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Soil Research Innovation for Sustainable Natural Resource Management: An Overview

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Natural resource management (NRM) based on scientific principles plays a crucial role for an inclusive and sustainable growth in India. The shrinking per capita natural resources leads to intensive land use and results in further environmental degradation. This calls for developing agro-ecoregion specific land-use plans based on homogeneity in soil, water and climatic features in a particular region and managing a particular land unit on watershed basis involving the local community. Soil is the place where food begins. It also silently provides us with almost all ecosystem services and functions that enable life to exist on earth. It is responsible for cleaning, filtering and storing water, recycling nutrients, regulating the climate and floods, and removing carbon dioxide and other gases from the atmosphere. Caring soil is extremely important for sustaining healthy life. However, the soil is facing acute challenges not only from agriculture but also due to acute challenges of rising population besides diversion of agricultural lands for other sectors. Further, due to misuse and overuse of soil, it is either lost or degraded. So, protecting the soil for the future generations is the most important priority. This article consolidates information on the science-based efforts made by the Government of India through various scientific establishments and science-led development schemes for NRM over time. The technological innovations in NRM research are discussed in this article keeping in view the emphasis of the government and the importance of natural resources in promoting inclusive and sustainable growth in India.

Keywords: Natural resource management, Land degradation, Soil health, Climate change, Nutrient and food security

Natural resource management (NRM) based on scientific principles plays a crucial role for an inclusive and sustainable growth in India. The importance of natural resources, comprising land, water and vegetation, has felt immensely in recent past than ever before for the need to ensure sustainability in the face of changing climate, increased biotic pressure and declining resource productivity. Economic growth can be inclusive only if the natural resources are sustainably managed. The economic development will be sustainable only if it is pursued in a manner which protects the environment. With acceleration of economic growth, these pressures are expected to intensify, and we therefore, need to pay greater attention to the management of natural resources *viz.,* soil, water and forests. The shrinking per capita natural resources leads to intensive land use and results in further environmental degradation. This calls for developing agro-ecoregion specific land-use plans based on homogeneity in soil, water and climatic features in a particular region and managing a particular land unit on watershed basis involving the local community.

Soil is the most wondrous gift of nature to human society. It is the "soul of infinite life". Soil is a fingerprint of human health, instinct, culture and humanity. Without soil, there is no life on the planet Earth. About 87% of life is present within an average of one meter of topsoil. One spoon of a healthy soil contains more than one billion microorganisms, 10 thousand different species. While, soil formation is a slow process, it takes 80 to 750 years to generate 1 cm of soil. As early as 5000 B.C, the Vedas and the Upanishads in Indian history witnessed the soil as synonymous with land, the symbol of Mother, for survival and nourishment of all lives on the Earth. Soil is accordingly worshiped as Mother Earth, on the other hand, soil is a huge storehouse for variety of waste materials on way to keep our environment clean. Soil is a source as well as a sink to absorb, desorb, fix or release mineral elements and gases and grow plants and decompose crop residues incorporated into it. It is a living factory where millions of tiny organisms are working day and night, transforming the organic matter and participating in carbon (C) and nitrogen (N) cycles and many mineral elemental cycles.

Soil is the place where food begins. Soils not only give us 95% of the food we eat, but also silently provide us with almost all ecosystem services and functions that enable life to exist on Earth. This thin skin of the planet, on which humans stand up every day, is also responsible for cleaning, filtering and storing water; recycling nutrients; regulating the climate and floods; and removing carbon dioxide and other gases from the atmosphere. Caring soil is extremely important for sustaining healthy life on Earth. The soil is facing acute challenges not only from agriculture which is being the backbone of nation's prosperity and development but also facing acute challenges due to rapidly rising population besides diversion of agricultural lands for other sectors. Further, due to misuse and overuse of soil, it is either lost or degraded. In the last 40 years, ~40% of the world's topsoil has been lost. The United Nations says we have soil left only for approximately another 45-60 years of agriculture. Nearly 30% of India's land is already degraded. So, protecting the soil for the future generations is the most important priority. Our survival will depend how best we use this precious natural resource.

Agriculture is the mainstay of the Indian economy. Two thirds of the Indian population depend on agriculture. With only 2.4% of the world's land area, India is home to 17.5% of the world's human population and 15% livestock population and contributes immensely to global biodiversity with about 8% of total number of species (Chaudhari *et al*., 2020). India is recognized as a mega biodiverse country and has four identified bio-hotspots *viz*. the Himalaya hotspot, the North East of India, the Rainforests of the Western Ghats and the Andaman & Nicobar Island chain.

India has vast livestock resources including poultry. Livestock production and agriculture are intrinsically linked, each being dependent on the other, and both crucial for overall food security. Livestock is an important source of income for most the farmers and plays an important role in national economy and supporting agriculture in the form of critical inputs, contributing to the health and nutrition of the household, supplementing incomes, offering employment opportunities, and finally being a dependable asset in times of

need. It acts as a supplementary and complementary enterprise. According to the 20th livestock census in 2019, the country has about 536.76 million livestock population and 851.81 million poultry population, being the first in cattle and buffalo population, second in respect of goat and third in respect of sheep population in the world (Annual Report, 2021-22). India has 57% of the world's buffalo and 16% of the world's cattle population. This means there is not only human population but also livestock population pressure on the shrinking natural resources. Though India is bestowed with 4% of the world's freshwater resources, the distribution is highly skewed across regions. The Ganga–Brahmaputra–Meghna basin with 33% of the land mass has 60% of total water flows, while the western coastline with 3% of the area has another 11%. This leaves just 29% of water resources in the remaining 64% of the area (peninsular India), thus keeping most of peninsular India water-starved compared to other parts of the country.

With tremendous demographic pressure on land, the per capita availability of agricultural land in India has already decreased sharply from 0.48 ha in 1951 to 0.13 ha in 2011 which is likely to decrease further to 0.08 in 2035. The major challenges in Indian agriculture facing are deterioration of soil chemical, physical and biological health, depletion of soil organic matter (SOM), imbalance in fertilizer use, emerging multi-nutrient deficiencies, particularly of secondary and micronutrients, declining nutrient use efficiency, declining crop response ratio and negative soil nutrient balance, accelerating soil erosion, salinization, soil compaction, and surface sealing, and improper crop husbandry practices. Other concerns are low water productivity, low farm productivity and profitability, climate change impact on agriculture and risk management, loss of tree covers and deterioration of ecosystem services. It is the need of the hour to manage soil resource for achieving food, nutritional, environmental and livelihood security, conserving the vital natural resources for future generations without any deterioration.

Research and Innovation for Natural Resource Management (NRM)

Land degradation continues to be a threat to the food and nutrition security of the country. Deterioration of soil health is considered as one of the main reasons of declining nutrient use efficiencies and stagnation of agricultural productivity. It is estimated that out of total geographical area of 328.73 million hectares (Mha), about 104.20 Mha of arable land has been degraded in one form or the other, out of which, around 73.27 Mha suffers from water erosion and 12.24 Mha from wind erosion. Nearly 89.52 Mha of land suffers from one or the other form of physical constraints like shallow depth, soil hardening, slow and high permeability, sub-surface compacted layer, surface crusting, temporary waterlogging, *etc*. Around 17.36 Mha of the country's arable land is affected by various kinds of chemical degradation. This includes about 10.72 Mha suffering from acute soil acidity (pH <5.5) and around 6.64 Mha of the arable land is salt-affected, comprising of 3.64 Mha under high sodicity (pH >9.5) and about 3 Mha under salinity.

The research network for natural resource management (NRM) is being run primarily by three separate agencies of Government of India *viz*., Ministry of Agriculture (MoA), Ministry of Environment and Forests (MoEF) and Department of Space (DoS). The ICAR under the MoA, New Delhi through its Division of Natural Resource Management (NRM) has been taking up the basic and strategic research programmes to develop technologies for conservation of soil and water, management and sustainable utilization of the natural resources ensuring food, nutritional and environmental security in the country through 15 research institutes, 10 All India Coordinated Research Projects, 3 Network projects and 2 Consortia Research Platforms on Water and Conservation Agriculture with a wide network of the Cooperating Centres and State Agricultural Universities (https://icar.org.in).

The major concerns of NRM Division are low farm productivity and profitability; land degradation; low water productivity; soil health deterioration and low nutrient use efficiency; abiotic stresses including climatic aberrations;

and loss of tree cover and deterioration in ecosystem services. To address the above issues, the NRM research programmes have been prioritized within the perspective of different themes, *viz*., soil inventory and characterization; integrated soil-water-nutrient management; watershed management; resource conservation technologies; crop diversification; integrated weed management; integrated farming system including agroforestry; dryland farming; arid, coastal and hill agriculture; abiotic stress management; climate resilient agriculture; conservation agriculture; waste water utilization; solid waste management; and applications of nanotechnology to enhance nutrient and water use efficiency. The NRM Division is also conducting research in farmers' participatory mode addressing issues at ground level and developing location specific, cost effective, eco-friendly, socially acceptable scientific farming practices keeping in view the farmers' resource availability, traditional indigenous technology knowhow and grassroot farm innovations. The outcome of NRM research has been promoted through various developmental Plan schemes of the Government and contributing towards increase in agricultural productivity in the country.

Research and innovation for erosion control and rainfed area management

Soil erosion is primarily caused by water and wind. Soil erosion by water (water erosion) is a three-step natural process involving three basic steps of detachment, transport and deposition. The rainfall and run-off erosivity are the two factors deciding the level of soil erosion by water. Rainfall erosivity is the intrinsic capacity of rain to cause erosion. The major factors deciding the rainfall erosivity are amount, intensity and drop size of rain. The Universal Soil Loss Equation (USLE) developed by Wischmeier and Smith (1965, 1978) is the most popular, easy to use and mostly used for estimation of soil loss by taking into account the rainfall erosivity, soil erodibility, topography and soil cover and management practices.

The soil erosion control measures recommended are based on three basic scientific principles:

a) Reducing the hitting action of the raindrop where it falls, through increasing the soil cover.

b) Reducing the run-off velocity through barriers such as contour bunds, graded bunds, stone bunds, vegetative barriers of grasses, establishing hedge row barriers of shrubs such as of *Gliricidia* spp., *Indigofera* spp. The methods depend on the degree of land slope. In higher slopes with land slope varying from 6% to 33%, terracing is recommended where the slope length is broken to a number of terraces.

c) Taking up measures such as increase in SOM content, soil structure improvement, cover and green manure crops *etc*., which allow more water to infiltrate down the soil profile rather than generating high run-off volume.

For conducting research on conservation of soil and water and particularly to control water erosion, the ICAR-Indian Institute of Soil and Water Conservation (formerly, Central Soil & Water Conservation Research & Training Institute, CSWCRTI) was established in 1974 with its Headquarter at Dehradun by combining seven Soil and Water Conservation Research, Demonstration and Training Centres of Government of India (http://cgwb.gov.in/). The Institute works on evolving strategies for controlling land degradation following watershed approach, tackling special problems such as ravines, landslides, mine spoils and torrents, demonstration of technologies for popularization and imparting training besides developing technologies for water harvesting and recycling. The first estimate of soil erosion of India was given by CSWCRTI in 1983 (Dhruvanarayana and Rambabu, 1983) based on the annual soil loss data of 20 land resource regions, sediment loads of some rivers, rainfall erosivity for 36 river basins and 17 catchments of major reservoirs of the country.

In view of the fact that the arid zone covers about 12% of the country's geographical area and occupies over 31.7 Mha of hot desert and about 7.0 Mha under cold desert, ICAR established the Central Arid Zone Research

Institute (CAZRI) at Jodhpur in 1959 to conduct research and development technologies for wind erosion control and arresting desertification processes, and to develop arid land-management technologies and sustainable farming system models for the arid ecosystems (http://www.cazri.res.in). At present, about 12.4 Mha area suffers from wind erosion problems (ICAR, 2010). Currently, the Institute also has five regional research stations at Bhuj, Pali, Jaisalmer, Bikaner and Leh.

In India, about 57% of net cropped area is rainfed, contributing only about 44% to the total foodgrain production because of a series of socio-economic problems such as low cropping intensity, intra- and inter-seasonal variability in rainfall, poor adoption of modern technology, low crop yield, inadequate public investment, and incidence of rural poverty. However, rainfed regions contribute more than 90% of pulses and about 80% of oilseeds production in the country. It is said that the possibility of a second green revolution can be better explored from the rainfed areas. Realizing the importance of rainfed regions, the Central Research Institute for Dryland Agriculture (CRIDA) under ICAR was established in Hyderabad during 1985, to work on development and popularization of suitable location-specific rainfed technologies for productivity enhancement in rainfed areas. CRIDA works along with 25 coordinated project centres located in different parts of the country.

Research and innovation for soil fertility and soil salinity studies

Excessive use of chemical fertilizers, combined with low use of organic inputs and irrational irrigation management have affected the productive soil adversely. This has caused a reduction in soil productivity, decrease in partial factor productivity of major plant nutrients (N, P and K) and reports of deficiency of several micronutrients, apart from being the leading cause for land and environmental degradation such as eutrophication and groundwater pollution. Therefore, the future gains of enhancing food production in a sustainable manner can essentially be realized through the generation and adoption of more appropriate nutrient and water management technologies that are based on basic and sound strategic research information.

In view of the growing importance of enhancing and sustaining productivity of soil resources, ICAR established the Indian Institute of Soil Science (IISS) at Bhopal in 1988 to conduct basic and strategic research with a mandate to 'provide scientific basis for enhancing and sustaining productivity of soil resource with minimal environmental degradation (http://iiss.nic.in).

Similarly, to cater to the problems of soil salinity and to suitably manage saline and alkali soils, and develop technologies for using poor-quality irrigation water in different agroecological zones of the country, the Central Soil Salinity Research Institute (CSSRI) is working at Karnal since 1969. The Institute was established as a follow-up to the Government of India appointed Indo-American Committee constituted to assist ICAR to develop a comprehensive water management programme for the country. The Institute has also three regional research centres at Canning town, West Bengal to look into the problems of coastal salinity; Lucknow, Uttar Pradesh for salinity arising from surface drainage congestion, high water table and indurated pans in the central and eastern Gangetic plains; and Bharuch, Gujarat to cater to the problem of inland salinity in heavy soils in the western parts of the country. The Institute has developed technologies for the reclamation of alkali soils with the addition of chemical amendments, reclamation of saline soils through sub-surface drainage, development and release of salt-tolerant crop varieties of rice, wheat and mustard and the reclamation of salt-affected soils through salt-tolerant trees. The basic principle behind reclamation of alkali or sodic soils is through leaching the sodium (Na) salts as Na_2SO_4. This is done by adding gypsum ($CaSO_4.2H_2O$) to the sodic soil so that Na_2SO_4 is formed, which is soluble and thus leached down from the root zone profile. As such, nearly 1.5 Mha salt-affected land has been reclaimed and put to productive use. It has been estimated that reclaimed area is contributing more than 15 Mt foodgrains to the national pool. For waterlogged saline soils, sub-surface drainage technology developed by the Institute initially for Haryana has been widely adopted and replicated in Rajasthan, Gujarat, Andhra Pradesh, Maharashtra and Karnataka. About 60,000 ha waterlogged saline areas have been reclaimed using this technology (http://cssri.nic.in/).

Research and innovation for water management

The Central Water Commission (CWC) and the Central Ground Water Board (CGWB) are the two key agencies of the Ministry of Water Resources, Government of India (http://cgwb.gov.in/). The CWC coordinates schemes for control, conservation and utilization of water resources throughout the country for flood control, irrigation, hydropower generation, *etc*. The CGWB provides scientific inputs for the management, exploration, monitoring, assessment, augmentation and regulation of groundwater resources of the country.

Irrigation accounts for 80% of India's total water usage. Further, 60% of irrigation water and 80% of rural drinking water come from groundwater. Thus, water management in agriculture to a large extent can solve the freshwater crisis in India. To develop water-use efficiency in different agricultural production systems, the Directorate of Water Management (now Indian Institute of Water Management), Bhubaneswar (under ICAR) was established in 1988.

Abiotic stress coupled with changing climate adversely affects agriculture production across the country. To take up high-end research programmes employing latest technologies such as biotechnology, nanotechnology, remote sensing, information technology and polymer sciences, in 2008 the National Institute on Abiotic Stress Management (NIASM) was established at Baramati, Pune.

Research and innovation for forest and vegetation

Forests are considered a national wealth and have a pervasive impact on micro-climate regulation and maintaining soil, water and environmental quality. In India, the Forest Research Institute (FRI), Dehradun is the premier institution with thrust areas on biodiversity conservation, social forestry and agroforestry, stock improvement of different tree species, restoration of ecologically fragile and risk-prone areas and developing technologies for mine-spoil areas and wastelands.

Research and innovations in space science for NRM

Space science, particularly remote sensing technology, has been effectively used in India for natural resources appraisal, survey, monitoring and management. Towards this following institutes/organizations have been established in India:

- The Indian Space Research Organization (ISRO), Bengaluru has established a network of centres with specific mandates. ISRO-based National Remote Sensing Centre (NRSC) located at Hyderabad has the primary responsibility of providing earth observation (EO) data from space and aerial platforms to users and capacity building of the users for utilization of the EO data.
- The Indian Institute of Remote Sensing (IIRS), Dehradun has the mandate for capacity building and development of trained professionals in the field of remote sensing (RS), geoinformatics and global positioning system (GPS) technologies for NRMs.
- The Space Applications Centre (SAC), Ahmedabad also works on applications of space technology for societal benefits, including disaster monitoring, environment monitoring and natural resources survey. There are also Regional Remote Sensing Centres under ISRO such as North-Eastern Space Application Centre (NESAC), Shillong and under some state governments for applications of space science in NRM activities in their respective regions.
- To make use of the high-end geospatial information and technology such as RS, GPS and geographical information system (GIS) in conjunction with conventional methods for NRM, environmental monitoring and disaster management on a larger (regional) scale, in 1983 the Planning Commission, Government of India established the National Natural Resource Management System (NNRMS). The prime objective of NNRMS scheme is utilization of RS technology for inventorization, assessment and monitoring of the country's natural resources.

Improving Fertilizer Use: Soil Health Card scheme

Among the various resources, fertilizers play a pivotal role in the development of the agriculture sector in India. The judicious use of fertilizers triggers the process of accelerated growth in crop production and thus ensures the food security of the country. Fertilizer accounts for 50% increase in the country's food grain production. Fertilizer consumption in India increased by about 13 times during 1970 to 2020 (FAI, 2020). There is a continuous mining of huge amounts of nutrients of ~40 Mt ($N+P_2O_5+K_2O$) from soil through crop removal against the consumption of about 29.8 Mt in 2022 (FAI, 2022). Soils of India are in general poor in fertility (low in organic carbon, N and P). Widespread nutrients deficiency (N 87%, P 65%, K 35%, S 35%, Zn 43.4%, Fe 14.4%, Cu 6.1%, Mn 7.9% and B 20.3%) is taking a toll on the food and economic security. The limiting nutrients do not allow the full expression of other nutrients, lower the fertilizer response and crop productivity. The fertilizer response ratio (kg grain per kg nutrient) decreased from 12.1 in 1960-69 to around 5.0 in 2010-2017 and continuing to decrease further. Soils low in micronutrient produces food/feed/fodder low in micronutrient content/density, affecting human/animal health, distressing productivity and economy of nation. India is likely to produce about 315 Mt of foodgrains in 2021-22. It is estimated that there will be an additional demand for 40–45 Mt of nutrients ($N+P_2O_5+K_2O$) along with the secondary and micronutrients by the year 2025 in order to meet the growing food production demand.

The use efficiency of nutrients in Indian soils are low ranging from 30-50% in N, 15-20% in P, 60-70% in K, 8-10% in S and 1-2% in micronutrients. The fertilizer use remained skewed in favour of N in India. The disproportionately higher use of fertilizer N resulted in loss of N to environment. While, low fertilizer P use efficiency leads to the deposition of P in soil and loss to water bodies either through leaching down to groundwater or runoff to surface water bodies. Harmful effects caused with excessive use of N and P resulted in soil and atmospheric pollution, eutrophication (a reduction in dissolved oxygen in water bodies caused by an increase of mineral and organic nutrients) of

rivers and lakes, threat to biodiversity and the health of native plant species and natural habitats, formation and release of nitrous oxide (N_2O), a highly harmful greenhouse gas (GHG), *etc*. There is a need to regulate and optimize the use of fertilizers for crop production; use of suitable crop management practices that reduce GHG emissions, to have balanced nutrient consumption, to adopt ecosystem-based approaches, and to strengthen the policies which have minimal or negligible impact on animal/human health and environment.

In terms of total fertilizer nutrient consumption ($N+P_2O_5+K_2O$), India ranks second in the world with 29.8 Mt, next only to China with 52.5 Mt (FAI, 2020). Fertilizer-N consumption in India during 1970 to 2020 increased by about 13 times, whereas the crop N uptake increased by 4 times, leading to 5 times more loss of N. Phosphorus consumption in India increased from 0.54 Mt during 1970-71 to 7.50 Mt in 2019-20. Thus, P consumption recorded more than 15 times increase during 50 years. Consumption of K which was very meagre at 0.24 Mt in 1970-71 increased 11-fold to 2.64 Mt in 2019-20. India announced the nutrient-based subsidy policy in 2010 to ensure application of fertilizers in a balanced approach; however, selective implementation of the scheme on P and K fertilizers led to a decrease in their use. The immediate effect of NBS was a sharp rise in prices of P and K fertilizers.

A critical issue in the Indian agriculture sector is farmers' inefficient application of fertilizer, which compromises the long-term productivity of farm soil. Farmers often don't have the information they need about how much to apply to improve their yield each year. To address this, the government had been providing personalized fertilizer recommendations to every single farmer on a Soil Health Card.

The Soil Health Card scheme, launched in February 2015, has distributed over 150 million cards to farmers throughout India. The expectation is that, by providing farmers with this information, the scheme can encourage judicious use of fertilizers to improve soil health and ultimately boost

stagnating agricultural productivity. The scheme was rolled out across India, yet there was little to no evidence of farmers using these recommendations.

There are many benefits of having a Soil Health Card and the farmer needs to understand it. The soil health card scheme will properly examine the farmer's soil and accordingly give them a formatted report so that they can decide upon which types of crops to be cultivated for more income. The appointed authorities will also monitor the soil on a regular basis and once every 3-years will give a report to the farmers. Also, the farmers will be regularly updated with data about their soil. Under the scheme, the government will also employ professionals to help the farmers in adopting remedial measures. With the help of the Soil Health Card Scheme, the farmers can plan the future of their crops as well as land. The best thing about the scheme is that government pays utmost attention so that the same individual conducts soil analysis for a farmer, further enhancing the effectiveness of the scheme. The SHC gives the farmers a clear idea of which nutrients is lacking in their soil, thus, in which crops they should invest.

Government programmes for NRM

Watershed-based planning for NRM has been the major focus in the recent past because of the scientific basis underlying in the 'watershed' concept. Hydrologically, watershed refers to a land area having a single drainage outlet. However, it is also a social and biological entity having similar land, climate and water resource conditions. Thus, watersheds are an integral unit for development and environmental planning purposes. Depending upon the size, drainage, shape and land use pattern, watersheds is classified as macro watershed (> 50,000 ha), sub-watershed (10,000 to 50,000 ha), milli-watershed (1000 to10000 ha), micro-watershed (100 to 1000 ha), and mini-watershed (1-100 ha). However, for effective rural development programmes, micro-watersheds are considered as a single unit consisting of one or more village habitations.

The integrated watershed management approaches consider the participation of the stakeholders for optimum development of land, water and biological resources to meet the basic needs of human and animals in a sustainable manner. Depending upon the land situation, the three basic principles of soil erosion control *viz*., reducing the hitting action of raindrops, reducing the velocity and volume of run-off, are employed through location-specific suitable measures so as to achieve optimum productivity without much degradation to soil, water body and environment.

Need for agro-ecoregion specific NRM

Being a vast country, India has a wide range of climate, soil and vegetation and thus the importance of regional development based on uniformity in natural resource endowments. A sustained regional development is possible only if the land use and regional development plans are based on relatively homogenous edaphic (soil) and bioclimatic conditions. In this context, NBSS&LUP, Nagpur has divided the whole country into 20 agro-ecological regions (AERs) and 60 agro-ecological subregions (AESRs) (Sehgal *et al*., 1992, 1995) based on uniformity in soil, bio-climate, physiography and length of conducive moisture availability periods (length of crop growth period). The AESRs have further been divided into agro-eco units at the district level for developing long-term land-use strategies. The AER and AESR-based classification permit land use based on land capability and thus arrests soil and environmental degradation. A recent publication of ICAR3 has identified the different categories of degraded lands in the 20 AERs of the country. This is a major gain for the development agencies and policy makers to select most efficient reclamation technologies for restoration of degraded lands in a particular AER.

Guidelines for Sustainable Soil Management

According to FAO (2019), the guidelines to be adopted for sustainable soil management are to minimize soil erosion; enhance soil organic matter content; foster soil nutrient balance and cycles; prevent, minimize and mitigate soil

salinization and alkalinization; prevent and minimize soil contamination; prevent and minimize soil acidification; preserve and enhance soil biodiversity; prevent and mitigate soil compaction; and improve soil water management.

Sustainable Development Goals (SDGs), adopted by the United Nations in 2015, act as the heart of the 2030 Agenda for Sustainable Development and provide a shared blueprint that incorporates social, economic and environmental dimensions of sustainability (UN, 2015). The goals included are the five Ps (People, Planet, Prosperity, Peace and Partnership) and cover the most critical and urgent challenges of our time. They express the urgent need to end hunger and poverty, improve health and education, promote development, and reduce inequality while addressing climate change and land degradation.

For reducing soil erosion, following strategies could be handy:

- Prevent overgrazing: Frequently move animals from field to field. This gives the grass a chance to recover.
- Avoid logging steep hillsides: Cut only a few trees in any given place. Plant new trees to replace those that are cut down.
- Reclaim mine-lands: Save the stripped topsoil and return it to the land. Once the soil is in place, plant trees and other plants to protect the bare soil.
- Use barriers to prevent runoff and soil erosion at construction sites. Plant grass to hold the soil in place.
- Develop paving materials that absorb water and reduce runoff.
- Restrict the use of off-road vehicles, especially in hilly areas.

For fostering soil nutrient balance and cycles, following strategies could be handy:

- Use of crop rotations with legumes, green- and animal manures, cover crops in combination with reduced- or no-tillage;

- Reduce herbicide use in agriculture as well as agroforestry; integrated systems such as crop-livestock systems or crop-livestock-forest systems;
- Apply balanced nutrition and add soil organic and inorganic amendments (*e.g.* compost and liming agents, respectively);
- Use of innovative products (*e.g.* slow and controlled release fertilizers), as well as the recycling and reuse of nutrients;
- Apply adequate secondary and micronutrients;
- Livestock movement and grazing should be managed to optimize manure and urine deposition;
- Naturally occurring mineral fertilizer resources like rock phosphate or potash should be allocated efficiently and strategically.

To prevent, minimize and mitigate soil salinity and acidity, following strategies could be handy:

- Surface cover, mulching should be optimized to reduce evaporation losses; increase efficiency of irrigation water use;
- Irrigation water quality should be tested and monitored; when feasible, water desalinization should be performed;
- Surface and sub-surface drainage systems should be installed and maintained to control rising groundwater tables and control soil salinity;
- If soils are already degraded and prevention is no longer an option, reclamation of saline soils can be achieved using a variety of techniques such as direct leaching of salts, planting salt tolerant varieties, domestication of native wild halophytes for use in agro-pastoral systems, chemical amelioration, and use of organic amendments; and
- Monitoring soil acidity and minimizing surface and sub-surface soil acidity by using proper amendments (such as lime, gypsum and clean ash); balanced fertilizer and organic amendment applications; and appropriate use of acidifying fertilizer types.

To improve soil water management, following strategies could be handy:

- In humid areas where precipitation exceeds evapotranspiration, additional drainage systems are needed to provide aeration for nutrient uptake. This is a concern, especially in fine-textured soils which have high water retention capacity.
- Surface and sub-surface drainage systems should be installed and maintained to control rising groundwater tables in order to mitigate potential waterlogging;
- In dryland cropping systems, measures should be implemented to optimize water-use efficiency such as the management of soil cover (*e.g*. previous crops, forage and fallow) and water harvesting to increase soil water availability at sowing; reduction of runoff and evaporative losses from the soil surface; and ensuring that there is adequate water available at each stage of crop development.
- Optimal soil water extraction by the crop through the selection of appropriate cultivars and careful timing of agronomic operation should be promoted; and
- Regularly monitoring of irrigation water quality for nutrients and potentially harmful substances.

Natural farming / Organic farming

Conventional systems of agriculture need to be relooked for addressing the sustainability of natural resources (soil, water, diversity in flora and fauna, and environment) that got deteriorated in terms of availability and quality. The concept of natural farming has emerged as one of the solutions for restoring the natural resources. It is solely based on the practices of crop cultivation following the pro-nature activities. During the phase of changing from existing system of intensive/conventional cultivation to natural farming is that it may face huge challenges that need to be addressed in details for harnessing the potentials of natural farming with least penalty on productivity. It will include

improvement in soil health, optimal crop rotations, conservation agriculture and potential management of pests. The main objectives of nutrient management through natural resources are to work within natural systems and cycles; maintain or improve long term soil fertility status; obtain optimum use of renewable resources; and reduce food that is safe with optimum quality.

Potentialities of Recycling of Natural Resources of P and K

The basic philosophy of nutrient management through recycling of natural resources emphasizes sustaining agricultural productivity with minimum inputs. Recycling of natural resources in agriculture is considered the best-known alternative to the conventional method, which has witnessed the ill effects produced by chemical agriculture. The basic understanding of nutrient management practices in both the natural resources and conventional production systems has many common objectives. Recycling of natural resources has the potential to provide benefits in terms of environmental protection, conservation of non renewable resources, and improved food quality. They mainly differ in respect to the source used for plant nutrition. However, the fundamental principle of supporting soil fertility and plant nutrition remains the same.

In-situ Crop Residue Management

In India, an estimated 500-550 Mt of crop residues are produced annually. After accounting for multiple competitive uses about 141 Mt are surplus most of which are burnt in-situ. Burning of straw poses phenomenal pollution problems in the atmosphere and huge nutritional and physical health deterioration to the soil. Entire amount of C, 80-90% of N, 25% of P, 20% of K, and 50% of S content in crop residues are lost upon burning. It is found that one tonne of rice residue contains about 400 kg of C, 5-7 kg N, 1.0-1.7 kg P, 15-25 kg K and 1.1-1.4 kg S in addition to significant amounts of micronutrients.

The main challenges of crop residue management are its huge volume of crop residues; collection and storage of residues; time window between harvesting and sowing of two (next) crops; awareness, dissemination of technology, capacity building of technical manpower and those of farmers; cost-effective mechanization, availability of appropriate machinery; utilization of crop residues; and technology up-gradation.

Conservation Agriculture Systems

Conservation agriculture (CA) practices and resource conserving technologies (RCTs) hold promise for improving soil health and attaining sustainable intensification of the crop yields. Conservation agriculture is a farming system having three essential principles that promotes minimum soil disturbance (*i.e.* no tillage), maintenance of a permanent soil cover, and diversification of plant species (intercropping). In addition to these principles, integrated weed management is also considered as the important part of CA. The CA practice enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production and the conservation of natural resources and the environment. Conservation agriculture is considered as "climate-smart" agriculture that strives to achieve acceptable profits along with high and sustained production levels while concurrently conserving and regenerating soils and protecting the environment.

New Generation Fertilizers or Smart Fertilizers as a Strategy for Sustainable Agriculture

In the coming decades there will be increasing pressure on global food systems, and agriculture will have the challenge to provide food security for a growing world population without impacting environmental security. Accordingly, it will be necessary to use modern technologies in agroecosystems in order to supply sufficient food and decrease the negative impacts on the environment induced by chemical fertilization and by inadequate disposal or reuse of agricultural wastes.

The drawbacks of conventional fertilizers are low nutrient use efficiency (NUE), overdose harmful and causes environmental pollution such as GHGs emission, groundwater pollution, eutrophication of waterbodies, heavy metal pollution, soil acidification/ alkalization, non-synchronous and increasing agricultural cost. Low NUEs are typically the result of higher release rate of fertilizers than the absorption rate by plants, and/or transformation of fertilizers/nutrients to forms that are not bioavailable to crops. As such, there is great interest in developing innovative fertilizers to increase NUEs. A combination of biotechnology and nanotechnology has the potential to revolutionize agricultural systems and provide solutions for current and future problems. These include the development and use of smart fertilizers with controlled nutrient release, together with bioformulations based on bacteria or enzymes.

Smart fertilizer is a fertilizer which works intelligently synchronizing the release of nutrients in tandem with crop demand (right amount in right time) having least adverse effects on environment (minimize pollution). Smart fertilizers are those fertilizers having low or devoid of impurities (clean), works according to the requirement of the plant and very quick in action. The molecule of smart fertilizer is water insoluble but has a "smart" feature so that nutrient is released only on demand by the crop. They are designed molecules that allow sustained release of nutrients by a plant-root activated mechanism. The fertilizer molecule functions like a nutrient storehouse providing a continuous nutrient supply throughout the crop growth period. The advantages of smart fertilizers are having high nutrient use efficiency, environment friendly, enhances water holding capacity, synchronous with crop demand, decrease agricultural cost, and improve productivity and soil health. Fertilizers like slow or controlled release fertilizers (SRF or CRF), nano-fertilizers, bioformulations, *etc*. conceptionally works as smart fertilizers. The SRF or CRF is a purposely designed fertilizer that releases active fertilizing nutrients in a controlled, delayed manner in synchronization with the sequential needs of plants for nutrients, thus, they provide enhanced nutrient use efficiency along with enhanced yields (Shaviv *et al.* 2005).

Nanotechnology is a group of emerging technologies in which the structure of the matter is controlled at the nanometer scale (1-100 nm) to produce materials having unique properties. The nanotechnology-aided applications such as nano-fertilizers, nano-pesticides, insect repellents, nano-sensors, nano-magnets, nano-films, nano-filters, *etc.* have the potential to change agricultural production by allowing better management and conservation of inputs. Nano-fertilizer may be defined as the nanoparticles, which can directly/augment supply of essential nutrients for plant growth, have higher nutrient use efficiency and can be delivered in a timely manner to a rhizosphere target or by foliar spray. Nanoparticles can adsorb on to the clay lattice thereby prevent fixation while releasing into the soil solution than can be utilized by plants. The process improves soil health and nutrient use efficiency by crops. The nano-fertilizer technology is an innovative strategy. Fertilizer particles can be coated with nano membranes that facilitate in slow and steady release of nutrients thereby reducing loss of nutrients and enhancing its use efficiency of crops. Nano clay composites have been developed in order to supply with range of nutrients in desirable proportions (Sarkar *et al*., 2011). Nano-sensors detect the availability of nutrients and water precisely which is very much essential to achieve the mission of precision agriculture.

Fixing the issues

The research establishments for NRM research in the country spread across different Departments and Ministries of Government of India have developed a number of useful technologies and generated sufficient database over time. However, few missing links need to be considered.

