldi, Bengan, Prosomillet, Bajra and many such other cultivars had now been well pronounced in Indian sphere for their potential benefits. In planta and in vitro biogenesis of millions of molecules are often observed under the influence of different kinds of signals including physicochemical and climatic inside plant machineries and or factories. *Picrorhiza kurroa* (Plantaginaceae)/Kutki is one such well traditionally practiced and established community herb of Himalaya caring various ailments of Human/animals including hepatic ailments. Though, diets are primarily from primary producers (photosynthates) as a result starch and cellulose are majorly required for the maintenance of farm activities such as aquaculture, apiculture, sericulture, mushroom cultivation animal/poultry farms so on and so forth except food crops inclusive of vegetables and fruits. Since, food crops are not secured in terms of protective and essentials of diets due to lacking capacity of biogenesis of functional molecules. And as a matter of fact hepatocytes are to initiate detoxifying function by virtue of mixed function oxidases. Therefore, our contention is for the hepatoprotective carrying functional crops like potato, banana, maize, and paddy. In present context CRISPR-Cas allows direct avenues without any issues of GMOs to edit specific crop genome in light of the function of interest from *Picrorhyza kurroa*. Thus, we are approaching for opportunities toward better management of hepatic functions via direct consumption of enriched diet coupled with enriched/secured food crops for an important hepatoprotective function.

Metals induced metabolic alterations in plants and strategies for improving stress tolerance

Rama Shanker Dubey
Vice Chancellor, Central University of Gujarat, Gandhinagar-382030, Gujarat

Metals such as Cd, Pb, Hg, Ni, As, Al are major environmental pollutants, and when present in high concentrations in soil, adversely affect the growth, metabolism and yield of crops. Through various transport systems, these metals are taken up by plant roots. Many transporter genes are responsible for the uptake of metals and their translocation in plant parts. Plants have developed several mechanisms to withstand against toxicity of these metals and to withstand in metal-contaminated soils. When present in toxic levels within the plant tissues, these metals interfere with key vital processes like photosynthesis, respiration, transpiration, stomatal conductance, etc., and in turn cause decrease in crop yield. Overproduction of reactive oxygen species (ROS) is a common feature associated with metal toxicity in plants that disturbs normal cellular metabolism. Metal exposure to plants causes activation of antioxidant system that leads to the induction of antioxidant genes, and synthesis of various antioxidant enzyme proteins and non-enzymic antioxidants that quench overproduced ROS and balance the level of ROS in the cells. Many novel proteins are synthesized in plants when exposed to various metals. These proteins have important role in conferring tolerance to the plans against these metals. Using proteomics studies it has been possible to analyse a wide range of specific proteins performing various functions using the most widely applicable technique of two-dimensional gel electrophoresis (2DE) followed by MALDI-TOF. We have conducted expression analysis of a wide range of genes and their corresponding proteins in rice plants exposed to various metals such as Cd, Pb, Hg, Ni, As, Al. Application of various alleviators such as chemical compounds, plant extracts, hormones have shown to mitigate metal toxicity effects in rice plants. These studies are aimed to develop strategies to improve metal tolerance in crop plants.

Harmonizing agriculture, climate resilience, and ecological vitality: Nurturing a sustainable environment

Vir Singh
Department of Environmental Science, GB Pant University of Agriculture and Technology, Pantnagar-263145, Uttarakhand, India
prof.virsingh@gmail.com

Harmonizing agriculture, climate change mitigation, ecological processes, and the environment has gained significant attention in recent years due to the urgent need for sustainable practices in food production and environmental stewardship. Agriculture, as a fundamental human activity, has a profound impact on the environment and is significantly influenced by climate change. Climate change poses numerous challenges to agricultural systems (agroecosystems), including increased frequency and intensity of extreme weather events, altered precipitation patterns, and rising temperatures. These changes affect crop yields, water availability, soil fertility, and pest and disease dynamics, thereby threatening global food security. However, agriculture itself contributes to climate change through greenhouse gas emissions from deforestation, land-use change, and the use of synthetic fertilizers.

Addressing these intertwined challenges necessitates adopting sustainable agricultural practices that mitigate climate change while preserving ecological processes. Sustainable agriculture embraces a holistic approach that aims to maximize productivity, conserve natural resources, and reduce environmental impacts. This approach entails implementing practices such as agroforestry, conservation agriculture, organic farming, and precision farming, which optimize resource use, enhance biodiversity, promote carbon sequestration, and foster ecosystem services. Furthermore, ecological processes play a crucial role in maintaining the balance and resilience of agricultural systems. Biodiversity, soil health, water quality, and nutrient cycling are interconnected components that support the functioning of ecosystems and agricultural productivity. Preserving and restoring natural habitats, promoting biodiversity-friendly farming practices, and adopting agroecological principles facilitate the enhancement of ecological processes and provide multiple benefits, including natural pest control, improved soil structure, and increased resilience to climate change impacts. Achieving a harmonious relationship between agriculture, climate change mitigation, ecological processes, and the environment requires integrated approaches that involve collaboration among farmers, policymakers, researchers, and civil society.

Can nitric oxide mitigate stress in plants and increase in crop plant productivity? -An assessment through photosynthetic studies

Amarendra Narayan Misra
Ex-Professor of Life Sciences, CUJ, Jharkhand
misra.amarendra@gmail.com

Plant productivity is severely affected by various stress factors arising due to natural phenomena and anthropogenic factors. The major problems of climatic stress which affects plant growth and productivity are soil moisture/ water, atmospheric humidity, temperature, salinity, heavy metal stress, etc. There have been several techniques and technologies developed to mitigate these stress factors and improve crop performance. Nitric oxide is reported to be a signal factor regulating various metabolic pathways in plants, and has the capacity to ameliorate climatic stress. In the present study, the effect of nitric oxide on photosynthetic performance of plants under stress conditions is studied. The possibility of increasing productivity in adverse climatic conditions will be elucidated.

