BIOTIC SCIENCE CONGRESS, 2022

International Conference on

Recent Advances in Agricultural, Biological and Applied Sciences Research

8th -9th August, 2022, Nagaon, Assam, India

Organized by:

Society for Biotic & Environmental Research (SBER), Tripura

Nowgong College (Autonomous), Nagaon, Assam

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ABOUT SBER

The SOCIETY FOR BIOTIC AND ENVIRONMENTAL RESEARCH (SBER) came into existence on 2018 in Tripura under Act XXI of 1860 (Regd. No. 8067 of 2019/ NITI Aayog ID No. TR/2019/0229149) as a nonprofit scientific and educational society of likeminded academician, researchers, scientists from all over the nation for the increased furtherance and diffusion on knowledge of Life Sciences in general and Environment Science in particular.

OUR AIM AND OBJECTIVE

The main objective of the society is to make attempt for the development and extension of scientific research related to Life Sciences including Agriculture and allied branches and implementation of these research out comes in the upliftment of scientific and farming community. Its major aims and objectives include promotion and dissemination of innovative research outcomes among young minds and researchers, setting up regional and state Chapters, to hold national/international level conferences, symposium, seminars, training, brainstorming sessions, meetings.

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Any individual having degree or interest in Science and Environment including Agriculture and Allied branches of science/technology can be a member of the Society. The SBER shall consist of Honorary Members, Annual Members, Regular Members, Life Members, Student Members, Donor/Institutional Members. To be a member or fellow, the applicant must apply through online mode or through mail to the Secretary/Chairman along with membership fees.

Categories	Membership Fees (Rs.)
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MESSAGE

It is quite gratifying to note that Society For Biotic and Environmental Research (SBER) in collaboration with Nowgong College, Assam, will host an international conference on "Recent Advances in Agricultural, Biological, and Allied Sciences" on August 8 and 9, 2022. Recent Advances in Agricultural and Allied Sciences are the most important tools for assuring the future success of food sustainability in our country. The theme of this year's conference will focus on recent advancements in agriculture, and the timing of its organisation reinforces our goal of establishing an environment conducive to the interchange of ideas in the agricultural sector development despite the COVID-19 crisis. The entire world has steadily confronted agricultural issues posed by the pandemic of COVID-19 sector in addition, it is necessary to evaluate the immediate post-COVID-19 difficulties in agricultural sector and mitigation strategies for a sustainable food system in the aftermath of global warming COVID epidemic. It is hoped that there will be presentations, discussions, and knowledge sharing.

The distribution of information throughout the conference would serve as the foundation for addressing recent Agriculture and Allied Sciences encounter numerous obstacles. I'm aware that this conference is full with eminent speakers, a presentation of an innovative research study, and invited speeches. This will undoubtedly contribute to enhancing the knowledge of the participants in biological sciences. Agriculture and related sciences. I am thrilled that numerous international delegations are presenting papers and delivering keynote addresses and invited talks at the conference. Such a large meeting cannot be arranged without total dedication and assistance, participation of numerous individuals, including faculty, students, and sponsors. I respect them and send Greetings on the successful conclusion of the meeting. I strongly believe that this conference will aid future research initiatives and become the impetus for the interchange of research concepts.

I welcome you all once again to the conference and hope that you all will have great time ahead.

(Sarat Borkataki)
Principal
Nowgong College (Autonomous)
Nagaon::Assam

उद्यान एवं वानिकी महाविद्यालय

College of Horticulture and Forestry

केन्द्रीय कृषि विश्वविद्यालय, पासीघाट-७९११०२, अरुणाचल प्रदेश

Central Agricultural University

Pasighat-791102, Arunachal Pradesh

Prof. B N Hazarika
Dean

MESSAGE

The agrarian economy like India, where agriculture would be achieving its desired goal when the benefits trickle down to all the walks of the society, has tremendous scope for the development of agriculture sector. The ever increasing demand for agriculture products to meet the escalating human food basket necessitates growth of the industry. Therefore, I must say that adequate utilization of the resources through effective agricultural technology initiatives for agricultural development of India is must.

I am very happy to know that Society for Biotic & Environmental Research, Ward No-14, Ganki Near Gas Agency, Khowai, Tripura, India-799201, is organizing 2nd BIOTIC SCIENCE CONGRESS (BioSCon, 22) and International Conference on "*Recent Advances in Agricultural, Biological and Applied Sciences Research"* at Nowgong College, Assam, India on 8th – 9th August, 2022 and a Souvenir is going to be released on this occasion.

I am also happy to see that the society has initiated "Kisan Shiromoni Samman" for farmers and KVKs to encourage them in doubling the farmers income.

I truly believe that scientific presentations and deliberations during the conference will be stimulating and informative and would help in strategizing the action plan to enhance agricultural development throughout the globe.

I heartily extend my greeting and warm welcome to all the guests, delegates and participants of the event. I wish this event to be a great success.

01-08-2022

Prof. B N Hazarika

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MESSAGE

Agriculture plays a pivotal role in Indian economy. The important of the sector may be sector may be imagined fact that over 58% of the rural households depend on agriculture as their principal means of livelihood. The agricultural in India employs half of our population and we are greatly dependent on the farmers and agricultural labours to provide us with a means of substances. Yet, agriculture is one of the riskiest sectors to be employed in because it is dependent on uncontrolled factors like weather, market fluctuations and topographical conditions. So, technological and innovative inventions in agriculture are need of the hour.

In this context, Society for Biotic & Environmental Research, Ward No-14, Ganki Near Gas Agency, Khowai, Tripura, India-799201, is organizing 2nd BIOTIC SCIENCE CONGRESS (BioSCon, 22) and International Conference on "*Recent Advances in Agricultural, Biological and Applied Sciences Research*" at Nowgong College, Assam, India on 8th – 9th August, 2022 to provide agriculture a new height of success.

I am sure the conference would offer a platform for a wide array of stakeholders of agriculture and allied sectors to effectively discourse, especially on the matters of different issues, potentials and challenges in the agriculture sector. I wish the event all success.

A. Alice R.P. Sujeetha
2/8/22

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डा. अ. अरुणाचलम / Dr. A. Arunachalam
निदेशक / Director

MESSAGE

I am very happy to know that Society for Biotic & Environmental Research-Tripura is organizing 2nd BIOTIC SCIENCE CONGRESS (BioSCon, 22) and International Conference on "*Recent Advances in Agricultural, Biological and Applied Sciences Research"* at Nowgong College, Assam, India on 8–9 August, 2022 and an e-Souvenir is being brought out to mark the occasion.

The conference will provide great scope for networking and foster fruitful partnerships between various stakeholders. The keynote and plenary talks from leading scientists and experts, as well as the oral and poster abstract presentations in the various scientific sessions, will provide you the participants with the most up-to-date information in the field and insights for addressing the current societal needs.

I sincerely hope that this international conference will be intellectually rewarding and will provide the most benefit to young researchers, faculty, and students. I convey my warm greetings and extend my best wishes for the success of the conference.

I convey my best wishes for the grand success of the International Conference on "*Recent Advances in Agricultural, Biological and Applied Sciences Research"*.

(A. Arunachalam)

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Floristic Diversity of Assam: Species Novelty, Rediscovery and New Additions

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Abstract

Assam is located at the central part of the North-East India and with an area of 78,438 km² representing 2.39% of Indian land mass situated in between 24°18′ and 28°18′ N latitude to 89°42′ and 96°30′ E longitude. The state is having great diversity of ethnic communities with rich flora and fauna. The largest floristic outcomes of Joseph Delton Hooker, *i.e.*, "Flora of British India" (1872-1897) and the first regional flora, *i.e.*, "Flora of Assam" by U.N. Kanjilal and his co-workers (1935-1940) have focused the botanical composition of the region. The first systematic works were concerned with the flora of Assam which includes all seven states of North-East region. However, before that many workers had initiated the pioneer botanical work from this region. Some of the renowned botanists like Roxburgh (1820-1824, 1832), Wallich (1820-32), Hooker (1854, 1872-97) are among such earlier collector's. Dr. N.L. Bor, a forest officer studied the grasses of Assam and Published the 5th volume of the Flora of Assam in 1940. After that Botanical Survey of India is taking initiatives to explore floristic diversity in the state and an account of the flora was published in Floristic diversity and Conservation strategies in India. A list of 3,017 species belonging to 115 genera and 21 families for the Flora of Assam was compiled which constitutes about 86% of the Kanjilal's Flora of Assam. Besides that the documentation of floristic diversity of several such area of the state has been made by a number of works. A total of 4,273 species comprising of 148 genera, distributed in 272 families of vascular plants were recorded from Assam, which represents about 25.12% of the total flora of India but unfortunately, there are areas and certain plant groups still remain to be explored scientifically. In the last couple of years we involving the floristic study of the present political boundary of the state and collected and documented almost 1,400 flowering and non flowering plants. However, as the present work is concern the author presented 30 interesting floristic elements, including new species, new variety, and additions to Flora of Assam with several rediscovered taxa. Of the reported species two species *viz*., *Ophiorrhiza recurvipetala, Smilax sailenii* are new to the plant science. Two species *viz*., *Tacca chantrieri* André (Taccaceae) and *Smilax china* L. (Smilacaceae) are reported as a new record for the Indian flora. *Sarcopyramis subramanii* Nayar (Melastomataceae) has only been collected once in India, from the Lushai Hills in Mizoram state in 1926. Besides these several flora has been reported as an additions to flora of Assam and rediscovered elements.

Keywords: Exploration, Flora of Assam, New report, Species novelty, Utilization

Underutilized Horticultural Crops of North East India and their Exploitation Potential

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Abstract

The North-East India the richest reservoir of plant diversity in India and is one of the 'biodiversity hotspots' of the world supporting about 50% of India's biodiversity. Northeastern region occupy 7.7% of total geographical area of country and harbours 50% of Indian flora (8,000 species) of which about 4% is endemic (2,526 species). The distinct tribes in the region have rich indigenous knowledge system on the use of components of biodiversity for their daily sustenance like food, fodder, shelter and healthcare. The region has several unique features such as fertile land, abundant water resources, evergreen dense forests of about 66%, high rainfall, and agriculture-friendly climate. Its unique phyto-geographical positions, topography and high degree of precipitation are some of the important factors which are mainly responsible for its enormous biological diversity. As a result, an array of diverse plants are grown across the region ranging from tropical to alpine. A large number of diversity in fruits belonging to the genera Artocarpus, Annona, Averrhoa, Garcinia, Musa, Passiflora, Phyllanthus, *etc*. are reported from the region. Besides diverse vegetables particularly wild leafy vegetables, rare genotypes of cucurbits, solanaceous vegetables, chilli, ginger, turmeric, *etc*. are there with some unique quality because of their locational advantage. The region has a great ethno-cultural diversity with major and sub-tribes, which explains the wealth of traditional ecological knowledge among farmers. People of region have their own culture, tradition and medicinal system of treatment and knowledge acquired through close observation of nature. Its ethnic people living in the remote forest areas still depend to a greater extent on the forest ecosystems for their livelihood they collect different medicinal plants and use them in traditional ways to cure their health related forms. The minor and wild fruits are mostly used to cure various gastrointestinal disorders, respiratory problems, cardiovascular compliance, muscular illness, bone diseases, gynaecological problem, cancers, snake bite, allergy and malaria *etc*. by local people of the region. This indigenous system of treatment based on such fruits is still an important part in social life and culture of the tribal people. However, this traditional knowledge of the local people has been transferred from generation to generation without proper technological interventions.

Keywords: Biodiversity, Gynaecological problem, North East India, Underutilized horticultural crops

Treescapes for Achieving 4 per Mille Carbon: Research Experiences from Darjeeling Himalayas and its Foothill Landscapes

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Introduction

Forests are the storehouse of several resources that benefit lives environmentally, ecologically and socially. They are widely recognised as a carbon pool that sequesters enormous amounts of carbon in biomass and soil. Soil is a complex mixture of mineral nutrients, water, air and organic matter (Well and Brady, 2017). It provides a substratum for all living organisms in the terrestrial ecosystem (Lal, 2008). Soil sustains healthy vegetation and plays a significant role in an organism's food and life cycle, being a nutrient reserve. Forest soils are unique due to the deep-rooted plants, decomposing litter, organic matter and presence of soil organisms (Boyle, 2005). Forest soils are characterised by organic humus layers L, F, H and woody debris; they harbour microorganisms beneficial to decomposition. Besides, forest soils regulate the global carbon cycle by sequestering a significant amount of carbon stock from the atmosphere (Shapkota and Kafle, 2021). Despite the importance, nowadays, forest soils are facing threats that may be natural (drought, storm and wildfire) or anthropogenic (deforestation, fragmentation and pollution) (Wilpert, 2022). COP 21 launched the "4 per mille Soils for Food Security and Climate" to increase global soil organic matter stocks by 4 per 1000 (or 0.4%) per year as a compensation for the global emissions of greenhouse gases by anthropogenic sources (Minasny *et al*., 2017). Forest soils are far way apt for achieving the goal of 4 per mille compared to other agricultural lands.

In addition to forests, the trees outside forests (TOF) are the determining factors in the expansion of tree cover, which in turn helps to achieve the carbon sequestration goals of the country. According to the state of forest report 2021 by the forest survey of India, there is a high rate of increase in growing stock in TOF (8.35%) compared to forests (2.68%). Hence, not only the restoration of forest ecosystems, but also the elaboration of TOF is essential for sustaining the resources and overcoming the climate change crisis.

Forest Soil: Peculiar Features and Importance

Forest soils are porous, aggregated, well-differentiated soils with plenty of organic matter. Although they are thin, less fertile and stonier than soils from other land-use forms, they provide mechanical anchorage to trees (Burst, 2020). Forest soils are pivotal in the functioning of the ecosystem, nutrient storage and decomposition. Also, they ensure a consistent supply of forest resources, especially vegetation, nutrients, water and oxygen (to roots). Thus, forest soil is a central "coordinating entity" for most ecosystem services (Wilpert, 2022).

Forests are efficient nutrient recyclers. Nutrients from the unreachable soil layers absorbed through deep-rooted plants will be stored as biomass and reach the surface through litterfall (Pierret *et al.,* 2016). Forest floors, covered with organic residues in various stages of decomposition, make a typical habitat for several soil-dwelling organisms (Takahashi, 2021). Compared to other land-use types, deeper reaching rooting zone and high activity of microbes, soil fauna, and plant roots in forest soil result in high humus contents that make it over-proportionally porous (Sokołowska *et al*., 2020). Moreover, the high demand of trees and soil biota for essential nutrients like phosphorous and nitrogen leads to low leaching rates of those elements in most forest soils (Makowski *et al*., 2020).

The litter layer in forest soils acts as a blanket to prevent surface runoff and erosion and increase soil water-holding and infiltration capacities. Furthermore, the litter or dead organic matter is considered synonymously with carbon pool by the Inter-Governmental Panel on Climate Change. Thus, the highly differentiated, hierarchical soil structure with the ion exchange capacity and the acid buffering capacity are the main characteristics of forest soils, confounding the desired ecosystem services (Wilpert, 2022). However, those functions of forest soils are vulnerable to several environmental and forest management activities such as monoculture, soil compaction (machinery use) and soil acidification. It necessitates the urgent need for sustainable forest

soil conservation to preserve their rich biodiversity, productivity and functionality. Soil and vegetation depend on and interact with each other one cannot flourish without another (Rwibasira *et al*., 2021). Among all other peculiarities of forest soil, its carbon sequestration potential is one of the globally demanding needs in this period of global warming and climate change.

Forest Soils: Sequestering Carbon to Reach the Goal of 4 per Mille

At the Conference of Parties (COP) 21, the French Minister of Agriculture Stéphane Le Foll set an ambitious international research program, the '4 per mille Soils for Food Security and Climate' of the Lima-Paris Action Agenda. The 4 per mille or 4 per 1000 aspire to increase global soil organic matter stocks by 0.4% per year as a compensation for the global emissions of greenhouse gases by anthropogenic sources (Minasny *et al*., 2019). It was launched during COP 21 in December 2015 and was supported by almost 150 signatories (countries, regions, international agencies, private sectors and NGOs). Stakeholders commit to a voluntary action plan to implement farming practices that maintain or enhance soil carbon stocks in agricultural lands and preserve carbon-rich soils (Chambers *et al.,* 2016; Lal, 2016). The outcomes highlight region-specific efforts and scopes for soil carbon sequestration. But the role of forest soil in meeting the objective is less discussed among stakeholders.

Soil organic carbon (SOC) stock is a principal part of the global carbon cycle that involves carbon cycling through the soil, plants, ocean, and atmosphere (Shapkota and Kafle, 2021). Forest soils account for 86% of the vegetation carbon pool and 73% of the soil carbon pool, and they serve as a global carbon sink (Zhang *et al.,* 2007). Global forest SOC stock was 580 Pg (Eswaran *et al.,* 1993), and interestingly 60-70% of carbon in forests is stored as organic material in the soil (Janssens *et al.,* 1999). Forest ecosystems fix two-thirds of the carbon in all terrestrial ecosystems annually. Moreover, forest ecosystems play an irreplaceable role in regulating the carbon balance, mitigating greenhouse gas concentrations, such as CO_2 and maintaining global climates (Zhang *et al.,* 2009). SOC in Indian forests is 1.6-1.8% of the carbon stored in the world's soils (23.4-47.5 Pg C or 23.4-27.1 Gt) (Shukla *et al.,* 2012).

Bhattacharyya *et al.* (2008) estimated that Indian soils contain only 9.55 and 24.04 Gt organic C (SOC) out of about 13.69 and 46.50 Gt of total carbon in the top 0.3 and 1 m soil, respectively. Sreenivas *et al*. (2016) estimated SOC of 22.72±0.93 in the top 1 m. Similarly, using modelling approaches, Falloon *et al.* (2007) estimated C stock for Indian soils as about 6.5-8.5 Gt, whereas Banger *et al.* (2015) reported the stock at 20.5 to 23.4 Gt. Thus, the Indian contribution to the global SOC pool is around 20-25 Gt for the top 1 m. Forests contribute around 9.38 Gt to the total SOC stock with a high mean SOC density (139.9 t C ha^{-1}) (Sreenivas *et al.,* 2016). Maji *et al.* (2010) suggest the requirement of immediate rehabilitation measures to improve SOC stock by considering the declining forest area and availability of 147 M ha of degraded land in India.

Increasing SOC; not only reduces greenhouse gas CO_2 in the atmosphere but also improves the soil structure. As a strategy for climate change mitigation, soil carbon sequestration buys time over the next ten to twenty years while other effective low carbon technologies become viable (Minasny *et al*., 2019).

Treescapes in 4 per Mille Carbon: Experiences from Darjeeling Himalayas and Its Foothills

The forest soils are facing several threats along with the population pressure, which attributes to the conversion of forest lands, decline in soil organic carbon (SOC) and heavy erosion (Zingore *et al.,* 2005). Hence, adopting suitable land uses and conservation strategies are essential; there comes the importance of trees outside forests (TOF) and other treescapes. Trees in the land restore the SOC that further enhance the soil structure, fertility, productivity and yield (Nyamadzawo *et al.,* 2007). Moreover, litters from trees are the principal source of SOC and other nutrients (Chakravarty *et al.,* 2019).

Corbeels *et al.* (2019) reviewed SOC storage under agroforestry systems and conservation-agricultural systems of sub-Saharan Africa. The result shows that multi-strata agroforestry systems store more SOC than the goal of 4 per mille.

Diverse vegetation and treescapes are characteristics of Darjeeling Himalayas- part of the Eastern Himalayan range and foothill Himalayas. Studies from this region revealed the importance of several treescapes, especially in urban parks, agricultural farmlands, homegardens and university campuses. Such landscapes are suitable for carbon sequestration nowadays, where land is a limiting factor and serious concern. Achievement of 4 per mille carbon becomes easy through small initiatives such as treescapes that involve local people and society in building up vegetation.

Himalayan Forests and Foothills

Rai *et al.* (2021) analysed the carbon storage by a single tree and mixed tree dominant stands of the eastern sub-Himalayan

region. In selected five forest stands, *Tectona grandis, Shorea robusta, Michelia champaca, Lagerstroemia parviflora* and miscellaneous, they quantified litter production, decomposition, periodic nutrient release, soil fertility status, and soil organic carbon (SOC). SOC varies significantly under different forest stands, highest estimated on miscellaneous species stands. In the study region, the SOC ranges between 75.9 and 107.7 Mg ha^{-1} up to 60 cm.

The study by Shukla and Chakravarty (2018) reported the soil carbon in the Sub-Himalayan forests of West Bengal as 75.83 Mg ha^{-1}. The SOC in the forest soil at 0-15 cm and 15-30 cm soil depth estimated was 1.80 and 1.59% which amounts to 40.27 and 35.56 Mg ha^{-1}, respectively.

The quantification study by Shukla *et al.* (2017) analysed the soil organic carbon and available nutrients in the litter of foothill forest plantations in the eastern Himalayas. The highest soil organic carbon was observed in *Tectona grandis* (2.52 Mg ha^{-1}) litter and the lowest in *Lagerstroemia parviflora* (2.12 Mg ha^{-1}). Litter is the source of soil organic matter, and the more litter, the higher the content and amount of soil organic carbon in the plantations and forests.

In teak stands of foothill forests in Indian Eastern Himalayas Shukla *et al.* (2014) analysed litter, nutrient status and carbon storage. The study highlights the linkage between carbon stock and land use, silvicultural practice, species and site quality. Total carbon is the sum of soil carbon (71.29), biomass carbon (873.1) and litter carbon (2.52) accumulated over a year, and it was estimated as 946.91 Mg ha^{-1}). In 2019, from the same location, Shukla *et al.* (2012) documented the biomass and carbon storage potential of shrubs. Like trees, shrubs also possess the ability to store carbon not significant as theirs. Besides, they increase the soil organic matter through litterfall.

Homegardens

The forest-like characteristic structure of homegardens enhances its carbon sequestration potential (Saha *et al.,* 2009). The carbon stock study by Subba *et al.* (2018) in the homegardens of Darjeeling and Terai region, West Bengal, reported the SOC in two soil depths as 26.24 and 19.49 Mg C ha^{-1}, respectively. Among the size-based categories of homegardens highest SOC tested in small homegardens (46.85 Mg ha^{-1}), followed by medium (46.38 Mg ha^{-1}) and large (42.82 Mg ha^{-1}). Home gardening practices sequester carbon in soil and aboveground and belowground biomass (Chakravarty *et al.,* 2017). Moreover, in addition to storing carbon in biomass and soil, homegardens reduce fossil-fuel burning by promoting wood fuel production and conserving biodiversity (Kumar and Nair, 2004; Subba *et al.,* 2018). Also, they help in conserving carbon stocks from existing natural forests by alleviating the pressure on these areas (Subba *et al.,* 2018).

In the northern part of West Bengal, the size of the homegardens ranges from 0.06 ha to 2.66 ha (Subba *et al.,* 2018). These small fragmented lands contain vegetation in 3-4 vertical layers along with households and livestock. Such systems ensure the conservation of soil organic matter through its high species richness and associated litterfall. The study from the Darjeeling Himalayas by Sarkar *et al.* (2020) documented 262 species, of which trees constitute 81. Homegardens are heterogeneous and ensure food security in addition to their environmental services like carbon sequestration and soil and water conservation. The study by Pala *et al.* (2020) reported total woody species biomass of 7482.67 Mg from 45 homegardens with the potential to offset 507.94 Mg CO_2 with a monetary value of US$ 1270, on an average of 83.31 Mg carbon $Homegarden^{-1}$ $year^{-1}$.

Urban Treescapes

Pradhan *et al.* (2022) investigated the potential of urban parks and institutional green areas as carbon sinks in the sub-Himalayan region. The study estimated the total plant biomass carbon of 434.78 Mg ha^{-1} and soil carbon of 50.82 Mg ha^{-1}. This study highlights the importance of human-modified and people-dominant landscapes in achieving the goal of 4 per mille. These urban green parks and institutional sites are permanent units that ensure sustainable carbon storage and help climate change mitigation.

University Treescapes

The study by Tamang *et al.* (2021a) at the university campus, Uttar Banga Krishi Viswavidyalaya, West Bengal- documented 1816 individuals belonging to 95 species that store a significant amount of carbon as aboveground (AGB) and belowground biomass (BGB). Total biomass carbon from woody tree species is 812.211 Mg ha^{-1}, of which AGB constitutes 79.40% and BGB 20.60%. Forest tree species sequestered more biomass carbon (322.95 Mg ha^{-1}) compared to plantation crops (169.695 Mg ha^{-1}), roadside plantations (107.069 Mg ha^{-1}) and fruit crops (45.190 Mg ha^{-1}).

Agricultural Landscapes

Tamang *et al.* (2021b) assessed the structure, biomass and carbon storage of the *Gmelina arborea* plantation from the agricultural landscape in the foothills of the Eastern Himalayas. The study strongly recommends the need for carbon farming units, especially in unutilized lands that trap additional CO_2 emissions due to anthropogenic actions. The research reported 48.18-55.73 Mg ha^{-1} available soil organic carbon (up to 60 cm depth) and 104.81-110.77 Mg ha^{-1} ecosystem carbon.

Conclusion and Recommendations

Understanding the long-term effects of tree species on soil properties is crucial for the development of forest restoration policies concerning the choice of species that meet both environmental and local livelihood needs. Soil C 4 per mille can make soils a sustainable resource, not a renewable resource. The best strategy is to restore the SOC content in degraded areas, as it offsets greenhouse gas emissions and provides benefits of enhanced soil conditions. Progress in 4 per mille requires collaboration and communication between scientists, farmers, policymakers, and marketeers. In addition, the initiative is an opportunity to implement a sound and credible soil carbon auditing protocol for monitoring, reporting, and verifying SOC sequestration, which can fit into national GHG inventory procedures (Chambers *et al.,* 2016). Trees outside forests are also a tremendous source of SOC accumulation. Hence, preference should be given to tree dominant land use conversions.

By considering the potential of forest soils and treescapes in organic matter accumulation and storage as organic carbon, their conservation measures should be considered in local, regional and national level planning. Conserving forest soils with vegetation is a cost-effective strategy to make the 4 per mille vision come true.

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Efficacy of Microbial Antagonists and Entomopathogens against Pathogen of Brinjal and Identification of Compatible Biocontrol Agents for Preparation of Consortia

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Abstract

Brinjal growers of Assam completely depend on the chemocentric cultivation practices to combat harmful pests and diseases, which not only increase the cost of cultivation but also affect consumers with pesticide residues. Moreover, the indiscriminate use of chemical pesticides, fertilizer *etc*. also causes harm to the environmental matrix. Development of an alternative eco-friendly IPDM module for sustainable production of the crop is the need of the hour. The study was undertaken with an aim to develop a consortium of the best phytopathogenic biocontrol agent and entomopathogens to get a combine effect against diseases and pests of brinjal. *In vitro* dual culture study revealed that out of six (6) biocontrol agents *T. harzianum* showed marked inhibition against *Rhizoctonia solani* (74.44%), *Fusarium solani* (70.68%), *Alternaria melongenae* (72.48%), *Sclerotinia sclerotiorum* (69.15%) and *Phomopsis vexans* (77.82). The best entomopathogens against brinjal pests *viz*., *Beauveria bassiana* and *Metarhizium anisopliae* selected from earlier *in vitro* study along with *T. harzianum* were tested for compatibility by co-culture method. The results showed that amongst the tested biocontrol agents, *T. harzianum* and two entomopathogens *viz*., *B. bassiana* and *M. anisopliae* were found to be compatible. All the three biocontrol agents may be used for preparation of consortium for management of pests and diseases of brinjal in organic cultivation.

Keywords: Brinjal, Biocontrol agents, Co-culture, Consortium, Entomopathogens

Pollination Management in Seeds Spices

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Abstract

Seed spices are the most important segment of food industry, plays a key role in creation of aroma and test of cooked vegetables and countless dishes over the world and predominantly in Indian sub-continent. India is blessing with 63 spices crops, among them, 20 spices are considered as seed spices, producing 20.64 lakh tonnes of seeds from 21.49 lakh hectare area. The foremost seed spices, includes coriander (*Coriandrum sativum* L.), cumin (*Cuminum cyminum* L.), fennel (*Foeniculum vulgare* Mill.), fenugreek (*Trigonella foenum-graecum* L.), ajwain (*Trachyspermum ammi* L.), celery (*Apium graveolens* L.), dill (*Anethum* sowa Roxb., *A. graveolens*), nigella (*Nigella sativa* L.), anise (*Pimpinella anisum*), and caraway (*Carum carvi* L.). Among these seed spice crops, all crops except fenugreek are of cross pollinated in nature. Pollination in these crops is a very simple practice involving transfer of pollens from the anther to the stigma of flower of same or different plants. In cross pollinated crops like seed spices, an external carrier is required to accomplish this process. A number of field trials were conducted at research farm of ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan to study the various aspects of pollination. Based on data it was found that the different seed spices crops attained a number of insect visitors have been reported to visit the floral component of a range of seed spices under natural field conditions. 28 species of floral visitors were recorded on coriander and dill seeds, 34 species were on ajwain and 26 floral visitors were recorded on fennel from different order and family. Among total floral visitors recorded, few honeybee species *i.e.*, *Apis dorsata* F., *A. florea* F., *A. mellifera* L., were found most frequent floral visitors on most of the crop flower canopy. *Ceratina sexmaculata* Smith, *Polistes hebraeus* and unidentified hymenoptera sp. 1 (Hymenoptera); *Episyrphus balteatus*, *Eristalis* sp., *Musca* sp. 1, *Musca* sp. 2, *Musca* sp. 3 (Diptera); *Dysdercus koenighii* F., *Oxycarenus leatus* Kirby were also recorded on seed spices to visit flowers. It was also found in the study that the managed pollination services through Aphis mellifera enhanced the productivity and essential oil content in seeds of seed spices *i.e.*, 49.4% seed yield and 0.48% higher essential oil content recorded in dill seeds over control plots.

Keywords: Crop, Management, Pollination, Seeds Spices

Conservation Agriculture Faming System Approach: New Paradigms for Resource Utilization

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Introduction

One of the challenges for food security is the exploding population which has little or no control. Based on the current rate of population growth (1.4%) and per capita consumption (215-230 g day^{-1}), the projected demand for rice by 2025 would be around 130 m tones respectively. The rice production has to be invariably enhanced by more than 2 mt annually to meet the future requirements. The projected demand has to be met in the background of declining land and water resource scarcity of labour and costly inputs which are making rice cultivation too expensive. Reducing the cost of cultivation and making rice cultivation more profitable to the farmers is the need of the hour. Among these constraints water scarcity will pose a major threat to rice cultivation and all out efforts are needed to enhance water productivity and to ensure production of more rice crop from every drop of water. The other aspects include greater competition for land, labor and water - good land diverted to other sectors, increasing production costs, resource fatigue - reducing factor productivity and land degradation so far challenges for food security is concerned.

Conservation Agriculture

India in general and Assam in particular is endowed with a rich and vast diversity of natural resources, particularly soil, water, weather and multipurpose tree species. To realize the potential of production system on a sustained basis, efficient management of natural resources is really a vital issue. Hence, we need to conserve these valuable resources to harvest the maximum and at the same time to sustain the same.

Resource conservation is the planned management of natural resources to optimize their utility, efficient usage in their original application, reuse and recycling. It is concerned with the energy consumption and wastes generated in all stages from production through the life of the product right up to its final disposal (Khanpara *et al.*, 2009).

Conservation Agriculture refers to the system of raising crops without tilling the soil while retaining the crop residues on the soil surface. It has emerged as a way of transition to the sustainability of intensive production system and it permits management of water and soil for agricultural production without excessively disturbing the soil, while protecting it from the processes that contribute to degradation like erosion, compaction, aggregate breakdown *etc*. (Bhale and Wanjari, 2009).

Need of Conservation

Tillage, the mechanical manipulation of soil is the main operation in conventional arable agriculture. Tillage has in the past been associated with increased soil fertility, which originated from the mineralization of soil nutrients as a consequence of the soil tillage operation. This process in the long run leads to reduction of soil organic matter which not only provides nutrients for the crop, but it is also, above all else, a crucial element for the stabilization of soil structure. Therefore, most soils degrade under prolonged intensive arable agriculture. This structural degradation of the soils results in the formation of crust and compaction and leads to use of certain implements like ploughs, disk harrow and rotary cultivators that have detrimental effect particularly on soil structure. Excessive tillage of soils may result in short term increases in soil fertility, but will degrade soils in the medium-term, structural degradation, loss of soil organic matter erosion and falling diversity are all to be expected.

- Conservation Agriculture (CA) is now a globally accepted agro-ecological approach to sustainable intensification of crop production.
- CA comprises resource conserving agricultural production practices that aim to produce more at fewer costs while enhancing the quality of the natural resource base.

- CA is all about generating multiple options for farmers who are endowed differentially.

Conservation Agriculture: The Principles

- Continuous minimum mechanical soil disturbances.
- Permanent organic soil cover.
- Diversified crop rotations in case of annual crops or plant associations in perennial crops.

New Paradigms in Conservation Agriculture

Reduced Tillage

Conservation agriculture means dramatic tillage reductions combined with adequate surface retention of crop residues. It aims at reducing tillage to the minimum necessary for ensuring a good seed-bed, rapid germination, a satisfactory stand and favourable growing conditions. It is practiced as ***row-zone tillage***- after primary tillage, the secondary tillage operation is done in the row zone only, ***Plough plant tillage***- after the soil is ploughed, a special planter is used and in one run over the field, the row zone is pulverized and the seeds are sown ***and wheel track planting-*** ploughing is done as usual and tractor is used for sowing and the wheels of the tractor pulverize the row zone.

Crop Diversification/ Rotaions

Conservation Agriculture is Enhanced by Diversified, Economical Crop Rotations. The rotaion of crops is not only necessary to offer a diverse diet to the soil micro-organisms but as they root at different soil depths, they are capable of exploring different soil layers and that are no longer available for the commercial crops, can be recycled by the crops in rotations. A diversity of crops in rotation leads to a diverse soil flora and fauna, as the roots excrete different organic substances that attract different types of bacteria and fungi, which in turn play an important role in transfornmation of theses substances into available nutrients. It shows: higher diversity in plant production, reduction and reduced risk of pest and weed infestations, greater distribution of channels or biopores created by diverse roots, better distribution of water and nutrients through the soil profile, exploration

for nutrients and water of diverse strata of the soil profile by roots of many different plant species resulting in a greater use of available nutrients and water, increased nitrogen fixaxtion through certain plant-soil biota symbionts and improved balance of N:P : K from organic and mineral sources and in-creased humus formation. Agroforestry can contribute to landscape diversity, benefiting the environment.



System of Rice Intensification (SRI)

This is an agro-ecological approach to agricultural and environmental conservation. The System of Rice Intensification (SRI) changes the management of plants, soil, water & nutrients promoting the growth of root systems and increasing the abundance and diversity of soil organisms.

The System of Rice Intensification (SRI) has been accepted as an alternative methodology for rice (*Oryza sativa*) cultivation (Laulanié, 1993). Developed in the 1980s in Madagascar it offers some instructive insights to focus on 'positive plant-microbial interactions'. SRI makes changes in age-old practices for managing rice plants, soil systems, irrigation and soil nutrient amendments that can increase crop yields by 50-100%, and sometimes by more, while at the same time reducing farmers' requirements for seed, water, fertilizer, agrochemicals, and often even labor (Uphoff and Kassam, 2009).

