Souvenir and Abstracts of
National Symposium on Self-Reliant Coastal Agriculture

11-13 May, 2022

Organised by:

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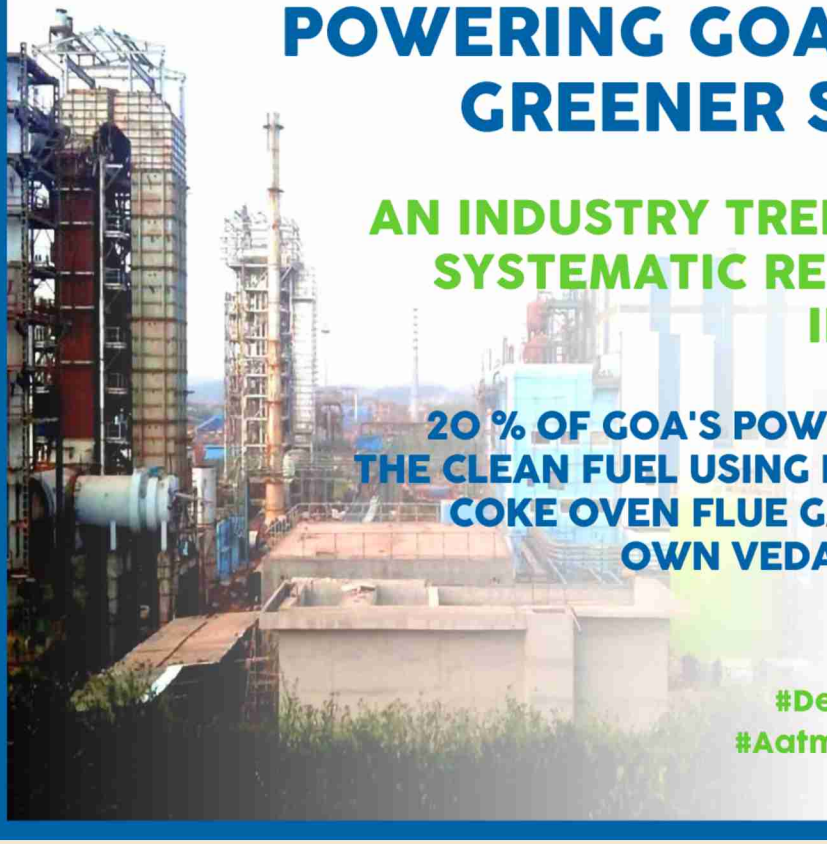

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Title: Souvenir and abstracts of National Symposium on Self-Reliant Coastal Agriculture, 11-13 May, 2022, Goa

Editors: Parveen Kumar, V Arunachalam, Bappa Das, Gokuldas, P P, Susitha Rajkumar, Trivesh S Mayekar, Uthappa, A R

Published by: ICAR- Central Coastal Agricultural Research Institute, Goa

Publisher Address: ICAR- Central Coastal Agricultural Research Institute, Ela, Old Goa - 403402, Goa, India

Printer Details: Arial Prints, Near St. Anthony Chapel, Goa-Velha-403108, Goa, India

Edition: I

Citation: Kumar P, Arunachalam V, Das B, Gokuldas PP, Rajkumar S, Mayekar, TS, Uthappa AR (2022) Souvenir and abstracts of National Symposium on Self-Reliant Coastal Agriculture, 11-13 May, 2022, Goa, ICAR- Central Coastal Agricultural Research Institute, Goa India.

Preface

Coastal ecosystem is one of the most fragile and climate-vulnerable ecosystems. Agriculture and allied sectors in this ecosystem are threatened by a number of constraints. Important among these are higher frequency and intensity of the natural disasters like cyclones, flooding, landslides, drought, climate change and sea-level rise, drainage congestions, high demographic pressure, deforestation, coastal erosion and accretion, low productivity of the field and horticultural crops and livestock, over-exploitation of the fishery resources, unplanned tourism activities, coastal pollution, etc.

Introduction of climate-resilient technologies for the management of natural resources, conservation, improvement and sustainable utilization of plants, horticultural crops, animals, and fish genetic resources including production and post-harvest management are some of the important approaches to achieve self-reliance in coastal agriculture. Agro-tourism in coastal regions is emerging as one of the potential sectors as this region has a rich diversity of climate, topography, soils, crops, livestock, fisheries resources, etc. The theme of the present symposium is very relevant to the existing and future needs of the coastal agriculture and allied sectors. I hope this National Symposium will be deliberated on present and future challenges faced by the coastal agriculture and allied sectors and it will bring about valuable recommendations which would greatly benefit the overall growth and development of coastal areas in the country.

The financial assistance received from Research and Development Fund of National Bank for Agriculture and Rural Development (NABARD) towards printing of Souvenir and Abstracts of the National Symposium on Self-Reliant Coastal Agriculture is gratefully acknowledged.

Foreword

The coastal region of India is characterized by a rich diversity of climate, topography, soils, crops, livestock, fisheries, etc. Despite the abundance of natural resources, the productivity of the crops and livestock in this region is poor as compared to the inland areas. Unlike other parts of the Country, the region faces unique problems like demographic pressure, land degradation, deforestation, rapid urbanization and industrialization, environmental pollution, climate change effects like increased frequency of floods, cyclones, droughts, and sea-level rise, etc. Coastal agriculture is a challenging agro-ecology which is threatened by sea level rise, floods, cyclones, tsunami, and other natural disasters.

This fragile ecology is also home to ~16.5% of human population whose livelihood depends on agriculture and allied activities. Hence, research strategies are required to provide sustainable livelihoods to the human populations thriving in the

se coastal regions. Owing to these, coastal agriculture is getting adversely affected, at a time when there is tremendous pressure to cater to the needs of the coastal population.

In this regard, Association for Coastal Agricultural Research (ACAR) in collaboration with ICAR-Central Coastal Agricultural Research Institute, Old Goa, Goa is organizing the National Symposium on "**Self-Reliant Coastal Agriculture**" during 11-13 May, 2022. The symposium covers the work done by the host institute and other research institutes and Universities on converting the fragile coastal agriculture into a self-reliant and vibrant climate resilient activity, and sustaining the livelihoods of coastal inhabitants. The symposium attracted nearly 200 participants including researchers, academicians, students, extension workers and progressive farmers to deliberate important issues in the form of lead talks, oral, poster (physical and online) presentations and panel discussion. The symposium covers all aspects of coastal agriculture including natural resource management, fisheries science, horticulture, animal science, plant genetic resources, secondary agriculture, policy interventions. A special session on agro-ecotourism comprising of panel discussion and interaction with agri-entrepreneurs is also organized to make policy planning and salient recommendations for the development of the sector.

This symposium provides a platform for researchers, academicians, farmers, stakeholders, and policy makers to have in-depth deliberations and prepare a roadmap for the self-reliance and sustainability in the coastal agriculture and provide valuable recommendations for planning future research and policy making.

(Dr Parveen Kumar)
Director

ICAR-Central Coastal Agricultural Research Institute, Goa

About Goa

'Now our road takes us to the magnificent kingdom of Goa. The people of this kingdom are strong, prudent and very hardworking. The kingdom of Goa is the most important in India. It is civilized, having famous orchards and water. It is the coolest place in India and it is the most plentiful in foodstuffs.'

'The white people make a practice of going to the kingdom of Goa to enjoy the shade and the groves of trees and to savour the sweet betel.'

These revealing remarks on Goa come not from the hippies or 'flower power' generation of the sixties and early seventies who thronged the beaches of Anjuna, Vagator and Arambol in search of salvation and 'peace'. These remarks were made over five centuries ago by the Portuguese Ambassador to China who visited Goa around the year 1511. They serve as a vivid precursor to the generations that followed in our times to the fabled land of Goa.

In those tumultuous and rebellious times in the sixties, it was then not the 'sweet betel' that was the prime attraction but a different kind of 'weed'. But Goa, since those days of the angry generation, has moved on to attract a multitudinous, peaceful and cosmopolitan school of visitors from all around the globe.

Down the corridors of time, Goa has been different things to different people. To the Portuguese conquerors, it was 'Golden Goa', the El Dorado, the 'Rome of the East'. Such was its beauty and grandeur, that a traveller was moved to remark: 'Whoever has seen Goa, need not visit Lisboa'-Lisbon, which was then the grand epicenter of the Portuguese dominions.

Some decades later, the early 17th century French traveller Francois Pyrard wrote: 'Whoever has been in Goa may say that he has seen the choicest rarities of India, for it is the most famous and celebrated city, on account of its commercial intercourse with people of all nationalities of the East who bring there the products of their respective countries, articles of merchandize, necessaries of life and other commodities in great abundance because every year more than a thousand ships touch there laden with cargo.'

Pyrard continued with near prophetic veracity: 'as for the multitude of people, it is a marvel to see the number which comes and go every day by sea and land on business of every kind. One would say that a fair was being held every day for the sale of all sorts of merchandise.'

While the contemporary traveller may not come to modern, thriving Goa 'for the sale of all sorts of merchandise', the 'fair' is still very much on. The traveller is here to find something different: a balm on the busy mind, to enjoy days of freedom on Goa's magnificent beaches, to parasail or swim with the tide of fellow visitors from all around the globe, to savour its unique cuisine and imbibe its spirits, to take a long and invigorating trek in its unexplored interiors, to marvel at its majestic temples and churches, in short, to be at one with the most friendly people in the country.

In the sixties and seventies, it was, as we have remarked, a haven for the hippies. Since then Goa has moved on to fullfledged Statehood, its own Council of Ministers, a magnificent new Assembly complex, its citizens among the most literate in the country with a per capita income the highest in the land. At the hub of this prosperity, is the Tourism industry.

About the Institute

The Indian Council of Agricultural Research, New Delhi, established the ICAR research Complex for Goa in April, 1976. After a short spell under the ICAR Research Complex for North East Hill Region, the complex was brought under the administrative and technical control of the Central Plantation Crops Research Institute, Kasaragod, Kerala. After functioning at different Government agricultural farm sites in Goa, the location was finally shifted to Ela, Old Goa in 1982. In order to intensify the transfer of technology and to impart grass-root level vocational training, a Krishi Vigyan Kendra was also established at the Research Complex in 1983. The Institute was upgraded to a full-fledged Institute in April 1989 to cater to the growing needs of agricultural research, education and extension in the state of Goa.

It is noted that in India, the coastal ecosystem covers an area of 10.78 million ha along 8129 km long coastline. All the above districts together cover about 3.99 lakh square km of the area to form the coastal ecosystem of the Country with an estimated population of about 20.13 crores accounting for about 17% of the total population of the country. The major activities in the coastal region include agriculture and allied sectors, tourism, mining, industries, shipping transport, etc. The institute has been further upgraded to ICAR- Central Coastal Agricultural Research Institute to address the sustainable agricultural and allied activities in fragile coastal ecosystem of the country. The Institute is poised to carry out the research and extension work on field and horticultural crops, livestock, and fisheries relevant to natural resource base for sustainable productivity, to develop climate-resilient land use and farming systems and agro-ecotourism.

The Institute is headed by the Director, who is supported by 26 Scientists, 18 Technical, 21 Administrative and 28 Skilled Support staff, making the total staff strength of the Complex to 88.

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ICAR-Central Coastal Agricultural Research Institute, Goa

(Formerly ICAR Research Complex for Goa)

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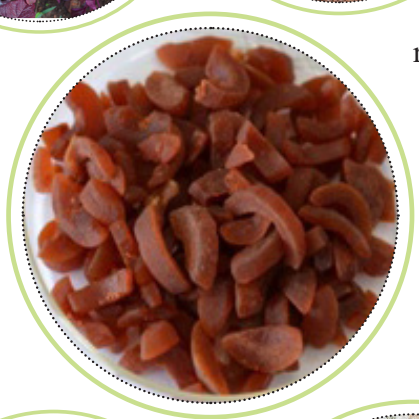

The important areas of research of the Institute are Identification of promising crop varieties/accessions of field and horticultural crops; Development of suitable soil and water conservation measures in cashew, coconut and mango; Development of integrated farming system models; Development of eco-friendly management practices of major insect pests and diseases in plantation, field and vegetable crops; Development and standardization of production technologies for field and horticultural crops of Goa; Standardization of low cost protected structures for vegetable and flower crop production; Standardization of packages for rearing cattle, goat, buffalo, pig and poultry; Standardization of hydroponics green fodder production and bypass fat production; Disease diagnosis and animal health management; Standardization of ornamental fish culture, carp culture and brackish water fish farming; Standardization of mussel farming practices; Dissemination of PFZ advisories and validation of advisories; and Exploration of fish diversity of Goa. The staff of the Institute has also received several awards and recognitions in research, technical, administration, sports, etc.

Mission

- Introduction and improvement of all potential crops and various species/breeds of livestock and scientific exploitation of various aquatic resources for improving fish production.

Mandate

- Researches on field and horticultural crops, livestock, and fisheries relevant to natural resource base of coastal India for sustainable productivity.
- Develop climate resilient land use and farming systems for improved and sustainable livelihood through coastal agriculture.
- Act as a centre of agro-eco-tourism.

National Symposium on Self-Reliant Coastal Agriculture

11-13 May 2022, Goa

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Technical Session 1

Climate resilient technologies for management of natural resources

Lead Paper

Soil and water conservation technologies for achieving land degradation neutrality in coastal region

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Introduction

India has a coastline of about 7,516 km, of which about 5,400 km belong to peninsular India and the remaining to the Andaman, Nicobar and Lakshadweep Island which is less than 0.25% of the world's coastline. India houses approximately 11% of the global population living in low elevation coastal areas. The coastal districts (73 out of a total of 593 districts) have a share of 17% of the national population, and nearly 250 million people live within 50km of the coastline. Accelerated soil erosion in coastal land poses severe threat to agriculture in coastal regions climate change further aggravates the risks to coastal communities and infrastructure. An assessment with satellite data revealed that around 45.5% of the coastal length is observed to be under erosion (Rajawat *et al.,* 2014). The Goa state experiences varying rainfall from 2700 mm to over 3800 mm per annum. The soils are predominantly lateritic (73.4%), followed by alluvial and marshy soils (11.1%), sandy soils (10.1) and saline (4.79%). The majority of the soil series are coarse to medium textured with well-drained and poor water holding capacity. Plantation crops predominantly occupy the steep slopes of lower coastal Ghats and central undulating upland consisting of the central part of Goa from north to south connecting Pernem and Quepem taluks. High rainfall with higher intensity and erosivity coupled with steeper and longer lengths of slopes and horticultural crop cultivation without proper soil and water conservation measures are causing severe erosion and land degradation problems in the area. This leads to washing away of topsoil and nutrients and loss of productivity, siltation of drainage channels, reservoirs and ponds, floods and droughts. Though the coastal lower ghats receive higher rainfall, still many places experience severe water scarcity during the summer months as the maximum amount of rainfall is received during monsoon period (June to September). As a result, moisture stress and drought adversely affect the productivity of horticultural crops like cashew, mango, arecanut, coconut, etc. Apart from this, on the other hand, higher runoff amounts are causing frequent floods in the coastal ecosystem and greater dependence on groundwater exploitation in the absence of surface water leading to declining groundwater tables at alarming rate. All these problems are warning signals and do suggest to lay greater emphasis on sustainable agricultural development through integration of soil, water and vegetation resources in harmony with the human resources.