1. ***Weak network*:** The NRM research is essentially multidisciplinary in nature. Hence, there should be an established network and coordination among the public-funded research organizations cutting across the various Departments and Ministries engaged in NRM research. The network should be mandatory for the research organizations so that mutual data transfer and multidisciplinary investigations can be possible without unnecessary repetition.

2. ***Need for scientific database*:** The generated scientific data from public-funded research needs to be archived by each organization and the archive should be accessible to all the public-funded research organizations engaged in NRM research. This will help the researchers in strengthening the research objectives and also in preparing collaborative studies without much procedural obstacles in getting generated data.

3. ***Regular monitoring and appraisal of natural resources is essential to develop appropriate planning.*** The land degradation statistics is reported by various agencies with different figures by adopting different methodologies and monitoring is not done at regular periodicity. It is essential to develop a sound methodology using the conventional and the remotely sensed data by involving NRSC, ICAR, Wasteland Development Board and the other user agencies, in a common platform and develop a framework for monitoring at a fixed time interval, say 10 years.

4. ***Soil quality monitoring*:** Though most of the estimates on land degradation report the degraded and wasteland statistics, no report is available on the status of soil quality, at least for crop production. The depletion in soil quality is a type of hidden hunger to agricultural growth and may not be visible to be classified as a degraded land till the soil becomes fully exhausted. The efforts required to bring back a depleted soil is much higher than those for a depleting soil. Thus, there should be an effort to develop soil quality indices and monitor the soil quality at regular time intervals so as to plan appropriate land-use measures that ensure maintaining soil productivity and allow the soil to perform optimum soil functions and provide ecosystem services.

5. ***Nature-based Solutions***: It is an umbrella concept of ecosystem-based approaches to address societal challenges, such as climate change mitigation and adaptation, disaster risk reduction, economic and social development, human health, food, and water insecurity, and environmental degradation and biodiversity losses, giving both human wellbeing and biodiversity benefits.

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II

ABSTRACTS OF SYMPOSIUM/ INVITED LECTURES

Soil and Nutrient Management Policies

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Land being a finite resource is already under severe stress due to increasing population and diversion of prime agricultural land to meet various human demands. India has to raise farm productivity through intensive agriculture to feed their teeming millions. Achieving targets is a formidable challenge as agricultural development with positive growth and long-term sustainability cannot thrive on a deteriorating natural resource base as evident from loss of soil organic matter, accelerated soil erosion, deterioration of soil physical, chemical, and biological health, poor input (water and nutrient) use efficiency, groundwater pollution, declining water tables, salinization and waterlogging, loss of biodiversity including ecosystem services. Scientific and judicious land-use planning is, therefore, the need of the hour.

Although issues of soil and nutrient management are addressed through various schemes, these are being implemented in isolation. As a result, the real impacts of these measures are not achieved. The real challenge, at present, is to take up these measures in mission mode by way of formulating comprehensive policy interventions for sustainable intensification of agriculture to meet food, nutritional and environmental security without harming the environment and conserving soil our precious land resources for future generations.

Keywords: Soil health, Soil erosion, Salinization, Biodiversity, Nutrient management

Arsenic in Human Food-Web and Mitigation Options

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The issue of arsenic contamination in groundwater in parts of the country and its adverse effect on human health has been agitating the scientists, physicians, community workers, lawmakers and the general public at large, especially those who are suffering from its toxic effect. The primary attention, however, is directed towards solving the problem of such contaminated resource-based drinking water supplies to mostly the rural population. However, what remains to be addressed is the food-chain issue which gets contaminated due to the entry of arsenic in it through the contaminated groundwater sources being pressed to irrigate the agricultural crops. This is not to undermine the existence of quite a vast amount of experimental data already generated by not only the agricultural scientists, but also the geologists, hydrogeologists, environmental experts and, most of all, the medical professionals (the latter till date in a moderate scale though) working in a consortium mode. It is quite reasonably well-established now that the food-chain contamination provides *yet another potential pathway of arsenic exposure* of the population in rural areas. Hence it is imperative that any comprehensive mitigating intervention of chronic arsenic toxicity in people requires integrated approaches toward reducing arsenic entry into the food-chain, on one hand, while reducing arsenic in the drinking water below the safe limits, on the other. Unless this is attempted and accomplished, the food bio-safety concern, in its totality, is unlikely to go hand-in-hand with the food and nutritional security concerns of the country, not only for the domestic population but also for the export market. The success

of such an integrated approach would essentially depend on its multi-level stakeholder nature, involving researchers, technologists as well as the planners with a focus on the real beneficiaries.

Keywords: Arsenic contamination, Groundwater, Human health, Food-Web, Mitigation options

Sustainable Soil Management for Food and Environmental Security: Strategies and Challenges

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Soil is comprised of dynamic reservoir of biodiversity within which the interactions between microbes, animals and plants provide many benefits for human well-being. Achieving sustainable goals in agriculture is challenging due to rapidly increasing food demand, depletion of natural resources and climate change. To attain sustainability, the current model of agricultural production system needs to restorative of natural resources, which is centred on sharing, reusing, and recycling of materials with a minimum of waste. India is an emerging economy largely based on agro-industries, which generates large amount of agricultural wastes. In natural or organic farming these huge organic resources should be returned to soil. Return of organics in soil improves the abundance and diversity of soil flora and fauna. The soil organisms regulate ecosystem services through controlling primary production, carbon sequestration, climate change, nutrient, water cycles, degradation of pollutants and human health. Sustainable soil management is a key to a better ecosystem services, representing multitude of benefits that ecosystems provide

to human, from food to cultural heritage. Ecosystem services are classified as provisioning, regulating, supporting, and cultural services. Several literatures emphasize the significance of soil on ecosystem services, but information specifically on soil diversity is limited. This paper addresses the role of sustainable soil management for ecosystem services, importance of soil microbial processes and the linkage between soil diversity and ecosystem services. It also highlights technology landscape for sustainable soil management, economic valuation of soil diversity and identifies research gaps for sustainable soil management and ecosystem services.

Key words: Microorganisms; Biodiversity; Ecosystem services, Organic and natural farming

Technology Innovation for Sustainable Natural Resources Management: Food and Nutrition Security

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For the past 50 years, the growth in agriculture was the result of technological innovations in the form of green revolution. When combined with increased use of external inputs, the benefits were even greater. With the result, supply exceeded demand and real prices of food such as cereals went down and boosted the average income of farmers. The second-generation problems especially problems related to insect pest build-up, soil health and water scarcity are important reasons for such a downtrend. Resource Conservation Technologies (RCT) therefore, has become a critical component to growth in

agriculture. These technologies require complementary innovations through multi-disciplinary, multi-institutional and farmer's participatory approach. This is even more important in the eastern states because the livelihood of small and marginal farmers will depend on technologies that raise outputs per labour-hour and per unit area at less cost. National Innovations on Climate Resilient Agriculture was scaled up from 151 villages in 2018 to 446 villages in 2020-21. Total Climate resilient practices tailored to context and location specific situation under 4 modules were demonstrated by 121 KVKs. Custom Hiring Centres, Seed & Fodder Bank, District level Contingency plans were also some of the prominent models which were successfully developed and implemented. District Agro-meteorology Units were established at KVKs in partnership with IMD for providing agro-met advisories and alerts to the farmers. Crop residue management were done successfully in partnership with the stakeholders in Punjab, Haryana and Western UP and the residue burning events halved in three years. An experiment was laid out in collaboration with CSISA-CIMMYT to create database through concurrent feedback. The scope of agricultural extension has expanded well-beyond its traditional role in pushing the frontiers of production and productivity in pursuit of the nation's food security. Extension processes will remain same but the focus on the content has to be in context to the national priorities including precision farming involving application of sensor based and drone technology, yield gaps (both technology gap and the extension gaps), ensuring sustainability in production system and minimizing natural resource degradation including soil, water etc., promotion of cooperative/group farming and marketing through FPOs, promotion and handholding of youth led agri-startups, climate change adaptation and mitigation, nutrition and biofortification for ensuring production sustainability.

Keywords: Technological innovation, Resource conservation technologies, Residue burnings, Climate change, Farmer's participatory approach

Education

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Education is an authoritative operator of development and one of the strongest instruments for plummeting poverty and refining health, gender equality, peace, and solidity. It is the most important asset, and is as important as food, shelter, and clothes. Early education in India started under the supervision of a guru in the Gurukula. The relationship between Guru and his Shishya (students/disciples) was very important part of the education. Developing countries have made marvellous advancement in getting children into the classroom and the majority of children worldwide are now in primary school. Nevertheless, some 260 million children are still out of primary and secondary school. India has the third largest education system in the world spending 2.7% of its Gross Domestic Product (GDP) on education (Ministry of Finance 2018). According to National Statistical Office (NSO) data, as of the Year, 2021 India's average literacy rate is 77.7%. The male literacy at the India level in 2021 stands at 84.7% & female literacy stands at 70.3%. Kerala tops the rankings, followed by Delhi, Maharashtra and Tamil Nadu. Bihar is the lowest among states, followed by Arunachal Pradesh, Rajasthan, Jharkhand etc., however, the condition is improving, after the Finance Minister of India launched the "Revitalising Infrastructure and Systems in Education (RISE)" in February 2018with a total investment of Rs.100,000 crore up to 2022 to enhance quality of higher education in India. Government is focusing on education and Goal 4 of Sustainable Development Goal (SDG) is related to Education for all which ensures equitable, inclusive and quality education along with the promotion of lifelong learning opportunities for all by 2030. With the inclusion of the new national education policy 2022 it will provide

a lot of individual attention to the students who have special needs and also education will be provided at all levels through the new educational policy presented by the Government of India.

Good education is always constructive, a person who is educated well is respected by society and even has a role that would help in the development of society Being well educated does not only mean having fancy degrees from reputed colleges and a high-paying job but it also means being kind towards everyone around. The sole purpose of getting an education is to be a good citizen towards everyone and then being successful in personal and professional life. Education helps in bringing economic progress and social change to the country. People who are educated will help in inventing and bringing new ideas, which will help in the development of the country.

Keywords: Education, Social changes, Literacy, Economic progress, Sustainable development goal

Technological Innovations for Sustainable Agriculture

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Agriculture has been the mainstay of food and nutritional security, and source of livelihood for millions of farmers and stakeholders. The challenge of feeding the ever-increasing population with depleting natural resources is gigantic. Climate change with enhanced occurrence of drought, heat and waterlogging stresses coupled with emergence of new diseases and insect-pests have made

the situation more challenging. Besides, malnutrition is prevalent in large segment of human population. While, 'molecular breeding' and 'speed breeding' have contributed to acceleration of development of crop cultivars of our need; 'crop biofortification' has led to the development of biofortified crop varieties rich in nutritional qualities. More recently, 'CRISPR' technology has given new impetus to develop gene-edited crop cultivars suitable for specific purposes. Natural resource management plays pivotal role to achieve sustainability in agriculture. The new understanding of the interdependence between plants and the associated microorganisms suggests that the host plants' fitness, health, and productivity depend on the diversity, microbial networks, and interactions. Reduction of green-house gas (GHG) emission from agriculture is of paramount importance. The low carbon technologies can further help to reduce cost of cultivation due to reduced inputs and improved resource use efficiency, improve soil organic carbon and reduce pollution. The resource conservation and best agricultural practices such as 'zero-till' and 'permanent broad bed with residue' can mitigate GHG emissions. By following these practices, the cost of cultivation can be reduced due to reduced inputs; soil organic carbon can be enhanced, pollution can be reduced and; additional income can be achieved from 'carbon credits'. The problem of 'on-farm burning of residues' is intensifying in recent years due to unavailability of labour, high cost in removing the residues by conventional methods and use of combines without straw spreading mechanism. With the advancement in space-based imaging technologies, satellites can be used for near-real time monitoring of burning events using thermal remote sensing sensors, while multispectral satellite sensors are used for mapping the area burnt. Besides, precision agriculture (PA) involving global positioning system (GPS) guided sensors, precision variable rate technology, robotics, unmanned aerial vehicles (UAVs) and internet of things (IoTs) are important for enhancing sustainable production through more precise farm input use and resource efficient approach. Over-exploitation of groundwater is causing rapid decline in water availability in several parts of the country. Automated irrigation,

artificial intelligence (AI) and machine learning (ML) have great potential for improving irrigation efficiency in assured water supply situations. Judicious use of combination of these technologies will further help in attaining sustainable production of food crops in ever-challenging environmental-, socio-economic and geo-political situations.

Keywords: Technological innovations, Sustainable agriculture, Food and nutritional security, Carbon credits, Precision agriculture

Women Empowerment for Resilient and Adaptation under Changing Paradigm

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Women have played a significant role in the field of science since the emergence of modern civilization. However, women's status is very low that poverty impacts them more than men, thus the only way to solve all issues is to empower women and gender balance. Women empowerment is the process of enhancing and strengthening the social, economic, political, and legal position of women in order to guarantee their equal rights. Integrating science and technology (S & T) for women's empowerment is essential for advancing women's rights, and improving women's overall quality of life and social standing which ultimately leads to sustainable development. Under the changing paradigm, women empowerment can be achieved through various means in which S&T can be integrated. Among those, social women empowerment for promotion of gender equality as a prime objective to attain sustainable development; Educational empowerment of women to provide

them with the required information, skills, and self-belief to fully participate in development; Empowering women economically and professionally to improve their standard of living by integrating them into the human resource base; Legal women empowerment for addressing the discrepancies between what the law requires and what really occurs and most crucially, Political women empowerment for a political system that values women's participation and control in political governance and decision-making processes. Agriculture is a big opportunity where women can have huge potential as large number of agri-students in India are girls. Their role is critical in rural and urban activities and growth in agriculture, agri-startups, self-help groups, job creation and overall agri-entrepreneurship. The growth of science and the acquisition of riches could both be aided by the empowerment of women through science and technology, allowing them to realize their potential and design their lives in accordance with their goals towards achieving sustainable development goals (SDGs).

Keywords: Women, Science and Technology, Gender Balance, Agriculture, SDGs, Job Creation and Livelihoods

Genome Editing for Development of Climate Resilient Rice Crop

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Rice is the major staple food crop of India. Rice productivity is adversely affected abiotic stresses such as drought, salinity, heat and cold stresses.

Therefore, identification of genes and genetic improvement of stress tolerance is imperative for sustainable rice production. The CRISPR-Cas technology has emerged as disruptive next generation precision breeding technology for targeted crop improvement. Globally, this technology is being used extensively for crop improvement and already genome edited high oleic acid soybean and high GABA tomato are cultivated and available to the consumers. Considering it potential, several countries have exempted genome edited mutants free from the GMO regulation. India also exempted SDN1 and SDN2 type of genome edited mutants free of introduced exogenous DNA from GMO regulations.

Our lab is focussing on gene editing in rice for gene function validation and development of rice genotypes with improved yield and abiotic stress tolerance. Rice genes *DROUGHT AND SALT TOLERANCE* (*DST*), Clade A *PROTEIN PHOSPHATASE 2Cs* (*PP2Cs*), *FARNESYL TRANSFERASE* (*FTA*), and *PHYTOMELATONIN RECEPTOR 1* (*PMTR1*) are edited in rice. We used two different gRNAs to target regions of DST protein that might be involved in protein–protein interaction and successfully generated different mutant alleles of *DST* gene in mega rice cultivate MTU1010. We have generated five different alleles of *DST* gene. Four different mutant alleles of *dst* produced leaves with broader width and reduced stomatal density, and thus enhanced leaf water retention under dehydration stress. Our study showed that the reduction in stomatal density in loss of function mutants of *dst* is, at least, in part due to downregulation of stomatal developmental genes. The Cas9-free *dst*$^{"366bp}$ mutant exhibited moderate level tolerance to osmotic stress and high level of salt stress in seedling stage.

Analysis of drought and salt tolerance of homozygous *dst* mutants and WT plants planted in the same pot under greenhouse conditions revealed that these mutants exhibited tolerance to drought and salt tolerance and produced significantly higher yield as compared with WT plants under both stress and control conditions. The *dst* mutants use about 25% less water per unit leaf area as compared with WT MTU1010 cultivar. Further, these mutants showed

>25% yield enhancement over wild type plants under field conditions in a transgenic net house in *kharif* 2021 and 2022. Currently seed multiplication of the genome edited foreign gene free mutants of *DST* is in progress for their testing at multilocations throughout India. This drought-resistant rice variety developed for the first time in the country using genome-edited technology is expected to be available for field evaluation by *kharif* 2024 and for commercial cultivation by farmers by 2026. Mutants with high yield and stress tolerance are useful to release as variety and as a genetic stock for introgression of *dst* mutations in other indica varieties for genetic improvement in yield and climate resilience. Genome editing technology has a great potential for the next agricultural revolution, specifically by developing crops with desired traits for sustainable crop production.

Keywords: Genome, Draught and salt tolerant mutant, Climate resilient, Rice crop

Land Resource Information System for Combating Land Degradation

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To achieving sustainable development in agricultural production, we have to understand the natural resources of that area. For that purpose, continues monitoring and evaluating the natural resources is critical and it helps to creating a strategy for long-term development. Among the natural resources land resources inventory is very important. Soil erosion is a major threat to the sustainability of agriculture all around the world and more specifically in developing countries. Soil erosion is a major cause and effect of land

degradation in the arid, semi-arid and dry sub- humid areas (*i.e.,* drylands) of the India, where climate change and land use dynamics are the key drivers. The development of contemporary geospatial tools and techniques such as Remote Sensing (RS), Geographic Information Systems (GIS), Global Positioning Systems (GPS), and Information Technology (IT) has made it possible to monitor and assess land resource utilization, which is a crucial step in creating a sustainable development strategy. Watershed management is now a recognized strategy for the advancement of rainfed agriculture in semi-arid tropical regions. Major applications of geospatial technologies related to watershed development are Land use-resource inventory and land evaluation for optimum use, soil fertility and its quality assessment, generation of soil fertility thematic maps using GIS technology, soil quality assessment, land degradation assessment erosion modeling, land use land cover change detection, digital soil mapping, digital terrain modeling, soil-landscape modeling, land use/land cover mapping, agricultural land use planning, etc., can have a significant impact on crop and land resource mapping, monitoring, and management on a sustainable basis.

Keywords: Land degradation, Geospatial techniques, Remote sensing, GIS, GPS

Nature Pro Farming Techniques for Sustainable Soil Health and Food Security

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India is an agrarian country and supports 1/6th of global population with limited land (2.5%) and water (4%) resources. It is very crucial to retain the quality

and quantity of these vital resources to ensure food security of the vast population. Unfortunately, majority of the arable land suffers from one other kind of degradation. The organic carbon in arable soil is declining day by day due to imbalance use of nutrients which is another threat to soil microbial diversity and sustainable food production. This requires shift in farming techniques from current practice to a method which will take care of these emerging problems. In this direction, organic farming and natural farming practices, though an age-old practice but regaining its popularity and is considered a milestone. Inclusion of crop diversification, compost addition, crop rotation, restraining use of chemicals to augments natural processes of nutrient recycling; microbial activities can restore environmental quality by maintaining ecological balances between all the biotic and abiotic components of agroecosystem. Recent reforms in government policies and awareness of people toward our food safety and environmental security is very encouraging for bringing the changes for judicious use of natural resources for welfare of mankind. Studies and experimentation have proven that organically maintained soil has better microbial activity, soil biodiversity disease suppressiveness and can maintain soil health for long term for food production. However, more research on nutrient budgeting, crop productivity, cultivar suitability, quality of organic food needs a very thoroughly investigation to convince the farming community and consumers with strong back up of research data. Besides policy reformation, investment on research aspect is highly required for bringing out the science behind the practice and optimizing the methodology for sustainable soil management and food security and safety.

Keywords: Natural farming, Composting, Organic carbon, Soil microbes

Geo-environmental Suitability Assessment for Agricultural Land in Agro-ecoregions of India

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The geo-environmental assessment is a prerequisite for adopting agro-ecological principles and achieving sustainable crop yields. We present three case studies from three agro-ecological regions. Pedological datasets were made and used to evaluate bio-physical parameters in Pulivendula tehsil in Kaddappa, cotton-producing Yavatmal district, and rice-farming Majuli, Assam. According to the suitability assessment, 56091 ha are suitable for bananas under drip irrigation and 16364 ha are at high erosion risk. Cotton can be grown on 25% of total arable land in Yavatmal district, but 28.43% cannot be irrigated. Rice can be grown on 32% of Majuli island. However, there are limitations such as subsoil acidity, shallow groundwater tables, poor organic carbon status, and low cation exchange capacity. Through land evaluation exercises, land resources can be harnessed using sustainable soil-land management techniques. With the use of soil quality assessment and erosional status using USLE, the case studies shed light on region-level biophysical constraints that affect productivity.

Keywords: Geo-environmental sustainability, Agro-ecological region, Crop yield, Soil quality

Sustainable Soil and Crop Management through STCR-based Fertilizer Prescription Equations

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The fertilizer recommendations based on qualitative/semi-quantitative approaches or methods do not give expected yield responses. Therefore, inductive approach, a refined method of fertilizer recommendation for varying soil test values has been developed by All India Coordinated Research Project Soil Test Crop Response (AICRP-STCR) for different crops under different agroecological sub-regions. Soil Test Crop Response studies have used the targeted yield approach to develop relationship between crop yield on the one hand, and soil test estimates and fertilizer inputs, on the other. Lately, the calibrations are being developed under integrated supply of organics and fertilizers keeping into account the nutrient contribution of organics, soil and fertilizers. The technology of fertilizing the crops based on initial soil test values for the whole cropping system is also being generated. Ready reckoners in the form of fertilizer prescription equations have been developed by different centres for facilitating users for profitable use of fertilizers based on soil test values and the same has been demonstrated through various multi-location / verification follow up trials as well as front line demonstrations. In these trials soil test-based rates of fertilizer application helped to obtain higher response ratios and benefit: cost ratios over a wide range of agro-ecological regions. It is evident that STCR based approach of nutrient application has definite advantage in terms of increasing nutrient response ratio over general recommended dose of nutrient application. Front Line Demonstrations conducted under STC (erstwhile Tribal Sub Plan, TSP) in Assam, Bihar, Chhattisgarh, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka,

Kerala, Madhya Pradesh, Maharashtra, Manipur, Odisha, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh and West Bengal with tribal farmers also clearly brought out the superiority of STCR-based fertilizer recommendation for different crops over blanket recommendation and farmer's practice. An appraisal of the effect of nutrients (NPK) applied on crop yield and benefit: cost ratios (BCR), both under (NPK) alone and under IPNS for 15 agricultural and horticultural crops showed that out of 66 crop x target combinations, the BCR was between 1 and 2 in 35% cases and between 2.1 and 3.0 in 62% cases; in 3% cases BCR was above 3. Irrespective of the crops, higher yield has been recorded at higher yield targets over lower target coupled with higher net return and BCR. Of late, STCR has developed algorithms of leaf colour chart, SPAD and field scout CM 1000 m values at three critical growth stages with yield in rice-wheat system; also developed fertilizer prescription equation for hitherto untouched secondary nutrient (sulphur). Besides, soil testing protocol for organic farming system including characterization and quantification of microbiologically exploited organic phosphorus-pools in organic farming systems has been developed. DESSIFER, the Decision Support System for Integrated Fertilizer Recommendation for Tamil Nadu state encompassing soil test and target-based fertilizer recommendations through Integrated Plant Nutrition System was also developed. AICRP (STCR) has provided the technical backstopping for Government of India Soil Health Card Scheme; STCR prescription equations were integrated in Soil Health Card Portal. STCR has also taken up the development of user-friendly software for preparation of Soil Health Card.

Keywords: Soil test crop response, Fertilizer recommendation, Decision support system, Integrated nutrient management

Micro-Nutrient Enrichment of Agri-Produce and Enhancing Their Availability for Addressing Malnourishment

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Burgeoning population, declining natural resources, low nutrient use efficiency, abiotic stresses and other complexities related to plant mineral nutrition are some of the major challenges that threaten agriculture and its contribution to human health. We have serious issues of nutrient deficiencies, toxicities and imbalance, all of which inhibit grain/crop yields and threaten human nutrition and health. Fortification of commodities is being tried in many developing countries however, its economics is debatable. Scientists are also working on the idea of producing nutrient rich crops *i.e.*, biofortification approach and a large number of global disciplinary programs are currently in operation, one such effort is the harvest plus. This strategy is similar to the production and use edible vaccines. However, a major challenge here is to improve the nutrient uptake and use efficiency so as to enable a higher accumulation of nutrients in seed/grain. It is important to determine the root to shoot to grain translocation of micronutrients and also their retranslocation from the senescing leaves to the grain. We need to also improve our understanding of the rooting behavior in response to different nutrients and nutrient availability condition and abiotic stress. Nutrient-phytohormone interaction and role of nutrient sensors and transporters for *e.g.* NRT 1.1, 1.2 *etc*. needs to be deciphered with unquestionable certainty. Role of root exudates and phytosiderophores in determining the nutrient efficiency under deficiency is another area that requires attention. All the above aspects must consider

multiple nutrient deficiency and multiple abiotic stress scenarios which are not uncommon under natural conditions of crop cultivation.

Keywords: Biofortification, micronutrient deficiency, nutrient deficiency, phytohormones, phytosiderophores, abiotic stress

Zinc Biofortification for Food and Nutrition Security

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Zinc has emerged as the most widespread micronutrient deficiency in soils and crops worldwide, resulting in severe yield losses and deterioration of nutritional quality. Almost half of the global soils are deficient in zinc. India is not an exception, about 37% of the Indian soils are deficient in zinc. Since cereal grains have inherently low concentrations, growing these on the potentially zinc deficient soils further decreases grain zinc concentration. There is a high degree of correlation between zinc deficiency in soils and humans. About one-third of the world's population suffers from zinc deficiency. Zinc is an essential nutrient for human health. There is no life without zinc. The widespread zinc deficiency has led to micronutrient malnutrition in humans, especially in developing nations, like India. The possible solutions for micronutrient malnutrition are i) Food supplementation, ii) Food fortification and iii) Biofortification. There is a developing field of research on biofortification of plant foods with zinc. This involves both the breeding of new varieties of crops with genetic potential to accumulate a high density of zinc in cereal grains (genetic biofortification) and the use of zinc fertilizers to increase zinc density (agronomic biofortification). Fertilizer use is the fastest route to improve zinc density in diets, though the plant breeding route is

likely to be the most cost-effective approach in the long run. In order to replenish the zinc taken up by the improved cultivars, higher and sustainable use of fertilizers is inevitable. Scientific evidences show that combining both the approaches is a better strategy to address the widespread zinc deficiency in crops and humans.

Keywords: Zinc, Biofortification, Balanced plant nutrition, Food security, Nutrition security, Micronutrient malnutrition

Remote Sensing Technology for Diagnosis and Management of Abiotic Stresses in Crops

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Abiotic stresses experienced by crops range from water deficit, water logging, extreme temperatures, soil salinity, nutrient deficiency, *etc*. which limit their growth and development leading to lower crop productivity. This invited paper presents technology-based diagnosis, monitoring and management of abiotic stresses in crops, ranging from field to regional scale. The technological approaches range from imaging techniques acquired from hand-held devices, to drones to satellites. Many of these techniques comes under the ambit of smart-digital agriculture. The advances in data analytics like machine learning, the connectivity provided by wireless/mobile networks, the advances in high end computing at cheaper prices are the enabling backend technologies which work in tandem with sensors and images to provide for accurate diagnosis, monitoring the status and suggesting/triggering management options. Water deficit stress is the foremost abiotic stress and measurements of soil moisture and evapotranspiration are good estimators of water deficit. The remote sensing

based optical and thermal based indices can directly monitor plant water status, soil moisture and combined with physical model can provide the diagnosis of water stress and can be integrated into an automated irrigation system. Examples of field to regional scale water deficit stress and its management will be presented. Among the nutrient deficiency, nitrogen is the most important and also the major limiting factor for agriculture productivity. A system of N application in wheat (timing and dose) has been developed by combining satellite remote sensing with crop simulation model and demonstrated which showed higher N efficiency and lower GHG emission. Besides, imaging sensors have been used for plant phenotyping shown to screen crop varieties simultaneously performing under multiple stresses, like, nitrogen and water deficit. The paper will present examples and their scientific basis along with future directions in which technological solutions are expected for diagnosis and management of abiotic stresses.

Keywords: Water deficit, Drought, Nitrogen, Crop, Resource efficiency, Resource management

Development of Biological Filter for Safe Wastewater Irrigation Exploiting Microbial Bioremediation Trait

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Water use has greatly outpaced population growth. Water demand for the agriculture sector has increased to meet the increased food requirements. Strong socio-political and economic considerations are likely to lower future water allocations for agriculture in the face of demand for urban supply and

higher-value demands. Increased diversion of water towards cities will only increase wastewater generation. Now, India generates over 62000 mld (million litres daily) of urban wastewater, while the maximum treatment capacity of all the centralized sewage treatment plants (STPs) is only 37%. Technologies like activated sludge, trickling filter, and stabilization pond are mostly used. And yet, STPs are unsustainable due to huge costs, land requirements, and treatment efficiency. Meanwhile, above 75% of raw wastewater is discharged in environment. Peri-urban farmers use unsafe raw wastewater to grow crops, compromising food quality and consumer's safety. Providing a tool to treat wastewater in an eco-friendly and economic means to farmers will ensure perpetual availability of treated wastewater for safe irrigation. The development of a tool to treat wastewater using microbes with bioremediation traits is an eco-friendly and economic option. The objective of the present deliberation is development of biological filters(s) exploiting the microbial bioremediation traits. Many types of pollutants including heavy metals and organics are encountered in urban wastewater. The main challenge was to look for potential microorganisms with effective remediation capabilities and creation of congenial environment for them in treatment system. Free cells were unsuitable for column-packing due to their susceptibility to hostile conditions. Physical confinement of cells was an option to retain their catalytic activities in hostile conditions. Packing material for the filtration system was also a challenge where conductive material had great scope. The design of low-cost landless filtration systems with modification options was a difficult proposition. The author of this paper address those challenges. Six novel strains with efficient heavy metal and organics removal capacity were authenticated through 16SrRNA. Novel microbial consortia of hydrogel-based axenic beads were developed. Four types of biofilters, namely, tunnel, biobed, column, and gabion biofilters have been developed.

Keywords: Microbial consortia, Immobilization, Biofilter, Bioremediation, Landless filtration

Harnessing the Genetic Potential in Maize for Crop Diversification, Nutrition and Livelihood Security and Climate Resilience

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Maize (*Zea mays* L.) is the highest producing cereal crop in the world, and second to wheat in terms of area. The USA and China are the largest producers and consumers of maize. The ever-increasing use of maize in poultry and cattle feed industry puts it apart from other cereal crops globally. Starch industry also counts heavily on maize. The increased use of maize for ethanol production for fuel in the USA and many European countries adds further value to the crop. Though maize assumes tremendous importance worldwide in India it ranks third to rice and wheat among cereals. The compound annual growth rates of maize in terms of area, production and productivity are one among the highest among the cereals, mainly driven by its demand in feed and starch industries. Worldwide though India ranks 4th in terms of area it assumes 7th rank in production due to lower productivity. Productivity of maize as compared to the world average though is almost half, per day productivity of maize in India is comparable to many developed countries.

Maize in India is cultivated in nearly 10 Mha of area with total production of over 32 Mt. It is cultivated predominantly in two seasons *i.e. khairf* and *rab*i. *Khairf* maize assumes over 80% of maize area, being grown mostly under rainfed situation, while rabi maize is cultivated under most assured agro-ecological condition. The productivity of kharif maize is little more than half of rabi maize productivity, mainly due to rainfed growing conditions which is prone to various climatic vagaries including prevalence of diseases and pests. Other reasons are low inroads of single cross hybrids, the vicious cycle

of low return – low priority – low yield due to poor price realization and less policy support as compared to competitive crops like rice. Though maize requires less than one third of water that of rice policy support favours rice forcing maize out of its traditional growing areas in north India. Wide cultivation of rice has pushed the north western Indo-Gangetic plains to ecological devastation in terms of severe depletion of ground water and continued environment pollution due to burning of rice straws and indiscriminate uses of fertilizer and pesticides. Being a C4 day neutral plant maize has potential to give higher yield in a shorter period and can be grown in any season. Shorter duration of kharif maize crop enables sowing of succeeding crops like wheat, potato, vegetables earlier allowing early catch of the market and escape from terminal heat stress.

Though the history of organized maize research in India dates back to 1957 with the establishment of the first All India Coordinated Research Project (AICRP), systematic utilization of plant genetic resources towards maize improvement has remained less focused till recent past. The paper highlights the recent initiatives undertaken in India in terms of heterotic grouping of available germplasm, line recycling, systematic characterization of the collections in the National GeneBank, deployment of advanced tools (marker assisted selection, genomic selection, double haploids and genome editing), bio-fortification activities, aggressive commercialization of public bred hybrids, better management of natural resources, novel measures in protect maize from pests and diseases among others. An invasive pest, fall armyworm has recently invaded India after causing havoc in the African countries. The fight against this pest was a unique experience the country had just before the onslaught of Covid 19. Establishment of yield maximization platform in the states of Punjab and Haryana has clearly demonstrated that potential of maize as a viable alternative for crop diversification. Policy support is key in realizing the full potential of maize to contribute to crop diversification, ensuring nutrition and livelihood security under changing climate.