In SRI, rice plants do best when their roots can grow large because the plants are transplanted carefully at wider spacing and grown on soil that is kept well aerated with abundant and diverse soil microorganisms. SRI offers increased factor productivity of land, labour and water. Higher yield with lower inputs like water, fertilizers, seed, labour, *etc*. have made SRI attractive and rewarding. SRI is basically a set of principles and ideas that translated into agronomic practices. Now, SRI has acquired the status of yield enhancing and resource saving rice production technology (Dass *et al.,* 2015).

Aerobic Rice

A fundamental approach to reduce water inputs in rice is to grow the crop like an irrigated upland crop such as wheat or maize. Instead of trying to reduce water input in lowland paddy fields, the concept of having the field flooded or saturated is abandoned altogether.

Aerobic rice is a production system in which especially developed "aerobic rice" varieties are grown in well-drained, non-puddled, and non-saturated soils. Aerobic rice is a renewed way of growing rice in non-submerged unpuddled condition in aerated soils. Aerobic rice is grown like any other crops like Maize or Sorghum on dry soils with surface irrigations provided when necessary with intensive agronomic practices. With appropriate management, the system aims for yields of at least 4-6 t ha^{-1}. IRRI recently coined the term "aerobic rice" to refer to high-yielding rice grown in non-puddled, aerobic soil (Bouman, 2001). Aerobic rice has to combine characteristics of both the upland and the high yielding lowland varieties.

Aerobic rice is a suitable technology, in the following situations:

- "Favorable uplands": areas where the land is flat, where rainfall with or without supplemental irrigation is sufficient to frequently bring the soil water content close to field capacity, and where farmers have access to external inputs such as fertilizers.
- Fields on upper slopes or terraces in undulating, rainfed lowlands. Quite often, soils in these areas are relatively coarse-

textured and well-drained, so that ponding of water occurs only briefly or not at all during the growing season.

- Water-short irrigated lowlands: areas where farmers do not have access to sufficient water anymore to keep rice fields flooded for a substantial period of time.

Farming System Approach (FSA)

Farming system approach refers to the farm as whole rather than individual elements. Normally, it is driven by overall betterment of farming households through utilization of resources and profitability. The farming system approach introduces a change in the farming techniques for maximum production in the cropping pattern and takes care of optimal utilization of resources. In the integrated system, the farm wastes are better recycled for productive purposes.

The FSA takes care of all components/ elements in a holistic way which often we apparently call as integrated farming system or sustainable integrated farming system. In this integrated system, the farm wastes are better recycled for productive purposes. Moreover, judicious combination of crop enterprises and allied sectors like dairy, poultry, piggery, fishery, sericulture *etc*. in a given agro-climatic situation and socio-economic status of the farmers bring prosperity in this particular system of farming. Integration of various agricultural enterprises not only supplements the income of the farmers but also help in increasing the family labour employment. Thus, integrated farming is an approach to boost up family farming and a sustainable Integrated Farming Systems (SIFS) focuses on resource utilization and increasing farm productivity by increasing diversification, resource integration and creating market linkages (Korikanthimath and Manjunath, 2009).

Strategy for Farming Systems Approach

In the context of the challenges for horizontal expansion of land and agriculture, only alternative left is for vertical expansion through various farm enterprises required less space and time but giving high productivity and ensuring periodic income especially for the small and marginal farmers located in rainfed areas.

Under such circumstances, following farm enterprises could be combined:

- Agriculture + Livestock.
- Agriculture + Livestock + poultry.
- Agriculture + Horticulture + Sericulture Agro-forestry + Silvipasture.
- Agriculture (Rice) + Fish culture.
- Agriculture (Rice) + Fish + Mushroom cultivation.
- Floriculture + Apiary (beekeeping).
- Fishery + Duckery + Poultry.

Conclusion

Conservation agriculture can be looked towards as a way of farming and at the same time conserving and utilizing resources efficiently. The paradigms discussed are combination of several practices that includes changes in management of resources like labor, capital water, weeds and organics as source of nutrients. The basic principles followed in CA do better under any situation particularly for soil which is kept well aerated and rich with diverse microorganisms. Hence, based on results obtained so far CA wit new paradigms appear to be promising to enhance factor productivity and also increasing resource use efficiency in the days to come.

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Honeybee as Entrepreneurship for Agriculture Graduates in North-Eastern Region of India

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Abstract

The North-eastern region of India with assorted forage resources encompasses great potential in beekeeping. The honeybee species alive in the north-eastern hill region are *Apis dorsata*, *A. florea*, *A. cerana himalaya, A. mellifera, A. laboriosa*, *Tetragonula srikantanathi* and *Lepidotrigona arcifera*. Modern agriculture has come to depend greatly on the bees to fulfil its pollination needs. Pollen analysis from North-eastern hill region revealed that the dominant sporomorphs were *Brassica* sp., *Solamun* sp., *Helianthus* sp., *Wendlandia* sp., *Clematis* sp., *Adhatoda* sp. and *Mussaenda* sp. Bee flora was recognized as 107 plants from North-eastern region of India. Different types of entrepreneurship can be developed through beekeeping like honey bees rearing, queen rearing, consultancy to farmers for honey bee rearing, processing of honey at large scale and marketing of honey and by-products. Honeybee rearing is tranquil part of the small industry and has slight scientific support and infrastructure provided for the industry. It is important to distinguish the need for Indian honey in domestic and international markets and to start exploring new customs to increase productivity to meet growing demand. The beekeeping industry also plays a significant role in providing nutritious food to a plenty number of people.

Keywords: Beekeeping, Encompasses, Entrepreneurship, Forage

Scenario and Challenges in Agritech for Startup Ecosystem in India

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Introduction

The agritech ecosystem has attracted a surge of startups in India offering technology-based solutions like offtake marketplaces, storage and transportation services, and agronomy advisory services while large traditional players seek to reduce operational costs and manage scale more efficiently. India's Budget 2022-23 also contains provisions to support 'digital agriculture'.

As the global population reaches 7.9 billion in November, and estimated to reach 9.8 billion by 2050, food security has become a top concern across the world. The urgency for action also needs to address the scarcity of resources, distortions in distribution and access, and the need to expand agriculture outputs. Policymakers everywhere are now seeking sustainable methods to leverage technology in agricultural practices to alleviate this crisis.

It has catapulted the attention given to emerging agriculture technology (agritech), with startups in the area raising US$ 26.1 billion in funds in 2020 worldwide. This was a 35.4% growth over 2019. In fact, the global agritech market is projected to grow at a compound annual growth rate (CAGR) of 12.1% between 2020-27. India, too, is competing in this segment alongside China and the US.

Developments in agritech are hugely relevant to India's economy. Its agriculture sector, which is worth US$ 370 billion, continues to remain the main source of livelihood for over 40 percent of the population and contributes 19.9% (FY 2021) to the national GDP. However, despite the sector's contribution, it remains mired in structural weakness that inhibits the growth and productivity. In order to address these challenges and improve farmer's incomes, Indian agriculture needs technology-aided modernization, backed by resilient reforms - this is where agritech is expected to play a significant role.

India currently has over 1300 agriculture startups - which are actively employing artificial intelligence (AI), machine learning (ML), internet of things (IoT), *etc*. - to increase efficiency and productivity in the sector. The COVID pandemic has now put them on an upwards growth trajectory. The states of Karnataka and Maharashtra and the Delhi National Capital Region (NCR) are major hubs for agri-startups in India.

Contribution of the Agriculture Sector to India's Economy

Indian agricultural sector broadly comprises of farming (crops and horticulture) and forestry, livestock (milk, eggs, meat), and fisheries. Ranking second after China, it accounts for 11.9 percent of the global agriculture gross value added (GVA) of US$ 3,320.4 billion and contributes 12 percent to India's exports. Additionally, the sector also impacts consumption and production dynamics in non-agricultural segments, such as consumer products, retail, chemicals, and e-commerce.

The economic inter-linkages make the agricultural sector central to India's economic output and growth potential. It's also why reforms in the sector are sorely needed.

Impact of Agritech on Productivity and Efficiency in India's Agriculture Sector

Agritech primarily refers to an ecosystem of companies and startup enterprises that are capitalizing on technological advancements to deliver products or services for increasing yield, efficiency - both in terms of time and cost, and profitability for farmers across the agriculture value chain. The various segments within the agritech sector, which support the overall value chain, are:

- **Market linkage - farm inputs:** Digital marketplace and physical infrastructure to link farmers to inputs.
- **Biotech:** Research on plant and animal life sciences and genomics.
- **Farming as a service:** Farm equipment for rent on a pay-per-use basis.

- **Precision agriculture and farm management:** Use of geospatial or weather data, IOT, sensors, robotics *etc*. to improve productivity; farm management solutions for resource and field management, *etc*.
- **Farm mechanization and automation**: Industrial automation using machinery, tools and robots in seeding, material handling, harvesting, *etc*.
- **Farm infrastructure:** Farming technologies, such as greenhouse systems, indoor-outdoor farming, drip irrigation, and environmental control, such as heating and ventilation, *etc*.
- **Quality management and traceability:** Post-harvest produce handling, quality check and analysis, produce monitoring, and traceability in storage and transportation.
- **Supply chain tech and output market linkage:** Digital platform and physical infrastructure to handle post-harvest supply chain and connect farm output with the customers.
- **Financial services:** Credit facilities for input procurement, equipment, *etc*. as well as insurance or reinsurance of crop.
- **Advisory/ Content:** Information platforms online platform for agronomic, pricing, market information.

Agritech provides opportunity to plug several pain points that exist in the agriculture sector at present across the value chain, thereby expanding the market potential. Leveraging technology in India's agriculture sector can create opportunities for investment through modernizing and introducing systemic efficiencies.

Some ways in which this can be achieved are:

- Facilitating input market linkages supported with robust physical infrastructure network can address the existing issues related to volatility in input prices as well sub-optimal input selection.
- Precision agriculture can enhance yield by up to 30 percent.
- Digitalizing records through farm management can improve operational efficiencies and save costs.
- Introducing quality management and traceability will help farmers attain better outcomes in terms of high quality produce, further incentivizing them to continue with modern methods.
- Facilitating output market linkages through efficient post-harvest supply chain by eliminating inefficiencies, such as high wastage of farm produce, which is a win-win for both farmers as well as consumers.
- Offering better financial services, which could serve 30 percent of farmer households through access to credit, and 65% of farmer households through access to crop.

With ever increasing internet penetration in the country, and rural regions being the primary driver of this growth, India stands well equipped to adapt to changing methodologies in agriculture and transition from conventional business models to various innovative business models propelled by agritech.

Novel Alginate and β-lactoglobulin Matrix used as Wall Material for Encapsulation of Polyphenols to Improve Efficiency and Stability

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Abstract

The present study was aimed to develop a novel encapsulate materials of calcium-alginate and β-lactoglobulin complex for polyphenols using jet-flow nozzle vibration method. Encapsulated microbeads were characterized using SEM, FTIR, DSC, and MSI. Encapsulation efficiency of the microbeads varied depending upon the coating material in the range of 74.17-84.87%. Calcium-alginate-β-lactoglobulin microbeads (CABM) exhibited a smooth surface and uniform shape with an average particle size of 903.19 µm. CABM also showed better thermal and storage stabilities as compared to calcium alginate microbeads. The CABM resulted excellent target release of polyphenols (84%) in the intestine, which is more than 3 fold of the bioaccessibility offered by free polyphenol powder. Further study on individual phenolic acids after simulated gastrointestinal digestion (SGID), photo-oxidative and osmotic stress revealed that CABM significantly retained a higher amount of polyphenols and exhibited improved antioxidant capacity after SGID environment, and may have high industrial application for nutraceutical production.

Keywords: β-lactoglobulin, Blood fruit, Microencapsulation, Simulated gastrointestinal digestion, Target delivery system

Vascular Fatty Acid Mediates Host Resistance in *Arabidopsis thaliana* to a Clonal Proliferation of *Myzus persicae*

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Abstract

The present study explores a compatible interaction of *Arabidopsis thaliana* and *Myzus persicae* to enhance host susceptibility from a previous aphid herbivore mediated priming. The resumption of host resistance from the 'reduced host resistance' or 'enhanced host susceptibility' was also recorded in temporal scale when aphid herbivore was removed from leaf foliage. The vascular sap, isolated from the midpoint timing from the 'reduced host resistance' or enhanced host susceptibility' to the 'resumed resistance' phase resolved in GC-MS analysis that identified an enrichment of dodecanoic acid (DA), an antibacterial metabolite and a saturated medium-chain fatty acid with a 12-carbon backbone. DA infiltration into leaf foliage revealed a significant reduction of aphid clonal proliferation on leaf foliage with concomitant reduction of the vascular microbiota titer as well as aphid body. The 'resumed resistance' from 'reduced host resistance' or 'enhanced host susceptibility' also showed a comparable microbiota titer in comparison to control but the 'reduced host resistance' evidenced a significant higher microbiota titer which was correlated with an enhanced aphid clonal proliferation on the leaf foliage. The DA infiltrated leaf foliage had no effect on total vascular sap ingestion by the aphid herbivore but induced RNA level of *gus* expression under the control of promoter of *pad-4, mpl-1,* and *sag-13*. The similar pattern of *gus* expression recorded from aphid herbivore. Thus, DA mediates aphid resistance towards aphid clonal proliferation in the host plant by manipulating vascular and aphid body microbiota titer.

Keywords: *Arabidopsis thaliana*, Host resistance, *Myzus persicae*, Vascular dodecanoic acid

Importance of Microbiome and Its Impact on Rice Research

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Abstract

Rice is the staple food for more than 50% of world population. However, In India, researches are mainly looked at above-ground plant responses and very rarely focus on belowground interactions, such as soil health. Therefore, we have studied the various aspects of basic, strategic and applied research covering soil microbiology, soil biogeochemical cycles, and soil fertility particularly under changing climatic scenario to cater the problems associated with rice. Our long-term fertility and pesticide experiments revealed that continuous application of N-fertilizer alone over 47 years suppressed the certain bacterial phyla which were linked to rice yield reduction. Non-target effect of chlorpyrifos, imidacloprid and bispyribac sodium showed prominent affect on soil microbiome in paddy soil. Our study also showed that real-time N-application through leaf colour chart and slow release N-fertilizers could reduce N_2O emission, minimize yield loss and lower green house gas intensity in aerobic rice. Besides, we have developed rice-specific microbial formulations, *Azolla*-sporocarp-based biofertilizer, livestock feed and microbial-growth medium. Odisha government has given a grant of Rs. 284.36 lakhs to construct rice-specific liquid biofertilizers, *Azolla*, BGA and AM fungal production units. We have developed csaXpert mobile app and characterized the microbial resources in relation to nitrogen-fixation, nitrification, denitrification and straw-decomposition.

Keywords: Climate change, Microbial formulations, Nutrient management, Rice

Recent Advances in Host Plant Resistance to Stem Borer in Rice, *Oryza sativa* L.

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Abstract

Rice is the major and important staple food crop in Asian countries and the productivity is hampered by various biotic and abiotic stresses. Among various biotic stresses insect pests causes severe havoc on the yield of rice crop which leads to use of more chemical inputs. Recently, yellow stem borer, *Scirphophaga incertulas* W. is becoming major insect pest attacking rice crop and causing considerable yield loss. Stem borer cause damage at vegetative stage as well as reproductive stage and expressed the symptoms as 'dead heart' and 'white ear' respectively. The management tactics become futile due to the nature of internal feeding by the larva and most of the strategies failed to reach the target pest. Use of host plant resistance is a viable and eco-friendly option for the management of this borer pest. Promising and stable resistance in rice genotypes is yet to be realized. Major constraint in the development of resistant varieties includes viable screening technique and pest complexity. Even though no high level of resistance against this borer was reported in the primary gene pool of rice, conventional breeding has led to development of rice varieties like Ratna, Sasyasree, and Vikas which derived moderate level of resistance from the donor TKM-6. Field screening along with different types of artificial screening has to be adopted for identifying prominent and durable source of resistance. The data derived from the field screening has to be confirmed through artificial screening methods under controlled condition to verify the resistance for its stability and durability. However, artificial screening is difficult in case of yellow stem borer since lack of mass culturing techniques. The phenotype of resistance *viz*., morphological, physiological and biochemical factors controlled by different sets of genes are important criteria in resistant breeding programmes. Biotechnological approaches like genetic transformation, recombinant DNA technology are proved to be successful method for incorporation of resistance genes particularly *Bacillus thuringiensis* (*Bt*) genes. Another important strategy is RNA interference (RNAi) or RNA silencing which control the expression of resistance.

Keywords: Biotechnology, Rice, Resistance, *Scirpophaga incertulas*, Screening, Yellow stem borer

Challenges of Integrated Pest Management in the Twenty First Century: New Tools and Strategies to Combat Old and New Foes Alike

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Abstract

Seventy five years of research in the field of pest management, researchers are no closer to winning the "war against pests". In recent times a number of new promising pest management technologies and opportunities were developed to achieve the goal of reducing pre-harvest crop losses, however none of these alone are likely to be a panacea for pest management except in few of specific contexts. In last thirty years few genetically modified crops has grown steadily, but even for those crops this technology has not entirely displaced the use of chemical pesticides. There are few to which we can lessen our dependence on pesticides in the foreseeable future - modifying the goal from reducing pre-harvest crop losses to achieving acceptable or optimal yields with fewer chemical inputs - will rely not only on advances in the science of pest management, but also on society's willingness to accept newer technologies along with their inherent, and presumably lesser, risks. As one expert explained, we may need a crisis in food production or prices to deviate from current pest management practices, as in the industrialized world, "the alternatives all come down to economics." Going forward, risk and regulation will be key determinants of pest management practice. We should hope, at the least, that government regulatory decisions are informed by good science in the future.

Keywords: IPM, Pest, Pesticides, Technologies

Natural Farming: Principles, Practices and Opportunities in North East India

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Introduction

In India, more than 85% farmers are smallholders and more than 100 million farmers are working on an average 0.38 hectare (ha) land (MoA& FW, 2019). Most of the world's hungry and disadvantaged people reside on tiny farms and struggle to survive on insufficient amounts of land using low input/ low yield methods (Hazell and Rahman, 2014). The use of cutting-edge technology and innovation in Indian agriculture is seen as the only viable solution in this situation. Due to a number of factors, modern chemical-based agriculture has raised production costs, decreased factor productivity and depleted environmental resource base (Singh *et al.,* 2011). Crops grown year after year, such as rice, wheat, cotton, and sugarcane, deplete soil fertility, make topsoil infertile, deplete soil vitality, and primarily reduce the number of helpful soil bacteria (Sreenivasa *et al*., 2010). Environmental contamination may be occurring due to continuous use of chemical fertilizers, agricultural residue burning, and pesticide application (Singh *et al*., 2021). Their continuoususage decrease the soil micro and macrofauna which may directly affect C-N ratio, soil enzymatic activities and nutrient availability to plants (Shaikh and Gachande, 2015). Heavy use of

pesticides and chemical fertilisers, especially those containing heavy metals as Cd, Cu, Mn, and Zn, can pollute the soil profile and leach down to reach groundwater (Barabasz *et al*., 2002). The soil root zone contains various microbial communities which are beneficial effects on crop productivity. Continues use of herbicides decreased the soil microbial population (Agoramoorthy, 2008). When farmers invest more amount on inputs and does not get satisfactory production due to the incidence of pests and diseases and also/or adverse climatic conditions/ poor soil properties, it lead to amisery to their livelihood. The high-input, resource-intensive conventional agriculture practices cannot continue to deliver sustainable food and agricultural production (Babu *et al*., 2020). Hence, there is a pressing need for cost-effective and environment-friendly alternatives in agriculture to ensure sustainability (Devarinti, 2016).

The Natural Farming approach is farmers centric instead of production centric. It promotes sustainability, input use efficiency, healthy and safe foods, efficient supply chains and farmer's income. It is an agro-ecology based farming approach which relies on on-farm resources and inputs (Palekar, 2014). It focuses on changing social relations, empowering farmers, local value addition, and promoting short value chain. Methods like diversification of cropping, legume intercropping, mulching, seed priming and increased water retention through less tillage, *etc*. when used individually or in combination are likely to improve crop yield and adaptability under changing climatic conditions (Khadse *et al*., 2019). Replacing chemical inputs with natural inputs in certain ecosystem may promote better and well distributed root system and the ability to interact with beneficial soil microorganisms; contributing to soil, crop and seed health, good product quality, better yield levels and yield stability (Andow and Hidaka, 1998). Thus, natural farming in specific identified areas can help India to move towards achieving many SDGs by mitigating hunger, conserving natural resources and ensuring food and nutritional security in a sustainable manner (NITI Ayog, 2022). However, not many studies and information are available on this very important aspect of safe food production system which conserves and promotes all round sustainability of ecosystem and wellbeing of humanity.

Natural Farming Principles and Practices

Organic and natural farming systems are rooted to culture and customs of India. India has a rich heritage of traditional farming practices which are environment friendly and less resource intensive (Patel *et al*., 2022). The farmers of ancient India were known to have evolved nature-friendly farming systems and practices such as mixed farming, crop rotation, livestock and fish based farming and tree based farming among many others. Natural farming is a practice of synthetic chemical free farming based on livestock and local knowledge and resources. It is a cow centric agriculture with emphasis on inputs made using cow dung, cow urine, jaggery, pulse flour combined with mulching practices and symbiotic intercropping. Natural farming in India is presently promoted as Bharatiya Prakritik Krishi Paddhati Programme (BPKP) under Govt. of India scheme on Paramparagat Krishi VikasYojana (PKVY). THE BPKP is a diversified farming system which integrates crops, trees and livestock, allowing optimum use of functional biodiversity, with the promise to enhance the farmer's income while delivering multiple benefits, such as restoration of soil fertility as well as environmental health (NITI Ayog, 2022). Agro ecological practices such as natural farming offer less resource-intensive farming solutions and help reducing the dependency on chemical inputs. Agro-ecological practices are an alternative to conventional high-input agriculture, resulting in better yields without compromising the needs of the future generation and avoiding intergenerational conflict. These have been also advocated by the Food & Agriculture Organization (FAO) of the United Nations (Das *et al*., 2022). The possibility of crop production through natural processes like effective *in-situ* biomass (crop residues, weed biomass) recycling, minimum tillage and selection of tolerant crops have been indicated by Das *et al*. (2008; 2014). Such practices reported to sustain soil health, reduce cost of production and stabilize productivity under low input - marginal hill ecosystem (Das *et al.,* 2014). It is believed that more than 2.5 million farmers in the country still practice natural farming in India, most of them may be in rainfed areas, hills and mountain ecosystems.

The unchecked extraction of natural resources, combined with rising input costs sent many farmers into a debt trap. Low and stagnating yields and declining factor productivity, crop failure, depleting groundwater levels and associated issues of climate change negatively affecting the agricultural development and livelihood (IPCC). Climate change exacerbates the processes of land degradation including increase in extreme rainfall events (intensity and distribution), flooding, heat stress, dry spells, *etc*. Issues like pesticide residue in grains and economic products, depletion of groundwater, greenhouse gases emission, pesticides resistance, depletion of water quality and loss of biodiversity and genetic erosion and increasing production costs are some of the challenges around chemical intensive agriculture. The soil organic carbon content of Indian soils Particularly in IGPs has declined from 2.5% in 1947 to 0.4% which is at present well below than acceptable limit of 1-1.5% (Vision 2030). Deficiency of NPK, secondary nutrients (S, Ca and Mg) and micronutrients (B, Zn, Cu and Fe *etc*.) in most soils of the country is a limiting

factor in increasing food productivity (DAC, 2008). Most farming practices like increasing tillage intensity, timing of tillage, residue removal/burning, low organic manure application and others in intensive cereal-based cropping systems cause physical degradation of soil. Further, the use of agrochemicals for plant protection and weed management leads to the accumulation of toxic compounds in soil (Shahane and Shivay, 2021). Depletion of SOC has led to degradation of physical, chemical as well as biological properties of soil. Further, the indiscriminate use of agrochemicals has adversely affected soil biodiversity, composition and biochemical processes (Meena *et al*., 2020). The average annual soil loss in India is about 16 t ha^{-1} or about 5 billion tonnes annually (Saroha, 2017). Natural Farming aims at cultivating plants by promoting self-reliance to farmers while protecting the environment and stimulating harmony between animals, humans and plants for a sustainable development. The fundamental principle underlying natural farming is to guides the farmers in practicing sustainable farming that helps in retaining soil fertility to ensure chemicals-free agriculture and to ensure low cost of production (Palekar, 2016). Jeevamrit- nectar of life (consisting of microbes) that is prepared from dung and urine of indigenous cow (no other animals like exotic or cross-bred cows, bulls or buffaloes, Beejamrit- the seed treatment, Acchadana- mulching and Waaphasa- soil aeration/ moisture are some components of natural farming (Das *et al.*, 2022). The basic principles of natural farming are:

No or minimum soil disturbances: That is, no or minimal ploughing or turning of the soil. For centuries, farmers have assumed that the ploughing is essential for growing crops. However, minimal soil disturbance is fundamental to natural farming. The earth cultivates itself naturally by means of the penetration of plant roots and the activity of microorganisms, small animals, and earthworms.

No chemical fertilizer/ pesticides: Human beings interfere with nature and, try as they may, they cannot heal the resulting wounds. Their careless farming practices drain the soil of essential nutrients and the result is yearly depletion of the land. If left to itself, the soil maintains its fertility naturally, in accordance with the orderly cycle of plant and animal life. The sensible approach to disease and insect control is to grow robust crops in a healthy environment.

Managing weeds without chemicals: Weeds play their part in building soil fertility and in balancing the biological community. As a fundamental principle, weeds should be controlled, not eliminated.

Practicing intercropping ensures regular income for farmers as they can harvest different types of produce at regular intervals. Legume intercropping in cereal based system also helps in biological nitrogen fixation in soil and uniform distribution of nutrients in soil profile. The mixed cropping system also enables better nutritional value of soil, which boosts productivity levels. Further intercropping and mixed cropping/ farming reduces farmers' risks against crop failure and provides resilience against climatic vagaries (Das *et al*., 2022). Recent studies have observed that farmers cultivating rice, using chemical inputs, spent INR 5,961 $acre^{-1}$ on an average, while a farmer using natural farming techniques incurred only INR 846 $acre^{-1}$ as costs of natural inputs (Gupta *et al*., 2020). Mulching techniques used in natural farming improve the water retention capacity of soil, reduce crop irrigation requirements and control the concentration of groundwater contaminants. Chemical and water use substantially reduces under natural against conventional farming. Avoidance of unscientific chemical use and subsequent groundwater pollution also is additional benefit leading to better health. Beejamrit is a low-cost product of dairy excreta (*e.g.*, cow dung and cow urine) and forest soil, often supplemented with limestone. Population of free-living nitrogen fixers (FNFs) and the phosphate solubilizers (PSBs) reported to proliferate progressively up to 4- and 5-days of incubation. It has been identified as potential seed priming agenda for enhancing crop establishment and productivity (Mukherjee *et al*., 2022). Beejamrit is reported to rescue the seeds and plants from insect-disease infestation, especially against seed-borne diseases (Chadha *et al*., 2012).

India is the world's highest livestock owner with the sector having a growth rate of 4.6% per annum as per the 20th Livestock census. Further emphasis on livestock sector which provides multiple livelihood benefits may be revived due to promotion of natural farming, thus reducing risks associated with farming. Such practice may also lead to saving of huge amount spent on fertilizer and electricity. Due to promotion of RWH, soil moisture conservation, efficient water use, groundwater withdraw will also be minimized leading to sustainable development. The important components of natural farming are presented in Table 1.

Advantages of Natural Farming

- Reduction in cost of production.
- Effective utilization of on-and off-farm resources.

Table 1: Component of natural farming practices

Farming components	Soil and water conservation measures	Nutrient and Soil fertility management	Pest management (weed, insect and disease)	Remarks
Rice, maize, millets, vegetables, pulses and oilseeds, Indigenous cow, buffaloes, goat, farm mechanization, fodders in farm fences, MPTs (Tree bean, Moringa, Mango, Jackfruits, Alder etc., banana, pineapple), indigenous/ underutilized crops, apiculture, compost units etc.	Mulching, rain water harvesting, sowing 18 crops together (Navadanya), inter cropping, system of rice intensification, farm ponds, cover crops, composting, hedge row planting, ploughing/ sowing across the slopes in sloping lands, minimal soil disturbance/ no-till, minimum tillage.	Crop residue recycling, composting, dravajivamrit (200 l acre-1), Ghanajivamrit (kg acre-1), legume in rotation, cow dung, beejamrit, Panchagavya, *etc*.	Kashayam, Botanicals, HW, trap crops, bird perches, need extracts, sticky cards, leaf clipping, crop rotation, pheromone traps, light traps.	Adoption of location specific farming components based on agro-climate, soil, farmers resources and markets.

(Source: NITI Ayog, 2022, Das *et al*., 2022 & other sources)

- Improved soil health.
- Less residues in products.
- Increase in biodiversity.
- Reduction in lodging due to stronger root system.
- Climate resilient in nature.
- Improved soil and moisture conservation.
- Availability of fodder.

Scope of Natural Farming in North East India

Natural and organically produced commodities are a unique feature of the North Eastern Region (NER) of India that still has not reached their full potential. Much of the NER uses no or limited quantity of chemical inputs, and farmers mostly practicing traditional and natural farming. The hilly terrain, fertile plains, agro and forest biodiversity, wetlands, and good rainfall and soil fertility have supported the growth of nature based farming in NER. Efficient on-farm resource recycling, selection of seeds/ varieties for desired traits and identification of location with inherent advantage (high soil fertility, suitability to a particular crop, Geographical indicators, niche crop, high market demand, premium price *etc*.) may contribute to development of a natural farming package for the NER (Das *et al.,* 2008). The region has several location specific indigenous farming systems (like alder based farming system, Zabo farming, Panikheti, pond based farming system, Apatani rice farming *etc*.) which conserves natural resources, uses wisdom and rich traditional knowledge and promotes sustainable development (Das *et al.,* 2012; Das *et al*., 2015). Addressing the gaps that prevent natural, traditional and organic produce of the NER from leveraging the global market can provide significant economic gains and employment generation for the region. With its proximity to south East Asian markets, being home to diverse & exotic varieties of fruits, spices and orchids, the NER could emerge as a hub of agribusiness opportunities & can command a premium price both in domestic & international markets. Some potential natural agri-products from NER are indicated in Table 2.

Table 2: Important natural agri-products from North East India

States	Assam	Arunachal Pradesh	Meghalaya	Manipur	Nagaland	Mizoram	Sikkim	Tripura
Natural agri-products	Joha rice, Ketakirice, Karbian-glong ginger, and lemon Tezpurlitchi, Arecanut, Tea	Orange, Banana, Passion fruits, Jhum rice	Breakfast rice (Jasulia), Ginger, turmeric (*Curcuma longa* L.), Cashew (*Annacardiumoccidentale* L.) and Khasi mandarin	Tree bean (*Parkia roxburghii*), Rice bean (*Vigna umbellata*), Black rice, Purple rice, Kachai lemon	King chillis (Naga chilli) & Kholar bean (rajma), Naga tree tomato	Bird's eye chilli, Sugarcane, cowpea Chow-chow Banana and paddy	Large cardamom, Ginger, Dallechilli, Buck-wheat, Chow-chow, Sikkim mendarin, turmeric, tree tomato	Aromatick rice (Haryna-rayana, Kalikhasa, Binnidhan) Queen, pine apple [*Ananas comosus* (L.) Merr.], aromatic rice and jackfruits, Banana, Jampui orange, Arecanut, Tea

(Source: Das *et al*., 2022)

Products "Naga tree tomato", "Arunachal orange", Sikkim's "large cardamom", "Mizo bird eye chilli", Assam's "Karbi Anglong ginger", Tripura's "queen pineapple", Tezpur litchi, Meghalaya's "Khasi mandarin" and "mamangnarang" and Manipur's "kachai lemon" are the 10 agri-items of the NER that have GI tags. This serves as incontrovertible proof of their distinctive origin in the Northeast and protects them from production elsewhere (Das *et al*., 2022). There is a very huge scope of natural and organic livestock farming in the region. The NEH Region is enriched with an enormous livestock population, having 13.38 million cattle, 0.51 buffalo, 0.37 sheep, 5.4 goat, 4.24 pig, 69.22 poultry, 0.39 mithun and 0.029 million yak (20th Livestock Census - 2019, GOI) and among them most of livestock (cattle and buffalo, pig, goat *etc*.) and poultry population in the region are indigenous/ local, non-descript type, and well adapted in these climatic conditions. There are very huge demands of local animals and poultry birds particularly *desi* chicken and ducks and their eggs, which are sold at the premium prices in local villages or nearby urban settlements.

Strategies for Promotion of Natural Farming in North East India

In the present scenario, infrastructure & industry presence for processing and value addition of natural/ organic produces are negligible particularly in NER of India. Central Sector Scheme "Mission Organic Value Chain Development for North Eastern Region (MOVCD)" launched in January 2017 for implementation in the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, during the 12th plan period. In similar way, natural farming produces can be marketed with some special schemes and promotional activities. Most of the natural products are marketed either raw or semi-processed stage resulting to low income to the producers. However, few processing facilities set up by the Government or other agencies are running at a low key. According to the Agricultural and Processed Food Products Export Development Authority's (APEDA) data, only two North-Eastern States (Assam 11 metric tonnes and Meghalaya 1 metric tonnes) exported organic products in 2016-2017. Govt. of Tripura recently exported some pineapples to Dubai opening hope for income enhancement of farmers. Thus, farmers in this region are still far from the export market which could have helped them earn a premium price for their produce. Following strategies may promote natural farming and improve farmers' income.

- Identification of potential districts, locations and products.
- Capacity building of stakeholders for production, processing and marketing.
- Developing protocols for natural farming.
- Credit and marketing support to producers and marketing agencies.

- Packaging, branding and marketing strategies.
- Promotion of natural product based FPOs/ FPCs.
- Development of infrastructures for transportation, storage, processing, and marketing.
- Certification as natural farming products.

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Advances in Rapeseed-Mustard Disease Management in Assam

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Abstract

Oils and fats form an integral part of foods and flavours, cosmetics and condiments, soaps and detergents, lubricants and laxatives, besides their medicinal and therapeutic value. North East India is endowed with a wealth of vegetable oil resources in the form of cultivated annuals, which are grown during *Rabi* and *Kharif* seasons. The important oilseed crops grown in Assam are rapeseed-mustard, sesame, niger and linseed although in some areas groundnut and castor are also grown. Among the rapeseed-mustard group, *toria* is predominant because of the suitability of prevailing agro-climatic conditions and early duration (90-95 days) of the crop, which enables the farmers to go for the summer crop after harvest of *toria*. It is the major source of income especially for the marginal and small farmers in rainfed agro-ecosystems. Due to its low water requirement (80-240 mm), the *toria* crop fits well in rainfed cropping system and, it suits and adapts well in different cropping patterns. Rapeseed-mustard group of crops are cultivated in 26 states in the northern and eastern plains of the country and, about 6.4 m ha is occupied by these crops. In Assam, total oilseeds occupy 3.10 lakh ha with a production and productivity of 1.998 lakh t and 645 kg ha^{-1}, respectively (2020-21). Out of these, rapeseed-mustard group covers 2.86 lakh ha area contributing almost 93% of total oilseed production with an average yield of 647 kg ha^{-1} (Dept. of Agriculture, Govt. of Assam, Khanapara, Guwahati). Assam occupies about 4% of the national and 70% of NE India oilseed area under rapeseed-mustard; however, its contribution towards total production of oilseeds in the country is around 2% only. The major rapeseed-mustard growing districts of Assam are Lakhimpur, Kokrajhar, Barpeta, Dhubri, Dhemaji, Kamrup (Rural), Karbi Anglong, Chirang, Darrang and Morigaon.