Land Degradation Neutrality

Land degradation is a major economic, social and environmental concern to many countries around the world. The increasing pressure on land resources and depleting quality of land, air, water and biodiversity, halting reversing land degradation became extremely important and the concept of Land Degradation Neutrality (LDN) evolved. Land Degradation Neutrality (LDN) is a state whereby the amount and quality of land resources, necessary to support ecosystem functions and services and enhance food security, remains stable or increases within specified temporal and spatial scales and ecosystems. Sustainable Development Goals of Target 15.3 aims

to achieve Land Degradation Neutrality (LDN) worldwide and 26 million hectares in India by 2030. To meet this Land Degradation Neutrality target, India needs to reduce, restore and reverse land degradation in an area of approximately 30 M ha, i.e. 2 M ha per year from 2015 to 2030. To achieve this target, it is very important to implement the soil and water conservation technologies through participatory approach. This would help in reducing and reclaiming the degraded land in lesser time and more heterogeneous and discontinuous patches of land which could facilitate a larger area to be restored.

Soil and water conservation

Runoff and soil loss behaviours under different land use with different conservation measures are prerequisites to suggest suitable conservation measures for any type land use system. Hence, a field study was conducted in lower coastal region of Goa state to understand the runoff and soil loss pattern of different conservation measures under different land uses. *In-situ* retention of rainwater in the field itself is the most efficient method to recharge and store moisture in the root zone for better plant growth. This can be achieved by suitable agronomic measures such as crop geometry, crop combinations, mulching etc. and also by promoting moisture retention by mechanical measures such as trenching, bunding, terracing, basins or micro catchment, contour furrow etc.

Mechanical and bioengineering measures

Continuous contour trench (CST) is a trench, which is made for entire field length continuously along the contour at a certain vertical interval. Graded trench (GT) is the trench, which is made for entire field length continuously in different grades. Staggered contour trench (SCT) should be excavated for the length of 2 m, top width 0.45 m, bottom width 0.30 m and depth of 0.45 in a staggered manner of an aligned contour. The trench with the length of 2 m, top width of 0.45 m, bottom width of 0.30 m and depth of 0.45 m was prepared in respect to each plant in a semi-elliptical manner on the upstream side of the plant is called semi-elliptical trench (SET). The trench that will be taken up in crescent shape is called a crescent shaped trench (CST).

The trenches or terraces supported with live barriers are called bioengineering measures. Vegetative barriers such as *Vetiveria zizanioides, Stylosanthes scabra* and *Gliricidia maculata* can be planted as hedge crops on the bunds of trenches.

Effect of conservation measures

Experiments were conducted on the hydrological effect of different conservation measures under different crop spacing. Based on the studies, the quantitative impacts of different soil and water conservation measures on runoff, soil and nutrient loss, soil moisture content, major nutrient status and growth parameters, yield and economic feasibility of different conservation measures were assessed. Two sets of experiments were conducted with different high-density planting methods. One set of soil and water conservation measures was evaluated under 4 m × 4 m spacing and another set with 6 m × 6 m spacing. Field data on runoff, soil loss, nutrient loss, soil moisture content, growth of cashew and yield parameters were recorded for six years period. Thus, collected data were pooled, analyzed and reported.

Continuous contour trenches with *Stylosanthes scabra* and *Vetiveria zizanioides* and staggered contour trenches with *Stylosanthes scabra* and *Vetiveria zizanioides* reduced the runoff by 44.5 and 34.6 per cent, respectively under spacing of 4 m X 4 m cashew plantations. Similarly, continuous contour trenches with vegetative barrier of *Stylosanthes scabra* + *Gliricidia maculata,* staggered contour trenches with *Stylosanthes scabra* and *Gliricidia maculata* and crescent shape trenches

with *Stylosanthes scabra* and *Gliricidia maculata* recorded runoff reduction of 46.3, 35 and 29.0 per cent, respectively in the field where cashew was planted at 6 m x 6m spacing.

Continuous contour trenches with *Stylosanthes scabra* and *Vetiveria zizanioides* and staggered contour trenches with *Stylosanthes scabra* and *Vetiveria zizanioides* reduced the soil loss by 11.3 and 8.1 t ha^{-1} yr^{-1} in 4 m × 4 m cashew field. Similarly, continuous contour trenches with vegetative barrier of *Stylosanthes scabra* + *Gliricidia maculata* significantly reduced average soil loss (6.5 t ha^{-1}) followed by staggered contour trenches with *Stylosanthes scabra* and *Gliricidia maculata* (5.6 t ha^{-1}) and crescent shape trenches + *Stylosanthes scabra* and *Gliricidia maculata* (5.7 t ha^{-1}) in the plot where the cashew was planted at 6 m x 6 m spacing.

Continuous contour trenches and staggered contour trenches with vegetative barriers recorded the maximum plant growth and yield. Total cashew nut yield of 7.72, 14.21 and 18.1 q ha^{-1} was recorded in treatment comprising of continuous contour trenches with *Stylosanthes scabra* and *Vetiveria zizanioides* during fourth, fifth and sixth years, respectively under 4 m × 4 m cashew plantations. The total cashew nut yield of 6.80, 3.50 and 5.20 q ha^{-1} were recorded in treatment comprising of continuous contour trenches with *Stylosanthes scabra* + *Gliricidia maculata* during fourth, fifth and sixth years, respectively under 6 m × 6 m plantations. Maximum NPW of Rs. 4, 61, 820 per ha was obtained under cashew cultivation with continuous contour trenches with *Stylosanthes scabra* and *Vetiveria zizanioides* followed by Rs. 4,08,090 per ha under cashew cultivation with staggered contour trenches *Stylosanthes scabra* and *Vetiveria zizanioides*. Maximum NPW of Rs. 1,64,900 per ha was obtained under cashew cultivation with continuous contour trenches with *Stylosanthes scabra* + *Gliricidia maculata* followed by Rs. 1,27,190 per ha under cashew cultivation with staggered contour trenches *Stylosanthes scabra* + *Gliricidia maculata*. Higher benefit-cost ratio and Internal rate of return were obtained under the continuous contour trenches with *Stylosanthes scabra* and *Vetiveria zizanioides* (6.87 and 20 per cent, respectively) followed by staggered contour trenches with *Stylosanthes scabra* and *Vetiveria zizanioides* (6.82 and 18 per cent, respectively) under 4 × 4 m cashew plantation. Similarly, BCR and IRR were higher under the continuous contour trenches with *Stylosanthes scabra* and *Glyricidia maculata* (5.07 and 13 per cent, respectively) followed by the staggered contour trenches with *Stylosanthes scabra* and *Glyricidia maculata* (4.64 and 12.5 per cent, respectively) under 6 m × 6 m cashew plantations and these measures can be adopted for cultivating cashew in lateritic soils of hilly slopes.

Rainwater harvesting

Geddes (1963) first defined water harvesting as the collection and storage of any form of water; either runoff or creek flows, for irrigation use. In many parts of the world, the collected rainwater from natural precipitation is the only source of water supply and it is considered an economical and useful method. Proper water harvesting techniques will mitigate the problems of soil erosion and flood to a large extent. It will also enhance the agricultural productivity in the region. The water harvesting can be done through the following techniques

- Harvesting the surface runoff from the land surface
- Diversion of surface/subsurface water sources
- Direct rainwater harvesting in undulating topography and hilly region
- Subsurface water harvesting

Surface Water Harvesting

Surface water harvesting includes harvesting the water from catchments and storing it in tanks, ponds, lakes etc. The total number of tanks, ponds and lakes of the Goa state is 3928 contributed by 2744 and 1184 in North Goa and South Goa districts, respectively. Tank is generally a small storage reservoir formed across a stream in a valley. Sometimes these tanks could be having independent catchments, drawing their supplies from the run off from the catchment areas. Tanks fully dependent on the rainfall in their catchments are called as non-system tanks. In addition, some tanks that may have a supply channel from a neighbouring stream or river, which has a dependable flow, are known as system tanks. The following tanks are constructed after liberation of Goa. Farm ponds may be constructed where the largest storage volume of water can be obtained with the least amount of earth-filled within or close to the point of use. In general, the farm ponds are constructed in rectangular or trapezoidal shapes. These ponds may be constructed with or without lining depending upon the soil conditions. Polythene sheets may also be used for lining to minimize percolation losses. Pollution of farm pond water should be avoided from drainage, farmsteads, sewage lines and mine dumps. Where this cannot be done successfully, it is recommended that water from such areas should be diverted from farm ponds.

Dugout ponds

Where the topography does not lead itself to embankments construction, dugout or sunken pond can be constructed in relatively flat terrain. Since dug out ponds can be constructed to expose a minimum water surface area in proportion to volume, they are advantageous where evaporation losses are high and water is scarce. Some of the important physical features that must be considered in locating dugout sites are the watershed characteristics, silting possibilities and topography and soil types. The watershed must be capable of furnishing the annual runoff sufficient to fill the dugout ponds. The lowest point of a natural depression is often a good location for a dugout pond. The soil type at the site should be thoroughly investigated to determine the permeability of the soil as well as to avoid cutting in very hard stuff. At location, where the water table rises within a few meters of the ground surface, dugout pond can be constructed to intercept the water adjusting the depth to the fluctuations expected. Location of this type may supply water all round the year. These kinds of dugout ponds are found in valleys in the Western Ghat regions of Goa.

Larger Farm Ponds

Larger farm pond in the dimensions of 40 × 20 m has to be excavated in trapezoidal manner and fine sand has to be placed to a depth of 30 cm followed by spraying of weed control chemicals. The sides of the farm pond have to be prepared in step by step enable to withhold the plastic sheet. The silpaulin sheets having 250-300 GSM thick have to be placed and completely covered.

Diversion of Surface / Subsurface Water

The surface water from stream and drainage lines is being stored and diverted to irrigate the nearby fields. The source of water is excess runoff as well as subsurface flow during summer seasons *Bandharas* are the small diversion structures constructed across the streams and drainage line and the stored water is irrigated to the nearby fields by gravity flow. There are two types of bandharas based on the type of materials used for construction viz. earthen dam and concrete masonry dam. The height of such structures varies from 1m to 1.5 m. A sluice gate is provided in the centre of the structure to facilitate draining of water completely during the heavy rains and consequent floods which avoids damage to the crops during peak flow of water. These *bandharas* are serving the purpose of storage and are catering to the needs of both water supply and irrigation.

These structures existed since Portuguese regime. These structures are found to be quite cost-effective and yield quick benefits to the farmers. Large numbers of bandharas have been constructed by Water Resources Department under minor irrigation scheme. The bandharas of Sanquelim, Bicholim, Maulinguem, Assonora and Koperdem were constructed many years ago and they need modernization.

Direct Rain Water Harvesting

Goa receives 2800 mm to 3800 mm annual precipitation and there is a possibility to store water for the depth of 2 m to 3.5 m from the self-catchment of pond area. To harvest the water during the rainy season for recycling during the summer season, small ponds are dug up with the dimension of 2 m × 2 m × 1 m or 4 m × 1 m × 1 m depending upon the soil depth. If the soil depth is more than one meter, farmers can go for 2 m × 2 m × 1 m dimensions pond and evaporation losses also will be less in 2 m deep ponds. These smaller ponds have to be lined with silpaulin or HDPE, 200 GSM thick plastic poly films. Before lining the ponds, paddy straw or any other materials as a cushion has to be placed adequately. These water harvesting systems store water to the tune of about 4 m^3 and will serve the irrigation purpose to 8-10 perennial crops for seven months. Accordingly, farmer can increase the number of ponds depending upon the number of trees or other crop components. To reduce the evaporation losses neem oil may be applied to the water surface.

Subsurface water harvesting

Springs constitute the major source of water supply in the hilly regions, especially in valleys. Springs are the manifestations of the groundwater hydrology of hilly regions. These springs are frequently found on the hill slopes and in the valleys of Western Ghats. There are small as well as large springs depending upon the degree of concentration and seasonal or perennial springs. Most of the springs in Western Ghats valley are perennial and will supply water throughout the year for small landholdings.

Summary

In view of achieving land degradation neutrality in lower coastal region of Western Ghats, in-situ moisture conservation should be taken up for cultivation of all crops. Continuous contour trenches with vegetative barriers were the best as compared to all other treatments for runoff, soil loss and nutrient loss reduction. Staggered contour trenches with *Stylosanthes scabra* and *Vetiveria zizanioides* were the alternative measure for the reduction of runoff and soil loss for cashew land use. Additional income could be generated from the vegetative barriers, which can be used as either fodder or biomass during the initial periods of cashew plantation by adapting the bioengineering measures. Continuous contour trenches with vegetative barriers and staggered contour trenches with vegetative barriers were found economically viable and these technologies are recommended for adoption in the cashew plantations in hilly terrain. Water should be harvested either on surface or subsurface by various technologies. The possible subsurface water harvesting technologies at Goa are springs, wells and sunken ponds. Artificial recharge of groundwater should be entertained by constructing percolation ponds and check dams in watercourses and it should be promoted in all watershed development programmes in the region. Direct rainwater harvesting in smaller ponds and recycling is the solution for providing protective irrigation to the plantation crops in hilly regions. Lining of ponds is recommended where the percolation losses are very high. The harvested water should be used efficiently by adopting advanced irrigation technologies viz. micro-irrigation methods, mulching etc.

Reference

Geddes, H.J. (1963). Water harvesting. In Proceeding of National Symposium on Water Resources, Australia Academy Of Science, Canberra, Australia

Juyal, G.P., Katiyar, V.S., Sastry, G., Singh, Gurmel, Joshi, P., Arya, R.K. (1991). Geojute for rehabilitation of steep minespoil areas, CSWCRTI, Dehradun. Bulletin No.T-26/D-19.