Evidence of Exosomal communicational changes in plants induced by Plant Growth Promoting Microbes

Rana Pratap Singh
Department of Environmental Science, Babasaheb Bhimrao Ambedkar University, Lucknow 226025, India
rpsingh@bbau.ac.in/dr.ranapratap59@gmail.com; Web: www.ranapratap.in

Plant growth-promoting microbes (PGPMs), are capable of colonizing plant roots, impact plant growth in a variety of indirect and direct ways and protect it against disease and insect assaults. Seed-inoculation and soil application of microbial bio-stimulants or their consortia are gaining popularity as bio products for increasing nutrient availability to plants, its growth promotion, disease management, bioremediation and nutrient recycling. Seed germination, seedling growth, crop production and crop protection are all aided by PGPMs like *Pseudomonas*, *Azospirillum, Azotobacter, Klebsiella, Enterobacter, Alcaligenes, Arthrobacter, Burkholderia*, *Bacillus*, and *Serratia*, etc. In order to develop a successful crop-specific PGPM formulation, the candidate should have high rhizosphere competence, extensive competitive saprophytic ability, growth-enhancing ability, ease of mass production, broad-spectrum action, environmental safety, and compatibility with other partnering organisms.

Some recent studies have demonstrated interkingdom communication between plants and microbes. The microRNAs delivered by exosomes provide a cross-kingdom bi-directional communication channel between the plant and its related rhizospheric microbes. The evidence linking plant microRNAs to the intestinal microbiota and plant microRNAs to pathogens implies that microRNAs have a role in regulating the quantity, composition, functions, and activities of the rhizospheric microbiota. Exosomes are nanoparticles released by all cell types that make up a major portion of the wider class of nanoparticles known as extracellular vesicles (EVs). Exosomes enter the interstitial space and, eventually, the circulation, where they exert local paracrine or distal systemic effects. As a result, exosomes are critical components of an intercellular and intraorgan communication system that transports biological information from one cell type or tissue to another. The exosomal cargo includes proteins, lipids, miRNAs, and other RNA species, and miRNAs have been linked to many of the physiological impacts of exosomes. Exosome miRNAs have also been employed as biomarkers for illness. Plants create a variety of nano- and micro-sized vesicles. Plant nano and microvesicles (PDVs), which were discovered for the first time in the 1960s, and their biological importance have been mysteriously understudied for a long time. It includes several proteins with antifungal and antibacterial action, as well as bioactive metabolites of significant medicinal interest, according to proteomic and metabolomics techniques. The PDVs have also been implicated in the intercellular transmission of short non-coding RNAs like microRNAs, implying intriguing methods of long-distance gene regulation, horizontal transfer of regulatory RNAs, and inter-kingdom communications.

In this work, we show that PGPMs have a role in the regulation of *Triticum aestivum* miRNA. We extracted miRNA from the plant and its exosome for our research. The miRNA was further sequenced using the microarray method, and the results revealed in comparison to chemical fertilizer treated, the PGPMs treated plant showed a 5.4-fold decrease in tae-miR5086 miRNA, which regulates the Glu-1D-1d gene responsible for high molecular weight glutenin synthesis, and a 3.3fold decrease in tae-miR1120a miRNA, which regulates gamma gliadin in chemically treated wheat plants. Several studies have shown that gluten is a nonalcohol-soluble protein and that Gladin is an alcohol-soluble protein that can cause celiac disease in people. It demonstrates how microorganisms may act on top-tier users, implying that additional research is required to understand all other paths via which cross-kingdom communication is conceivable, the function of microbes in that, and how it might help humanity.

Secondary Agriculture Bioprocessing (SAB) innovations: Taking agriculture from survive to thrive

Rajender Singh Sangwan
Faculty of Life Sciences Indira Gandhi University, Meerpur (Rewari), Haryana 122502, India
dr.sangwan@gmail.com

Agriculture has always been encountering challenges of profitable sustenance worldwide and is losing attraction not only as a competitive business profession but also as a significant way of return on investment/assets. Globally, subsidies have survived the agriculture in the interests of food supply assurance indigenously and/or food affordability of low-income class of consumers. In a 21st century principles of scale of profits in enterprises, present (largely) practice of agriculture would be probably last to fit. In India, on an average, about 1400 and 1100 farmers have been leaving their true status as 'main cultivators' per year for last 20 years and 30 years, respectively. Even positive factors of higher crop productivity due to better varieties/package of practices or wider markets evolved during the period have not been substantially diminutive for this trend of farmers leaving the profession of crop cultivation. Therefore, a paradigm shift in the philosophy of agri-profession is urgently needed i.e. taking it from '*survive to thrive*' through dynamically active technologies and innovations on contemporary business principles. In science and technological perspectives, it has to (a) move from single product to multi-product harvest and marketing, (b) farmgate technologies for early or precursor products, (c) customising technologies in alignment with Indian farm and farmer realities, (d) technologies and scales of their operation in tune with ground realities of land holdings and productivity and many more. The problem demands invoking much more of 'Bioprocessing Technologies for Agriculture (BTA)' rather than 'Plant Biotechnology'. BTA with interdisciplinary approach of research and innovations as well as 'high value low volume bioproducts from underutilized and/or unutilized agri-biomass coupled with farmers' skilling in farm gate technologies can give a quantum jump in farmers income sooner than later and by a scale probably unachievable by any other approach.

The recently launched Biomanufacturing Mission of the Government of India, calls for research scientists to re-model their research path and goals in alignment with mission and expectations of the exchequer. This challenge is more serious for plant/agricultural bioproducts than for non-agricultural (animal, microbial) to achieve tangile outcomes of scale and sustainability. There are many parameters (for the target technology and product) to be wisely selected for fairness of holistic costs, farm feasibility and by farmer operationality, sustainability and growing needs, production promoted rise in product demand. Some of the case examples of our own products and technologies related to Secondary Agricultural Bioprocessing as well as others would be presented in the lecture.