The consumption of fats and vegetable oil in India is far below (11-14 g day^{-1} $adult^{-1}$) as compared to the recommendation of the Indian Council of Medical Research (35 g day^{-1} $adult^{-1}$). India imports about 70% of its edible oil requirement, estimated at around 23 million tones. The requirement of oilseeds in Assam is estimated at 6.11 lakh tones which show a deficit of 4.11 lakh tones. The present production can meet only about 33% of our requirement, and the deficit of about 67% has to be brought in annually.

Despite the high quality of oil and meal and also its wide adaptability for varied agro-climatic conditions, the area, production and yield of rapeseed-mustard in India have been fluctuating due to various biotic and abiotic stresses coupled with India's domestic price support programme. Biotic stresses caused by insect-pests (sawfly and aphids), fungal (*Sclerotinia* stem rot, white rust, downy mildew and *Alternaria* blight), bacterial and viral pathogens, parasitic weed *Orobanche* and other weeds collectively result in heavy yield loss. In Assam, the major biotic stress excluding insect-pests is *Alternaria* leaf and pod blight disease. *Alternaria* blight disease has been reported from all the continents of the world and is one among the important diseases of Indian mustard causing yield losses of 46-47% in yellow sarson and 35-38% in mustard with no proven source of transferable resistance in any of the hosts. *Alternaria* affects most of the cruciferous crops, *viz*., broccoli and cauliflower (*Brassica oleracea* L. var. *botrytis* L.), field mustard and turnip (*B. rapa* L. (synonym: *B. campestris* L.), leaf or Chinese mustard (*B. juncea*), Chinese or celery cabbage (*B. pekinensis*), cabbage (*B. oleracea* var. *capitata)*, rape (*B. campestris*), and radish (*Raphanus sativus*). *A. brassicae* and *A. brassicicola* are cosmopolitan in their distribution. *A. raphani* and *A. alternata* are widespread in the Northern hemisphere. Different species of *Alternaria* on *Brassica*s vary in host specificity. *A. brassicae* also produces a host-selective pathotoxin 'dextruxin B'. Survival of the pathogen on diseased seed or affected plant debris in tropical or sub-tropical India has been ruled out, unlike the situation in temperate conditions. Thus, air-borne spores of *A. brassicae* form the primary source of inoculum of this polycyclic disease. The inoculums get dispersed in field through air current and rain splashes. Weather plays an important role in the severity of *Alternaria* blight of oilseed *Brassicas.* Severity of *Alternaria* blight on leaves and pods were higher in late sown crops. To make Assam self-sufficient in oilseeds production through productivity increase, proper disease management through cultural, chemical and biological needs special attention.

Keywords: Alternaria leaf & pod blight, Biotic stresses, Epidemiology, Management, Rapeseed-Mustard

Exploring Community Mobilization for Pest Management

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Extended Summary

Social engineering is a data-based scientific system used to develop a sustainable design so as to achieve the intelligent management of resources and capital with the highest levels of freedom, prosperity and happiness within a population. A participatory approach, tends to focus initially on small numbers of clients participatory and is location specific in nature. Rather than "passive participation," it is aimed to inspire "self-mobilization", where communities organize and take initiatives independently to solve their problems/ issues. Community mobilization is the process of engaging communities to identify community priorities, resources, needs and solutions in such a way as to promote representative participation, good governance, accountability, peaceful change and achieving the objectives. Being a group approach, this concept profoundly relies on all the members coming together to achieve a common goal, finding technical solutions and building capacities in the extension system and bridge the gaps in knowledge and technology dissemination. An underlying purpose of participatory approaches is the 'empowerment' of disadvantaged groups (Farrington and Martin, 1988; Tavernier, 2006) where large community mobilization can effectively and intelligently be explored in solving some crucial constraints related to agriculture and allied sciences. Such type of approaches not only improves crop productivity and livelihood but also tremendously improves overall knowledge contents and capacity building of the farming community (Deka *et al.,* 2018). Most of such approaches are ecofriendly, economical and sustainable. One major benefit of working through farmers' group is that farmers support each other to learn and adapt (Akinnagbe and Ajayi, 2010) and it also reduces the cost of public extension services (Conroy, 2003). The visibilities of extension programmes as well as accountability are also become more vibrant. Under the aegis of All India Network Project on Soil Arthropod Pests, a group based research and extension programme was embraced to tackle a highly endemic and severe key pest species of white grub (*Lepidiota mansueta*) in Majuli river island of Assam, India. The island is a "Bio-diversity hotspot" and has rich ecology with rare breeds of flora and fauna and is a part of a major path for many species of migratory birds. Of late, this island is trying to get the tag "World Heritage Site" from UNESCO because of its unique historic importance, rich biodiversity and co-existence of various cultures.

The white grub, *L. mansueta* was first detected in October 2005 in the farmers' field of Majuli. Field surveys conducted during 2005-2009 revealed that *L. mansueta* had appeared as an extremely severe key pest and the most severely affected crops were potato, sugarcane, Colocasia and green gram and the extent of damage varied from 42-48, 15-20, 35-40 and 30-35%, respectively (Bhattacharyya *et al.,* 2013). Realizing the seriousness of the problem, the seasonal life cycle and biology of *L. mansueta* were studied in crop fields of Majuli and in the laboratory of AINP on Soil Arthropod Pests, AAU, Jorhat during 2005-2009. *L. mansueta* has a biennial life cycle, which is the first of its kind from North East India. It is a unique biennial species, spending its entire life cycle under the ground except for a very short period during which adults come out of the ground for mating. Grubs are voracious feeders. However, there is no evidence showing that the adults fed on any plants either in the field or laboratory and hence this species has the unique distinction as the first Indian phytophagous white grub species with non-feeding adults (Bhattacharyya *et al.,* 2015). The probable reasons of endemism/ outbreak due to the high organic carbon content of the soil (0.75-1.00%) and presence of abundant thatch zone (dead grass, stems and other organic debris) in the endemic pockets. Other reasons may be nonarrival for last several years of the migratory bird Siberian crane (*Grus leucogeranus)*, a seasonal predator of the grubs in Majuli probably because of the changing climate with erratic rainfall and early onset of summer in the riverine island. Moreover, conversion of virgin low grass lands (sand bars) by the flood and erosion affected people without taking any grub management measures is also responsible for the outbreak of the species in massive proportions.

After unravelling the seasonal cycle and biology, few vital tipoffs worthy of managing the beetles were learned as mentioned below:

- Rush of adult emergence took place for a short period of time in the evening during April-May, except for this short

aerial life for nuptial activity, the species lives a subterranean life.

- Both sexes of the beetles were positively phototactic.
- Beetles emerged from the soil for mating during evening hours and spend almost one hour (6.15-7.15 pm) for premating flight. Beetles could be collected in huge numbers by operating light traps in endemic pockets during 6.30-7.00 pm.
- Scouting for hand collection is also effective since the mated pairs are found abundantly on selected sheltering plants in field during 7.00-8.30 pm.
- Beetles can also be used as animal feed for poultry, pigs, dogs, cats *etc*.
- Some indigenous tribes also consume the beetles as their food.
- Concept of Social Engineering/ Farmers' participatory approach could be encouraged for the mass collection and destruction of beetles during the period after premonsoon showers in the endemic areas.

A parallel planning was done to carry out both: basic research as well as community action programmes/ social engineering/ farmers participatory approaches aimed at collecting adult beetles during evening hours (6.00-9.00 pm during April-May) as a practical and cost-effective method of management. These extension activities were initiated from 2010 onwards in collaboration with different stakeholders under the theme "Mass campaigning against *L. mansueta* in Majuli River Island through social engineering". Group based approach for the mass collection and destruction of beetles was given the top most priority. Each village was selected based on the population and extent of damages caused by the grubs, presence of functional farm management committee/ self-help groups/ gram panchayats and a "Lepidiota Management Group" was formed in each endemic village (total 40 villages) consisting of 10 active farmers. Besides involving farmers, collaboration in this regard was sought from farm management committee, self-help groups, KVK, state extension staff, gram panchayat, NGOs and district administration, Majuli. To sensitize farmers the various tools of social engineering *viz*., smart SMSing to farmers through www.way2sms.com, video-conferencing, use of social networking site, use of print and electronic media, extension trainings, farmer-scientist interaction, field day, exhibition, awareness meeting, documentary shows, posters and banners, distribution of photographs/ leaflets, exposure visit, documentary show, use of public address system, conducting field experiments in endemic areas, telephonic discussion, demonstration on collection of beetles using Solar LED light traps, demonstration on using *Lepidiota* beetles as human food/ animal feed were used. This mass campaigning programme received overwhelming response and was exceedingly successful leading to massive collection and killing of about 12.35 Lakhs *L. mansueta* beetles in Majuli during 2010-2021. The project team also demonstrated the power of "Social Engineering" by entering into "India Book of Records" by setting a national record of "most beetles collected in three hours" by collecting 73,700 white grub beetles at Majuli River Island in 2018. The major advantages of such approach are: (i) the gravid females are killed before egg laying (ii) capacity building amongst the farmers in white grub endemic areas and the management approach is ecofriendly and cost effective. It is worth mentioning that some of the local tribal people relished the cooked/ fried adults of *L. mansueta* as protein rich food which opens up an avenue of further research on its nutritive/ nutraceutical value (Bhattacharyya *et al.*, 2018). The other impacts of the approach are mentioned below:

a) There were lesser emergences of beetles from soil and low population of grubs in both cultivated and non-cultivated fields in areas where the mass collection and destruction of adults by light traps and scouting were undertaken in the previous years.

b) The crop productivity had also increased in different crops after formation of groups and group based activities.

c) Farmers re-adopted the crops that were discontinued due to white grub infestation.

d) Farmers who had the capacity to increase their area under cultivation had started to expand the crops due to reduction of white grub infestation.

e) Farm income was increased after involving in group activity.

f) The readoption of Colocasia cultivation by the farmers has restored the nutritional security of farmers.

g) Some tribes relished the cooked/ fried adults of *L. mansueta* as protein rich food which opens up an avenue of further research on its nutritive/ nutraceutical value. Since, the traditional method of preparation of the beetles was some-what crude, attempts were made to float up a concept of "Beetle Fry" and "Roasted Beetles" dish. Beetles were also used in bulk quantities as feed for pig, dog and poultry. Besides, the farmers were also encouraged to explore the grubs of *L. mansueta* as bait for fishing purpose.

h) Even, the famers who were not included in groups showed their eagerness to form groups for the task due to spreading effect of group approach in a passive way.

i) The mass collection and destruction of beetles were carried out during the evening hours (6-9 pm) during the months of heavy emergence of beetles *i.e.*, April-May. Therefore, the farmers virtually did not lose any effective working hours/ man-days.

j) Majuli River Island is organic by default. Therefore, the farmers have shown preference as well as adopted the technology because without applying insecticides this dreaded pest could be managed. Farmers were convinced and specially delighted when they could kill the gravid females before egg laying in their field.

k) Others stakeholders associated with this mass campaigning have also endorsed this technology because a non-chemical approach of management strategy which was primarily based on the concept of the beetle population regulation was successfully implemented.

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Agar Wood: Pathogenesis to Fragrance

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Abstract

Plant-microbe interaction, especially a pathological condition is always thought to be destructive though, sometimes these sorts of relationships have tremendous potential to get valuable commercial products. An excellent example of this kind of pathological condition is found in agarwood tree (*Aquilaria malaccensis* Lamk.). The resinous patches of fragrant wood of the plant is known as 'agar' and the oil obtained from 'agar' is described as stimulant, cardial tonic, carminative and is used in cosmetic and pharmaceutical industries. Agar is considered to be a pathological product produced by fungal invasion of the host. A detailed investigation was carried out on isolation and identification of fungal organisms from the infected area, artificial inoculation, post-infectional biochemical changes and amount and quality of essential oil. Isolation of fungal organisms from diseased plant parts revealed five species, *viz*., *Aspergillus niger*, *A. flavus*, *Chaetomium globosum*, *Fusarium oxysporum* and *Penicillium italicum*. The most frequently isolated fungi from infected agarwood (*e.g.*, *Chaetomium globosum* and *Fusarium oxysporum*) were inoculated to the healthy plants by artificial boring on to the plants. In the present investigation, biochemical analysis of naturally infected plant parts in comparison to healthy and artificially inoculated plants showed marked differences. The oils obtained from the inoculated plants showed almost similar distribution of the components. But some of the components were found in the oils of artificially inoculated plants including naturally infected whereas those are totally absent in the oil of healthy plants.

Keywords: Agarwood tree, *Aquilaria malaccensis* Lamk., Fragrance, Pathogenesis

Recent Advances in Biodiversity and Conservation Status of Indian Fishes

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Extended Summary

The Convention on Biological Diversity (CBD) which came into force in 1993 after United Nations Conference on Environment and Development (UNCED), Rio de Janeiro (June 03-14, 1992) reaffirms the sovereign rights of the member nations over their entire genetic resources. It also envisages conservation, sustainable use and equitable sharing of the benefits arising from the biological resources. Rio+20, the United Nations Conference on Sustainable Development (UNCSD-2012), held during June 20-22, 2012 at Rio de Janeiro was attended by 192 UN Member states with the three objectives: (i) securing renewed political commitment for sustainable development, (ii) assessing the progress and implementation gaps in meeting previous commitments and (iii) addressing new and emerging challenges. Our natural resources, including fishes are the backbone of sustainable development. There are more than 33,100 finfish species throughout the world which is more than the combined total of all the other vertebrate species (amphibians, reptiles, birds and mammals).

India has been identified as one of the mega biodiversity centers for the genetic resources in the world and the same is true in case of fishes too. Nearly 2,936 species of finfishes belonging to 44 Order, 252 Family and 1,069 Genus have been recorded from different ecosystems ofthe country. The approximate ecosystem-wise distribution of fish germplasm resources of this subcontinent are- freshwater (936; 31.78%), brackishwater (113; 3.85%) and marine (1887; 64.37%). Out of these, about 258

species are commercially important which include cultured, cultivable and wild taxa, 199 endemic and 275 game fishes. There is record of the introduction of 462 exotic species in Indian water, most of which are of ornamental value. Due to various anthropogenic stresses, a number of fishes are showing declining trends in their catches from the conventional fishing grounds and somehave become threatened too. Though the decline of individual fish species is very often related to more than one proximate factors, the various causes of imperilment of fishes in the different ecosystems have been identified as: (i) physical habitat loss due to construction of dams and weirs across the rivers, soil erosion due to deforestation and excessive utilization of waters, (ii) chemical pollution due to industrial and municipal wastes, (iii) over-exploitation and indiscriminate killing of juveniles and brood fishes, (iv) competition from the introduced non-indigenous species, and (v) spread of dreaded diseases. Maintenance and preservation of fish biodiversity along with other biotic resources is being viewed as prerequisite even for human well-beings.

The status assessment conducted by the American Fisheries Society (AFS), Bethesda revealed that about 33% of the native freshwater fish taxa in North America are either endangered, threatened, or of special concern with membership of each group exhibiting significant increase during the last two decades. At least 106 Pacific coast stocks of anadromous salmon and trout are extinct and 212 more are at the risk of extinction or of special concerns. Similarly, out of nearly 793 freshwater species distributed throughout the heavily industrialized Europe, about 101 species were declared threatened during 1987. Of the 662 native freshwater and diadromous fishes assessed recently in the Southern United States, 7 have been categorized as Extinct, 41 (6%) endangered, 46 (7%) threatened and 101 (15%) vulnerable. Further, there exist reports that around 36% of the crayfishes and 55% of mussels in North America are either extinct or imperiled. As per Red Data Book of IUCN (2008), 16,928 taxa of life forms are threatened globally which includes 1,275 species of fishes. In Asia, 6,106 organisms are threatened of which 688 are finfish. IUCN recorded 659 (3% of world-wide) animal species of India are threatened of which 42 species are fishes. India possesses maximum number (27.8%) of endemic freshwater fish species among Asian countries followed by China, Indonesia and Myanmar.

Though the formidable task to categorize threatened fishes of India on the line of IUCN list is still to be completed but efforts have been made during the past in this direction. Menon (1989) compiled a list of 21 vulnerable fishes in India which comprised 4 Endangered (*Barilius bola, Puntius chilinoides, Semoplotus semiplotus* and *Enobarbichthys maculatus*) and 17 Threatened species (*Notopterus chitala, Acrossocheilus hexagonolepis, Cirrhinus cirrhosa, Labeo fimbriatus, Labeo potail, Labeo kontius, Puntius carnaticus, Puntius curmuca, Puntius jerdon, Tor khudree, Tor putitora, Tor tor, Schizothorax richardsonii, Schizothoraichthys progestus, Silonia childreni, Pangasius pangasius* and *Bagarius bagarius*). Interestingly, out of 762 fishes featured in the IUCN Red Data Book of Threatened Animals (1990) throughout the world, only 2 species - *Schistirasijuensis* (Family: Bolitoridae) and *Horaglanis krishnai* (Family: Clariidae) were included from the Indian waters as Rare species. During 1993, the NBFGR, Lucknow had tentatively identified 4 Endangered, 21 Vulnerable, 2 Rare and 52 Indeterminate fishes from the different ecosystems of the Indian waters. Molur and Walker (1998) released a long list (227 out of 329 species evaluated) of the threatened freshwater species but conservation status of these fishes requires further verification through the actual field surveys.

The most endangered cobitoid loach, *Enobarbichthys maculatus*, is known by a single specimen kept in the British Museum. It is felt that this species might have become Extinct as no specimen has so far been found ever since it first described by Day in 1867. *Gymnocypris biswasi* has been reported as Extinct from Ladhak region of this country. Similarly, the Gangetic shark, *Glyphis gangeticus*, has been reported as "probably Extinct" because only three museum specimens are currently known in the collections- one each in the Museum National d' Histoire Naturelle, Paris, Humboldt Museum, Berlin and Zoological Survey of India, Calcutta. All these specimens were collected during 19th century with no confirmed record after 1867. Threatened fishes of Malabar region (Western Ghats) of the Peninsular India, include 8 Endangered (*Barilius canarensis, Hypselobarbus jerdoni, H. kurali, H. lithopidos, H. periarensis, H. pulchelus, H. thomsi* and *Etroplus cararensis*), 2 Vulnerable (*Labeo dussumieri* and *Pseudobagrus cryseus*) and 8 Rare species (*Osteobrama bakeri, Echanthalakenda ophiocephalus, Puntius chalakudensis, Lepidopygopsis typus, Batasio travancoria*, *Horaglanis krishnai, Monopterus fossorius* and *Pristolepis fasciatus*). Out of 27 species recorded from the Periyar Lake-stream system of southern-western Ghats (Kerala), 14 (52%) are reported to be threatened. Menon (2004) listed 74 species as Threatened from the Indian waters while Lakra *et al.* (2010) extended the list to 120 taxa. Among 52 species of catfishes recorded in Nepal, 22 arereported as Rare from Gandaki, Kosi, Karnali and Mahakali rivers. The whale shark (*Rhiniodontypus*) occurring in the north-west coastal waters of India has become critically endangered due to

directed fishing off Saurashtra (Gujarat) coast since 1980s and needs immediate protection. However, it is pertinent to remark that several species of snappers and groupers (Lutjanidae, Serranidae), rockfishes (Sebastinae) and some sharks (Selachi), rays (Rajidae) and sawfishes (Pristidae) have also become Vulnerable/ Endangered in the American waters due to excessive fishing as these fishes have slow growth rate, late maturity and low fecundity.

It is essential to prevent the further decline of fish germplasm resources by devising all the possible *in situ* as well as *ex situ* measures of conservation and rehabilitation. The conservation policy should promote the management practices that maintain integrity of aquatic ecosystems, prevent endangerment and enhance recovery of the threatened species. Five principal elements or tasks in the recovery programs have been suggested which include: (i) habitat management, (ii) habitat development and maintenance, (iii) native fish stocking, (iv) non-native fish invasion and sport-fishing, and (v) research data management and monitoring. The Government of India has various Acts, Rules and Regulations for helping society to conserve fish and aquatic biodiversity with judicious utilization for betterment of human beings. Consequent to CBD (1992), the Government of India has enacted Biological Diversity Act, 2002 (BDA-2002), Biological Diversity Rules, 2004 (BDR-2004) and National Biodiversity Action Plan (NBAP, 2008) to put administrative procedures with a view that the inherent biological resources are optimally utilized along with protecting sovereign right of the nation over them. The irreparable harm caused to fish and habitats need be compensated through forestation, eco-restoration, soil conservation, complete ban on deforestation, particularly in the fragile mountains and strict implementation of Endangered Species Act (ESA)/ Indian Fisheries Act (1887, modified in 1956). Declaration of "State Fish", closing season for mahseer in Himachal Pradesh and conservation aquaculture of *Tor putitora, Lates calcarifer, Mugil cephalus, Etroplus suratensis, Chitala chitala* are the positive steps in this direction. Balakrishnan Nair Committee Report (2001) reported the ban of fishing in Kerala (i) has led to an increase in fish landing, (ii) revived the stock position leading to improvement in catch per unit effort (CPUE), and (iii) real improvement in size group of exploited commercial fisheries. Furthermore, in a huge country like India with diverse ecosystems, enforcement of law is not an easy task. The most effective way of tackling the problem seems to be the mass consciousness (awareness) drive through active participation of the public.

Keywords: Biodiversity, Brackishwater fish, Conservation, Freshwater fish, Indian Fish, Marine fish

Harmonized and Integrated Approaches to Biosecurity

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Extended Summary

Biosecurity is a holistic concept to manage the risks to biotic and abiotic factors with policy and regulatory framework. Biosecurity has few main goals, *i.e*., sustainability of agriculture, public health concerns and protection of environment including biodiversity. Plant Biosecurity has gained global attention in recent years due to the increased pest incursions across the world. In the post WTO era, there is tremendous changes in the trade of agricultural products and intensified the economy of the country. On the other hand the movement of goods through such trade has provided pathways for invasive alien species to spread and colonize in new areas. Invasive Alien Species are a major driver of species extinction and also threaten agriculture, forestry production at large scale.

There is a dire need to create awareness to all stakeholders pertaining to biosecurity. Learning about the plant biosecurity will help to reduce the risk of introduction of exotic pests and will help to protect crops/ biodiversity. Biosecurity is instrumental to safeguard and protect agriculture from serious threats caused by insects, pathogens, nematodes and weeds. This really poses greater implications in the context of agricultural biosecurity of a nation.

The biosecurity systems can save the nation from bioinvasions, bioterrorism and the threats posed to many nations due to Travel, Trade, Tourism and Transport. The relevant international standard setting bodies and the international organizations emphasized the need for a unified biosecurity approach to tackle the risks posed to human, animal, plant and the environment. The identification of risks posed to biosecurity is paramount and the risk analysis plays major role in identifying such risks and the relevant mitigation options. The need of the hour to safeguard every country from pests and diseases and it is the dire need to have an effective coordination at International, Regional and National level. The integration of various sectors in agriculture and allied fields shall lead to improved agricultural production due to harmonization of procedures adopted keeping in view of risks posed to life and health of human, animal, plant and the associated environment. Thus ***Biosecurity***' is a balancing act between a nation and people and encouraging tourism and international trade that are vital to a nation's economy. The increase in agricultural production will lead to improved livelihoods of the farming community and enhanced international trade.

A nationally coordinated system of surveillance, inspection and control using entry and post-entry measures and implementation of domestic quarantine at State borders is required to prevent the establishment and spread of unwanted pests that may have a deleterious effect on humans, plants, animals or the environment. These activities are the responsibility of the Indian government, State/ Union territory governments, plant industries and the farming community. The aim of Incursion Management is to prescribe the management arrangements for the prevention, preparedness, and response and recovery functions associated with an exotic, or major endemic plant pest or disease outbreak in India.

Keywords: Agriculture, Biosecurity, Environment, Integrated Approach, Sustainability

Can Green Engineered Nanoparticles be an Alternative to the Plant Health Management?

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Abstract

Nanotechnology is the art and science of manipulating matter at the nanoscale with novel properties (physical, chemical, biological *etc*). Nanotechnology is the understanding and control of matter at the nanoscale, at dimensions between approximately 1 and 100 nm, where unique phenomena enable novel applications. The science has wide opportunities in applications like medicine and healthcare like biotechnology, materials and manufacturing, energy, information technology, environment, cosmetics, textiles and agriculture & food industry. Nanotechnology-based products and its applications in agriculture include nano-fertilizers, nano-herbicides, nano-pesticides, recalcitrant contaminants from water, nano-scale carriers, nanosensors, veterinary care, fisheries and aquaculture, detection of nutrient deficiencies, preservation, nanobarcode *etc*. While playing with nanoparticles like Ag, Cu, Au, ZnO, SiO_2, it was found that green engineered nanoparticle can effectively management the soil borne, seed borne and foliar fungal and bacterial diseases with enhanced plant growth parameters and major secondary defense metabolite. Encapsulated formulation prepared with nanoparticle and biocontrol agents showed as an effective plant health material for management of different fungal and bacterial diseases. As a nanopriming agents, nanoparticeles like Ag and ZnO was also found effective in the management of seed borne diseases and better field stand without any harmful effect upto 200 ppm concentration. This work will present the synthesis and characterization of green engineered nanoparticle, standardization of dose against targeted pathogen, effect of soil biological matrix, nutrient uptake, effect on plant defence metabolite, plant growth and yield attributing parameters *etc*. which ultimately helped in to say that green engineered nanoparticles can be an alternative for better plant health management.

Keywords: Nanoparticle, Nanotechnology, Plant diseases, Plant health management

Sustainable Agriculture Ecotourism Concept in Bali

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Abstract

Bali is a province of Indonesia and the westernmost of the Lesser Sunda Islands, east of Java and west of Lombok. The province includes the island of Bali and a few smaller neighbouring islands, notably Nusa Penida, Nusa Lembongan, and Nusa Ceningan. The provincial capital, Denpasar, is the most populous city in the Lesser Sunda Islands and the second-largest, after Makassar, in Eastern Indonesia. The upland town of Ubud is considered Bali's cultural centre. The province is Indonesia's main tourist destination, with a significant rise in tourism since the 1980s. Bali is one of the most famous tourist destinations in the world, because of its natural beauty, agriculture, beaches, and culture. Various programs have been implemented in Bali to keep tourism sustainable. One of the concepts used to maintain Bali tourism is the concept of a sustainable agriculture ecotourism based on Balinese cultural values in the form of Tri Hita Karana, namely three concepts of harmony with God, humans, and nature. The organic garden villa concept is a concept developed in this research as a direct practice in collaboration with the Dewandaru Flora organic garden, by combining a natural Balinese style villa with an organic garden. In planting of rice, vegetables and fruits in this organic garden, compost, liquid organic fertilizer and biopesticides are being used, where the ingredients are taken from agricultural waste from their own organic garden and cattle waste that is reared by themselves. For the use of biopesticides, *Piper caninum* extract is picked from the organic garden in the villa. All materials for the needs of guests in this villa are all taken from the organic garden contained in the villa. With a passion of Balinese culture, served with Balinese cuisine. Guests could enjoy the serenity of Bali's nature and organic food such as rice, vegetables, and fruit from our garden of the villa. As a courtesy, our villa resort will be surrounded by our own grown organic gardens. Guests could do Balinese-style organic gardening practices coupled with Balinese-style cooking practices. Among these, interested parties could do aromatherapy meditation with ingredients of Balinese plant spices and flowers raised from Luh's organic garden.

Keywords: Agriculture, Bali, Ecotourism, Organic, PGPR

Entomopathogenic Endophytes: Role in Insect Pest Management

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Abstract

Insect-pest management through biological methods has received a lot of attention in recent years with the aim of lessening the use of pesticides in agriculture. Entomopathogenic fungi have proved a highly effective biocontrol agent when integrated into Integrated Pest Management (IPM) programmes. These entomopathogenic fungi, including *Beauveria bassiana* and *Metarhizium anisopliae*, have additional advantage due to their capacity to live inside plants as endophytes and defend their colonised host plants against the main herbivore pests. Numerous host plants have been shown to naturally harbour fungal endophytes. Several fungi that were formerly considered of as insect pathogens, like *Beauveria bassiana*, *Metarhizium anisopliae*, *Isaria farinosa*, and *Neotyphodium* sp., have been discovered to occur naturally as endophytes in asymptomatic plant tissues. Several endophytic entomopathogenic fungi were found to have been re-isolated from colonised host plants following artificial inoculation. Therefore, an effort was undertaken to artificially inoculate efficient *B. bassiana* strains in an effort to establish them as endophytes of cotton crop, which could reduce insect pests. By using this entomopathogenic fungus as endophytes, cotton crops are protected from insect infestation. It has the ability to decrease infestation from lepidopterous larvae and sucking pests. The feeding deterrence or antibiosis caused by fungal metabolites secreted in planta was the mechanism for the harmful effects against herbivores feeding on plants harbouring fungal entomopathogens as endophytes. They are known to infect specific hosts and to provide no harm to beneficial insects or non-target organisms. Entomopathogenic endophytes might be a good substitute for entomopathogenic fungi, which are typically used as inundative sprays to provide momentary pest control. When successfully established as endophytes in plants, these entomopathogenic fungi can provide long-term pest and disease management. By providing resistance against a variety of biotic and abiotic stress conditions, endophytic fungi provide considerable promise for plant protection.

Keywords: Biocontrol agent, Endophytes, Entomopathogenic Fungi, IPM

Multifaceted Plant Growth Promoting Bacteria having ACC-Deaminase Activity Confer Better Fitness to Rice Crop in Stressed *Jhum* Soils

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Abstract

This study assessed whether the slash-burn practice (*jhum*) induced disturbance on the above-ground biological inputs (plant leaf litters and microbial inoculation) had any influence on the physiology of rice crop in soils of different *Jhum* cycles. This study also determined how the pH stress (4.0, 5.5 and 6.8) of growth medium influence the plant growth promoting (PGP) traits of bacteria containing 1-aminocyclopropane-1-carboxylate deaminase activity (+ACCD) and lacking ACCD activity (-ACCD), those inhabitant of *jhum* rice rhizosphere collected from strongly acid soils (pH 4.5 to 5.2). A microcosm experiment was conducted using *jhum* soils (before and after burnt and unburnt from 5 yr and 10 yr fallows) to compare the effects of litter amendment (LA), microbial consortium (MC), LA+MC, ash amendment (AA) and no input on physiology and growth of *jhum* rice and soil biochemical properties. Out of 200 bacteria screened for acidity tolerance, only 70 isolates could grow at pH 4.0 indicating 35% incidence of acid tolerant bacteria (ATB) associated with rice rhizosphere and root tissues. Among ATB, 20 isolates possessed the ACCD activity (22.8 to 191.4 hmol α-ketobutyrate mg^{-1} protein h^{-1}) at pH 5.5 and referred them as +ACCD group. From remaining 50 ATB, 20 isolates were randomly selected and referred as –ACCD group. The higher pH stress had significant negative effect on the PGP traits (IAA-production, dissolution of $Ca_3(PO_4)_2$, $FePO_4$, $AlPO_4$, and $ZnPO_4$, and mineralization of Na-phytate) of isolates from both ACCD groups. Though +ACCD and –ACCD groups didn't differ significantly on above PGP traits, the exceptions were: +ACCD group possessed the significant higher ability for mineralization of Na-phytate and the significant lesser dissolution of $Ca_3(PO_4)_2$ than that of –ACCD group. The extent of benefits on rice seedling growth due to inoculation with +ACCD bacterium was significantly greater than inoculation with –ACCD bacterium under high pH stress condition, but such benefits of +ACCD bacterium became obscure under reduced pH stress condition. The benefit of inoculation of +ACCD bacterium to rice seedlings was more prominent under higher acidity stress than inoculation with –ACCD bacterium. Findings of the microcosm experiment indicated that the extent of physiological stress in *jhum* rice was the minimum in LA+MC followed by MC and AA. Application of LA+MC and MC supported better soil enzyme activities (AMY, ASA, DHA, GSA, PHA and PRO) in both 5 yr and 10 yr burnt *jhum* soils as compared to other LA and AA alone applied pots.

Keywords: Abiotic stress, Dissolution of insoluble phosphates, Endophyte, IAA production, Mineralization of organic phosphate, Rhizobacteria

Phytonematode Problems in Agri-Horticultural Crops and their Eco-Friendly Management

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Abstract

Phytonematodes are microscopic invertebrate animals often called as threadworms, eelworms or roundworms. They are distributed all over the world in different kinds of habitats and found in nearly every biological niche that supports life. Sasser and Freckman (1987) have indicated an annual crop loss due to nematodes on worldwide basis to the tune of $100 billion. The destructive plant-parasitic nematodes are one of the major limiting factors in crop production throughout India. They cause severe losses to economically important crops like vegetables, cereals, pulses, oilseeds, fruit crops, *etc*. Low production and productivity of vegetables are mainly because of biotic and abiotic stresses, among the biotic stresses nematodes also one of them. Large number of plant parasitic nematode is recorded from the rhizosphere of many crops like Root-knot Nematode (*Meloidogyne* spp.), Reniform nematode (*Rotylenchulus reniformis*), cyst nematode (*Heterodera* spp.), lesion (*Pratylenchus penetrans*) *etc*. They damage the crops not only by feeding on plants but also by interacting with various other organisms. These nematodes predispose the crops to fungal and bacterial pathogens, especially *Fusarium* spp., *Pythium*, *Rhizoctonia*, *Ralstonia solaneacearum*, *etc*. However, predisposition occurs due to mechanical wounding of the roots, rhizosphere modification and disruption of resistance mechanism caused by the nematodes. Such interactions aggravate the damage caused to the crop. Majority of the farmers remain unaware of nematodes as pests as no conspicuous aboveground symptoms are observed on the plants. Various eco-friendly options of nematode management are available such as crop rotation, soil solarisation, use of bio-nematicides, botanicals and integrated nematode management approach can reduce nematode pest densities in the soil and increase crop yield. However, use of *Trichoderma viride, T. harzainum, Paecilomyces lilacinus, Calotropis procera*, marigold, neem has played a great role in controlling nematode population as bio-management.

Keywords: Agri-Horticultural Crops, Bio-management, Crop yield, Eco-Friendly Management, Phytonematodes

Wild Silk Moth Diversity in North-Eastern Region of India: A Potential Source for Novel Silk

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Extended Summary

Fibre is an important commodity for human kind that stands only next to agriculture products. Of the total global requirement of fibre, about 46.0% are of natural origin (cotton, wool and silk). Silk is a natural filament created by the silkworm and contributes only 0.2% of production in the world. However, Indian silk exports in the global silk trade are 4-5%. This because India has a large domestic market for silk goods and about 85% of silk goods produced is sold in the domestic markets. The history of silk is as long as that of civilization itself. Silk is named in legend, fable and folklore. The superiority of silk as a textile fibre has been recognized from time immemorial; luxurious look, sleek feel and lustre of silk fabric are unquestionably inimitable. From its origin in China in about 2200 BC the silk industry has had an adventurous course of evolution, becoming established from time to time in other parts of the world. The natural silks are broadly classified as mulberry and wild or non-mulberry.