Keywords: Genetic potential, Crop diversification, Nutrition and livelihood Security, Climate resilience, Maize

Stubble Burning-A Problem for the Environment, Agriculture and Humans: Possible Remedies

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Indian Agriculture produces about 500-550 million tons (Mt) of crop residues annually. However, a large portion of this, about 90-140 Mt annually is burnt on-farm primarily to clear the field for sowing of the succeeding crop. In north western part of India comprising of Punjab, Haryana and western Uttar Pradesh, the situation is precarious due to burning of rice residues on farm for making the field ready for sowing succeeding wheat crop. Due to deployment of combined harvester, large amount of residues gets accumulated in the field and clearing the field by conventional approach is time consuming and labour intensive. The easiest option left to the farmers in this region is to burn the rice residues on farm. The latest data of Ministry of Agriculture and Farmers' Welfare in the year 2019 showed that about 9.96 and 1.34 Mt of rice residues are burnt in Punjab, and Haryana, respectively. It has been estimated that on one ton of stubble burning releases 2 kg SO_2, 3 kg particulate matter, 60 kg CO, 1460 kg CO_2, 199 kg ash. Therefore, burning not only causes loss of essential plant nutrients but also adversely affects the soil biological health and creates huge environmental pollution. In this scenario, proper management strategies are to be evolved to safely dispose the residues in an environmental friendly way. One of the options is to convert the residues into useful manure by faster composting with microbial consortium. Production of biocoal, disposable tableware from rice residues is also attempted. Conversion of residues into heat, electricity, and bio-oil in a big bioenergy plant can solve

the disposal problem of rice residues. This approach is a win-win strategy to convert crop residues into useful energy and the biochar thus produced as a byproduct can be used as an amendment for reclamation of acid soils and other degraded soils. The biochar, besides acting as a soil conditioner, also has huge carbon sequestration potential. Management of residues *in-situ* by conservation agriculture is also a promising option. Turbo happy seeder, tractor mounted chopper cum spreader can successfully manage the rice residues in-situ. In order solve this stubble burn issue, sustainable management strategy is to be adopted by the Government

Keywords: Rice residue, Environmental pollution, Bioenergy, Conservation agriculture

Enhancing Water Productivity and Reducing Water Footprint in the Content of Climatic Variability

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Changing climatic patterns coupled with declining per capita availability of land and water resources of India have create a great challenge for sustainable agriculture. The water resources potential of India which occurs as natural runoff in the rivers are estimated at about 186.9 M ha-m. Considering both uneven distribution of water resource over space and time about 112.2 M ha-m of the total potential can be put to beneficial use, 69 M ha-m through surface water resources and 43.2 M ha-m by groundwater. India also experiences high degree of spatial variability of annual rainfall, highest annual rainfall of

11,690 mm is recorded at Mousinram near Cherrapunji, Meghalaya, and lowest of 150 mm at Jaisalmer of Rajasthan. Average 75% precipitation of the country occurs during southwest monsoon season (June to September) only. For adequate living standards as in western and industrialized countries, a renewable water supply of at least 2000 m^3 per person per year is necessary. If only 1000-2000 m^3 per person per year is available, the country is 'water stressed', while the value comes below 500 m^3 per person per year, the country is called 'water scarce'. With the population of India expected to stabilize around 1640 million by the year 2050, the gross per capita water availability will decline from 1820 m^3/person/year in 2001 to as low as 1140 m^3/person/year in 2050 and the country will be entered into the 'water stress' category. With rapid population growth and rising expectation of better life, there will be ever increasing demand of water for various competing sectors like domestic, industrial and agricultural needs. Also more and more water will be required for environmental concerns such as aquatic life, wildlife refuges and recreation. Therefore, the available land and utilizable water resources would be inadequate to meet the future demand unless these precious resources are utilized precisely and efficiently. Adoption of suitable agro-techniques and water management practices are need of the hour to produce 'more crops per drop' that is to enhance water productivity so to check the decline of surface and ground water resources in India. Water forms the backbone for all the future endeavors to achieve the vision of food security. In the present data context, up-scalling agricultural economic growth to more than 4% annually is the main challenge. Taking water technologies for better water management from lab to land is a formidable task to be addressed. Modernization/automation of irrigation systems, precision irrigation, land reforms, corporate farming, cooperative farming, water and energy pricing, crop insurance, institutional mechanism for better governance, water rights are some of the key issues for better water management in agriculture. These have direct role in climate change mitigation and adaptation. The projected food requirement demands a pronounced role for research, development and training in the water and agriculture sector.

Strategies to enhance water use efficiency and irrigation efficiency which includes improved irrigation system management to provide more reliable water supply to farmers through storage and improved operation of reservoirs, better distribution of water with improved control structures as well as more responsive management. More reliable water supply allows farmers to invest in better on-farm water management such as better land leveling, zero tillage, or pressurized irrigation. Improved management usually requires improved institutions as well as improved technologies.

Keywords: Water productivity, Water footprint, Climatic variability, Strategies, Water use efficiency

Impact of Nitrogen Use Efficiency on Environmental Performance of Indian Agriculture

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Although, the food grain production showed remarkable increase with increase in fertilizer N use over the time, the average global N use efficiency (NUE) is quite low (0.460). Thus, the rest of the N input (54%) into cropland contributes towards environmental air and water pollution. Over the 60% of N pollution is estimated to originate from crop production. United General Assembly has

proposed the NUE as an indicator for assessing the progress made in achieving Sustainable Development Goals. Sustainable N Management Index (SNMI) approach can be used to assess the environmental performance of agriculture at country and global level. Global NUE should be raised to 0.70 by 2050 while achieving the crop production targets to reduce the N waste to desired level. India is the 2nd largest fertilizer consumer after China. It is necessary to increase the average NUE of Indian agriculture to 0.70 to achieve the global NUE target by 2050. Therefore, the current status of NUE and SNMI was assessed at country level as well as in different states of India during the last 10 years (2010-11 to 2019-20) in the present study to identify crop production constraints of low NUE and to suggest crop-specific and state-specific N management strategies. The mean NUE at country level was very low which varied from 0.451 in 2015-16 to 0.527 in 2017-18. The low NUE resulted in huge N surplus (N_{sur}) which actually contributes to environmental pollution varied from 13.45 Tg in 2017-18 to 15.8 Tg in 2015-16. The lower NUE and higher N_{sur} led to the relatively higher SNMI during the last 10 years which is directly proportional to the environmental pollution. Mean NUE of the last 10 years of 32 states and union territories showed the highest NUE of 0.878 in Nagaland and the lowest in Puducherry (0.196). The NUE and environmental performance of Indian agriculture increase at international level only when the environmental performance of agriculture and NUE of different states and UTs would improve. The 32 states and UTs under assessment were divided into 5 groups based on the NUE and fixed the target increase in NUE by 2050 for each group to achieve overall NUE of 0.70 at country level. In each group the major constraints responsible for low NUE were identified and suggested the measures to improve NUE to target level.

Keywords: Nitrogen use efficiency, Environment, Air and water pollution, Sustainable management, Indian Agriculture

Enhancing Agricultural Water Productivity: Present and Future Prospects

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Water management in agriculture sector in coming decades will play a vital role to meet the escalating food demand of the country. Irrigation sector in India would require 30% more water from the present level of 588 billion cubic meter to feed the burgeoning population by 2025. Moreover, about 46% of the net cropped area in India is irrigated leaving 54% of area without any irrigation facility. Therefore, it is essential to produce more food from less water by enhancing the Crop Water Productivity (CWP) in irrigated agriculture with share of 65% from groundwater resources and 35% from canal commands. Keeping in view of the above, implementation of judicious agricultural water management technologies would assist in accomplishment of the prime objective of *Pradhan Mantri Krishi Sinchai Yojana* (PMKSY) to provide irrigation water to each farmers' field. Moreover, under the changing climate scenarios the agricultural water management technology needs to be restructured by deciding proper irrigation schedule for different crops using Internet of Things (IoT) enabled soil moisture sensing systems, measurement of irrigation water, integration of geospatial tools and modelling techniques to develop mobile applications besides application of Decision Support systems (DSS) and ICT based protocols for enhancing water productivity. Further, the crop water demand based rostering in the canal commands, integration of crop model and climate generator for sustaining the crop yield under changing climate. Water footprint estimation at watershed scale would assist in delineation of regions for taking of suitable crops to reduce the water footprint. Also, the ground water and energy nexus impacting the environment

can be reduced by deciding ground water pumping schedule based on the crop water requirement. Moreover, recent development in use of sensors coupled with ICT technologies would assist stakeholders in enhancing water productivity and ensure sustainability in irrigated agriculture.

Keywords: Crop water productivity, Irrigation scheduling, Water measurement, DSS, Modelling, Water footprint

Soil Resources of Bolangir District, Odisha - their Assessment for Formulating Agricultural Landuse Plan

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The Bolangir district, Odisha covering 6575 sq km occurring in the hot moist subhumid agroecological subregion (AESR 12.1) developed on Eastern Ghat Super Group of rocks consisting of Khondalites, Charnokites and Gneissic rocks/Magmatites along with quaternary alluvium deposits was selected to develop District level Land Resource Information System (LRIS) in GIS environment. Interpretation of IRS–P6 LISS-IV and Sentinel II data followed by digital terrain analysis lead to delineation of the landform of the district into 6 broad physiographic regions occurring under different elevations varying from >720 m to 170 mm *viz*. Hills, Pediment, Upland, Valleyfill, Undulating Plains and Active Alluvial plains. The landuse data shows the forest cover occupies 1327.03 sq kms (20.18% of TGA), while, area under croplands, along with present and moist fallow together accounting for the arable lands occupy 3776.4 sq kms (57.43% of TGA). Based on soil survey on 1:10,000 scale , 24 soil series were identified. Alfisols are the dominant soil order

covering 48.56% area, followed by Inceptisols (37.89%), Vertisols (4.19%) and Entisols (3.87%). The great group Paleustalfs (27.85%) occupy the major area followed by Endoaquepts, (20.55%), Haplustepts (17.34%), Haplustalfs(16.19%), Haplustalfs (10.3%), Haplusterts (9%), Rhodustalfs (4.52%) and Ustorthents (3.87%). Physico-chemical properties of the surface soils show that slightly acidic soil reaction class occupies major area of the district (34.41%) while soils having sandy loam texture and low organic carbon content (<0.5%) is observed in 48% and 53% of TGA, respectively. About 42% of TGA are having moderate to very severe erosion constraints while soils with moderately shallow depth occur in about 15% of TGA. The major constraints are soil acidity, low organic matter, moderate to severe erosion hazards which along with erratic rainfall and undulating topography adversely affected the crop growth and productivity.

Keywords: District level soil information system, Soil resources, Mapping, Soil taxonomy, Constraints

Integrated Pest Management (IPM): Is it a Priority?

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Since the time of *Silent Spring* and the public-response to it, through the ecological movement across the world, the Government of India and the Indian Council of Agricultural Research (ICAR) advocated integrated pest management (IPM) as part of the National Agriculture Policy. IPM provides a long-term solution to these problems by employing as many pest management techniques as possible to enable use chemical pesticides judiciously. Chemical pesticides have been understood to have severe impact on human health apart

from affecting the environment. The ICAR appreciated the task of spreading the message of IPM across pan Nation India rather tough due to poor awareness about the subject among government officials and the farmers. Apart from lack of awareness among growers, it was understood that a long prescription for IPM was not suiting the financial provision of the farmers for the purpose. This was due to the fact that each of the components of the IPM package or the prescription thereof involved some cost, which totalled to a huge figure that varied with location, etc., which was not financially viable. For effective adoption of IPM, input-based economics have to be considered, for which methods have been devised. Thus, there is need for efforts to obtain precise estimates for economics of different interventions as a part of prioritized component-wise IPM for easier adoption of crop health management strategies. Under the circumstance, it becomes imperative to not only clarify the input cost, the benefit thereof individually and as component of IPM for managing the pest problem as also ensure that the complete package of practice for crop production leads to a remunerative return.

Keywords: Chemical pesticide, Human health, Residue, Safe food, Farmers' awareness

Engineering Plant Virus Genome for the Expression of Foreign Protein in Plant System

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Plant viruses are known as significant constraints in the production of various crops. However, plant viruses have many features that are increasingly being realized to exploit for the useful purposes. Plant viruses contain small genome

with a few genes that perform efficiently to replicate and spread between the cells and between the plants. Many different plant viruses have been engineered as expression vectors for the production of many useful foreign proteins like vaccine and antibodies in plant system. We developed expression vectors utilizing the genome of two RNA viruses, cucumber green mottle mosaic virus (CGMMV, tobamovirus) and soybean yellow mottle mosaic virus (SYMMV, carmovirus). A virus vector based on the complete genome of CGMMV was developed that expressed green fluorescent protein (GFP) at 23-fold high level over a plant protein,actin. Further engineering of the CGMMV genome was conducted to delete the viral pathogenicity function and to enhance the ability of foreign protein expression. As a result, a truncated vector was constructed that produced no disease symptoms but expressed GFP at the level of 234-fold higher over actin. Full virus vector strategy was also utilized to develop a vector based on SYMMV, which successfully resulted systemic expression of GFP in french bean. Both CGMMV and SYMMV based expression vectors will be useful in producing foreign protein in cucurbits and legume crops.

Keywords: Plant virus, Genome, Foreign Protein, Vectors

Integrated Nutrient Management: A Key to Sustainable Agriculture

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India is the second most populous country in the world and more than half of the Indian population depends on agriculture for their livelihood. Over the years of intensive cultivation, continuous use of chemical fertilizer and

imbalanced fertilizer use, the soils of the Indian subcontinent have become deficient in several nutrients and have caused losses in soil organic carbon (SOC) and soil health, often leading to unsustainability of crop production systems. Recently, the use of organic sources of nutrients in agriculture is rapidly gaining favour. However, owing to the problems related to the lack of availability of a good quality and quantity of organic materials, the systems could not be sufficient to achieve food security and sustain the production system. Integrated nutrient management can be a useful holistic approach to management of plant nutrients in different land use systems which not only reduce the nutrient gap between addition and removal but also ensure the higher nutrient use efficiency, sustainability of the system and minimize the environmental pollution. The STCR-IPNS approach of nutrient management considering nutrient supplying power of soils and crop needs for fertilizer and manures has been found to be useful over different agro-ecological regions determined from soil test results for different yield targets based on resource endowment capacities of the farmers. Agro-climatic region-specific best practices for integrated nutrient management interventions have been discussed in details. Challenges for upscaling of IPNS and future strategies also included in this paper.

Keywords: Integrated nutrient management, Chemical fertilizers, Organic manures, Crop residues

Sulphur in Balanced Plant Nutrition for Food and Nutritional Security

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The accessibility of food has improved in the past couple of years but the growing human population and the changing environment are great challenges for ensuring food security for future generations. Sulphur is the 4th major plant nutrient along with N, P and K in Indian agriculture. Sulphur is a constituent of the amino acids (methionine and cysteine), vitamins (biotin and thiamine), involved in chlorophyll formation, activation of enzymes, formation of oils and the SH linkages are the sources of pungency in onion, oils, *etc*. Sulphur is associated with the production of crops of superior nutritional and market quality as well as acclimation to abiotic stresses and also critical for animal nutrition. Sulphur is the third most abundant mineral in the human body, after calcium and phosphorus, representing ~0.3% of total body mass. In spite of these numerous sulphur roles being well acknowledged, agriculture has paid scant regard for sulphur nutrition, until only recently. Deficiency of sulphur in Indian soils is on increase due to intensification of agriculture with high yielding varieties and multiple cropping coupled with the use of high analysis sulphur free fertilizers along with the restricted or no use of organic manures have accrued in depletion of the soil sulphur reserve. On average, the sulphur absorbed per tonne of grain production is 3-4 kilograms in cereals, 8 kilograms in pulses, and 12 kilograms in oilseeds. Significant response to sulphur application has been reported in all the soils and crops. In the wake of huge demand for high quality cereal and vegetable diets, sulphur can play a key role in augmenting the production, productivity, and quality of crops. In this deliberations, the role, extent of

deficiencies, critical limits, the current knowledge of the impact of the changing environment on plant sulphur nutrition and the consequences for human nutrition and food security will be discussed with the aim to identify knowledge gaps and propose research directions to ensure sufficient sulphur in food for future generations.

Keywords: Balanced nutrition, Food and nutritional Security, Sulphur, Critical limits

Recent Development of Soil Degradation in India for Food Security in Battling Climate Crisis

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Out of 142 Mha net cultivated areas in India, 120.2 Mha is degraded of which 70% (84 mha) is water erosion. Soil degradation and climate crisis are two major challenges to cope up with food security though India had potential to global food supply chain. With increasing population growth rate of 1.0%, food grain production though presently 310 Mt but remain challenge for next decades in these two issues. Appropriate natural resource management (soil and water) adopting modern technology like nano-fertilizer, drone utilization for precision use of nutrient, water and input can not only increase higher productivity but also decrease GHGs emissions to reduce GWP keeping temperature rise <1.5 ^{o}C set target given to each country as SDGs by UNCCC. COP26 summit (Glasgow) with the commitment for India to be net zero by 2070 and reduce emissions by 1 billion tonnes very year by 2040 would reduce emissions intensity by over 45%. Soils not only serve as holding nutrient and

water for plant growth but also perform ecosystem services including carbon sequestration. Farmers/Farms do not get paid for soil ecosystem services (PES). IPCC protocol in REDD^{++} pathway pay carbon credit to farmers in developing countries in afforestation in degraded of land but still now not credited for field crops carbon sequestration for adoption of appropriate SWC, soil and input management practices. Pay credit to farmers for sequestration of SOC as soil serve as ecosystem services to mitigate climate change is critical issues. Soils have the capacity to store 2.5 to 3 times more C than present in the atmosphere. COP21 gave target of 4 mille to all the countries for the field crops to reduce CO_2 emission by 30% by 2040. In controlling soil degradation, climate adaptation and mitigation, use of precision technology in small holder farmers are the new challenges for food security and supply to global food chain.

Keywords: Soil degradation, Natural resources, Sustainable development goals, Food security

Water Quality and Food Security

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India ranked 101st out of 116 countries in the 2021 global hunger index as per the April 2022 country briefing of the World Food Programme. Food and nutritional security comprise not only the quantity of production but the quality and accessibility too. Water is one of the most important natural resources, fundamental to life, livelihood, food security and sustainable development. Huge share of this resource is utilized in agricultural sector and is fundamental for global food security. With a growing population and rising needs of a fast

developing nation coupled with the possible impact of climate change, water scarcity will worsen in future. The possibility of conflicts among water demanding sectors may rise.

The hazards and insecurities introduced by modernization and technology have created a form of 'risk society'. Water quality influences the food quality. Large irrigation schemes, which are important contributor in global food security, has been associated with land and water salinity problems. Both, expansion and intensification of agriculture with increased injudicious use of fertilizers and pesticides has degraded the water quality of fresh waterbodies. Concentrating organic inputs increase the potential transmission of pollution from animal waste like eutrophication of freshwater bodies. With shortage of fresh water millions of farmers worldwide are driven to irrigate with marginal quality water such as wastewater from urban areas or saline agricultural drainage water. Food safety and, yet, extracting benefits from marginal water is an enormous challenge. Additionally, concerns about the use of naturally occurring arsenic-laden groundwater in agriculture are growing and, therefore, this emerging issue needs special attention. These are all examples of the complex interactions between agriculture and water quality that needs to be systematically analyzed. Prioritization of technologies and a policy framework with a unified national perspective is the need of the hour.

Keywords: Water quality, Irrigation, Groundwater quality, Water management

Nanotechnological Intervention in Soil Fertility Improvement and Polluted Land Decontamination

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Nano-fertilizers are molecular modified or synthesized material, with the help of nano-technology used to improve the fertility of soil for a better yield and crop quality. In the case of conventional fertilizers, nutrient use efficiency hardly exceeds 30–35%, 15–20%, and 60–70% for N, P, and K, respectively and these estimates more or less remained constant for the past several decades, whereas the nano-based fertilizer formulations are capable of releasing nutrients for a much longer period of time than the conventional fertilizers. Since they provide a larger surface area for reaction and a prolonged availability of nutrients to the crop plant, this situation favors quality parameters, such as protein, oil, and sugar contents, by enhancing the rate of reaction or synthesis process in the plant system, as observed in various crops. Nano-materials also find applications in detecting and treating existing environmental contaminants and preventing new pollution. They can be used in the treatment of various contaminated media by chemically transforming contaminants or acting as a "super adsorbent" for many compounds. They also play a promising and vital role in the development of rapid and precise environmental sensors which can be used in the detection of pollutants at molecular levels and also for inactivating harmful bacteria. The ICAR-IISS, Bhopal, produced different nano-fertilizers for phosphorus (nano rock phosphate), potassic nano-fertilizer from glauconite, waste mica, zinc from Sphalerite *etc*. and nano amendments like different nano-composites for soil and water decontamination purposes. However, most of the nano-fertilizers

studies conducted so far have lacked the nano-specific quality assurance and adequate controls, and no comprehensive study is yet available on the efficacy and environmental impact of nano-agrochemicals and nano amendments under field conditions. There is a need to develop guidelines for testing and demonstration of nano-fertilizers and nano amendments in India.

Keywords: Nanotechnology, Soil fertility, Pollution, Nano-amendments, Decontamination

Effect of Five Years of Conservation Agriculture Practices on Soil Organic Carbon Sequestration and Carbon Management Indices under Irrigated Wheat-based Cropping Systems in the Indo Gangetic Plain

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Rice (*Oryza Sativa*)-wheat (*Triticum aestivum*) cropping system under conventional tillage practices in the Indo-Gangetic plain region has become unsustainable because of high water requirement, depletion of soil organic carbon (SOC) and degradation of soil health. Cotton (*Gossypium hirsutum*)-wheat, maize (*Zea mays*)-wheat and pigeon pea (*Cajanus cajan*)-wheat cropping systems have the potential to replace rice-wheat cropping system in the Indo Gangetic plain region. A study was conducted in an ongoing long term field experiment initiated in 2010 with three wheat-based cropping systems *i.e.* cotton-wheat, maize-wheat and pigeon pea-wheat under seven treatments involving conventional tillage and zero tilled- flat bed, narrow

bed and broad bed with and without residue retention arranged in a randomized block design with three replications to study their effect on SOC sequestration, relative distribution of SOC pools in different soil layers and SOC management indices. It was observed that only in maize-wheat cropping system zero tillage and residue retention registered higher SOC sequestration than conventional tillage system. Among the tillage treatments, zero tilled flatbed with residue retention (ZT-FB+R) registered maximum SOC sequestration in the 0-15 cm soil depth. The active pool of SOC was higher and the passive pool of SOC was lower at 0-5 cm soil depth under conservation agriculture than the conventional tillage in all the three cropping systems. Carbon lability index, carbon pool index and carbon management index under conservation agriculture was higher than conventional tillage at 0-5 cm soil depth in all the three cropping systems. However, at 5-15 and 15-30 cm soil depth only in maize-wheat cropping system the carbon lability index, carbon pool index and carbon management index under conservation agriculture was higher than that of conventional tillage. Therefore ZT-FB+R tillage practice may be followed in maize-wheat cropping system for improving SOC sequestration and carbon management index in the Indo Gangetic plains.

Keywords: Conservation agriculture, Soil organic carbon, Carbon management, Wheat-based cropping system

Role of Rootstock for the Improvement of Temperate Horticulture

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Since prehistoric times, wild fruits plants have been an important source of food for mankind. As man developed through the ages so did the utility of these fruits. However, over the ages conscious selection for superior edible types has systematically deprived our cultivated fruit crop varieties of qualities like resistance to diseases and pests, winter hardiness, drought tolerance and vigour. Valuable genes and germplasm, which were available in nature thus got discarded and are now on the brink of extinction. The Himalayas are abundant in wild fruit species that are distinct from the tropical types found elsewhere in India.

It is pertinent to show the extent of variability that exists in the two indigenous *Malus* species *viz*., *Malus baccata var. himalaica* and *Malus sikkimensis*. This variation is of great economic significance as it could be instrumental in introducing far reaching improvements in apple production. Some like the walnut (*Juglans nigra*), *Prunus* spp, *Pyrus* spp*, Actinidia* spp*, Fragaria* spp*,* and *anardana* or *daaru* (*Punica granatum* Linn.), *Prunus* species are consumed by a sizeable local population and find an important place in local markets. The most urgent need today is to enhance the production, productivity and quality of nutritious food in an eco-friendly manner so as to improve farm income to ensure household food and nutritional security. An ideal rootstock should possess uniformity in vigour, resistance to diseases and pests without impairing the productivity and quality. Biodiversity played an important role

in the evolution of fruits crop plants and act as genetic reservoir for breeding purposes. So, diversity among crops, species, varieties is now paramount important to cope up with the climatic change as well as monocrop failure due to unavoidable circumstances. IARI, RS, Shimla has identified one each ideal rootstock for apple and Pear and another for temperate stone fruits from the wild population which could be utilized for the improvement of temperate fruit crops. Lateral bearing walnut also identified which is precocious, semi-vigourous and suitable for high density orcharding. The Himalayan region is rich in plant biodiversity which includes wild relatives of temperate fruit crops as well as cereal crops. Some of these have been identified as potentially useful for use as better rootstocks or for reorienting breeding programmes. *Malus baccata* collected from Shillong in the north-east deserves special mention. Likewise *Prunus cornuta, Prunus nepaulensis, Prunus* spp. Behmi, *Sorbus* spp., *Pyrus pashia* and *Pyrus pashia var. kumaonii* have been found of particular utility for stone fruits and pear.

Keywords: Rootstock, Temperate horticulture, Biodiversity, Productivity, Quality of fruits

Satellite Monitoring of Soil Moisture: An Aid to Critical Agricultural Decisions

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Due to high spatiotemporal variability, retrieval of real-time soil moisture data over agricultural fields remains a challenge. Satellite remote sensing can update the surface or near-surface soil moisture (SSM) on a regular basis

over a large area, although not able to penetrate down the soil. Microwave remote sensing technique from the space-borne platform like Soil Moisture Active Passive (SMAP) and Soil Moisture and Ocean Salinity (SMOS) has been mostly used for SSM estimation. Presence of crops/vegetation cover and soil surface roughness are the two major interfering parameters. During growing seasons, vegetation is the most critical factor influencing the signal (backscattering coefficient, $ó^0$). Increase in wavelength can reduce the effects of vegetation on backscattering as longer wavelengths (L-band) penetrate through the canopy and reflect from the soil surface. Intermediate wavelengths (C-band) generally reflect from both the canopy and soil surface, causing strong two-way attenuation. Amongst contemporary SAR products such as ALOS 2 and PALSAR, Sentinel (C-band) data has a lead due to its spatiotemporal resolution and can be applied in gap filling or data fusion with low spatial resolution SSM products such as SMAP because of their corresponding orbits and crossing time. Study at IARI employed the use of scattering models with Sentinel-1 (SAR) & Sentinel-2 (optical) data to operationalize high resolution SM mapping (~10m). The Dubois & WCM models were used to approximate $ó^0$ with medium accuracy (R^2 =0.73) and derive SM maps. Results were validated against in-situ data collected over past two years. We aim to further improve the results by incorporating filed observations on soil roughness using soil profilometer. Despite, it remains a complicated approach and the ability of RS data in estimating accurate SSM under a variety of topographic and land cover conditions remains to be explored. A combination of optical (vegetation), thermal (soil moisture) and micro-wave remote sensing data can give better SSM estimates by overcoming the disadvantages of single technique.

Keywords: Soil moisture, Spatio temporal variability, Remote sensing, Soil roughness

Sustainable Coastal Salinity Management Technologies for Enhancing Crop Productivity

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Salinity is one of the major environmental factors causing land degradation. It is estimated that nearly 831 Mha of land in the world are affected by salt. In fact, out of the 6.74 Mha total salt-affected area in the country,1.25 Mha coastal saline. Direct seawater intrusion, intrusion through estuaries and the upward movement of salt from shallow water tables are the major causes of salinity in coastal soils. Salinity causes soil structural changes and affects water, air movement and available water capacity, further affecting the osmotic and matric potential and microbial activities. This ultimately reduces the rate of organic matter decomposition and release of nutrients and thereby affects plant growth and yield. Soil microbial community structure, their activities, and enzyme activities are adversely influenced by salinity. NaCl and Na_2SO_4 are the dominant salts with an abundance of dissolved cations in the order Na > Mg > Ca > K. The salt reaches the soil surface through capillary rise during the dry season and makes the soil saline and unproductive for agriculture. To improve the crop productivity in the coastal saline soil a better understanding of the nature, properties, and constraints associated with different coastal soil groups are needed to implement better management practices to increase the productivity and quality of saline soil. Based on the research findings selection of suitable saline tolerant crops, adoption of land shaping technique, integrated nutrient management, organic manure application, rainwater harvesting, conjunctive use of saline water with rainwater and use of modern irrigation techniques. Further based the intensity of salinity promote agroforestry, conservation agriculture, and sustainable crop intensification to sustain the

soil health and improve the livelihood security of farmers of coastal regions of India.

Keywords: Coastal salinity, Salt tolerant crops, Water management, Land shaping, Integrated nutrient management

Management of Natural Resources for Sustainable Livelihood Security under Changing Climatic Scenario

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As it is known that natural resource management is an essential part of sustainable agriculture which continues to play significant role in food and nutritional security, there are certain issues such as nutrient mining, imbalanced nutrition, nutrient loss during the crop production cycle and rising fertilizer costs that must be addressed in order to achieve higher crop productivity while maintaining soil health. The increasing awareness towards challenges in human health due to consumption of poor-quality crop produce has led to a quest for new and improved technologies of improving both the quantity and quality of crop without jeopardizing human health. New scientific knowledge and innovative technologies provide considerable opportunities to reduce current yield losses and minimize the detrimental effects on soil health. Continuous efforts in developing new cost-effective and environmentally sound solutions are important in improving the soil health.

Developed different INM technologies for various crops, Fe efficient varieties / hybrids in calcareous soils, management technology for soil compaction

and soil fertility for maintaining sustainable livelihood food security. In addition, an array of fertilizer products including crop specific TNAU micronutrient mixtures, chelates, liquid multi-micronutrients and water soluble fertilizers have been developed and evaluated for various crops. Microbial inoculants *viz.,* Stage specific inoculants, zinc solubilizing bacteria and pink pigmented facultative methylotrophs (PPFM) for rice, Antioxidant microbial consortia (AOMC) for rice under water scarcity and Sulphur oxidizing bacteria for sesame which are reliable supplements to the use of chemical inputs and can act as biofertilizers for providing nutrients, plant growth promoting substances, drought mitigation and enhancement of soil health. With a view to find solutions to the environmental pollution problems "TNAU Biomineralizer" – a microbial consortium to decompose the biodegradable wastes into nutrient rich compost that upon application to the soil improves fertility, soil stability, reduce pollution and ultimately eliminates the thrash burning issues that dooms the environment. Account on nanotechnology interventions in the era of precision agriculture provides new agrochemical agents and new delivery mechanisms to improve crop productivity and it provide scope to reduce input applications. In line to this, nano inputs *viz.*, seed invigorants, chitosan-based emulsion for drought mitigation, multinutrient pellet technology, biopesticide *etc.,* for crop improvement. Also, formulations like EFF (Fruity Fresh), nanostickers/ pellets for enhancing shelf life of fruits were used to maintain natural resources in sustainable way for improving yield with different climatic condition.

Keywords: Natural resource management, Livelihood security

Recycling of Crop Residues for Silicon and Other Nutrients for Sustainable Crop Production

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Attaining food and nutrition security (FNS) is precedence in developing countries. With increasing demand for sustainable crop production, the need of the hour is to effectively utilize site-based resources. One such resource is the remaining crop residues, both above and below ground, after harvest. Being an agrarian country, India generates more than 500 million tonnes (Mt) of agro-wastes every year. However, due to lack of on-site management technologies, farmers usually prefer burning of the crop residues as the inexpensive way to get rid of them without thinking its negative impact on environmental quality. Contrastingly, due to the presence of significant nutrient content, these crop residues can consider to be 'potential black gold' as a natural and valuable resource. Generally, residues of different cereal crops contain 25% of nitrogen (N) and phosphorus (P), 50% of sulphur (S) and 75% of potassium (K), which can be considered as a potential nutrient source, if the residues are recycled back to the soil. Among the different crops grown in India, residues of rice, wheat and sugarcane, deliberated as Si accumulators which contain more than 10% silicon (Si) in their shoots. It has been computed that one tonne of Si accumulating crops can removes approximately more

than 2.5 times K compared to nevertheless, the removal of Si is 8 times higher compared to N. Therefore, the exportation of residues from the field will deplete the soil with Si followed by K and N. This mainly calls for the attention of the agricultural scientists to promote the recycling of crop residues for boosting the Si including other nutrients. Hence, the aim of this paper is to compile the negative consequences of crop residue burning and the importance of crop residue recycling for balancing the Si content in soil along with K and N for sustainable crop production.

Keywords: Crop residues, Recycling, Silicon and other nutrients, Indian Agriculture

Leveraging Greater Genetic Gains and Base Broadening Through Prebreeding and Germplasm Enhancement in Chickpea

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Precise phenotyping and expensive phenotyping platforms have been a bottleneck for chickpea improvement, recent advances in genomics technologies and the availability of ample genotyping platforms have made the cost of genotyping much cheaper in comparison to phenotyping. With the advent of FIGS approach, development of TILLING population and identification of putative candidate genes for various stresses both biotic and abiotic, prebreeding and germplasm enhancement through targeted introgression of genomic regions from wild species and landraces appears a way out for base broadening and improvement of pulse crops. QTLs from donor ICC 4958 has led to development of drought tolerant introgression lines BGM 10216, 10218, BG 3097, BG 4005 into AICRP programme. These lines are carrying the drought QTL on LG4 and are showing better yield (ranging from 10-12%) over the recurrent parent. Wilt QTLs on LG 2, from the donor WR 315 have been introgressed into the lines BGM 20211, 20212 which have proved their superiority and were released as WRIL variety Pusa Chickpea Manav. Genomic selection by way of development of training population and model fitting has been done in chickpea for yield improvement. Thus, the recent developments in sequencing technologies, saturated genetic maps, QTL maps as well as sequencing are greatly helping in using marker assisted technologies to be applied in pre breeding and germplasm enhancement of pulse crops. Genomics-assisted breeding for marker-assisted backcrossing (MABC) for introgressing QTL region, marker assisted recurrent selection, gene pyramiding, marker-assisted selection (MAS) and genomic selection are now underway routinely for pulse crop improvement.

Keywords: Germplasm, Genomic sequence, Marker-assisted backcrossing, Chickpea

Technological Innovation Led Sustainable Development in Temperate Fruit Crops for Ensuring Nutritional Security in India

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Temperate fruits are nutritionally rich in health beneficial compounds, which plays an important role in boosting immunity against dreaded diseases and keeps the tissues healthy. Therefore, fruit crops in general and temperate fruits in particular playing vital role in ensuring nutritional security. Globally, India is the second largest producer of fruit crops. The economically important temperate fruit crops include, apple, pear, peach, plum, cherry, apricot, walnut and almonds are the backbone of economy in the north-western Himalayan as well as in some parts of north eastern region. Therefore, sustainable development of temperate fruits in the regions is important to provide the handsome livelihood as well as ensuring nutritional security. In this regard, significant technological advancements have been made like, improved varieties, high density orcharding systems, efficient nutrient and water management techniques, plant protection technologies, quality planting material production, biotechnologies innovations and post-harvest management practices. Large number of high yielding varieties which are rich in nutraceutical properties have been introduced from countries like USA, UK, Germany, Italy, France, Australia, New Zealand, Hungary and Bulgaria; where breeding work is at advanced stage. Some of the improved varieties have also been developed in India through clonal selection and hybridization

in apple, apricot, cherry, peach, walnut and almonds. Use of improved varieties, high-density technologies, fertigation and integrated pest management have revolutionized the temperate fruit production and resulted in many folds increase in yield. In addition, efficient post-harvest management technologies have also been developed for reduction in post-harvest loss. This technology led production of temperate fruits resulted in increase of farmers income and also increased the availability of fruits per capita. The paper attempt to document the recent technological innovation in temperate fruit and nut crops for sustainable development in hilly regions (temperate) as well as nutritional security. The information is valuable for breeders and academician for further studies.

Keywords: Sustainable development, High-density technologies, Efficient nutrient and water management, Temperate fruit crops, Nutritional security

Carbon Sequestration: An Efficient Mechanism for Food and Nutritional Security

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The restoration of atmospheric carbon in the deeper layer of soil as organic carbon along with enhancement of soil fertility is known as carbon sequestration. This process is quite helpful in minimizing the carbon dioxide concentration in the atmosphere. Increased carbon dioxide concentration in the atmosphere (approx. 11% increment in the last 20 years) leads to climate change which imposed a significant threat on food security because of lower productivity caused by depletion of carbon content in soil. The transfer of atmospheric carbon to long-term pedological pool of carbon may be a result

of either carbon addition (mulching, conservation agriculture, organic amendment addition *etc*.) or reducing the carbon loss from soil (reducing soil erosion and soil respiration) or a combination of both.