Functional genomics and crop improvement using genome-editing approach

Prabodh Kumar Trivedi
CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow

Genome-editing using sequence-specific nucleases, particularly CRISPR-Cas ribonucleoprotein, is the centerpiece of plant research and crop biotechnology. Around a decade ago, Cas9 was initially discovered to have a role in adaptive immunity in bacteria. However, later research demonstrated that Cas9 could be guided in a sequence-specific manner for efficient gene editing in organisms. CRISPR-Cas9-based genome editing revolutionized crop biotechnology by developing resilient commercial crops with improved yield and adaptation to various stresses. The approach has been used extensively for understanding genes' functions and developing new plant varieties with better traits. Our group has been using the CRISPR/Cas9 approach to determine the function of miRNAs, miRNA-encoded peptides (miPEPs), and various genes involved in secondary plant product biosynthesis and stress response. Our study, through developing CRISPR/Cas9-based mutants, suggests an involvement of the light-regulated miR858 and associated pri-miRNA-Encoded-Peptide (miPEP858) in the flavonoid biosynthesis as well as plant growth and development. CRISPR-based miR858a/miPEP858a-edited plants and miPEP858a overexpressing lines showed altered plant development and accumulated modulated levels of flavonoids. Transcriptome datasets from tissues of miR858 overexpressing lines and miR858a/miPEP858a edited plants suggest modulation in the expression of a set of genes, including the member of PSK gene family (AtPSK4), a small peptide. Genetic analysis using AtPSK4 and miR858a suggests the interaction of small molecules consisting of miPEP858/miR858-AtPSK4 regulates plant growth and development as well as the phenylpropanoid pathway leading to flavonoids biosynthesis. In addition, our group could develop tobacco and tomato CRISPR-based editing plants with improved traits. Some of these results will be discussed in the presentation.

SlERF36-mediated regulation of the GA pathway controls developmental transitions in plants

Rashmi Garg, Hrishikesh Mahato, Upasana Choudhury, Vidhu Sane, Aniruddha Sane
Plant Gene Expression Lab, CSIR-National Botanical Research Institute,
Lucknow-226001, India

The life cycle of a plant is punctuated by multiple developmental transitions that lead from dormancy to germination, juvenile to adult growth, vegetative to reproductive phase and the transition to senescence. These transitions, governed by a cross-talk between different hormones, determine the duration of the plant life cycle in annuals and are important agricultural traits facilitating early crop rotation. GA is a key hormone governing many of these transitions. We identified SlERF36 in tomato as an EAR-motif repressor that regulates the GA pathway and thereby governs the transitions. Suppression of *SlERF36* delays germination, reduces organ growth, delays the transition to flowering, delays fruit growth and ripening as well as whole plant senescence by 10-15 days. Its over-expression promotes growth and accelerates these transitions thereby leading to early completion of the life cycle. These changes are associated with reciprocal changes in the expression of most GA pathway genes between suppression and over-expression lines. SlERF36 interacts with the promoters of two GA2 oxidase genes, *SlGA2ox3/4* (involved in GA degradation) reducing their transcription and increasing GA_3/GA_4 levels by 3-5 fold. Its suppression increases *SlGA2ox3/4* transcript levels and reduces GA_3/GA_4 levels by 30-50%. Similar results are obtained by manipulation of the Arabidopsis homologues of *SlERF36*. The conservation of the gene across families makes it an important candidate for manipulation in agricultural and horticultural crops to reduce life cycles for faster harvest.

Genomic insights in cellular processes in Medicinal Plants, the powerhouse of specialized metabolites

Neelam Sangwan
Central University of Haryana, Mahendergarh-123031
drneelamsangwan@gmail.com

The plants biosynthesize and accumulate substantial quantities of unique and highly useful phyto-molecules in its plant parts, including leaves, roots and inflorescence. The terpenoid based phyto-compounds are produced by two pathways viz. mevalonate and DOXP isoprenoid pathway. In case of sesquiterpenoids, the plant recruits sesquiterpenoid biosynthetic pathway with additional steps. The biosynthesis and accumulation of various kinds of terpenoids are tightly regulated. The factors such as developmental phase, genotype, stress conditions such as drought, salt stress or in response to elicitation, these metabolites respond in a characteristic manner. The duration of stress and the developmental stage of the plants exhibit interesting corelation with the biosynthesis of metabolites. Observations have revealed that specialized metabolites accumulation are modulated under abiotic stress and developmental phases. Genomic studies have exhibited expression of transcripts of both pathways under regulation. Interestingly, over-expression of pathway gene(s) yielded metabolite alterations as well as impacting reservoir of other terpenoids such as total content of monoterpenoids, sequiterpenoids and higher terpenoids. Thus, differential responses could be noticed under different parameters of stress and developmental phase. Therefore, insight into the structural aspects and molecular regulation of pathway could reveal the cross talk of MVA/DOXP. The transcription factors too have complex regulation of pathways being the master regulator. Pathway genes and transcription factors play a key role in mediating the responses through biogenetic steps in glandular trichomes/specialized structures. The presentation would highlight the status and progress in genomic and molecular responses for development, stress adaptation, and phytochemical enrichment under varied conditions. Such information is highly desirable in determining the relation with yield and productivity specifically of valuable specialized metabolites for their advancement for health and agriculture sector.