Wild silk moths or the non-mulberry silk moths, also known as 'Vanya silks' are economically and ecologically important forest based insects which are in generally not reared in captivity. Majority of them belong to the family Saturniidae, containing 1861 species in 162 genera and 9 subfamilies all over the world; of these, about 80 species occur in Asia and Africa to produce lustrous silk of economic value and estimated over 50 species found in the Indian sub continent. They constitute part of the "Charismatic mega fauna" of the insect world which include medium to very large size, bright and strikingly coloured moths which produce lustrous silk. The North-Eastern region of India makes ideal home for a number of wild sericigenous insects and is centre of wild silk culture including muga (*Antheraea assamensis* Helfer), eri (*Samia ricini* Donovan), oak tasar (*Antheraea proylei* Jolly) and mulberry silk (*Bombyx mori* Linn.). A recent review of the species composition of India has enlisted 47 species of wild silk moths in which 26 species under 13 genera of the family Saturniidae recorded from the North East India. They exhibit variation in their food habits, consumption, morphological traits; voltinism and adaptability to severe winter at higher altitudes of the region. Experimental findings of various qualitative and quantitative characters of all unexploited wild silk moths NE India indicate a promising future in terms of novel silk with high economic value for the region. While salubrious climatic conditions during spring and summer has assured better production of the cocoons, the diapausing character of these wild silk moths in their natural habitat indicate their adaptability to severe winters at higher altitudes of the state. Wild silk moth populations comprising diverse gene pool hold great potential utility for mankind. Hence, conservation of this precious genetic resource would be imperative for breeding of better adapted and more desired genotypes. The recent advances in molecular biology and biotechnology could play a major role for improvement on characterization, classification and documentation of all the sericigenous insects. As molecular markers are accurate for genetic diversity studies, similarly; characterization of moth sex pheromone will give complete information about inter and intra-species, subspecies, race, strains and ecotype; together help us to maintain uniform EST database of wild silk moth of the region. Hybridization between cultivated species and their wild counterparts/ related species to evolve commercially and economically desirable improve strains or species and to evaluate the hybrids in the natural condition is one of the tool for molecular biology application. Eri culture (*Samiaricini*) in the region has been practiced since time immemorial in traditional way for its silk and more often for pupa which form a delicious food items for a large section of the population. If the superior quality of the eri cocoons (*Samia ricini*) could be achieved through cross breeding with *Samia canningi*, it could be a breakthrough in the field of eri culture. Use of biotechnology in improving the productivity of silk, the quality of yarn and qualitative and quantitative improvement of the host plants *etc*. are some of the prospects for the development of the sericulture industry of the region. Further, the genetically useful and important traits of these wild silk moths such as hibernation, reelability may be a sound basis for all future breeding programmes of other domesticated silk moths in evolving commercially and economically desirable improved strains of species. Wild silk moth culture not only has an economic bearing on the local inhabitants of North-Eastern India but also helps to save forest ecosystem.

These wild sericigenous insects have in due course of time to stay as semi-domestic for the regular efforts and interests that revolved round its economic utility. Non-mulberry sericulture in India was not an industry but a tradition and culture of the tribal and other weaker sections of the society. It was in the recent past that this tribal tradition transformed into an industry of an immense potential. The rich production potentialities, interalia, the recent advances made in rearing methods, seed and cocoon

production over the past, promoted commercial exploitation of non-mulberry silkworms. Studies on various aspects of tasar, muga and eri silkworm rearing such as efforts towards domestication, conducting silkworm rearing on economic plantation, chawki rearing and silkworm seed technology namely, preservation of seed cocoons for synchronization of emergence, reutilization of male moths for coupling and preservation of eggs to delay hatching *etc*., organized this sector of sericulture to a great extent. This led to quality seed and cocoon production. Considering the overall potentiality of wild silk moths in India, technology perfection and its adoption could go a long way in harnessing the available flora for rearing of non-mulberry silkworms which in turn can be expected to increase the cocoon productivity.

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Regenerative Agriculture for Ecosystem and Human Health

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Abstract

Soil health is directly related to plant and therefore human health, as soil is the ultimate mineral source for most terrestrial plants used for human and livestock nutrition. While extensive research has addressed plant macronutrients such as nitrogen, phosphorus, and potassium, few studies have explored the impact of long-term micronutrients decline (or trace elements) in farm soil on food quality. Micronutrient deficiencies cause complex interactions at every level of the food web, from the location of de novo protein and vitamin synthesis (from soil fungi, or microbes to plants), to altered gene regulation in plants and animals, to human food consumption patterns driven by "hidden hunger" for deficient nutrients.

The importance of regenerative agricultural practices for increased ecosystem services and improved farm profitability will be of enormous importance, especially for small farmers and the stakeholders. Incorporating balanced nutrient management and other regenerative agricultural practices like forest farming and the can benefit the ecosystem and human health.

Keywords: Soil, Health, Ecosystem

Enhancing the In-Situ Decomposition of Crop Residues with the Application of Bio-Inoculants

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The research study was conducted to evaluate the enhancement of crop residue decomposition through bio-inoculants. The experiment was laid out in split-plot design with four main plot and with four sub plot factors and replicated thrice. Crop residues taken for decomposition were considered as the main plot factors such as C_1: Paddy straw, C_2: Maize stalk, C_3: Cotton stalk and C_4: Blackgram stalk with various bio-inoculants as sub plot factors such as B_1: No spray, B_2: TNAU Biomineralizer, B_3: NCOF Waste decomposer and B_4: Cow dung. The data computed during 0th, 15th and 30th days were microbial load in soil, soil available N, P, K and OC and also the dehydrogenase enzymatic activity were statistically scrutinised. There was no significant difference found with all the parameters recorded on 15th day. Among all the crop residues taken for study, blackgram stalk (C_4) recorded better decomposition activity with all the parameters on 30th day, respectively. With the bio-inoculant treatments, NCOF Waste decomposer (B_3) registered the highest decomposition rate and it was found on par with TNAU biomineralizer (B_2). By taking the interaction of the treatments into account, enhanced crop residue decomposition was recorded in blackgram stalk with NCOF Waste decomposer (C_4B_3). And least activity was found with paddy straw and no spray treatment (C_1B_1).

Keywords: Crop residues, Decomposition, NCOF waste decomposer, TNAU biomineralizer

Farm Income Revolution in Eastern and North-Eastern India through Secondary Agriculture

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NSSO's Situation Assessment of Agricultural Households and Land and Livestock Holdings of Households in Rural India, 2019 reveals 10 states whose household income is lower than the National average. Out of this, seven fall in Eastern and North-Eastern India. This shows how lagged the states are in terms of income realization despite being a largely agriculturally dependent economy. Hence, agriculture needs a greater thrust and more opportunities to promote rural industry through secondary agriculture are required to uplift livelihood status in these states. This paper highlights the agribusiness opportunities, challenges and scope for secondary agriculture activities in the region. As vol IX of the Report of Doubling Farmers Income emphasized the need to promote farm linked secondary agriculture activities through the setting up of Directorate of Secondary Agriculture, the state of Karnataka has already emerged as the one to set up the same. The secondary agriculture is categorized into three specific avenues. Type A avenues are those which add value to either the inputs or the harvested output, example vermicomposting, custom hiring centers, pre-cooling of fruits, grading, sorting *etc*. Type B avenues are those which do not compete for resources, and hence may be called as alternative enterprises like beekeeping, lac cultivation, agro-tourism *etc*. and type C avenues of secondary agriculture are all those activities which utilize crop residues. Each of these avenues provides a lucrative income and job opportunity in rural areas. This positively impacts production and consumption activity and uplifts the overall economy. We assess the economic contribution of some secondary agriculture enterprises and their role in income and employment generation. The paper also tries to explore the challenges faced by secondary agriculture-based enterprises and suggests ways to overcome the same.

Keywords: Doubling Farmers' Income, Employment, Opportunities, Poor states, Secondary agriculture, Small and marginal holdings

Effect of Integrated Weed Management in Summer Green Gram (*Vigna radiata*)

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A field experiment was conducted in the experimental research farm of School of Agricultural Sciences and Rural Development (SASRD), Nagaland University during the summer period of 2021 to study the "Effect of Integrated Weed Management in summer green gram (*Vigna radiata*)". The experimental design was randomized block design (RBD) with three replications. The treatment consists of Weedy check, Hand weeding at 20 DAS and 40 DAS, Rice straw mulching @ 5 t ha^{-1}, Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Hand weeding at 20 DAS, Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Rice straw mulching @ 5 t ha^{-1}, Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS, Imazethapyr @ 0.5 kg ha^{-1} (EPoE) at 15 DAS *fb* Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS. The result revealed that hand weeding at 20 DAS and 40 DAS gave the highest growth and yield of green gram (627.81 kg ha^{-1}) which was found to be at par with pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Hand weeding at 20 DAS (614.64 kg ha^{-1}). Among the weed management practices, hand weeding at 20 DAS and 40 DAS gave minimum weed population, weed dry weight accumulation thereby, giving the highest weed control efficiency and recorded highest growth and yield in green gram followed by pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Hand weeding at 20 DAS recorded the highest growth and yield parameters. Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Hand weeding at 20 DAS gave the highest B:C ratio (1.59) and was found to be economically best feasible treatment for summer green gram.

Keywords: Green gram, Hand weeding, Pendimethalin, Weed management

Homology Modeling and Characterization of Cytochrome C Nitrite Reductase (NrfA) in Three Model Bacteria Responsible for Short Circuit Pathway, DNRA in Terrestrial Nitrogen Cycle

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NrfA is the signature molecular marker for dissimilatory nitrate reduction to ammonium (DNRA) activity, catalysing cytochrome c nitrite reductase enzyme. However, limited study was done to understand the structural homology modeling of NrfA protein in DNRA bacteria. Therefore, three model DNRA bacteria (*Escherechia coli*, *Wolinella succinogenes* and *Shewanella oneidensis*) were chosen for *in-silico* protein modeling of NrfA which roughly consists of similar lengths of amino acids and molecular weight and they belonged to two contrasting families (α-proteobacteria and β-proteobacteria). Multiple bioinformatic tools were used to examine the primary, secondary, and tertiary structure of NrfA protein using three pipelines *viz*., Phyre2, Swiss model, and Modeller. The results indicated that NrfA protein in *E. coli*, *W. succinogenes* and *S. oneidensis* was mostly periplasmic and hydrophilic. Four conserved Cys-X1-X2-Cys-His motifs, one Cys-X1-X2-Cys-Lys haem-binding motif and Ca ligand were also identified in NrfA protein irrespective of three model bacteria. Moreover, 11 identical conserved amino acids sequence was observed for the first time between serine and proline. Secondary structure of NrfA revealed that α-helices were observed in 77.9%, 73.4%, and 77.4% in *E. coli*, *W. succinogenes* and *S. oneidensis*, respectively. Ramachandran plot showed that number of residue in favored region in *E. coli*, *W. succinogenes* and *S. oneidensis* was 97.03%, 97.01% and 97.25%, respectively. Our findings also revealed that among three pipelines, Modeller was considered the best *in-silico* tool for prediction of NrfA protein. Overall, significant findings of this study may aid in the identification of future unexplored DNRA bacteria containing cytochrome c nitrite reductase to monitoring less studied N-retention processes in terrestrial nitrogen cycle.

Keywords: DNRA, Homology protein modeling, NrfA protein, Ramachandran plot

Genetic Variability Analysis of M4-M5 Mutants of Indian Mustard (*Brassica juncea* L.)

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stard [*Brassica juncea* (L.) Czern. & Coss.] is an important oilseed crop grown in India under diverse agro-ecological conditions in the temperate and subtropical regions during *Rabi* season. It fits well in the rainfed cropping system with low production cost and high potential to increase edible oil. Farmers in Assam grow rapeseed toria due to its short duration but ends up with low yield. Development of short duration superior Indian mustard varieties is required to increase the average yield of rapeseed-mustard in Assam. Some Indian mustard genotypes were developed by induction of mutations at Assam Agricultural University, Jorhat. In the present study, 143 M_4 lines from the parent variety NRCHB-101 of Indian mustard developed by gamma irradiation, were evaluated during *Rabi* 2020-21 followed by 116 M_5 selected lines during the *Rabi* 2021-22 to assess to genetic variability and interrelationships between yield component traits. Significant variation due to genotypes, environment and genotype × environment interaction for most of the characters observed. Moderate genetic variation was observed for seed yield plant^{-1}, number of primary and secondary branches plant^{-1}. Moderate heritability coupled with high genetic advance was observed for number of siliquae in main shoot, number of primary branches and number of secondary branches. The mutant lines JMM-NRCHB101-37, JMM-NRCHB101-57, JMM-NRCHB101-107 were found to be promising exhibiting superior performance for most of the yield attributing characters. The mutant line JMM-NRCHB101-86 and JMM-NRCHB101-95 also showed potentiality for early maturity with high yield which could be exploited for the development of early maturing mustard varieties.

Keywords: *Brassica juncea,* Genetic advance, Genetic variability, Heritability, Mustard, Short duration

Genome Edited Crops for Improved Food Security

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Food is a basic necessity of all forms of life. There are over 50,000 edible plants but not everyone is lucky enough to have enough food to eat. Food security is a burning issue all over the globe. According to FAO, food security means that everyone, at all times, has physical, social and economic access to sufficient, safe and nutritious food for an active and healthy life. In India around 195 million people are currently undernourished. Conventional plant breeding has developed numerous crop varieties but not enough to meet the ever-increasing demands of food requirements. Major problems of conventional plant breeding are due to limited genetic variation and linkage drags of undesirable traits. Genome editing could be utilized as a promising tool to address these problems for achieving the goal to end hunger by 2030. After the discovery of various genome-edited tools *viz*., Zinc Finger Nucleases (ZFNs), Meganucleases, Transcription Activator-like Effector Nucleases (TALENs), and Clustered Regularly Interspaced Palindromic Repeats (CRISPR-Cas9), research on genome editing of crops is increasingly applied in crop improvement. There are many varieties of crops that have been improved for higher yield using genome editing tools at CGIAR centers. Scientists have reported improvements in crops using knock-out and knock-down techniques of genome editing. With the advancement of research on modern Site-Directed Nuclease (SDN) improved varieties could be developed for the benefit of smallholder farmers and consumers.

Keywords: CRISPR-Cas9, Food security, Genome editing, Site-Directed Nuclease, TALENs, ZFNs

Agro-Morphological Characterization, Quality Analysis and Study of Divergence in Aromatic Rice Genotypes of North-East India

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An investigation was carried out in experimental field of Department of Genetics and Plant Breeding, CAU, Imphal, during *Kharif*, 2017 to characterize 32 indigenous aromatic rice genotypes collected from North East region *viz*., Arunachal Pradesh, Mizoram, Manipur, Meghalaya, Tripura, Nagaland and Sikkim along with two national variety PD-1503 and Basmati 370 based on agro-morphological and quality traits as well as to study the extent of their genetic diversity. Maximum genotypes were observed to possessed green coleoptile colour, green leaf blade colour, intermediate leaf pubescence, just exserted panicle, white or light green colour of stigma, open type panicle, short and partly awned, white seed coat colour and straw hull colour. Significant variations were observed in 32 genotypes under study for agronomic characters such as length of leaf blade, width of leaf blade, plant height, panicle length, no. of panicles plant^{-1}, days to 50% flowering, days to 80% maturity, no. of grains panicle^{-1} and 1000 grains weight. Among the quality traits under study, significant variations were observed in amylose content, amylopectin content, crude fat content, grain length breadth ratio and decorticated grain length width ratio. In relative to Mahalanobis D^2 values the genotypes were group into 4 clusters following Tocher's method of clustering. Maximum genotypes *viz*., 27 genotypes fall in cluster I, while 4 genotypes fall in cluster II, cluster III has 2 genotypes whereas cluster IV has only 1 genotype.

Keywords: Agro-morphological traits, Aromatic rice, Genetic diversity, NE region, Quality traits

Effect of Date of Transplanting and Integrated Weed Management on Growth and Yield of Black Rice (*Oryza sativa* L.) under SRI

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A field experiment was conducted in the experimental farm of SASRD, Nagaland University during *kharif* season of 2019 and 2020 to study the "Effect of date of transplanting and integrated weed management on growth and yield of black rice (*Oryza sativa* L.) under SRI". The experimental design was split plot design with three replications. Main plot treatment consist of three date of transplanting *viz.* D_1: 15th June, D_2: 30th June and D_3: 15th July and sub plot treatment consist of five weed management practices *viz*. W_1: weedy check, W_2: conoweeding at 20 and 40 DAT, W_3: pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb* handweeding at 40 DAT, W_4: pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb* conoweeder @ 40 DAT and W_5: pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb* bispyribac-Na @ 25 g a.i ha^{-1} at 20 DAT. Results revealed that 15th June date of transplanting recorded significantly highest plant height, number of green leaves plant^{-1}, number of grains panicle^{-1}, grain yield and straw yield. Among the integrated weed management treatments, pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb* handweeding at 40 DAT gave the maximum decrease in weed population and dry weight resulting in higher weed control efficiency, growth and yield of black rice.

Keywords: Bispyribac-Na, Black rice, Date of transplanting, Pretilachor, Yield

Evaluation of Safe AWDI Practices for System of Rice Intensification during *Kar* and *Pishanam* Season under Tamirabarani Command Area of Tamil Nadu

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Field experiments were laid out in the wetland of Rice Research Station Ambasamudram during the *Kar* and *Pishanam* seasons of 2014-2015, to evaluate efficacy of Safe Alternate Wetting and Drying Irrigation method on growth, yield parameters and grain yield of SRI rice and to assess the impact of safe AWDI practice on water saving with the help of field water tube. The experiment was laid out in randomised block design replicated four times with three AWDI treatments under system of rice cultivation method. The AWDI levels tested were irrigation at different depletions *viz*., 10 and 15 cm below the soil surface and conventional irrigation method. In both the seasons, AWDI after 10 cm depletion from 7 days after transplanting up to 10 days prior to harvest registered significantly higher grain yield of 6,550 kg ha^{-1} during *Kar* and 6,159 kg ha^{-1} in *Pishanam*; whereas, higher water use efficiency of 6.87 and 6.07 kg ha^{-1}mm^{-1} was recorded with 15 cm depletion level. During Kar season the safe AWDI at 10 and 15 cm consumed 980.2 and 910.32 mm of irrigation water with water saving of 195 and 265 mm respectively over conventional method and in Pishanam season the safe AWDI at 10 and 15 cm consumed 1037.3 and 981.3 mm of irrigation water with water saving of 115 and 171 mm respectively over conventional method.

Keywords: Alternate wetting and Drying, Field water tube, SRI, System of Rice Intensification

Energy Budgeting and Economic Analysis of No-Till Winter Legumes Production in Maize-Legume Cropping Sequence

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A field experiment was conducted on "*Energy budgeting and economic analysis of no-till winter legumes production in maize-legume cropping sequence*" at the Agriculture Farm of Palli Siksha Bhavana, Visva-Bharati, Sriniketan, West Bengal, during *kharif* and *rabi* season 2017-18 and 2018-19. During *kharif*, a general crop of maize was grown uniformly under recommended package of practices. In *rabi*, after maize, the crops were grown under zero tillage with three cropping systems (CS) as main plot treatments *viz*., Maize-Chickpea (CS_1), Maize-Lentil (CS_2), Maize-Lathyrus (CS_3), and five bio-mulching measures as sub plot treatments *viz*., no mulch (M_0), *in-situ* maize stalk mulch (MSM) (M_1), M_1 + *water hyacinth* (5 t ha^{-1}) (M_2), M_1 + *paddy straw* (5 t ha^{-1}) (M_3), M_1 + *water hyacinth* (2.5 t ha^{-1}) + *paddy straw* (2.5 t ha^{-1}) (M_4). Results from the experiment revealed that *in-situ* retention of maize stalk along with *water hyacinth/ paddy straw* mulch helped to conserve soil moisture and improved soil physico-chemical and biological properties. The system productivity was highest in Maize-chickpea under MSM + *paddy straw* mulch (35.78 kg ha^{-1}day^{-1} and 36.09 kg ha^{-1}day^{-1} in 2017-18 and 2018-19). The net return (Rs. 61,377.00 ha^{-1} and Rs. 60,242.00 ha^{-1}) and B:C ratio (1.85 and 1.83) was maximum in Maize-chickpea system. The energy output, net energy and energy productivity were maximum in Maize-chickpea system whereas energy use efficiency was maximum in Maize-lathyrus system. It was concluded that Maize-chickpea cropping system with MSM + *water hyachinths/ paddy straw* mulch in chickpea is a profitable option with higher productivity in dry region of West Bengal in *rabi* season.

Keywords: Bio-mulches, Cropping systems, Energy productivity, Maize equivalent yield

Marker Assisted Selection: Opportunities and Challenges

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Molecular markers have enormous potential to improve the efficiency and precision of conventional plant breeding *via* marker-assisted selection. Conventional plant breeding can no longer sustain the global demand with the increasing population, decline in agriculture resources, and decrease in the yield curve of staple crops. In order to achieve plant breeding goals rapidly and effectively, marker-assisted selection (MAS) employs molecular markers along with different statistical and bioinformatics tools. The success of MAS depends upon several factors, including the genetic basis of the trait and the degree of association between the molecular marker and the target gene. For germplasm characterization and manipulation of genomic regions for single gene transfer, molecular markers play a very vital role. However, when several genomic regions need to be manipulated, marker-assisted selection has turned out to be less useful. Integrating MAS into traditional breeding practises to make it more economically attractive and applicable in developing countries for crop improvement is the great challenge for plant breeders in the next few decades.

Keywords: Conventional Breeding, Marker Trait Association, Molecular Marker, Quantitative Trait Loci

Yield Attributes and Yield of Rabi Maize (*Zea mays* L.) as Influenced by Fertigation of N&K and Microbial Consortium

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A field experiment was conducted on maize (*Zea mays* L.) during *rabi* (November-February), 2018-19 to study the effect of drip fertigation of Nitrogen (N), Potassium (K) and microbial consortium (MC) at Water Technology Centre, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad. The experiment was laid out in randomized block design and replicated thrice. The treatments, comprising of two fertility levels *viz*., 75% and 100% recommended dose (RD) of N&K as first factor and biofertigation of MC as second factor. The interaction effect between RD of N, K and biofertigation of MC was not significant. Significantly higher cob length, cob girth, number of rows cob^{-1}, cob weight, number of grains cob^{-1} and grain weight cob^{-1} were recorded with fertigation of 100% RD of N & K compared to 75% RD of N&K and five MC biofertigation recorded significantly higher cob length, cob girth, number of rows cob^{-1}, cob weight, number of grains cob^{-1} and grain weight cob^{-1} than that of treatment without application of MC and was on par with biofertigation of MC three times. Maize grain and stover yield recorded with 100% RD of N&K were significantly higher compared to 75% RD of N&K. Biofertigation of MC five times and three times were on par and recorded significantly higher grain and stover yield compared to treatment without application of MC. Significantly lower grain and stover yield were observed under treatment without application of MC.

Keywords: Biofertigation, Biofertilizers, Fertigation, Maize, Microbial Consortium, Yield attributes

Broom Grass: A Boon to Hill Agriculture and Livelihood Security

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Broom grass (*Thysanolaena maxima*) is a tall perennial grass of Poaceae family which is mainly used to prepare brooms. It is locally known as *Phool Jhadu* in Assamese, *Arphek* in Karbi and *Balangsi Nosheb* in Dimasa. It can flourish in a wide range of soils and agro-climatic conditions ranging from sandy loam to clay loam soils; steep rocky mountain slopes to plain areas. It grows well in drought conditions as well as withstands high rainfall situations in the hilly areas, provided there is no water stagnation. This versatile crop can be grown as a climate resilient crop in hill zone, most particularly, in the abandoned *Jhum* lands of Karbi Anglong district which cover an area of 76,000 hectares. Moreover, a part of the district falls under rain shadow area and the rainfall pattern depends on the locations of hills and valleys. The average annual rainfall of the district is less (around 1400 mm) as compared to that of Assam. In such situation, broom grass can be grown as an alternative. Its long and fibrous root system protects the top soil and nutrients from erosion in the hill slopes as well as in agricultural fields, thereby restoring the soil fertility. It helps in reducing water run-off and soil loss from lands degraded due to shifting cultivation. It also works as a weed suppressor in hills. This multipurpose grass has various medicinal properties; leaves and tender culms can be used as forage, woody culms for fuel and mulch material in farming. This wonder grass, thus, has a huge potential in hill agriculture which also helps in poverty reduction through employment generation, thereby contributing to the upliftment of economic status and enhancing the livelihood security of the rural people in the district.

Keywords: Climate resilient, Erosion, Hill agriculture, Shifting cultivation

A Study on Correlation and Path Coefficient Analysis for Yield and Associated Traits in Bread Wheat (*Triticum aestivum* L.)

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Wheat (*Triticum aestivum* L.) is the world's most important cereal grain which contains carbohydrate, protein, fat, minerals and significant amounts of vitamins. A study was conducted in Augmented Block Design with 105 genotypes of bread wheat with four checks (HD-2967, DBW-222, DBW-107 and HD-2733) for estimation of means, range, correlations and path-coefficient. A wide range of variations were observed for different characters under study. The genotype RAJ-4549 (16.35), UP-3056 (15.78), DBW-344 (15.78), produced highest grain yield plant^{-1} followed by NW-8076 (15.36) and NW-8019 (15.14). In case of correlation study, grain yield plant^{-1} had a highly significant and positive correlation with tillers plant^{-1}, biological yield plant^{-1}, peduncle length, and spike length; whereas a non-significant negative correlation was found with Days to 50% flowering, Plant height and Days to maturity. In path coefficient analysis, major positive direct effect on grain yield plant^{-1} was exerted by biological yield plant^{-1}, followed by harvest-index, number of grain per spike, peduncle length, number of tillers plant^{-1}, test weight, days to 50% flowering and spike length. Tillers plant^{-1} and Peduncle length exhibited high order positive indirect effects on grain yield plant^{-1} biological yield (0.87) and (0.69) respectively. The characters showing highly significant positive correlation among yield and its components can be further validated and if consistent performance is found in future study; emphasis should be given to those characters while developing high yielding varieties.

Keywords: Correlation, Grain yield, High yielding varieties, Path coefficient, Wheat

Crop Improvement in Wheat (*Triticum aestivum* L.)

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Wheat (*Triticum aestivum* L.) is the staple food and an important source of carbohydrates, protein, vitamin gluten and other minerals too. It is the foundation crop of India's agriculture. At present, it is next to rice in acreage production. It has been made possible through the better genetic understanding of this crop plant, breeding techniques, and availability of technology. There are two points that have been reviewed in India: generating genetic advancement for yield and all other traits are genetic dwarfs. Early selection worked on pureline for the development of the NP series. Later, the objective-oriented traits, *i.e.*, dwarfing gene and rust resistance, were adopted. In the 20th century, semi-dwarf wheat called "Norin" developed with very large ears in Japan, and Olsen, Rht1 and Rht2 are responsible for gene dwarfing in wheat. The MLKS11 variety was released using the multiline approach gene transferred to Norin10 by CIMMYT, which was involved in the development of semi-dwarf varieties by hybridization. Th. Lerma Rojo carried the one dominant gene that conferred resistance to yellow rust. In resistance breeding, the genes Yr1, Yr3, and Yr4b are frequently found. Choti Lerma, another variety, is resistant to all rusts. In India, most studies were done on brown rust, then yellow rust, and karnal bunt. Later, other aspects, *i.e.*, gene action, gene advancement, and heterosis, were evaluated. Many mutant varieties have been released during the past 10 years using mutational breeding and new biotechnology used in gene mapping of wheat that will facilitate molecular marker-assisted plant breeding. Another improvement was the *triticale,* which is the result of intergeneric hybridization. It has a high yield and is rich in protein. More genetic progress will be made in the future.

Keywords: Biotechonology, Gene action, Heterosis, Pureline, Resistance breeding, Semi-dwarf

Utilising Genome Resources and Information for Crop Breeding Programs: Challenges and Opportunities

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In recent times, considerable information has been generated out of sequencing projects and rich bioinformatics resources are available to the researchers. Bioinformatics helps to study plant breeding problems with the help of statistical tools. The most critical tasks in bioinformatics involves identification of genes in DNA sequences, developing methods to predict structure and function of proteins and RNA sequences, clustering families of related sequences, development of protein models, *etc*. for improvement of any crop plants. However, till date limited application of genomic resources are being observed in varietal improvement programme, which is mostly limited to Marker Assisted Selection (MAS). Limited marker traits association across the population, marker trait segregation in repulsion phase, lack of physical and functional validation of markers in respective QTLs as well as in respective trait limits the utilisation of genetic resources in plant breeding. Molecular cytogenetics holds a promise under this study where physical validation of linked marker can also be attempted. Bioinformatics, which deals with sophisticated computational approaches along with genome resources helps in understanding the function of specific traits by using genomics, transcriptomics, proteomics and metabolomics *etc*. It also helps to predict responses of plant against various biotic and abiotic stresses. This could lead to prevention and targeted treatment of diseases, improved food production and eventually filling the gap between bioinformatics and varietal improvement programme.

Keywords: Bioinformatics, Expression of traits, Genomics, Prediction of response, Varietal improvement

An Investigation on Correlation and Path Analysis of Mungbean (*Vigna radiate* L. wilczec) Yield and Yield Components

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Mungbean has long been a popular traditional food all over the world. It is a good source of protein, foliateand iron when compared to other legumes. An experiment was carried out in Randomized Block Design for evaluation of thirty seven (37) genotypes along with four checks (Pant M 4, IPM 2-3, Varsha and MH 1142) which were obtained from mungbean gene pool maintained at Department of Genetics and plant breeding, ANDUAT, Ayodhya. Observations were recorded for thirteen (13) yield contributing characters for the estimation of mean, range, least significant differences, correlations and path-coefficient. Result shows that the genotypes Daftri Vikas followed by RM03-71, GJM 1701, IPM 1603-3, SKNM 1904, Pusa M 2172, ML 2500, RMG 1132, COGG 18-17, BCM 20-9 and MH 1857 produce highest grain yield plant^{-1}. High mean performance for several other characters were also found in the above mentioned genotypes and can be useful as parental materials in future breeding programme. Studies of correlation coefficients revealed that the traits- biological yield plant^{-1}, pods plant^{-1}, clusters plant^{-1}, 100 seed weight, pods clusters^{-1}, seeds pod^{-1}, harvest index and grain yield plant^{-1} showed highly significant and positive connections. According to path analysis, biological yield plant^{-1} emerged as the most significant indirect yield component; whereas, harvest index and biological yield plant^{-1} are the key direct contributors to the expression of grain yield plant^{-1}. Therefore, it is important to focus on these features while choosing candidates for mungbean enhancement.

Keywords: Grain yield, Mungbean enhancement, Parental materials, Protein, Yield contributing characters

Variability Studies in Foxtail Millet

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Fifteen land races of foxtail millet were collected and evaluated during Kharif, 2018 & 2019 consequently year at the Instructional farm, Krishi Vigyan Kendra, Mon (Aboi) Nagaland. Different genotypes were planted at spacing of 30 cm × 10 cm in a randomized block design with three replications under fully natural conditions. Observations were made on seven characters *viz*., days to half bloom, days to maturity, plant height (cm), panicle length (cm), productive tillers plant^{-1}, hay yield (g), seed yield (g). Among the economic characters of the genotypes FMM 14, FMM 11 and FMM 10 showed more yield potential (198.40, 194.50 and 178.20 g plant^{-1}) with early in maturity (80-82 days) on the other hand late in maturity (96-102 days) and more yield potential (210.60, 181.80 and 175.30 g plant^{-1}) were found in FMM 12, FMM 6 and FMM 15 genotypes, respectively. Highest seed yield was also recorded (10.15 q ha^{-1}) when the crop was planted between 10th April to 25th April, irrespective of all the land races and different planting time. The highest estimates of PCV and GCV were observed for productive tillers per plant (28.55 and 19.66) and seed yield plant^{-1} (24.13 and 21.75). High heritability coupled with moderate genetic advance at percent means was observed for grain yield plant^{-1} (91.32% and 23.93), panicle length (85.65% and 13.41), and productive tillers plant^{-1} (75.45% and 28.33) indicating that additive gene effects were operating for these characters and selection of superior genotypes was possible. Panicle length had highly significant and positive correlation at genotypic and environmental level with seed yield plant^{-1} (r_g = 0.743 and r_g = 0.786). Productive tillers plant^{-1} also showed highly significant and positive correlation at the genotypic level and phenotypic level with seed yield plant^{-1} (r_g = 0.748 and r_g = 0.744). These two characters were found to be positively correlated to seed yield plant^{-1}. Path analysis revealed that only panicle length showed high direct effect and highly significant positive correlation with grain yield plant^{-1} (1.424 and r_g = 0.764), indicating the importance of selection based on this character to increase seed yield plant^{-1}. Sowing of crop at optimum period is very important no-monitory input in obtaining higher yield. Sowing operation for foxtail millet should be also find-out during the month of April of the district.

Keywords: Foxtail millet, Genotypes, Landraces, Panicle

Assessment of Marker Trait Association in Low Land Rice for Iron Toxicity

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Iron (Fe) is an essential nutrient in plants participates in several important metabolic processes such as photosynthesis, chloroplast development, chlorophyll biosynthesis, electron transport, and redox reactions. Iron toxicity is a root related abiotic stress; affect the yield of rice in lowland production systems. High concentration of reduced iron (Fe^{2+}) leads to iron toxicity and yield losses varied from 15% to 100% depending on the genotype of rice, growth stage of plant, soil fertility and stress severity. The production of resistant rice genotypes through breeding programs is one of the most promising ways to increase yield under iron toxicity conditions. A powerful way to classify novel loci involved in complex phenotypic characteristics, is Genome-Wide Association Studies (GWASs). In this present study, 150 germplasm lines of rice were screened in iron toxicity a hot spot and in control condition as well. Germplasm lines like Ganjamgedi, Kusuma, Pratikhsya, Ranidhan, Lalat *etc*. are found iron toxicity tolerant by LBI scoring (IRRI, 2013). Based on the morphological characterization, 120 panel Populations have been created for the genotyping with 70 SSR markers. A total of 238 alleles were amplified with the 70 SSR markers and average alleles $locus^{-1}$ were 4. The highest number of allele was 6 in the marker RM296. The PIC value was maximum in RM335 and minimum value in RM339. While considering both the model GLM and MLM, RM346, RM492, RM293, RM201 and RM258 markers are strongly associated with leaf bronzing score. Significant association of RM293 present on chromosome 3 (193.4 cM) designated as qFeTox3.1 and RM346 present on chromosome 7 (78.3 cM) designated as qFeTox7.1 was detected as novel QTL for Fe-toxicity tolerance.