Enhancement of soil organic carbon (SOC) storage through different cropping systems of the country is an efficient agronomic practice to accelerate the C-sequestration process in the soil. The SOC content and carbon management index of agroforestry systems were 65% and 15% higher than that of the maize-wheat system in North Eastern region of Punjab. Incorporation of perennial horticultural and/or forest trees in conventional agricultural systems and pulse cover crops in traditional cereal crops significantly increases the C pool in soil. The SOC plays an important role in sustainable agriculture as it increases crop yield by improving soil fertility and physical properties. Thus, it becomes imperative to increase the SOC content for optimization of crop productivity for food and nutritional security.

Keywords: Carbon sequestration, Soil organic carbon, Maize-wheat system, Food and nutritional security

RNA Interference-Mediated Crop Improvement

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RNA interference (RNAi) is a mechanism of gene silencing present in all the higher domains of life. RNAi in plant is manifestation of broadly two different functions-defence against molecular parasites like viruses, transposons, *etc*., and regulation of endogenous genes to orchestrate development and adaptive

responses to biotic and abiotic stresses. This endogenous regulatory process had been enticed for quality improvement and imparting biotic stress resistance in crops of national importance.

Storing of potato in cold is an integral post-harvest handling of this semi-perishable crop. However, reducing sugars get accumulated in potato during cold storage due to an unwanted physiological process called cold-induced sweetening (CIS). Potato with high reducing sugar content becomes unfit for processing due to development of dark colouration in processed potato products. Potato processing industry suffers due to lack of suitable cold chipping potato cultivar. Amelioration of CIS was achieved by RNAi-mediated silencing of vacuolar invertasegene. Many fold reduction of reducing sugar accumulation was achieved in cold-stored transgenic potato that produced light colouredchips.

Late blight, caused by *Phytophthora infestans,* is the most infamously devastating and economically damaging global disease of potato. Host-delivered RNAi mediated silencing of an effect or gene responsible for virulence of *P. infestans*, resulted in lower disease progression and reduction in pathogen load as demonstrated by disease scoring and quantification of pathogen biomass on transgenic potato plants. *Helicoverpa armigera* is the most damaging insect pest of many food and fibre crops causing huge economical loss. Improved resistance against this insect-pest was obtained by transgenic tobacco-delivered artificial micro RNA-mediated silencing of gene(s) of this insect pest. Resistance was due to growth reduction and mortality of larvae and developmental deformity in adult.

Keywords: RNA interference, Crop improvement, Potato, Late blight

Improving Plant Immunity to Insect-Pests and Pathogens in Indian Mustard (*Brassica juncea*) through Biotechnological Interventions and Genomics

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Indian mustard (*Brassica juncea)* is the most important among the rapeseed-mustard group of oilseed crops. Over the last decade, the annual production of rapeseed-mustard in India has increased from 8.03 Mt (FY 2013) to 11. 4 Mt (Statista 2022). However, its productivity has not been sufficient to meet the domestic demand. There are several biotic and abiotic factors which constraint the productivity of Indian mustard. The crop lacks resistance genes against many of its economically important insect-pests and pathogens. The gene pool available through conventional breeding in this crop is of limited scope for genetic improvement of stress tolerance against the insect-pests and pathogens. As a result, among the various breeding objectives of Brassica improvement, developing genetic resistance against major biotic stresses remained intractable. For example, developing genetic resistance against the sap-sucking insect-pest mustard aphid, and the Alternaria blight disease caused by *Alternaria brassicae*, could not be achieved due to nonavailability of resistance sources. In overcoming these constraints, interventions through biotechnological means have been imperative. Studies indicate that a cascade of defense signalling is involved in manifestation of host-defense in mustard. In case of aphid infestation, the insects have evolved mechanism to attenuate the host-defense response. Two elicitor peptides have been identified which are potential inducer of defense signalling cascade in *B. juncea*. Like many

other crop species, the wild relatives of *B. juncea* harbour array of genes related to important agronomic traits like resistance against major insect-pests and pathogens. Utilizing a crop wild relative (CWR), resistance against *A. brassicae* has been successfully introgressed into Indian mustard. The genomic studies are underway for understanding the genes and pathways associated with the resistance. A brief account of the basic research related to developing genetic resistance in Indian mustard against mustard aphids and Alternaria blight disease will be discussed.

Keywords: Plant Immunity, Resistance genes, Biotechnological interventions, Genomics, Indian mustard

Induced Systemic Resistance in Plant against Diseases through Bio-agents as Inducer

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Plant diseases are the major constraint of agricultural production in India as well as in the world. The management of diseases can be done through cultural, chemical, biological and use of resistant variety. The conventional method of its control is based on direct elimination of the pathogen but researches are going on in search of non-conventional and eco-friendly management measures that can give good return to growers. Therefore, biological control is getting popularity in the coming era. In this context, *T. harzianum, T. viride*, *Aspergillus niger* AN-27, *C. globosum* and *P. fluorescens etc*., have been used for management of plant diseases. Recently, bio-agents are using as inducers in inducer resistance in plant. In this context, bio-agents has been used as an inducer in induced resistance against spot blotch in wheat, brown leaf spot in

paddy and *Fusarium* wilt in tomato. Biochemical analysis of the treated plant prior to challenge infection sensitized the plants to produce increased levels of soluble proteins and total phenol content. Correlation coefficient and regression equation showed that there was a negative correlation between disease incidence and soluble protein content as r = -0.4312 to -0.4694 in wheat, r = -0.43 to 0.47 in paddy and r = -0.6364 in tomato. Similarly, negative correlation was also been observed between disease incidence and total phenol content r = -0.324 to -0.3835 in wheat r = -0.32 to -0.38 in paddy and r = -0.7653 in tomato. Protein profiling by SDS-PAGE revealed that the variable numbers of protein bands were found in inducers treated plants. In case of wheat, new proteins of different molecular weight *i.e.* 110, 105, 38, 35, and 32 kDa were synthesized due to application of crude extract of *C. globosum.* Isolation, purification and characterized the secondary metabolites as Chaetomin, BHT, Mollicelin G, Cochliodinol, Chaetoglobosin A and one isomer of Mollicelin G from culture filtrate of *C. globosum.*

Keywords: Induced systemic resistance, Spot blotch, Brown leaf spot, Fusarium wilt, Biochemical changes, Correlation regression

Multimedia based Extension Model named Pusa Samachar for Technology Information Dissemination and Agro-advisory through Social Media

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Access, efficiency and affordability of agricultural in-formation are a prerequisite for achieving set targets of agricultural productivity. Information

and communication technology (ICT) equipped with social media reach can play a leading role in disseminating correct information to needful farmers at the right time. The ICAR-Indian Agricultural Research Institute in-house initiative 'Pusa Samachar' is an innovative multimedia-based extension advisory model that targets to reach farmers across India with timely, location-specific and customized farm information. The present study was conducted to get an overall idea about the viewership pattern and to validate this model under content, design, ease of understanding and fulfilment of information needs. Analysis of secondary data from YouTube analytics and primary data collected from different stake-holders has shown that with changes in the format, style and presentation of the content, the trend of view-ing changed and therefore four episodes performed better than the others with respect to the number of views, watch hours and subscribers added per episode. The findings also indicate that the number of views de-pend on the episode duration ($\chi^2 = 83.049$, $P = 0.001264$); however, the average view duration per episode is in-dependent of episode duration ($\chi^2 = 3.1821$, $P = 1$). Overall, the present study has shown how initiatives like Pusa Samachar have immense potential to reach farmers across the nation through social media. Such initiatives can be taken up by other public institutions as reliability and validity of their content is high. How-ever, the results have shown that diversification with respect to content and audio-visuals is further needed to attract and retain more audience.

Keywords: Multimedia, Pusa Samachar, Information Dissemination, Agro-advisory, Social media

Utilization of Tropical *japonica* Lines in Rice Improvement to Create New Plant Types

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Moreover, half of the world's population relies mostly on rice as a food source. About 90% of the world's rice consumption comes from Asia, and while rice demand is rising overall, it is not enough to meet the predicted nine billion people's food needs in 2050. In India, rice contributes to 40–43% of the country's total food grain production. To increase the typical farm yields of the irrigated rice ecosystem while taking the diminishing land and water resources into mind, rice cultivars with better yield potential must be created. Although semi-dwarfism and heterosis have been used to raise grain yield genetically over the past 50 years, a significant increase in grain productivity is still needed to feed a growing global population. Therefore, we need an alternative breeding strategy to overcome such yield barriers. Development of New Plant Type based rice genotypes could be one of the alternatives.

Due to their robust barriers to cross-hybridization, the two subspecies of cultivated rice (*Oryza sativa*), *indica* and *japonica*, have evolved into genetically distinct species. As a result, genetic diversity within each subspecies has been constrained. While *japonica* genotypes are more diverse than *indica* genotypes. Being genetically less diverse, rice has a low average level of heterosis. Therefore, merging the genetic diversity across subspecies could bring in increased genetic diversity and therefore increased heterosis,

for which tropical *japonica* would be useful, therefore, we have we systematically utilized diverse tropical *japonica* genotypes to develop NPT based lines. By increasing the yield potential of the current cultivars, the new plant type concept is significantly gaining attraction in the effort to double farmers' incomes. The emphasis is currently on breeding for high yielding lines with more than 10 t/ha. The trial on New Plant Type was started in the All India Coordinated Rice Improvement Project (AICRIP) to evaluate and identify entries with high yield of >10 t/ha with effective agronomic and soil management approaches. In this situation, it is crucial to search for practical solutions that offer the chance of achieving the desired high yields of more than 10 t/ha.

Keywords: Tropical *japonica* Lines, Rice improvement, New plant types, Cross-hybridization

Sustainable Soil Land Management towards Land Degradation Neutrality in the Nilgiris of Western Ghats, Southern India

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Unfavorable climatic conditions coupled with the mismanagement or misuse of land resources lead to higher emission of greenhouse gases, degradation

and vulnerability. Agriculture is one of the sectors that contributes to the release of greenhouse gases (GHGs), affecting the quality of air and biodiversity and increasing global warming. Stabilizing GHGs emissions from croplands is an essential climate change mitigation strategy but could be a tough task as agricultural demand grows every day. Main drivers of climate change are frequent changing in land uses with unsustainable land practices, increased GHG's emission and global warming, increased occurrence of landslides due to frequent cloud bursts, anthropogenic effects, increasing population dynamics including tourism. Our study in Western Ghats indicates that forests and grasslands are very good sink to the atmospheric CO_2. Therefore, restoration of degraded lands through afforestation schemes and by planting various grass species will improve the carbon sequestration potential of the soil and also prevent top soil erosion. We found that soil loss from sloppy land (5-28%) ranged from 3.9 t/ha under 5% slope to 25.5 t/ha under 28% slope categories. Even though there was no significant yield reduction in vegetable crop, the loss of clay (10 t/ha) and soil organic carbon (SOC) loss (450 kg/ha) in the higher slopes is a concern. Bench terrace found to reduce soil loss from 39 t/ha in the sloped land to 300 kg/ha. Biological bench terrace formation using grasses will be useful not only for resource conservation but sequestered atmospheric carbon. Besides, farmers can change nutrient management practices to reduce emissions from fertilizers and manure applied without reducing yields include trying improved variety, soil testing, precision application, use of slow-release fertilizers or nitrification inhibitors, and changes in application timing to better match plant uptake of nutrients. In the Nilgiris hilly region, soil erosion is severe in steeply sloping lands. Construction of bench terraces, contour bunds using stone walls and vegetative barriers especially of fodder grass are suggested to minimize soil erosion and land degradation.

Keywords: Agricultural practices, Greenhouse gases, Land degradation, Western Ghats

Silicate Mineral Powders for Agricultural and Environmental Sustainability: A Tropical Perspective

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A significant amount (about 7 billion tonnes) of low-grade silicate mineral powders (SMPs) are generated annually as by-products of mining activities. The SMPs vary considerably in the composition and have recently been used for meeting plant nutrient demands in all continents. The published literature on SMPs application in agriculture have so far focused mainly on agronomic benefits but have paid very little attention to environmental sustainability. Silicate minerals rich in cations, especially Mg and Ca, are most appropriate for enhanced weathering process. The weathering or dissolution of silicate minerals consumes CO_2 because it releases cations such as Ca^{2+} and Mg^{2+}, thus increasing total alkalinity and drawing CO_2 in to the solution to form carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions. Over the geological timescales, those cations can lead to the precipitation of minerals, such as $CaCO_3$, which sequestrate carbon in mineral form. So, it is quite expected that warm and wet climate with soil having limited pool cation releasing minerals are suitable for enhanced weathering. This implies that application of silicate minerals and enhanced weathering is suited in highly weathered soil of tropical climate. Advanced application strategies of SMPs application in agriculture have been highlighted to harness more benefits for agriculture and environment. Some advanced strategies have been identified for maximizing the effectiveness of SMP in tropical soils. However, strategies for economic and environmental soundness of SMP application need further

development. Thus, it can be concluded that advanced SMP strategies hold promises in tropical agriculture and environment.

Keywords: Silicate minerals, Weathering, Environmental sustainability, Strategies

Redefining Protocol of Conservation Agriculture in Maize- Wheat System Productivity - *a Paradigm Shift towards Future Commitment of Food and Nutrition Security*

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Conventional agriculture comprising usual tillage and stubble burning not only threatens soil health for sustainable crop production, but ever-increasing C-footprints to the global warming potential. To expedite early sowing, especially of wheat compels farmers adopting traditional practice of indiscriminate stubble burning in Asian and south Asian regions. What they are not fully aware is inevitable nutrient depletion with *en mass* destruction of beneficial soil microorganisms. Accomplishing significant contribution to the global food and nutrient security, maize and wheat are gaining paramount importance. Thus, in pursuit to generate tangible information, a field experiment was conducted addressing tillage and stubble management among diverse array of agro-techniques under the aegis of 'Conservation Agriculture' in maize and wheat system during 2017 to 2020 in the IARI, New Delhi.

Results revealed that maize and wheat productivity progressively increased having been consistently promoted over the years, which was pronounced significantly higher at zero tillage stands supplemented with stubble residues

(6.71 and 5.67 t/ha), than that at conventional tillage stands (6.13 and 5.41 t/ha). While, practice of burning stubbles declined grain yields of maize(6.61t/ha) and wheat (5.59 t/ha) at zero tillage, and at conventional tillage (5.89t/ha and 5.25 t/ha).Consequently, total system productivity (wheat equivalent yield) was also derived higher at zero tillage with stubble residues (12.38 t/ha) followed by without stubble residues (12.20 t/ha); while, conventional tillage recorded the lowest system productivity with stubble residues (11.54 t/ha) and without stubble residues (11.14 t/ha). Therefore, the study could establish the merits of zero tillage in cognizance with stubble residue retention while redefining 'Conservation Agriculture' and could advocate the viable mitigation options to alleviate detrimental impacts of stubble burning and soil compaction aiming at food and nutrition security with sustainable maize–wheat production system.

Keywords: Conservation agriculture, Maize-wheat system, Food and Nutrition Security, Productivity

Sub-Soiling Improves Root Growth and Productivity of Transgenic BGII Cotton Hybrid and Asiatic Cotton Cultivar

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Soil compaction is one of the major physical constraints restricting the growth of cotton and ultimately reduces seed cotton yield. This soil physical constraint

can be overcome by sub-soiling. With this hypothesis in mind, field experiments were conducted with a fixed layout, to study the effect of sub-soiling on cotton root growth and crop productivity of a transgenic BGII cotton hybrid *vis-a-vis* an Asiatic cotton cultivar. Pot experiments were also conducted to study the effect of soil strength on the root growth. Pot studies indicated that root growth was better with bulk density less than 1.5 g cm^{-3}. As the density increased root growth was poor because impedance was greater. Interestingly, the indigenous *desi* cotton (*Gossypium arboreum* L.) cultivar showed a decline beyond 1.7 g cm^{-3}. There was less contraction of the pores (xylem and phloem vessels) in the roots of the sub-soiled treatments than the control as evident from the SEM images. Under field conditions, as compared to the non sub-soiled treatment (control), sub-soiling reduced penetration resistance by 22 to 36%. Seed cotton yield of the deep sub-soiled treatments was 14.3% greater than the control for the BGII hybrid, but had no positive influence in the case of the *desi* cotton cultivar.

Keywords: Asiatic cotton, Bulk density, Compaction, *Gossypium hirsutum*, Penetration resistance, Semi-arid, Vertisols

Potential of Millets to Achieve Sustainable Development Goals

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The sustainable development goals or Global Goals are a collection of 17 interlinked global goals designed to be a "shared blueprint for peace and

prosperity for people and the planet, now and into the future". The SDGs were set up in 2015 by the United Nations General Assembly and are intended to be achieved by 2030.

In order to attain sustainable and food secure world for all, producing more and nutritious food for a growing population without overburdening land resources is a massive global challenge. Millets – often called "Nutri-Cereals" due to their high nutritional value – are a group of small-seeded grasses grown mainly in dry zones of Asia and Africa. These include sorghum (or great millet), pearl millet, finger millet, proso millet, foxtail millet, teff, grain amaranths *etc*. More than 90 million people in Africa and Asia depend on millets in their diet. Africa accounts for more than 55 per cent of global production, followed by Asia with nearly 40 percent, while Europe represents around three per cent of the world market. Although the global millet consumption has declined at a rate of 9 per cent, the millet market forecast for 2022-27 shows promising trends. India dominates the global production at 41 per cent, whereas the consumption has been receding over the years. On the other hand, Africa has become the largest consumer of millets at 40 per cent.

Being C4 crops, millets have higher efficiency in absorbing and utilizing carbon dioxide. Most varieties of millets are well known for their hardiness and have the capacity to withstand prolonged periods of drought, high temperatures and still produce grains and fodder. Growing millet has many advantages: Being rainfed crops with minimal use of fertilizers; no pesticide as they are less vulnerable to insect attack; seeds of millet can be stored for years making them advantageous in drought-prone areas. Presence of these inherent qualities, millets have the potential to help achieve the sustainable development goals (SDGs)—mainly SDG 2 (Zero Hunger), SDG3 (Good Health and Well-being), SDG 12 (Sustainable Consumption and Production), SDG 13 (Climate Action) and SDG 17(Global partnership).

Key words: Millets, Productivity, Sustainable development goals, Food security

Cytokinin Seed Priming- Molecular Mechanisms and Crop Sustainability in Wheat under Terminal Heat Stress

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Plants have evolved various molecular mechanisms to combat abiotic stresses. Terminal heat stress in wheat has become a recurrent and important issue in the face of climate change. Multifunctional plant hormone cytokinin plays important role in growth, development, reproduction and high temperature tolerance. After seed priming of a popular wheat cultivar HD2967, its molecular basis and stress memory under high temperature stress was analyzed in a transgenerational study. The results document that cytokinin seed priming can be utilized as an alternative strategy to ameliorate adverse effects of high temperature in wheat production, towards sustainable crop productivity under changing climate scenario.

Keywords: Cytokinin, wheat, high temperature, climate change, priming

Technology Innovation for Sustainable Natural Resources Management: Food and Nutrition Security

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India shares 2.4% land resources, and 4.0% water resources but is supporting >18% human and >12% cattle populations and>50% buffalo population globally. The poor resource use efficiency in India is a very serious concern, especially in the context of the increasing population and consequently the demand for various Agri and allied commodities. To remain long-term sustainable, the available resources, need to be used efficiently. Technological innovations are playing a vital role in achieving high resource use efficiency. Since independence, the food grains, vegetables, and fruits, milk, egg, fish production have increased 6.2, 13.3, 12.4, 67.8, and 17.8 times respectively, while the net sown area has increased only 1.1 times. This clearly shows the significance of technology in enhancing farm productivity. The path-breaking research in these areas by NARS lead to many fold increase in food production. Before independence poor research and development in Indian agriculture were the reasons for frequent famines, starvation, and hunger which had engulfed millions of people to death. But the overall increase in production should be environmentally friendly, the over-exploitation of natural resources will certainly lead to disaster. Innovations in technological fronts are consistently required to ensure the sustainable use of resources. The worrisome trend of declining factor productivity, increasing multi-nutrient deficiency, huge nutrient gaps, erosion of biodiversity, and increasing pollution of land, water, and air quality due mainly faulty practices need to be reversed. The unawareness of technological advancement and continuously following the

age practice are the main reasons for the degradation of natural resources, lower crop/fa5rm productivity, and increasing food and nutritional insecurity. Practice like shifting cultivation, poor irrigation network, and low level of technology adoption is the reason for many of the problems. The holistic approach to farm production is the need of the hour, in this regard, the integrated farming system, suitable crop diversification with high-value crops, bio intensification, and precision resource management strategies are profoundly required. The majority of farmers (>85%) are small and marginal in our country, hence for small holding the suitable technological options in terms of integrated framing system, crop diversification, precision resource management, post-harvest management, value addition, along with improved plant and animals are dire need to ensure efficient sustainable use of resources and for food and nutritional security.

Keywords: Technology Innovation, Natural resources management, Food and nutrition security

Accelerating Fodder Production through Integrated Systems Approach towards Fodder Plus India

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Livestock resources play a crucial role in providing livelihood support to rural mass and imparting resilience to Indian economy, as proved during the present crisis of Covid-19 pandemic. Poor productivity of Indian livestock is mainly due to non-availability of quality feed and fodder resources. At present,

the country faces a net deficit (demand vs supply) of around 31% green fodder (851 vs 590 Mt) and 12% dry forages (531 vs 468 Mt), resulting in shortage of nutrient supply in terms of crude protein and energy. In changing climatic scenario, forages become the most important life pillar for sustaining the soil-plant-animal-human continuum. Hefty competition of food crops with fodder crops for cultivated area, uncontrolled grazing, climate change, cultivation of low yielding varieties, disrupted seed chain and fodder cultivation on marginal lands are the major causes for the fodder deficit. Integrated farming system (IFS) for round the year fodder production, inclusion of fodder crops in the prevalent cropping systems, cultivation in problem soils, exploring new niches and promoting dual purpose fodder crops (fodder-grain) would be viable options to increase fodder availability in the country. Rejuvenation of degraded grazing lands, adoption of horti-silvipasture systems and resource conservation technologies contribute significantly in ecosystem restoration and enhanced fodder production. Mechanization of fodder production, post-harvest operations and adoption of fodder conservation technologies *viz*., ensiling, bailing, total mixed ration, feed pellets, densification and value addition of crop residues will lead to sustainable production and ensure availability during lean period. Utilization of available gene bank diversity led to the development and release of more than 350 varieties of 20 fodder crops for cultivation under different agro-climatic situations. To accelerate forage breeding, crop wild relatives and novel genetic resources coupled with emerging next generation technologies available in genotyping and phenotyping should be harnessed for improving biomass and nutritional quality. By developing a comprehensive and integrated systems approach, it may be possible to bring in greater resilience in farming systems, intensification and diversification of fodder production through management of biodiversity and ecosystem services.

Key words: Fodder production, Yield, Integrated farming system

Achieving Fodder Security to Livestock through Innovative Climate Resilient Technologies in Semi-Arid Regions of India

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In the current decade food security is being pursued at policy and intervention level through appropriate mechanism. But, feed and fodder security to huge livestock has still is questionable. Livestock is fast growing sector, however its productivity is dependent on availability of adequate and good quality feed and fodder. According to IGFRI Vision 2050, at the current level of growth in forage resources, there will be 18.4% deficit in green fodder and 13.2% deficit in dry fodder in the year 2050. The availability of green fodder will be more difficult under changing climatic conditions prevailing in the country in terms of floods, drought, cyclones *etc*. will lead to livestock rearing will further become costlier.

The forage-based production systems can be better adapted to climate change through diversification by including perennial grasses, legumes and trees, integrating livestock (integrated farming system, IFS approach), and changing the timing and locations of farm operations. Innovative and climate resilient approaches will go long way in tapping the available potential to increase fodder and feed supplies to wealth of huge livestock population. The food-fodder based systems in rainfed areas can sustain 3-4 animals of small and marginal farmers from one hectare land and provides at least 35-45% of food grain for family use. There is need to reduce the cost of livestock management particularly on feed and fodder, which can be achieved through integration of crop and livestock on IFS model basis. Such models are being promoted by

ICAR-IGFRI Jhansi at farmer's field having advantage of assured fodder supplementation to livestock and raising their income by 2.5 to 3.0 times and adequate employment generation. Economic fodder models with perennials grasses and legume bushes along with seasonal fodder/grain component with inbuilt soil and water conservation measures need to be promoted at district and block level. This can be done with the help of designated implementing agencies like state line departments, NGOs, SHGs, milk unions, dairy federations and through various government schemes. The untapped area requires immediate attention towards proper utilization of unutilized lands, pasture/gochar lands, gaushalas and riverside areas for growing of fodder. New niches like farm bunds, irrigational channels and integration of forages in old orchards can provide round the year fodder in different agro-ecologies. The non-conventional fodder resources like spineless cactus, azolla and lathyrus in rice fallows or in marginal soils have much potential to combat dry spells and fodder supplementation during lean period. Thus, it is imperative that feed and fodder security can be achieved through focused R&D on production, conservation and utilization of forages supported with policy on protection and promotion of sustainable fodder growing practices in existing farming systems and new niches across the regions.

Keywords: Livestock, Non-conventional fodder resources, Fodder yield, Climate change

Tank Silt Hybridization: Sustaining Agriculture Production under Very Shallow Soil

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Tank silt referred as eroded soil deposited in the tanks and lakes of the villages and in delta areas. It is mainly applied to improve soil and moisture conservation, enhancement of water holding capacity as well as increase the soil aeration, porosity and nutrient status of the soil for a good crop growth. The use of tank silt as manures, the tank silt application in agricultural lands is a traditional activity done by the villagers to benefit the crops. These activities have been stopped by the farmers because of the changes in cropping pattern, application of fertilizers and manures. Over the years, the non-removal of silt annually has resulted in heavy siltation. The storage capacity of the tanks is getting reduced at an accelerated rate leading to a continuous decline in irrigable area. Further, the reducing storage capacity causes problems in water distribution among the farmers leading to several conflicts. Tanks thus serve as a good trap for eroded soil generating large quantities of accumulated sediment. Invariably tank sediments have higher nutritive value over their respective cultivated catchment soil. Tank sediments can be used preferably in the fields of respective catchment to build up their productivity. Addition of tank sediments to cultivated fields improves the physicochemical properties of the soil which results in good crop growth and higher yields. Tank silt invariably is available free of cost to the farmers, except the cost for its transport. Soil hybridization with tank silt @1500-2000 m^3/ha improve the two to threefold soil quality, productivity and land value of very shallow soil. The tank silt hybridization hastens the process weathering of saprallite and

enhances the speed of soil formation. It is a good practice to recycle of essential nutrients (B:C ratio fertilizer equivalent is 1: 79) in soil. The benefit cost ratio in term of market value was varied from 1.8 to 3.3. This indicated that the tank silt desilted from water tanks and hybridized in agriculture field appears to be an economical viable option for returning the essential nutrients in soil, increased storage capacity of tank and recharge of ground water.

Keywords: Tank Silt, Hybridization, Physicochemical properties, Production, Shallow soil

Climate Crisis and Food Security: Can Science, Technology and Innovation (STI) alone Build Agriculture Resilient to Climate Change?

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Food security ensures all people, at all times, physical, economic and social access to safe, sufficient, and nutritious food that meets their daily dietary requirement for an active and healthy life. Climate change is the result of indiscriminate land use, unsustainable energy consumption and production, and unendurable life styles and is affecting every pillar of food security. It has posed a serious threat to our natural resources. While agriculture serves as both source and sinks for GHG emissions, it is important to look at the other causes of the climate change. The cause and effect relationship must be addressed to reduce the impact of climate change on food security. The global food policy report 2022 by the IFPRI has warned that 'climate change may push many Indians towards hunger by 2030 due to a decline in agricultural production and disruption in the food supply chain'.

The challenges to food security include biotic and abiotic stresses, improving crop and livestock productivity, soil health assessment, precise agriculture, post harvest losses, lack of nutritious food, weather forecasting, and lack of financial mechanisms to ensure income etc. Science, technology and innovation (STI) to climate resilient agri-food systems include climate smart crops, adaptive crop breeding and management, crop diversification, AI, big data, IoT, and robotics applications, early warning systems, and convergence of new and emerging technologies etc. However, one should not ignore several indigenous sustainable solutions that have a transition towards a climate resilient agri-food system. The government of India's policy decision and action taken to reduce the emission in phased manner is also important to reduce climate change impacts on food security. At the country level, understanding the gaps and barriers that prevent the inclusion of technologies and innovations within climate-resilient agri-food systems is equally important too. The net zero emission target announced by many countries including India seems to be an ambitious one. Though it is bit late but it will serve the humanity if sincerely implemented and the planet earth can still successfully feed more than 10 billion people.

Keywords: Food security, Technology and innovation, Climate change

Climate Resilient Agriculture and Food Security in Eastern India

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Climate change effects start to be recognized as threats to food system sustainability and food security which compromises food system functionality

by contributing mainly to water scarcity and pest exacerbation. Climate resilient agriculture has the potential to contribute to food security by enhancing farmers, and other stakeholders, capacity for foreseeing and adapting to possible changes. While agriculture produces food, it also produces greenhouse gases (GHGs) about 17% nationally, methane emissions from rice fields and livestock, nitrous oxide from fertilizers use, carbon dioxide from crop residue burning, ploughing and tilling land releases soil carbon, excessive use of agro-chemicals kill soil biota, depleted soil fertility reduces soil capacity to capture carbon. To combat the situation one national initiative was undertaken to launch a network project which focuses on how the farmers can be helped with existing technologies on farmers' fields enhancing the resilience and also to develop improved technologies through short- and long-term research. The project incorporates the current best practices for climate resilience established in 251 vulnerable districts, while also reinforcing the need for infrastructure development at important research institutes with adequate scientific manpower for monitoring climatic change scenarios across field conditions. Few successful cases having impact were out-scaled in different areas of eastern India which are as: Land shaping and land embankment cultivation; tank cum well system; sand bag check dam; rain-water harvesting structures; stress tolerant varieties; ridge and furrow method; multi-tier horticulture; crop diversification; seed bank; fodder bank; weather station; custom hiring centres *etc*. All these efforts have contributed to the goal of optimal resource use and the promotion of sustainable agriculture practices for achieving food security.

Keywords: Climate change, Resilient, Technology, Food security

Study on Soil Nutrient Status according to Global Positioning System in Different Blocks of Birbhum District, West Bengal

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A global positioning system (GPS) based soil sampling and testing was done in 10 blocks of Birbhum district under monitoring of Rathindra Krishi Vigyan Kendra, Birbhum during 2018 and 2019. In this regard, some soil chemical attributes were analyzed through Mridaparikshak in the laboratory of KVK and after statistical analysis pooled data were compared based on GPS to record a data base for east fertilizer recommendation of different crops without soil testing. As a result of soil analysis, it was found that soil pH (6.29 to 5.50), soil organic carbon (0.77 to 0.31%), available potassium (292.12 to 226.60 kg/ha), available boron (0.81 to 0.17 mg/kg) and available iron (44.4 to 21.5 mg/kg) had been decreased with the increase in latitude from 23°04' 07.4500 " to 24°11' 15.3400" and longitude whereas available nitrogen(184.00 to 296.95 kg/ha), available phosphorus (15.05 to 62.76 kg/ha), available sulphur (11.43 to 44.52 kg/ha) and available zinc (0.20 to 1.04 mg/kg) showed sharp direct relation with the increase in Latitude. According to the CV value, difference between values of these attributes was experimented.

Keywords: Global positioning system, Soil nutrients, Fertilizer recommendations, Nitrogen, Phosphorus, Potassium

Plant Growth Promoting Effect of Multi Heavy Metal Tolerant Endophytic Fungal Isolates on Maize Crop

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Endophytic fungi are ubiquitous in the nature, which causes asymptomatic infection on living plant tissues and attacks other fungal pathogens. Endophytic fungal species has been found to be resistant to heavy metals toxicity and have potential role in phytoremediation besides additional advantage of plant growth promotion. To determine the toxicity nature or/and plant growth promoting effect of multi heavy metal tolerant endophytic fungal isolates, pot study were carried out using maize seeds. Further, to what extent endophytic fungal strain influences the host plant growth in the presence and absence of heavy metals (Pb, Cr, Cd, Hg) were compared. Fungal isolates, Eczi-1 (*Curvularia buchloes*), EAca-1 (Fusarium sp.), ECgi-2 (*Fusarium fuikroi*), and ECto-4 (*Fusarium falciforme*) were used for this study based on their higher tolerance index value. The inoculation effect of endophytic fungal isolates on maize plant growth (root and shoot length) was examined after 30 days of cultivation. Further to what extent endophytic fungal strains influences the host plant growth (root + shoot) and dry biomass weight were compared with control group**.** The inoculation experiment revealed that the presence of selected fungal isolates had no pathogenic effect on maize seeds or even in its presence promotes the plant growth. Surprisingly in this preliminary study, the root and shoot length was significantly increased in all inoculated and

heavy metal spiked pots of maize. Moreover, significant differences were observed when compared to control pot.

Keywords: Endophytic fungi, Plant growth promotion, Heavy metal tolarence, Maize crop

Yield and Economics of Brinjal *(Solanum melongena)* as Affected by Different Mulching Types and its Effect on Soil Moisture Content and Weed Dynamics in Post Flood Situation of Coastal Odisha

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A field experiment was conducted at the farmer's field at Ratanpur village of Marshaghai block of Kendrapara, Odisha to evaluate effect of different mulching practices on weed population, moisture content in soil and yield of brinjal. The village is an adopted village by Krishi Vigyan Kendra Kendrapara, in which various activities in agriculture are going on under National Innovations on Climate Resilient Agriculture (NICRA) programme to combat the flood-affected area of the locality. The experiment consists of five mulching treatments like Black polythene mulch, Black and silver polythene mulch, Transparent mulch, Organic mulch (rice straw) and No mulch. Results revealed

that black with silver colour polythene mulch was recorded with significantly higher yield per plant (2.59 kg) and yield per ha (62.1 t/ha) which was at par with black colour polythene mulch. Organic mulch was found to be next best treatment with respect to yield per plant (2.40 kg) and yield per ha (53.5 t/ha). The same treatment also resulted in the higher gross return (Rs. 434700/ha), net return (Rs. 274150/ha) and B:C ratio (2.71) which was followed by black polythene mulching and organic mulching practices. Weed suppression and moisture retention was higher with black polythene mulch.

Keywords: Poly mulch, Organic mulch, Brinjal, Yield, Weed population, Coastal Odisha

Biochar Application for Acid Soil Improvement in Western Ghats Region, India

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Biochar is a carbonaceous material produced from biomasses by the thermal pyrolysis process with limited oxygen to use in agriculture. Biochar is characterized with many favourable properties to improve the soil qualities. It has high pH, surface area and porosity which are the supreme properties of biochar to improve the soil qualities especially the acid soil. Quality and characteristics of biochar are dependent on types of feedstocks, pyrolysis temperature and retention time. Combination of feedstocks, pyrolysis temperature and retention time gives biochars of various qualities. Acid soils are poor quality soils and crop production is constrained due to inferior quality of soil. Acidity is the major issue that deters crop growth and yield.