Spatio-temporal regulation of ripening in mango: role of MAP kinases

Vidhu A. Sane
Plant Gene Expression Lab, CSIR-National Botanical Research Institute, Lucknow-226001, India, and AcSIR, Ghaziabad

Ripening in mango is under a complex control of ethylene. In an effort to understand the molecular basis of ripening related changes in mango we had previously characterized several cell wall disassembly related genes such as *MiEXPA1, MiPEL1, MiCEL1* and others like *MiHPPD* and *MiADH* that regulate VitE levels and aroma. A temporal control in their expression is associated with changes in softening. Apart from temporal changes that govern its timing, ripening in mango is also associated with spatial regulation of gene expression with differences between inner and outer zones and top and bottom regions. In an effort to understand the complex spatio-temporal control of ripening we have made use of two popular varieties that differ in the polarity of ripening. MAPKs have been extensively studied in various development processes of the plant, yet their role in ripening in mango is not studied till date. Our studies reveal differential expression of MAP kinases. Seven MAP kinases exhibited significant higher mRNA abundance fruits. Out of the 7 MAP kinases, MiMPK3 and MiMPK4 were selected for Virus induced gene silencing (VIGS) and transient over-expression studies to understand their role in ripening. Transient silencing and transient over-expression of the genes not only led to the modulation in ripening but also affected endogenous ABA levels in the fruit. Besides unravelling the complexity of ripening, this study could help develop ripening related markers for selective breeding to reduce the problems of excess jelly formation during softening in the Dashehari variety.

Bacterial assisted heavy metals phytoextraction potential of native plants and their histological observation growing on distillery sludge: A novel green technology tool for *in-situ* phytoremediation of hazardous industrial waste management for eco-restoration

Ram Chandra
Department of Environmental Microbiology, School of Earth and Environmental Sciences, Babasaheb Bhimrao Ambedkar University (A Central University), Lucknow-226 025, Uttar Pradesh, India

Sugarcane-molasses based distillery waste is a threat to environment for its safe disposal due to complexation of endocrine-disrupting chemicals (EDCs) containing mixture of organic pollutants. This study revealed that distillery sludge contains not only mixture of complex organic pollutants but also retains high quantity of Fe (5264.49), Zn (43.47), Cu (847.46), Mn (238.47), Ni (15.60), and Pb (31.22 mg kg^{-1}) which aggravate the toxicity of sludge to the environment. The major identified organic pollutants were benzene, 1-ethyl-2-methyl, benzene, 1-ethyl-4-methyl benzoic acid, 3,4,5-tris(TMS oxy), TMS ester; hexanedioic acid, dioctyl ester; stigmasterol TMS ether; 5α-cholestane,4-methylene; campesterol TMS; β-sitosterol and lanosterol. These compounds are listed under the EDCs also as per U.S. Environmental Protection Agency. However, the phytoextraction potential of growing native weeds and grasses i.e. *Argemone mexicana, Saccharum munja, Saccharum arundinaceuym, Cynodon dactylon, Pennisetum purpureum, Chenopodium album, Cannabis sativa, Parthenium hysterophorus, Ricinus communis, Rumex dentatus, Tinospora cordifolia, Calotropis procera* and *Basella alba* revealed the high accumulation of Fe, Zn, Cu, Mn, Ni, and Pb in their root and leaves compared to shoot. The rhizosphere of these plants were dominated by *Bacillus albus* (MN793207), *Bacillus cereus* (MW793498), *Bacillus paranthracis* (CP045777) and plant growth promoting activities i.e. IAA production, HCN production, organic acid production, phosphate-zinc-potassium solubilizing, Nitrogen fixing ability, were noted positive. Further, metagenomics analysis revealed Proteobacteria (50%), Bacteriodetes (33%), Firmicutes (5%) Gemmatimonadetes (2%), Chlorofexi (2%), and Tenericutes (2%). The dominant three genera were detected as *Rheinheimera* (21%), *Sphingobacterium* (17%), and *Idiomarina* (8%). In addition, other minor genera such as uncultured *Bacillus* (4%), *Acidothermus* (4%), *Bacillus* (3%), *Pseudomonas* (2%), *Flavobacterium* (2%), uncultured bacterium (2%), *Parapedobacter* (2%), *Alcanivorax* (2%), *Acholeplasma* (2%), *Hyphomonas* (1%), and *Aquamicrobium.* This indicated high accumulation and translocation capabilities of these plants due to bacterial communities growing in the rhizospheric of tested plant. Further, the bioaccumulation coefficient factor (BCF) and translocation factor (TF) was found>1 for majority of plants for various metals. Thus, this given strong evidence for hyperaccumulation tendency of these native weeds and grasses from complex polluted sites. Furthermore, the

ultrastructural observations of root tissues also revealed the deposition of heavy metals at various cellular components without any apparent toxic effects. This indicated the variable adaptive characteristics of these plants growing at a hazardous waste polluted site. Thus, the study given a strong evidence for application of these weeds and grasses as tools for in- situ phytoremediation and eco-restoration of polluted sites.

Sustaining food security through improved resource use efficiency: Physiological approaches in the omics era

S.K. Guru
Department of Plant Physiology, G.B. Pant University of Agriculture and Technology, Pantnagar

Green plants have the remarkable capacity to convert carbon dioxide and water into biomass that sustains our life on earth. They also utilize the mineral nutrients in this process. It is an irony that such natural resources that are transformed by plants to sustain life are under a constant threat. The situation becomes more complex given the fact that current projections of population increases will certainly have more pressure on the production systems. Meeting the targets of doubling yield of major food crops by 2050 can be a real challenge in a climate whose components are reaching dangerous proportions due to natural and anthropogenic activities. This is the major bottleneck in increasing food production. The inherent capacities of plants to utilize natural resources like water and nutrients are very low. Approaches to increase yields must include sustainable use of resources which requires improving the resource use efficiency of green plants. There have been many approaches at physiological and molecular levels to improve the use efficiencies of nutrients like nitrogen as well as that of water. The components of the pathways that are involved in uptake and utilization of nutrients have been dissected into finer components as well as understandings of the processes at system level have advanced a lot. While discoveries in the twentieth century have improved our understanding of the functioning of plants, the scientific advancements in the last few decades have been unprecedented. The "omics" approaches have revolutionized the way we understand the functioning of plants. It is time to utilize these approaches to improve resource use efficiency of plants. The current targets of increasing production per unit land area in a sustainable manner will require a perfect blend of the classical as well as the omics approaches. Though carbon dioxide concentrations are increasing, the process to utilize it still depends on the utilization of nutrients and water. One promising approach have been realizing an improved photosynthetic efficiencies of crop plants as envisaged in the RIPE project.