Keywords: GWAS, Iron toxicity, LBI scoring, SSR marker

Effect of Electromagnetic Field on Physiological, Biochemical and Molecular Behavior of Plants

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Plant responses to stress conditions are arising in an accelerated manner and an increasing trend has also found in today's environmental condition exposed to high frequency nonionizing electromagnetic fields. Plant architecture constitutes an outstanding model to study these interactions as they possess high surface area to volume ratio which helps in optimizing their interaction with the environment. The present study indicated the response of plant after exposure to high frequency electromagnetic field and the observed the cellular, molecular, physiological changes after exposing them to main exposure devices (Transverse and gigahertz electromagnetic cells, wave guide and mode stirred reverberating chamber). The result confirmed that there are modifications in numerous metabolic activities like chlorophyll content, pentose phosphate pathway, terpene emission, Krebs cycle, α and β-amylase, reactive oxygen species metabolism, various gene expression and growth and development rate of plants after exposing them to low power high frequency electromagnetic field. The notable changes were found in contact tissue as well as the distant tissue. The long term impact on these metabolic changes remains largely unknown and but definitely there are some heritable changes which can alter the plant growth development and directly causing a greater impact on environment.

Keywords: Abiotic stress, Electromagnetic frequency, Gene expression, Metabolic Pathways, Plant response

Double Haploid Production Technique for Crop Improvement

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According to the 2015 Revision of World Population Prospects, the global population will reach 9.7 billion by the year 2050 (https://esa.un.org/unpd/wpp/). To feed this increasing population in 2050, food production is projected to increase by 70 percent (http:// www.fao.org/wsfs/forum2050/wsfs-forum/en). To meet this requirement, agricultural performance must be continually enhanced to raise the production of important food crops such as maize, rice, and wheat throughout time. As we face the problems of limited natural resources, land, and water, as well as the global climate change, it is extremely difficult to meet this food demand using current plant breeding procedures, which takes 10 to 12 years to develop a new cultivar. With the introduction of marker technologies and other creative breeding techniques, however, it is possible to shorten the breeding cycle for cultivar development and increase genetic gain per unit of time. Doubled haploid (DH) technology is one such new breeding technique that represents a significant accomplishment in accelerating cultivar development. By utilising doubled haploids (DHs), homozygous and homogenous lines can be created in only two generations, as opposed to five or more generations using standard methods. The benefits also include lower costs for cultivar production, more accurate evaluation of phenotypic traits, efficient deletion of unwanted genes, and trait fixation in haploids utilising marker-assisted selection. The DH method requires two primary phases for cultivar development: i) the creation of haploid plants, and ii) the duplication of the genome of the haploid plants generated. As the success of breeding programmes depends on the genetic gain per unit of time, the application of DH technology to improve the performance of the key crop species has become a standard practise.

Keywords: Breeding Techniques, Cultivar, Double Haploid, Rice

Physiological Basis of Growth and Yield of Low Land Rice Cultivars Grown under Low Light Environment

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Rice is the primary food crop worldwide. It ensures the livelihoods of millions of people worldwide, particularly in the poorest regions of Asia. Rice yield is greatly affected by abiotic stresses such as salt, drought, heat and light intensity. Low light stress is one of the most pervasive abiotic stresses affecting rice yield in India, particularly in the Eastern and North Eastern states, where it has a significant impact on agricultural productivity. Low light conditions reduce rice yield, impacting not only time but also physiological and agronomic factors. In this regard, the present study screened and evaluated genotypes (physiological, biochemical, and molecular) in response to low light stress. The experiment was done in Cuttack, Odisha, during the Kharif seasons of 2016 and 2017 with a total of 100 rice varieties. Kharif 2018 and 2019 have chosen ten genotypes (used as seed material for detailed investigation). During Kharif, the trials were done under Normal Light, 75% light intensity (with 25% cut off), and 50% light intensity (50% light cut off). Matted agro-shade nets of varied light intensities were installed on the hardwood frame as a measure for low light stress study. At 30 days post-treatment, morphological attributes were recorded during the flowering and harvesting periods. Alternatively, biochemical data were recorded at various phases of flowering. In low-light conditions, Panindra, PS-3, and Swarnaprabha outperformed other rice genotypes. Panindra outperformed all other varieties in terms of grain yield, grain weight per thousand grains, and Harvest Index. We analysed genes for photosynthesis and starch (Source-Sink). Low light stress did not significantly downregulate genes in Panindra, PS-3, or Swarnaprabha, whereas it did in HKR-126 and IR-8. Photosynthetic and starch-biosynthesis genes are affected by light. The results suggest that Panindra, PS-3, and Swarnaprabha could be used as model plant for low-light tolerance in crop plants.

Keywords: Abiotic Stress, Low light stress, Panindra, Rice, Source-Sink, Swarnapraha

Nanotechnology: An Emerging Technology in Agriculture

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Nanotechnology is the art and science of manipulating individual atoms and molecules at the nanoscale of less than 100 nanometers. Due to the increasing challenges of sustainable production, food security, and climate change, researchers are engaging in the new field, nanotechnology in agriculture. Nanomaterials (NMs) as vehicles of agrochemicals or biomolecules in plants have the great potential to enhance crop productivity through emphasizing its numerous applications in agriculture sectors. The most important application is the use of nanomaterials as fertilizer which helps in minimal use of fertilizer either by facilitating site-targeted controlled delivery or enhanced delivery systems to improve the uptake of conventional fertilizers. NMs can be applied to the soil as nanostructured fertilizers (nano fertilizers, as for Fe, Mn, Zn, Cu, Mo NPs). Metallic nanoparticles based on Iron oxide, ZnO, TiO_2, and copper have been directly applied as nanofertilizers in soil by irrigation or *via* foliar applications in different plants.

The use of nanotechnology in plant protection has exponentially increased due to the development and exploitation of nanosensors for rapid detection and precise quantification of fungi, bacteria, and viruses in plants. Nanomaterials have been applied to develop biosensors or they have been used as "sensing materials" as tools for detection and quantification of plant metabolic flux, residual of pesticides in food and bacteria, viral and fungal pathogens. Different categories of nanosensor types have been tested in plants, including plasmonic nanosensors, fluorescence resonance energy transfer (FRET)-based nanosensors, carbon-based electrochemical nanosensors, nanowire nanosensors, and antibody nanosensors.

Nanomaterial engineering is the cutting-edge track of research that supports the development of high-tech agricultural fields by offering a wider specific surface area crucial for the sustainable development of agriculture which not only reduces the uncertainty but also coordinates the management strategies of agricultural production as an alternative to conventional technologies.

Keywords: Agriculture, Nano-materials, Nano-sensor, Nanotechnology

Calibration and Validation of Rice Yield Forecast using CERES-Rice Model and Statistical Model in Different Districts of Telangana, India

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CERES-Rice model (DSSAT v 4.7) was calibrated and validated for rice crop using district wise weather data on maximum and minimum temperature, rainfall, RH I & RH II was collected from Met Centre, Hyderabad as per the forecast schedule. Soil profile characteristic data generated by NBSS & LUP, Nagpur was used for different districts of the State for DSSAT model. Six major rice cultivars (MTU-1010, MTU-1001, JGL15048, IR64 & BPT 5204) was used for simulations.During *kharif,* 2019 The F_1 and F_2 stage rice yield forecast using simulated model ranged from 2,866 to 5,236 kg ha^{-1} and 2,483 to 4,184 kg ha^{-1} in different districts of the Telangana state. Calibrated model used for further validation with during Kharif 2019 validation of rice yield forecast using simulation model (CERES- Rice) at F_1 and F_2 stages indicated that the RMSE values were 637 and 603 kg ha^{-1} respectively. The forecast was found to be good as the NRMSE values at F_1 and F_2 stages was 17 and 16% respectively. In *Rabi*, 2019-20 the forecast was found to be fair as the NRMSE values at F_1 was 27%. Whereas, using statistical modelat F_1 and F_2 stages indicated that the RMSE values were 669 and 649 kg ha^{-1} respectively. The forecast was found to be good as the NRMSE values at F_1 and F_2 stages was 18 and 17% respectively.

Keywords: CERES-Rice model, DSSAT, Forecast of rice yield, Statistical model

Estimation of Genetic Diversity in Rice Germplasm Morphological and Molecular Markers

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Rice is the staple food crop of the world population. The world population continues to grow steadily, while land and water resources are on the decline. The sustainable increase of rice production for food security will require efforts to enhance the capacity of rice production systems to adapt to global climate change as well as to mitigate the effects of rice production on global warming. Development of high yielding rice varieties may be used as sustainable and viable option for adaptation and mitigation in changing climate scenario. Understanding the extent of genetic diversity among the rice germplasm provides a great scope for harnessing the yield advantage arising through hybridization programme. In present study genetic relatedness among one hundred rice germplasm were assessed using 50 diversity panel markers developed under IRRI's Generation Challenge Programme (GCP). The number of alleles per microsatellite locus ranged from 1 to 5, averaging 2.45 alleles locus^{-1}. Polymorphism information content (PIC) values ranged from 0 to 0.56, with an average of 0.2.47. UPGMA clustering was done based on molecular marker data. The dendrogram thus constructed has grouped the hundred germplasm into four clusters. Analysis of molecular variance was performed to detect population differentiation. Percentages of variation present among populations and among individuals within population were 41 and 50% respectively. Characterization of the rice germplasm was also done for various morphological parameters including number of grains per panicle, thousand grain weight, yield plant^{-1} and spikelet fertility percentage. First three principal components based on morphological characterization have explained 65.1% of variation. The phenogram based on morphological traits has divided the rice germplasm into three groups each with two sub cluster. Information generated through cluster analysis based on phenotypic and molecular marker data could be efficiently used in hybridization programme.

Keywords: Germplasm, Diversity, Microsatellites, Rice

Enzyme Activities as Affected by Biochar and Pig Manure to Alter Soil Biological Indicators in Acidic Soil of Nagaland

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Biochar application to soil has been projected as an approach to improve soil quality, which can also influence soil microbial activities. A field experiment was conducted in the Department of Agricultural Chemistry and Soil Science, Medziphema during the *kharif* season of 2019-2020 in rice bean crop under acidic soil condition. The study was conducted to assess the effect of biochar and pig manure on the enzyme activities. The treatment consisted of 2.5 and 5.0 t ha^{-1} wood and bamboo biochar, 2 t ha^{-1} pig manure and 20 kg N, 40 kg P_2O_5 and 30 kg K_2O. The experiment was laid out in a randomized block design with 3 replicates in plots of 2.25 × 2.1 m^2. The highest microbial biomass carbon was found in wood biochar followed by bamboo biochar. The dehydrogenase activity in different biochar treatment increased significantly along with control. This study demonstrated that with increased biological indicator was more at 2.5 t ha^{-1} biochar application rates than 5.0 t ha^{-1} *i.e.*, lower concentration of biochar enhanced more than higher concentration. The result further revealed that effect of soil amendments (biochar and pig manure) significantly improved acid soils by improving microbial biomass carbon up-lift while increasing potential soil enzyme activity.

Keywords: Biochar, Growth, Pig manure, Rice bean, Wood, Yield

Effect of Tillage Practices and Pendimethalin on Soil Microflora and Dissipation Kinetics of the Herbicide in an Acid Inceptisol under Subtropical Region

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India is the fourth largest oilseed economy in the world. The low productivity of mustard is due to poor management practices and weed infestation in early stages are some of the important factors. Minimum tillage along with crop residue retention may be an option for conserving soil moisture, enhancing soil organic carbon, higher microbial and enzyme activities which in turn may improve mustard productivity. Pendimethalin [N-(1-ethylpropyl) 3,4-dimethyl-2,6-dinitro aniline], a pre-emergence herbicide is commonly used by farmers for weed control in mustard. The present study was carried out in instructional cum research farm, Assam Agricultural University, Jorhat, Assam, India during four consecutive years from 2016-2020 with soil textural class of the experimental plot was Aeric Endoaquept with sandy clay loam texture. The experiment consisted of five treatments as - [T_1: Conventional Tillage (CT) + Transplanted rice (TR) followed by (fb) Mustard (CT), T_2: CT + TR + Pretilachlor (fb) Mustard, [Minimum Tillage (MT) + Pendimethalin], T_3: CT + DSR (Direct seeded Rice) + Pretilachlor (fb) mustard (CT + Pendimethalin), T_4: MT + DSR + Pretilachlor (fb) mustard (MT + Pendimethalin + Residue retention), T_5: MT + DSR + Pretilachlor + Residue retention (RT) fb mustard (MT + Pendimethalin + RT), was arranged in randomized block design replicated thrice. Estimation of biological properties and Pendimethalin residue in soil was done by collecting treatment wise soil samples (0-15 cm) at 0 (within 4 hours of herbicide application), 3, 7, 15, 30, 45, 60, 75 and 90 DAA (days after application) of Pendimethalin and finally at crop harvest. The study revealed that Pendimethalin application showed significantly higher population count under MT as compared to CT. Dissipation of pendimethalin was faster in MT as compared to CT. The Pendimethalin at 750 g ha^{-1} can safely be used for weed control in Indian mustard for effective control of weeds.

Keywords: Conventional tillage, Dissipation, Minimum tillage, Pendimethalin, Population count

Effect of Different Nutrient Management Practices on Growth and Yield of Upland Rice-Based Intercropping System

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A field experiment was conducted during the *kharif* season, 2019-20 in the experimental farm, Department of Agronomy, NU, SASRD, Medziphema campus to study the effect of different nutrient management practices on growth and yield of upland rice-based intercropping system. The experiment was laid out in a Factorial Randomized Block Design with three replications. The treatment consisted of five cropping system *viz*., C_1: Sole rice, C_2: Sole groundnut, C_3: Sole soybean, C_4: Rice + groundnut (3:1), C_5: Rice + soybean (3:1) and three nutrient management practices *viz*., N_1: 100% RDF + FYM @ 2.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed, N_2: 75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed, N_3: 50% RDF + FYM @ 7.5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed. The result revealed that among intercropping system, rice + soybean (3:1) cropping system recorded highest plant height (cm), number of leaves plant^{-1}, dry matter yield (g) plant^{-1}, grain yield, straw yield and rice equivalent yield. Among different nutrient management practices, application of 75% RDF + FYM @ 5 t ha^{-1} + biofertilizer consortium @ 20 g kg^{-1} seed recorded significantly higher growth attributes and yield.

Keywords: Biofertilizer, Dry matter, FYM, Nutrient management

N-Fixing Capability and Rate of Mineralization of Dhaincha (*Sesbania bispinosa*)

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An experiment was carried out during summer kharif to study the N-fixing capability and rate of N mineralization of dhaincha (*Sesbania bispinosa*) in field as well as laboratory condition. The field experiment was laid with six different dhiancha genotypes *viz*., NSB-6, NSB-7, NSB-9, NSB-13, CSD-123 and CSD-137. The growing and incorporation of dhaincha genotypes employed a significant effect on soil available N, soil organic carbon, NO_3^- nitrogen, NH_4^+ nitrogen, pH and soil microbial population. On average, the increase in soil available N was up to 125 days after sowing (DAS) (273.5 kg ha^{-1}), soil organic carbon (SOC) up to 85 DAS (0.729%), nitrate-N up to 125 DAS (61.27 mg kg^{-1} of soil) and NH_4^+ nitrogen up to 85 DAS (69.320 mg kg^{-1}). The total bacterial count (61.17 CFU × 105 g^{-1}) and total fungi count (24.5 CFU × 103 g^{-1}) also found to be increased significantly at 45 days after sowing from initial soil. The soil incorporated with genotypes CSD-137 and NSB-9 attained higher values of soil available N, SOC, leghemoglobin, NO_3^- nitrogen, and NH_4^+ nitrogen concentration fixing more nitrogen. The dhaincha genotype NSB-9 subjected for decomposition under laboratory condition, revealed with higher decomposition constant and lower half life of total N (k = 0.00823 and DT5 0 = 84.20 days) and total organic carbon (k = 0.01009 and DT5 0 = 68.6 days) degraded at faster rate and mineralized more N into the lechate.

Keywords: Decomposition, Half life, N mineralization, *Sesbania bispinosa*

Performance of Soil Biological Properties and Yield as Influence by Integrated Nutrient Management on Direct Seeded Rice in Dystrudepts of Nagaland

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A field experiment was conducted during the kharif season of 2019 and 2020 to "Study the performance of soil biological properties as influence by Integrated Nutrient Management on direct seeded rice in Dystrudepts of Nagaland. The experiment was laid out in Randomized Block Design with 3 replications and 12 treatments namely: T_1: Control, T_2: RDF (120 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 30 kg K_2O ha^{-1}), T_3: 100% RDF +PSB, T_4: 100% RDF + 2 t FYM ha^{-1}, T_5: 100% RDF + 2 t FYM ha^{-1} + PSB, T_6: 75% RDF + PSB, T_7: 75% RDF + 2 t FYM ha^{-1}, T_8: 75% RDF + 2 t FYM ha^{-1} + PSB, T_9: 50% RDF + PSB, T_{10}: 50% RDF + 2 t FYM ha^{-1}, T_{11}: 50% RDF + 2 t FYM ha^{-1} + PSB, T_{12}: 109 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 46 kg K_2O ha^{-1} (SSNM). Pooled mean of two years of the treatment T_5 revealed significantly higher microbial count, higher soil microbial biomass carbon and dehydrogenase activity of soil which is at par with T_4. Higher grain and straw yield were also observed in T_5. Therefore, combined application of inorganic fertilizer with FYM and bio-fertilizer proved to be more efficient in increasing rice productivity and improving soil health by increasing the microbial load and enzymatic activity significantly in Dystrudepts of Nagaland.

Keywords: DHA, INM, Microbial biomass, Microbial count, Yield

Integrated Nutrient and Weed Management Practices on Quality and Soil Properties of Soybean in Nagaland

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A field experiment was carried out during the *Kharif* seasons of 2017 and 2018 at the research farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, to study the effect of integrated nutrient and weed management treatments on soil properties of soybean (*Glycine max* L. Merrill). It was laid out in a split-plot design with three replications. The main-plot consisted of three nutrient management treatments and the sub-plot consisted of five weed management treatments. The pooled results indicated that among the different nutrient management treatments, significantly lower weed density at 60 DAS was recorded with the application of 50% RDF + *Rhizobium* + Phosphate Solubilising Bacteria. Among the weed management treatments, hand weeding at 15, 30 and 45 DAS recorded significantly minimum weed density at 60 DAS. Application of 75% RDF + 5 t ha^{-1} FYM + Phosphate Solubilising Bacteria recorded higher seed yield (16.28 q ha^{-1}), stover yield (22.69 q ha^{-1}) and protein content (38.10%). Hand weeding at 15, 30 and 45 DAS recorded higher seed yield, stover yield, oil content and protein content over the rest of the weed treatments. It was followed bypropaquizafop @ 0.075 kg *a.i.* ha^{-1} PoE + hand weeding at 45 DAS and pendimethalin @ 1 kg *a.i.* ha^{-1} PE + hand weeding at 30 DAS. Application of 75% RDF + 5 t ha^{-1} FYM + Phosphate Solubilising Bacteria recorded significantly highest soil organic carbon (1.38%), soil available N (360.07 kg ha^{-1}), P (17.37 kg ha^{-1}) and K (82.83 kg ha^{-1}). The soil physical properties were not significantly influenced by different weed management treatments.

Keywords: Nutrient, Quality, Soil properties, Soybean, Yield

Changes in Secondary Nutrients of Soil in the Post Flood Scenario in Agroforestry and Other Land Use Systems of Thrissur, Kerala

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Millions of people in India are affected by floods, which have increased during the past decades and likely to increase further in response to warming climate. Flood like events can alter the farming production by affecting the soil properties of soil. Kerala had a flood on August, 2018 with a different duration or temporal variation from three to five days due to heavy and unexpected rain on that month. Flooding had a different impact on soil characteristics in specific land use systems. The current study was focussed on the impact of flood on secondary nutrients of soil (Ca, Mg and S) in home gardens, coconut plantations and open land use systems at Thrissur district of Kerala. Soil samples were collected from each land use systems from flood affected area and adjacent non-flooded area after six months of flood. The trial estimated that flood has a negative impact on secondary nutrients of soil in open condition followed by coconut plantation. Homegarden showed an increase in calcium and magnesium content (279.8 mg kg^{-1} and 174.1 mg kg^{-1} respectively) after flood while coconut plantation (366 mg kg^{-1} and 131.4 mg kg^{-1} respectively) and open condition (269.1 mg kg^{-1} and 33.9 mg kg^{-1} respectively) showed a decrease. There is no significant change observed in the soil sulphur content. Thus, the study indicates that the resilience of homegarden in maintaining the soil productivity after flood than coconut plantation and open land. Therefore, integration of tree species in any land use system or introduction of agroforestry would help to maintain the soil productivity as well as the production of land immediately after flood or agroforestry can be act as adaptation strategies for flood.

Keywords: Calcium, Coconut plantation, Flood, Homegarden, Magnesium, Sulphur

Evaluation of Sweet Corn Based Intercropping System on Lateritic Red Soils of Tripura

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A field experiment was conducted during two consecutive rabi seasons of 2020-21 and 2021-22 at the Research Farm of College of Agriculture, Tripura to enhance the productivity potential of sweet corn based intercropping system in lateritic red soils (tilla lands) of Tripura under North-Eastern region. 11 (eleven) numbers of treatment combinations comprising of diverse sweet corn based intercropping system along with sole crop of sweet corn as well as other intercrops were laid out in a Randomized Block Design replicated thrice. Intercropping system consists of one row of main crop (sweet corn) with one row of intercrops (*viz*., Mustard, Field Pea, Vegetable Pea, Toria, Pencil Bean at 1:1 ratio) in additive series. Treatments are *viz*., T_1: Sole Sweet Corn, T_2: Sole Mustard, T_3: Sole Field Pea, T_4: Sole Vegetable Pea, T_5: Sole Toria, T_6: Sole Pencil Bean, T_7: Sweet Corn + Toria, T_8: Sweet Corn + Field Pea, T_9: Sweet Corn + Vegetable Pea, T_{10}: Sweet Corn + Mustard, T_{11}: Sweet Corn + Pencil Bean. Sole cropping of main crop as well as different intercrops also accommodated in other treatments. Sweet corn + Vegetable Pea intercropping performed better in terms of crop equivalent yield (2,700 kg ha^{-1}) as well as land equivalent ratio (1.04). As per as the economics of cultivation is concerned, highest gross and net return obtained in T_9 treatment (Sweet Corn + Vegetable Pea). B:C ratio (4.5) was also maximum in Treatment T_9. From the findings of the experiment Sweet Corn + Vegetable Pea intercropping (T_9) can be recommended for farmers to cultivation for rabi season in red lateritic soils of Tripura.

Keywords: Crop Equivalent, Intercropping, Sweet Corn, Tripura, Yield

Determination of Growth-Stage-Specific Crop Coefficients (Kc) for drip Irrigated Wheat (*Triticum aestivum* L.) under Different Land Configurations

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Determination of the actual crop evapotranspiration (ET_c) during the crop growth is important for precise irrigation scheduling, sustainable development and environmentally sound water management. Development of a crop coefficient (K_c) can enhance ET_c estimations in relation to specific crop phenological development. An experiment was conducted on sandy loam soil at Junagadh Agricultural University, Junagadh to determine growth stage specific K_c of wheat (GW-366) using drip irrigation under different land configurations (L_1: broad bed furrow and L_2: flat land) at different irrigation levels (I_1: 1.0 ET_c and I_2: 0.8 ET_c).Soil moisture sensors were utilized to estimate Actual crop evapotranspiration. Results revealed that adjusted FAO K_c predicts higher value than sensor-based K_c values under both land configurations. Broad bed furrow (BBF) land configuration observed lower K_c values compared to flat land configuration at all growth stages of wheat. Sensor based $K_{c\text{-}ini,}$ $K_{c\text{-}dev,}$ $K_{c\text{-}mid}$ and $K_{c\text{-}end}$ values of BBF observed 0.21(7.26%), 0.59(13.78%), 1.00(7.27%) and 0.29(9.48%) and 0.20(8.43%), 0.55 (13.04%), 0.91(8.18%) and 0.26(9.48%) lower than flat land configuration. Overestimated adjusted FAO-K_c values caused a loss 106.18 mm and 89.43 mm precious water for wheat under BBF and flat land respectively.

Keywords: Broad bed Furrow, Crop coefficient, Drip irrigation, Land configuration, Wheat

Effect of Different Levels of Zinc Fertilizers on Quality of Maize (*Zea mays* L.) in West Tripura

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The present study was conducted at Experimental Farm, College of Agriculture, Tripura to find out the effect of different levels of Zn application on quality of maize during Rabi season of 2018 & 2019. The experiment was laid out in Randomized block design (RBD) design replicated three times. In this experiment zinc was applied by two methods, soil, foliar and their combinations. Zinc was applied @ 10, 20 and 30 kg ha^{-1} in soil during sowing while foliar application @ 1% Zinc sulphate was given during silking stage. Recommended dose of fertilizer for maize crop @ 150:70:70 kg N, P_2O_5 & K_2O ha^{-1} were applied according to the treatment details. The application of zinc *via* soil and foliar @ 30 kg ha^{-1} and 1% $ZnSO_4$ respectively recorded better quality of Maize grains in terms of N-content, P- content, K- content, protein content & other micronutrient content (Zn, Cu, Mn, Fe) *etc*. From the study, it was concluded that application of Zn *via* soil and foliar combination not only increased the maize quality but also the yield of Maize.

Keywords: Quality, Rabi Maize, *Zea mays* L., Zinc fertilizer

Deepor Beel, A Wetland of International Importance: Status, Threats and Future Protection

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Internationally recognized Ramsar site, wetland Deepor Beel has garnered a huge attraction towards itself leading to implementation of various protection policies. Deepor Beel, an area of 40.14 sq. km, is home to a variety of fishes and birds including Kingfishers, Adjutant Storks and various species of ducks. This rich ecosystem has been observed to get affected by significant degradation factors such as garbage dumping by the municipality sector at the vicinity of the beel, brick making factories which cause air pollution, use of pesticides during agriculture of crops near the lands, excessive fishing in the waters and large scale encroachment like a railway track running in the southern boundary of the wetland killing many Asiatic elephants. The most affected areas are water ecosystem and land ecosystem. Unplanned urbanization around Deepor beel has reduced water spread area and microplastics accumulation in the water surface from dumping of garbage has increased death rates of many species of fishes. Research has been carried out to deal with these threats with a view to the present status of the wetland. Prospective for future protection includes satellite remote sensing and GIS which help in the monitoring and assessment of natural habitat and its environment. Restoration of the wetland can be achieved by management and policy, monitoring, restoration, knowledge, and funding.

Keywords: Deepor Beel, Degradation, Ramsar site, Restoration

A Study on the Wetland Dakhinpaat Low Lying Area of Majuli, Assam, India

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Wetlands serve as potential reservoirs of water which also harbour bioresources, which sustain animal life. There are around 150 large and small wetlands/ beels/ derelict/ semi-derelict waterbodies or floodplain lakes are present in Majuli Island, Assam. Some of them are registered and some are unregistered. These are rich in both flora and fauna. The study site is Dakhinpaat Satra low lying area which is located in Majuli Island, the largest inhabited river island in the world. It is an unregistered beel located in Dakhinpaat gaon panchayat with an area of 2.00 ha. Diffferent types of birds including geese and swans, cranes, stork, Indian spot billed duck are seen visiting the beel. The birds migrate from other parts to breed, feed and raise their offsprings. Bar headed goose migrate over the Himalayas to spend their winter in Assam. Ruddy shelduck also called Brahmini duck is seen in the winter. Greylag goose (*Anser anser*), a species of large goose in the water fowl family is also found. Varieties of fishes like *Channa punctata, Systomus sarana, Colisa chuna, Channa orientalis* are found. Various submerged water plants like *Nymphaea nouchali, Ipomea aquatic, Ipomea carnea* are found. This beel is located in debutter land. Ahom Kings gifted the land to the Satra and the Satra look after the beel. The property is revenue free.

Keywords: Fauna, Flora, Island, Wetlands

Biochar: A Holistic Approach for Sustainable Crop Production

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Biochar is a potential soil amending solid material produced during pyrolysis, a process of thermo-conversion of biomass under little or no oxygen. There are numerous types of biochars depending on the original feed material from which they are derived. Each specific type of carbon-rich material results in a very specific and different type of biochar, reflecting the physical and chemical properties of the parent material. Biochar has been used in agricultural fields with mostly positive effects on soil microbiota, changes in soil properties, nutrient cycling in the soil, reduction in soil bulk density *etc*. This carbonaceous material can also stabilize heavy metals and used for remediation of toxic wastewater. Application of biochar not only acts as a potential source of micronutrients but also helps to mitigate the climate change by carbon sequestration. Considering the point of pollution control, biochar acts as a good adsorbent that helps the soil to retain nutrients, water and other agrochemicals for a longer period of time, thus minimizing the groundwater pollution. Efficient use of biochar could pave a way to manage soil health as well as can promote fertility. In India, there is an immense scope for converting millions of tones of biomass (weed and crop residues) into biochar and use the same for enriching soil carbon. The incomplete carbonization of the biomass during pyrolysis changes the properties of the feedstock, and provides the biochar with its characteristic porous structure, high surface area and pH, presence of active functional groups and a graphite-like aromatic structure, which can boost nutrient availability as well as increase microbial diversity. We can definitely use biochar as a holistic approach to improve crop yield and maintain soil health for a longer period of time.

Keywords: Biochar, Productivity, Nutrient, Soil Health, Sustainability

Mapping Land Use, Land Cover (LULC) Changes and NDVI in the Subansiri River Basin of Eastern Himalaya and the Alaknanda River Basin of Western Himalaya using Satellite Remote Sensing Technique

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This paper endeavours to analyse and interpret the land use and land cover changes in two Himalayan river basins *viz*., the Subansiri and the Alaknanda of Eastern and Western Himalayas respectively using Remote Sensing and GIS technologies. Both the unsupervised digital as well as visual interpretation methods are adopted to detect the changes in the landuse and landcover patterns of the basins with the help of LANDSAT imageries of the years 2000 and 2014 for the Subansiri basin in the eastern Himalaya and of the years 2000 and 2013 for the Alaknanda basin in the western Himalaya. It is found from the study that the vegetation cover and barren land had declined while there was a positive change in agriculture and built-up land in both the basins during the study period. The reason for the decline of the forest cover may be due to the increasing agricultural practices, population pressure and construction activities in the basins. A negative change is found in water/ snow/ glacier covered areas in case of the Subansiri basin of eastern Himalaya, whereas, there is positive change in such areas in the Alaknanda basin of western Himalaya. On the other hand, NDVI study shows high vegetation indices for both the basins of eastern and western Himalayas.

Keywords: Alaknanda, Himalaya, Landuse and Landcover (LU/LC), NDVI, RS and GIS, Subansiri

Cytotoxic Effect of Arsenic, Lead and Fluoride on Boar Semen In Hilly Region of Meghalaya

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Male fertility has declined in recent decades, with male factor infertility accounting for 40-50% of all infertility cases. Environmental factors, rather than a pre-existing origins, and exposure of heavy metals are thought to be the cause of the drop in sperm quality and cause infertility. The aim of this study is to investigate the cytotoxic effect of heavy metals on boar semen in Meghalaya. In the experiment, we investigated the *in-vitro* cytotoxic effect of heavy metals *viz*., Arsenic (As), Lead (Pb) and Fluoride (F) on sperm motility, viability, membrane integrity, as well as mitochondrial membrane potential in crossbred boars. For this study the sperm functional parameters were assessed after exposure of different concentrations (5, 10, 25, 50, 100, 200 µM arsenic and lead, as well as 0.5, 5, 10, 20 50 and 100 mM fluoride) in 0, 0.5 and 1 h of incubation. Sperm viability, membrane integrity, and mitochondrial membrane potential were assessed using a fluorescent microscope (Eclipse, Nikon, Japan). The results of the study revealed that in comparison to the control group, the long-term incubation (1 h) lowered the percentage of sperm motility, viability, membrane integrity, as well as the mitochondrial membrane potential in all experimental groups ($P<0.001$). It was concluded that As, Pb and F at high doses is a toxic element on the sperm functional attributes, which subsequently disrupts the viability of cells.

Keywords: Arsenic, Boar semen, Cytotoxic, Fluoride, Lead

Effect of Nano Selenium on Boar Sperm Motility and Membrane Potential during Short Term Preservation

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In India, about 79.03% of the total pig population is of indigenous and nondescript type (20th Livestock Census, 2019). Therefore, artificial insemination can be an important technology for their rapid genetic improvement. Boar semen preservation has two major challenges. Firstly, boar spermatozoa is highly sensitive to exposure to temperatures below 12 °C inducing cold shock. Secondly, boar semen contains a high concentration of polyunsaturated fatty acid that results in harmful effects of reactive oxygen species on sperm motility, morphology, viability and fertilizing ability. Recent advances in the use of biocompatible nanoparticles for semen preservation have been found advantageous due to their oxidation stress reducing properties. Selenium nanoparticles (Se-NPs) are important antioxidants that can remove harmful peroxides from the body through activation of glutathione peroxidase (GSH-Px) enzyme and thus protect the membrane structure of cells. Therefore, the present study was designed with an objective to evaluate the efficacy of different concentrations of Se-NPs on boar sperm motility and mitochondrial membrane potential (MMP) during short term liquid preservation. A total of 20 semen ejaculates from four healthy Hampshire crossbred boars were collected by gloved hand method. The semen was diluted in Beltsville Thawing Solution (BTS) and split into three equal aliquots and supplemented with two different concentrations of Se-NPs (1 µg ml^{-1} and 2 µg ml^{-1}) keeping one as control. The extended semen was then preserved at 15 °C for five days and sperm motility and MMP were evaluated on 0, 3 and 5 days. It was found that the per cent sperm motility and MMP was significantly higher on 3rd and 5th day in the Se-NP supplemented samples with concentration of 1 µg ml^{-1}. In conclusion, supplementing boar semen extender with nano selenium at a concentration of 1.0 µg ml^{-1} significantly improved the motility and MMP of spermatozoa during short term preservation.

Keywords: Boar sperm motility, Mitochondrial membrane potential, Selenium nanoparticles, Short term liquid semen preservation

Strategies for Sustainable Utilization of Openwater Fisheries Resources of Meghalaya: A Way Forward

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The Northeast Indian state of Meghalaya with its vast inland fishery resources in the form of rivers, floodplain wetlands, reservoirs, lakes and ponds offers tremendous scope for developing its fisheries sector, but lags behind in harnessing the potential. The state is deficient in fish production; it depends on additional fish supplied from Andhra Pradesh and other neighbouring states to fulfil its demand. There is an urgent need to increase fish production from available resources to fill the gap. To increase fish production, there is a need to utilize openwater fisheries resources of the state in a sustainable manner besides pond aquaculture. Sustainable development requires necessary initiatives in right direction at right time with appropriate technological interventions. Right direction can result in holistic fisheries development based on proper planning taking into account contribution from all fisheries resources. Implementation of strategies in time with indicator of development can be worked out with proper planning. Strategies to prioritize the developmental work with realistic targets and guidance to achieve the goals are also required. Strategies also clearly depict priority action to be taken on immediate, medium term and long term basis along with milestones to track the progress and to achieve the goal. In this paper, we discuss strategies for sustainable enhancement of fish production from open water fisheries of Meghalaya based on the present scenario along with required infrastructural and human resources development with a realistic approach.