Neutralization is essential for acid soil with some basic materials and the routine materials are lime and dolomite. Use of biochar is the recent development to neutralize acid soil with the basis that biochar produced with high pyrolysis temperature become alkaline material. The alkalinity is depending up on types of feedstocks, pyrolysis temperature and retention time. The biochar which gains high alkalinity are used to correct the acidity. The soils of western ghats are extremely acidic that needs a strong alkaline material. Among biochars produced from various feedstocks, poultry-manure-biochar has the potential to neutralize severely acidic soil of western ghats and improve the soil quality to get highest yield equivalent to dolomite and lime. It improved the crop stand, growth and yield parameters. Soil physical, chemical and biological qualities have improved to favourable condition to support crop yield.

Keywords: Biochar; Acid soil neutralization; Severely acidic soil; Crop growth and yield

Advanced Techniques for In-Situ Ammonia Measurements for Nitrogen Management in Agriculture

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The advanced in-situ ammonia measurement methods are the aerodynamic gradient (AG), the eddy covariance (EC), and the inverse modelling (IM) methods. The aerodynamic gradient method with wet denuders and conductivity analysis with gaseous separation on a semi-permeable membrane

is still the reference method for measuring NH_3 fluxes. Recently, the conditional time averaged gradient (COTAG) method has been developed based on time integration of the AG method conditioned by thermal stability, to allow longer term and low cost monitoring of NH_3 fluxes, but these may not be well adapted yet for very unstable conditions. The eddy covariance (EC) technique has been recently available for NH_3 with the development of highly sensitive and fast Quantum Cascade Laser (QCL) devices. Inverse dispersion methods are also increasingly used to evaluate NH_3 losses following slurry application using either Lagrangian Stochastic models or Gaussian models or both. These methods are very well adapted for geometrically well-defined and isolated sources, and have been demonstrated as being valid when compared to reference methods in the case of high fluxes. The DELTA (DEnuder for Long-Term Atmospheric sampling) system is a low-cost diffusion denuder system that was originally developed for long-term sampling of ammonia and ammonium, and which has also been tested for long-term sampling of acid gases (HNO_3, HONO, HCl, SO_2) and aerosols (NO_3^-, NO_2^-, Cl^-, SO_4^{2-}). The system is based around the concept of a single bore glass denuder for sampling trace gases. When a laminar air stream passes through the denuder coated on the inside with an acid coating such as citric acid, ammonia is captured by the acid walls (to be later extracted in the laboratory), while aerosols pass through and can be collected by aerosol filters placed downstream of the denuder. Conversely, an alkaline coating (*e.g.* K_2CO_3) on the denuders will collect acid gases such as HNO_3, HONO, SO_2 and HCl. The separation of aerosol from gaseous components is achieved due to the much more rapid diffusion of gaseous species to the tube wall compared with that of particles.

Keywords: Aerodynamic gradient, Eddy covariance, Quantum Cascade Laser

Current Status of Pearl Millet Diseases and its Management Approaches

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Pearl millet is one of the most widely grown millet in India, extensively cultivated in arid and semi-arid regions after rice, wheat and sorghum. India is the largest producer of pearl millet in the world, Rajasthan state being the largest producer of pearl millet in India. The crop is best suited for areas with low soil fertility, drought, high temperature, low pH or high salinity. Pearl millet plays an imperative role in the food and energy security to the rural people especially in the rainfed areas.It is affected by a number of diseases caused by fungus, bacteria, virus, oomycetes and nematodes, among which few are economically very important, namely downy mildew, blast, rust, ergot and smut. Among various constraints, downy mildew disease is considered as one of the major problems. The severity of rust disease has also amplified due to changing climate. The use of host plant resistance is the most suitable approach in managing these diseases under ruthless climatic conditions and by resource-poor farmers of India. Due to commercialization of new hybrids in the past two decades in India, the status of downy mildew infestation has changed, resulting in new virulent strains. In the meantime, severe outbreaks of Magnaporthe blast disease have been reported in pearl millet growing states of India during the past five years. Rust disease, which was reported limited to post rainy sowings, has turned out to be severe in rainy and summer crops. These findings indicate the need to recognize novel sources of resistance to be employed in the pearl millet breeding program. Management practices

aim at reducing the disease impact on the crop and prevent crop loss. In this process, the main objective is to reduce the primary inoculum source and subsequently to prevent the secondary spread. This can be achieved by using disease resistant cultivars which is most economical and practical to farmers. Continuously monitoring in the shift in virulence of pathogen and breakdown of resistance in the released hybrids in the farmers' fields is critically important to keep track of development of new virulent pathotypes of pathogen in order to identify the sources of resistance and incorporate them in new parental lines of hybrids. In addition, cultural practices and chemical control can also be adopted by the farmers wherever it is feasible. Integrated approach for disease management includes using host resistance, chemicals and bioagents. Identified and formulated several environmentally safe fungicides, bioagents, and plant growth promoting rhizobacteria, by many researchers for the management of major diseases of pearl millet. An interface between pathologists and breeders would assist develop disease resistant and durable hybrids and varieties in pearl millet to prevent losses caused by major disease-causing organisms.

Keywords: Pearl millet, Diseases, Management approaches, Food and energy security

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III

ABSTRACTS OF ORAL PRESENTATION

A. Natural Resource Management

Enhancing Adaptive Capacity and Developing Resilience against Climate Change by the Small and Marginal Farmers of *Laterite* Zone of West Bengal

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Resilience, adaptive capacity, and vulnerability are the three basic concepts to explain how human and natural systems respond to perturbations of environmental shocks. So to enhance the adaptive capacity and developing resilience against climate change by the small and marginal farmers, two districts of West Bengal namely, Purulia and Bankura that are prone to recurrent droughts, were selected for study. Erratic rainfall with long dry spells, in between, is a barrier to sustainable livelihoods for the small and marginal farming communities In these two districts, The community experiences drought as a major recurring disaster in their livelihood. In addition to that, the rising of winter temperature and increasing variability of rainfall due to climate change, agriculture sector faces many challenges. Hence, to increase the resilience of small and marginal farmers against the climate change, and climate shocks 2021the present study was undertaken in collaboration with the Development Research Communication and Services Centre (DRCSC) with fund support from the National Bank of Agriculture and Rural Development (NABARD) during 2016-2021- The extensive plantation on

barren pediment, mixed cropping practices, winter cropping, organic farming and multi-level cropping system with integrated approach were found to be effective in enhancing adaptive capacity. Seed bank and fodder bank were installed at selected villages and soil and water conservation measures were undertaken, using step ponds, semi circular bunds, check dams, gully plugs and infiltration ditches in the selected villages on alternative generation of livelihood with encouraging results.

Keywords: Climate change, DRCSC, NABARD, Drought, Livelihood, Soil and water conservation, check dam, ditch, gully plug.

Nutrient Status of Cherry Orchard Soils in Ganderbal District of Central Kashmir

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To study the "Nutrient status of cherry orchard soils in Ganderbal District of Central Kashmir" soil samples were collected from 10 cherry orchards at different locations. The soil samples collected were taken from three depths viz. 0-30, 30-60 and 60-90 cm, respectivel and analysed for various physico-chemical parameters, available nutrients, biological parameters and correlation between available soil nutrients and physico-chemical properties were worked out. The study revealed that soils were silt loam to clay loam in texture. The soils were slightly acidic to slightly alkaline with normal electrical conductivity. Organic carbon content was medium to high. Bulk density, particle density and porosity varied from 1.23 to 1.43 Mg m-3, 2.30 to 2.46 Mg m-3 and 40.0 to 47.0 per cent respectively. The available nitrogen was medium with a range of 274.3 to 415.9 kg/ha. The available phosphorus and potassium were medium to high with a range of 17.0 to 31.7 and 154.0 to

347.5 kg/ha respectively. The soils revealed a high content of available calcium and magnesium and varied from 2025 to 2275 and 224 to 286 ppm respectively. The available sulphur content showed an erratic trend down the profile and was found in the range of 9.77 to 12.27 ppm. The DTPA- extractable zinc, copper, iron and manganese ranged from 0.98 to 2.57, 0.77 to 1.80, 14.84 to 50.21 and 16.48 to 37.86 ppm respectively. The micronutrients revealed a decreasing trend with increase in depth. The bacteria, fungi and actinomycetes were found in the range of 5.3 to 7.5 × 106 cfu/g soil, 4.1 to 5.6 ×105 cfu/g soil and 1.3 to 2.6 104 cfu/g soil respectively. The correlation studies revealed that the pH showed negative and significant correlation with available nitrogen, phosphorus, sulphur, DTPA-extractable zinc, copper, iron, manganese while as it showed positive significant correlation with available calcium and magnesium. The soil organic carbon showed positive significant correlation with available nitrogen, phosphorus, sulphur, DTPA-extractable zinc, copper, iron and manganese while as negative non-significant correlation with available calcium and magnesium. The electrical conductivity exhibited non-significant and negative relationship with available nitrogen, phosphorus, potassium, sulphur, DTPA-extractable zinc, copper, iron and manganese however it revealed a significant and positive correlation with available calcium and magnesium in the cherry orchard soils of Ganderbal under investigation. It can be concluded that programmes can be very useful for farmers in assessing the need of fertilizers as to when and what quantity is to be applied for improving the yield of their orchards.

Keywords: Cherry, Ganderbal, Nutrients, Soil, Correlation

Soil Quality Indices of Different Land Uses in a Lesser Himalayan Region of Kashmir

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In Lesser Himalayas which is one of the three distinct landform units of the Indian Himalayan region, soil quality degradation is the major concern for sustainable agriculture, forests, maintaining eco-friendly environment and livelihood for the people. Different land uses have variable impacts on soil quality due to changes brought about in soil's biological, chemical and physical properties. In this study multiple approaches for quality assessment of soils under forests and pastures, as well as horticultural and agricultural use were employed. The physical, chemical and biochemical attributes of soils were evaluated for development of four types of indices viz., Unscreened additive index(SQI-un), Principal component Analysis based index (SQI-pca), Regression equation based index (SQI-reg) and Conceptual framework model based index (SQI-con)using linear scoring function(LSF) and non-linear scoring function (NLSF). The unscreened additive indices SQI-un.1 (using LSF) and SQI-un.2 (using NLSF) revealed the following order for quality of different soils: forest(0.99, 0.99) >apple(0.76, 0.71) > vegetable(0.73, 0.69) > maize(0.71, 0.67) >rice(0.68, 0.64). The mean un-SQI.1 and un-SQI.2 for native ecosystem(forest) and cropland ecosystem were 0.99, 0.99 and 0.70 and 0.66, respectively. The PCA based soil quality indices SQI-pca.1 and SQI-pca.2 were also found to be maximum for forest soil (0.99. 0.99) followed by apple orchard soils (0.76, 0.69), vegetable soil (0.70. 0.64), maize soil (0.70, 0.64) and least in paddy soil (0.69, 0.64).Regression based soil quality indices (SQI-reg.1 and SQI-reg.2) presented a slightly different ranking of soil quality among different land uses than other methods. SQI-reg.1 and

SQI-reg.2 were found in the order: forest soil (1.00, 1.00) followed by almost equal values for vegetable soil (0.62, 0.57) and apple orchard soil (0.62, 0.55) and further decreased in the order of maize (0.57, 0.51) and paddy (0.53, 0.48).

The conceptual framework model based quality indices developed through linear scoring LSF (SQI-con.1) for paddy, maize, vegetable, apple and forest soil were recorded as 0.58, 0.60, 0.68, 0.73 and 1.00, respectively. The same model based quality indices developed through non-linear scoring (SQI-con.2) for paddy, maize, vegetable, apple, and forest soil were estimated as 0.56, 0.57, 0.67, 0.68, and 1.00, respectively. Thus the SQI-con displayed the same soil quality ranking among land uses as SQI-pca and SQI-un. This indicates that conceptual model based on potential indicators and assigning weights accordingly, was also effective and suitable for detecting the differences between soils under various land use types/ecosystems. From the results of the study it can be inferred that forest soils in the region are maintaining the highest soil quality and they are functioning at 99 to 100% of their potential capacity, whereas paddy soils with the lowest SQI scores are functioning at 48 to 68% of their potential capacity.

Keywords: Soil Quality index, indicators, land use, Kashmir soil

Evaluation of Customized Micronutrient Fertilizers to Enhance Cotton and Soil Nutrient Status

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Among the agricultural commodity, cotton consumes 8.5% of NPK fertilizers. However, the amendments of micronutrient fertilizers are not a common practice under rainfed vertisols, and their deficiencies hamper cotton productivity. A field experiment was conducted in Bt-cotton hybrid (Rasi-659 BGII) with a customized micronutrient fertilizer combination of Mg, Zn, Fe, Cu, B, and Mo (Rashtriya Chemicals & Fertilizers) with 12 treatments including soil application (50,100,150-kg ha^{-1}), 1% foliar spray (one and two time) and combinations of both using randomized block design with three replications. There found to be a non-significant difference among the treatments in the bolls per plant, though one time foliar spray at 60 DAS recorded maximum bolls and seed cotton yield compared with control. Combined application of micronutrient fertilizer (soil + foliar) on 40, 60 DAS significantly enhanced the boll weight compared with other treatments. One time foliar spray of micronutrient fertilizer on 60 DAS had higher seed cotton yield (3027±156 kg ha^{-1}) among the treatments, which was 78 kg higher than the recommended dose of fertilizers. From our study, it was found that the combined application of micronutrient fertilizer (50 kg ha^{-1} as basal dose + two foliar spray @ 1.0% i.e. 40 and 60 DAS) can enhance soil and plant micronutrient status and cotton productivity.

Keywords: Bt-hybrids, Fibre quality, Leaf reddening, Rainfed Cotton, Soil fertility, Vertisols

BHOOMI Geoportal - A Robust Digital Platform for Sustainable Management of Land Resources

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The core objective of this paper is to discuss the design and development of BHOOMI Geoportal digital platform, its architecture, services, and potential applications in sustainable management of land resources. BHOOMI Geoportal (ver 2.0) was designed and developed by using *open source GeoServer* platform that allows to host various Web Map Services (WMS) and tabular data from a variety of formats. The spatial data on physiography, agro-ecological regions, agro-ecological sub-regions, soils, soil fertility, land degradation, satellite data-based indices and land use planning were processed and deployed on BHOOMI Geoportal platform. The "Interoperable Platform" of BHOOMI Geoportal was developed to visualize geospatial information from other Geoportals on BHOOMI Geoportal. The upscaled BHOOMI Geoportal interoperability platform enable the users to integrate the land and allied resources on a single platform. BHOOMI Geoportal platform enable the users to visualize various cross-domain applications in land resource management, land degradation assessment and land use planning.

Keywords: BHOOMI Geoportal, Web Map Services, Geoportal applications

Land Use/Land Cover Changes Detection of Built-Up Land in Yadgir District, Karnataka, India-using Geospatial Technology

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Mapping and monitoring of land use/land cover (LU/LC) changes in the Yadgir district is vital for sustainable development, planning and management. Based on Geographic Information System (GIS) and Remote Sensing (RS) techniques, the WORK HAS BEEN attempted to monitor the changes in LU/LC patterns of Yadgir district for the periods 2000, 2005, 2011, 2015 and 2020. Study has been carried out through images from Landsat, Thematic Mapper (TM) from 2000 to 2020. The LU/LC classification maps were prepared through remote sensing and GIS technology. The results were indicates that there was a significant increasing trend in built-up land. LU/LC in the study area was found changes over the past two decades. Three major built-up classes viz; Industrial area / Mining / Quarry, Built-Up Rural and Built-Up Urban land have been identified in the study area. The overall results were shows that the built-up land was observed to be increased 0.05% (761.9 hectare) in 2005, 0.10% (1312.7 hectare) in 2011, and found be decreased 0.01% (1376.2 hectare) in 2015, and 0.04% (1636.0 hectare) in 2020. The analysed and findings of these studies may highlights the important policy implications for the sustainable LU/LC management in the Yadgir district

Keywords: Built-up land, LU/LC changes detection, RS and GIS softwar, Yadgir District

B. Crop Production, Crop Improvement and Crop Protection

A Preliminary Checklist of Moths from Akrani Tahsil (Dist.-Nandurbar), Maharashtra, India

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Nandurbar is an administrative district in the northwest corner (Khandesh Region) of Maharashtra state in India, Dhadgaon is a village in Nandurbar district of Maharashtra, India.It falls under Akrani Taluka.Moths are an integral part of most of the ecosystem. They are also monitored to indicate climatic changes and environmental degradation. They were collected and studied from Nandurbar district of Maharashtra from June 2019 to to January 2022. The present taxonomic study resulted in the collection and identification of 90 species of 78 genus, 14 families. Of these,Bombycidae (01 genus, species 01), Crambidae (17 genus, species 17), Erebidae (genus 21, species 23), Eupterotidae (genus 01, species 02), Euteliidae (genus 02,species 02), Geometridae (genus 08, species 11), Hyblaeidae (genus 01, species 01), Limacodidae (genus 02,species 02), Noctuidae (genus 11, species 13), Notodonidae (genus 03,species 04), Nolidae (genus 01,species 01), Saturniidae (genus 02,species 02), Sphingidae (genus 07, species 10), Uraniidae (01 genus, 01 species). This is preliminary study and an attempt has been made to study document the moth fauna from Akrani tehsil (Nandurbar District) Maharashtra (India).

Keywords: Moths, heterocera, species, taxonomic, North Maharashtra, Nandurbar, Akrani

Arthrobotrys spp. Nematophagus Fungus Linked relationship between Fungi and Nematodes: A Review

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Nematophagous fungi *Arthrobotrys spp.* is a predacious fungus of nematodes very useful in understanding the relationship between fungi and nematode. *Arthrobotrys spp.* is the most common nematode-trapping fungus with the characteristic ability of forming adhesive trapping nets once in contact with nematodes. The versatility and development of *Arthrobotrys spp.* as a system to identification of the ecology and biology of nematode-trapping fungi. Nematophagous fungi have been made through the discovery of special traits and virulence determinants involved in the pathogenic process in nematode. *Arthrobotrys spp.* play a model system in biological control research.

Keywords: *Arthrobotrys spp.,* nematophagous, fungi and biocontrol

Biocontrol of Alternaria Leaf Spot of Gerbera by using Parthenium Extract

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Gerbera (Gerbera jamesonii) is an important ornamental plant known for production of cut flowers. In gerbera massive losses occur due to diseases affecting gerbera growth and development. Among all the diseases, fungal

diseases have been found to cause enormous losses. There is need for proper management and reduction of fungal pathogens infecting gerbera plant. The causative agents of diseases were isolated and identified by using morphological and molecular charactoristics. Molecular characterization involved isolating DNA from fungal isolate, PCR amplification of ITS region. Invitro antifungal activity of parthenium extract against Alternaria was carried out by using PDA cultures. The biocontrol potential of Parthenium was evaluated against Alternaria. The Parthenium extracts showed significant antifungal activity against isolated strain of fungal pathogens. Experimental result indicated that lower dilution of extracts, the antifungal activity was maximum.

Keywords: Gerbera, Fungal pathogens, Isolation and identification, Antifungal, plant extracts

Bio-efficacy of Egg Parasitoid Trichogrammatoidea Bactrae Nagaraja against Pink Bollworm on Cotton

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Introduction of transgenic Bt cotton for commercial cultivation in India during 2002 clearly appeared to be beneficial in making India as second largest cotton growing country with an area of 115.53 lakh hectares and production of 375 lakh bales of cotton lint with an average productivity of 552 kg/ha. Upto 2006, Bt cottons grown in India were of BG- I expressing cry 1Ac toxin only. Later BG-II cotton expressing Cry1Ac+Cry2Ab toxins were introduced. Since, 2010 onwards BG-II genotypes only are grown in India. The productivity of cotton in India is low as compared to the productivity of 676 kg/ha in world

and owing to many factors. With the cultivation of transgenic Bt cotton, it was excepted to ensure favorable ecological, economical and sociological benefits apart from the drastic reduction in pesticide usage. A great deal of bollworm suppression has been evident due to Bt toxins. However quite recently the survival pink bollworm Pectinophora gossypiella Saunders has been a issue for cotton production as well as Bt technology itself in India. Initial reports of survival have been noticed from Gujarath state since 2008 itself. Dennehy et al (2003) have indicated field failure of first generation Bt cotton for PBW resistance in India. Further the resistance in PBW has been reported from selected localities of India for Cry 1Ac toxin (Dhurua and Gujar.,2011). Since 2015 the problem of PBW survival is sever in Gujarath, Telangana, Maharashtra and parts Karnataka where in BG –II cottons were sown extensively. Hence it was essential to develop target specific management practices for pink bollworms in Bt cottons. Bio-control tools would be ideal over insecticides as IRM tools. Egg parasitoid Trichogramma spp have been better choice against many lepidopteran pests. The potentiality of Trichogrammatoidea bactrae as egg parasitoid was subjected for field evaluation during 2016-17 at ARS, Dharwad using Jadoo a popular BG-II Bt hybrid. Continuous three release of T. bactrae @ 2.5 lakh/ha betwen 50 to 90 DAS could supress the PBW incidence as indiacted by significanlty low rosetted flowering (5.4%), green boll damage (8.2%) due egg mortality.This fact lead to lower number of PBW larvae(3.5/50 bolls) and least locule damage (5.95%). T. bactrae release was also tried with two and one time releases at same dosage. By bio-efficacy and yield advantage T. bactrae twice or thrice remained on par statistically, however highest of seed cotton (10.77q/ha) was recorded from three releases. Chemical control treatment appeared to be superior to egg parasitoid efficacy anyway. Considering advantage over untreated control (no release) efficacy of T. bactrae was quite appreciable and suggested its inclusion in IPM strategies conveniently. Though T. bactrae has been considered as potential bio-agent of PBW long back in Australia and US (Hutchinson et al., 1990) the real applications are warranted in India now.

Keywords: Cotton, Pink bollworm, Parasitoid, Biocontrol

Biology of Asia Giant Honeybee, *Apis Dorsata* Fabricius (Hymenoptera: Apidae)

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The honeybee, *Apis dorsata* is well distributed across southern Asia comprising both in plains and hilly regions of up to 1600 m. Worker bees of these species are about 17 to 20 mm long. The queens are usually darker in colour in contrast to the workers, which are usually yellow in colour. *A.dorsata* builds single large sized vertical arboreal nests on suitable natural and manmade structures. They tend to nest high in the air, usually from 3 to 60 m above the ground. Congregation of *A. dorsata* colonies is quite common and the number varies from 50 to 200 on a tree or rock where the bee forage sources are quite abundant. Its combs are 1 to 2 m long and 0.5 to 1.0 m height. Similarly, the thickness of the comb cells was varied and the size of the worker, drone and honeycomb cells was found to be 3.3 cm, 3.7 cm and 19 cm respectively. The colonies of *A. dorsata* perform short periodic mass flights of up to six times in a day. They respond to disturbance by its enemies with a characteristic defence body twist, while the thorax rotates, the head lowered and the abdomen and wings are thrust upwards.

Keywords: *Apis dorsata*, nesting biology, colony congregation, periodic mass flights

Diversity of Pteromalidae (Hymenopter: Chalcidoidea) Parasitoid with Some New Records from Odisha and Re-description of Two Poorly Described Species

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The Pteromalidae family is one of the important groups of insect parasitoid of various insect pests of agriculture, horticulture and forestry. They are parasitic at larval, pupal and adult stages of various insect pests. The diversity study of Odisha was conducted, and eighteen species have been reported and out of them seven species (*Systasis parvula, Halticoptera circulus, Asaphes vulgaris, Trichomalus perfectus, Mokerzakia manzeli, Asaphes suspensus* and *Halticoptera shimlica*) were recorded first time from Odisha. Additionally, re-description of poorly described species *Cephaleta austrliensis* (Howard) and *Cephaleta brunniventris* Motschulsky have been done with addition of new characters and illustration of colored picture plates.

Keywords: Pteromalidae, *Cephaleta brunniventris, Cephaleta austrliensis*, *Hibiscus,* Coccids, Cerococcids

Effect of Incorporation of Sprouted Soybean for the Preparation of Ready-to-Eat (RATE) Snack Food

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The composite flour was taken in the ratio of Finger millet: Foxtail millet: Peral Millet: Barnyard millet :: 40:30:20:10 respectively. The sprouted soy percentage was varied (5%, 10%,15% and 20%) in composite millet flour to prepare optimally soy fortified composite minor millet flour based snack foods.The puffed product from composite millet flour based sprouted soy fortified RTE food was developed by preparing strip type cold extrudate and puffing it using microwave techniques. The incorporation of sprouted soybean upto 20 % db in composite millet flour was useful for preparation of RTE snack foods.

Keywords: Millet flour, sprouted soybean, extrusion, microwave puffing, RTE snack

Effect of Pesticide Poisoning on Mortality of *Apis Dorsata* Colonies in Bengaluru, India

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The colonies of *Apis dorsata* are characterized by construction of single large sized combs that is usually attached to a tree branch, rocks and ceilings of buildings etc, protecting from direct sunrays and rainfall. The distribution of *A. dorsata* colonies is quite common in urban regions and builds nests on suitable habitats such as multi-storeyed buildings, high-rise apartments, towers, and school and college buildings during winter. We recorded thousands of *A. dorsata* colonies in Bengaluru from October to April every year due to availability of huge amounts of pollen and nectar. However, these nests are most frequently exposed to pesticide poisoning due to their frequent disturbance to general public. The impact of pesticides on mortality of *A. dorsata* colonies during removal of colonies from public nest-sites was studied. It was observed that, the pest control agencies used highly poisonous insecticides belonging to different chemical groups. However, Lindane and Melathion were used in large scale compared to Sevin. The percent colonies killed by application of Lindane, Melathion and Selvin were 45, 39 and 16% respectively. These pesticides poisoning is responsible for morality of thousands of *A. dorsata* colonies from July to April in Bengaluru, India.

Keywords: *Apis dorsata,* pesticide poisoning, bee mortality, urban regions

Ethanol Industry : Agro-based Article of Green Chemistry for Sustainable Auto Fuel and Global Warming Mitigation

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As prerequisites of the thermodynamic equilibrium of earth and healthy civilization, by normalizing global warming, conventional chemistry has to be transcended into green chemistry. It is a branch of chemistry necessitated by environmental sciences to produce environment-friendly and health-friendly chemicals and redesign prevailing chemical processes and products, hazardous chemical reactants and environmental pollution; and sustainable raw materials and not exhaustible like : Enriched Uranium.

Green chemistry is to be studied in deeper cognizance in the context of 'Food Security Vs Fuel Security'. Key issues are :- transition of exhaustible petrol, diesel, LPG, CNG to biofuels like ethanol, biodiesel, biogas, biomass; transition of synthetic chemical fertilizers to natural organic manures; existing refrigerants to ozone-friendly chemicals; carcinogenic petrochemicals like benzene to human health-friendly chemicals from natural resources; control of wastages of natural resources and waste-to-wealth; unfortunate change into artificial lifestyle to bring back to natural lifestyle, etc. Many natural chemicals contribute to build up Future Green Chemistry in which predominant one is ethyl alcohol / ethanol wherefrom many green chemicals emanate in which an important outlet is Auto Fuel. It is a green chemical versatile in mainly energy, automobile, higher chemicals, medical, solvents and other sectors in which we shall confine its use here as sustainable auto Fuel. In

World and Indian Ethanol Scenarios; large benefits are as auto fuel in the context of interfaces between Energy : Environment : Economics : Education : Water (E4W); comparison between India and Brazil; production technologies of Modern Distillery / Ethanol Plant; waste to wealth; ethanol in diesel : diesenol; biofuel policies; role of ethanol in environmental protection; and finally, sustainability of ethanol industry. To meet rising needs of ethanol, the existing molasses quantity is not enough. Hence, advanced 2nd generation technology of Biomass to Ethanol has emerged worldwide to produce alcohol abundantly to cater to numerous applications of ethanol including as Auto Fuel.

GOI have formulated 'National Biofuels Policy-2018' for threefold advantages: 1) To reduce import of crude oil 2) To reduce environmental pollution at least partially caused by transport sector; 3) To increase farmers' income to make agriculture viable. Hence, GOI have come out with various strategic schemes to accelerate ethanol production for huge requirement to admix in petrol in gradually increasing proportion. Therefore, ethanol being a prominent article of Green Chemistry, is playing pivotal role in various walks of Indian Economics especially in Agricultural Sector and in Global Warming Mitigation.

Keywords: Environment sciences, Green chemistry, Green energy, Green technology, Green Initiatives, Ethanol, Ethyl Alcohol, Power Alcohol, Gasohol, OPEC, CDM , Climate Change, Global Warming, Renewable Energy, 'National Biofuels Policy-2018'

Potential Kairomone Molecules from Sweet Potato (*Ipomoea batatas*) Vines for Managing Sweet Potato Weevil (*Cylas formicarius*)

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The volatile chemistry of the sweet potato, *Ipomea batatus* (L.) was studied over the host-finding behaviour of sweet potato weevil (*Cylas formicarius* Fabricius). In this study, both the dried vines and fresh vines of the host plant were employed for the extraction of volatile organic compounds; separately in soxhlation-based solvent extraction *via* rotary evaporation method, and fresh vines were employed for the cold extraction *via* lyophilization. Both the techniques were employed by using solvents of different polarity as, hexane, acetone, methanol and double-distilled water. Comparatively, the significant attraction was observed high in the acetone fraction through olfactory response studies. Purification of the acetone crude extract obtained from all the three aforesaid sources was achieved through automated silica-gel column chromatography (ACC) by employing solvents in an ascending grade of polarity (hexane> diethyl ether >dichloro methane > acetone > ethanol > methanol> dd. water). The crude, as well as purified fractions from ACC, were tested in the laboratory and field for the olfactory response of the weevil. Analysis of the acetone fractions using gas chromatography-mass spectroscopy- electro antennogram (GC-MS-EAG) revealed that the extract contains 8 different chemical species that show significant stimulus in the

antennae of *C. formicarius*. The study observes three female sex pheromone mimics and five compounds, 3,4-Hexanediol, 2,5-dimethyl; (S)-4-Amino-2-benzyl butanoic acid; 9-Acetoxy nonanal; 5-t-Butyl-6-methyl-hept-3-ene-2,5-diol and 6-Acetyl-beta-d-mannose interestingly exhibitssex-neutral attraction in *C. formicarius*. Field studies confirm fractions containing these will work as potential kairomones. From the current study, no compounds were observed with a female-specific response.

Keywords: Semiochemicals, sweet potato kairomone, biocontrol measure, Sex-neutral kairomone, electro antennogram study.

Assessment of Devastating Fungal Pathogens causing Fruit Drops in Nagpur Mandarin (*Citrus reticulata)* - A Serious Threat to Damaged Farmer's Orchards

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Mandarins occupy largest area and provide more than 43 per cent production among all citrus fruits grown in India. The commercial cultivars being grown in different regions are 'Nagpur' mandarin (*Santra*) in Maharashtra and Central India; The 'Nagpur' mandarin established itself well in Central India and its producing centres are Vidarbha region of Maharashtra and other states comprising Madhya Pradesh (Agar Malwa, Rajgarh, Shajapur, Chhindwara, Mandsaur) and Rajasthan (Jhalawar and Bhilwara districts). Citrus decline is associated with a combined effects of abiotic and biotic factors. The loss comes in a series of waves varying in the different citrus fruits in length of time between them. In citrus, the shedding of flowers and fruits comes more

or less in three distinct waves known which are also known as post-bloom drop, June drop and pre-harvest drop. Pathological fruit drop usually starts during August and continues till harvest with its peak in mid-September to mid-October. The drop in the months of September-October is the most detrimental, as the fruits are near maturity and have drawn nourishment from the tree. Pathological fruit drop is caused by different plant pathogens, most common of these are observed terrible pathogens *Colletotrichum gloeosporioides* 17.3%, *Diplodia natalensis* 2.5% and *Alternaria citri* (3.7%) and new pathogen (22.4%) was also observed in 2022 and serious quality damaged in experimental farm but not in farmers field and this pathogen is under identification.

Keywords: Fungal pathogens, Nagpur mandarin, Fruit

C. Forestry and Agroforestry

Classification of NTFPs, Their Role in Livelihood and as a Potential Component for Achieving REDD+ Strategy in Jharkhand

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Cooperation and involvement of the tribals, other forest dwelling people and the society as a whole, is crucial for the implementation of the REDD+ strategy. REDD+ activities will help in sustainable livelihood of local communities and also in conservation of biodiversity. NTFPs play an important role in the livelihood support of tribal and forest dwellers in terms of subsistence and income generation which they have been using since time immemorial. The study identifies factors which determine people dependence upon NTFPs. From these factors policy implication can be derived for the main causes of exploitation of NTFPs to provide suggestion for developing strategies for REDD+. These NTFPs can be grouped into Edible products, Fodder trees and shrubs, Bamboo, Gums, Resins, Medicinal plants and Tendu leaves. They get employment in activities related to NTFPs like plucking of Tendu leaves (*Diospyros* sps.), rearing of Silk- *(Antheraea mylitta* Drury), cultivation of Lac- *(Kerria lacca* Kerr), Bamboo etc. Non-timber forest products are also integrated components of the forestry sector and have been gaining recognition as potential resources for promoting sustainable livelihoods and conservation. The present paper throws light on these NTFPs, their classification, their uses, their role as a source of livelihood and traditional knowledge related to them and a strategy for their conservation so that these can act a major component of REDD+ strategy.

Keywords: Jharkhand, Livelihood, NTFP, REDD+, Traditional Knowledge

Forest Fire: A Burning Issue in the Uttarakhand Himalaya

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Widespread forest fires are a major concern worldwide. The Himalayan forests are not spared from these periodic events of forest fire. Around 63% of the area of Uttarakhand state in India is susceptible to forest fire. These instances of forest fire in this region are mostly caused due to human negligence and are usually intentional. The development of a proper policy for forest fire management in India is extremely crucial to prevent any further degradation of the forests especially in the Himalayas which is home to a rich variety of flora and fauna.

Keywords: Forest Fire, Uttarakhand, Management and Control

Sustainable Utilization of Biodiversity vis-à-vis Development of Environmentally Friendly Technology

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India is habitat to a rich biodiversity carrying immense wealth of wood and non wood forest products namely food, fibre, essential oil, dyes, drugs and

gums which have enormous medicinal, aromatic and industrial significance.

The natural dyes were prepared using forest based raw materials available in plenty. Aerial parts of the selected species were taken for dye extraction experiments. The natural colour producing extracts with several optimizations were prepared and investigated for their coloring properties on fabrics and wool, using a variety of eco-friendly mordants. Moreover, natural mordants were also used for developing a variety of dye shades when applied on fabric and wool. Dyes were applied to the fabric as well as wool and then color fastness properties were determined. Research findings established the approach for sustainable use of biodiversity and development of value added products from forest repository. This has always been conducive to the growth and prosperity of flora and fauna.

Present research addresses the need for developing environmentally friendly methods of dye extraction which leads to the development of technology for the process of manufacturing dye by using abundantly available natural raw materials.