Manivannan. S, V. Thilagam, K., Khola, O.P.S. (2017). Soil and water conservation in India: Strategies and Research Challenges. Journal of Soil and Water Conservation 16 (4): 312-319.

Manivannan.S., O. P. S. Khola (2013). Soil and water Conservation in the Nilgiris : issues and Strategies. In An anthology of Nilgiri Biosphere Reserve (Ed.) B.Ramakrishnan and A Veeramani.Government Arts College, Udhagamandalam, Tamil Nadu. PP 528-535. (ISBN: 978-93-5165-099-9)

Ministry of Water Resources, Central Ground Water Board (2007). Manual on artificial recharge of groundwater.

Rajawat, A.S., Chauhan, H.B., Ratheesh, R., Rhode, S., Bhanderi, R.J., Mahapatra, M., Kumar, M., Yadav, R., Abraham, S.P., Singh, S.S., Keshri, K.N. (2014). Assessment of coastal erosion along Indian coast on 1: 25,000 scaleusing satellite data. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, *40*(8), p.119.

Samra, J.S., Sharda, V.N., Sikka, A.K. (2002). Water harvesting and recycling – Indian experiences. CSWCR & TI, Dehradun.

Sharda, V.N., Jual, G.P. (2002). Water harvesting and recycling in Himalayas. In Proceedings Of National Symposium On Soil and Water Conservation Measures And Sustainable Land Use systems With Special Reference To The Western Ghats Region, Invited and Contributed Papers, 16-17th November 2002, ICAR Research Complex for Goa, Old Goa – 403 402, Goa

Tideman, E.M. (1996). Watershed Management. Guidelines for Indian conditions. Omega Scientific Publishers, New Delhi-110 024.

Manivannan. S., Sikka A.K. (2013). Hydrological impact of bioengineering measures on Cashew plantations in Lateritic soils of Konkan region, Journal of Agricultural Engineering, Vol. 50(3):57-65.

Manivannan, S. (2010). Impact of bioengineering measures on soil moisture retention and major nutrients under cashew land use in lateritic soils of Goa, Journal of the Soil and Water Conservation, 9(1): 9-12.

Manivannan, S., Sikka, A.K., Manjunath, B.L., Priyadevi S., Ashok kumar, J. (2007). Effect of bioengineering measures on runoff, soil and nutrient losses under Cashew plantations in Western Ghat region, Journal of Agricultural Engineering, 44(4):16-22.

S1-OP1

Vulnerability to climate change: An economic analysis on rice production in the coastal districts of Tamil Nadu and Puducherry

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Climate change is one of the biggest challenges facing the world today. The present study was undertaken with the objective of assessing vulnerability to climate change in the coastal districts of Tamil Nadu and Puducherry on production of rice. Coastal districts of Tamil Nadu and Puducherry are more sensitive to climate change and most disaster-prone districts. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. A total of 22 indicators were selected for the assessment of vulnerability index with positive and negative functional relationship. Data were collected and normalized in which observation can be transformed between 0 and 1 for all indicators/ variables. Index was calculated by applying weights to variables using Principal Component Analysis (PCA). With the mean and standard deviation of the index it was categorized into high, moderate and less vulnerable zones. Karaikal (0.71) is the most vulnerable region with the highest exposure (0.55) and low adaptive capacity (0.36) across the study district and Thanjavur (0.11) is the least vulnerable region with the lowest sensitivity (0.28) and highest adaptive capacity (0.60). Further, the result shows that Karaikal, Nagapattinam, Thoothukudi, Cuddalore and Pudukottai were classified as the most vulnerable region. With this mapping of the vulnerable zone was also done.

S1-OP2

Organic farming system approach to sustain productivity, income and employment under climate resilient agriculture

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Integrated organic farming system (IOFS) approach will provide ways to recycle products and waste materials of one component as input through another linked component and reduce the cost of production ultimately raise the total income of the organic farm. Considering the multiple benefit of organic production system and from the view of sustainability, one acre integrated organic farming system (IOFS) model for irrigated upland ecosystem of Southern India was developed in Tamil Nadu Agricultural University (TNAU), Coimbatore to cater the needs of marginal farmers of Tamil Nadu, Southern India and was evaluated continuously for six years from 2013-2019.The system consists of crops, livestock, fodder, agro forestry, pest repellent cafeteria, composting and beekeeping. The system productivity on CEY was 3034 kg/ha/year. *Kharif* crops share 45% of the net return compared to *Rabi*. Totally 34 t of crop residues were recycled through which revenue of Rs.11762 was realized. About 29 t of green fodder was produced per annum, which met the fodder

requirement of the livestock for 342 days. Annually 1742 lit of milk was produced to assure an annual income of Rs. 37426. Annually 11.8 t of cow dung and 9217 lit. of cow urine were obtained with the nutritional value of Rs. 5586. On an average 2004 kg of compost was produced through which Rs. 3007 was realized. Net income of Rs.5544 was realized through boundary plantations. From the IOFS model, a total mean annual net income realized was Rs. 72095. Through recycling of residues and manures, 12% of the total cost of the model was saved. The relative share of different components in the order of merit was livestock (43%), crops (29%), fodder (20%), boundary horticultural crops (6%) and compost (2%). The benefit-cost ratio of the IOFS model was 2.24 with an annual employment generation of 571 man-days.

Keywords: IOFS, Crop-Livestock, System productivity, Residue recycling, Employment generation, Economic analysis

S1-OP3

Population dynamics, natural enemies and eco-friendly management of invasive insect pest Fall Armyworm (FAW) *Spodoptera frugiperda* in fodder maize (*Zea mays* L.)

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Maize (*Zea mays* L.) is grown for both grain and fodder purposes and is an ideal fodder crop grown throughout the country. Weekly observation on the incidence of Fall Army Worm (FAW) was taken on randomly selected 20 plants from four different spots in "Z" fashion at IGFRI, SRRS, Dharwad round the year in 2021. The highest incidence of 50% was noticed during last week of August and second peak of incidence of 30% was noticed during last week of December. Incidence was more during the *kharif* season than in *rabi*. Correlation between seasonal incidence of maize fall armyworm and weather parameters indicated that there was a significant negative correlation with the rainfall (-0.60**) and morning humidity (0.50*). Among all the entomopathogens tested *Metarhizium (Nomuraea) rileyi* was found to be more effective and was at par with standard check Azadiractin 3000 ppm @ 5 ml/l and superior over all other treatments. The highest GFY (q/ha) and DMY (q/ha) was recorded in *Metarhizium (Nomuraea) rileyi* treated plots and at par with the standard check Neem formulation Azadirachtin 3000 ppm. Among the natural enemies two Coccinellid predators *Coccinella transversalis* and *Harmonia octomaculata,* one earwig species *Forficula* sp and entomopathogen *Metarhizium (Nomuraea) rileyi* were recorded.

S1-OP4

ITKs on livestock and fodder management to avert climate change risks and their scientific rationality

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Livestock sector supplements farmer's income and helps to absorbs income shocks due to crop failure in drought/floods. Indigenous traditional knowledge (ITKs) has always played an important role in addressing climate change shocks and managing livestock. A study was undertaken to document and analyze scientific rationality of the ITKs related to livestock, in northern transition (zone 8) and hilly zone (zone 9) of Karnataka. ITKs were collected through focus group discussions with 200 farmers of 8 villages. Totally 20 ITKs on livestock and fodder management were collected from these villages. Besides, 17 ITKs from the past studies were considered based on the similarity with crops and geographical condition of the study area. So, totally 37 ITKs on fodder and livestock management practices were included for scientific rationality analysis. A questionnaire containing list of these 37 ITKs was prepared to assess the scientific rationality of ITKs. This questionnaire was administered to 30 scientists in the field. Data was analysed using mean, standard deviation and Chi square to know the variability in responses. Study revealed that only 8 ITKs found to be highly rational, 17 ITKs as moderately rational and 12 ITKs belonged to less rational category. Paddy straw is preserved for fodder using common salt (NaCl) to increase palatability and to keep rodents away, use of local feed prepared with various ingredients like wheat flour, rice, jaggery, butter and barnyard millet or wheat, black soybean, wheat or cotton seeds, methi, dhania and jaggery is practiced to enhance milk yield, dry nose indicates fever in animal so wet cloth is covered across horns and on forehead of the animal to reduce fever are few examples of highly rational ITKs. However, moderately rational ITKs provide lot of scope for experimentation to fine tune so that these ITKs could be upgraded to highly rational category. It is proposed that already practicing ITKs if fine-tuned have better adoption among farming community.

S1-OP5

Soil properties mapping for site-specific nutrient management in crops of Goa

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Soils of Goa are lateritic and erosion sensitive with undulated topography and high rainfall. Productivity of major crops in the state is low as compared to other regions of the country. Soil test based site-specific nutrient management in crops of state may increase their productivity. Considering this, a study was conducted to assess the spatial variability of soil properties for implementa-

tion of site-specific nutrient management in the crops. The specific objectives of the study were to characterize the spatial variability of soil properties, study relationship among them, develop the spatial distribution maps of the soil properties and identify the potential soil management zones. A total of 641 geo-referenced soil samples were collected from Goa and analyzed for soil pH, electrical conductivity, organic carbon, available macro- (nitrogen, phosphorus and potash) and micro-nutrients (zinc, copper, iron and manganese). The analyzed data revealed that the soils of the state are acidic in nature and neutral in salinity. However, high salinity was recorded in low lying areas. Available nitrogen and phosphorus were found in lower availability and available potassium showed wide variability. Among the micronutrients, wide spread deficiency of zinc was recorded across the state. Soil organic carbon exhibited a significantly positive correlation with available nitrogen, potassium and zinc. Spatial distribution maps were developed for soil properties for implementation of site-specific nutrient management in crops of the State.

S1-OP6

Groundnut agro-ecosystem as influenced by in-situ moisture conservation techniques and organic manures

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A field study was conducted at ICAR-Directorate of Groundnut Research, Regional Station, Ananthapur during the *kharif* season of 2021 to evaluate in-situ moisture conservation techniques and organic manure effects on yield and moisture content in groundnut (*Arachis hypogaea* L). The experiment consisted of 4-moisture conservation techniques (compartmental bund, deep tillage, deep tillage + compartmental bund and conventional method/farmers practice) assigned in main plots and three organic manures (control, FYM and vermicompost) assigned in sub-plots using split-plot design with three replications. The results revealed that deep tillage with compartmental bund (DT+CB) exhibited significantly higher pod yield (1335 kg/ha), haulm yield (3338 kg/ha), kernel yield (968.7 kg/ha), shelling % (72.4%) and 100 kernel weight (46.8 g) as compared to farmers practice and only compartmental bunds. However, it was at par with deep tillage plots. Among organic manures, application of vermicompost (2 t/ha) recorded significantly higher pod yield (1338 kg/ha), haulm yield (3344 kg/ha), kernel yield (972.8 kg/ha), shelling % (72.7%) and 100 kernel weight (46.6 g) than control plots and it was at par with FYM (5 t/ha) applied plots. The higher groundnut production in the DT+CB plots may be due to higher soil moisture content in the respective plots.

S1-OP7

Climate change impacts on habitat suitability of rugose spiralling whitefly, *Aleurodicus rugioperculatus* based on MaxEnt modelling

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Climate change has a major impact on species distribution, severity of agricultural insect pests and its invasion. Rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae) is a recent invasive pest in India causing widespread damage to coconut and other horticultural crops. The current study aimed to predict the potential habitat distribution of RSW under present and future climate change scenarios in 2050 and 2070 with 19 bioclimatic variables through Maximum Entropy (MaxEnt) niche modelling. The MaxEnt model performed significantly better than the random predictions. Jackknife test for estimating predictive power of the variables showed annual mean temperature followed by annual precipitation as the most important bioclimatic variables for RSW distribution. The bioclimatic suitability map of RSW distribution under current and future climate is highly concentrated in the entire coastal and southern states of India. Multi-model ensemble is predicted to increase the suitable areas of RSW in 2050 and 2070 under future climate change scenarios compared to current climatic conditions. The predictions could be used to forecast the potential spread of RSW in India and combat outbreaks well in advance. Our results will be an important guide for researchers, policymakers and governments to devise suitable management strategies against this highly invasive pest.

Keywords: Invasive pest; *Aleurodicus rugioperculatus*; Climate change; Spread; Invasion; Forecasting; Prediction

S1-OP8

Estimation of the lime requirement for the agricultural lands of the state of Goa

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Soil acidity is one of the important abiotic stresses which pose serious limitations to crop production. It affects the soil's chemical processes and imbalances the availability of the essential nutrients to the crop plants. By and large, the soils of the State of Goa, India are acidic in soil reaction. It is evident by the fact that of the total 1194 soil samples collected and analysed for the soil pH, 93.47% were below 6.0 and 98.91% below 7.0. Liming the soil is one of the most effective ways to correct soil acidity. As a rule-of-thumb, soils with pH less than or equal to 6.0 were considered to estimate the lime requirement. The soil pH ranged from 3.35 to 6.00 with a mean value of 5.09 and a coefficient of variation of 10.01% indicating the preponderance of the soil acidity. The buffer soil

pH measured using the Shoemaker-McLean-Pratt (SMP) buffer method varied from 4.75 to 6.72 with an average of 5.75. Based on the blanket estimations of the lime requirement, the soils of the State of Goa require 2.43-22.11 (12.15 t ha^{-1}), 2.92-25.76 (12.15 t ha^{-1}) and 3.40-30.13 (16.61 t ha^{-1}). Further, based on the results, the lime requirement maps for the State of Goa were prepared. The empirical values estimated look exorbitantly high and may not be economical and cost-effective. Thus, it needs corrections owing to factors like rainfall and crop type. The heavy rainfall received during the monsoon season and its effect on leaching is to be kept in mind to optimize lime use. The crop pattern and diversification of the state are very diverse. General and blanket recommendations of the lime might not be suitable and thus further crop-specific and site-specific lime requirement needs to be estimated for better yield benefits. The results of the present study, one of the earliest for the region, could be useful to arrive at the crop- and site-specific lime recommendations.