Keywords: Openwater fisheries, Production enhancement, Sustainability, Meghalaya

Effect on Growth and Economics of Vanaraja Poultry on Azolla Feed Supplementation

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A study was conducted by *Krishi Vigyan Kendra*, West Siang, Indian Council of Agricultural Research, Arunachal Pradesh Centre, India for a period of 72 weeks, from January, 2021 to May, 2022 with 300 unsexed 4 weeks old brooded Vanaraja chicks which were provided to the farmers. The birds were randomly divided into five feeding trial groups (20 birds in each treatment group with 3 replications), namely TO_1 (birds were let out for foraging with no supplementation), TO_2 (basal diet), TO_3 (basal diet + 5% fresh Azolla), TO_4 (basal diet + 10% fresh Azolla) and TO_5 (basal diet + 15% fresh Azolla). Data on weekly body weight gain up to 20th weeks showed no significant difference between Azolla fed groups and basal diet fed groups whereas, number of egg production up to 72nd weeks recorded as 62.4±3.4, 110.5±3.1, 116.2±3.2, 120.5±4.6 and 128.2±4.8 in TO_1, TO_2, TO_3, TO_4 and TO_5 respectively. Economic efficiency of Azolla fed birds showed higher economic returns in terms of benefit cost ratio in group TO_5 (4.42) than that of basal diet (3.04) and group where birds were let out for foraging (2.59).

Keywords: Azolla, Egg production, Feed, Growth performance, Poultry

Decadal Shift in Fish Landings and Catch Composition in Brahmaputra River, Assam, India

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Analysis of long-term (1987-2019) fish landing data showed that an average 191.93 t yr^{-1} of fish landed at Uzanbazar (Guwahati) landing center of River Brahmaputra. The total landings exhibited a relatively upward trend since 1987 until registered peak landings of 471.8 t in 2002 and thereafter a consistent declining trend occurred to the lowest levels of 84.06 t observed in 2016. Following the peak landings in 2002, the average landings diminished by almost 80% in the last decade (2010-2019). Fish landings suffered changes in the qualitative and quantitative aspects of River Brahmaputra fishery in Assam. Whereas average total landings during last decade declined by almost 60% as compared to the average landings of 234.97 t yr^{-1} in the previous two decades (1987-2009), the contribution of Indian major carps (IMC) and minor carps towards total landings declined from 17.54% & 35.11% during 1987-2009 to only 4.86% and 8.94%, respectively during 2010-2019. Miscellaneous fishes group became a dominant group contributing 58.28% of the average landings in last decade (54.30 t yr^{-1}) compared to 69.38 t yr^{-1} during 1987-2009. Average landings of catfishes also decreased from 26.96 t yr^{-1} in 1987-2009 to 19.77 t yr^{-1} in 2010-2019, but percentage contribution increased from 11.47% to 21.28% over decades. Similarly, average landings of Hilsa declined from 8.24 to 3.42 t yr^{-1} but percentage contribution to total landings remained unchanged over the period. Such changes in the fish landings and composition of River Brahmaputra fishery can be partly ascribed to climate change, habitat modification, over exploitation and other anthropogenic causes. The sharp decline in IMC landings as well as changes in landing composition from the river due to these alterations in the last decade is directly affecting livelihood of the fishermen community. Observed changes in fish landings over the decades are discussed in this paper.

Keywords: Brahmaputra, Catch composition, Fish landings, Hilsa, Indian major carps

Treated Municipal Wastewater as a Water Source for Sustainable Pisciculture: A Study in Bhimasandra Pond Tumkur, Karnataka, India

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Fish culture has been the fastest growing food production sector during the last decades. The supply demand gap for fish is constantly widening and declining freshwater availability is becoming a major limiting factor for production. Exploring alternative water resources, such as treated wastewater (TWW), has become a growing strategy for coping with the increasing water demand in agriculture. Reuse of treated water for agriculture and fish culture has been practiced around the world. However, the extent of the practice and the scientific attention paid to TWW reuse for fish culture are negligible compared to those for agriculture irrigation. The TWW fish culture is a biological means of waste water treatment. The Bheemasandra pond receiving treated water from treatment plant. The periodical physico-chemical analysis of Bheemasandra pond was carried out from January 2021 to December 2022. Water quality for fish culture was estimated with the parameters such as temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), acidity, alkalinity and hardness. The obtained values of the investigated parameters were temperature 29-38.3 °C, pH 6.8-7.12, DO 1.1-6.9 mg l^{-1}, BOD 1.4-4.2 mg l^{-1}, transparency 32.5-57.5 cm, TDS 85-164 mg l^{-1}, EC 138-274 µs cm^{-1}, acidity 20-36.3 mg l^{-1}, total alkalinity 43.5-62.5 mg l^{-1} and hardness 20-27 mg l^{-1}. All the values were compared with the water quality standards for fish culture. The comparative analysis showed that the water quality parameters of the Bheemasandra pond was suitable for fish culture while the temperatures recorded were higher in most cases than the desired level, and transparency, TDS and DO level were also fluctuated highly. From this investigation, it is recommended that necessary steps should be undertaken to improve the water quality of the pond to a suitable level for fish culture. Steps should be implemented in such a way that they not ensure high yield fish production only to bring economic benefit but also conserve environmental quality.

Keywords: Bheemasandra, Fish culture, Physico chemical parameters, Pond, Treated waste water

Characterization of Extended Spectrum Beta-Lactamase (ESBL) Producing Escherichia coli Isolates from Food Producing Animals

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A total of 484 *Escherichia coli* isolates from feacal samples of pig (n=127), cattle (n=77), goat (n=15), buffalo (n=86), poultry birds (n=153) and duck (n=26), collected between the year 2015 to 2021 were characterized for their bla_{ESBL} genes, other antibiotic resistant genes and antibiotic resistant pattern. A total of 61 isolates (12.60%) were confirmed as bla_{ESBL} producers, where, isolates 36 (7.43%) for bla_{TEM}, 25 (5.16%) for bla_{CTX-M}, were positive for bla_{ESBL} genes. For other resistant genes, isolates 8 (1.65%) for *tet*A, 3 (0.61%) for *tet*B, 3 (0.61%) for *aac(3')IIa* and 6 (1.23%) for *aac(6')Ib* genes were positive. Phylogrouping of the isolates revealed that phylogroup A (43.38%) was the most prevalent phylogroup followed by B1 (29.33%), D (17.56%) and B2 (9.71%) respectively. Antibiotic sensitivity test of all the isolates revealed that 302 (62.39%) isolates were resistant to Ampicillin, and 361 (74.58%) and 342 (70.66%) of the isolates were susceptible to tetracycline and nitrofurantoin respectively. Genotyping using Enterobacterial Repetitive Intergenic Consensus-Polymerase Chain Reaction (ERIC-PCR) of the bla_{ESBL} and other resistant isolates showed a similar clonality among the isolates.

Keywords: ESBL, *Escherichia coli*, Food producing animals, PCR

Plankton Composition in Relation to Physio-Chemical Parameters of Yamuna River at Three Different Cities of India

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To evaluate plankton diversity in relation to physico-chemical parameters of the Yamuna river, the present study was conducted from March 2019 to February 2020. Three sites along the Yamuna River were chosen for regular sampling: Delhi (B_1), Mathura (B_2), and Agra (B_3). 11 species of phytoplankton and 9 species of zooplankton were recorded from site B_1 with a concentration of 15,517 individual L^{-1}. At site B_2 14 species of phytoplankton and 5 species of zooplankton with a concentration of 15,329 individual L^{-1} was observed. At site B_3 a total 15 species of phytoplankton and 5 species of zooplankton were recorded with a concentration of 19,453 individual L^{-1}. The highest abundance of group Cynophyceae in phytoplankton and Rotifera in zooplankton was observed during the study period at sites B_1, B_2, and B_3. Physico-chemical parameters were found suitable for plankton growth at site B_3.

Keywords: Delhi, Phytoplankton, River, Yamuna, Zooplankton

Vegetational Diversity and Ecosystem Services of Large Cardamom based Traditional Agroforestry Systems of Darjeeling Himalaya, India

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Managing soil and biomass carbon in the traditional farming systems will be both an avoided emission and net addition of carbon and conserving these systems will not only improve livelihood but will also improve the carbon footprint of a region. The study was conducted in Darjeeling Himalayas which was classified into three altitudinal for analyzing the variation on phyto-sociology, diversity, soil parameters and ecosystem carbon stock of the systems adopting stratified random nested quadrate sampling method. Overall, 130 plant species were documented, of which 37 were trees, 25 shrubs, 46 herbs; eight ferns, 11 climbers and three orchids. The system was estimated with higher soil fertility with medium to high available primary nutrients and high available SOC. The tree biomass, tree biomass carbon, SOC and ecosystem carbon stock estimated was 447.67, 210.40, 84.62 & 295.02 Mg ha^{-1}, respectively. The contribution by the tree biomass carbon to the ecosystem carbon stock of the system at low-, mid- and high-altitude class was 81.57%, 68.59% and 59.39%. The systems due to heterogeneous composition and structure with restrictions in biomass removal were permanent, stable and resilient tree-based land use systems viable for offsetting regional carbon emission. The study recommends bailing out this dying tradition by supporting the growers in their effort to preserve their traditionality through institutional, extension and policy interventions which will not only improve the livelihood of the growers but will also fulfil the global 4 per mille initiative.

Keywords: *Amomum subulatum*, Darjeeling Himalaya, Ecosystem service, Traditional agroforestry system

Vegetable Breeding for Disease Stress Tolerance

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Crop improvement for biotic stress tolerance in vegetables is a traditional objective of breeders for long term consequence. Although application of fungicides and pesticides has helped control plant diseases, but indiscriminate use of hazardous chemical causes environment pollution, chemical residues in vegetables above threshold levels and emergence of new races/biotypes. At this junction, breeding for the improvement of disease resistant cultivars is key intent of vegetable breeder's. Fundamental research on the genetic bases of disease resistance in vegetables and of host-pathogen interactions has significantly improved the competency of manipulating disease resistance genes in practical breeding programs and resulted in the development of high-yielding genetically resistant cultivars. In contrast to breeding for yield and other morphological characters, the development of varieties with resistance to biotic stresses involves manipulation of two genetic systems *i.e.*, one of plants and other of the pathogen, not independently, but with regard to the interaction between the two systems. Protection breeding methodologies are not different from production breeding techniques. Breeding for host plant resistance is switching from conventional *viz.* introduction, selection, hybridization towards non-conventional approaches like genetic engineering and molecular approaches, as later has broadened the scope of gene manipulations at the level of specific DNA segments across wide range of organisms to produce novel genomes with enhanced levels of resistance to disease stresses.

Keywords: Breeding strategies, Disease, Mechanism, Resistant breeding

Identification of Ginger Genotype Suitable for Intercropping in Coconut Garden

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Ginger (*Zingiber officinale* Roscoe) is a cash crop of immense value having medicinal properties, pleasant pungency, spicy aroma and essential component of number of byproducts *viz*., confectionary, curry powder, ginger cordial, cocktail, ginger tonic, ginger candy, ginger brandy, ginger wine, beer, flavoring pickle, sauce and preserves *etc*. A study was carried out to study the effect of coconut shade on ginger crop performance at Coconut Research Station, Aliyarnagar. The experiment was carried out with fourteen genotypes for five years in Randomized Block Design (RBD) with three replications. The recommended cultural practices and plant protection measures were adopted to raise a healthy crop. From the results, it is revealed that, the ginger genotype Athira is ideally suitable for cultivation as intercrop in coconut gardens of Western Zone of Tamil Nadu, since the genotype Athira proved its superiority by registering higher values for number of primary fingers (4.8), length of primary fingers (4.4 cm), diameter of primary finger (2.5 cm), number of secondary fingers (5.7), TSS (10.4 °Brix), dry matter content (18.9%), essential oil content (11.2 mg g^{-1} of dry ginger) and gingerol content (19.6 mg g^{-1} of dry ginger).

Keywords: Coconut Garden, Ginger Genotypes, Intercrop; Quality, Yield

Grafting Performance of Khasi Mandarin (*Citrus reticulata* Blanco.) on Different Citrus Species

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An experiment was conducted for two consecutive years (2021 & 2022) under protected condition to evaluate the performance of Khasi mandarin scion grafted on different species of citrus. The experimental design was laid in Randomized Block Design (RBD) consisting 8 treatments with 3 replications. The treatments were, T_1: Indian wild orange (*Citrus indica*), T_2: Tasi (*Citrus sinensis*), T_3: Rangpur lime (*Citrus limonia*), T_4: *Citrus latipes*, T_5: Citrange, T_6: Karna Khatta (*Citrus karna*), T_7: Kachai Lemon (*Citrus jambhiri*) and T_8: Rough Lemon (*Citrus jambhiri*). The highest grafting success (91.30%) was recorded in T_8 which were at par with T_3, T_7 and T_2; whereas the lowest grafting success was observed in T_4 (61.67%). The minimum days (16.80) taken for sprouting of the scion was recorded in T_6 and maximum days in T_1 (19.08). The maximum scion height, maximum number of leaves, leaf area and leaf width were recorded maximum in T_8 (Rough lemon). From the above investigation, it was concluded that among the different species of citrus tested, T_8 (Rough lemon) was found to have most vigorous effect on Khasi mandarin scion followed by T_3 (Rangpur lime), T_7 (Kachai lemon) and T_6 (Karna Khatta) at nursery stage.

Keywords: Citrus, Grafting, Kachai lemon, Khasi mandarin, Rough lemon

Understorey Light Availability and Productivity of Selected Cereal Fodder Grasses in Homegardens - A Major Agroforestry System in Kerala

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Light is one of the most important factors influencing the harmony between understorey and overstorey plants in any intercropping system. Homegardens, a traditional agroforestry system in Kerala is a low-light available agroforestry system. Livestock is an integral component of these systems; however, recently due to the high cost of feed and fodder, livestock rearing in homegardens is diminishing. In this present scenario, the integration of cereal fodder grasses in homegardens seems to be a viable option for enhancing livestock productivity. With this background, a study was conducted to analyze the total productivity, per day productivity and crude protein yield of selected cereal fodders *viz*., maize, sorghum and pearl millet in a selected homegarden and open contiguous areas in Central Kerala. The study also analyzed the relative productivity of cereal fodders with hybrid napier, the commonly cultivated fodder grass by the farmers of Kerala, and the influence of light in fodder productivity. The experiment was laid out in Randomized Block Design (RBD) with 8 treatments and 3 replications. The total productivity, per day productivity and crude protein yield were found higher in open contiguous areas compared to the homegarden with a light transmittance of 31.7 and 49.2 percent respectively during rabi and summer. In the homegarden, hybrid napier recorded the highest mean for total fodder production and crude protein yield but was found to be on par with maize. Pearl millet and maize exhibited the highest productivity per day with the shortest duration during the rabi season, while in summer, hybrid napier outperformed all other crops. Thus, the study indicates that cereal fodder maize is a suitable intercrop that can be integrated into the homegardens of Kerala, while pearl millet showed a moderate performance and sorghum cultivation appears to be an unviable approach.

Keywords: Cereal fodders, Crude protein yield, Dry fodder yield, Duration, Homegarden, Productivity per day

Cultivation of Low Chill Temperate Fruits in Eastern Plateau and Hill Regions for Sustainable and Profitable Farming

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Nowadays some of the temperate crops could be cultivated in subtropical sub-temperate climates successfully with intensive care and management. These are low chill apples, Asian pears, peaches; strawberry and low chill plums, *etc*. In non conventional areas, these crops showed promise due to a wider adaptation of the temperate fruits which permit sound harvesting and marketing of fruits and net profits. A 50.0% pruning with 2-3% thio-urea spraying improves fruit set and quality of low chill apple and Asian pear. After 1.5 months of fruit setting, 20-30 ppm GA_3 spraying to low chill temperate fruits leads to desirable growth. Some problems of temperate fruit production in mild tropics are lack of adopting training and pruning procedures, effective disease control and lack of availability of superior low chill cultivars. At high temperature bacterial canker and black spot on fruits and fungal diseases are the major problems which cause yield reduction by 12.0-40.0% in severe cases. Light irrigation is essentially required during the initial phase of fruit growth for all crops. With effective disease management and horticultural practices and use of suitable genotypes and their cultivation may pave the way for higher income of poor and tribal farmers of eastern plateau and hill regions. Net profits ranging from 1.25-5.2 lakhs $ha^{-1}year^{-1}$ were observed in different low chill temperate fruits cultivation from mono-cropping and at adult bearing orchards (> 9.0 years). Hence, for sustainable development, establishment of low chill orchards could be a better option to farmers of eastern plateau and hill region.

Keywords: Cultivation, Eastern Plateau, Hill Region, Low Chill, Temperate Fruits, Yield

Taro (*Colocasia esculenta*): A Cheap and Rich Source of Carbohydrate and Low Glycemic Index for Preparation of Papad for Small Scale Cottage Industry

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Papad is a popular Indian traditional snack item consumed after frying and roasting. In the present study, Papad was prepared from Taro in two stages. Twelve types of flour blends were prepared to make papads, each set containing six blends. Set-I contained blends of taro flour and black gram malt flour in different 6 ratios. Developed papads were subjected to sensory analysis and the treatments with highest and second highest scores from each set were selected for nutritional analysis and found the highest overall acceptability in S1T4 (7.85) both in fried and roasted type and second highest in S1T2 (7.55) fried and (7.50) in roasted type, hence they were selected from Set-I. From Set-II, the treatments S2T4 (7.10- fried, 7.05- roasted) and S2T5 (6.90- fried, 6.95- roasted) were selected. It was observed that the nutritional properties of the selected taro based papads varied significantly and were found to retain most of the nutritional qualities. The nutritional analysis at the end of storage period showed that the treatments retained a good amount of protein, carbohydrate as well as crude fibre. The developed products were also found to be organoleptically acceptable at the end of 50 days of storage without much deterioration in quality. The expansion percent of the selected treatments of papads of taro, black gram malt and unmalted black gram were found to be varied significantly. The study revealed that the treatment S1T4 with 60% black gram malt flour and 40% taro flour showed the highest overall acceptability as well as a high amount of carbohydrate and protein content.

Keywords: Carbohydrate, Ingredient, Papad, Protein, Taro

Impact of Invasive Species *Mikania micrantha* Kunth on the Fruit Production of *Citrus limon* L.

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Invasive plants are considered the most problematic weeds to indigenous plant cultivation in an area. All India Coordinated Research Projects (AICRP) on Weed Control at Assam Agricultural University (AAU) Jorhat, has regularly monitored invasive flora in Assam since 1983 and determined the dominance spectrum of recorded invasive species. Among dominant species, *Mikania micrantha* originating from South America and Central America has invaded many croplands and non-cropland areas of Assam. During World War II, *M. micrantha* was introduced into Northeast India which results in adverse effects on fruits and vegetables. Assam Lemon (*Citrus limon* L.) of the family Rutaceae, regionally known as *Kaji Nemu*, is exclusive to Northeast India. The fruit of *Citrus limon* is rich with many nutrients, carotenoids, flavonoids, vitamins, essential oils, and dietary fibers that impart health benefits.

Many lemon orchards present in a village named Bengena-ati located in Nagaon district in Assam, India are in an invasion of *M. micrantha* and causing economic loss on the selling of fruits by the farmers. Therefore, the present investigation was conducted to assess some important quantitative and qualitative features related to the fruit production of lemon trees. The investigation revealed that there is a significant change in fruit's numbers, sizes, rind thickness, LPA, pulpiness, juiciness, *etc*. of affected trees by *M. micrantha* as compared to unaffected trees. The rapid spread of *M. micrantha* in lemon orchards of the study area must get high priority to manage and reduce the spread of the *M. micrantha* and thereby minimize the economic loss of lemon farmers.

Keywords: Assam, Citrus, Fruit, Invasive, Mikania, Weed

Assessment of Genetic Diversity of Aroid species in Tribal Households of West Garo Hills, Meghalaya, India

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Aroids is an important group of tuber crops belong to family Araceae, grown widely for its leaves, petioles, corm and cormels. To study the genetic diversity at household level, this experiment was carried out with the collections from the village Rombagre in West Garo Hills of Meghalaya, India. Total 16 accessions of Aorids were observed at household level, and out of 16 accessions, 6 were grown under *Jhum* land as well as backyards and 13 accessions were grown under the backyards. Based on the population study in *Jhum* land accession Rengma was dominated with 47% of the total population followed by Tamachonkham (36%) and Tasakrek (12%). However, in backyards Pugarkusu (33%) and Chigi (24%) were major accessions. Under evaluation trials (53 accessions) with popular cultivars, wider variability was observed for yield and quality attributes. The high yielding accessions were identified as Tamachokgkham, Rengama-2 and Rongrem collections from Garo hills and popular cultivar Panchmukhi and C-3 (dasheen type) and White Gauriya and SJ-1 (eddo type). Among the accessions, the highest starch content was recorded in popular cultivar Kandha-5 (32.49%) followed by White Gauriya (30.32%). Molecular analysis (33 polymorphic SSR markers), detected a total of 136 alleles ranged from 2 to 8 alleles marker^{-1}. The heterozygosity ranges form 0.00-0.84, and observed average heterozygosity (0.24) was less the expected heterozygosity (0.69). Among the accessions, group wise maximum genetic divergence was observed between *Alocasia* spp. and *Xanthosoma* spp., *Alocasia* spp. to *Colocasia* spp (leafy type). Moreover, least divergence was observed between eddo and dasheen type accessions of genus *Colocasia*. The findings of the study indicated the wider diversity in the accessions of Aroid species at house hold levels with different ethnobotanical uses, need to conserved and popularize in other parts of the region for nutritional security.

Keywords: Aroids, Genetic diversity, Qualitative traits, SSR markers

Effect of Antioxidants and Polyamines on Physical Parameters of Sapota [*Manilkara achras* (Mill) Fosberg] cv. Kalipatti

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The present investigation entitled "Effect of antioxidants and polyamines on physical parameters of Sapota [*Manilkara achras* (Mill) Fosberg] cv. Kalipatti." was carried out at PG laboratory in College of Horticulture, Rajendranagar during 2016-2017 and 2017-2018. The experiment was carried out in Completely Randomized Design with three replications. The physical parameters like physiological loss in weight (PLW), number of days for ripening, firmness, ripening percentage, shelf life, and spoilage were estimated. PLW, firmness and spoilage were estimated at 3 days interval during ripening. The data on physical parameters showed that there was significant influence of post harvest application of antioxidants and polyamines on shelf-life of sapota. Fruits treated with BA @ 100 ppm (T_2) recorded lower PLW (17.76%), maximum number of days for ripening (8.50 days), and minimum spoilage where as shelf life (12.17 days) and firmness (1.95 kg cm^{-2}), were higher in BA @ 100 ppm (T_2) treated fruits during both the years and in pooled data respectively.

Keywords: Antioxidants, Benzyl Adenine, Physiological loss in weight, Polyamines, Shelf life

Comparison of Organic Fertilizer vs. Inorganic Fertilizer on the Growth of Cucumber (*Cucumis sativus* L.)

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Chemical fertilizers have been utilized extensively over the last five to six decades. They significantly contribute in damaging the ecosystem, including the soil properties and the health of the future generation. Organic farming is employed as a substitute to obtain better and healthier output. To increase output and replenish soil fertility without harming the environment or having any negative impacts on human health, organic fertilizers such as sawdust, cow dung and cow urine are used instead of chemical fertilizers. Nowadays, organic farming is widely practiced around the world. Efforts were made to study the effects of organic and inorganic fertilizers on the growth of cucumber (*Cucumis sativus* L.). Experiment was conducted in pots with four treatments *i.e.*, control (water and soil), organic (cow dung, cow urine, sawdust), inorganic (NPK) and mixture of organic and inorganic. The parameters observed were stem height, number of leaves and the length of leaves. Antimicrobial activity of cucumber leaves, seeds and cow urine was checked on different bacterial strains including *E. coli*, *Pseudomonas* sp. and *Salmonella* sp. Phytochemical analysis was conducted to analyze the presence of alkaloid, carbohydrate, tannins, saponins, flavonoids, terpenoids, phenol and anthraquinone content in cucumber. In comparison to alternative treatments, organic cucumber cultivation produces higher growth rates. Cow urine was more effective against *E. coli*, moderate against *Pseudomonas* and resist against *Salmonella*. The seed extract of cucumber was more effective against *Salmonella* and less effective against *E. coli*. The leaf extract is more effective against *Pseudomonas* and less effective against *E. coli*. In cucumber leaves alkaloids, carbohydrate, tannins, saponins, flavonoids, terpenoids, phenol and anthraquinone content are present.

Keywords: Compost, Cucumber, Manure, Organic fertilizers, Sustainable Environment

Process Optimization of Microencapsulated Polyphenols from Blood Fruitpomace Extract by Novel Jet Flow Vibration Technology and Its Evaluation as a Target Delivery System

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The aim of this study was to optimize process parameters of vibration nozzle-based micro-ensapsulator for polyphenols from freeze-dried blood fruit pomace extract (FDBPE) and to assess its performance under *in vitro* gastrointestinal digestion (IVGID) and stress conditions. Optimum alginate beads loaded with polyphenols were prepared using jet flow vibration technique; subjected to simulated IVGID, photo-oxidation (PO) and high osmotic pressure (HOP) to determine its efficiency as a target delivery system (TDS). Microencapsulated beads were produced by vibration nozzle-based microencapsulation using 150 µm and 1.5% alginate after optimization using response surface methodology (RSM) and Box-Behnken design (BBD). The total phenolic concentration (TPC) of optimally encapsulated FDPE was 24.97±0.10 mg GAE g^{-1} with encapsulation efficiency of about 81%. Under simulated digestion, the TPC of encapsulated microbeads showed delayed superlative five-fold and three-fold releases at the intestinal level as compared to oral and gastric levels respectively. Loss of polyphenols under UV-C irradiation was found to be only at 10% level compared to a total loss of 40% for nonencapsulated polyphenols. The effect of an osmotically stressed medium on the encapsulated microbeads could be treated as negligible. The optimized microbeads could be potentially used to increase bioavailability of health beneficial polyphenols from FDBPE.

Keywords: Blood fruit, Jet flow vibration, *In vitro* gastrointestinal digestion, Microencapsulation, Polyphenols

Optimization of Enzyme-Assisted Microwave Extraction of Phytochemical Rich Sohiong (*Prunus nepalensis*) Juice using Response Surface Methodology

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The novel extraction technology with latest advances showed an increase in the solvent free aqueous extracts. It extracts a higher amount of bioactive and phytochemical properties of the sample. The main objective of this study was extraction of Sohiong juice (SFJ) *via* enzyme-assisted microwave extraction and to optimize the conditions applied to assess potential phytochemicals (phenolic content, anthocyanin content and antioxidant activity), using a response surface methodology (RSM). The synergistic effect of enzymatic microwave treatment on extraction of Sohiong fruit juice was investigated. To observe the juice yield, with optimal total phenolics concentrations (TPC), total anthocyanin content and high antioxidant activity, based on the IC50 value of the scavenging of the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical; RSM was used for the determination of the extraction condition (microwave power, enzyme concentration, enzyme incubation time and microwave treatment time). These extraction parameters with better juice yield and good quality were found to be optimum at 600W microwave power, 0.05% enzyme concentration, 60 min of enzyme incubation time and 195s of microwave treatment. It was then estimated statistically for the four responses (Juice yield, TPC, TAC and DPPH). Under these optimal extraction conditions, Sohiong juice extracts with high TPC (151.4 mg GAE g^{-1}), TAC (2200 mg l^{-1}) and DPPH (89.61%) could be obtained. The results highlighted that the optimized extraction parameters could be a promising solution for the high yield of phytochemicals in Sohiong juice.

Keywords: Anthocyanins, Enzyme-assisted microwave extraction, Optimization, Phenolics, *Prunus nepalensis*

Promotion of Potential Agri-Business Ventures in North East India: A Way Forward

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Agribusiness is an emerging sector that supports the growth of the agricultural and allied sector industry, which is pivotal to economic growth. It also continues to play a crucial role in the growth of the region and country as a whole. Similarly, the North Eastern Region has much potential in the agribusiness sector due to the richness of agricultural and horticultural bio-resources. The region is the hub of aromatic & medicinal plants, spices, orchids, bamboo, and fruits & vegetables. The bamboo forest of Mizoram, the lakadong turmeric of Meghalaya, Tezpur Litchi and Bhoot Jolokia (chilli) of Assam, Tree tomato of Nagaland, Queen pineapple of Tripura, large cardamom of Arunachal Pradesh, Kachai Lemon of Manipur and organic nature of Sikkim is attracting the world for value chain development. In the last six years, the region witnessed an 85.34 percent growth in the export of agricultural products and did foreign exchange business from USD 2.52 million in 2016-17 to USD 17.2 million in 2021-22. The major destination of export has been Bangladesh, Bhutan, the Middle East, the UK, and Europe. This is possible due to the continuous efforts of agribusiness incubation centre's and other line departments' capacity-building programme on the value chain, market linkage, networking, legal support, business strategy development, technological support, and grant in aid to make *Atmanirbhar* (self-reliant) North East India. The Incubation Centre, North Eastern Hill University, Tura Campus funded by the Ministry of Micro, Small, and Medium Enterprises incubated 300 entrepreneurs, and 50 youths under AC & ABC Scheme and extended handholding support. They are running a successful business worth more than 3 crores and more than 1000 employment is generated.

Keywords: Agri-business, Capacity building, Market linkages, Technical and financial supports

Nutritional and Anti-Nutrient Composition, Bioavailability and Acute Toxicity Potential of *Haematocarpus validus* Bakh. f. ex Forman

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Haematocarpus validus, is one of the promising underutilized wild edible fruit spices found in the state of Meghalaya, India. The pulp of the fruit was subjected to analysis of its proximate composition, mineral content, phytochemical composition, composition of anti-nutritional factors along with the evaluation of acute toxicity. Among the minerals in the pulp, Potassium was found to be the most abundant at 262.71 mg/ 100 g. Phytate (267.25 mg/ 100 g) was the most abundant anti-nutritional component followed by saponin (39.12 mg/ 100 g). The Anti-Nutrient-Mineral ratios were calculated and compared with the critical values. Acute toxicity of blood fruit was found to be greater than 2,000 mg kg^{-1}. This fruit has essential nutritional components and offers good potential for the development of products for human use and consumption upon further processing.

Keywords: Acute toxicity, Anti-nutritional factors, *Haematocarpus validus,* Khoonphal

Response of King Chilli (*Capsicum chinense* Jacq.) to Boron Application

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King chilli (*Capsicum chinense* Jacq.) is one of the potentially high-value crops in the northeastern (NE) region, traditionally cultivate on hill slopes, rice fields and vegetable gardens by farmers in the region. Flower and fruit drop in king chilli is one the major main concern, which significantly reduces the yield of king chilli. We studied the effect of boron application on yield and yield attributes of king chilli and identified the optimum dose of Boron for maximizing the crop yield in a field trial during the year 2021. The treatments of the study comprised of four nutrient combinations of N, P, and Kalone and along with three levels of B for each basal (0, 1.5, 2 kg B ha^{-1}) and foliar (0%, 0.25%, 0.5%). The experiment were conducted in soil of pH- 4.9, N- 351.6 kg ha^{-1}, P- 21.3 kg ha^{-1}, K- 581.7 kg ha^{-1} and SOC- 2.1%. Result revealed that foliar application of boron @ 0.25% and basal application of boron @ 1.5 kg B^{-1} increased the number of fruits $plants^{-1}$ and yield in king chili. The treatment comprising of nutrient combinations, 120:50:65::N:P_2O_5:K_2O kg ha^{-1} + 0.25% B (foliar application) recorded the highest yield among all the treatment combinations and resulted 264% and 36% increase in yield respectively over the treatment with no fertilizer application (control) and 120:50:65::N:P_2O_5:K_2O kg ha^{-1} (N:P_2O_5:K_2O without Boron) respectively. The lowest yield (2.6 t ha^{-1}) was recorded in control with average fruit weight of 4.2 g. Therefore, we suggest nutrient management package comprising of 120:50:65::N:P_2O_5:K_2O kg ha^{-1} + 0.25% B for optimizing the yield of king chilli in the region.

Keywords: *Capsicum chinense* Jacq., King chilli, Nutrient management, Yield

Impact of Intercropping of French Marigold (*Tagetes patula*) with Gladiolus (*Gladiolus grandiflorus* L.) on Growth and Flowering as Influenced by Different Levels of Spacing and Fertilizer

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Field experiment conducted in Experimental farm of Assam Agricultural University, Jorhat to analyze the effect of varied levels of spacing (40 cm × 20 cm, 50 cm × 20 cm, 60 cm × 20 cm) and Nitrogenous fertilizer (130 + 220 + 200 kg NPK ha^{-1}, 160 + 220 + 200 kg NPK ha^{-1}, 190 + 220 + 200 kg NPK ha^{-1}), upon intercropping of French marigold with Gladiolus on growth and flowering attributes of both crops. Superior results on vegetative parameters of gladiolus were attained in sprouts $plants^{-1}$ in T_9 (S_2F_3) and maximum plant height and leaves per plant in T_{12} (S_3F_3). Application of 190 + 220 + 200 kg ha^{-1} NPK and 60 cm × 20 cm spacing acquired significant results on growth parameters of French marigold, including plant height, number of branches, number of leaves and plant spread. Flowering characters of both crops was found to depict better results on application of optimum spacing level of 60 cm × 20 cm and 160 + 220 + 200 kg ha^{-1} NPK. Spikes per corm, rachis length, internodal length, spike length and floret diameter of spike, fresh weight, dry weight, self-life and vase life recorded highest in treatment T_{11} (S_3F_2). Number of florets open and florets $spike^{-1}$ obtained maximum in T_8 (S_2F_2). Intercrop flowering productivity was observed to have maximum number of flowers $plant^{-1}$, flower diameter, fresh weight, self-life, loose flower life and yield $plant^{-1}$ was attained maximum in spacing of 60 cm × 20 cm (S_3) and NPK supplied at 160 + 220 + 200 kg ha^{-1} (F_3). In intercropping of French marigold with Gladiolus, treatment combination at 60 cm × 20 cm (S_3) and 160 + 220 + 200 kg ha^{-1} NPK (F_3) was found to be optimum in attaining flowering attributes in both crops, while 190 kg ha^{-1} N depicted superior results on vegetative parameters of both crops upon intercropping.

Keywords: French marigold, Gladiolus, Intercropping, Self-life, Spike, Vase life

Hormone Engineering to Prevent Preharvest Sprouting

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According to a simulation model, the world population would reach around 9 billion people by 2050, need to increase the seed productivity and reduce the loss to meet the demand. The recent occurrence of cyclonic storms with heavy rainfall flooding rice fields in the eastern region of India during the grain maturity season of October-November has significantly impacted rice productivity. HYV, which largely maintain farmers' and consumers' rice bowls, need dormancy to withstand the onslaught of variable weather. As the plants lodge on the ground, pre-harvest grains collect rain water. Viviparous germination degrades the food quality of rain-soaked seeds, lowering the market value of the crop. With the occurrence of such disasters on the rise, rice production stability can be maintained by integrating the seed dormancy in the seeds. Dormancy in rice, as in other angiosperms, is regulated by a balance of ABA and GA, both steroidal hormones, one of which is antagonistic to the other.