Keywords: Biodiversity, Eco-friendly, Technology, Dye, Manufacturing

D. Women Empowerment

Roles of Ornamentals in compliance to the Sustainable Goals and Women Empowerment

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Floriculture is a subdiscipline under Horticultural sciences basically deals with the ornamental crops which are categorized under the perishable commodities but was subdued by the other subdisciplines albeit since last few decades the global floriculture growth rates are really neck paining. Key reasons of the less exploration of this sector are the cost implications during production (pre-harvest phase), maintenance (post-harvest) and marketability (high selling price basically confined the ornamentals' market within the affluent societies). In this backdrop, the main aim of floriculturists, zeroing in on its massive promotions, are to make its production and after use utilization Economically (E), Socially (S) and Ecologically (E) Sustainable. To attain these 3 bottom lines of sustainability, modernization in production strategies which will involve the minimum usages of natural resources; change of thinking pattern of social beings, so that they become environmentally educated; development by tailored breeding approaches and usage of environment perfect crops; and ethical and efficient utilization of post-harvest ornamentals focusing towards the generation of employment opportunities are needed. To exemplify, the 'Smart' and 'Organic' farming systems could be emphasized as these can satisfy the 3 aspects of sustainability. These cause the high productivity, augmented profit ratio, environment-friendliness and improvement in quality of life of the employees. Furthermore, Value-addition

is another cardinal sector which meets all the fundamental principles of sustainability. For example, the production of Dehydrated Floral Products and Natural Colorants using colorful ornamental plant parts. These 2 cited examples are few of the booming industries in pan world because in both cases, fresh as well as wasted ornamental plant parts could be utilized, the employment opportunities especially for the women groups could be ventured, support and momentum to several pro-environmental strides could be provided and the entrepreneurial perspectives could be nurtured also. The potential of ornamentals has also been unveiled in the field of 'Green' *alias* 'Sustainable chemistry'. Since, the role of different nanoparticles (NPs) [eg. silver, gold, zinc etc.] to protract the vase-life of cut blooms and the environmentally unfriendly chemical synthesis of them are known; hence, the employment of broad-array of tropical ornamental blooms (eg. ornamental zinger, marigold etc.) for Green Synthesis of NPs could add an additional magnitude to the ornamentals. Thus, ornamental crops beyond the role of a décor pieces can epitomize its multitudinous applications in adherence with the sustainable principles and fostering of economy. Comprehensively, they can unequivocally contribute towards the basic principles of sustainability, the formation of a gender-neutral society, the offering of better livelihood opportunities and the objectives of several government flagship programs like PMKVY, NSDC and Green India.

Keywords: Ornamental(s), Sustainability, Environment, Value-addition, Biocolor, Employment, Entrepreneurship

E. Medicinal Plants

An Ethno-Medicinal Survey of Plants Used in Rheumatoid Arthritis Treatment Practiced By Traditional Healers of Surgana Tehsil, Nashik (MS)

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Arthritis is one of the leading causes of disability among millions of people in India. Rheumatoid arthritis is a chronic inflammatory disease of the joints characterized by a specific plan of destruction for bones and joints. Ethnomedicine is a term that is frequently used interchangeably with folk medicines. Rheumatoid arthritis is a long-term autoimmune condition that affects more than one's joints. The illness can harm a variety of body organs in certain patients, including the skin, eyes, lungs, heart, and blood vessels. Arthritis, generally inflammation of joints is one of the oldest known diseases occurring almost in all age groups. In India, more than about 20% of total population is suffering from arthritis. Many arthritic patients may not have reported to be arthritic as they may not have detected their problem of arthritis due to illiteracy, poverty and unaffordability for medical check-ups. The use of alternative therapies, such as medicinal herbs, is on the rise because of many side effects and toxicities associated with the synthetic drugs. Herbal medications for the treatment of rheumatism arthritis are an alternate and efficient means of treating chronic illnesses with few or no health risks. The present paper reveals about different plants species belonging to different families being utilized in rheumatoid arthritis. The aim of this study is to provide the knowledge about plants used in rheumatoid arthritis treatment by

local people reside in Surgana region. Available data suggests that the extracts of most of these herbs or compounds derived from them may provide a safe and effective adjunctive therapeutic approach for the treatment of arthritis. This study shows a high degree of ethnobotanical novelty in traditional folk medicine among the aboriginal people. Further pharmacological studies of these plants may provide some important drugs for the treating common rheumatoid arthritis disorders.

Keywords: Ethnomedicine, Folk medicine, Rheumatism arthritis

Medicinal Plants: Importance and Scope in Human Life

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Medicinal plants are rich in secondary metabolites and/or potential sources of drugs. These secondary metabolites include *alkaloids, glycosides, coumarins, flavonoids, steroids* etc. These plants form the main base for the manufacture of drugs of Indian Systems of Medicine (Ayurveda, Unani, Siddha) and Homeopathy. These plants are found in various parts of the country in different environmental and climatic conditions.

In ours country, almost all the known medicinal plants can be cultivated in one or the other part of the country. Among the various plants the great demand in the country and abroad are Safedmusli, Kalmegh, Satawar, Sarpagandha, Stevia, Ashwagandha, Bach, Giloe, Opium poppy, tropane alkaloid bearing plants, Senna, Psyllium husk and seeds, Cinchona and Ipecac. ISM is predominantly a plant-based *Materia Medica* making use of most of our native plants. It caters to almost the entire rural population of our country

mainly because of the scarcity of modern allopathic health care in our villages. ISM offers most appropriate or first line therapy against many diseases like jaundice, bronchial asthma, rheumatoid arthritis, diabetes etc. for which allopathic medicines have as yet no cure. India has more than 2,500 species of medicinal plants. Most of the allopathic medicines produce many morbid side- effects and a vast- geographical area with high production potential and varied agro-climatic conditions. Most of these plants can subsist under stress conditions and are thus suited even for rainfed agriculture. Cultivation of medicinal plants offers considerable scope for rural employment and export for foreign exchange earnings. It is for this reason that more and more people in the western societies are showing increasing interest and preference for organic drugs and their preparations.

Medicinal plants are regarded as indispensable therapeutic agents for the prevention of diseases in almost all parts of the globe and more so in developing nation like India. Increasing demand of herbal medicine in the country reflects a sustained history of standardization that has completely changed the tradition of native medicine industry. India, has more than 80% of world's biodiversity, including plant genetic diversity with medicinal properties, holds tremendous scopel in occupying a prime position in the global market for medicinal plants based herbal formulations, medicines and products. Our country is perhaps the largest producer of medicinal herbs and is rightly called the "Botanical Garden of World". There are very few medicinal herbs of commercial importance which are not found in our country. In the recent years, the growing demand for herbal product has led to quantum jump in volume of plant materials traded within and across the countries. As per the estimation, the international market for herbal products is anticipated to acquire a market worth of US $5 trillion by the end of year 2050. The global production of medicinal plants which acquired a worth of 1150 million USD in the year 2000 is anticipated to acquire a worth of 5 trillion USD mark by the end of the year 2050. Near about 80% of the contribution to the global supply of medicinal plants will be handled by India and China alone

Keywords: Medicinal plants, Human life, Human diseases

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IV

ABSTRACTS OF POSTER PRESENTATION

A. Natural Resource Management

A-01: Climate Smart Agriculture shaped Soil Microbial Communities for Sustainable Agricultural Production in Changing Climate Scenario

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Due to spikes in the level of CO_2 in the atmosphere from natural and/or man-made causes, It is predicted that drastic changes in the global climate will take place during the 21st century. Particular climates are ideally required for growing different agricultural crops. In current scenario, climate-smart agriculture (CSA) would be better approach to reduce the negative impact of climate change on the agricultural soil. Additionally, climate smart agriculture improve the overall soil health by increasing soil microbial communities. The study proposes Omics technologies to unveil the significance of these unseen microbial communities and their application in climate-smart agriculture.

Keywords: Soil microbial communities, Carbon sequestration, Soil fertility, Agricultural outputs

A-02: Effect of Rhizobium Bio Fertilizer Treatment on the Production of High Pod Yield in Pigeon Pea (*Cajanus cajan* (L.) Millsp.) in Deola Tahsil of Nahik District (Maharashtra)

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In India, Pigeon Pea (*Cajanus cajan* (L.) Millsp.) is one of the most popular pulses, being an important source of protein in a mostly vegetarian diet. It is the primary taken with rice or roti. In regions where it grows, fresh young pods are eaten raw or as a vegetable in dishes such as sambar. In present research paper it is found that, when seeds are treated (Seed dressing) with Rhizobium bio fertilizer before sowing increases pod yield by 20 to 25 percent (Shafie and Shikha 2003).

Keywords: Pigeon Pea, Rhizobium, Seed dressing

A-03: Effect of Seed Polymerization with Micronutrients to Enhance the Growth and Seed Yield of Bio Fortified Pearl Millet Genotypes [*Pennisetum Glaucum* (L.)]

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The field experiment was carried out in the Department of Seed Science and Technology, UAS, Dharwad during *Kharif* 2018-19. The experiment was laid

out in a factorial randomized block design with thirteen biofortified genotypes and twelve treatments including control with four replications. The results revealed that seeds treated with combined application of 5ml polymer per kg seed along with micronutrients namely, $ZnSO_4$+ $FeSO_4$ + Boron + each at 2 g per kg of seed was recorded higher the seed yield and better quality in pearlmillet. The higher seed yield of 24.65 per cent over control recorded due to seed polymerized with $ZnSO_4$ + $FeSO_4$ + boron each @ 2g per kg. The increased seed yield mainly attributed higher panicle length, panicle girth, panicle weight, number of productive tillers per plant, test weight and seed yield (23.26 cm, 2.90 cm, 0.568 g, 2.51, 13.43 g, 2520 kg/ha respectively) as compared to control, followed by $ZnSO_4$ + $FeSO_4$ + boron each @ 4 g per kg of seed (22.79 cm, 2.86 cm, 0.546 g, 2.41, 12.87 g, 2393 kg/ha respectively) and seed polymerized with $ZnSO_4$ + $FeSO_4$ each @ 2g per kg of seed (21.90 cm, 2.77 cm, 0.523 g, 2.31, 12.54 g, 2345 kg/ha, respectively). Micronutrient application through seed treatment improves the stand establishment, advances phenological events, increases yield and micronutrient contents in grain in most of the crops. Seed polymerization (5ml/kg of seed) of pearlmillet seeds coupled with micronutrients viz., $ZnSO_4$ + $FeSO_4$ + Boron each at 2 g per kg of seed found to be better treatment to record higher growth and seed yield parameters in pearlmillet.

Keywords: Seed yield, Micronutrient, Seed polymerization

A-04: Effect of Trace Elements on Mycelial Growth and Sporulation of *Alternaria alternata* (Fr.) Keissler causing Black Heart of Pomegranate

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Fruit rot of Pomegranate (*Punica granatum* L.) caused by *Alternaria alternata* is one of most serious post harvest disease in throughout India. Rotted pomegranates were collected from various localities of Maharashtra. A total fifteen isolates of *Alternaria alternata* were isolated from rotted Pomegranate. Their sensitivity was tested against carbendazim. MIC of all these isolates was obtained ranges from (834.6 ìg/ml -1123.8 ìg/ml). The isolate *Aa*13 was sensitive (834.6 ìg/ml) while isolate *Aa*15 was resistant (1123.8 ìg/ml). Total of seven trace elements were used for the growth of *A. alternata*. There was significant variation in the growth of the both sensitive and resistant mutant in various trace elements. However, the growth was also higher in case of resistant strain when compared with sensitive isolate. Interestingly no trace element enhanced the growth of both the strains over control. Copper sulphate (146 mg/50ml) and Cobalt sulphate(158mg/ml) were highly inhibitory. Ferrous sulphate gave higher sporulation in sensitive(542mg/ml) and resistant strain (582mg/ml) while moderate sporulation in Magnesium sulphate (382mg/ml), Maganese sulphate (322mg/ml) and Sodium sulphate (376 mg/ml) and without trace elements serve as control.

Keywords: *Alternaria alternata*, carbendazim, trace elements, pomegranate

A-05: Exotic Facilitates Exotic Species: Association between Invasive Earthworms and Invasive Plants and their Effects on Native Flora and Fauna

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The composition, structure, and function of ecosystems around the world are being altered by invasive species. Invasive species causes dramatic reductions in indigenous species variety and, may be extinction because of rapid spreading as well as by out-competing native species. Introduced belowground species have effects as powerful as posed by introduced aboveground species is less visible because to observe quickly. Among, several invasive belowground species, earthworm invasion has become a global problem. Once introduced, invasive species quickly spread across the soil ecosystem, where habitat destruction, deforestation, and increased cultivation provide the necessary conditions for invasion. The study concluded diversity of indigenous species is severely harmed by invasive earthworms and may lead to extinctions.

Keywords: Biological invasion, Exotic earthworms, Ecosystem engineers, Invasive species

A-06: Geophysical Technology for Pedology

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Lithosphere-Regolith, pedosphere pedology Soil mapping,uphole Seismic survey, ground penetrating radar, aquifer mapping, earth Critical zone rhizosphere,solum soil horizon, Agriculture Geophysics- soil and water agro meteorology, climate change,soil carbon sequestration,etc are integral part of soil science. Geophysical methods play a pivotal role in agricultural geophysics-Ground Probing Radar(GPR), Vertical Electrical Sounding (VES), magnetometry, self-potential, seismic, Magnetic Resonance Sounding & nuclear magnetic resonance, induced polarization (IP), seismoelectric, Resistivity and Electromagnetic Induction EMI, etc., are employed for soil investigation. GPR is a fast technique for investigating the near surface with a high spatial resolution. It is used for pedology which can be deduced as e.g. moisture or clay content of soils which are important factors for solving hydrological or agricultural problems. Near Surface Geophysics research delve deep into hydrogeophysics, geological, hydrogeological, geotechnical, environmental, agricultural geophysics, etc. By employing GPR pedology forensics soil investigation task is completed. Soil horizons differ in their properties, both phys¬ical and chemical. The physical properties include electrical properties, and the change in electrical conductivity and permittivity of soil is the basis of the GPR method. apparent soil electrical conductivity (EC) measured using resistivity and electromagnetic induction imaging(EMI), Electromagnetic conductivity imaging (EMCI) of soil methods, is significantly influenced by temperature and moisture conditions. Moisture conditions also govern the soil relative permittivity (or dielectric content); there by influencing GPR measurement. Geophysical techniques currently used in agricultural research include electrical resistivity (ER), time domain reflectometry (TDR),

ground-penetrating radar (GPR), Estimation of soil properties from spectral induced polarizationIP tomography:Estimates of soil properties such as Cation Exchange Capacity (CEC), water content, grain size characteristics, and permeability are important in geotechnical engineering, water resources, and agriculture, capacitance probes (CPs), radar scatterometry or active microwaves (AM), passive microwaves (PM), neutron thermalization, nuclear magnetic resonance (NMR), gamma ray attenuation, and near-surface seismic reflection. Optical Fiber Sensor remote sensing volatile organic compounds (VOC) VOC compounds are detected by special detectors, such as flame ionization detectors (FID), photo-ionization detectors (PID), and direct sampling ion trap mass spectrometers (DELCD). Membrane Interface Probe system (MIP) Thermal Desorption Sampler (TDS) is specifically used for the insitu characterization of vadose zone soils. Soil sampling tools Soil gas samples are typically used to detect elevated concentrations of VOCs in soil gases which provides information about vadose-zone contaminants and the distribution and concentration of VOC in soils and groundwater. Use of Nuclear Techniques for Determination of Soil Properties, Gamma Ray SoilSensor, Neutron Back-Scattering Method, Proximal Soil Sensing (PSS) and high resolution digital soil mapping, Fiber optic soil water content sensor for precision farming, heated distributed temperature sensor (HDTS) and sensors based on Fiber Bragg Gratings (FBG) or Long Period Gratings (LPG) etc.Geomatics engineering, remote sensing, remote sensing imagery image processing, In SAR, LIDAR/LADAR, GPS, hyperspectral imaging, Partial Differential Equations for image processing Remote Sensing Image, Geophysical Methods for Soil Structure tecture Characterization, etc.Integration of the Global Positioning System (GPS) and Geographic Information Systems (GIS) to Agricultural Geophysics is very efficient for statistical analysis of agriculture economics. Salinity affected soil coastal zone salt intrusion detection- Geophysical methods such as EM, magnetic and radiometric survey are employed in salinity studies. EM survey is the most used method to map the three-dimensional variation in the soil (bulk) resistivity

(conductivity), caused by changes in mineralogy, intensity of alteration, water content or salinity. Land Degradation Extractive Industry Minerals Mining, Agricultural carbon storage /geoengineering-Agricultural practices can make a significant contribution to carbon storage, etc. Seismology and soil-Uphole seismic survey:,Uphole/Downhole Seismic Survey For Near Surface Geophysics Weathered Layer Soil Thickness The importance of the weathering layer and sub-weathering layer velocities and thickness of the weathering layer in static and normal move out corrections. Prediction of seismic and volcanic activities by changes in the concentration of radon in soil and groundwater, high concentrations of helium in soil must be attributed to a deep source, such as petroleum or geothermal reservoir or to a highly concentrated uranium deposit..Detection of Soil Pipes Using Refraction Seismics- P and S wave seismic refraction information to identify soil pipes. Geotechnical engineering landslides problem, Seismic microzonation seismic or earthquake prone area into zones with respect to some geological and geophysical characteristics of the sites such as ground shaking, liquefaction susceptibility, landslide and rock fall hazard, earthquake-related flooding, so that seismic hazards at different locations within the area can correctly be identified. Microzonation provides the basis for site-specific risk analysis, which can assist in the mitigation of earthquake damage. In most general terms, seismic microzonation is the process of estimating the response of soil layers under earthquake excitations and thus the variation of earthquake characteristics on the ground surface. Spectral Analysis of Surface Waves – SASW, multichannel analysis of surface waves (MASW) used to create a new soil classification map. Soil Tectonics, pedochronology ("soil dating"), as a technique in paleoseismology,

Keywords: Geophysical technology, Regolith, Pedology

A-07: Increasing Farmers' Income by using of Technology Bunch Cover in Banana in Cooch Behar District of West Bengal

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Banana is a profitable crop of Cooch Behar district due to having high demand throughout the season. The price of banana also fetches high round the year but the major problem of banana cultivation is development of scars on fruit skin by insect named banana scarring beetle; as a result, the fruit fetch less market price. Generally, period of infestation of this insect is government by hot humid weather which is typical characteristics of this district. Here rainfall coupled with hot humid condition start from the month of April and continues up to September. In order to mitigate this problem of banana scarring beetle nearly 0.9 ha of banana field was taken under National Innovation of Climate Resilient Agriculture Project in the village khagribari. and Singhimari. The banana branches immediately after emergence were covered with non-woven polypropylene skirt bag. Covering the bunches with polypropylene cover reduced about 4-5nosof insecticide spray for controlling scar beetle which is abridged the environmental pollution and increased fruit quality. Fruits under bunch cover showed very less to nil infestation of insects, than without any bunch cover. Moreover, the cover itself protected the banana fruits from outside dust, bird droppings, spider net etc. As a result, bunches under cover produced good quality fruit having shiny surface and free from any scar and dust particle and fetched higher market price by Rs 35-50 per bunch as compared to bunches without any cover. Considering the economics produce under bunch cover

yielded produce of 4.62 lac/ha with BCR 2.65 as compared to produce without cover to the tune of Rs. 2.92 lac/ha with BCR 1.95

Keywords: Banana, Bunch cover, Scarring beetle

A-08: Mangrove Forests: A Mature-based Solution for Climate Change Mitigation and Adaptation

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Mangroves are a nature-based solution to climate change holding immense potential for climate mitigation and adaption. Their immense carbon sequestration potential qualifies them as one of the most robust and reliable carbon sinks. Mangrove restoration projects have multiple benefits like community development, marine conservation etc. They are halophytic plants acting as a transient line between ocean and land. Mangroves forest are generally found along shoreline, tidal creeks, and backwaters. Mangrove forests are unique, and their trees have stilt submerged roots acting as nursery to biodiversity. They are the ecosystems providing important supplies and services to coastal communities and marine biodiversity. Mangrove conservation is the need of the hour and efforts must be made to save of Mangrove Forest. Awareness of mangroves protection among common people may aid in the process of formulating proper conservation and afforestation strategies along diverse shoreline environment.

Keywords: Mangroves restoration, Carbon sink, Carbon sequestration, Mitigation, Adaptation

A-09: Preliminary Studies on Water Quality Assessment of Pedda Cheruvu, Manakondur, Karimnagar District, Telangana State, India

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The present study is an investigation that was carried on the physico-chemical parameters of Pedda Cheruvu located at Manakondur village, Karimnagar District. The study has been carried out for a period of one year i.e., from June, 2018 to May, 2019.The Water Temperature was ranging from19.0p C to 31.0p C, Transparency was ranging from 18.50cm to 44.30cm, Total Dissolved Solids was ranging from200(mg/l) to 350(mg/l), PH ranges from 7.5 to 8.3, Dissolved Solids was ranges from5.2(mg/l) to 12.0(mg/l), Carbon di Oxide ranges from3.0(mg/l) to 9.2(mg/l),Total Hardness ranges from110(mg/l) to 210(mg/l), Total Alkalinity was ranging from 165(mg/l) to 300(mg/l), Chlorides was ranging from35.00(mg/l) to 50.20(mg/l), Phosphates was ranging from0.02(mg/l) to 0.16(mg/l), Nitrates was ranging from 0.02(mg/l) to 0.14(mg/l) and Biological Oxygen Demand from2.5(mg/l) to 7.0(mg/l) were analyzed. These parameters vary from month to month and in three different seasons. The results showed that the variation in these results parameters in four at the different sampling stations. The results indicated that physico-chemical parameters of the water were used for drinking, domestic use, irrigation and pisciculture.

Keywords: Physic-Chemical parameters, Pedda Cheruvu (Manakondur)

A-10: Production and Optimization of Cellulolytic Enzymes by *Trichoderma harzianum* MTCC 8230 under Solid State Fermentation Technique

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Seven different upstream and downstream process conditions for cellulase production by *Trichoderma harzianum* MTCC 8230 from agro-residues were optimized. The cultural conditions for maximum cellulase production varied with the substrate utilized for instance, the highest cellulase production on sugarcane bagasse was observed under optimal conditions of incubation time (8 days), initial pH (6.0), incubation temperature (36°C), moistening agent (Mandel's medium), pretreatment (1 N H_2SO_4), extraction solvent (50 mM sodium citrate buffer of pH 6.0). As the selected agricultural biomass produced significant yield of cellulase, they can be successfully utilized as feedstock for the biofuel industry.

Keywords: Agricultural biomass, Cellulases, One-factor-at-a-time approach, SSF

A-11: Study of Multiple Regression Modal between Soil Properties and Colony Forming Unit Collected from Diverse Regions of Rajasthan, India

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Soil mapping of its properties gives better understanding relevant to soil fertility, microbial diversity and environmental protection. Many studies have been performed for the bioremediation but few of them were focused on the regression modal between the soils physicochemical along with the microbial population. In the present investigation we have tried to develop simplified regression models to predict soil properties on different landscape positions from observed values. Soils samples (Normal and Petroleum Contaminated) were collected from diverse regions of Rajasthan, India. The Coefficient of Correlation was calculated between the Colony Forming Units and the physicochemical properties of soils like PH, Conductivity, Moisture content, Organic matter, Heavy metals etc. Before applying the Regression models, the dependency of several soil properties with CFU, the principal component analysis was applied. As a result, only three principal components have eigenvalues greater than 1. In regression analysis of variance, the p value is found greater than 0.05 so the regression model is significant. This approach would promote soil sampling and variable rate application of agricultural chemicals and would serve as a fast, inexpensive, and reasonably accurate method to develop a soil database for fields that have similar soil characteristics.

Keywords: Colony forming units, Regression, PCA, Correlation

A-12: Vermicomposting by Use of Different Garden Waste using *Eisenia fetida*

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The present experiment was conducted with the objectives of exploring the vermicomposting process, which involves of vermicompost using dry leaves of four different types and cow & goat manure. The vermicompost produced can be significant value to the end users like farmers for replacement of chemical fertilizers and procuring station; import of a compost earthworm (*Eisenia fetida)*; and production using such composting material locally can be made available at much lower cost. Vermicompost was done using *Eisenia fetida* with five setups T1 (cow& goat manure + mixed leaves+ kitchen waste), T2 (cow and goat manure + Banyan leaves), T3 (cow and goat manure+ lemon leaves), T4 (cow and goat manure + neem leaves), T5 (cow and goat manure + pigeon pea leaves). The population of earthworm, the production of vermicompost, and the chemical characteristics of the vermicompost were recorded after 30 or 45 days.

Keywords: Vermicomposting, Garden waste, *Eisenia fetida*

A-13:Effect of In-Situ Rice Stubble Burning on Physico Chemical and Biological Properties of Soil and Yield

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India is the second largest agro based economy with year round crop cultivation produced a large amount of agricultural waste, including crop residues. It has major environmental issues which causing health problems and also contributing to global warming which leads to ozone depletion. Also it leads to the adversely effect on the nutrient conditions of the soil. It results in the emission of smoke; if smoke is added to the gases that present in the air can cause atmospheric air pollution problems which occur from stubble burning. These gases emission can cause health problems like asthma, chronic bronchitis and decreased lung functions. On the other hand if the proper use of crop residue it is used ad dry fodder of animals, in bio thermal power plants and mushroom cultivations, bedding material for cattle, used for production of bio oil, paper production and also used for bio gas production. Incorporation of crop residues into soil has several positive influences on physical chemical and biological properties of soil.

Keywords: Rice, Stubble burning, Environment, Crop residues, Pollution

A-14:Productivity and Soil Biological Properties as Influenced by Nutrient Management through Biomanuring under Organic Cultivation of Turmeric

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The relevant research work was carried out at Certified Organic Farm, Centre of Organic Agriculture Research and Training, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2020-21 and 2021-22 using all possible combinations of available organic manures and biofertilizers in combination. The impact of nutrient management through bio-manuring on productivity and soil biological properties was studied in turmeric cultivation under organic farming. The findings of both year indicated that productivity and soil biological properties verified significantly higher with application of 100% RDN through 50% Vermicompost + 50% Neemcake + Biofertilizers than other treatments of nutrient management through bio-manuring.

Keywords: Productivity, Soil biological properties, Turmeric

A-15:A Case Study on the Circular Bioeconomy using the Potential of Pomegranate Peels (*Punica granatum*)

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Processing of fruit & vegetable generate biodegradable waste (seeds, peels, pomace) which can cause environmental pollution. However, these waste contains bioactive components (polyphenols) having antibacterial and antioxidant properties. Pomegranate peels (PP) contribute to 40–50% of the total weight of the fruit. PP, otherwise a waste, can be sustainably converted into wealth using the principle of circular bioeconomy. Polyphenols were extracted from PP using greener deep eutectic solvent and was subjected to quantification using LC-MS/MS, and further tested for antioxidant and antimicrobial activity. Residue obtained depicted the presence of total dietary fibers, thus depicting circular bioeconomy with zero waste.

Keyword: Deep eutectic solvents, Pomegranate peels, Circular bioeconomy, Dietary fibers, Bioactive components

A-16:Waste to wealth: A Green Approach to Environmental Sustainability

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Management and agricultural production systems that combine high levels of biodiversity with environmental practices that protect natural resources and have strict animal welfare standards. Compared to conventional agriculture, organic farming uses fewer pesticides, reduces soil erosion, reduces nitrate leaching into groundwater and surface water, and recycles animal waste back to the farm. Agricultural waste is waste generated from various agricultural processes. Harvesting various crops creates a large amount of residue both on and off the farm. India's current waste management system is unable to keep up with the growing waste generated by a growing urban population, posing threats to the environment and public health. Crop residues, weeds, leaves, sawdust, forest debris, and animal manure are examples of agricultural waste. These are non-industrial products and treating them may bring some benefits to mankind. If agricultural wastes are properly managed and utilized to ensure sustainability, soil health, and environmental protection, Demand for mineral fertilizers is minimized. A fundamental solution to agricultural waste management is composting. Agricultural waste contains biodegradable hemicellulose and cellulosic components, which upon decomposition provide abundant nutrients to plants. The purpose of this study is to explore how to reuse all waste generated in agriculture and other sectors, how to recycle as much crop residue, fruit and vegetable waste as possible using different adaptation strategies, and Educate farmers, students, and the common man on how to extend the life of agriculture, and sustainable management of the ecosystem. In particular, agricultural waste can be used

by farmers to produce "Fertilizers", resulting in improved field fertility. Farmers' selection of agricultural waste in the fields results in increased fertility and demand for crops, increasing income for farmers. Identify and use the natural waste from nature and understand environmental protection through effective waste management.

Keywords: Crop residue, Biodegradable, Sustainable management, Ecosystem, Waste to wealth

A-17:Microplastics Identified in Farmyard Manures from Agricultural Lands -An Emerging Threat to the Agroecosystem

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While studies on microplastics have been extensively done in aquatic and terrestrial ecosystems, their presence in organic farmyard manures which are a major element of agricultural lands remain largely unexplored. Considering the potential of organic farmyard manures to be a potential source of MPs in agricultural lands, the present study investigated the abundance of microplastics in farmyard manures prepared in farm backyards noncommercially. The results of the study reveal that these organic farmyard manures are profoundly contaminated with macro and microplastics. The Physicochemical properties of farmyard manure and farmyard water of the respective four different samples were assessed and results were found to be within the admissible limits. Interestingly, among the experimented samples, only one farmyard manure sample collected from a rural area was not

contaminated with microplastics but all other samples were found to be contaminated with microplastics. The abundance, size, shape and colour of the microplastics were identified using a trinocular microscope (Digital Research Microscope). Further, an aliquot of sample was identified using FTIR and a total of 5 different polymer types were identified from the samples. They are Polyvinyl chloride, Cellulose Acetate, Polypropylene, Polyethene tetraphthalate, and Polycarbonate. All these identified polymer types were closely related to households and farmlands as they are used to produce water bottles, food packaging, irrigation pipes, mulches in farmlands, etc. Hence, organic farmyard manure cannot be considered a fully safe option to use in agricultural lands and before applying any kind of fertilizer checking its quality may help to avoid further contamination of agricultural lands and the terrestrial ecosystem. Additionally, more studies should be done on this aspect as the farmyard manures as a potential source of microplastics to the terrestrial ecosystem.

Keywords: Microplastics, Farmyard Manure, Agricultural Ecosystem, Physiochemical Properties of Farmyard Manure

A-18: Reducing Ammonia Volatization and Denitrification Losses in Wheat Field by using Integrated Nutrient Management (INM)

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One of the most important nutrients for wheat growth and productivity is nitrogen. Nitrogen losses from the soil and plant system not only reduce soil

fertility and agricultural productivity, but they can also have significant environmental consequences. Nitrogen losses in agroecosystems are mostly caused by ammonia volatilization and denitrification. As a result, the integration of biofertilizers with inorganic fertiliser is urgently needed to improve the nutrient delivery system by incorporating the use of recommended dose fertilisers in conjunction with biofertilizer and reducing nitrogen losses. The objective of this research is to investigate the influence of INM on nitrogen losses in wheat crop and to evaluate its effect on nitrogen losses and the yield of wheat crop. Under this research eight different treatment had been taken those are Control (unfertilised, Tc), Azotobacter (Ta), Mycorrhiza (Tm), Azotobacter + Mycorrhiza (Tam), NPK Recommended (Tr), NPK Recommended + Azotobacter (Tra), NPK (Recommended) + Mycorrhiza (Trm), NPK Recommended + Azotobacter + Mycorrhiza (Tram). An upsurge in soil microbial activity was reflected in the form of soil microbial biomass carbon (MBC) and soil microbial biomass nitrogen (MBN). Tram showed MBC and MBN value 146.9 mg kg^{-1} and 45.2 mg kg^{-1} respectively. In Tram plot vigorous root growth was recorded, which helped in increasing the uptake of soil available nutrient ultimately it was reflected in higher nitrogen content in wheat straw and grain. The soil urease activity at flowering was found to be 24.4 mg urea g^{-1} soil h^{-1} for Tram, which is significantly higher compare to Tr and Tc. The cumulative emission from ammonia flux varied from 10.4 to 10.6 kg ha^{-1} and denitrification losses varied from 2.4 to 2.5 kg ha $^{-1}$ in Tram plot which is recorded minimal compare to the plot receiving Tr treatment. The yield obtained under Tram plot recorded as 6.4 t ha^{-1} which is higher as compare to plot receiving treatment Tr i.e. 5.8 t ha^{-1}. Thus INM practices proved to be reducing nitrogen losses as well as increases crop yield compare to conventional agriculture practices.

Keywords: Ammonia volatization, Denitrification, Microbial biomass carbon, Microbial biomass nitrogen

A-19:Micronutrient Management Strategies for Food and Nutrition Security

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Natural resource management includes the management of natural resources such as land, plants, animals, water and soil with the sole focus on how management affects the quality of life for both present and future generations. During the last few decades, the country has made remarkable progress in food and agricultural production particularly cereals by adopting different agricultural technologies. Food security is becoming an increasingly important global issue; while micronutrient malnutrition now afflicts over two billion peoples across the world causes health problems especially in women and children in developing countries.

The deficiencies of Zn @ 40% and Fe @ 12.6% have been reported across the soils of India. Among the different cereals, mainly rice and wheat, are inherently very low in concentration of Zn and Fe in grain, particularly when grown under Zn- and Fe stress soils. Deficiency of micronutrients in soil is affecting crop productivity, quality of food, and human nutrition. Hence, suitable management strategies are required to overcome the adverse effect on soil and plant health. The large variation in rate of micronutrient application has emanated from the sensitivity of crops to soil type and deficiency status, soil environment, sources and their residual effects, and method of application. The consistent monitoring of the soils under different crops and cropping systems acts as a useful guide in determining the frequency, rates, sources, and time of application of the micronutrients. Different sources of micronutrients *viz.,* mineral solutions, chelates and nanoparticles play a pivotal role and regulates the absorption rates and mechanisms in plants. Apart from

the quality parameters, biofortification also improved the crop yield due to alleviation of hidden hunger; thus, proving to be a sustainable and cost-effective approach. Besides agronomic strategy, microbial and physiological interventions help to mobilize micronutrients from source to sink and resulted in micronutrient- dense grain production with an increase in crop yields which helps to combat malnutrition in animals and humans.

Keywords: Micronutrients, Bio-fortification, Food and nutrition security

B. Crop Production, Crop Improvement and Crop Protection

B-01: Assessment of Anti-dengue Activity of Squalene and Arachidonic Acid for the Target NS2B-NS3 Protease through Molecular Docking Studies

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Dengue is an acute mosquito - borne viral infection that has become a major health problem worldwide in the recent years. Currently no specific antiviral therapies are available to treat dengue fever. squalene and arachidonic acid are the well-known antiviral compounds which is not yet studied for Dengue protein targets. In this study, the inhibitory activity of the squalene and arachidonic acid were tested against the DENV NS2B-NS3 protease complex through *in-silico* methods. The phytochemicals were docked in the catalytic site of the NS2B-NS3 protease complex. The results of this study provide a way through for the development of novel antiviral therapies for the treatment of dengue fever.