This talk will focus on some of the key aspects of improving resource utilization efficiency of green plants through a blended approach. Translating the approaches into reality of improving biomass production under natural conditions will require a change in mindset and policy.

Novel approaches for low grain arsenic rice crop for sustainable environment and agriculture

R.D. Tripathi[1], P. Tiwari, P.K. Singh, P.K. Srivastava[1], S. Dwivedi[1], D. Chakrabarty[1], and B. Adhikari[2]
[1]CSIR-National Botanical Research Institute, Lucknow-226001, India
[2]Rice Research Station, Department of Agriculture, Chinsurah, West Bengal, India
[3]Department of chemistry university of Lucknow, Lucknow-226001
tripathird@gmail.com

Arsenic is a widely recognized pollutant and declared a non-threshold carcinogen pollutant worldwide. The most common routes of arsenic exposure to humans are the usage of contaminated water for drinking and irrigation in agricultural fields. This leads to arsenic contamination in rice crops and vegetables grown on such soil eventually contaminating the food chain. Rice, being a cereal consumed by half of the world's population, accumulates more arsenic due to wet land growing conditions. Through breeding and selection, a rice cultivar CN1794-2-CSIR-NBRI was developed. This rice cultivar, while accumulating low As, maintains higher levels of micronutrients such as Fe, Cu, Zn, Se, and Ni. Selenium and Sulphur including nano sulphur supplementation reduced As the level in rice plants. In order to restrict As in the rice roots, a transgenic approach has been followed through the expression of phytochelatin synthase PCS, Cd*PCSI,* from *Ceratophyllum demersum,* an aquatic As accumulator plant. Rice transgenic lines showed enhanced accumulation of As in root. However, all the transgenic lines accumulated significantly reduced As in grain and husk in comparison to non-transgenic plants. The higher level of PCs in transgenic plants relative to non-transgenic presumably allowed sequestering and detoxification of higher amounts of As in roots thereby restricting its accumulation in grain. Another approach involved As volatilization through genetically engineered *Arabidopsis thaliana* with arsenic methyltransferase (*WaarsM*) gene from one of the fungal strains, *Westerdykella auantiaca* (MTCC10845), isolated from arsenic-contaminated sites. The *WaarsM* transgenic *A. thaliana* plant showed enhanced tolerance to AsV and AsIII, compared to wild-type (WT) plants. *WaarsM* expressing transgenic paddy evolved a significantly amount of volatile arsenicals as *WaarsM* gene expressed in rice was able to convert toxic inorganic arsenicals to methylated volatile arsenic species, reducing arsenic accumulation in rice grains.. Transgenic line 1, grown in soil irrigated with arsenic-tainted water accumulates about 50% and 52% lower arsenic than the NT in shoot and root, respectively, while the Arsenic concentration in polished seeds and husk of the transgenic rice line was reduced by 52% compared to NT. Selenium application lead to reduced Arsenic accumulation in rice plants. Thus, the present study demonstrates that the expression of *WaarsM* in rice induces arsenic

methylation and volatilization, and provides a potential strategy to reduce arsenic accumulation in rice grains. Transgenic plants expressing PC synthase and *WaarsM* appear suitable for phytoremediation of As. Suitable combined biotechnological and microbe plant interaction approaches may lead to safer levels of arsenic in the food crop.

Elucidating the role of plant transcription factors in millets for global food and nutritional security: An overview

Dinesh Yadav
Department of Biotechnology, D.D.U. Gorakhpur University, Gorakhpur (U.P.) 273009, India
dinesh_yad@rediffmail.com

Substantial efforts have been made to achieve global food and nutritional security by incorporating traditional breeding technologies with the advanced genomics driven technologies. Deciphering the whole genome sequencing of several crops have expedited the implications of recent crop improvement technologies. Emphasis has been made to enhance the crop yield but in the present scenario it is more relevant to reduce the loss incurred by several biotic and abiotic stresses. Biotechnological approaches have high potential for developing stress tolerant crops. Millets belong to the Poaceae family and are used as a multipurpose crop i.e. foods, feeds, and forage. It possesses highest stress tolerance capacity among all cereals and have high nutritional value, also termed feminine crops. A comprehensive understanding of millet transcription factor and the recently used strategy for its improvement against various stresses will enlighten its contribution toward agrarian, food and nutritional challenges. Transcription factors are essential components of the regulatory mechanisms that allow plants to withstand these stresses through expressing such genes. Compared with structural genes, TFs usually control multiple steps in a pathway; this makes them powerful tools for manipulating complex metabolic pathways. A variety of transcription factors are known to have played a role in the response of millets to various growth, developments, biotic and abiotic stresses, viz. MYB, WRKY, NF-Y, NAC, Dof etc. Understanding the fundamental regulatory mechanisms of millets TFs will helps to improve crop plants' stress tolerance for sustainable agriculture. Recently, there have been increasing discoveries about the function of millets TFs in drought and salinity stress responses. This knowledge has led to practical approaches for improving plant stress tolerance. Our lab is presently working on genome-wide identification and characterization of Nuclear Factor-Y transcription factors in finger millet.