Keywords: Coastal region; Liming acid soils; SMP buffer method

S1-OP9

Neural network-based feature selection and extraction models for weather-based cashew yield prediction

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Cashew is an eminent cash crop that is also environmentally sensitive, making it predisposed to climate change. As a result, the current study compares the performance of stepwise linear regression (SLR), least absolute shrinkage and selection operator (LASSO), elastic net, and artificial neural network (ANN) models separately to the ANN model integrated with SLR, LASSO, elastic net, and principal components analysis (PCA) for cashew yield prediction based on meteorological factors. Three methods were used to assess the model's performance namely (1) Taylor plot, (2) statistical measures such as coefficient of determination (R^2), root mean square error (RMSE), and normalised RMSE (nRMSE), and (3) ranking followed by Kruskal-Wallis and Dunn's post-hoc tests. During calibration, the R^2 and RMSE ranged from 0.486 to 0.999 and 2.184 to 88.040 kg ha^{-1}, respectively, whereas during validation, the RMSE and nRMSE ranged from 3.561 to 242.704 kg ha^{-1} and 0.799 to 89.949%, respectively. The Kruskal-Wallis and Dunn's post hoc test found that LASSO was the best model, with ELNET, SLR, and ELNET-ANN all scoring similarly. So, these models may be used to forecast cashew yields for the study region well in advance.

Keywords: Cashew yield, Artificial neural network, Hybrid models, Penalised regression models

S1-OP10

Residue recycling potential, nutrient budgeting and soil quality index of integrated farming system in lowland situations of Goa

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The effect of integrated farming system on residue recycling and soil quality was evaluated in Goa state of India wherein rice-based integrated farming systems were practiced pre-dominantly. The results indicated that twelve tonnes of organic matter were recycled, and the major share was from the dairy unit (~58%) in the form of cow dung and cow urine. Total internal nutrient supply due to recycling was estimated at 72 kg of nitrogen, 25 kg phosphorus and 85 kg of potassium which is equivalent to 125 kg urea, 119 kg SSP and 136 kg MOP, thus reducing in cost of inputs. In the rice+fish+poultry-cowpea system, the indices of soil quality showed higher values, which indicated the improvement in soil fertility due to availability of poultry manure, plankton production, and the continuous fish movement. The current study confirmed that available N, DHA, Zn, B and Fe as the key indicators of soil quality under humid tropics of west coast India, which greatly influence the soil functions and soil productivity. The study conclusively reveals that integration of dairy, fishery and poultry components with diversified cropping in coastal lowland ecosystem is essential to offset the ecological imbalances arising due to continuous cultivation of rice crop.

S1-OP11

Traditional wisdom of water conservation in Goa and its enhancement through scientific interventions and participatory approach

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The state of Goa is blessed with natural resources and receives an average annual rainfall of 2900 mm. However, the major area is under laterite soils with poor water holding capacity, leading to moisture stress after the monsoon season. Goa is known for its rich traditional knowledge and the farmers here have devised some of the traditional methods of water conservation, which are being practiced for ages. The sub-surface flow/spring water from the hills locally known as *Jhara* is diverted to the fields through network of small unlined channels and by using the semi-circular trunk of arecanut or palm trees for irrigation in non-monsoon season. But, the limitations of the existing traditional systems are seepage, low discharge, poor storage and distribution of water in the field. To refine this system, interventions were made in the farmers fields by establishing water harvesting ponds along with gravity-based drip irrigation system through farmers participatory approach. After selecting suitable sites, ponds were excavated, locally available material like fine soil and paddy straw was used for smoothening and cushioning as indigenous technology along with silpaulin polyfilm lining. The capacity of the established ponds was 4 lakhs, 2 lakhs and 45,000 litres at a cost of Rs. 0.51, 0.28 and 0.12 lakhs at Bhupar, Badsare (lowland) and Badsare (upland) villages, respectively of Canacona taluka, South Goa. The cost per unit of harvested rainwater was Rs. 0.12, 0.14 and 0.26, respectively. This technique of lining has improved the durability of the ponds in the laterite soils while at the same time reducing the total cost and saving upto 70% water by adopting gravity-based drip irrigation system. Such farms can be a good attraction for the tourists as they highlight the traditional wisdom of farmers coupled with modern techniques of in-situ water conservation. These farms can be powerful agroecotourism centres for creating awareness among the tourists about conservation of natural resources and their judicious use for sustainable agricultural production.

S1-OP12

Rapid vermicomposting of coconut leaf waste using shredded biomass

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On an average, one hectare of the coconut garden produces a leaf and coconut waste of around 7-9 tons. This waste is relatively rich in lignin and takes longer time to decompose. The time for decomposition of these biomass is approximately two years naturally. This limits the recycling of the waste and its use in agriculture as manure or compost. One of the ways to address this issue is to increase the surface area of the coconut leaf and shell waste through mechanical shredding and chipping. At the farm of ICAR-Central Coastal Agricultural Research Institute, Old Goa, Goa, biomass of coconut leaves, petioles, and coconut shells was used for the vermicomposting. The present technology relies on increasing the surface area of the biomass through shredding and chipping to expedite the decomposition and vermicomposting process. The coconut leaves are chaffed using the shredder and the hard biomass like leaf petiole are ground into chips and coconut shells to husk using a shredder-cum-chipper. The vermicomposting of this biomass was done using the earthworms (*Eudrillus euginiae*). The average time for production of vermicompost is 90 days (3 months), produced in a silapaulin vermicomposting bags, besides the regular vermicomposting methods. The cost of production and net income to prepare the vermicompost from 1 ton of the shredded coconut biomass was Rs. 3900/- and Rs. 9220/- using low-cost silapaulin bags. The conversion ratio of biomass to the vermicompost (end product) was 0.62 and thus 0.62 tons of vermicompost were produced from 1 ton of biomass. With this, a 1 hectare of coconut orchard can annually recycle approximately 7 tons of waste-producing 4.75 tons of vermicompost with a net income and benefit to cost ratio of Rs. 27334/- and 3.36, respectively. Rapid vermicomposting with 90 days (3 months) duration with all practical demonstrations were explained to the visitors, students and trainee farmers at the ICAR-CCARI farm regularly.

S1-PP1

Weather-based agro-advisory services to improve the income of the coastal farmers

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Weather varies spatiotemporally and it has a profound influence on agricultural production. Timely information on the weather forecast and the advice accordingly could be a viable approach to avoid crop losses and improve the poor crop yield and ultimately the farmers' income. To provide real-time weather forecasts and agro-advisories at a block/taluka level to the farming community of North Goa district, District Agro-Met Unit (DAMU) was set up at ICAR-CCARI, Old Goa.

The advisories were compiled in the form of weather-based Agro-Advisory bulletins twice a week which are every Tuesday and Friday. Wider and effective dissemination was achieved through bi-lingual bulletins published in English and Konkani (local language of the region) languages. About 130 WhatsApp groups were created to disseminate the AAS bulletins to farmers that covered farmers of 195 villages from North Goa district. The agro-advisories were disseminated to 7000 farmers twice every week. A framework of reaching out of advisories to farmers at village and block level was also achieved by hosting it on different departmental websites of Goa state. Awareness and capacity building programmes were also conducted. Weekly feedback was collected from the farmers about the usefulness of the Agro-Advisories. Based on the feedback collection and impact assessment, an additional income of Rs. 9.0 crores was estimated by enabling farmers to save the crops from aberrant weather and plan timely agricultural operations. Thus, the Agro-Advisory bulletin based on current and forecast weather is a useful tool for enhancing the production and income of coastal farmers.

Keywords: Weather-based agro-advisories, Feedback, Income

S1-PP2

Forewarning and weather-based advisories to cope with the challenges of the Tauktae cyclone: A case study

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Extremely severe cyclonic storm 'Tauktae' was a major tropical cyclone in the Arabian Sea in 2021. It formed as a result of a tropical disturbance and was first observed by the India Meteorological Department on May 11, 2021. Cyclone 'Tauktae' was active from May 13-19, 2022. It caused severe damage to the coastal states of India. The present study was taken up for the assessment of the work done by District Agromet Unit (DAMU), North Goa to minimize the crop losses to the farmers of the North Goa district during cyclone and also estimate the impact and crop damages caused by the Cyclone Tauktae in North Goa district. To analyse the benefit of the timely warnings Cyclone Tauktae and specific agromet advisories, a feedback survey was conducted. As a result, the study showed that about 4000 farmers were issued real-time weather forecasts and warnings at 3 hours intervals through 75 WhatsApp groups. Based on the stages of the crop, possible impacts and specific management practices were issued to minimize the losses during the cyclone. The preliminary estimation of the Directorate of Agriculture, Government of Goa showed that there was a crop loss of 3 crores from 227 hectares of agriculture fields in Goa state. Further damage reports were also collected from the farmers of different blocks of the North Goa district. Feedback was collected from farmers through field visits and digital IT tools. About 30 representative farmers were surveyed from the 5 blocks of the North Goa district. Feedback analysis showed that farmers found the advisories and forecast useful and also the farmers were able to save their crops through timely management practices.

Keywords: Cyclone Tauktae, Damage, Feedback

S1-PP3

Population dynamics of insect pests in natural, organic and conventional farming practices in redgram + soybean crop ecosystem

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A study was conducted to monitor the incidence of insect pests on red gram + soybean ecosystem at Main Agricultural Research Station (MARS), Dharwad on three different farming practices viz., conventional farming (CNF), organic farming (OF) and natural farming (NF) practices during *kharif* 2020-21. The insect pest incidence/population count were recorded at 40, 80 days for soybean and 40, 80 and 135 days for red gram after sowing (DAS) on randomly selected five plants in each four quadrants of each treatment. The larval population (soybean) of spodoptera recorded least in CNF (0.00-1.00/plant) and organic (0.25-1.25/plant) methods of farming as compared to NF (0.50-1.00 /plant) at 40 DAS respectively and a day before the imposition of treatments the population were on par with each other. Similarly, in red gram, the thrips population was recorded least in CNF (0.35-6.23/plant) and organic farming (0.95-5.45/plant) methods as compared to NF (1.45-5.24/plant) and the leaf hopper population were least in CNF (0.50-8.25/plant) and organic farming (1.50-7.55/plant) as compared to NF (2.50-8.95/plant) at 40 DAS, respectively. At 80 DAS, the larval population (soybean) of spodoptera was recorded least in CNF (0.00-1.25/plant) and organic farming (0.25-1.50/plant) as compared to NF (0.75-1.50/plant) and a day before the imposition of treatments the population were on par with each other. Similarly, in red gram the thrips population was recorded least in CNF (0.22-4.07/plant) and organic farming (1.37-4.26/plant) as compared to NF (2.10-4.54/plant) and the leaf hopper population were least in CNF (0.50-8.00/plant) and organic farming (1.00-7.75/plant) than NF (1.75-8.25/plant). In red gram, the per cent pod damaged by the *Helicoverpa* was recorded least in CNF (15.23-17.37/plant) and moderate in organic farming (21.16-25.14/plant) and higher in NF (26.05-29.69/plant) and the damage caused by the pod borer *Moruca vitrata* were less in CNF (9.50-10.61/plant) and organic farming (11.60-12.85/plant) than NF (14.38-15.38/plant) methods. Hence organic farming practices of pest management can be adopted in agro-tourism farms by the youth for creating pollution-free environment.

Keywords: Conventional farming (CNF), Helicoverpa, Natural Farming (NF), Organic Farming (OF), Redgram, Soybean and Spodoptera.

S1-PP4

Performance of *adsali* sugarcane-based intercropping systems under natural, organic and conventional farming practices

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A field experiment was carried out at Agricultural Research Station, Hukkeri (Dist. Belagavi) during 2019-20 to study the effect of different farming practices, spacings and intercropping

systems on performance of *adsali* planted sugarcane. Experiment was laid out in split-split plot design with eighteen treatment combinations. The main plot consists of three farming practices *viz*., M_1: Recommended package of practices (RPP), M_2: Organic farming (OF) and M_3: Natural farming (ZBNF); in sub-plots two spacings *viz*., S_1:60-180-60 cm × 60 cm and S_2: 240 cm × 60 cm and in sub-sub plots three intercropping systems *viz*., I_1: Sugarcane+soybean *fb* chickpea *fb* turmeric, I_2: Sugarcane + onion + cowpea + coriander + green chilli and I_3: sole sugarcane were taken. Among the farming practices, RPP recorded significantly higher cane yield (137.8 t/ha) and net returns (₹ 317423/ha) as compared to organic and natural farming. Row spacing, S_1:60-180-60cm × 60cm recorded significantly higher cane yield (136.5 t/ha) and net returns (₹ 284511/ha), respectively as compared to S_2:240cm × 60cm. Among the intercropping systems, sugarcane + soybean - chickpea - turmeric registered significantly higher sugarcane equivalent yield (160.0 t/ha) and net returns (₹ 260258/ha) as compared to sole sugarcane, but it was on par with sugarcane + onion + cowpea + coriander + green chilli with respect to net returns.

Keywords: *Adsali* sugarcane, natural farming, organic farming, RPP, sugarcane equivalent yield

S1-PP5

Crop diversification through redgram + barnyard millet intercropping system under natural, organic and conventional farming practices

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A Field experiment was conducted at College of Agriculture, Hanumanamatti during *kharif* of 2019-20 and 2020-21 to study the effect of different farming practices in redgram + Barnyard millet intercropping system. The experiment was laid out in RCBD with three replications. The Four farming Practices were, T_1:Recommended Package of Practices (RPP) T_2:Organic Farming, T_3:Natural Farming and T_4:Chemical Farming. Pooled data indicated that cultivation of Redgram + Barnyard millet under RPP recorded significantly higher red gram grain yield (884 kg/ha), Branyard millet yield (1968 kg/ha) and Redgram equivalent yield (2025 kg/ha) as compared to other farming practices. Barnyard millet yield under natural farming practices (1898 kg/ha) was on par with RPP. The less cost of cultivation was incurred under natural farming (Rs. 42,393/ha), RPP (Rs. 60,020/ha) and organic farming (Rs. 78,326/ha). Without premium price, higher net return was obtained under natural farming (Rs. 69,978/ha) than RPP (Rs. 67,867/ha) and organic farming (Rs. 34,722/ha). The B:C ratio was higher under natural farming (2.65) than organic farming (1.45) and RPP (2.13). With premium prices, net again the return and B:C ratio were higher under natural farming (Rs. 90,379/ha & 3.13, respectively) than RPP (Rs. 67,867/ha) and organic farming (Rs. 55086/ha). Hence Natural farming practices can be adopted in redgram + barnyard millet intercropping systems for crop diversification and can be adopted in agroeco tourism farms.