Keywords: NS2B-NS3 protease, DENV, Squalene, Arachidonic acid

B-02: Association Analysis for Flower Related Traits in Rose (*Rosa* × *hybrida* L.)

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Rose is an economically important ornamental crop and is sold as cut flowers, pot roses and garden roses. It is an important crop for association studies due to extremely polymorphic cultivars and simultaneous study of many traits in populations of moderate size. Association mapping is an effective approach to detect markers-trait associations in a set of samples which are not closely related. The present investigation was carried out with the objectives of marker-trait association to identify genomic regions governing flower related traits in rose. Out of 256 correlations, 150 correlations were found significant among genotypes. Numbers of factors which contribute majorly to diversity are found to be two by parallel scree plot. The wide phenotypic trait variations among 96 rose genotypes indicated that the constituted association panel is suitable for association mapping for selected traits. Out of 200 SSR markers screened, 140 markers were amplified and 53 markers were found to be polymorphic. The 4 clusters of rose genotypes confirmed the similarity of phenotypic and genotypic results. The identified genomic regions (MK-120947, MK-117697, MK-124082, CTG-356, Rh-72, MK-141434, MK-93184L, H12F12, Rh-96, MK-2373, Rh-78, Rh-77, Rpu-12) provided information for marker assisted selection for important traits in rose genetic improvement.

Keywords: *Rose genotypes*, SSR Markers, Association analysis

B-03: Bio-fortification of the Sweetcorn Hybrid using the Marker Assisted Backcross Breeding

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Sweet corn is an economically important crop consumed for its high sugar content. The aim of the study is to bio-fortify the sweet corn hybrid with high β-carotene. The parents of the sweet corn hybrid are bio-fortified with a common donor parent. The *crtRB1* gene is introgresed in to the sweet corn parents and screened with the *crtRB1* genespecific marker. The bio-fortified sweet corn parents are crossed to form the constituent hybrid with high β-carotene content. Background genome recovery, total sugar content and β-carotene estimation is done in each generation and the progenies are selected.

Keywords: Sweet corn, β-carotene*, crtRB1*, MABB

B-04: Biosynthesis of Zinc Oxide Nanoparticles for Growth Promotion and Management of Downy Mildew of Pearl Millet

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Downy mildew caused by *Sclerospora graminicola* is the most devastating disease in pearl millet which leads to a decrease in fodder and grain yield. The application of nanoparticles has become a major thrust for disease management in agriculture. In this study, the efficacy of ecofriendly zinc oxide nanoparticles in controlling downy mildew disease of pearl millet was evaluated. The green synthesized nanoparticles were characterized by using FTIR, SEM, XRD, DLS, EDAX and UV spectroscopy. The highly susceptible pearl millet seeds 7042s were treated with different concentration of nanoparticles showed significantly enhanced the seed germination, seedling vigour, plant height, fresh and dry weight of seedlings under laboratory conditions. When compared to the untreated control seed treatment with nanoparticles significantly induced systemic resistance against downy mildew disease under greenhouse conditions. Seedlings raised from treated seeds recorded an early and increased hypersensitive response as a reaction to *S.graminicola* inoculation.

Keywords: Downy mildew, *Sclerospora graminicola,* Pearl millet, Zinc nanoparticles

B-05: Comparative Evaluation of Macroporous Resins in Quest of Adsorption Driven Purification of Acylated and Non Acylated Type of Anthocyanin

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Seven macroporus resins were screened for preferential adsorption of acylated (sources: black carrot, purple cabbage) and non-acylated anthocyanins (sources: rose petals, black rice) from crude extracts. Chemo-profiling of the extracts through UPLC-HRMS revealed the molecular identities of the anthocyanins. OPTIPORE-L493 demonstrated highest adsorption capacity irrespective of chemical nature of anothocyanins. Highest multilayer sorption capacities of 98.84 and 95.81% were observed for DIAION HP20 and OPTIPORE L493 for acylated and non-acylated anthocyanin respectively, after fitting the data into Freundlich adsorption isotherm. Particle diffusion adsorption mechanism was found to be more predominant at resin surface as observed from Dubinin Radushkevich adsorption isotherms. Real-world validation through continuous column-based purification exhibited 44.1-243.6% improvement of anthocyanin purity.

Keywords: Anthocyanin, Macroporus resin, UPLC-HRMS, Adsorption, Freundlich isotherm

B-06: GCMS Analyses of Conventionally and Organically Grown *Capsicum annuum* L. Fruit Samples for Volatile Bioactive Compounds

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Organic farming is the best alternative method to keep away the harmful effects of conventional farming. Currently, India ranks ninth in terms of the organically farmed area according to the FiBL 2020 survey (2018-19). The concept of quality food has undergone a drastic change over the past few decades. The claimed benefits of organic foods have not been proved especially in case of Rajasthan. Nawalgarh- Ajeetgarh – area is now dominantly converting into hub of organic farming in Rajasthan. The GC-MS analysis revealed the presence of 52 compounds in extract of conventionally grown chilli while significantly fewer *i.e.,* 36, 40, and 39 compounds in organically grown chilli fruits. Capsaicins, ascorbic acid (Vitamin C), beneficial esters, were reported very high in organically grown fruits in comparison to conventionally grown chilli fruits. GC-MS studies revealed that chilli produced in organic farming systems for more than 5 years has the advantage to be safe and nutritionally superior to conventionally grown chilli.

Keywords: GC-MS, Organic farming, Volatile compounds

B-07: GC-MS Analysis of Methanolic Extract from the Stem Bark of *Neolamarckia cadamba*

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Neolamarckia cadamba, also known as kadam, is a traditional medicinal plant used to treat various diseases. Using the Soxhlet apparatus, the phytochemical constituents of *N. cadamba* bark were extracted. Metabolites were analyzed using Gas Chromatography Mass Spectrometry, and the mass spectra of the compounds found in the extracts were compared to the National Institute of Standards and Technology (NIST) library. The major chemical constituents were 3-O-Methyl-d-glucose, 3,4,5-Trimethoxyphenol, Erucic acid, squalene, tocopherol, sitosterol, piperidine and catechol. Some of the identified compounds have biological activities such as antioxidant, antimicrobial, anesthetic, antiseptic, anti-diabetic, hypocholesterolemia, and etc.

Keywords: Kadam, GC-MS, Stem Bark, Phytochemicals

B-08: Genetic Diversity Analysis and Agro-morphological Characterization of Aromatic Rice (*Oryza sativa* L.) Germplasm

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Aromatic rice is a special type of rice known in the World. India has a rich source of small and medium grained aromatic rice with high aroma, but majority of research work is based on long grained Basmati types. 20 genotypes of aromatic rice were evaluated at the Agricultural Farm of University of Calcutta to characterize and estimate Genetic Diversity. In this study, a close relation was maintained by Phenotypic coefficients of variation with Genotypic coefficient of variation for all the traits. Correlation study and path analysis showed that grain yield per plant was positive and significantly correlated and directly affected by panicles per plant and total number of filled grains per plant. Manhattan cluster analysis revealed two distinct clusters on the basis of the agro-morphological traits.

Keywords: Aromatic rice, Genetic Diversity, Agro-morphological traits, Cluster, Correlation

B-09: Host Preference and Comparative Biology of Guava fruit fly, *Bactrocera correcta* (Bezzi) on different Fruits

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Fruit flies are polyphagous insect pest and infesting various fruits and vegetables. The host preference and biology of the Guava fruit fly (*Bactrocera correcta*) was studied on seventeen fruits. The results showed that total developmental period was longer on Pomegranate (26.7±2.1 days), Ber (26.1±2.4 days) and Custard apple (25.1±1.5 days) while shorter period was observed on Sweet banana (20.1±1.6 days). Per cent pupal recovery and adult emergence of *B. correcta* was maximum on Sweet Banana with 93.33% and 90.00 % respectively. *B. correcta* preferred Sweet Banana for oviposition followed by Guava, Papaya and Sapota under laboratory condition.

Keywords: Guava fruit fly, *Bactrocera*, Host preference, Fruits, Biological parameters

B-10: Impact of Cultivation Practices on the Incidence of Different Insect Pest on Kharif-paddy and Effect on Vegetative and Yield Attributing Characters as Well as Cost Benefit Ratio in Terai Region of West Bengal

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The studies were conducted at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India with a view to find out the impact of cultivation practices on the incidence of insect-pests of kharif and effect on vegetative and yield attributing characters as well as cost benefit ratio under Terai agro-ecology of West Bengal**.** Two types of cultivation processes like bio-accelerated and conventional farming system were adopted for the study. The maximum infestation of different insect-pests of rice namely leaf folder, yellow stem borer, gall midge, gundhi bug and grass hopper were observed in the plots where conventional farming system was practiced while the minimum was recorded in the bio-accelerated one. Amongst the different plant parameters studied, tiller number/hill, panicle/hill, panicle length, grain/panicle, filled grain/panicle, panicle weight were found more in bio-accelerated than conventional farming system excepting plant height, root length and chaffy grain which were more in conventional over bio-accelerated farming. In terms of grain yield, bio-accelerated farming was found to be better than conventional farming system. Return cost analysis concluded that bio-accelerated climate resilient farming in all respect showed better performance as this farming system was associated with low input, high quality product,

environment friendly system. Hence, the practice of bio-accelerated farming was found to be more promising over conventional methods under rainfed situation in terai region of West Bengal.

Keywords: Paddy, Bio-Accelerated Farming, Conventional Farming, Pests, Yield, BC ratio

B-11: Insect-pest Management of Okra (*Abelmoschus esculentus* L.) - A comparative Study between Natural and Conventional Farming System

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Okra, *Abelmoschus esculentus* (L.) Moench of family Malvaeceae, cultivated widely in the tropical and subtropical part of the world and grown well in India as well as in West Bengal and having good export potential. The experiment was carried out under natural and conventional farming system in the Instructional Farm Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. Out of the tree seasons tried the pre-kharif season was prone to both jassid (8.26/leaf) and fruit borer (8.15%) infestation and in kharif and post kharif crops, jassid population ranged only 0.93-1.65/ leaf and fruit borer infestations were 9.06% and 12.15%. Avoidable loss in yield was 24.00-24.88% in conventional and 16.98-24.39% in natural farming. In respect to pest population suppression and yield the natural bio-insecticide

(60.92-85.52% and 11.24 t/ha) performed at par with other conventional insecticides including bio-rational (23.16-94.85% and 7.99-11.73t/ha). Hence, natural farming can be recommended for Okra cultivation in *terai* agro-climatic conditions of West Bengal as it is safer to health, environment and soil.

Keywords: Okra, Insect-pests, Yield, Insecticides, Jeewamrita, Agniastra, Natural farming, Conventional farming

B-12: *In-silico* Analysis of Glyphosate Herbicide Binding on Rice GSTs

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Glutathione S-transferases (GSTs) are a diverse class of xenobiotic defence enzymes. Plant GSTs plays an important role in biotic, abiotic stress responses and the conjugation activity of glutathione on the sulphur atom of serine helps in detoxification of herbicides through binding of a high affinity hydrophobic compounds. In the present study, rice GST of seven classes which includes Phi, Tau, Dehydroascorbate reductase (DHAR), Theta, Zeta, Elongation factor 1 gamma (EF1G) and Tetrachlorohydroquinone dehalogenase (TCHQD) were modeled and docked with herbicide glyphosate to understand their binding mechanism. Results from this study provided insight on the binding of herbicide on the catalytic site of serine, which will enhance the role of detoxification observed among various classes of GSTs.

Keywords: GST, Glyphosate, Herbicide detoxification

B-13: Integrated Disease Management for Spot Blotch Disease of Wheat caused by *Bipolaris sorokiniana*

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Some biotic, abiotic and chemical agents were integrated for the management of spot blotch disease of wheat. Out of those 14 formulated treatments, it was found that seed treatment as well as foliar spray with UBPF 6 (*Pseudomonas fluorescens*) produced the lowest AUDPC of 89.51 which was very closely followed by seed treatment with UBPF 6 + foliar spray with tebuconazole @ 1.5 ml/litre of water that produced AUDPC of 91.57. Highest SPAD reading of 47.89 and highest canopy temperature depression of 4.41^{0}C was achieved by the best treatment. Highest yield of 4.69 t/ha was also recorded by that treatment. which was closely followed by second best treatment (4.61 t/ha). In biochemical analysis of all the treatments, it was found that all the defense related parameters like phenol, OD phenol, peroxidase, polyphenol oxidase and Phenyl Alanine Ammonia Lyase (PAL) was either highest or second best in the best treatment.

Keywords: Wheat, Spot blotch, AUDPC, UBPF 6, Yield, Biocehmical parameters

B-14: Isolation of Pathogenic Micro Organisms Involved in Gastro Intestinal Diseases

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Using proper sampling techniques (IS5404.1984) the microbiological study was conducted to find out the infectious agent which was causing stomach problems. Samples of food items were collected maintaining proper aseptic techniques. We have also collected swab samples 3 times from each workers hand and 3 times in different locations in the processing area to minimize the chances of error prone report. Sample was transported to the laboratory (maintaining aseptic techniques) for further analysis.

The sample was properly received and analyzed using the methods of Indian standards. Laminar air flow, Autoclaves, Hot air oven, Test tubes, Micro pipets, Petri dishes, Incubators, PH meter and Micro biological enrichment media's were used to ascertain the presence of pathogens. Salmonella and coliform were present as causative pathogen for the gastro intestinal problems. Food sample was also contaminated. Further investigation confirms not only hygiene problem of the workers but also some pest problem in the processing area. Implementation of HACCP was ensured after analyzing some critical control points. External pest management service was contracted for further pest management. This emergency situation will create awareness for the management system and the workers will learn valuable hygienic lessons.

Keywords: Emergency situation, Food industry, Detection, Pathogens

B-15: Metabolome and Transcriptome Analyses of *Neolamarckia cadamba* Reveal the Presence of B-16: Important Metabolites and Key Pathways Controlling Their Biosynthesis

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Neolamarckia cadamba (Roxb.), commonly known as Kadam, is one of the evergreen tropical medicinal trees belonging to the Rubiaceae family. Different parts of cadamba have been used to treat various diseases *viz*., diabetes, anaemia and menorrhagia. In the present study, untargeted metabolites profiling was carried out using GC-MS analysis. Metabolites from various tissues were annotated to biosynthetic pathways and differentially accumulated metabolites between tissues were identified. *De novo* transcriptome study was performed to identify differentially expressed genes involved in respective pathways. Integrated metabolome and transcriptome analyses revealed the presence of important metabolites and their corresponding genes.

Keywords: Cadamba, GC-MS, Metabolome, Transcriptome

B-17: Metagenomic Analysis Exploring Microbial Diversity in Rice Rhizosphere of Bhandara District

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Most of the beneficial soil microorganisms are known to find ecologically advantageous niches in the rhizosphere. The rhizosphere's abundant microbial activity supports a number of biological and ecological processes vital to plant health. In comparison to other elements of the rhizosphere, our understanding of the variety of these bacterial populations is limited. Less than 1% of the total microbial population on land and in ocean has been successfully isolated in pure culture, according to estimates. Aim of this present work reveals 16S rRNA Clone library construction, culture-independent molecular methods, and the bacterial communities found in the rice rhizosphere of paddy fields in Bhandara.

Keywords: 16S rRNA, Clone library, Rhizosphere

B-18: Molecular Characterization of Streptomyces scabiei causing Potato Scab and their *In-vitro* Management

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In present investigation, 18 presumptive Streptomyces spp. were isolated from different farmer's field and cold storage of Daurala block of Meerut, U.P. Only 5 isolates were confirmed as S. scabiei based on their pathogenicity, 16S rDNA sequence and txtA and nec1 genes. For their management, 20 drugs were tested against all five isolates and found that Gentamicin and Tobramycin was recorded highest exhibiting 50 to 58 mm inhibition zone against S. scabiei isolates. Different bio-agents were also evaluated and found that T. harzianum, showed maximum inhibition zone of S. scabiei.

Keywords: Treptomyces scabiei, Isolates, Drugs and bioagents

B-19: *Phelipanche aegyptiaca* Pers. : Life cycle and Infestation in Mustard fields

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Phelipancheaegyptiaca Pers. (Egyptian broomrape) is an obligate holo-root parasitic weed. This broomrape sp. parasitizes a variety of flowering plants such as cruciferous, leguminous, and solanaceous. Mustard has a major

contribution to the Indian economy. Rajasthan holds the first position among the mustard-growing states with the highest contribution (44.57%) in mustard production. *P. aegyptiaca* has emerged as a serious threat to mustard production. In this study, the biological life stages of *P. aegyptiaca* and its infestation intensity were investigated in the Nawalgarh-Jhunjhunu area of Rajasthan. To identify the underground and aerial life stages of *P. aegyptiaca*, various greenhouse and field studies were conducted. To estimate the infestation level, different mustard-grown regions of Nawalgarhwere selected. Underground life stages of *P. aegyptiaca* were studied through greenhouse experiments and found attachment in increased number with each next observation. Among the selected study areas, the Mukundgarh-Nawalgarh plot was found the most susceptible with the highest number of *P. aegyptiaca* shoots in the emerging, flowering, and fructification stages (0.68, 2.05, and 2.33 parasites per host plant respectively)and lowest mustard biomass. While the minimum infestation was displayed in the Nawaldiplotin every stage (0.05, 0.24, and 0.53 parasites per host plant respectively) with the highest mustard biomass.

Keywords: Broomrape, Parasitism, *Phelipanche aegyptiaca* Pers., Mustard, Infestation

B-20: Phenological Studies of *Tecomella undulata* with Reference to Different Flower Colour Morphotypes

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Tecomella undulata (Bignoniaceae) is an economically and medicinally important timber yielding tree species of Rajasthan. It is an out-breeding

species and growing in nature with three different morphotypes of red, orange and yellow trees based on the colour of the petals. In this study phenological traits of *Tecomella undulata* with reference to three different morphotypes were studied, in which ninety trees were marked at Jalore, Bhadrajune and phenological parameters, fruiting and flowering pattern were monitored for two consecutive years. Results of the study revealed that phenological parameters like pod length, seed length and leaf size (length and width) of the orange morphotype were more than the other two morphotypes whereas pod width was found to be more for yellow morphotypes and seed weight for red morphotypes. Variations in the onset of the flowering seasons among the three morphotypes were also observed during the survey. Results shows that orange and red morphotypes flowers about two-three weeks earlier than yellow morphotype. Peak flowering for all morphotypes was observed in the month of February with a decline towards the end of March.

Keywords: Bignoniaceae, Morphotypes, Phenology, Variability

B-21: Population Dynamics, Abundance and Diversity of Fruit Flies (Diptera:Tephritidae) in Northern Karnataka

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Fruit flies are the one of the important pests infesting many fruit crops. An attempt was made to study the abundance, species diversity, influence of weather factors on fruit fly population. Among total fruit flies population collected, most dominant fruit fly species was *Bactrocera. dorsalis* (55.22%),

followed by the *B. correcta* (33.60%), *B. zonata* (6.13%) and *Zeugodacus cucurbitae* (5.03%). Correlation analysis showed that overall fruit fly population were significantly positively correlated with minimum temperature, minimum relative humidity and rain fall. Multiple linear regression analysis showed that, fruit fly population were influenced by the all the weather factors.

Key words: Survey, fruit flies, Population dynamics, Abundance, Diversity, *Bactrocera dorsalis*, *B. correcta*, *B. zonata, Zeugodacus cucurbitae*

B-22: Seasonal Abundance of Oriental Hornet in *Apis mellifera* L. Colonies

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An attempt was made to study seasonal abundance of predatory wasp *Vespa orientalis* attacking *Apis mellifera* colonies during blooming period of *Prosopis cineraria* and *Capparis decidua* in Jodhpur (Rajasthan). The data on the abundance of hornet wasp was collected for four seasons viz., winters, spring, summers and monsoon, starting from February to July. No *V. orientalis* wasp was recorded attaching the colonies in winters and spring. *V. orientalis* activity started in May and increased during June to July. Hornet wasps were found attacking honeybee colonies frequently with the on onset of monsoon rainy season with high population in late July.

Keywords: *Vespa orientalis*, *Apis mellifera*, Seasonal abundance

B-23: Seasonal Incidence of Muscardine Infection, in Silkworm, Bombyx Mori, in Western Vidarbh Region (Maharashtra) India

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Pathogens like viruses, bacteria, fungi and protozoan attacks silkworm differently during different seasons, causing corresponding diseases. Fungal diseases of silkworm are called muscardine. In present paper, season-wise survey was conducted during 2011-1212 on incidence of muscardine in Akola, Amravati, Buldhana, Washim and Yevatmal districts of Vidarbha regions in Maharashtra. We reported that in monsoon season the incidences of Muscardine in Akola district during 2011-12 was found to be 1.79%, in Amravati 1.53%, in Buldhana it was 1.24%, in Yevatmal was 1.43% and in Washim district was reported to be 1.31%. Muscardine prevalence in post monsoon season in Akola district during Year 2011-12 was found to be 4.17%, in Amravati 4.26%, in Buldhana it was 4.38%, in Yevatmal was 4.47% and in Washim district was reported to be 3.17%. The incidences of muscardine in winter season in Akola district during Year 2011-12 was found to be 18.34%, in Amravati 18.17%, In Buldhana was 18.34%, in Yevatmal was 17.23% and in Washim district was reported to be 16.32%. In spring season, the incidences of Muscardine in Akola district during same Year was found to be 1.34%, in Amravati 0.65%. In Buldhana, it was 0.34%, in Yevatmal it was 1.47% and in Washim district was reported to be 1.53%.

Keywords: Muscardine, Fungal infection, Bombyx mori, Aspergillosis, Vidarbha

B-24: Studies of Moths from Nandurbar District, Maharashtra (India)

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Lepidoptera is a group of insects that contains many large and beautiful, showy species. Moths are of economic importance as some of them feeds on agricultural, horticultural and forest products. Moths are strongly influenced by the local weather and are highly sensitive to environmental changes. On perusal of literature, it was found that, taxonomic studies on this fauna from Nandurbar are unexplored. Moth collection has done from Nandurbar district of Maharashtra during June 2019 to November 2019 to determine their diversity, taxonomic study and occurance. Some moths specimens were collected by various places of Nandurbar district especially Hill station Toranmal, Akkalkuva, Khapar, Taloda, Dhadgoan, Navapur. Collected Moths were carried out during evening onwards till morning on next day by using Light Trap. A total number of 30 species from 07 families have been identified from Nandurbar district. The moths were identified up to family level. Families Noctuidae (06), Geometridae(03), Sphingidae(04), Saturniidae(02), Crambidae(05), Hyblaeidae(01), Erebidae(09), were presented in collected sample. Hence, in the present study an attempt has been made to study document the moth fauna from Nandurbar District, Maharashtra (India).

Keywords: Lepidoptera, Moths, Agricultural, Horticultural, Diversity, Taxonomic

B-25: Study on the Toxicological Impact of Chlorpyrifos on *Leptolyngbya species* Isolated from Paddy Field of Bhandara District, Maharashtra, India

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Extensive employment of pesticides in agricultural practices needs immediate action for their removal from land and water. The recent scenario focuses mainly on sustainable and eco-friendly techniques for the remediation of pollutants. Present study aimed to identify *Leptolyngbya* species effective against toxicological impact of chlorpyrifos and also capable of degradation of pesticide in paddy field. Lower concentration (40 ppm) of Chlorpyrifos supported good growth with a high dry weight of biomass, total protein content, carbohydrate content, and photosynthetic pigments compared to untreated control cultures while higher concentrations (60 and 80 ppm) inhibited these parameters. The result clearly suggests organism is capable of degrading pesticide which can further be used for bioremediation of pesticide in paddy fields.

Keywords: Cyanobacteria, Chlorpyrifos, Toxicity, Paddy field

B-26: Suitable Methods for Isolation, Culture and Storage of Pearl Millet Blat Fungus *Magnaporthe grisea*

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Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is a popular millet and an important crop in India and Africa, where it is commonly cultivated in arid and semi-arid regions. In recent years, Pearl millet blast caused by *Magnaporthe grisea* (T.T. Hebert) M.E. Barr. has become a major disease in the country. Efficient and suitable methods for isolation, storage, inoculum production can help in achieving the target of sustainable management of the disease. In this study, we aimed to develop suitable methods for isolation, storage of *Magnaporthe grisea* collected from the blast-infected leaf. In the present investigation the effect of media, photo-periods and isolation techniques influenced on mycelial growth and conidial production of *M. grisea* were studied. Oatmeal agar and host extract agar were found to be suitable for culturing different isolates of *M. grisea.* Highest radial growth of mycelia is seen on sixteenth day in media.

Keywords: *Magnaporthe grisea,* Pearl millet, Culturing media

B-27: Synthesis of Silicon Dioxide Nanoparticles and their Efficacy in Inducing Protection against Pearl Millet Downy Mildew Pathogen

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Downy mildew of pearl millet (*Pennisetum glaucum* (L.) R. Br.) caused by the biotrophic oomycete *Sclerospora graminicola* is the most devastating disease which impairs pearl millet production causing huge yield and monetary losses. Silicon di-oxide nanoparticles were synthesised and was evaluated for their efficacy against downy mildew disease of pearl millet. Sporangicidal assay of nanoparticles showed that 10-25ppm of nanoparticles treatment led to plasmolysis and inhibition of spore germination of *S. graminicola*. Analysis of defense enzymes showed that nanoparticles treatment significantly enhanced the activities of glucanase, peroxidase, phenylalanine ammonia-lyase, and polyphenol oxidase in comparison to untreated control. These results indicate that synthesized Silicon di-oxide nanoparticles could promote growth and induce systemic resistance in pearl millet against *S. graminicola* and can be effectively used to manage downy mildew.

Keywords: Silicon di-oxide nanoparticles, Defense enzyme, *S. graminicola*

B-28: Use of Specialized Packing Materials to Prolong the Seed Longevity and Storability in Groundnut

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A laboratory experiment was conducted at Department of Seed and Science and Technology, College of Agriculture, Bheemarayanagudi to know the influence of specialized packaging materials on storability of groundnut seeds. Treatment composed of the freshly harvested seeds of K-9 variety of groundnut kernel and pods were stored in specialized packing materials viz., Super grain bag, Purdue improved crop storage (PICS) bag and polylined (700 gaues) gunny bags (PLGB) with four replications under ambient conditions. The monthly observations recorded on seed quality parameters up to eight months. The results revealed that, pods stored in PICS bags recorded significantly higher germination percentage (90.0 %), shoot length (6.0 cm), root length (18.3 cm) and seedling vigour index (2130) at initial month of storage. Whereas, after eight months of storage it was observed that germination percentage was (78.0 %), shoot length (3.3 cm), root length (11.8 cm), seedling vigour index (1173). Both kernel and pods were stored in PICS bag recorded better results compared to other bags. When compared to kernel and pods, pods showed best result since kernel is protected by shell. The kernels are very delicate so that embryo loss is more. Hence, seed quality parameter affected. Among packaging material PICS bag has three layer hermitic storage bag which is air tight moisture impervious bag compared to other super grain and polylined gunny bags. From this study it can be concluded that PICS bag found best storage bags for groundnut pods than that of other packaging bags.

Keywords: Packaging materials, Longevity, Storability and Groundnut

B-29: Value Addition through Agro-food Processing : Co-operative A Tool: An Analysis

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"Creative India and Innovative India" has been a slogan for women and youth for promoting economic interest and scientific temper in any sector of development especially in Science, Technology and Innovation (STI) and it's application for resource conservation and development in the economy. However, the dichotomy between rural and urban area development has diversified the food consumption pattern in terms of living standard and it's quality food with traditional technical knowledge (TTK) and intellectual Property Rights (IPRs) thereby the need for promotion of food processing and adopt technology to enhance the income of the people of small farm household to revitalise local economy. The living standards of people in rural India has been improved comparatively in urban area. The importance of agro-business sector in rural area that is from farm gate to consumers has been gradually increasing according to changes in socio- economic and technological environment and consumption pattern from grains to high-quality products like fast moving consumer goods (FMCGs) such as processed food, meats, vegetables, fats, and fruits has improved the prospects of food processing enterprises in MSME sector. Food processing enterprises enhances the derived demand for agricultural raw material products through processing and increase value addition by extending the marketing period through processing and cold chain storage and increase non-farm income of small farm household, generate employment opportunities for women and youth labour force, trade (internal and International) development lead to human well-being. However, the behavioural change of population with gender participation and the consumption pattern in rural /tribal area require more

scientific and technological development in the field to sustainable use of natural resources for human and community wellbeing.

Keywords: IPR, Bio-diversity, Co-operation, Environment health

B-30: Mapping of Novel Leaf Rust and Stripe Rust Resistance Genes Introgressed into Bread Wheat from Wild Progenitor

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Wild emmer wheat, *Triticum dicoccoides*, the tetraploid progenitor of wheat is an important source of novel disease resistance genes. *T. dicoccoides* acc pau 14716 was used to develop an introgression line (IL^{dic}) in the background of *T. aestivum* cultivar WL711(NN) followed by crossing IL^{dic} with *T. aestivum* cultivar HD2967. The F_4 population derived from HD2967-IL^{dic}, segregated for a separate single gene against leaf and stripe rust resistance. The bulk segregant analysis in combination with whole-genome resequencing (BSA-seq) revealed a 10Mb region on chromosome 7A with 12 genes and a 20Mb region on chromosome 3A with one gene (NBS-LRR domain) were associated with leaf and stripe rust resistance, respectively.

Keywords: Leaf rust, Stripe rust, *Triticum dicoccoides*, Whole-genome resequencing, BSA-seq, NBS-LRR

B-31: Carboxymethyl Cellulose Comprising Essential Oil Edible Coating Formulation to Improve the Postharvest Quality of Apples

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Edible coating is an emerging concept to increase the shelf life of fresh fruits in order to decrease the food waste globally. This study investigate CMC and essential oil coating (COP) to increase the shelf life of apple fruits. The COP coating could significantly reduce the weight loss and fungal decay as compared to the control fruits. The COP coated apples displayed increased shelf-life upto 40 days with good physicochemical properties. The sensory score were higher for coated fruits than the control. Thus, COP formulation holds great potential as an edible coating to increase the shelf life of apple fruits.

Keywords: CMC, Essential oil, Coating, Apple, Edible packaging

B-32: *In silico* Analysis of Tomato Metabolites for Anti-microbial Properties

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Tomato (*Lycopersicum esculentum*) is one of the globally important vegetable crops. Major economic loss in tomato is due to biotic stress in which *Pseudomonas syringae* pv. tomato, the causative agent of bacterial speck, plays a major role. The pathogen secretes a phytotoxin called coronatine (COR) which is a structural mimic of active jasmonic acid isoleucine which helps in the entry and proliferation of the bacteria. Therefore, the present work is to investigate the interaction of COR with the phytochemicals of tomato through molecular docking.

Keywords: *Pseudomonas syringae*, Coronatine, Molecular docking

B-33: Microbial Biopesticides : Its Risk and Benefits in Pest and Disease Control and Regulatory System in India

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Biopesticides are the biological substance or organism that can kill, damage or repels pests and diseases organisms. These are produced from

microorganisms, animals and plants. Biopesticides are potential alternative to pesticides and widely acceptable for sustainable Agriculture and safe food supply. Microbial Biopesticides are produced from microbes like bacteria, fungus, virus and protozoans. These are eco-friendly, target-specific and easily biodegradable. In India, Biopesticides are registered and regulated under the guidelines of the Insecticides Act, 1968 and Rule 1971 of India, FAO and WHO.

The present study is based on secondary data report and research papers. In present paper, Microbial Biopesticides and its regulatory system in India is discussed. In 19th century Professor Illya Metchnikoff demonstrated the use of Metarhizium anisopliae to control grain beetle in Ukrain. The first recorded registration of a microbial pesticide was in USA in 1948. In India, the use of biopesticide was started in 1910. Globally, there are about 1400 biopesticides products being sold, and in India there are about 400 registered biopesticides active ingredients. The biopesticides are produced from plants, microorganism, insect and animals. They are categorise in three groups: 1) Plant extracts, 2) Living organisms, and 3) GM plants. The microbial biopesticides comes under category of living organisms. The important microbial biopesticides are Bti, Btk, Trichderma sps., Beauveria bassiana, NPV, CPV. Nosema sps., Vairimorpha sps. and EPNs. Biopesticides are potential alternative to pesticides and widely acceptable for sustainable Agriculture and safe food production and supply. These are eco-friendly, reduce air pollution, target-specific, easily biodegradable, effective in less quantity and less toxic. The risk are possibility of resistance due to long term use, need of high specific microbes for complex pest species, affect of biotic and abiotic factors and spurious biopesticides.. World over regulation of pesticides in general and biopesticides in particulars has engaged the attention of Organization for Economic Cooperation and development (OECD), Food and Agriculture Organization (FAO), European Union (EU) and in India biopesticide fall under the Insecticide Act, 1968 and Rule 1971) and are registered under Central Insecticides Board and Registration Committee (CIB & RC) Faridabad. WHO guidelines are also

followed for house hold and public health use and environment safety. The act regulate the import, manufacture, transport, sale, distribution, and use of pesticides and biopesticides, which can be produced in desired purity and yield.

Keywords: Microbes, Biopesticides, Risks, Benefits, Regulatory System

B-34: Organic Farming: Present Day Demand

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A method of crop production known as "organic farming" forgoes the use of synthetic chemicals such as fertilizers, pesticides, growth regulators, environmentally sound and socially acceptable, the use of organic fertilizers and nutrients in crop management. Organic farming should be a holistic approach to food production that emphasizes the use of comprehensive management practices without synthetic inputs to improve soil health and restore ecological balance, through biodiversity and soil biological activity. Organic farming's main objectives include enrich soil fertility, providing balanced nutrients to plants, improving soil microbial activity, lowering production costs, and reducing pollution. By utilizing locally accessible natural resources and pursuing an environmentally friendly strategy to protect biodiversity and other biological processes.

Keywords: Organic farming, Fertilizers, Organic manures, Soil properties

B-35: Study of Genetic Diversity in Rice (*Oryza sativa* L.) Genotypes under Direct Seeded Condition by using Principal Component Analysis

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The present investigation was carried out to assess the genetic diversity by using principal component analysis for yield and yield contributing traits in thirty-two genotypes of rice under direct seeded condition (DSR). The experiment was conducted at Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar in randomized block design with three replications. The results revealed that first four component axes had eigen values e"1.0, representing a cumulative variability of 76.86 %. Principal component analysis (PCA) indicate that four components (PC1 to PC4) accounted for about 76.86% of the total variation present among all the traits. Out of total principal components PC1, PC2, PC3 and PC4 with values 33.781%, 19.02%, 13.859% and 10.206% respectively, contributed more to the total variation. The first principal component had high positive loading for 15 traits out of 17. Similarly, second and third principal component had 7 traits each, fourth component with 6 traits had high positive loadings which contributed more to the diversity. Genotypes in cluster V showed higher mean performance for most of the yield attributing traits. Therefore, selection of parents for different traits would be effective from this cluster. Thus, result of the present study could be exploited in planning and execution of future breeding programme in rice under direct seeded condition.