Processing and utilisation of millets for nutritional security and strengthening agriculture

Neelam Yadav
Centre of Food Technology, Science Faculty Campus, University of Allahabad, Praygraj
neelam_aidu@yahoo.com

Millets are small grains that have long been a staple food in dry land areas and are classified as nutri-cereals due to their high nutritional value. They are the crops of ancient times and also suited to current perspective of climate change as it requires less water and have 25% less carbon foot print than wheat and rice. Millets are rich in various nutrients, including protein, essential fatty acids, dietary fiber, B-vitamins, and minerals. They are highly nutritious, versatile, resilience in various agricultural conditions and provide a distinct range of health benefits. Finger millet, Red rice, Kodo millet, and Barnyard millet have been explored for their functional properties such as dietary fiber, total polyphenols, and antioxidant activity. Finger millet was found to be high in calcium content (337mg/100g), while barnyard millet had a rich iron content (18.3mg/100g). Kodo millet (38.31%) and finger millet (19.06%) had significant amounts of dietary fiber. Red rice showed high DPPH scavenging activity (61%) and total carotenoid (146 μg/100g). Effect of different processing methods (malting, microwave, extrusion cooking, roasting, and pressure cooking) on the physicochemical characteristics, nutritional composition, anti-nutritional factors (such as phytic acid), and antioxidant properties of the selected cereals had been studied. Roasting was found to have the highest antioxidant properties, followed by extrusion, microwave, pressure cooking, and malting treatments. Glycemic index (GI) of underutilized cereals and millets (finger millet, red rice, kodo millet, barnyard millet, sorghum, pearl millet) have been found to be low in comparison to staple cereals and can be recommended for prevention and management of diabetes and degenerative diseases. Additionally, treatments like germination, fermentation, and roasting led to a decrease in GI values. Starch modification through cross-linking also resulted in a reduction in GI. The study provides valuable information for the development of low GI food products using these cereals. Effect of different processing methods like malting, microwave treatment, extrusion cooking, roasting, and pressure cooking demonstrated that roasting treatment had highest antioxidant properties, followed by extrusion, microwave treatment, pressure cooking, and malting. Based on the findings, ready-to-eat (RTE) extruded products were developed by formulating composite flour from finger millet, kodo millet, barnyard millet, and red rice. For this, a linear programming model was applied to meet the recommended daily allowances (RDA) of nutrients for sedentary women and preschool

children. Developing RTE snack products can serve the nutritional needs of different age groups. Millets being rich in oligosaccharides and dietary fibre also shows good prebiotic activity and can be used for development of probiotic products. Furthermore, the millets could be utilized for gluten-free product development and managing regressive diseases. Hence, production of millet should be promoted at national and global level in order to meet the objective of SDG's (sustainable Development Goal) and international year of millet.

Food Grain processing in general and Rice Technology in specific

Vasudeva Singh
Former Chief Scientist, CSIR-CFTRI, Mysore
Emeritus Medical Scientist (ICMR), Dept. of Food Science and Nutrtion, Manasagangotri, Mysore, Mysore Univ.
Professor, Dept. of Bio-Engineering and Technology, Food Science Division, Gauhati University, Gauhati, Assam 781 014, India
singhva2003@gmail.com

Production of Cereals in World is around 2800 million tonnes (MT) and India produces around 280 MT as on 2018-19. 750 MT of paddy rice is produced in World and India produces around 160 MT. From this, ~10% (16 MT) goes for the production of rice products like rice flakes, expanded rice and popped rice which are generally prepared in small scale industries. Around 75 MT is used for production of raw rice and balance (75 MT) is used for the production of parboiled rice. World rice have been classified into 8 groups based on some of their physico-chemical properties like amylose content, gelatinization temp., alkali score, pasting behavior or viscographic parameters, cooking behavior etc. Importance of brown rice along with manufacturing large scale brown rice as well as nutri rice will be highlighted. Importance of Tiny rice mill will also be informed. Parboiling, a method of improving the technological properties and nutritive values of rice will also be highlighted. Medicinal rice Njawara, a pigmented variety, having high nutrients compared to other normal pigmented and non-pigmented rice varieties, its various physicochemical properties, protein and lipid profile in comparison with non-medicinal rice will be touched upon. Preparation of pre-gelatinized starches will be informed. Usage of cereals, millets, legumes in the preparation of multi grain ready to cook (RTC) and ready to eat (RTE) products will also be touched upon. Making of dhal from whole pulses and their technologies which are generally followed all over the world & in some parts of Asia will also be focused upon. Millet technology in brief, maize grits manufacture and products from maize grits, in addition manufacture of starch from tapioca, which is generally used for the manufacture of Sago will also be touched upon. If time permits weaning foods preparation will also be spoken.

Global warming, climate change and greenhouse effect: Causes, consequences and remedial measures

Sudhir Mehrotra
Professor and Head, Department of Biochemistry, University of Lucknow, Lucknow -226 007 U.P.
sudhirankush@yahoo.com

Climate change refers to the increasing changes in the measures of climate over a long period of time – including precipitation, temperature, and wind patterns. This term is not new, it has always happened on the Earth and is clearly seen and felt; what concerns us is rapid rate and the magnitude of climate change occurring now worldwide. We know that the planet has warmed by an average of nearly 1°C in the past century. As the planet continues to warm, climate pattern changes. Extreme and unpredictable weather has become more common across the world and it is causing severe natural calamities that humans have not foreseen. Not just humans, climate change and global warming has shown drastic impacts on all life forms present on the Earth.