Keywords: Barnyard Millet, Crop diversification, Intercropping, Natural Farming, Organic farming, RPP, Redgram,

S1- EP1

Managing water resources for agricultural development in Indian Ganges delta

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The Ganges Delta also known as the Sundarbans Delta is a river delta in the Bengal region of South Asia, consisting of the Indian state of West Bengal and Bangladesh. The Indian Sundarbans is a typical salt and flood-affected low-elevated coastal region and home to 4.5 million people who are mostly poor and vulnerable to natural hazards. Though agriculture is the major livelihood of people in the region, agricultural productivity is typically low. The resource-poor farming communities, often face water-related risks like sea-level rise, flooding with saline water, brackish groundwater, drainage congestion during monsoon season and non-availability of fresh irrigation water along with high soil salinity in dry season. Due to lack of fresh irrigation water and higher soil and water salinity, most of the agricultural lands remain fallow during dry season. The Sundarbans is intersected by intricate network of interconnecting waterways, however, the water in the rivers is mostly saline and not –suitable for irrigation. The groundwater aquifers at shallow depths are saline and freshwater aquifers at higher depth (160-400 m) are beyond the reach of poor farming communities. Enhancing agricultural production through water resource management is the major challenge for alleviating poverty in this delta region. Maintenance of the existing river embankments, raising embankment height and systematic retreat of selected embankments away from tidal channels are required for the stability of embankments for protecting agricultural lands from saline water inundation. De-siltation of drainage channels and proper maintenance of sluice gates connecting the internal canal network are essential to improve drainage. The excess rainwater of this region, estimated as 2.7 times higher than crop evapotranspiration in monsoon season needs to be harvested for creating freshwater resources for the dry season. Different land shaping techniques like farm fond, deep furrow & high ridge, shallow furrow & medium ridge and paddy-cum fish cultivation systems have been developed for harvesting rainwater and integrated cultivation of multiple crops and fish round the year under on-farm situations. The rainwater can also be harvested by creating water detention structures using silted up canals/drainage channels/old creeks, building freshwater reservoirs by partial or complete closure of estuaries. Improved water management practices including conductive use of water, use of pressurized irrigation techniques and integrated water management are experienced for efficient and sustainable use of scarce water resources in agriculture in this delta region.

S1- EP2

Delineating salt-affected soil in coastal India using satellite remote sensing

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An attempt has been made to delineate the coastal salt-affected soils in India using satellite remote sensing. The Landsat-8 satellite OLI (Operational Land Imager) was used for the study. These images were downloaded from the United States Geological Survey (USGS) EarthExplorer website. Absolute radiometric calibration was carried out for multi-temporal studies in order to reduce the effects due to changes in atmospheric condition, solar angle and sensor view angle. Total 57 scenes of Landsat-8 OLI were downloaded, georeferenced and converted to spectral reflectance. Images were classified using unsupervised classification in ERDAS software. Initially, images were classified into 150 classes and then re-coded to broad 5 to 6 land use classes and the Google earth software was used for ground-truthing. Three indices Normalized Difference Vegetation Index (NDVI), Salinity Index (SI) and Canopy Response Salinity Index (CRSI) were used for identifying salt-affected regions. For testing the vegetation index with soil salinity, 192 soil samples from Indian Sundarbans were collected. A relationship has been developed between NDVI, SI and square of CRVI (CRVISQR) with ECe (electrical conductivity of saturation paste extract) and EC (1:2; soil: water). Maximum r^2 (0.49) was found between ECe and square value of CRVI and the value of CRVISQR <0.08 was considered salt-affected soils for the coastal region. India has estimated 13143 km^2 of total salt-affected soil in all the coastal districts and Gujarat (6939.15 km^2), West Bengal (4286.814 km^2) and Maharashtra (916.29 km^2) are identified as the top 3 salt-affected states.

S1- EP3

Policies for sustaining *Nel Kittangi* for climate adaptation and mitigation

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Nel Kittangi, a traditional warehouse for storage of paddy grain and seed is a large scale secured structure found as a common property resource at a hamlet named Agaramaathur in Velangudi village, Nannilam taluk, of Tamil Nadu state, India. It was constructed and maintained by an ancestor named Thirumeni Chettiyar more than a century ago and is now possessed by Naagammai Trust. It was constructed using mud walls and bricks, with three-layered roofing of three different ancient tiles, slope, ventilation, flooring made of Mahua timber and doors, all designed to provide a preferable microclimate conducive for protected storage. It served farmers

who cultivated 96 acres of land around. But of late, the procurement centres purchased and stored the grains of farmers shortly after harvest. Therefore, its utility has dwindled. Hence, the study suggests to the Government of Tamil Nadu to designate *Nel Kittangi* as a heritage site and needs multidisciplinary research to unravel its architectural secrets in order to explore the hidden wisdom of sustainable and climate-proof seed and grain storage, essential to adapt and mitigate to extreme climate events in the future.

S1- EP4

Screening of acid and saline tolerant beneficial microflora from *Pokkali* soils of coastal Kerala

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Pokkali lands represent the lowlands, often below sea level, in coastal regions of Ernakulam, Thrissur, and Alappuzha Districts of Kerala in South India. The study was undertaken to isolate and screen the saline tolerant beneficial microbes. Soil samples were collected from *Pokkali* fields (Chellanam, Kumbalangi, Ezhikkara, Kottuvally, Varappuzha, Chittatukkara, Poyya, Puthenvelikkara, Chedamangalam and Vadakkekara) in Ernakulam District, Kerala, India. Standard methods were followed for isolation, enumeration, and salinity screening of microbes. The microbes were screened for salinity tolerance at electrical conductivity (EC) of 0, 2,4,6,8,10, and 12 ds/m The highest population of nitrogen fixers, phosphate solubilizers, zinc solubilizers, and fluorescent pseudomonas was $7.3\times10^{5,}$ 12×10^{5}, 17×10^{5} and 1×10^{4} CFU g^{-1}, respectively. Potassium solubilizers*, Azotobacter* and *Azospirillium* were absent in the soil. Altogether 29 predominant isolates were selected, out of which 17 isolates belonged to Zn solubilizer, 6 isolates were P solubilizer, 5 were nitrogen fixers and 1 isolate was fluorescent pseudomonas. The highest Zn solubilization was found at 144.4 mg/L (EC 6) shown by S_7F_1Zn. Zinc solubilizer obtained from Poyya showed the highest Zn solubilizing efficiency of 141.3%. The isolate S_9B_1P from Chendamangalam showed maximum P solubilization of 22.91 mg/L (EC10) and also displayed 94.73% P solubilizing capacity. The highest nitrogen fixation was recorded by S_5B_4N with 67.72 mg/L (EC 8) collected from Varappuzha. The present study indicated that three isolates S_7F_1Zn, S_9B_1P, S_5B_4N have the potential for tolerance to salinity. However, further study is in progress to identify the beneficial microflora for *Pokkali* fields.

S1-EP5

Yield, nutrient uptake, economics and energetics of *kharif* groundnut as influenced by seed inoculation and nutrient management in South Odisha

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An experiment was carried out to evaluate yield, nutrient uptake, economics and energetics of groundnut as affected by seed inoculation and nutrient management at Bagusala farm, M.S. Swa-

minathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha in 2018 and 2019 during *kharif* season. The experiment was laid out in FRBD with 2 factors and replicated thrice. One factor was seed inoculation, comprised of 2 levels, S_1: solid carrier-based *Rhizobium* and S_2: liquid carrier-based *Rhizobium*, another factor was nutrient management with 5 levels, N_1: 100% RDN (Inorganic fertilizer), N_2: 75% RDN (Inorganic fertilizer) + 25% RDN (FYM), N_3: 50% RDN (Inorganic fertilizer) + 50% RDN (FYM), N_4: 25% RDN (Inorganic fertilizer) + 75% RDN (FYM), and N_5: 100% RDN (FYM). RDF is 20:40:20 kg N: P_2O_5:K_2O per ha. Two years of data were recorded and pooled data analysis was done. The treatment combination S_1N_1 recorded the highest pod yield (2781 kg ha^{-1}) and kernel yield (1764 kg ha^{-1}). The same treatment combination S_1N_1 also resulted in the highest NPK uptake, gross and net energy output and highest B:C ratio (3.0).

Keywords: Economics, energetic, groundnut, nutrient management, nutrient uptake, seed inoculation, yield

S1-EP6

Integrated approach to enhance farm productivity in the coastal area of Ramanathapuram District

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Ramanathapuram District has a long coastal line of 271 km in length with 6 of the 11 blocks lying on the sea coast. The soil constraints and high climatic vulnerability in the district let to low productivity of crops in this region. In the coastal area, rainfed rice and coconut are grown by the farmers. The high soil salinity, low fertility status, low water holding capacity of coastal alluvium and sandy soils are the major constraints to the coastal farmers. The Krishi Vigyan Kendra intervened with introduction of salt-tolerant varieties and management practices to increase crop productivity. In rice, saline tolerant varieties like TRY 3 and TRY 4 were demonstrated at farmers› fields. Also, management practices like application of iron and zinc micronutrients, *CSR-BIO* consortia of microbes to enhance nutrient mobilization and enriched farmyard manure (FYM) were demonstrated. These interventions enhanced the rice productivity to 4400 kg/ha which is 16 per cent more over the conventional varieties. To enhance the farm income and to improve the resource utilization in coconut gardens the inter-cropping of cowpea varieties like CO (CP) 7 and VBN 3 was demonstrated which provided additional income to farmers, enhanced the soil fertility and helped to meet the fodder demand. The training and demonstration on apiculture created awareness, which provides additional income to the farmers and improves coconut productivity by enhancing pollination.

S1- EP7

Extension of indigenous and exotic technologies for climate risk-prone coastal farmers: Case of RHWE Programme of PAJANCOA & RI

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Coastal farmers need basket of choices to combat and mitigate extreme climate events that throng the coastal district of Karaikal in the Union Territory of Puducherry. Rural Horticultural Work Experience Programme for undergraduate students during their fourth year of the Bachelor of Horticulture degree programme offers scope for extending knowledge to such vulnerable farmers. Pandit Jawaharlal Nehru College of Agriculture & Research Institute embarked on such an initiative. The 2018 batch of students showcased many indigenous and exotic technologies for coastal farmers by organizing an exclusive exhibition with a combination of extension teaching methods and aids viz., specimens, samples, models, mock-ups, posters, charts, photographs, and oral presentations to reach out to them. Salient technologies disseminated include Kyminasi Plant Booster an advanced customized micro transmitter utilizing 3000+ low-frequency radio waves attached to an irrigation system, Permaculture which gives farmers a way to achieve high yields and productivity while doing it in a more sustainable and environment-friendly way than conventional farming methods, Bee hotel, Aquaponics, Hydroponics, Zero Energy Cool Chamber and organic formulations viz., Panchakavya, Fish amino acid, Egg amino acid, Jeevamirtham, Ginger-Garlic-Green chilly extract and five-leaves extract etc. Such proven extension is a worthwhile approach to emulate in similar biophysical, socioeconomic and geopolitical agro-ecosystems.

S1- EP8

Assessment of efficacy of Deltamethrin and Ivermectin against *Rhipicephalus microplus*

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Rhipicephalus microplus is a major animal pest and is a voracious bloodsucker of both small and large ruminants and transmits haemoprotozoan parasites of cattle. The ticks are controlled mainly using acaricides and also by macrocyclic lactones. During the present investigation efficacy of both these compounds was assessed by *in vivo* trial and adult immersion test (*in vitro* assay). For *in vitro* assay both these medicines were tested in five different concentrations to come out with dose-dependent response. For *in vivo* test, therapeutic doses as recommended by the manufacturer were used. By adult immersion test and *in vivo* trial, this was found that *R. microplus* has developed resistance against Deltamethrin and is susceptible to Ivermectin.

S1- EP9

Addressing climate change impact on bush pepper through field experiments

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The impact of changing climate with causative factors such as high temperature on productivity of black pepper is largely limited to modelling exercises suggesting decline in productivity of black pepper with rising temperature in major pepper producing centers of Kerala. Realistic understanding about the response of high temperature on black pepper requires additional data from field experiments. However, owing to perennial nature of pepper, the experiments in field environment are quiet difficult to execute. Field experiments were conducted on well-established bush pepper plots at experimental field of CWRDM. Portable chambers were designed and established to expose plants to high temperature and further high-temperature impact on bush pepper with mechanistic understanding is worked out. Different physiological traits at different time intervals were collected to assess changes in photosynthetic efficiency of bush pepper under high temperature. Results revealed that under humid environment with anticipated high-temperature stress may affect physiology through altered gas exchange, oxidative damage and carbon allocation. Impact assessment for multiple combination stresses viz. high temperature and drought in field environment is warranted to address climate change impact, on bush pepper and enhancing water use efficiency under future climate change.

S1- EP10

Response of bacterial leaf blight at different soil moisture conditions in rice

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Xanthomonas oryzae pv. *oryzae* (Xoo), the causal agent of rice bacterial blight is a common reason for severe economic yield losses in rice. Plant response to one type of stress can be affected by simultaneous exposure to a second stress, for example when abiotic and biotic stresses occur together. In this study, two genotypically contrasting genotypes were challenged inoculated under different drought levels (based on field capacity). In compatible interaction, the susceptible genotype TN-1 showed great response to infection and expressed highly under all drought conditions. Symptoms appeared firstly at 6 DPI (day post-inoculation) and gradually increased up to 14 DPI. Maximum lesion length was observed at drought level of 60% field capacity (12.02 cm) and minimum (5 cm) was recorded at no drought condition (100% field capacity) on 14 DPI. Same in case of bacterial multiplication rate, maximum CFUs (colony forming units) were recorded at drought level of 60% field capacity and minimum were recorded at no drought condition. In incompatible reaction, BPT5204 genotype showed no symptoms, on the contrary bacteria multiplied in the host and observed maximum numbers of colonies at drought level of 60% field capacity.