ABA, a key hormone for seed dormancy, may be genetically modified to improve dormancy and prevent PHS by using nine-cis-epoxycarotenoiddioxygenase (NCED), a rate-limiting enzyme in ABA production. Same result found in Arabidopsis. NCED-induced hyperdormancy can be reversed by activating counteracting genes such as NCED RNA interference or gibberellin (GA) production. ABA and GA hormonal theory helps in rescue fro germination as well as induces the germination. Genetic research has identified genes associated with seed dormancy and PHS resistance, some of which are associated with grain color. Seed dormancy has been associated with red grain color in cereal crops for a century. This pleiotropic gene expressed in early developing seeds plays a role in flavoinoid synthesis (ABA improvement in seeds level) as well as inducing the seed dormancy in the colored rice and by developing such type of pigmented rice helps to prevent PHS.

Keywords: ABA, GA, Hormonal Engineering, NCED, Pre-Harvest Sprouting

Impact of Climate Change on Fruit Production: Adaptation and Mitigation Strategies in Northeast Himalayan Region

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The North-eastern Himalayan region possesses a rich resource of diverse horticultural crops including major and lesser known underutilized fruit crops indigenous to this region. These crops contribute to the economy of the region and will make a major share if tapped to its potential wealth. The availability of these crops however is reduced due to genetic erosion owing to many factors including the climate change and related variabilities. Fruit production in the hills which is mostly grown as rainfed crop, is vulnerable to temperature rise, climatic variability, and drought caused by the shifts in rainfall pattern and inter-seasonal variability. Besides many others, the most significant impact as a result of climate change is the genetic erosion of fruits indigenous to its origin at higher elevations and being replaced by low chilling requiring fruits demonstrating a shift in agro-ecological region that is evident in some areas. The abundance of many local temperate crops of the Prunus species such as peaches, plums, cherries, pears, bird cherry (*Prunus nepalensis*) and others like walnut, wild apple (*Docynia indica*), *Pyrus pashia*, *Myrica* spp., *Rhus semialatus, Rubus* spp., *Eleagnus* spp., *Elaeocarpus floribundu, Spondias axillaris etc*. are reduced and being replaced by low chilling requiring crops like kiwi, avocado, low chilling apples (Anna, Golden Dorsett, HRMN 99) in Ukhrul district in Manipur. Tropical fruits like mango, banana and guava are seen growing at home gardens at higher elevations which was earlier not possible even for the seedlings to survive due to severe winter frosts. The apple growing belts in the foothills of Bomdila, Dirang of Arunachal Pradesh is being replaced by kiwi even after using rootstocks which are more adaptive to warmer climate, as the desired quality is not obtained. This is similar to the shift of the apple growing belts at the foothills to higher elevations in Kullu Valley and Bajaura in Shimla being replaced by kiwi, mango and vegetables.

Keywords: Agro-ecological shift, Climate change, Fruits, Low chilling

Management of Cumin Wilt through Fungicides, *Trichoderma* spp., Phytoextracts and Organic Inputs under *in vitro* Conditions

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Nine fungicides (systemic, non-systemic and ready-mix fungicides) were tested against *F. oxysporum* under *in vitro* condition by poisoned food technique and no growth of mycelial and cent percent inhibition of *F. oxysporum* f. sp. *cumini* was observed in carbendazim 50% WP and thiophanate methyl 75% WP at 500, 1000 and 1500 ppm concentrations remained statistically at par with each other. Six *Trichoderma* spp. evaluated against cumin wilt by using dual culture technique. Among all, *Trichoderm*a spp., *T. viride* (AAU isolate) was found significantly superior in growth inhibition with 73.89 percent and lowest mycelial growth of pathogen with 23.50 mm) of *F. oxysporum* f. sp. *cumini* which was followed by *T. viride* (JAU isolate). Nine phytoextracts were evaluated against *F. oxysporum* under *in vitro* condition by poisoned food technique and maximum growth inhibition of *F. oxysporum* f. sp. *cumini* was recorded in neem leaf extract 76.59, 77.26 and 78.33 with minimum colony diameter 20.83, 20.17 and 19.50 mm at 5, 10 and 15 percent concentrations, respectively. Out of seven organic inputs evaluated against *F. oxysporum* f. sp. *cumini* under *in vitro* condition by poisoned food technique, Panchagavya was found effective against *F. oxysporum* f. sp. *cumini* and resulted that no growth of mycelial and cent percent inhibition of *F. oxysporum* f. sp. *cumini* at 5, 10 and 15 percent concentration.

Keywords: Dual culture, Fungicides, Fusarium, Phytoextracts, Poisoned

Efficacy of Encapsulated Formulation of *M. anisopliae* against Three White Grub Species

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An alginate based encapsulated formulation using minimum ingredients were tested for its efficacy against three species of white grub *viz*., *Holotrichia serrata*, *Adoretus* spp. and *Lepidiota mansueta*. Grubs mortality of *H. serrata*, *Adoretus* spp. and *L. mansueta* was recorded as 80.00%, 80.00% and 40.00% respectively when treated with 500 mg encapsulated formulation till 21 days of treatment. While treated with 1 gram of encapsulated formulation of *M. anisopliae*, the mortality was 80%, 88% and 60% against *H. serrata*, *Adoretus* spp. and *L. mansueta*, respectively after 21 days of treatment. The LD_{50} value of the *M. anisopliae* formulation after 21 days of treatment was 352.5 mg, 310.8 mg and 759.3 mg against *H. serrata, Adoretus* spp. and *L. mansueta,* respectively. Laboratory results revealed that developed encapsulated formulation of *M. anisopliae* can be a viable option against soil dwelling insect pests like *Holotrichia serrata* & *Adoretus* spp.

Keywords: Entomopathogens, Formulated product, *M. anisopliae*, White grub

Unravelling Detailed Insights of AI and IOT in Precise Evaluation of Citrus Canker Disease Suppression in Assam Lemon

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Citrus Canker caused by *Xanthomonas citri* pv. *citri* (*Xcc*) is one of the most destructive disease of citrus. The present study was aimed at managing the disease using beneficial microbes (Endophytes and rhizospheric microbes), Botanicals (Aloe, Neem, Bael, Onion, Lemon grass, Garlic) and Organic formulations (Panchagavya and Jeevamrut). The treatments were tested *in vitro* against the pathogen using dual culture assay. The results showed that Endophyte (*Bacillus velezensis*), Rhizospheric microbe (*Pseudomonas putida*), Botanicals (Lemon grass and Onion) and Organic formulation (Panchagavya) were the most effective, which were later evaluated in field conditions. Assessment of Percent disease severity and yield enhancement of different treatments at different time intervals was done using AI and IOT technology. Manual observation of Percent disease severity was also done to check accuracy of both the datasets. Endophyte *Bacillus velezensis* applied both in soil and as foliar spray reduced the disease (40.87% to 7.56% in case of AI and 43.98% to 10.87% in case of manual observations) and also enhanced the yield from 140 to 155 no of fruit plant^{-1}. T-test analysis have revealed the efficacy of AI over manual observations and showed a positive correlation between both the data sets.

Keywords: AI, Citrus canker, Correlation, IOT, T-Test

Applications of Nanosensors in Robust Detection of Plant Diseases

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Rapid detection of plant diseases is gaining momentum for reducing the economic loss incurred by the farmers. Conventional serological techniques are present as well as utilized though, are unable to detect the pathogens at asymptomatic stage and require a wholesome complex process. For this purpose, we need an easy, accurate, reliable and sensitive detection tool to provide a helping hand for the farming community *i.e.*, nanosensors. Nanosensors are chemical or mechanical sensors that detect the presence of certain substance on a nanoscale (1-100 nm) dimension. They are emerging as research area in life sciences, which offer an enormous potential improvement in selectivity, sensitivity and speed. Composed of metals, non-metals as well as metal-oxides such as gold (Au), silver (Ag), copper (Cu), cupric oxides (CuO), silica (SiO_2) *etc*. which have the properties such as high sensitivity, brownian movement, thermal conductivity, high specificity and that enables them to include in the category of nanosensors. Its basic components are an analyte, a sensor, a transducer and a detector. These are synthesized by two approaches *i.e.*, Top down and Bottom Up. Nanosensors are advantageous from the perspective of high and specific sensitivity, fast response detection ability, reliability and accuracy. In the other hand, it has some drawbacks such as high initial costs of production, difficulty in developing reproducible calibration methods, restriction on using some dye probes due to cell toxicity and sequestration. To minimize these drawbacks, extensive research is required in this field. The challenges that we need to overcome are mass production and commercialization, reducing the cost of inputs as well as the production process, spreading awareness among the farmers *etc*. in order to enhance the yield and quality of the produce so that, the financial conditions of the farming community can be improvised.

Keywords: Analyte, Detector, Nanosensor, Sensor, Transducer

Role of Insects and Soil Erosion

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Soil is a living entity that provides the nutrients and serves as a habitat for different organisms, which live together as communities. Soil biota consists of the micro-organisms (bacteria, fungi, archaea and algae), soil animals (protozoa, nematodes, mites, spiders, soil dwelling insects and earthworms) and plants living all or part of their lives in or on the soil. Soil fauna can be classified into three different categories *viz*., micro, meso and macrofauna on the basis of their body size, which participates in direct and indirect nutrient turnover processes of the soil. Nearly, most of the insects present in the earth spend a part of their life cycle or whole of their stages in soil. However, all the insects or their any life stage are not responsible to cause significant amount of soil erosion on the earth crust. Mainly, the soil dwellers or subterranean insects which spent almost all the life stages in soil are responsible for causing such erosion by tunneling in the soil or making nest for their habitat. Among them, termites, ants, mole crickets, field crickets, *etc*. are the most significant insects that contribute to soil erosion. Soil dwelling and nesting insects remove soil particles from the underground onto the ground, and loosen the surface soil by creating burrows which are prone to erosion process. However, available literature reflects that insects causing heavy soil erosion are not a common phenomenon and it is mostly location specific and triggers by some abrupt climatic condition followed by some changes in population ecology. The present research abstract aims to find out the actual basis of the fact, whether insects are really responsible for causing soil erosion or it is a myth only.

Keywords: Nutrient turnover, Population ecology, Soil biota, Soil erosion, Subterranean insects

Exploration of Entomopathogenic Nematodes (EPNs) in Integrated Pest Management Programme

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Entomopathogenic nematodes (EPNs) have been successfully used as an effective alternative to chemical control against many economically important pests, especially in the case of soil insect pests such as white grubs, termites, cutworms, wireworms, *etc*. Since the discovery of the first EPN *Aplectanakraussei* Steiner (now *Steinernemakraussei* Travassos) in 1923, about 90 species of Steinernematidae and 20 species of Heterorhabditidae have reportedly displayed pathogenic quality towards various insect pests.In the last few decades itself, EPNs have gained an increase in popularity due to theirgood host searching capacity, host specificity, and pathogenicity. EPNs are characterized as obligate parasites which mainly belong to the families Steinernematidae and Heterorhabditidae. Their high pathogenicity and ability to cause insect mortality is accredited to the endosymbionts living in classic mutualism with the nematodes. The bacteria *Xenorhabdus* and *Photorhabdus* live in specific mutual association with the nematodes Steinernematidae and Heterorhabditidae, respectively to form a nematode-bacteria complex. Recent studies on the nature of endosymbionts and their relationship with the EPNs has shown that the endosymbionts produce toxic compounds that possessmiticidal, antimycotic, antibiotic, nematicidal, and anticancerous properties. Hitherto, EPNs have shown virulence against a wide range of target insectpests belonging to different habitats *viz.,* foliar, cryptic, and subterranean. Currently some EPN species like *Heterorhabditis bacteriophora*, *H. megidis*, *Steinernema carpocapsae*, *S. riobrave*, *S. kraussei*, *S. feltiae* and *S. glaseri* are commercially produced all over the world. EPNs are eco-friendly, contribute positively to the soil health and have shown synergistic effects when used in association with agrochemicals and other biocontrol agents. Moreover, local strains of EPNs are generally preferred as they have an added advantage. Since EPNs have a vast genetic diversity across the world, the option of collection and isolation of local EPNs should be explored and exploited.

Keywords: Biological control, Entomopathogenic Nematodes, IPM Programme, Integrated Pest Management

Management of Rust Disease of Bach (*Acorus calamus*) through Integrated Approach

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Acorus calamus L., a tall, perennial, grass-like monocot plant from the family, acoraceae is a well-known plant in Indian traditional medicines for centuries. It is a highly valued herb as it acts as a rejuvenator for brain and nervous system. It is a main medhya drug, which has the property of improving the memory power and intellect. Rhizomes of the plant are widely used in the treatment of number of ailments such as epilepsy, mental ailments, chronic diarrhoea, dysentery, fever, abdominal tumours, kidney and liver troubles, and rheumatism. *A. calamus* leaves, rhizomes and its essential oil possess many biological activities such as antispasmodic, carminative. But crop is suffered from various fungal diseases and the most common is the rust disease which affects its cultivation. Owing to the importance of the crop in the medical sector an integrated approach for the mangement of rust disease was carried out in the horticulture farm with biocontrol agents and chemicals under All India Coordinated Research Project on Medicinal and Aromatic Plants. Results showed that none of the biocontrol agents is found to be effective in managing the rust disease. But chemical fungicide Nativo was found to control rust disease with a percent disease incidence of 5.98%.

Keywords: *Acorus calamus*, Biocontrol, Nativo, Rhizomes

Rice Root-Knot Nematode (*Meloidogyne graminicola*): A Major Menace in Rice Production

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Rice is an important major staple food crop of the world which is affected by various biotic and abiotic stresses. Among biotic stresses, plant parasitic nematodes are considered as major constraints. However, of late, *Meloidogyne graminicola* has emerged as pest of International importance and it is considered as number one enemy of rice crop. Being a soil borne and hidden organism in rice causes a yield loss up to 80%. Due to its adaptation, distribution, broad host range and ability to survive under different abiotic factors especially physical and chemical properties of soil, such as soil pH, organic carbon, EC, nutrition, temperature, soil type, moisture, *etc*. The management is a challenging issue due to non-availability of nematicides and also effective management practices all these factors represents, *M. graminicola* a serious menace for rice production. Considering the impact of this nematode in rice production a literature is mainly focusing on symptoms, distribution, biology, survival strategies and management practices.

Keywords: Management, *Meloidogyne graminicola*, Plant Parasitic nematodes, Rice Root-knot Nematode

Biostimulants on Management of Seed and Soil Borne Diseases of Pulse Crops under Agro Climatic Condition of Tripura

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Pulses are of paramount importance in our diet and are considered as the second most important food source after cereals. Tripura is a Northeastern state of India and pulses are the cheapest source of protein and, therefore, occupy an important position in balancing human dietary needs. The natural conditions in Tripura are ideal for diverse patterns of cultivation. Pulses like Green gram, Black gram, Cowpea, French bean, Lentil, Field pea and Pigeon pea *etc*. are cultivated in Tripura during Kharif and Rabi seasons, either as sole or intercrops, under rainfed or irrigated conditions. Seed and soil borne diseases are one of the several factors responsible for low pulse production and leading to dependency of pulse on others state sources. Plant diseases cause economic losses in the yield to a great extent (25%). Biological control using antagonistic microorganisms has proved to be successful for controlling various plant diseases. Bio-priming is a new technique of seed treatment. It integrates biological and physiological aspects of disease control and used as an alternative method for controlling many seed- and soil-borne pathogens. In recent times the application of biostimulants as seed priming agents have been increased many folds in promoting plant growth and improved stress response. Bio-priming by involving many beneficial microbes like *Trichoderma, Pseudomonas, Bacillus* and various sea weed extracts provide resistance to plant against biotic and abiotic stresses while improving the crop production and productivity. Various bio stimulants like beneficial microbes or biological products are used in seed bio priming. The study of biostimulants as seed priming agent to control the seed and soil borne pathogens in pulses for improvement of seed quality and production under Agro climatic condition of Tripura will occupies a major thrust in coming future.

Keywords: Biostimulant, Diseases, Pulse, Seed Borne, Soil Borne

Development of a Rapid Detection and Quantification Technique for Chilli Leaf Curl Virus and Its Validation in Different Chilli Genotypes

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Plant viruses cause huge economic loss in vegetable crops worldwide. The frequent emergence of new strains of plant viruses are results of rapid evolution of the viral genome. This rapid rate of evolution makes the management of viral diseases very challenging. Begomoviruses, from the family *Geminiviridae* are major group of plant-infecting viruses with single stranded DNA genome. In the south-eastern parts of Asia monopartite begomoviruses are predominant possessing six protein coding genes. In North-eastern sub-Himalayan Terai and Dooars region, Chilli leaf curl virus, a monopartite begomovirus affecting chilli, can cause about 30-50% yield loss. Early infection of the virus may cause severe symptoms like upward curling of leaves, puckering, streaking, dwarfing of the plants *etc*. Management of these diseases strongly relies on early detection and quantification of the virus.

In the present study we cloned and sequenced six proteins coding ORFs of chilli leaf curl virus infecting chilli in sub-Himalayan terai region. These sequences were reported in NCBI and compared with available chilli and pepper leaf curl begomoviruses. Different genes of the viruses exhibited 90-92% similarity with Tomato Leaf curl Joydebpur virus and Chilli leaf curl Bangladesh virus. Using the gene sequences of this new virus, primers were designed from unique av2 region of the viral genome. A SYBR based real-time PCR technique for absolute quantification of the virus was developed using these primers to detect and quantify chilli leaf curl virus directly from extracts of infected leaf samples. With the developed method total seventeen locally popular chilli genotypes and land races were screened. Local genotype Sadalanka and Line boya were found to be highly susceptible; whereas, Chuapara and Pusa Sadabahar was found to be resistant to the virus. The defence responses of these resistant and susceptible genotypes after viral infections were studied which showed discrete differences in the inductions of different stress enzymes.

Keywords: Absolute quantification, Begomovirus, Chilli leaf curl virus, Real time-PCR

Beauveria bassiana (Balsamo) Vuillemin Establishes an Endophytic Association with Rice, *Oryza sativa* Linn. and Protects from Sheath Blight Disease Caused by *Rhizoctonia solani* Kuhn

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Beauveria bassiana (Ascomycota: Hypocreales: Cordycipitaceae), a potential entomopathogenic biocontrol agent, has drawn attention worldwide for its additional beneficial roles such as plant disease antagonist, beneficial rhizosphere colonizers, plant growth promoter and an endophyte. In the present study, endophytic colonizing behaviour of *B. bassiana* isolates were studied in rice following challenge inoculation by seed treatment, root inoculation and foliar spray methods by culture-plate assay. Also, antagonistic abilities of native *B. bassiana* isolates were also evaluated against *Rhizoctonia solani* both under *in vitro* and field conditions. The results showed highest per cent colonization (96%, 92% and 28%) of *B. bassiana* on 14th day post inoculation (dpi) respectively in stems, leaves and in roots, whereas, lower colonization was recorded on 7th, 21st and 28th dpi as compared by culture plate and light microscopy studies. Further, *B. bassiana* also exhibited efficient antagonistic abilities against *R. solani* with maximum percent mycelial inhibition recorded up to 71.15%, and the underlying mechanisms were identified as production of cell wall degrading enzymes, siderophore and virulent genes. Indirect mechanism of plant growth promotion and endophytic abilities of *B. bassiana* was also explored. However, under field condition, combined application of liquid based microbial consortium of *B. bassiana* isolates as seed treatment, seedling root dip and four foliar sprays with 10 ml in 1000 ml water at 60 days after transplanting at 15 days interval, resulted in reduced sheath blight disease severity by 65.80% and enhanced yield attributes in treated plots as compared to control plots. From the present study, *B. bassiana* as plant disease antagonist was identified, which further add new dimension in crop protection by introducing newer concept in integrated plant disease management programmes along with overall health of plant.

Keywords: *Beauveria bassiana*, Endophyte, Mechanisms, Rice, *Rhizoctonia solani*

Transcriptome and Gene Expression Analysis of *Maconellicoccus hirsutus* in Response to Gibberellic Acid

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The use of agrochemicals for crop production and protection always poses some drawbacks, the major concern being the development of increased xenobiotic metabolism in insects. Gibberellic acid has been extensively used in grapes to increase fruit yield. Although several studies have been conducted on the ecological and toxicological aspects of *Maconellicoccus hirsutus* in grapes, the knowledge about the molecular mechanisms underlying the detoxification of agrochemicals and hormoligosis effects, if any, is lacking. The *de novo* transcriptome assembly produced 1,47,074 transcripts with 82,098 unigenes of which 775 were differentially expressed between gibberellic acid treated and control samples with 362 genes being up-regulated and 413 genes being down-regulated. The transcriptome sequences were annotated with gene ontology (GO) and KEGG orthology (KO). According to the GO classification, a total of 9007, 8701 and 8147 DEGs were assigned to the biological processes, cellular components and molecular function categories, respectively. The KOG classification revealed that most of the genes predominantly belonged to Signal transduction mechanisms, lipid transport and metabolism and cell motility. Significant DEGs were confirmed by qRT-PCR. The *M. hirsutus* transcriptome and DGE data provide a comprehensive gene expression profile, which will help us understand the molecular processes underlying many biological traits and further design suitable management strategies.

Keywords: Gene expression analysis, Gibberellic acid, *M. hirsutus*, Transcriptome

Insectivorous Plants

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Insectivorous plants are perennial herbaceous plants that trap insects and use them as a supplementary source of nourishment. The carnivorous plants originated nine times in different orders to possess the property of carnivory. There are approximately 700 identified species of carnivorous plants placed in 15 genera of nine families of four orders of dicotyledonous plants. In India, a total of five genera of carnivorous plants are reported with 44 species; *viz*., *Utricularia* (38 species), *Drosera* (3), *Nepenthes* (1), *Pinguicula* (1), and *Aldrovanda* (1). Interestingly, North-East India is the home of all five insectivorous genera, namely *Nepenthes* (pitcher plant), *Drosera* (sundew), *Utricularia* (bladderwort), *Aldrovanda* (waterwheel plant), and *Pinguicula* (butterwort) with a total of 21 species. They are found in both terrestrial and aquatic habitats, but most of them are found in bogs, marshy and swampy areas. The insectivorous plants have got six basic trapping mechanisms (with representative genera or species), *viz*., adhesive trap, pitfall trap, lobster pot trap, pigeon trap, snap trap and suction trap.

Carnivorous plants are integral to their ecosystems, and these ecosystems in turn are necessary for the health of the planet and mankind. They not only maintain the ecosystem but also likely prevent secondary extinctions of other specialist species that rely on them, like the world's smallest frog, *Microhyla nepenthicola*. Habitat destruction is one of the main threats. Excessive poaching, developmental activities, deforestation, fragmentation, increasing production of waste and pollutants, forest fire, *jhum* cultivation, and poor seed germination ability of the plant are also some of the causes of declining populations. These carnivorous plants are now included in the IUCN red list of endangered species. Hence, conservation of such ecosystem service provider is a prime concern among the ecologist worldwide.

Keywords: Carnivory, *Drosera*, Ecosystem service provider, Insectivorous plants, *Nepenthes*, *Utricularia*

Efficacy of Some Botanical Powders as Grain Protectants against Pulse Beetle (*Callosobruchus chinensis* L.) on Ricebean (*Vigna umbellata* Thunb.)

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An experiment was conducted during January-June of 2019 and 2020 in the laboratory of the Department of Entomology, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus to evaluate the efficacy of some botanical powders as grain protectants against pulse beetle, *Callosobruchus chinensis* (L.) on ricebean, *Vigna umbellata* (Thunb.). The experiment was conducted in a Completely Randomized Design (CRD) with 3 replications. A total of 7 plant materials *viz*., *Azadirachta indica*, *Piper nigrum*, *Ocimum tenuiflorum*, *Eucalyptus globules*, *Allium sativum*, *Pongamia pinnata* and *Litsea citrata* were evaluated for their effect on oviposition reduction, adult emergence, infestation and weight loss by *C. chinensis.* All the plant products were mixed with susceptible ricebean seeds @ 5% w/w, Malathion 5% dust @ 1% w/w was used as standard check and untreated seed was used as control. Among the botanical powder treatments, the highest reduction in oviposition was found in *L. citrata* followed by *A. indica* and *P. nigrum*. The % adult emergence was also lowest in *L. citrata* treatment (55.23%) compared to the other botanical treatments. *L. citrata* seed powder also provided effective protection up to 2 months of storage with an infestation of 16.12% and weight loss of 2.40%, respectively followed by *P. nigrum* seed powder with an infestation of 31.67% and weight loss of 6.93%, respectively. The least effective was found in *P. pinnata* leaf powder. The findings revealed the potential of *L. citrata* and *P. nigrum* as grain protectants against pulse beetle in storage.

Keywords: Botanical, Grain protectants, Infestation, Pulse beetle, Ricebean, Storage

Guild Structure Analysis and Distribution of Spiders during Different Growth Stages in Rice Ecosystem

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Spiders are general predators serving an important role in ecosystem as they feed on several insects and small vertebrates. A preliminary study was conducted to document the spider fauna based on their feeding guild and distribution of dominant spiders during different stages of crop growth. Composition of guild structure revealed that six feeding guilds were identified namely, stalkers, ground runners, ambushers, foliage runners, space web builders and ambushers. Of these, orb-weavers were the most dominant guild with 41.86% followed by ground runners (25%) and stalkers (22.60%). Availability of spider species differs with stages of crop growth. During the early stage of rice crop, ground runners such as *Lycosa mackenzei* was abundantly found and *Pardosa sumatrana* was fairly common. During tillering stage, three species of spiders were abundantly found *viz*., *Oxyopes bimanicus*, *Oxyopes bharate* and *Pardosa sumatrana*. *Argiope* sp. and *Ruborridion* sp. was abundantly present at flowering stage while at maturity stage, orb weavers such as *Argiope pulchella* and *Tetragnatha* sp. were abundantly found forming webs in the crop canopy. The uses of chemical insecticides as a management practice in plant protection programme have posed major threat to environment as well as mans. There is a need for exploration of more species of spiders as they serve as an important tool for biological control of insect pests.

Keywords: Argiope, Guild, Insecticides, Predators, Spiders

Mobile Application on BIPM ON TUTA

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Tomato is an important vegetable crop grown widely all over the world. The South American tomato leaf miner, *Tuta absoluta* (Meyrick) (Gelechiidae: Lepidoptera) is a devastating pest of tomato. The larval stage of *T. absoluta* causes damage by mining leaves, stems and buds. The larvae burrow into fruits and feed on the inner contents. The damage so caused reduces the market value of the fruits and severe infestations cause 100% yield loss. Knowledge dissemination about this pest and its management strategies to the farmers and tomato growers is essential to control this pest early and to take adequate control measures. In view of this, the mobile application on BIPM ON TUTA has been developed and hosted in the ICAR-NBAIR server. This mobile app gives elaborate details about the pest *T. absoluta* like Biology, Identification keys, damage symptoms in the field and its management strategies by using advanced methods. This mobile app is having unique feature like 'Diagnostics' in which the user/ farmer can upload the image capturing from the tomato field to identify whether the damage is due to *Tuta absoluta*. Hence, this mobile app 'BIPM ON TUTA' can act as a handy tool to know about the pest and its management and also to identify the pest by using field photographs.

This mobile app is available online at https://mobileapptuta.nbair.res.in.

Keywords: Biological control, Knowledge dissemination, Mobile application, Pest management, Pheromone, *Tuta absoluta*

Bio-Efficacy of Broflanilide 30 SC against Fall Army Worm, *Spodoptera frugiperda* (Noctuidae: Lepidoptera) on Corn

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Chemical control is a common practice by the farmers to manage fall armyworm (*Spodoptera frugiperda*) in corn since its invasion in India from 2018. Thus, the main purpose of the work was to evaluate for the first time the field efficacy of a recently introduced novel insecticide *i.e.*, broflanilide against fall army worm (FAW) during winter 2019-20 and kharif 2020. Broflanilide 30 SC @ 60 ml ha^{-1} resulted highest overall mean mortality (86.15 and 87.02%) in larval population of FAW over untreated control. It was significantly at par with its next lower dose of 50 ml ha^{-1} (83.13 and 85.06%) followed by chlorantraniliprole 18.5 SC (79.58 and 81.30%) and emamectin benzoate 5 SG (78.75 and 81.81%). Statistically at par remarkable lower damage and attack intensity with considerable higher yield occurred in broflanilide (60 and 50 ml ha^{-1}), chlorantraniliprole (200 ml ha^{-1}) and emamectin benzoate (300 g ha^{-1}). So, broflanilide @ 50-60 ml ha^{-1} could be recommended as another alternative insecticide to manage *S. frugiperda* in corn.

Keywords: Bio-efficacy, Broflanilide, Corn, Fall armyworm, *Spodoptera frugiperda*

Lac Based Indigenous Technical Knowledge of Assam

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Survey on lac based Indigenous Technical Knowledge (ITK) amongst the farming communities of Assam revealed its prevalence mainly amongst the tribal people of West Karbi Anglong, East Karbi Anglong, Golaghat, Jorhat, Tinsukia, Goalpara and Dhemaji districts of Assam. Altogether six numbers of lac based ITKs were reported pertaining to lac culture, human medicine, dye making and post-harvest operations. Lac based ITKs have not been documented so far scientifically. For the first time some of the ITKs practiced by tribals/ farmers of Assam are reported, which might help other researchers/ scientists in further studies for scientific validation on lac based ITKs.

Keywords: Assam, Indigenous Technical Knowledge (ITK), Lac culture, Lac dye, Post-harvest operations

Biology and Morphological Characterization of *Eublemma amabilis* Moore (Lepidoptera: Noctuidae): A Major Pest of Lac Insect (*Kerria* spp.)

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Eublemma amabilis Moore (Lepidoptera: Noctuidae) is a notorious pest of lac insect, *Kerria* spp. (Hemiptera: Tachardiidae: Coccoidea) causing up to 20-25% damage of lac and its encrustation, which has an immense industrial utilities. The aim of the present study is to provide a life cycle, detailed morphological and morphometric assessment of adults and immature stages of *E. amabilis*. For the study, the lac encrustation with larvae (*E. amabilis*) were collected from the Regional Lac Insect Field Gene Bank, Department of Entomology, Assam Agricultural University, Jorhat and reared under laboratory condition in a plastic container. The gravid adult female of *E. amabilis* laid on an average 70.4±8.52 and 38.4.±8.52 number of eggs during her life span with the reproductive rates of 11.4±3.20 and 8.20±3.11 eggs female^{-1}days^{-1} in summer and winter, respectively. The study revealed that the life cycle duration of *E. amabilis* showed significant difference during summer (38 to 56 days) and winter (49 to 70 days) season.There were five larval instar of *E. amabilis*. Larval chaetotaxy differs significantly between the larval instars with increasing in number of setae from 1st instar to 3rd instar larvae and gradual decreased from 4th instar and 5th instar larvae. Important morphological characters of this insect include the following: eggs are depressed in the centre, ventrally flat and with sculptured chorion: pupa adecticous and object, with prominent spiracles. Adult moths are medium size and possesses filiform antennae with 36-42 flagellomere.

Keywords: *Eublemma amabilis*, Lac encrustation, Larval chaetotaxy, Morphometric

Adoption of Spot Blotch Pathogen *Bipolaris sorokiniana* of Wheat and Barley at Higher Temperatures

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Fifty-five isolates of spot blotch pathogen *Bipolaris sorokiniana* of wheat were evaluated at temperatures range of 10-40 °C for their growth and reproduction. Significant difference in mycelia growth was observed among the isolates at variable temperature. The temperature 25 °C supported best radial growth (89-90 mm) of isolates at 15th day of incubation. The maximum spore production (16.59×10^4 spores cm^{-2}) was also recorded at 25 °C. Minimum radial growth, mycelia mass, spore production and melanin content were recorded at 10 °C. The pathogen survived at higher temperature up to 40 °C with low protease activity, whereas at 25 °C the enzyme activity was maximum and lowest at 10 °C. Significant variations were observed for heat shock proteins among the isolates. HSP40 was the most common protein produced at temperature range 10-40 °C.

Keywords: *Bipolaris sorokiniana*, Heat shock, Protease, Proteins, Temperature, Wheat

Encapsulated Nano Zinc Oxide Loaded PGPR Bioformulation: A Potential Arsenal for the Management of Major Foliar Diseases of Rice

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Bacterial blight (BB) and brown spot (BS) are two major foliar diseases of rice that have been reported to cause heavy losses in yield upto 70% and 90% respectively. Besides, in India, Zn is considered as the 4th important yield limiting nutrient and accounts 10 Mha as Zn deficient in soil. In this study, Zinc oxide nanoparticles (ZnO-NPs) and bioactives from novel PGPR species were biologically synthesized to evaluate the antimicrobial efficacy against the pathogens of BB and BS of rice. The encapsulation of the nanomaterials serves better protection under harsh environmental conditions and also aids in target delivery of the synthesized products. Therefore, the microbe mediated synthesized nano Zn oxide and the bioactives were combined using a capping agent (Gum arabica). The effect of encapsulated nano ZnO loaded bioactive formulation (En-ZnO-NP-BF) at different concentrations was tested against *Bipolaris oryzae* and *Xanthomonas oryzae* pv. *oryzae* causing brown spot and bacterial blight respectively. After the satisfactory results in *in-vitro*, a field experiment was conducted during the study and evaluated for the yield attributing parameters.

Keywords: Bacterial leaf blight, Brown spot, Khaira disease, PGPR bioactive formulation, Zinc oxide nanoparticles

Biosynthesized Silver-Silica Nanocomposite: A Spanking New Weapon for Management of Sheath Blight Disease of Rice

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Sheath blight of rice caused by *Rhizoctonia solani* Kuhn, is one of the most destructive diseases in almost all the rice growing parts of the world. The disease has led to higher consumption of hazardous pesticides to mitigate the losses andincrease productivity. Nanotechnology has the potential to transform various fields of the agricultural sector including development of non-toxic nano-drugs. In the present study, silver (Ag) and silica (SiO_2) nanocomposite (NC) were synthesized using leaf extract of *Litsea salicifolia* acting as a reductant cum stabilizer. Ag nanoparticles (NP) have antimicrobial property and SiO_2nanogel (NG) is a good enhancer of plant defense mechanism. Combing both the nanoparticles, the NC was found to be a potent drug for management of *R. solani*. Characterization of Ag-NP and SiO_2-NG was done using UV-vis spectroscopy, dynamic light scattering, zeta potential, SEM, TEM, SAED, energy dispersive X-ray and nanoparticle tracking analysis. *In-vitro* efficacy test, conducted to study the efficacy of the NC at seven doses showed that, the effect was strikingly dependant on the concentration of the NC. The highest inhibition against both sclerotia and mycelia being at a concentration of 200 ppm with inhibition of 85.66% and 73.55% respectively with no sclerotial germination at 100 and 200 ppm. An encapsulated (EN) product of Ag-SiO_2 was prepared and when its efficacy was tested and compared with the Ag-SiO_2 NC and recommended chemical, we found 100% mycelial growth inhibition at 200 ppm of encapsulated product. Further analysis of the NC on rice plants with challenged inoculation of *R. solani* showed a reduction of per cent disease incidence up to 20% from 80% incidence in untreated control and also enhanced effect of plant growth parameters and biochemical defense mechanism in rice.

Keywords: Nanocomposites, *Rhizoctonia solani*, Rice, Sheath blight

Efficacy of Newer Insecticides against Gram Pod Borer *Helicoverpa armigera* (Hubner) on Chickpea (*Cicer arietinum* L.)