Global warming is just one aspect of climate change which refers to the rise in global temperatures. The impact that global warming is causing on earth is extremely serious. There are many hazardous effects that will happen in the future if global warming continues. It includes melting of polar ice caps, leading to an increase in sea level drowning coastlines and slowly submerging continents. Global warming has got many harmful effects on human health such as worsening of air quality which can lead to asthma attacks along with other respiratory and cardiovascular effects. Besides this there will be increased incidences of pathogens owing to increased temperature and decreased food production and loss of biodiversity. Greenhouse gases from human activities are the most significant driver of observed climate change and global warming since the mid-20th century. Increasing concentrations of greenhouse gases in the atmosphere is the main cause of global temperature rise. The current levels of atmospheric concentrations of greenhouse gases are just unprecedented. Emissions of the major greenhouse gases resulting from human activities and the concentrations of these gases in the atmosphere have changed over time and led to serious deterioration of our environment. As greenhouse gas emissions increase, it builds up in the atmosphere and warm the climate, leading to many other changes around the world i.e. in the atmosphere, on land, and in the oceans. Because many of the major greenhouse gases stay in the atmosphere for tens to hundreds of years after being released, their warming effects on the climate persist over a long time and can therefore affect both present and future generations.

Repercussion of climate change on the oxygen-evolving complex in plants

Ramwant Gupta[1] **and Munna Singh[2]**
[1]Department of Botany, Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur, UP, India
[2]Department of Botany, University of Lucknow, Lucknow, UP, India
ramwantgupta@hotmail.com

Photosynthesis is the essential process of autotrophs leading to primary production on the planet adversely affected by changing global climate. The process of photosynthesis takes place inside the green plastid *i.e.* chloroplast in higher plants. An oxygenic photosynthetic apparatus, embedded in the thylakoid membrane of chloroplasts used to convert light energy to chemical energy *via* photo- system I and II. The oxygen-evolving complex (OEC) is integrated into photo-system (PSII). The OEC is a super catalyst to split water into molecular oxygen in the presence of light. The OEC consist of four Mn atoms, one Ca atom and five oxygen atoms ($CaMn_4O_5$) and this cluster maintained by its surrounding proteins *viz.,* PsbQ, PsbP, PsbO, PsbR. The function of this super catalyst with a high turnover frequency of 500 s^{-1} in optimal condition. A study was aimed to understand OEC performance in response to abiotic stresses. Chlorophyll a fluorescence (OJIP transients) is used to understand structural and functional cohesion of photosynthetic apparatus in various plants to varied climatic conditions. An addition K-peak in OJIP curves reflects damage at the donor site of the OEC in response to salinity and high temperature. The decline in performance indices (PI, SFI) also revealed structural damage of photosynthetic apparatus that leads to disruption of electron transport rate under different abiotic stresses. This study reveals the structural and function cohesion of the OEC in plant against varied climatic conditions. Based on our finding a strategy can be developed to enhance the production and productivity of crops that can bring humanity closer to solving the future agricultural crisis.

Fascinating regulatory mechanism of silicon for mitigating drought stress in sugarcane (*Saccharum* spp.)

Krishan K. Verma[1], Xiu-Peng Song[1], Munna Singh[2], Chhedi Lal Verma[3], Yang-Rui Li[1]
[1]Key Laboratory of Sugarcane Biotechnology and Genetic Improvement (Guangxi), Ministry of Agriculture and Rural Affairs/Guangxi Key Laboratory of Sugarcane Genetic Improvement/Sugarcane Research Institute, Guangxi Academy of Agricultural Sciences, Nanning - 530007, Guangxi, China
[2]Department of Botany, University of Lucknow, Lucknow - 226007, India
[3]Central Soil Salinity Research Institute, Regional Research Station (RRS), Lucknow - 226002, India
drvermakishan@gmail.com; drvermakk@gxaas.net

Plants confront several environmental stresses that are crucial in defining plant productivity. Among these environmental stresses, drought stress is recognized as the foremost abiotic factor which affects the food security worldwide due to its harmful impact on the plant growth, development, and quality of plant output. Silicon (Si), an agronomically essential mineral nutrient, is recognized highly advantageous in upgrading plant growth at various phases of plant life cycle during water stress conditions.

Sugarcane (*Saccharum* spp. hybrid) is a major cash crop for sugar and ethanol production and requires essential nutrients for optimum biomass yield. Physiologically, it is a C_4 plant based on specific carboxylation profile having different developmental phases, such as sprouting, tillering, major growth period, and maturity, which experiences various degrees of water stress to affect plant development and productivity. Sugarcane plant developmental phases get affected by ambient air temperature and light intensity. Present study aims to reveal the consequences of foliar spray of silicon (Si) to mitigate the adverse effects of water stress on sugarcane plants. Silicon (0, 50, 100 and 500 ppm) was applied as foliar spray on normally grown 45 days old sugarcane plants. Further, these plants were raised at half-field capacity (50%) using water irrigation precisely up to 90 days under open environmental variables. Exposure of *Saccharum* spp. to water stress significantly reduced the photosynthetic rate (P_N, 28-31%), stomatal conductance to water vapor (gs, 31-41%) and transpiration rate (E, 50-54%). The intrinsic water use efficiency (P_N/gs, WUEi) and water use efficiency (P_N/E, WUE) were found higher (1.3-17 & 40-55%) in sugarcane plants as compared to normal plants after applying Si (50, 100 and 500 ppm). The higher leaf respiration *Rd* values were also noticed at 30, 60 and 90 days after foliar application of Si in stressed plants, varied significantly among Si application plants during the specific time of drought stress. The foliar application of Si alleviated *Rd* ca. 18-46% during stress conditions almost found similar to gs values in comparison to control and limited irrigation. The average gs values at night were lower than during the day (30, 60 and 90 days) in stress and Si applied plants, while gs varied significantly during the daytime.