S1- EP11

Soil erosion hazard mapping during pre- and post-Tsunami periods for Andaman Island ecosystem

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Andaman and Nicobar Islands receive more than 3000 mm rainfall annually with high intensity (>10-50 mm/hr), which leads to faster erosion of slopes leading to accelerated runoff and sediment flow. This results in a loss of fertile soil and reduction of 50% of agricultural productivity. This loss will not only be endangering to Islands but also entire coastal ecosystem. This is matter of serious concern and needs to be checked. Therefore, the soil erosion hazard mapping for Andaman Islands is generated using the soil erosion model (RUSLE) for the years 2000 (pre-tsunami), 2006 and 2019 (post-tsunami). This model was calibrated at the field scale based on data collected from the erosion plot studies at Central Island Agricultural Research Institute (CIARI), Port Blair. The model estimated annual average soil erosion rates for 2000, 2006 and 2019 years ranged from 0.7 to 108, 0.9 to 157 and 1.1 to 226 t ha^{-1} y^{-1}, respectively, indicating an increased rate of soil erosion over the time period in different land-use categories. Similarly, the average rate of erosion for the study area indicated a 47% increase (53 t ha^{-1} y^{-1}) in 2019 from the 2006 rate, whereas it exhibited a 25% increase immediately after the tsunami from the 2000 rate (27 t ha^{-1} y^{-1}). The study revealed that the highest soil loss either with or without conservation practices was recorded for mined sites and urban settlements, indicating the potential to accelerate land degradation. In these areas, suitable conservation measures can provide a conservation benefit.

Keywords: Erosion, Conservation, Islands, Land use, Tsunami

S1- EP12

Commercializing green synthesis of nano fertilizers for agronomic biofortification of seeds

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The green revolution is well known for bringing a significant transformation to the Indian agricultural system bringing food security, but not to the extent that it has improved grain nutritional quality. Agriculture in the future will rely heavily on nano fertilizers. However, industrially produced nano fertilsers that emit toxic compounds into the environment during the synthesis process are hazardous, and this problem can be solved through green synthesis of nano fertilizers. Agronomically biofortified grains with green synthesized nano nutrients attract higher price than traditional grains, helping to combat malnutrition and ensure nutritional security in the country. In the present study, iron nano fertilizer was synthesized using the *Tridax procumbens* weed leaf extract and $FeCl_3$ solution as precursor. The leaves extract when mixed with $FeCl_3$ solution, it was changed to black colour along with reduction in pH from 7.21 to 2.84. Then synthesized particles were further characterized using various instruments viz. UV visible spectroscopy, particle size analyser and synthesized nano iron fertilizer were used for biofortifying the rice seeds.

S1- EP13

Low land ecosystem soils of north Kerala, their characteristics, present status, consequences and future sustainability

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The present investigation was carried out to characterise and classify the natural and altered low land ecosystem soils of north Kerala namely *Kole* lands, mangroves and *Kaipad* lands. *Kole* and *Kaipad* lands, which are altered wetlands occupy 71,142 ha and 24,209 ha respectively next to Kuttanad and Palakkad, the major rice bowls of Kerala, in contributing to Kerala's rice production and food security in particular, despite the problems associated with these systems. But mangroves, which are natural wetlands occupying an area of 9,000 ha act as a filter for tidal seawater intrusions on a daily basis and protecting the biosphere from natural vagaries. The pedons were extremely acidic to moderately alkaline in reaction and high in organic carbon. CEC values were low to high and exchange complex was dominated by Ca^{+2} followed by Mg^{+2}, Na^{+} and K^{+}. Regarding nutrients status, the soils were medium to high in available nitrogen, low to high in available phosphorus, high in available potassium and very high in available sulphur. Soils were classified as Fine, mixed, super-active isohyperthermic Salidic Sulfaquepts (*Kole* lands), fine, mixed, acid, super-active isohyperthermic Sulfic Endaquepts (*Kaipad* lands) and fine, mixed, super-active isohyperthermic Typic Sulfaquepts (Mangroves). These lands are frequently affected with natural calamities, mostly with respect to tidal forces, seawater inundation, acid saline or potential acid sulphate sediments, which may lead to frequent changes in crop production or crop losses and affecting ecosystem sustainability.

S1- EP14

Assessment of biological properties of soil under INM on long term basis

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Biological properties of soil can be considered as better indicators of soil quality and soil health. Monitoring the changes in biological properties of soil over long term is essential for understanding the response and behaviour of soils to the management practices adopted. Long term application of manures and fertilizers is used to evaluate the complex issue of biological properties of soil. The investigation was carried out in Long-Term Fertilizer Experiments (LTFE) located at Regional Agricultural Research Station, Pattambi, Kerala, India started since 1997. The experiment was laid out in randomised block design on rice-rice cropping system with 12 treatments. The study focused on evaluating biological properties of soil with respect to long-term application of manures and fertilizers at different periods. Population of bacteria and actinomycetes were found to be the highest in integrated nutrient package, T_8 over a period of seven years while fungus in T_8 during 2014 and in green manure incorporated plots during 2021. Microbial biomass carbon (MBC) showed a decreasing trend with the highest level of 552 and 295.2 µg g^{-1} soils in T_8 in 2014 and 2021, respectively. The activity of dehydrogenase enzyme was highest in T_8 during 2014 while it decreased with an increased level of inorganic fertilizer application from 50 per cent NPK to 150 per cent NPK in 2021. Application of lime with 100 per cent NPK increased the dehydrogenase activity of the soil. The study strengthens integrated nutrient management (INM) as a stable practice for enhancing the microbial flora of soils.

S1- EP15

The adaptation methods practiced in response to perceived climate change by farmers of Zone-9 and Zone-8 of Karnataka

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To avoid the huge loss due to weather aberrations on farmers' livelihood security, it is important to adopt the climate-resilient adaptive measures as per the agro-climatic situations of the farming community. Keeping this in view present study was conducted to identify and assess the adaptation methods practised by farmers in response to perceived climate change in Zone-9 (Hilly Zone) and Zone-8 (Northern Transitional Zone) of Karnataka. This study revealed that practicing planting trees/ grasses on slopes is more common in zone 9 (57.50%), Multiple crops/ Diversification of crops was observed to be more in zone 8 (91.25%) compare to zone 9 (49.38%), Applying FYM was observed to be more in zone 9 (93.13%) compare to zone 8 (83.75%). Practising increased irrigation frequency (90.62%), shift in mode of irrigation from flood to sprinkler/ drip (75%) and holding livestock enterprises (88.12%) were found highest in zone-9 respectively compare to zone-8. Under socio-economic adaptive measures, majority of the respondents were following use of savings (93.13% and 96.25%) during drought and flood situations followed by claiming compensation from the government (90.63% and 91.88%). Very less number of respondents were following migration to cities along with family for work (1.88% and 4.38%) in zone 9 and zone 8 respectively.

Keywords: Adaptive measures, Climate resiliency, Zones of Karnataka

S1- EP16

Nitrogen mineralization changes following controlled fire under different land uses of North-Western Himalayas

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A study on impact of controlled fire on ammonification, nitrification and net nitrogen mineralization under four land uses namely burnt Chir Pine forest (*Pinus roxburghii*), grassland, scrubland and control of non-fire site in Chir Pine at three soil depths *viz.,* 0-5 cm, 5-10 cm and 10-15 cm for one year was carried out. The experiment comprised of five replications in a factorial randomized block design. A controlled fire of moderate intensity was caused in March 2018 and soil samples were collected before and after the fire at monthly intervals from April 2018 to March 2019. Results showed that the ammonification and nitrification rates were found highest under burnt Chir Pine forest, while unburnt Chir Pine recorded the lowest rates. Nitrification rate was found highest at 10-15 cm soil depth due to leaching losses. Post-fire, the net nitrogen mineralization was found

highest in burnt Chir Pine forest at 10-15 cm depth. However, net immobilization was observed at 0-5 cm soil depth under control. Therefore, controlled fire can be used as an effective management strategy for controlling wildfires as it did not have any detrimental effect on nitrogen mineralization which determines the primary productivity of terrestrial ecosystems.

Keywords*:* Chir Pine, Controlled fire, Ecosystems, Nitrification, Nitrogen mineralization.

S1- EP17

Integrated farming system: Encapsulating various methods of cattle-fish farming

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Sustainable agriculture intends to protect our environment through different farming methods such as integrated farming systems, crop rotation, etc. Integrated farming system aims in enhancing the productivity through integration of diverse resources like livestock and crops. For instance, cattle-fish integrated farming system is one of the well-known integrated farming systems which has aided in increasing the agricultural productivity. In such type of farming, we see that the cattle waste is directly dumped into the fish pond as food for the fish. When exceeding amounts of waste are dumped, the pond accumulated more nutrients from the waste which leads to the death of fish. In order to avoid such losses, this paper attempts to bring together various recommended strategies or methods that were implemented to provide nutritious food to the fish as well as make use of the extra cattle waste for other agricultural purposes. The cattle wastes are not fully dumped into the fish pond, instead, they are converted into fish feed by fermentation processes which were experimented internationally. Similar methods have been experimented and implemented according to our Indian standards and conditions to gain better results in agricultural productivity which in turn benefits economically and environmentally. Foregrounding such experiments and strategies enhances better understanding of the advantages and disadvantages of integrated farming system, especially the cattle-fish integrated farming system.

Keywords: Integrated Farming System, Cattle-Fish Farming, Fish feed, Cattle waste, Agricultural productivity

S1- EP18

Natural resource conservation and crop productivity as influenced by soil amendments in fragile ecosystem of Chambal ravines

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Soil degradation is a continuous process which undergoes huge loss of natural resources, threatening agricultural productivity, risking farmers income and impairing ecosystem services. Scouring of lands is a common phenomenon in the region with wide extensive gully formation. Various combinations of soil amendments treatments viz., control (without fertilizers and amendments-T_1); Recommended Dose of Fertilizer (RDF) for soybean (T_2); RDF + Gypsum (T_3); RDF + FYM (T_4); RDF + crop residue (CR) (T_5); RDF+ Gypsum + CR (mustard crop residue) (T_6); RDF+ Gypsum + FYM (T_7) ; RDF + Gypsum + CR+ FYM (T_8). Results showed maximum grain production in T_8, T_6 and T_7 treatments. Application of gypsum and FYM showed significant effect on soybean yield. Highest soil erosion recorded in control without any amendments and least runoff in case of T_6 and T_8 treatments. Greater soil and nutrient conservation were observed combined amendment followed by sole amendment treatments. Application of amendments not only reduced soil loss but improved crop productivity. Significant increase in available sulfur content and improved soil properties were observed with combined amendment treatments. Application of soil amendments are economically viable options for farmers in resource conservation especially in degraded lands of semi-arid regions.

Keywords: Soil loss, Runoff, Amendments, Productivity, Soil properties

Technical Session 2

Fisheries resources, production and post-harvest management

Lead Paper

Coastal Eco-system Based Sustainable Aquaculture Opportunities

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Abstract

Coastal eco-system based aquaculture mainly involves brackishwater species which fetch high market price. These species are mostly euryhaline in nature and are suitable for farming in fresh and brackishwaters of coastal regions. Farming of brackishwater species in coastal regions is known as coastal aquaculture. This brackishwater sector is regarded as the 'sunrise sector' that is yet to grow and cover the vast 1.2 million ha coastal and 8 million ha inland salt affected areas, and has a potential to contribute significantly to aquaculture production. This sector has grown at an average annual rate of 10% since 1984. Although, traditional costal aquaculture is an age-old practice in several coastal states of India, commercial farming has been mainly involving a single species, shrimp. This growth is mainly attributed to the farming of single species, Indian tiger shrimp, *Penaeus monodon* and more recently, the Pacific white-leg shrimp, *Penaeus vannamei*. India earns around INR 45000 crores annually from exports of seafood products, of which, over 60% by value is contributed by farmed shrimp species from coastal regions. However, the sustainability of shrimp farming has been frequently jeopardized by dreaded viral diseases. Therefore, to ensure sustainability of costal aquaculture, diversification of culture systems involving various species could be a practical alternative. Moreover, development of eco- friendly and cost-effective culture technologies targeting small-scale farmers is the much-needed step. Adequate availability of quality fish seeds and low-cost feeds will also help in expansion of culture. There exist some environmental issues, such as waste generation, conversion of agricultural land, salinization, degradation of soil and the environment due to the extensive use of drugs and chemicals, and destruction of mangroves, which can be harnessed by right management steps like awareness on use of scientific methods for reduced or no environmental impacts, participatory and community based planning and implementation, capacity building and social mobilization towards sustainable development of coastal aquaculture.

Keywords: Coastal Aquaculture, Species Diversification, Sustainable Development, Brackishwater Fishes, Shrimp, Environment-Friendly Approaches.

1. Introduction

World's population is predicted to reach 9 billion by 2050. Sustainable and responsible development of aquaculture can make a significant contribution to the food security for this accelerating population. It is forecasted that 62% of food fish will come from aquaculture by 2030. In Indian context, brackishwater aquaculture is regarded as the 'sunrise sector' that is yet to grow and cover the vast 1.2 million ha coastal and 8 million ha inland salt affected areas, and has a potential to contribute significantly to aquaculture production. These natural resources offer immense opportunities for the development of brackishwater aquaculture in the country; which can

be substantiated by the fact that the sector has grown at an average annual rate of 10% since 1984. Brackishwater aquaculture practiced in coastal regions is known as coastal aquaculture. Although, traditional costal aquaculture is an age-old practice in coastal states like West Bengal (*bheries*), Odisha (*gheries*), Kerala (*pokkali*), Karnataka (*kharlands*) and Goa (*khazans*), commercial farming has been centred on mainly involving a single species, shrimp. This growth is linked to the farming of single species, Indian tiger shrimp, *Penaeus monodon* and more recently, the Pacific white-leg shrimp, *Penaeus vannamei*. However, the sustainability of shrimp farming has been threatened by uncontrollable viral diseases. Therefore, to ensure sustainability of costal aquaculture, diversification of culture systems involving various species could be a practical alternative.

Several innovative technologies emerged over the years have been tested and adopted to attain sustainable coastal aquaculture development. Various ICAR institutes have generated enormous information on shrimp, fish, crab hatchery and grow-out production, nutrition and feed technology, disease diagnosis and management to address the growing needs of the coastal aquaculture sector and provided a platform for interaction with stakeholders. Efforts are being continued to bring the unutilized resources under scientific farming to maintain growth of the sector and achieve sustainability.

2. Resources and utilization status for coastal aquaculture

As the maximum sustainable yield is static and the capture fisheries trend is declining, it is expected that brackishwater aquaculture has to make a greater contribution to the fish production in Indian context. Along the 8118 km coastline of India, intercepted with innumerable estuaries, creeks, backwaters lagoons and lakes it is extended to a potential area of 1.2 million ha for costal fish farming. Apart from this, in the upland inland area a vast stretch (8.5-9.0 million ha) of saline ground and surface water exists, which can only be used for saltwater fishes.

Table 1. State-wise estimated potential brackishwater area, area under culture and total shrimp production.