Keywords: PCA, Genetic diversity, K-clustering, DSR

B-36: Comb Architecture of Dwarf Honeybee *Apis florea* F (Hymenoptera: Apidae)

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The honeybee, *Apis florea* build single exposed combs preferably in shrubs, bushes and small trees. They build sized combs and the dimensions of the cells varies among honeybee species. Studies were undertaken to find out the size of the combs, arrangement and measurements of brood cells, pollen cells and honey cells in the comb using Image J software. The observations showed that, the worker brood area was found in the centre of the combs. They stored pollen above the brood area and honey region was found above and around the supporting branches. Furthermore, the drone cells were found at the lower margin of the nest, and queen cells were found at the lower edges of the brood nest. Comparatively, drone cells were larger than worker cells and queen cells were conical in shape in contrast to hexagonal worker and drone cells. The details of size of combs, measurements of different comb cells in *A. florea* are discussed in detail during presentation.

Keywords: *Apis florea*, Nest architecture, Brood cells, Pllen cells, Honey cells

B-37: Efficacy of Consortium Biofertilizer on the Growth and Yield of Brinjal (*Solanum melongena*)

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Bio-fertilizer consortium contains living microorganism. Its beneficial effects on the yield attributing characters of brinjal (*Solanum melongena)* were studied. An experiment was carried out in farmers filed to study its efficacy on yield and growth parameters of brinjal. The experiment was laid out in a randomized block design with four treatments. Bio-fertilizer consortium comprising *Azotobacter* sp. (nitrogen fixer), *Bacillus* sp (Phosphorus solubilizer), *Frateuria* sp (Potassium solubilizer) and *Glomus* sp. (Mineral mobilizer) were applied in three different dosage mixed with farm yard manure through broadcast method at vegetative, flowering and fruit setting stage. Among all the treatments, it is noticed that the growth, yield and yield attributing parameters were found maximum with the application of 2000 g/ha showing 25.19% yield increase when compared to other dosages.

Keywords: Biofertilizer consortium, Brinjal, Biometrics, Yield

B-38: Molecular Characterization and Identification of Candidate Markers for Seed Longevity in Soybean [G*lycine max* (L.) Merr.] Genotypes

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High genotypic and phenotypic coefficients of variability coupled with high heritability were observed for the soybean seed longevity related traits viz., germination after accelerated aging, seedcoat permeability, EC and % reduction in germination suggesting scope of high response to selection. Eight genotypes were classified as 'good storer' namely, MAUS-162, JS-20-34, MAUS-710, MAUS-118, EC24004F, Cat1398, EC389154 and Cat269, those can be advocated as donors to breed improved soybean with high seed longevity. During molecular markers investigation, 17 SSRs were found to be 100% polymorphic, revealing Satt143 and Satt598 with highest PIC value (0.97), followed by Satt389, suggested their high resolving power to discriminate the 'good storer' from rest.

Keywords: Soybean, Seed longevity, SSR markers, Genetic diversity, PIC

B-39: Studies on Combining Ability and Heterosis for Yield and Yield Component Traits in Sesame (*Sesamum indicum* L.)

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The present investigation was carried to study combining ability and heterosis for yield and yield component traits in sesame by utilizing 6 lines and 6 testers. The 36 F_1s along with parents were studied for 14 quantitative and qualitative traits. The ANNOVA revealed that, there were significant differences exist among the genotypes for all the characters. The crosses Rajeswari x ACM-14-007 and IC 199438 x Hima were superior based on combining ability and heterosis. Hence, this hybrids used in crop improvement programme to increase the yield in sesame.

Keywords: Sorghum, Hybrid, Combining ability and Heterosis

B-40: Jatropha: An Alternative for Diesel in Future

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India listed among the top crude oil importer in world after US and China. India is a global agriculture powerhouse jatropha cultivation provide a solution

and will reduce the oil imports bills. The production of biodiesel from seed oil as it is non-edible and does not pose any problem. A perennial plant survive in poor dry soil which will benefit all the time. Low in free fatty acids and presence of unsaturated fatty acids make it to remain fluid at low temperature. The oil has been converted to biodiesel by transesterification process and used as biofuel. Jatropha extraction from seed and may be used directly in some diesel engines.

Keywords: Jatropha, Transesterification process, Alternative energy, biodiesel

B-41: Studies on Screening of Repellents against Asia Giant Honeybee, *Apis dorsata* Fabricius (Hymenoptera: Apidae)

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The development different formulation of repellents was designed to repel the pests many since centuries. Repellents are very much essential to control the spread of different types of insects born disease as many of the insects serve as vectors. There are various repellents formulations to repel insect pests including mosquitoes. However, more recently especially in urban regions, the giant honeybee, *Apis dorsata* is considered as a nuisance due to its aggressive and mass stinging behaviour despite, these honeybees play an important role in pollination of crops and honey production. A few plant based repellents have been tested on different honeybee species including African giant honeybee, *Apis mellifera scutellata*. However, these repellents showed

only limited repellence. In the present study, we initiated field experiments to repel these giant honeybee colonies found on apartments in Bengaluru, India using repellents *viz* stem extracts of *Amomum aculeatum* Roxb, DEET (N, N-diethyl-m-toluamide, (N, N diethyl-3-methylbenzamide) and citronella compounds. Preliminary results showed that, these repellents are partially effective in repelling *A. dorsata* colonies from apartments. The details of concentrations of repellents used and their efficacy will be discussed.

Keywords: *Apis dorsata*, Nesting biology, Colony congregation, Periodic mass flights

B-42: Population Improvement Approaches to Break Yield Plateau in Cotton Production

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Narrow genetic base of the cultivated cotton has adversely impacted cotton production and productivity. The cotton yields achieved about a decade back has remained stagnated to about 500 kg lint/ha, rather declining despite cultivation of BGII Bt cotton hybrids covering more than 95% area under cotton cultivation. Breeding methods and selection strategies used to accumulate desirable alleles in the population are referred as population improvement. This paper dealt with successful deployment of multi-parental GMS based random mating and recurrent selection strategies to weaken negative linkages, broaden the genetic base and to develop broad based varieties in diploid and tetraploid cotton.

Keywords: Random mating, Recurrent selection, Breakage of linkages, Cotton

B-43: Seed Priming to Mitigate the Impact of Drought Stress on Germination in Maize (*Zea mays* L.)

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Climate change has a great influence on crop production by inducing several negative impacts on plant growth. As the germination is one of the critical stages, this study was to assess the impact of drought stress on germination of maize. The study was conducted using the maize genotype COH(M)8 in artificially induced drought condition using PEG 6000. The efficiency of seed priming treatment with salicylic acid (SA), Brassinolides (BR), Sodium nitropruside and distilled water (hydropriming) to alleviate stress due to drought were studied. SA 75 ppm, Sodium nitropruside 50 µM and Brassinolides 0.5 ppm enhanced germination, other seed quality parameters along with á- amylase activity. Also, the activity of antioxidant enzymes like catalase, peroxidase and superoxide dismutase was increased. These parameters positively affected the germination and growth by mitigating the effect of oxidative stress induced under high temperature induced drought conditions. So, SA, CA and AsA can be effectively used for maintaining seed quality parameters and seedling growth during the stresses

Keywords: Climate change, Drought stress, Seed priming, Maize, Salicylic Acid, Sodium nitropruside, Brassinolides

B-44: Evaluation of Inducers against *Phomopsis* blight in Brinjal

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Phomopsis blight (*Phomopsis vexans*) is one of the devastating diseases of brinjal. The management of the disease is directed towards elimination of pathogen by use of cultural control. Therefore, in this context, trail of induced defence by certain inducing agents like potassium phosphate, sodium phosphate, sodium chloride, ferric chloride and silicon dioxide were assessed during the course of study. The physical and biochemical analysis were ascertained. Seed treatment with these inducing agents provides good protection to the seed against seed and soil born infection and also stimulates the germination of seed. The growth promoting effect was also perceived in seedlings.

Keywords: Induced systemic resistance, *Phomopsis vexans*, Inorganic inducers, soluble protein, total phenols

B-45: Deciphering the Mode of Action of Secondary Metabolites produced by Bacterial Endophytes for the Management of *Meloidogyne incognita* Infecting Banana

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Research and development efforts throughout the globe are now concentrating on biorational pesticides due to environmental concerns about synthetic pesticides and the need of integrated pest management as a fundamental principle. A scientific understanding of the mode of action of biomolecules over a range of pests is key to the successful development of biopesticides. The present investigation focused on the identification of biomolecules from *Bacillus velezensis* (YEBBR6) for the management of root knot nematode *Meloidogyne incognita* infecting banana. The molecules including furazan-3,4-diol, decane, nonanol, triamcinolone acetonide, 5-fluorouracil, formic acid, debrisoquine, 2-hydroxy-3-methyl succinic acid and diethyl trisulfide were screened for there nematicidal against *M. incognita* through molecular docking. *In silico* protein-ligand interactions revealed that, triamcinolone acetonide, produced during the ditrophic interaction of *B. velezensis* (YEBBR6) with *Fusarium oxysporum* f.sp. *cubense* (*Foc*) was effective against *M. incognita* protein targets such as cytochrome C oxidase subunit 1, calreticulin,

neuropeptide G-protein coupled receptor, chorismate mutase 1, venom allergen-like proteins and β-1,4-endoglucanase. *In vitro* bioassay of these biomolecules in wet lab indicated that, they had the nematicidal property and was effective against *M. incognita*. Exposing RKN Juveniles at 93 ppm, 76 ppm and 64 ppm caused 50% mortality after exposing at 24 h, 48 h, and 72 h, respectively. However, exposing the RKN juveniles at 100 ppm caused 100% mortality. Similarly, germination of egg masses was more than 60 percent at lower concentration and 100 percent germination was observed in control. However, exposure of egg masses to 100 ppm concentration had only one percent germination and thus confirmed the nematicidal property of the test biomolecule. In order to decipher the mechanism of action of these effective biomolecules, which was identified by were chromatography–mass spectrometry (GC-MS), was subjected to molecular docking and simulation studies against six putative protein targets of *M. incognita*. Triamcinolone acetonide exhibited the highest binding affinity with the selected protein targets of *M. incognita* than the carbofuran 3G and fluensulfone. Thus, the study establishes the potential of triamcinolone acetonide as a novel biopesticide, which can be utilized further to manage the infection caused by *M. incognita* in banana.

Keywords: *Meloidogyne incognita*, *Bacillus licheniformis*, *Bacillus velezensis*, Soluble protein, Total phenols

C. Forestry and Agroforestry

C-01: 'PM POSHAN'-Biomedicines Midday Meal Ecology (BMDME)': Enriched School Health Nutritious Food Agriculture Forestry Science Technology Biodiversity Wildlife Conservation

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In the 'Azadi Ka Amrit Mahotsav', the 'Biomedicines-midday-meal-ecology (BMDME)'- 'PM POSHAN' in school, is badly affected by lockdowns hampering human civilization; global education, research, health, and well-being, biodiversity conservation, ecological balance, food-producing systems, and climate regulation, enrolment, classroom hunger and malnutrition, socialization, attendance, and retention rates, and women employment playing a vital role in the education of underprivileged children. On the other hand, recently conventional vaccines have high production costs, and complex purification processes, and have not always had bio-safety in issues, time-consuming, and bio-safety test commercial production issues, and weakening the ability of vaccines to prevent pathogens causing diseases. To overcome it, the main objective is to see/confirm the impact/study of 'Bio-Medicines-Midday-Meal-Ecology (BMDME)' among school children for "Understanding Eco-System for Nutrition, School Health, Nutritious Food Science and Technology, and well-being". And the weed amaranth, vegetables; okra, and cowpea, fruits cucumber, and spices; ginger, turmeric, and garlic, are selected biomedicines for preventive treatment measures as "BMDME" following 'Mid

Day Meal Scheme or Menu', getting positive impact on growth, obesity, malnutrition, colds, cold and flu, and eye diseases, coronavirus-2/-3infections-or-reinfections with different diseases, 'Sedentary-Life-Style, Food-Habits, Health-Hazards, and Bio-Medical-Ecology-Research, Enriched School Health Nutritious Food Agriculture Forestry Science Technology Biodiversity Wildlife Conservation', and enriched biodiversity conservation with the joyful school environment. So, the 'PM POSHAN', 'BMDME', and the biodiversity of 'Wildlife (Owl, wild cats, mongoose, and bats) Conservation', are bringing together clues or experts in infectious disease diagnostics, surveillance, vaccine development, and therapeutics, that will enable a swifter and more focused response to the next global pandemic, and future immunotherapy design in type-2 diabetes and other inflammatory conditions also.

Keywords: Biomedicines-Midday-Meal-Ecology; Enriched; School-Health-Nutritious-Food-Agriculture-Forestry-Science-Technology-Biodiversity-Wildlife-Conservation

C-02: Agro Forestry for Sustainable and Boosting Agriculture Production

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Agroforesty is a new concept of cultivation which is a combination of Agriculture and forestry (trees). *Agroforestry* is a form of multicroping system along with beneficial trees and shrubs. Due to urbanization and Industrialization, which led to deforestation and destruction of environment. Trees will increase soil fertility, prevents soil erosion, restores soil moistures, retention of C^+ carbon in cultivation soil. Thus, all these favourably contributes

natural resource management. Trees are an ultimate solution to meet crisis of firewood, timber, fiber, cattle field & green manures etc.Hence, adoption to a new concept of *Agroforestry* is promising one. *Agroforestry* is self *sustenance* and round the clock profit earned by our farmers. *Agroforestry* subsequently increases National income to GDP and farmers economy.

Keywords: Agroforestry, Sustainable

C-03: Conservation and Sustainable Management of *Pithecellobium dulce* roxb. (benth.) - A Nitrogen Fixing Wild Edible Fruit

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Native wild edible fruiting tree species are being lost, mainly due to widespread deforestation resulting from population growth, demand for firewood or fodder and unsustainable harvesting of fruits making the major reproductive unit unavailable for natural regeneration. Realizing the importance of wild fruiting trees, the Institute of Forest Genetics and Tree Breeding, Coimbatore has undertaken the tree improvement and conservation of *Pithecellobium dulce*, commonly known as Jungli Jilebi. What's unique about *Pithecellobium dulce* is that it is a nitrogen fixing species that can adapt to wide range of soil types, survive environmental stresses and produces nutritionally rich fruits for consumption by humans, animals and birds. Conducted population survey, identified and selected 55 high fruit yielding candidate Plus Trees (CPTs) of

P. dulce from different agroclimatic zones of Tamil Nadu, recorded tree passport data, collected fruits and characterized for its nutritional parameters, raised and assembled germplasm of the CPTs for multilocational trials. The CPTs showed variation in its fruit and seed morphology and nutritional parameters indicating good scope for tree improvement and variety development. Hence conservation and sustainable management of *P. dulce* will help to promote cultivation of the species in dry lands, improve soil nitrogen, provide livelihood support for farmers and ensure nutritional security as a wild resource.

Keywords: Pithecellobium, Jungli jilebi, Wild fruit, Conservation, Sustainable management

C-04: Diversity of Family Coccinellidae in different Ecosystems under South Gujarat

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The study was carried out at Navsari Agricultural University, Navsari during the year 2020–2022. The istudy on diversity of family Coccinellidae revealed that a total of 1184 coccinellid specimens were observed and collected from different vegetation. The specimens were diagnosed and the morphs of different species were described. These specimens were grouped into sixteen species belonging to seven tribes and fifteen genera. Among the seven tribes, Coccinellini contributed 50 per cent with eight species followed by Chilocorini (12.50%) and Coccidulini (12.50%) with two species. The percentage of *Cheilomenes sexmaculata* (Fabricius) was highest contributing to the 30.07 per cent of the specimens collected followed by *Illeis cincta* (10.81%) and

Illeis sp. (7.94%). Among different crops and weeds, mulberry recorded the highest diversity with eight species, followed by cotton with seven species. The least diversity was recorded in Indian bean, okra, chilli, banana, chrysanthemum, *Gaillardia* sp. and the weed *E. hirta* with only one species. The prey associated with the different Coccinellid species in different crop ecosystems includes aphids, thrips and mites. Maximum numbers of coccinellid species were recorded during November-March months and decreased during April-June round the survey period. *Cheilomenes sexmaculata* (Fabricius) was found round the year and *Coccinella transversalis*, *Hippodamia variegata* (Goeze) and *Propylea dissecta* (Mulsant) were most frequent during survey and on different host plants.

Keywords: Diversity, coccinellid, ecosystems

C-05: Evaluation of Newer Insecticides against Poplar Leaf Defoliator *Clostera cupreata* But. (Lepidoptera:Notodontidae) in India

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Clostera cupreata But. is a dominant insect pest of *Populus deltoides* in Northwestern India. The infestation of this pest reported to be more than 50% in major poplar growing regions. In present study, bio efficacy of five newer insecticides (Flubendiamide 39.35% SC, Chlorantraniliprole 18.5% SC, Imidacloprid 17.8% SL, Emamectin benzoate 5% SG and F16 botanical extract) were evaluated against *C. cupreata* and the median lethal concentration (LC_{50} value) was calculated through leaf dip method under laboratory

condition. The result revealed that all the treatments were significantly superior over control and Emamectin benzoate was found to be the most toxic with least LC_{50} followed by Imidacloprid, Chlorantraniliprole, F16 botanical extract and Flubendiamide at 24, 48 and 72 hr. after treatment. This study will be useful for better management of this poplar leaf defoliator.

Keywords: Bio efficacy, Insecticides, Poplar

C-06: First Report on New Insect Pests of *Dalbergia latifolia* (Roxb.) from Uttarakhand, India

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Dalbergia latifolia is an economically important premium timber yielding tree species. Only two insect pests have been recorded from India till date. The present study was undertaken in to investigate the insect pest of *D. latifolia* from Uttarakhand. Resulted eight insect pests i.e., *Gastrophysa viridula, Chrysochus cobaltinus* (Coleoptera: Chrysomelidae); *Apoderus* sp. (Coleoptera: Attelabidae); *Ectropis bhurmitra, Hyposidra talaca*., *Plecoptera reflexa* (Lepidoptera: Geomatridae); *Ricania speculum* (Hemiptera: Ricanidae); *Leptocorisa acuta* (Hemiptera: Alydidae); *Leptocentrus taurus* (Hemiptera: Membracidae) and *Dorsicha stebbingi* (Hemiptera: Margarodidae) have been reported first time from India. Furthermore, the nature of damage and infestation intensity have also been studied.

Keywords: *Dalbergia latifolia*, Timber yielding, Coleoptera, Lepidoptera, Hemiptera

C-07: Identification and Development of Microsatellite Markers in *Terminalia bellirica*

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The *T. bellirica* genetic resource is still scarce. Genetic studies will offer great potential to detect allelic forms of a gene and phenotypes and accelerate the progress of *T. bellirica* research. The genome of *T. bellirica* was sequenced using Illumina paired-end sequencing technology and approximately 6 GB raw data was obtained, which was further de novo assembled into contigs. Totally 66015 SSRs were identified and 26,570 primers were successfully designed using Primer 3. Based on high GC %, no. of bp and unit size, a subset of 50 SSRs was selected and synthesised for validation. Based on the experimentation carried out, the PCR amplification conditions and annealing temperature was standardised for each primer. Out of 50 SSRs, 13 primers were successfully amplified within expected product range. Amplified SSRs were further screened for polymorphism on 25 randomly selected *T. bellirica* genotypes. The results showed that, 10 SSRs were polymorphic in nature.

Keywords: *T. bellirica,* PCR, SSRs

C-08: Identification of Seed Production Areas- An Important Step in Tree Improvement Programme

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Natural or planted stand or group of stands, set aside, periodically rouged, and treated to stimulate seed production is defined as seed production area. Developing seed production areas is one of the first step in tree improvement programme that can be used to obtain genetically improved seeds for immediate planting. It is usually for the short term in nature. The purpose of a seed production area is to provide, in quantity, seeds of known origin from the best phenotypes available. Establishment of seed production areas represents an innovative solution to securing much-needed understory species and improving regional biodiversity. Our study aims to identify seed production areas of important tree species (*Prosopis cineraria, Tecomella undulata, Zizyphus spp.* and *Salvadora spp.*) of Rajasthan and then their assessment based on the growth, form, seed yield and superior stands/ plantation by sampling and ranking them. Evaluation of seed stands of these species will be helpful in the identification of best seed production area for the operational planting programmes for the improved productivity.

Keywords: Biodiversity, Phenotypes, Quality seeds, Tree improvement

C-09: New Records of Pteromalid fauna (Hymenoptera: Pteromalidae) from Jammu and Kashmir

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Pteromalidae is one of the largest family of superfamily Chalcidoidea. They are parasitic to larval (e.g., *Dinarmus basalis*), pupal (e.g., *Pteromalus puparum*) and adult (e.g., *Scutellista caerulea*) stages thereby playing an important role in biological control of various insect pests. World pteromalid fauna is represented by more than 4200 described species belonging to 640 genera. The present study documents Pteromalid fauna from Jammu and Kashmir. The pteromalid species were collected through sweep net, Yellow Pan Trap and with the help of Aspirator. As of now, 32 species of Pteromalidae (Hymenoptera: Pteromalidae) are recorded first time from Jammu and Kashmir. *Synedrus Kasparyani* is recorded first time from India (both male and female).

Keywords: New records, J&K, *Synedrus Kasparyani*

C-10: Bamboo a Versatile Resource for Rural Livelihood in Jharkhand: A Review

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Bamboo is known as green gold. It is strong, durable, renewable as well as environment friendly crop. Bamboo species are generally hardy in nature and has the ability to grow in any environment. Jharkhand which is tribal dominated state in India. Various organisation are working together to promote production of bamboo. The popular demand for Jharkhand's bamboo has increased all over the world. Some of the bamboo species found in Jharkhand are Bambusa tulda, Bambusa nutans, Bambusa balcooa and Dendro calamusstrictus. Around 500 types of crafts are made up of bamboo in Jharkhand. This paper reviews the production and uses of bamboo and accessing its utilization for livelihood support in the state of Jharkhand.

Keywords: Bamboo, Rural livelihood, green gold, Jharkhand

C-11: Feasibility of Association Mapping of Economically Important Traits in Forestry Tree Species

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With the aim of sustainable development and to fill the gap between the demand and supply, it is time to look for the alternative method to increase the productivity, quality and quantity of our forest resources. Improvement in the economic traits of forest trees can assist the task along with the increase in forest area. To enrich and improve the forest trees with better economically important traits and get genetically superior trees, identification of genetic structures, their interaction and genes responsible for these traits are necessary. Many mapping methodology have been developed to realize the process. Association mapping seems to be most promising. It is based on estimation of linkage disequilibrium (LD) and utilizes genetic recombination concept. Single Nucleotide Polymorphisms (SNP) marker acts a reliable and effective tool in this method. The key to association mapping is the choice of germplasm, collection of high quality genotypic and phenotypic data, selection of appropriate statistical method and verification of marker-phenotype association. Fisher's exact test gives a signiûcance test for LD and the feasibility probability. Candidate gene association mapping and genomewide association mapping (GWAS) are two widely used approaches. Many models have also been developed. Unified mixed model approach is highly effective which makes use of random markers and reveal multiple level of relatedness. Candidate gene mapping is more feasible in tree species having large sized

genome. But Genome wide association mapping is also effective as compared to QTL mapping even in tree species having large sized genome. Major successes have been achieved in mapping 17 QTLs associated with tree height, diameter at breast height and stem volume in *Populus*. In *Eucalyptus camaldulensis*, two 32 SSR loci (Embra 167 and Embra 39) are associated with shoot length and root length. Similarly, genes and QTLs responsible for wood quality and other traits have been successfully mapped in *Pinus taeda*, *Tectona grandis* and other tree species. However, there are still some financial and technical challenges like requirements of a large amount of markers, strong genotypic and phenotypic data collection, exact verification of association, etc. which need to be addressed. In addition to SNP and microsatellite, use of CNV (Copy Number Variations) can prove effective. Using integrated approach and development of high throughput sequencing method may accelerate the mapping process. This can have better application in tree breeding, tree improvement, understanding gene interaction, evolution, etc.

Keywords: Association mapping, Linkage disequilibrium (LD), Genetic recombination, Candidate gene association mapping, GWAS mapping, QTLs

D. Women Empowerment

D-01: Emancipating the Euphony of Farm Women Empowerment for Sustainable Development

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In the changing social milieu, women empowerment through collectivization reconstitutes an emerging and fast growing trend towards sustainable development of the nation. The women collectivization is one of the innovative and much needed concept to accelerate the women entrepreneurship, women self employment and women empowerment. The present study was conducted to explore the impact and challenges of women collective group on women empowerment through income generation and enhanced social status. The study was conducted in Coochbehar district of West Bengal. The multi-stage, purposive and simple random sampling procedures were followed in the present study. The total number of respondents for the study was one hundred eighty women collective group members. The result depicted that the changes in decision making ability and social status were high in case of the women collectives after joining the group. The prime reason for joining the women collectives was only for promoting their savings to utilize the money in lean period. Primarily the members of the women collectives are saving money for food security. The optimum tangible benefit of the members in women collective was one and only the enhancement of income. The major micro-enterprises the women collective members were associated with the agro-based enterprises for developing women entrepreneurship. The inadequate

training facilities for managing the women collectives and developing new agri-preneurship were observed as the major challenge for sustainable development with women empowerment. To usher a new era of sustainable development with women empowerment there is a need of collectivized women entrepreneurship development.

Keywords: Women empowerment, Micro-enterprise, Women entrepreneurship, Sustainable development, Impact and challenges

D-02: Impact of Government Schemes Related to Agriculture and Forestry on Tribal Women Empowerment

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India's Tribal population is over-dependant on agriculture and forest based livelihood. Tribal Women in Tribal communities play a very crucial and substantial role as they work harder in collection of minor forest produce, farming etc. Still they are considered vulnerable and marginalized as they have limited control over economic resources. Therefore there is a need for empowerment of Tribal Women in order to overcome these challenges. Indian Government has launched various schemes with the aim of uplifting Tribal Women by way of extending concessional financial assistance. The goal of this research paper is to study the effectiveness of various government schemes in attaining Tribal women empowerment.

Keywords: Tribal Women, Agriculture, Minor Forest Produce, Empowerment, Government Schemes, Financial Assistance

D-03: Resource Use Efficiency in Dairy Entrepreneurship for Women Empowerment

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Dairy enterprise is marginally profitable and women have ample opportunities to increase output by using more feed and hired labour inputs. There is great variation in the productivity and resource use efficiency of different breeds of milch buffalo reared in different resource situation due to variation in genetic characteristics. feeding and management practices. Ultimately, these resources affect milk production. Therefore, we studied resource used efficiency in women dairy business in Amravati district of Maharashtra. The data was collected from 120 milk producers randomly in four tahasils in Amravati district through questionnaire. Out of which, 32 improved buffalo milk producers were selected for study. Resource use efficiency was calculated by using cobb-Douglus production function. In this statistical analysis of resources used in the improved buffalo milk production shown that, the partial regression coefficient value were positive in the variables viz; medicines, vaccination, concentrate feed, breeding charges and in family labour where as values were shown negative in variables hired human labour,dry fodder and in green fodder etc. It is concluded that medicines, vaccination, concentrate feed, breeding charges and family labour were positive and had significant effect. Whereas, hired human labour shown negative though not significant. This may due to over employment of family labour in dairy business. As per this analysis, the responsiveness of milk output to proper vaccination, breeding and concentrate feed was high. The hired human labour showed negative though not significant this may due to over employment of family labour in dairy enterprise. So it is suggested that, the milk production in improved

buffalo can be increased by increasing the women's technical efficiency with the same resource base and technologies. There is a need for technical guidance to women particularly regarding scientific feeds and fodder management practices.

Keywords: Fodder, Concentrates, Labour, Resource Use Efficiency

D-04: Socioeconomic Empowerment of Women through Sericulture in Assam

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The paper tries to understand the lives of rural women involved in sericulture activities in Assam. The culture of silkworm and production of silk is found in most of the rural household of Assam and the rural women play important role in its activities. The objective of the study is to explore the socioeconomic upliftment of women through sericulture and to understand the challenges faced by the women in sericulture activities. The study was carried out through a qualitative methodology where 30 women were interviewed through a interview schedule which were open ended semi-structured questionnaire, as well as observation was considered to understand their role critically. The respondents were selected through a purposive sampling in three districts of Assam which is Kamrup, Darrang and Udalguri district. It is found that the involvement in sericulture activities has helped women in rural areas to enhance their livelihood. The rural women involved in commercialization of production of silk have given them the opportunity to be socioeconomically empowered by having liberty of their income generation. It is also found that most of the labor that involves women in the production of silk are mostly

household spaced labor whereas, the outdoor labor would involve the men of the families. Climate change has impacted the production of silkworm which has led to low production in many locations of Assam, which has ultimately affected the livelihood of people involved in these activities. These locations are mostly near urban areas or industries. It is also found that the modern machines and technologies are not properly introduced and cannot be used as most of them are top to bottom approach based. It is suggested that the government initiatives need to be from the bottom-up approach. As we know the real development of a place will occur if women are empowered, and to reduce poverty and achieve most of the SGDs, upliftment of women socioeconomically is vital.

Keywords: Sericulture, Women empowerment, SDG, Socio-economy, Livelihood

D-05: The Study of Role of Rural Women Farmers for the Economic Development vs Women Empowerment

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Agriculture is the backbone of the Indian economy. Women play a vital role in building this economy. Rural Women form the most important productive work force in the economy of majority of the developing nations including India. Rural women often manage complex households and pursue multiple livelihood strategies. Women make essential contributions to the agricultural and rural economies in all India. Their activities typically include

producing agricultural crops, tending animals, processing and preparing food, working for wages in agricultural or other rural enterprises, collecting fuel and water, engaging in trade and marketing, caring for family members and maintaining their homes. Many of these activities are not defined as "economically active employment" in national accounts but they are essential to the wellbeing of rural households. In the present paper the study was carried out for the women labourer in a village of western UP wherein lots of disparity was identified between the wages of man and women labourers. Keeping in view the disparity the issue was discussed in the Gram Panchayat resulting into equal wages for man and woman thus sensitising women empowerment and gender issue as well.

Keywords: Agriculture, Economy, Women labourer, Disparity in Wages, Women Empowerment

E. Medicinal Plant

E-01: Antifungal Activity of Different Medicinal Plants Metabolites against Soybean Root Rot Complex Causing Fungi

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Under laboratory condition, extract of different parts of ten medicinal plants were evaluated against soybean root rot complex causing fungi (*Sclerotium rolfsii*, *Rhizoctonia solani* and *Fusarium solani*) with three concentration (1000, 500 and 250 *g ml^{-1}) at five different time interval. the fungitoxicity of alcohol extract of medicinal plants against root rot complex causing fungi significantly varied with concentration and time intervals. All plant extracts were inhibitory to the mycelial growth of *S. rolfsii*, *R. solani* and *F. solani* as concentration of extracts decreased, the effectiveness of extracts found to be slower in inhibiting mycelial growth. Therefore, maximum growth inhibition of these fungi was recorded at 1000 µg/ml concentration in all cases. The extracts at 250 µg/ml concentration failed to inhibit the mycelial growth of these pathogens. At this concentration, Ashwagandha leaf, Bawchi seed and Kali haldi root extracts were found to inhibit the mycelial growth of these pathogens. Ashwagandha recorded maximum average per cent inhibition of mycelial growth of *S. rolfsii* i.e. 25.8, 20.5 and 18.9 per cent at 1000, 500 and 250 µg/ml concentration, respectively. The average per cent inhibition of mycelial growth of *R. solani* and *F. solani* was found to be maximum in Bawchi at 1000 µg/ml (39.3 and 32.4%, respectively), 500 µg/ml (37.5 and

33.2%, respectively) and 250 µg/ml (34.5 and 29.4%, respectively) concentration followed by Ashwagandha treatment.

Keywords: Antifungal, Medicinal, Root rot, Soybean

E-02: Medicinal Plants: Importance and Scope in Human Life

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India has one of the oldest, richest and most diverse cultural traditions associated with the use of medicinal plants. Medicinal herbs are moving from fringe to mainstream use with a greater number of people seeking remedies and health approaches free from side effects caused by synthetic chemicals. Recently, considerable attention has been paid to utilize eco-friendly and bio-friendly plant based products for the prevention and cure of different human diseases. India is endowed with rich bio-diversity. Amongst the ancient civilizations, India has been known to be rich repository of medicinal plants. Medicinal plants are the plants i.e. rich in secondary metabolites and/or potential sources of drugs. These secondary metabolites include *alkaloids, glycosides, coumarins, flavonoids, steroids* etc. These plants form the main base for the manufacture of drugs of Indian Systems of Medicine (Ayurveda, Unani, Siddha) and Homeopathy. These plants are found in various parts of the country in different environmental and climatic conditions.

Keywords: Medicinal plants, Human life

E-03: Studies on a Medicinal Mushroom (*Sparassis crispa* (Wulf.) Fr.) from the North Western Himalyan Forests

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The ultrastructure of mycelium and spores of *Sparassis crispa* (Wulf.) Fr. was studied using Scanning Electron Microscope (SEM) at different magnifications and the antibacterial activity of methanolic extract of this mushroom was determined *in vitro* against two pathogenic bacteria *Escherichia coli* and *Staphylococcus aureus* following agar well diffusion method using four different concentrations (25, 50, 75 and 100%). The methanolic extract showed significant reduction in the growth of tested bacteria. The extract showed maximum inhibitory effect on the growth of *E. coli* as compared to *S. aureus*.

Key words: *Sparassis crispa*, Ultrastructures, Antibacterial, *in vitro*, *Escherichia coli, Staphylococcus aureus*

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B.L. Chona	1961
B.N. Singh	1960
B.K. Kar	1959
P.N. Bhaduri	1958
E.S. Narayanan	1957
S.P. Raychaudhuri	1956
R.J. Kalamkar	1955
B.P. Pal	1954
N. Parthasarathy	1953
K.L. Khanna	1952
J.K. Basu	1951
R.L. Sethi	1950
R.S. Vasudeva	1949
Rai Bahadur Kali Das Sawhney	1948
N.L. Dutt	1947
Rao Bahadur V. Ramanatha Ayyar	1946
N.V. Joshi	1945
Rao Bahadur D.V. Bal	1944
Rao Bahadur Y. Ramachandra Rao	1943
R.J. Kalamkar	1942
K. Ramiah	1941
Jai Chand Luthra	1940
Rao Sahib T.V. Ramakrishna Avvar	1939
Rao Bahadur T.S. Venkatraman	1938
Rao Bahadur B. Viswanath	1937
A.K. Yegna Narayan Aiyer	1936
FJ.F. Shaw	1935
S.S. Nehru	1934
M. AfZal Mosain	1933
G.N. Rangaswamy Avvangar	1932
Dewan Bahadur Sir T. Vijaya Raghavacharya	1931
George Clarke	1930
Gabrielle L.C. Howard	1929
Rao Sahib T.S. Venkataraman	1928
F.J. Warth	1927
G.S. Henderson	1926
R.S. Finlow	1925
B.C. Burt	1924
Rao Sahib M.R.	1923
Ramaswami Sivam	1922
S. Milligan	1921
D. Clouston	1920
G.F. Keatinge	1919
L.C. Coleman	1918
J. Mackenna	1917
B. Coventry	1916
H.M. Mann	1915