Dark-adapted chlorophyll fluorescence yield (*Fv/Fm*) of photosystem II decreased (11-~14%) at 30, 60 and 90 days after water stress condition. The highest reduction (~14%) was found in 90 days after stress, and minimum loss (10-13%) was found in limited irrigation of water with Si application (50, 100 & 500 ppm). Si mitigated the Chl a, Chl b, Chl a+b, and SPAD units by 3-25, 2-24, 3-25 and 7-18%, respectively, in stressed plants. The biomass of leaf, stem, senescence leaves and total biomass reduced ca. 42-44, 56, 53-63 and 44-53% at 30, 60 and 90 days after stress, respectively. The loss in biomass was significantly mitigated and gradually enhanced upon Si application.

The antioxidative enzyme activities such as CAT, SOD and APx were significantly enhanced in response to stress with or without Si. The maximum limited irrigation-induced CAT (102-132%), SOD (34-98%) and APx (21-136%) activities. However, the various concentration of Si (50, 100 & 500 ppm) showed a quite different pattern for improving the activities of various antioxidative enzymes. SOD activity increased (26-98%) with increasing Si levels. The CAT activity pattern was found to be similar to SOD with enhancing (67-131%) tendency associated with Si. Ascorbate peroxidase was evidently positively regulated by Si, which enhanced up to ca. 133-259%. The foliar spray of Si defended sugarcane plants from limited water irrigation stress as Si quenched the harmful effect of water deficit and enhanced the operation of antioxidant defense machinery for improved sugarcane plant performance, suitably favored stomatal dynamics for photosynthesis and plant productivity.

Eco-friendly synthesis of silver nanoparticles from some medicinal plants

Pooja Saklani
Department of Biotechnology, H.N.B Garhwal University, Uttarakhand

The fundamental component of nanotechnology is the nanoparticles (NPs) that are between 1 and 100 nanometres in size. They have applications in various fields of healthcare, agriculture, environment remediation, cosmetics and food. The NPs can be synthesized by physical, chemical or biological methods. The biological method of synthesis involves the use of microorganisms and plant materials. In the present study, green synthesis or plant-mediated synthesis of silver nanoparticles (AgNPs) was done and their medicinal potential was analyzed. AgNPs were synthesized from the methanolic extract of leaves of different medicinal plants viz., *Reinwardtia indica*, *Coleus forskohlii*, and *Picrorhiza kurroa,* by photoreduction method. For the study, the plant materials were collected from the Garhwal Himalayan region. The synthesized AgNPs were characterized using different techniques like UV Visible Spectroscopy, Scanning Electron Microscopy coupled with Energy Dispersive X-ray (SEM-EDX), X-Ray Diffraction (XRD), and Fourier Transform Infrared Spectroscopy (FTIR). The antimicrobial potential of AgNPs from *R. indica*, *C. forskohlii* and *P. kurroa* was determined against various bacterial strains using agar well diffusion method by measuring the zone of inhibition. The antioxidant potential of *P. kurroa* AgNPs was also determined by phospho-molybdenum and DPPH assays. The characterization of AgNPs revealed the synthesis of the nanoparticles. The determination of the antimicrobial potential revealed that these green synthesized AgNPs have an enhanced antibacterial effect compared to plant extract due to their small size that increases their surface area. The AgNPs from *P. kurroa* were also observed to have antioxidant activity, which can scavenge harmful reactive oxygen species. Therefore, this study signify that the green synthesised silver nanoparticles can enhance the therapeutic efficacy and strengthen the medicinal values of plants. Further studies can be performed to determine other biological activities that can be helpful in synthesizing different diagnostic and healthcare products.

Phytochemicals of nutraceutical importance from agri-horticultural waste

Charu Gupta and Dhan Prakash
Amity Institute of Herbal Research & Studies, Amity University-UP, Sector-125, Noida-201313 (India)
dprakash_in@yahoo.com

The agri-wastes including the food processing industry constitute a problem to environmental pollution due to their high rate of biodegradability. Fruit and vegetable processing businesses generate waste materials including peels, seeds, and stones. According to scientific research, these wastes have a substantial potential as a valuable source of phytochemicals for nutraceuticals. Utilizing waste from the food processing industry is a difficult but vital task. Their abundance of secondary metabolites makes them useful adjuvants in the treatment of a variety of medical conditions, including aging, high blood pressure, cancer, cardiovascular disease, and other degenerative illnesses. Because so many different fruits and vegetables are used, a wide range of methods are employed, and there are many different products produced, the waste generated by the food processing sectors is incredibly diversified. These materials can be effectively employed as a source of different phytochemicals and antioxidants that are important in nutraceuticals and functional meals. The agri-waste are good source of phytochemicals that can plays an important role in the prevention and cure of diabetes, obesity, atherosclerosis, heart diseases, colon cancer, and colorectal cancer. Mango peel contains phytochemicals such as polyphenols, carotenoids, vitamin E, and vitamin C. Polysaccharides isolated from granadilla, lemon, and tomato pomace wastes suggest that this biopolymer plays a part in regulating the process of inflammation and/or oxidative stress. Citrus wastes are abundant in pectin, essential oils, and other byproducts. The fruit juice industry generates huge quantities of citrus waste, which is one of the most important raw materials used in the manufacturing of commercial pectin. Commercial pectin is traditionally derived from citrus and apple wastes as citrus fruits have a high pectin content, ranging from 20 to 30% of dry matter waste. From an ecological and economic perspective, the most sensible course of action is to produce pectin from apple pomace. Protease can be produced from vegetable wastes such as soybean, onion, potato, pumpkin, cauliflower, cabbage, and brinjal by employing *Aspergillus niger* in solid-state fermentation. This is a cost-effective method for the bioconversion of vegetable wastes into industrially significant amounts of protease. Total antioxidant phenols in grapefruit, orange, and lemon peels have been found to be 15% greater than in peeled fruits. The present studies showed that agri-horticultural wastes have tremendous potential to be used as nutraceuticals in the prevention and management of disease.