State	Estimated potential area (ha)	Area under culture (ha)	Production (tiger, Pacific shrimp & scampi) (ton)
Andhra Pradesh	150,000	74,512	6,39,896
West Bengal	405,000	50,844	54,582
Kerala	65,000	2,971	1,868
Odisha	31,600	11,200	44,555
Tamil Nadu & Pondicherry	56,800	8,630	44,816
Karnataka	8,000	3145	3,186
Goa	18,500	0	0
Gujarat	376,000	9,021	50,526
Maharashtra	80,000	1,183	4,204
Total	1,190,900	1,61,506	8,43,633

Source: MPDEA, 2020-21

Coastal aquaculture is a traditional practice in India. In the low-lying fields of Kerala (*pokkali*), West Bengal (*bheries*), Odisha (*gheries*), Goa (*khazans*) and Karnataka (*kharlands*) which get influx of saline water, traditional farming of fish/shrimp has been practiced. The practice includes allowing entry of juveniles of fish/shrimp in the fields and letting them to grow, applying occasional supplementary, facilitating tidal water exchange and harvesting periodically at 3-4 months. With the improvement of technologies and realizing the importance of aquaculture, these practices were improved with the supplementary stocking and water quality management resulting in moderate to higher production. The technology improvement made in the aquaculture sector has opened new areas for the scientific farming which is called as semi- intensive and intensive farming following all the protocols for farming with production as high as 10 ton/ha/crop of 4-5 months for mainly shrimp and brackishwater fish, like Asian seabass (*Lates calcarifer*) production of 3 to 4 ton/ha/crop in the coastal area. Polyculture of fish and shrimp with different stocking patterns has yielded a productivity of 3 ton/ha/crop in Indian Sundarban. In addition to that, farmers have achieved a production of 3-4 ton/ha/crop of milkfish when it is practiced in monoculture system in West Bengal, Andhra Pradesh, Tamil Nadu, Kerala and Gujarat. Green water technology in brackishwater aquaculture has been standardized and farmers started adopting the same in different costal districts of Tamil Nadu. Phenomenal growth in Pacific whiteleg shrimp, *P. vannamei* farming has been occurred in the recent past. The technological advancement helped in establishment of more than 390 shrimp and 1 crab hatcheries. The coastal aquaculture witnessed a rapid growth during 1980s and in the beginning of 1990s. But the shrimp aquaculture sector witnessed severe setbacks from the later part of 1990s due to socio-economic and environmental issues coupled with the outbreaks of uncontrollable diseases like white spot syndrome virus (WSSV), Monodon slow growth syndrome, loose shell syndrome, early mortality syndrome diseases etc. The major reasons attributed to this are the unregulated development and unforeseen disease outbreaks. The sole dependency on single species tiger shrimp, *P. monodon* in coastal aquaculture has switched to *P. vannamei* farming since over a decade with the current production of 8,43,662 ton, out of 8,43,361 ton total shrimp production (MPEDA, 2020-21) and this had a pronounced impact on the coastal aquaculture sector doubting its sustainability.

3. Contribution of brackishwater aquaculture to India's economy

India, the seventh-largest economy in the world, is the second largest producer of fish and shellfishes from aquaculture. There was an all-time high of seafood exports in value (INR 46,663 crore) with quantity (12,89,641 ton), and earnings in 2019-20 (MPEDA, 2019-20). Among the items, frozen shrimp continued to be the major commodity in term of value (INR 34,152 crore) accounting 73% of the total earnings. Contribution of shrimp produced mainly from brackishwater aquaculture was more than 70% by value. Similar trend in production in recent years (65% in 2016-17, 68% in 2017-18 and 2018-19 by value) was primarily due to the contribution of *P. vannamei* farming in major shrimp farming states like Andhra Pradesh, Tamil Nadu, West Bengal and Gujarat.

3. Advanced coastal aquaculture systems towards attaining sustainability

Different innovative management options have been evolved to improve coastal aquaculture production. Improving traditional system of farming by polyculture, use of low-cost farm made feed, control of diseases and improved production through eco-friendly aquaculture practices, like biofloc and periphyton based system are the best options currently available to enhance farm income. Moreover, development of organic farming, genetic improvement of shrimp stock

through selective breeding, improved and intensive culture methods, adoption of cage farming of fishes and overcoming the constraints through participatory fisheries management, public private partnership, refinement of indigenous technical knowledge are the advances to be addressed in near future to make coastal aquaculture a sustainable one.

3.1. Traditional and improved grow-out practices of fishes

Asian seabass (*L. calcarifer*) is cultured in ponds traditionally as an extensive type of culture throughout the areas in the Indo-pacific region where this fish is distributed. Low- lying excavated ponds are stocked whenever the seabass juveniles are available in the wild seed collection centres (For e.g., April-June in West Bengal, May-August in Andhra Pradesh, Sept-Nov in Tamil Nadu, May-July in Kerala and June-July in Maharashtra). Juveniles of assorted size seabass are collected and introduced into the traditional ponds which will be already with some species of fish, shrimps and prawns. These ponds will have the water source from adjoining brackishwater or freshwater canals, or from monsoon flood. The juvenile seabass introduced in the pond will prey upon the available fish or shrimp juveniles as much as available and grow. Since seabass by nature is a species with differential growth, on introduction into the pond at times of food scarcity, the larger may resort to feed upon the smaller ones reducing the number. Seabass are allowed to grow for 6-7 months of culture period till such time water level is available in these ponds and then harvested. At the time of harvesting there will be large fish of 4 to 5 kg as well as very small fish. In this manner, production up to 2-3 ton/ha/7-8 months has been obtained depending upon the number and size of the fish entered/introduced into the pond and the feed available in the pond. However, this practice is highly unorganized and without any guarantee on production or return for the aquaculturists. With advances in the technology in the production of seed under captivity assuring the supply of uniform sized seed for stocking and quality feed for feeding, the seabass culture is done in South East Asian countries and Australia in more organized manner. The major problem in the development of seabass aquaculture in India is the availability of seed in adequate quantity and in time. The technology package for the seed production of seabass under controlled condition is available. Suitable feed for the culture of seabass has been developed. These technological improvements in the seabass culture have motivated the farmers to select seabass as a candidate species for aquaculture. Farmers have been adopting improved farming practices in seabass culture.

The traditional culture method is further improved with stocking of uniform sized seed at specific density and fed with low-cost trash fishes/formulated feed of required quantity. Water quality is maintained with exchange periodically. Fish are allowed to grow to marketable size, harvested and marketed for high unit price. Seabass culture can be done in a more organized manner as a small-scale/large scale aquaculture in brackishwater and freshwater pond cages. This practice was further demonstrated in Public Private Partnership mode in three different costal states of India. Successful crops have been demonstrated in Andhra Pradesh, Tamil Nadu, Maharashtra and West Bengal with production ranging from 2.5-4.5 ton/ha.

Grey mullet (*Mugil cephalus*) can be farmed in monoculture ponds. The pond for monoculture is prepared first, following eradication of unwanted organisms and application of manures and fertilizers. Advanced fingerlings of >50 g size are stocked at 10,000 no./ha. Fish are fed with supplementary feed. In an 8-month culture, fish become 500-800 g with total production of 3-4 ton/ha.

Milkfish (*Chanos chanos*) can be farmed in monoculture and polyculture ponds. The wild seeds are collected in an organized manner in Andhra Pradesh and Tamil Nadu, and seeds are stocked in farms in costal ponds. The seed production technology of this fish has been developed by ICAR-CIBA in 2015. The milkfish farming follows a protocol of nursery rearing and farmed with farm made feed and floating pellet available in the market for other species. The scientific water quality management and supplementary feeding have given a production of 3 to 3.5 ton/ha in West Bengal and a higher production has been achieved in Andhra Pradesh.

3.2. Polyculture of fishes and shrimps

Polyculture is a farming practice where two or more species of fishes are reared together. The concept of polyculture is based on the fact that rearing of two or more compatible aquatic species together will result in higher production compared to monoculture. The underlying goal of polyculture involves increasing productivity by more efficiently utilizing ecological resources within an aquatic environment. Sometimes, one species enhances food availability to other species and thus increases total fish production per unit area. It is commonly believed that polyculture gives higher production than monoculture in extensive and semi-intensive systems and is considered more ecologically sound than monoculture. Before stocking of seeds, pond is prepared well following eradication of pest and predatory fishes, removal of bottom mud and liming, fertilization etc. The ready ponds are stocked with seeds of fish species at 8000-15,000 no./ha along with tiger shrimp seeds of 20,000- 30,000 no./ha. The stocking density varies with the quantum of seed availability. Natural pond productivity is maintained by fertilization. In addition, supplementary feed prepared from locally available ingredients can be used at 2-5% body weight daily. This kind of system can yield a total production of 2-3 ton/ha in 6-10 months. The preferred species among fishes are: Mullets- *M. cephalus* (striped grey mullet), *Liza tade* (tade grey mullet),

L. parsia (goldspot mullet), milkfish- *C. chanos*, pearlspot- *Etroplus suratensis*, brackishwater catfish- *Mystus gulio*, tiger shrimp- *Penaeus monodon* and white shrimp- *P. indicus*.

3.3. Use of cost effective feed in polyculture

Several initiatives were taken to standardize polyculture practices with indigenous brackishwater fishes and shrimp using low-cost farm made feed with locally available feed ingredients and it proved the polyculture as a sustainable and economically viable activity. This successful model of polyculture has been disseminated among the farmers of the Sundarbans, West Bengal paving the way for its wide adoption in the region.

Several experiments using the low-cost feed were conducted in indoor system, on-farm and in farmer's ponds to standardize polyculture. Six species polyculture with different stocking densities, *L. parsia* (5000/ha), *L. tade* (5000/ha), *M. cephalus* (2500/ha), *Scatophagus argus* (2500/ha), *M. gulio* (30000/ha) and *P. monodon* (2500/ha), resulted in 4764 kg/ha production using low-cost farm made feed (INR 26/ kg) having FCR of 1.36, in three consecutive trials of 325 days in farmers pond (Table 2).

The farm made feed (Crude protein-29.77%) containing different unconventional ingredients (sunflower cake, mung husk) with 10% fish meal performed at par with that of feed containing 22% fish meal in respect to growth and FCR. Economic analysis revealed a net profit of about INR 2,91,000/ha with a benefit-cost ratio of 1.85. Feeding method standardization experiments

suggested that this feed may be offered @ 2-10% body weight daily at three equal quantities in the morning (09:00 h), at afternoon (13:00 h) and evening (17:00 h) in trays. Every ration may be offered in two split doses at 1 h interval to meet requirements of fish with size variation.

Table 2. Comparison of production performances of polyculture under different trials

Parameters	Polyculture with mash feed containing rice bran & mustard cake	Polyculture with farm made pellet feed		
		1st trial	2nd trial	3rd trial
Culture duration (days)	300	325	325	325
Productivity (kg/ha)	1597	3141	3855	4764
FCR	3.45	0.88	1.36	1.32
Survival (%)	-	75.6	70.5	75.6

3.4. Periphyton based farming system

Artificial substrates for periphyton development have been widely used in freshwater aquaculture, particularly in carps, tilapia and giant freshwater prawn to augment fish production. Similarly, promising result in terms of growth, survival and production was observed with periphyton in brackishwater penaeid shrimp, *P. monodon* (Khatoon et al., 2009) and *P. vannamei* (Audelo-Naranjo et al., 2011). Periphyton is also a heterogenous mixture of biota including bacteria, fungi, phytoplankton, zooplankton, benthic organisms, detritus, etc. But unlike biofloc-based system, here the mixture of biota is generally attached to any submerged surfaces, such as bamboo stick, plastic sheet, polyvinyl chloride (PVC) pipe, ceramic tile, fibrous scrubber, nylon net etc. Periphyton-based system also increases the aquaculture production and develops the resistance to different diseases by augmentation of immune response. In shrimp culture, there was 17.9% gain in production and 22.3% reduction in FCR compared to conventional culture in case of *P. monodon* (Anand et al., 2019). The submerged substrates added into the aquatic system improve the water quality and consumption of microbes and algal community present over submerged substrates enhances the growth of penaeid shrimp by providing natural food (Ramesh et al., 1999). In polyculture of mullets (*M. cephalus* and *L. parsia*), milkfish (*C. chanos*) and tiger shrimp (*P. monodon*), periphyton biomass can be utilized to replace feed (up to 30%) without affecting the production and return (Biswas et al., 2017). In monoculture of milkfish (15000 no./ha), FCR could be reduced maximum by 46% compared to total feeding system (Biswas et al., 2019). Therefore, utilization of periphyton biomass is appropriate for polyculture and monoculture of milkfish to reduce feed cost and ensure environmental sustainability.

3.5. Biofloc-based farming system

The principle of biofloc technology is based on manipulation of carbon:nitrogen ratio (C:N ratio) and for brackishwater shrimp aquaculture C:N ratio of 10:1 is stated to be optimum. The biofloc is a heterogenous mixture of bacteria, algae, protozoa, zooplankton, food particles and dead cells with bacteria being the dominated component. The cultured shrimps often use the floc particles as their feed. For management of C:N ratio, carbohydrate is applied from external sources including molasses, rice flour, wheat flour, tapioca powder, rice bran, wheat bran, etc. In presence of higher

carbohydrate, the heterotrophic bacteria utilize ammonia to produce biofloc and thus reducing the level of free ammonia in water. So, the chance of ammonia toxicity is reduced. This culture system improves growth rate of cultured shrimp. Apart from these, biofloc based system reduces the feed requirement leading to reduction in input cost and also lowers the possibility of diseases. It was demonstrated that biofloc improved the growth rate of juvenile and adult *P. monodon* by 29 and 12.6%, respectively over the control (Anand et al., 2014, 2017). However, this type of production system produces high level of turbidity, which increases need of aeration. The dissolved oxygen (DO) level should strictly be monitored regularly and the aeration should be done round the clock (24 h a day) particularly at the end of culture period.

3.6. Brackishwater integrated multi-trophic aquaculture (BIMTA) systems

IMTA is a farming practice which combines cultivation of fed aquaculture species (e.g., finfish/shrimp) with organic extractive aquaculture species (e.g., shellfish/herbivorous fish) and inorganic extractive aquaculture species (e.g., seaweed/ seagrass) in the appropriate proportions to create balanced systems for environmental sustainability, economic stability and social acceptability. The IMTA concept is very flexible and can be land-based (pond/RAS) or open-water systems (cage/pen), brackishwater or marine system. IMTA is well recognized as a mitigation approach against the excess nutrients/ organic matter generated by intensive aquaculture activities especially in brackishwater, since it incorporates species from different trophic positions or nutritional levels in the same systems. In addition, it is also relevant to implementation of the Ecosystem Approach to Aquaculture (EAA) that is propagated and conceptualized by FAO. Sometimes the more general term 'integrated aquaculture' is used to describe IMTA. The terms 'IMTA' and 'integrated aquaculture' differ primarily in their degree of descriptiveness. Different forms of IMTA are Aquaponics, fractionated aquaculture, integrated agriculture-aquaculture systems, integrated peri-urban aquaculture systems and integrated fisheries-aquaculture systems.