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Gram is a Key pulse crop of India; it is also known the king of pulses. It is the third most important pulse crop after pea and dry bean, this crop is grown on moderately heavy soils, black cotton soils and sandy loam soils. However, fertile sandy loam to clay loam soil with good internal drainage are best suitable for its cultivation. Soils should not be heavy alkaline in nature. Ideal pH range of 5.5 to 7.0 is suitable for chickpea farming. *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is a cosmopolitan, polyphagous and notorious pest which attacks numerous crops of agricultural importance and widely distributed in the tropics and sub-tropics. Chickpea is an important crop and amongst its several pests *H. armigera* (Hubner) is the most serious and causes 60-70% losses.The experiment was conducted with Randomized Block Design (RBD) using seven treatments namely Emamectin benzoat 5% SG @ 220 g, Spinetoram 11.7% SC @ 500 ml, Spinosad 45.0% SC @ 187 g, Flubendiamide 48% SC @ 100 g, Chlorantraniliprole 18.5% SC @ 125 g, Novaluron 10% EC @ 750 ml ha^{-1} including untreated control alongwith three replications. The plot size was 5.0 × 6.0 m^2 keeping row to row and plant to plant distance of 30 cm and 10 cm, respectively on evaluation of newer insecticides against gram pod borer on chickpea during 2018-19 and 2019-20 at experimental field of Department of Entomology, Rehti Farm of school of agriculture Mhow, BRAUSS, (MP). The seeds of variety JG-14 was sown on November 12th 2018 and 11th 2019. Evaluation of six insecticides *viz.,* Emamectin benzoat 5% SG, Spinetoram 11.7% SC, Spinosad 45.0% SC, Flubendiamide 48% SC, Chlorantraniliprole 18.5% SC, Novaluron 10% EC were evaluated against Gram Pod Borer (*Helicoverpa armigera* Hubner) larvae. The Gram Pod Borer (GPB) larval population was counted on 5 randomly selected plants 24 hr. before spray and at 3, 7 and 10 days after spray. The two-year experiment was conducted during *Rabi* 2018-19 and 2019-20 at the Rehti Farm of school of agriculture, Mhow, experimental field of Department of Entomology, BRAUSS, (MP). All the Chemical pesticides significantly reduced the GPB larval population. The GPB population varied from 2.23 to 2.57 larvae $plant^{-1}$ during *Rabi* season at one day prior to first spray. The population was significant lower with, Chlorantraniliprole 18.5% SC, followed by Spinetoram 11.7% SC, Spinosad 45.0% SC, Flubendiamide 48% SC and Emamectin benzoat 5% SG. These five Chemical pesticides are showing best management effects on the GPB larvae and pod damaging per cent and Novaluron 10% EC are least effective on larval population and pod damaging percent. The highest chickpea grain yield was obtained with Chlorantraniliprole 18.5% SC.

Keywords: Chlorantraniliprole, Chickpea, Emamectinbenzoat, Flubendiamide, *Helicoverpa armigera*, Grain yield

Evaluation of Bio-Pesticides against Gram Pod Borer *Helicoverpa armigera* (Hubner) on Chickpea (*Cicer arietinum* L.)

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Chickpea is a most important pulse crop of India; it is also known the king of pulses. It is the third most important pulse crop after peas and dry bean, this crop is grown on moderately heavy soils, black cotton soils and sandy loam soils. Ideal PH range of 5.5 to 7.0 is suitable for chickpea farming. *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is a cosmopolitan, polyphagous and notorious pest which attacks numerous crops of agricultural importance and widely distributed in the tropics and sub-tropics.The experiment was laid out in Randomized Block Design (RBD) with seven treatments *viz*., *Azadiractina* 1% (1000 ppm) Neem oil @ 1500 ml, *Baeuveria bassiana* 1% WP @ 3000 g, *Bacillus thuriengiensis* var. *kurstaki* 5% WP @ 3000 g, *Metarhizium anisopliae* 1.0% @ 3000 g, *Verticillium lecanii* 1.15% WP and HaNPV 250 LE ha^{-1} including untreated control, using three replications. The plot size was 5.0 × 6.0 m^2 keeping row to row and plant to plant distance are 30 cm and 10 cm, respectively on evaluation of bio-pesticides against gram pod borer on chickpea during 2018-19 and 2019-20 at experimental field of Department of Entomology, Rehti Farm of School of Agriculture Mhow, BRAUSS (MP). The seeds of variety JG-14 was sown on November 12th of 2018 and 11th of 2019. There were seven treatments including control. Evaluation of six insecticides *viz., Azadiractina* % (1000 ppm) Neem oil, *Baeuveria bassiana* 1% WP, *Bacillus thuriengiensis* var. *kurstaki* 5% WP, *Metarhizium anisopliae* 1.0% WP, *Verticillium lecanii* 1.15% WP and HaNPV 250 LE were evaluated against Gram Pod Borer (*Helicoverpa armigera* Hubner) larvae. The Gram Pod Borer (GPB) larval population was counted on 5 randomly selected plants 24 hr. before spray and at 3, 7 and 10 days after spray. The two-year experiment was conducted during *Rabi* 2018-19 and 2019-20 at the Rehti Farm of school of agriculture, Mhow, experimental field of Department of Entomology, BRAUSS (MP). All the biopesticides significantly reduced the GPB larval population. The Pooled GPB population varied from 2.30 to 2.50 larvae $plant^{-1}$ during *Rabi* season at one day prior to first spray. The population was significantly lower with, *Bacillus thuriengiensis* var. *kurstaki* 5% WP, followed by HaNPV 250 LE, *Baeuveria bassiana* 1% WP, *Metarhizium anisopliae* 1.0% WP and *Azadiractina* 1% (1000 ppm) Neem oil, these five biopesticides are showing best management effects on the GPB larvae and pod damaging percent and remain and least effective treatment was *Verticillium lecanii* 1.15% WP. The maximum reduction of larval population and pod damaging percent. The highest chickpea grain yield was obtained with *Bacillus thuriengiensis* var. *kurstaki* 5% WP in *Rabi* season.

Keywords: *Azadiractina, Helicoverpa armigera*, Chickpea, *Bacillus thuriengiensis* var. *kurstaki,* Grain yield, Gram pod Borer

Microbiome Engineering for Sustainable Crop Production with Special Reference to Plant Disease Management

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Modern agriculture must overcome several obstacles to maintain a growing population, which poses serious risks to the world's food and energy security. With their numerous plant growth-promoting (PGP) characteristics, plant-associated microorganisms have a great deal of promise to offer practical and long-lasting solutions to today's agricultural problems. Numerous PGP bacteria have been identified, and some are widely used as biofertilizers, biostimulants, and biocontrol agents despite the fact that plants offer a variety of biological niches for microbes. However, there hasn't been much success using PGP microorganisms on fields for commercial adoption. This is probably because the more resilient existing microbial communities, whose structure has been formed over time through complex multilateral interactions with the environment, exclude the new bacteria. Finding new microorganisms that can sustainably support plant development, nutrition, fitness, disease control, and productivity in dynamic and stressful environments is needed.

A new area of synthetic biology known as "Microbiome Engineering" might have solutions to this constraint. Recent developments support top-down and bottom-up methods for designing non-model bacteria and microbiomes to enhance advantageous plant-microbe interactions as well as new techniques for evaluating these interactions. Synthetic microbial communities (SynComs), a recent innovation, aim to tune plant microbe interactions by selecting and modifying microbial consortia with improved colonisation, prevalence, and stress tolerant features. Such artificially created microbial inoculants combine the ecology and genetics of microbial populations to provide sustainable agricultural outputs. Such microbial-based interventions have a considerable chance of overcoming the global stagnation in agricultural output, biomass needs, and climatic uncertainty.

Keywords: Bottom-up, DBTL cycle, Micro-biome, PGP, SynComs, Top-down

Nanopriming of Chickpea Seeds Can Enhanced the Plant Growth Parameters against *Fusarium oxysporum* f.sp. *ciceri*

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Among the pulses, chickpea is considered as an important pulse crop of India, but its productivity is quite low due to several biotic and abiotic stresses. Among the biotic stresses, diseases are the major constraints and wilt caused by *Fusarium oxysporum* f.sp. *ciceri* has been considered one of the devastating diseases which caused yield loss upto 10% annum^{-1}. To overcome this biotic and abiotic stresses priming is a very promising strategy in crop production and management. In the present study, two nanoparticles *viz*., Zinc oxide nanoparticles (ZnO NP) and Silver nanoparticles (AgNP) were taken to evaluate for plant growth in chickpea. The seeds were treated for 6 hrs with ZnO NP and AgNP in alone and in combination with one another at a concentration of 100 ppm. Comparison was done with chemical check (Carbendazim @ 0.1%) and control. The result showed that the seeds treated with ZnO NP @ 100 ppm regulate the plant growth by increasing root and shoot length, fresh and dry weight and weight of the seed along with the higher seed production. This was followed by seeds priming with both the ZnO NP @100 ppm and AgNP @ 100 ppm. Thus we can conclude that the ZnO NP is potential nanopriming agent against the wilt of chickpea.

Keywords: Chickpea wilt, Nanopriming, Silver nanoparticles, Zinc oxide nanoparticles

Effect of Weed Species as Trap Crops to Gomati on the Population of Entomophages and Pests Suppression in Rice under Indo-Burma Region

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In Mizoram, Nagaland, and parts of Arunachal Pradesh, rice is a staple diet. Rice consumption has roughly risen in recent years, but productivity has fallen. Inadequate use of chemical fertilisers and pesticides is a primary source of pest recurrence and secondary infestation, resulting in output losses of 15-20%. IPM in rice requires biological, cultural, and chemical control mixed with insect-resistant rice varietals. Rice insect management relies heavily on biological control via predators, parasitoids, and insect diseases. Investigations were conducted to develop ecological engineering cropping methods with weed species (*Echinocloa colona*, *Echinocloa crusgalli*, *Cyperus rotundus*, *Ammana baccifera* and *Marsilea quadrifolia*) as border crops or intercrops with the main crop Gomati Dhan to enhance entomophages and pest suppression in the rice ecosystem under zero insecticide conditions. This study was undertaken in 2017-2019 at the ICAR Mizoram Centre in Kolasib, Mizoram. Ecological engineering metrics such as pest defender ratio, occurrence ratio (OR) of entomophages, preference ratio (PR) of pests, biodiversity indices of entomophages and pests, and cost-benefit ratio (CBR) were estimated for all cropping systems. Among rice weed species compositions, Gomati Dhan + *E. colonum* and Gomati Dhan + *E. crusgalli* border and strip cropping systems influenced the maximum population of *Amauromorpha accepta metathoracica*, *Charops brachypterum*, *Trichomma cnaphalocrosis*, *Xanthopimpla flavolineata*, *Ophionea nigrofasciata*, *Lycosa pseudoannulata*. The Gomati Dhan + *C. rotundus* and Gomati Dhan + *A. baccifera* bund and strip cropping systems influenced rice entomophages more than Gomati Dhan alone. Gomati Dhan + *E. crusgalli* border and strip cropping methods reduced rice leaf folder, BPH, WBPH, GLH, thrips, stemborer, and ear head bug adults and dead heart, white ear, leaffolder, and ear head damage compared to Gomati Dhan alone. Gomati Dhan + *E. crusgalli*, Gomati Dhan + *C. rotundus*, Gomati Dhan + *A. baccifera* and Gomati Dhan + *M. quadrifolia* border and strip cropping systems showed moderate pest damage. Gomati Dhan + *E. crusgalli*, Gomati Dhan + *E. colona*, Gomati Dhan + *C. rotundus* and Gomati Dhan + *M. quadrifolia* border cropping systems (1:2.94, 1:2.74, 1:2.34, and 1:1.93 respectively) and strip cropping systems (1:2.98, 1:2.61, 1:2.57, and 1:2.18 respectively) performed better than Gomati Dhan + A. baccifera, Gomati Dhan.

Keywords: Cost benefit ratio (CBR), Indo-Burma border, Occurrence ratio (OR), Preference ratio (PR), Rice

Bio-Efficacy of Insecticides for the Management of Mustard Aphid, *Lipaphis erysimi* (Kalt.) in Mustard Crop

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Field experiment was conducted to evaluate the bio-efficacy of insecticides against mustard aphid, *Lipaphis erysimi* (Kalt.) on mustard crop. The result revealed that significantly low aphid population (12.14) was obtained with Imidacloprid 17.8 SL followed by Acetamiprid 20 SP (12.59) and Thiamethoxam 25 WG (12.76). Maximum reduction of aphid population (65.83%) was recorded with Imidacloprid 17.8 SL followed by Thiamethoxam 25 WG (63.91%) and Acetamiprid 20 SP (57.00%). The maximum yield was recorded in case of Acetamiprid 20 SP (15.76 q ha^{-1}) followed by Imidacloprid 17.8 SL (15.70 q ha^{-1}) and Thiamethoxam 25 WG (15.37 q ha^{-1}). NSKE 5% was found to be the least effective insecticides. The higher net return based on Benefit/Cost ratio (5.65:1) was obtained in case of Acetamiprid 20 SP followed by Profenophos (5.07:1) and *Verticilium lecanii* (5.05:1).

Keywords: Benefit/Cost ratio, Bio-efficacy, Insecticides, Management, Mustard aphid, Yield

Evaluation the Efficacy of Newer Insecticides against Brinjal Shoot & Fruit Borer Damage

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The study was conducted during the cropping season 2018-19 and 2019-2 to evaluate the noval insecticides against brinjal shoot & fruit borer. The data on percent shoot damage on brinjal crop in various treatments were recorded from one day before spray and 3rd, 7th, and 14th days after spraying during the both cropping season. Evaluation of eight insecticides *viz.,* Fenpropathrin 10% EC, Chlorantraniliprole 18.5% SC, Spinetoram 11.7% SC, Fluxametamide 10% EC, Fluxametamide 10% EC, Spinosad 45.0% SC, Betacyfluthrin 8.49% + Imidacloprid 19.81% OD and Emamectin benzoat 5% SG were evaluated against. The data recording the shoot damage percent in overall mean of the all the treatments showed statistically superior as compared to untreated control and found the significant difference of brinjal shoot and fruit borer, among all the treatments the minimum shoot damage was recorded in the Fluxametamide 10% EC 30 AI (g) (2.58%) but Fluxametamide 10% EC 30 AI (g) at par with Fluxametamide 10% EC 40 AI (g) (2.75%) followed by Spinosad 45.0% SC (3.58%) and Spinosad 45.0% SC also found at par with Spinetoram 11.7% SC (3.83%) followed by Betacyfluthrin 8.49% + Imidacloprid 19.81% OD (4.50%) but Betacyfluthrin 8.49% + Imidacloprid 19.81% OD is also at par with Emamectin Benzoat 5% SG (4.58%), Chlorantraniliprole 18.5% SC (4.67%) and Fenpropathrin 10% EC (5.42%). The overall maximum percent shoot damage was recorded in UTC [WATER] (8.42%). In 2019-20 also recorded the minimum shoot damage in Fluxametamide 10% EC 30 AI (g) (2.67%) but Fluxametamide 10% EC 30 AI (g) at par with Fluxametamide 10% EC 40 AI (g) (2.92%) followed by Spinetoram 11.7% SC (3.75%) but Spinetoram 11.7% SC also found at par with Chlorantraniliprole 18.5% SC (5.50%), Spinosad 45.0% SC (4.42%), Betacyfluthrin 8.49% + Imidacloprid 19.81% OD (4.33%) and Emamectin Benzoat 5% SG (4.50%), followed by Fenpropathrin 10% EC (5.92). The overall maximum percent shoot damage was recorded in UTC [WATER] (9.50%).

Keywords: Brinjal, Emamectin benzoat, Fluxametamide, *Leucinodes orbonalis,* Spinetoram, Spinosad

Bio-Efficacy Evaluation of Biopesticides against Brinjal Shoot & Fruit Borer Damage

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The observations on percent shoot damage on brinjal crop in various biopesticides treatments were recorded from one day before spray and 3rd, 7th, and 14th days after spraying during the cropping season 2018-19 and 2019-20. The five insecticides *viz., Azadiractina* 1% (1000 ppm) Neem oil, *Beaveria bassiana* 1% WP, *Bacillus thuriengiensis* var. *kurstaki* 5% WP, *Metarhizium anisopliae* 1.0% WP and NSKE, were evaluated. The treatments showed statistically superior as compared to untreated control and found the significant difference of brinjal shoot and fruit borer, among all the treatments the minimum shoot damage was recorded in the *Azadiractina* 1% (1000 PPM) Neem oil (3.75%) but *Azadiractina* 1% (1000 PPM) Neem oil at par with *Metarhizium anisopliae* 1.0% WP (5.08%) followed by *Beaveria bassiana* 1% WP (5.33%), *Bacillus thuriengiensis* var. *kurstaki* 5% WP (3%) but *Bacillus thuriengiensis* var. *kurstaki* 5% WP is also at par with all other treatments and the overall maximum percent shoot damage was recorded in UTC [water] (10.08%) and at 2019-20 overall mean of the all the treatments showed significant difference with respect to the percent shoot damage of Brinjal Shoot and Fruit Borer. All the treatments were found to be statistically superior as compared to untreated control. However, among all the treatments the minimum shoot damage was recorded in the *Azadiractina* 1% (1000 PPM), Neem oil (4.67%), *Azadiractina* 1% (1000 PPM). Neem oil over all showed maximum management action against shoot and fruit borer infestation followed by *Beaveria bassiana* 1% WP (6.50%) but *Beaveria bassiana* 1% WP was at par with all other treatments, except UTC [water] (11.17%).

Keywords: *Azadiractina, Bacillus thuriengiensis* var. *kurstaki*, *Beaveria bassiana*, Brinjal, Shoot & Fruit borer

Effective Management Strategies against Late Blight Disease of Potato

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Late blight disease of potato caused by *Phytophthora infestans* (Mont.) de Bary, is one of the most destructive foliar disease of potato worldwide. The pathogen can infect potato foliage and tubers at any stage of crop development and causes a severe, rapidly developing disease that can bring about complete defoliation and extensive yield loss. The current studies emphasized upon the management strategies with fungicides to mitigate the losses caused by the devastating disease. Results revealed that one spraying of Mancozeb 75% @ 0.25% at canopy closure (35-40 days after planting) and second spraying of Cymoxanil 8% + Mancozeb 64% @ 0.25% at first appearance of the disease and third spraying of Mancozeb 75% @ 0.25% after 10 days of second spraying and fourth spraying of Cymoxanil 8% + Mancozeb 64% @ 0.25% after 10 days of third spraying recorded least mean disease severity (10.54%), least mean disease incidence (15.00%), least CODEX value (1.58%), highest tuber yield (21.27 t ha^{-1}) with 26.6% yield increase and highest benefit:cost ratio of 1:1.62 over control followed by Cymoxanil 8% + Mancozeb 64% WP @ 0.25% as compared to control. Considering findings of the present experiment it can be concluded that the late blight disease of potato can effectively be managed by applying of contact fungicides as prophylactic spray followed by systemic/ translaminar fungicides.

Keywords: Fungicides, Late blight, *Phytophthora infestans*, Potato

Integrated Pest and Disease Management (IPDM) Approach in Mulberry Sericulture of Jammu & Kashmir

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Jammu and Kashmir is one of the traditional sericultural states of India. The state produces 735 MT of cocoons which is converted into 98 MT of raw silk. Spring is the major silkworm rearing season of J&K. when fresh mulberry leaf (sole food plant of silkworm) is available for rearing the silkworm, *Bombyx mori* L. Summer and autumn crops are also conducted in the state but due to pest and diseases infestation and climatic constraints the cocoon yield remains low, thereby reduces the quantum of silkworm rearing. The pests and diseases of mulberry are categorized in major and minor and based on the intensity of pest and disease infestation, an integrated pest and disease management approach has been adopted to keep the damage of mulberry foliage under economic threshold level. In integrated pest and disease management of mulberry various factors have been kept in consideration. In which one of the major factor is that our economic important silkworm *Bombyx mori* L. is a lepidopterian insect and the nature of various mulberry insect pests *viz*., *Glyphodes pyloalis*, *Spilosoma dalbergiae*, *Spilosoma oblique*, *Amsacta lactinea*, *Hemerophilla atrilineata etc*., are also from the same family *i.e*., lepidoptera. To eliminate such pests from the field, management approach could harm our own silkworm too. Hence, cultural, mechanical, biological and bio-pesticides management practices have been adopted to control the pests as well as the diseases of mulberry. The major diseases are powdery mildew and leaf spot which affect the foliage of the mulberry plant thereby reducing the quality and quantity of the silkworm feed. Results showed that the impact of IPDM has greater influence on the quality and quantity of mulberry besides improving the production of silk cocoons.

Keywords: Diseases, Insects, Mulberry, Pests, Sericulture

Effects of High Temperature Stress on Physiological and Yield Parameters of Mulberry Varieties

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High temperature causes alteration in physiological and yield parameters of mulberry plant. The present study was conducted to examine the tolerance/ susceptibility of five popularly cultivated mulberry varieties *viz.,* V1, G2, G4, MR2 and S36 exposed to high temperature stress. The varieties were maintained in Open Top Chambers (OTCs) at 40 ºC for two weeks. It is found that the variety V1 was tolerant to high temperature stress followed by MR2 and S36. After 14 days of high temperature stress, significant differences were observed among the varieties for leaf yield plant^{-1} under control and stress conditions compared to control and 7th day after stress. The variety G2 and G4 recorded highest reduction in Total Dry Matter Accumulation (TDMA) (55.60% and 55.96%) at 14th day after stress. Whereas, the lowest reduction percent of TDMA was recorded in V1 (23.06%) followed by MR2 (30.80%) and S36 (36.76%) compared over its control values at 14th day after stress.

Keywords: High temperature, Leaf yield, Mulberry varieties, Total dry matter accumulation

Scope and Prospects of Establishing Technical Textile Centre of Excellence/ FIC for Silk Sector: A Study and Analysis on Existing COE's under NTTM/ MOT & Justifying Silk's Potential

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Silk, the queen of textiles is known for its mechanical properties and aesthetic characteristics have proved in demonstrating its '*structural properties*'. Silk is equally having significant '*functional properties*' capable of using in non apparel application like technical textiles. This can be recalled on the use of silk to develop the first parachute for mankind during 2nd World War which includes surgical sutures, scaffolds, heartfills in Medical textiles, core wrapped silver foils in zari manufacturing, oil seal friction material in military tankers *etc*.

In this background, this paper enumerates the need and scope for establishing an exclusive silk Centre of Excellence (COE) on technical textile. Silk has all the merit and functional property oriented applications already established & to be exploited through systematic approach like setting up of FIC (Focus Incubation centre). This article discusses about the recent status of Centre of Excellence (COE's) established under NTTM Mission promoted by Ministry of Textile (MOT). It also gives a pen picture of COE's under NTTM established at Textile Research Associations (TRA's) and Textile Colleges with Segment-wise progress and infrastructure. The Authors do compliment the first phase initiative of NTTM on having established COEs on segment based approach like Indutech, Meditech, Agrotech *etc*. India being a vast country having widely located and densely functioning of textile activities in different parts of country, NTTM needs to consider in the second phase of COE's/ FIC's on '*fibre based*' Institutes and '*Textile Clusters/ Sectors*' based stations to widen its scope.

Considering the vast scope in silk, NTTM may initiate some steps for establishing FIC's/ COE's on Silk Technical textiles under the fold of CSTRI Bangalore which is already having very good infrastructure in the form of land, building and equipments. The contribution of Technical Textile in Textile export after these radical measures is expected to be significant and promising.

Keywords: Functional property, NTTM, Silk, Structural property, Surgical sutures, Technical Textiles

In vivo Evaluation of Agro-Waste Based Formulations of Yellow Pigment Producing Actinobacteria against Mulberry Root Rot Pathogens

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Mulberry is a multipurpose deciduous tree mainly cultivated for silk cocoon production. The continuous cultivation focusing on high yield made the crop prone to various diseases, especially root rot. To evade the detrimental effects of agrochemicals on sensitive silkworms and environment, the importance was given to bio-control approach.

In the preliminary studies, bright yellow pigment producing actinobacterial isolate NM5 obtained from mulberry rhizosphere exhibited significant antifungal activity against root rot pathogens. Based on their gene sequence, this potent isolate was molecularly confirmed as, *Streptomyces parvulus* and also deposited at NCBI GenBank (OL657043).

In the present study, four bio-formulations of the isolate NM5 were prepared using three carriers: talc, rice husk ash and silkworm pupal powder (TNM5, TPNM5, ANM5 and APNM5). For the *in-vivo* evaluation, virulent fungal pathogens associated with mulberry root rot disease obtained during the survey (2019-21) were mass produced in sorghum grains. From the *in-vivo* study against combined inoculation of root rot pathogens, the antifungal efficacy varies with formulations and the highest reduction of wilting (25.45%) and rotting (20.91%) was observed in APNM5 (rice husk ash : silkworm pupal powder - 1:1 ratio) treated plants which scored as mild to moderate infection. Untreated control was stunted with chlorotic leaves that defoliated prematurely with severe infection.

Moreover, in all NM5 treated mulberry saplings, as a result of defense action rotten root portions were stimulated to develop new healthy rigid roots. Biometric observations showed formulations had positive effect on plant growth parameters even in the presence of root rot pathogens including higher leaf numbers, enhanced leaf area and yield, root length, root weight, root : shoot ratio than uninoculated control saplings. Therefore, both the performance of potential isolate and effective utilization of agro-waste were enhanced by the nutrient based APNM5 bioformulation in an eco-friendly way.

Keywords: Actinobacteria bioformulation, Agro-waste utilization, Complex root rot pathogens, Mulberry

Evaluation of Nutritional Composition of Eri Silkworm (*Samia ricini*) Pupa

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Eri Silkworm is a part of cultural heritage for the people of North East India where it is mainly grown for silk production and food uses. Eri-pupa obtained from eri-culture is considered as the dietary staple and delicacy for most of the tribal communities of Assam. Silkworm pupae are known to be rich in proteins, essential amino acids and essential fatty acids mainly polyunsaturated fatty acids (PUFA). Considering the above fact the present study was aimed to evaluate the proximate nutrient composition of Eri Silkworm pupa. The study showed that eri-pupa consists of 10.21% of moisture, 4.66% of total ash, 51.51% of crude protein, 5.89% of crude fibre, 23.80% of crude fat and 9.82% of total carbohydrate. The results of the present study suggested that pupae could be good source of protein, fibre, fat and carbohydrate. Thus, the nutritive value of eri-pupa makes it an ideal candidate for formulating nutrient enriched diet with better protein quality which can be utilized in animal nutrition.

Keywords: Animal nutrition, Delicacy, Eri silkworm pupae, Protein, Proximate nutrient composition

A Comparative Analysis of Socio-Economic Transformation of National Food Security Mission in Uttar Pradesh and Karnataka

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National Food Security Mission (NFSM) is aimed at augmenting crop productivity and area under crops so as to ensure food security and nutritional security for the population. A study was conducted to analyse the socio-economic changes generated by National Food Security Mission in the states of Uttar Pradesh and Karnataka in 2022. 160 beneficiary farmers and 80 non-beneficiary farmers from both the states were personally interviewed to elicit the socio-economic transformation generated by the programme. The socio-economic impact was higher for beneficiary farmers in terms of annual income, occupational status, crop diversification, material possession and access to the programme than non-beneficiary farmers of both the states. Comparative analyses of socio-economic transformation on beneficiary farmers of Karnataka and Uttar Pradesh revealed significant changes in the socio-economic indicators except education, earning members, social participation and agricultural productivity. The changes brought about by the programme, before and after its launch were also analysed which revealed significantly higher socio-economic changes on beneficiary farmers.

Keywords: Beneficiary farmers, Farm Income, National Food Security Mission, Socio-Economic Transformation

Time Series Analysis of Monthly Coffee (Robusta) Prices in India using Box-Jenkins Approach

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Robusta coffee is a type of coffee made from the *Coffee canephora* plant's beans (seeds). It is the world's second most popular coffee, accounting for 40% of global coffee production. It is only second to arabica (from the Coffeearabica plant), which accounts for the remaining 60% (or more) of global coffee production. The purpose of this study is to focus on predicting monthly coffee prices in India by using the historic time series data. The objective of this paper is to fit an Autoregressive Integrated Moving Average model using Box-Jenkins approach. Numerous fields, including agricultural production, animal husbandry and dairy economics, stock price prediction, *etc*., depend heavily on forecasting. To choose the best model, Autoregressive (AR), Moving Average (MA), and Autoregressive Integrated Moving Average (ARIMA) processes was used to select the best model for monthly coffee prices in India. This paper discusses ARIMA (p, d, q) time series analysis and its components ACF, PACF, Normalized BIC, Box-Ljung Q Statistics, and Residual analysis. According to the best fitted model *i.e.*, ARIMA (0, 2, 1) monthly coffee prices in India is expected to increase to 189.35 INR kilogram^{-1} in the month of November 2022. The outcomes are represented numerically and graphically.

Keywords: Autocorrelation Function (ACF), Autoregressive Integrated Moving Average (ARIMA), Box-Jenkins Approach, Coffee Prices, Partial Autocorrelation Function (PACF), Residual Analysis

Use of Social Media in Enhancing Farmers' Satisfaction Level on Agricultural Extension Services: A Case Study of Farmers' Club in Thoubal District, Manipur

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Social media has become universal and practically inescapable, revolutionizing the way farmers communicate, interact and socialize; and has become an integral part of their social education through expressing opinion on varied issues. The agriculture sector is embracing social media and utilising it to increase knowledges of the farming and cropping management as well as interacting with others like agricultural professionals, Scientists, Subject Experts including research scholars. Social media tools can be viewed as social communication technologies in which opportunities of farmers' feedback, interaction, and networking are much higher than other forms of extension information delivery. Besides all these opportunities provided by the social media, the farmers' satisfaction level is also an important measures in dissemination of the information specially for agricultural extension and advisory services in order to improve the present communication system between farmers and the services provider. The present study sought to assess farmers' satisfaction level towards agricultural extensions services by means of social media.

Keywords: Extension Services, Information, Satisfaction level, Social Media

ICT in NEH Agriculture: Connecting Poor Farmers to Knowledge, Networks and Institutions for Enhancing the Production and Productivity

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The fate of agriculture decides the rise and fall of livelihood of world's poor farmers. The best efforts are made by the poor farmers of NE region to get themselves connected to the knowledge, network and labs and is the utmost requirement to improve the crop production and productivity. Always a need to support and promote the improved information access exists which could be a way to improve the socio-economic status of the farmers and also the immediate requirement of the researchers and agricultural workers. However, the contribution of information and knowledge by the powerful means of communication that is openly available and accessible by the farmers of the remote area is the only one factor which can bring a boost to agricultural income. The states due to the unfavorable climatic conditions have limited capacity to mobilize revenue from their own sources. Therefore the researchers are still grappling with the queries of how to make the best use if IC technology to improve the better implementation of IPM practices. A research work to study the extent of accessibility, availability and usage of Information tools in Integrated Pest Management, the difficulties faced by the farmers in accessing such tools is being conducted in the three states of North-East India *viz*., Meghalaya, Mizoram and Tripura in which 6 districts and 12 villages have been identified for the dissemination and implementation of communication media and to provide the timely management of different pests-disease for the welfare of farming community. In fact, there is a need to realize that in order to reach the farming and rural development community in an efficient manner, it is important to study the type of communication media and ICTs owned and accessed by the farmers, their frequency of usage as well as the degree of usefulness of various ICTs as knowledge of the use of different ICTs will be helpful in drawing a suitable extension strategy as well as to provide improved ICT extension services to uplift the socio-economic status of the farmers and the rural people and implement the IPM strategy in a most effective manner.

Keywords: Extension, Farmers, ICT, Income, IPM, Knowledge

Scientific Beekeeping: An Important Venture for Doubling Farmer's Income in Meghalaya

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Apiculture is the technique of rearing bee in a scientific way for production of honey for the benefits of human being. The beekeeping is considered as commercial part of apiculture. Sometimes it is practiced as a hobby or fascination, production of different hive products and for pollination services. Meghalaya is enriched with the great plant biodiversity. So the region have continues supply of food for the honey bee. In addition to the bee flora region is bestowed with the native bee Indian honey bee which are well adjusted with the climate and weather of Meghalaya. The beekeepers of Meghalaya have been practicing beekeeping for a long time with traditional ways. Due to traditional practices, farmers are getting low hive yield as well as not getting quality honey from their old age bee hives. Therefore, there is an urgent need to promote scientific beekeeping to increase honey production in the state. Keeping these views in mind, the present experiment was carried out by the ICAR Research Complex for NEH Region, Umiam, Meghalaya under Tribal Sub-Plan (TSP) programme for popularization of scientific beekeeping among the interested farmers/ beekeepers in the state with *Apis cerana Himalaya*. The experimental results showed that acceptance of modern bee hives was very high (> 90%) in the intervened villages. Beekeepers harvested about 50-60% more yield hive^{-1}year^{-1} as compared to indigenous hives. Hence, intervention of scientific beekeeping may be popularized in Meghalaya for increasing farmer's income.

Keywords: Apiculture, Doubling farmer's income, Honey, Meghalaya, Scientific beekeeping

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To promote innovation in Agriculture and allied Sciences with the broad objective of improving productivity, income and livelihood of farmers and conserve natural resources and environmental sustainability, a Scientific Non-profit Society was initiated in the year 2016 and registered under Society Registration Act during 2017 with its head quarter at Agartala, Tripura. The executive committee of the Society requests all prospective Academicians, Researchers, Extension workers, Students and others involved in agriculture or related fields to become life member of the society and contribute research papers, other articles as per the mandate of the SAAI to achieve its goal. Many distinguished academicians and research managers, professors, scientists are already in the executive committee of the Society and taken its life membership. It's a matter of pride top share that none other than Prof. M.S. Swaminathan, Chairman, Swaminathan Research Foundation and Former, Director General, ICAR New Delhi is the chief patron of SAAI. First Farm Innovation Congress (FIC 2018) was organized by the SAAI in collaboration with BCKV, Kolkata during 12-13 Jan, 2018 which was a grand successful event and about 300 delegates from across the country participated.

Aims and Objectives of SAAI:

- To make attempt for the development and extension of scientific research related to Agriculture and allied branches and implementation of these research outcomes for the upliftment of farming community.
- To recognize and support excellence achieved in scientific research and development in the field of Agriculture & allied sciences by individual scientists, inter-disciplinary teams, recognized institutions, learned societies and industries.
- To regularly bring out the journal *"INNOVATIVE FARMING"* and any other publications that broadly communicate knowledge in the above fields.
- Organizing Biennial National/International FARM INNOVATION CONGRESS.
- Conducting Brainstorming Sessions.
- Associate with other Society/ institute in organizing National/ International Seminars etc.

- Recognizing the contribution of Researchers/ Teachers/ Extentsionist's/ Students through various Innovative Awards.

Duly filled membership application form along with the DD/Online transfer in favour of Innovative Farming payable at UCO Bank, Khowai, Tripura (Account name: Innovative Farming, A/C no. 31470110024607, IFSC code- UCBA0003147, UCO Bank, Khowai) may be submitted to the following address. The Secretary General-SAAI, Krishi Vigyan Kendra, Divyodaya, P.O. Chebri, Khowai, Tripura – 799207, *Email to: secsaai@gmail.com*.

Membership Fees::

Annual Member:	**Rs. 1000/-**
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For details about the Society and journal please visit www.saaiindia.org // www.innovativefarming.in, Email: secsaai@gmail.com/ innovativefarming15@gmail.com

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