Currently, the existing major IMTA systems in the world are generally simplified with finfish, shellfish and seaweed. The aim is to increase long term sustainability and profitability for the cultivation unit, as the waste of one crop is converted into fertilizer, food and energy for the other crops, which can in turn be sold in market. It reduces adverse impacts on environment while producing economically viable products at the same time. The preferred species for BIMTA are: finfishes- milkfish and mullets; shellfish- green mussel/ oyster, shrimp; seaweed- *Enteromorpha* sp., *Gracillaria* sp. Recently, IMTA trial involving mullets (*M. cephalus* and *L. parsia*) and tiger shrimp (*P. monodon*) as fed-species, and estuarine oyster (*Crassostrea cuttackensis*) and seaweed, *Enteromorpha* spp. as extractive species exhibited a significantly 19% higher production with better water quality compared to that of polyculture (Biswas et al., 2019). In another IMTA trial involving *M. cepalus*, *L. tade*, *P. monodon*, water spinach, *Ipomoea aquatic* and oyster, *C. cuttackensis*, higher production with better water quality and economic return was obtained compared to conventional polyculture (Biswas et al., 2020). More recently, the oyster, *C. cuttackensis* could be used effectively as an organic extractive species at a biomass density of 1.8 kg/m^3 in *C. chanos* and *P. vannamei* polyculture (Naskar et al., 2022). Understanding the potentiality and sustainable nature of IMTA, all the stakeholders of coastal and marine aquaculture should be encouraged to promote it.

3.7. Advances in mudcrab farming

There is a huge potential for mudcrab farming in India. Still there is no organized aquaculture of mudcrab for supporting the export trade. Major reason is the unavailability or inconsistent availability of crablets for farming. Technology for seed production, culture and fattening of orange mud crab, *Scyllla olivacea* and green mud crab *S. serrata* has been developed by ICAR-CIBA. Some farmers are practicing crab fattening in the coastal districts of West Bengal with considerable success. Crab culture in box system is of recent innovation with floating and submersible type of boxes (Christina et al., 2019). After the starting of crab hatchery by Rajiv Gandhi Centre for Aquaculture (RGCA) in Nagapattinam district, Tamil Nadu, hatchery produced crab seeds are now available. Some progressive farmers in the Sundarban have started crab grow-out farming with 2-3 ton/ha production with hatchery produced seeds. Some compatible fish like goldspot and grey mullets and milkfish can be co- cultured with crab to obtain additional profit.

3.8. Brackishwater ornamental fish culture

Ornamental fishes have an excellent domestic as well as export markets. Brackishwater ornamental fishes, like spotted scat (*S. argus*), crescent perch (*Terapon jarbua*), green chromide (*Etroplus suratensis*), orange chromide, (*E. maculatus*), silver moonyfish (*Monodactylus argenteus*), green pufferfish (*Dichotomyctere fluviatilis*) and four-banded tigerfish (*Datnioides polota*) which are available in maritime states have good acceptance in ornamental fish market. A new avenue has been made by the successful breeding and seed production of these fishes. Seeds of pearlspot are produced in captivity using environmental manipulations (Biswas et al., 2014; Padmakumar et al., 2009). Farming of spotted scat and pearlspot is on the way and fetching substantial profit.

3.9. Organic farming option

Today, the demand in the importing countries for high quality safe shrimps/fish/crab and other food raised in an eco-friendly manner adopting good management practices has become an essential pre-requisite for Indian seafood export. Brackishwater area available in India for shrimp farming offers good potential for organic farming. This includes the vast traditional prawn filtration fields located in West Bengal and Kerala. The traditional type of prawn filtration system is highly environment-friendly as they use no chemicals, drugs or antibiotics. Organic aquaculture ensures that the farming activity is in harmony with the nature, with due care for the good health and welfare of the cultured organisms. Organic products have become very popular of late due to the rising awareness in health and food safety. There is a growing demand for organic products in the global market, especially in Europe, USA, Japan, China etc. The purpose to shrimp certification is to enhance the market share for the shrimp produced by responsible methods, inputs and practices that would meet the expectations of socially and environmentally aware consumers. Certification process has to be simplified and branding of shrimp produced through improved traditional methods as 'organic' may fetch better price. A few trials towards organic farming of tiger shrimp showed promising results with better profitability.

4. Species diversification: an urgent need for sustainable coastal aquaculture

Development of Indian coastal aquaculture in the country was driven by the technologies for seed production of tiger shrimp, *P. monodon* and the Pacific white shrimp, *P. vannamei*. Disease outbreaks due to WSSV during the last 10-16 years have acutely affected shrimp farming in the

country and in other continents. With the diagnostic kits developed for detecting WSSV, PCR-tested seed is available all over the country. Supplementary feeding is the most important management measure in commercial shrimp farming. Commercial shrimp farming in India largely involves use of formulated pellet feed, constituting a significant share of the input expenditure. While bulk of the feed used was imported from Southeast Asian countries till a decade back, it is at present mainly produced in the country. Unavailability of quality ingredients, especially the fish meal, has been a major constraint faced by these industries, requiring import. The high price of the commercial feed, however, is forcing the small-scale farmers to resort to farm-made feeds. For the sustainable eco- friendly aquaculture practice, diversification to other species is considered as one of the important steps. Fishes like Asian seabass (*L. calcarifer)*, grouper (*Epinephelus tauvina)*, snappers (*Lutjanus* spp.), which are high value carnivorous fishes and grey mullet (*M. cephalus)*, milkfish (*C. chanos)*, pearlspot (*E. suratensis)*, rabbit fish (*Siganus* spp.), orange chromide (*E. maculatus*) which are herbivorous/omnivorous suitable for farming in the coastal eco-systems are available. The species like cobia (*Rachycentron canadum*), silver pomfret (*Pampus argenteus*) and pampano (*Trachinotus carolinus*) are being considered as candidate species for farming. Efforts have been made to develop comprehensive technology packages for seed production under controlled conditions and farming of these candidate species. Technologies have been developed elsewhere in the world for several brackishwater and marine finfishes. In Indian scenario, the successful technology has been developed for the year-round seed production of *L. calcarifer* under controlled conditions and farming. Controlled breeding and seed production of several other species, such as grouper, *E. tauvina*, milkfish, *C. chanos*, pearlspot, *E. suratensis* and brackishwater catfish, *Mystus gulio* have been achieved. In addition, the successful breeding and seed production of ornamental fishes, such as spotted scat, *S. argus*, crescent perch (*T. jarbua*) and orange chromide, *E. maculatus* and silver moonyfish, *M. argenteus* have been achieved. Marine sea weeds have been a new area for coastal aquaculture in different costal states of India. Successful demonstration of seabass farming has been conducted in all the coastal states. High export prices of mudcrabs have made fattening of species, like *S. serrata* and *S. olivacea* as a remunerative farming practice.

5. Way forward

The aquaculture development project should try to achieve the maximum possible yield, which is not currently possible with existing technology and infrastructure. Development of eco-friendly and cost-effective culture technologies targeting small-scale farmers is the need of the hour. Some steps towards brackishwater aquaculture development are extension of culture to inland saline areas, bringing more areas under culture, species diversification from existing shrimp to fishes etc. Adequate availability of quality fish seeds will also help in expansion of culture. In the coastal aquaculture sector, major environment-related issues were waste generation, conversion of agricultural land, salinization, degradation of soil and the environment due to the extensive use of drugs and chemicals, and destruction of mangroves. Development and adoption of improved farming technologies like recirculatory aquaculture system (RAS), improved polyculture, IMTA will contribute to the acceptability of coastal aquaculture as an environment-friendly venture.

References

Anand PSS, Kohli MPS, Kumar S, Sundaray JK, Dam Roy S, Venkateshwarlu G, Sinha A, Pailan GH, 2014. Effect of dietary supplementation of biofloc on growth performance and digestive enzyme activities in *Penaeus monodon*. Aquaculture 418-419: 108–115.

Anand PSS, Kumar S, Kohli MPS, Sundaray JK, Sinha A, Pailan GH, Dam Roy S, 2017. Dietary biofloc supplementation in black tiger shrimp, *Penaeus monodon*: effects on immunity, antioxidant and metabolic enzyme activities. Aquaculture Research 48: 4512–4523.

Anand PSS, Balasubramanian PS, Christina L, Kumar S, Biswas G, De D, Ghoshal TK, Vijayan KK, 2019. Substrate based black tiger shrimp, *Penaeus monodon* culture: Stocking density, aeration and their effect on growth performance, water quality and periphyton development. Aquaculture 507: 411–418.

Audelo-Naranjo JM, Martínez-Córdova LR, Voltolina D, Gómez-Jiménez S, 2011. Water quality, production parameters and nutritional condition of *Litopenaeus vannamei* (Boone, 1931) grown intensively in zero water exchange mesocosms with artificial substrates. Aquaculture Research 42: 1371–1377.

Biswas G, Sundaray JK, Ghoshal TK, Natarajan M, Thirunavukkarasu AR, Kailasam M, Ponniah AG, 2014. Tank based captive breeding and seed production of the pearlspot (*Etroplus suratensis*). Aquaculture Asia, 19 (3) (Jul- Sept 2014): 12-16.

Biswas G, Kumar P, Ghosal TK, De D, Das S, Christina L, Bhatacharyya SB, Kailasam M, 2017. Utilization of periphyton biomass for partial replacement of commercial feed in sustainable brackishwater polyculture. In: Thomas SN, Rao BM, Madhu VR, Asha KK, Binsi PK, Viji, P, Sajesh VK, Jha PN (Eds.), Fostering Innovation in Fisheries and Aquaculture: Focus on Sustainability and Safety- Book of Abstracts. 11th Indian Fisheries and Aquaculture Forum, 21-24 November, 2017, Kochi, India. pp. 197.

Biswas G, Kumar P, Ghoshal TK, De D, Das S, Christina L, Bera A, Kailasam M, 2019. Utilization of natural fish food item, periphyton for replacement of commercial feed in milkfish (*Chanos chanos*) culture. In: Abstract Volume of 4th Regional Science and Technology Congress- 2019 (Southern Region), Department of Science and Technology and Bio-technology, Govt. of West Bengal and Mulana Abul Kalam Azad University of Technology, Haringhata, Nadia, West Bengal, December 23-24, pp. 18.

Biswas G, Kumar P, Kailasam M, Ghoshal TK, Bera A, Vijayan KK, 2019. Application of integrated multi-trophic aquaculture (IMTA) concept in brackishwater eco-system: the first exploratory trial in the Sundarban, India. Journal of Coastal Research 86: 50–56.

Biswas G, Kumar P, Ghoshal TK, Kailasam M, De D, Bera A, Mandal B, Sukumaran K, Vijayan KK, 2020. Integrated multi-trophic aquaculture (IMTA) outperforms conventional polyculture with respect to environmental remediation, productivity and economic return in brackishwater ponds. Aquaculture 516: 734626.

Christina L, Balasubramanian CP, Shyne Anand PS, Ghoshal TK, Kumar P, Vijayan KK, 2019. Mud crab farming: An alternative livelihood in the Indian Sundarban. Aquaculture Asia, 23 (3) (Jul- Sept 2019): 20-29.

Khatoon H, Banerjee S, Yusoff F, Shariff M, 2009. Evaluation of indigenous marine periphytic Amphora, Navicula and Cymbella grown on substrate as feed supplement in *Penaeus monodon* postlarval hatchery system. Aquaculture Nutrition 15: 186–193.

MPDEA, 2020-21. https://mpeda.gov.in/?page_id=651.

MPDEA, 2019-20. https://mpeda.gov.in/?page_id=438.

Naskar S, Biswas G, Kumar P, De D, Sawant PB, Das S, Roy U, 2022. Effects of estuarine oyster, *Crassostrea cuttackensis* as the extractive species at varied densities on productivity and culture environment in brackishwater integrated multi-trophic aquaculture (BIMTA) system. Aquaculture 554: 738128.

Padmakumar KG, Bindu L, Manu PS, 2009. Captive breeding and seed production of *Etroplus suratensis* in controlled systems. Asian Fisheries Science 22: 51–60.

Ramesh MR, Shankar KM, Mohan CV, Varghese TJ, 1999. Comparison of three plant substrates for enhancing carp growth through bacterial biofilm. Aquaculture Engineering 19: 119– 131.

S2-OP1

Osmoregulation pattern and salinity adaptation of the white shrimp *Penaeus vannamei* (Boone, 1931) during larval and nursery phase

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The Pacific white shrimp. *Penaeus vannamei*, is the most widely cultured and productive crustacean worldwide. I*t* is the most euryhaline crustacean, farmed across all the salinity regimes. The purpose of this study was to evaluate the acclimation protocol of to the desired salinity, and to evaluate osmoregulatory and growth pattern of juveniles at various salinities during the nursery phase. In the first experiment, Penaeus *vannamei* post larvae from early post larvae (PL4) to PL 12 under different salinity regimes on daily salinity acclimatization. The second experiment was carried out to understand the effect of different salinity regimes on growth and osmoregulatory pattern of shrimps under different salinities 2, 15, 30, 45 for a period of 42 days. In the first experiment the highest survival (89.2±3.14 %) was obtained in 15 ppt followed by in 2 ppt (86.8±2.73%), and lowest survival (60.17 ± 2.20%) was found in 45 ppt ppt. In the second experiment nursery reared shrimps under low salinity, 2 ppt recorded the highest survival (89.3±2.96 %), followed by 30 and 15 ppt salinities. The highest final average body weight, 0.7±0.09g, and SGR, 6.48±0.1 was noted in 15 ppt followed by 2 ppt. The hemolymph osmolality of the juvenile shrimp under each salinity regime showed that shrimp reared at low salinity was hyper-osmoregulator and animals at higher salinity were hypo-osmoregulator. The study revealed that *P.vanamei* nursery rearing can be performed better in lower salinity on par with medium 15 and 30 ppt through gradual acclimatization procedure compared with higher salinity nursery farming.

S2-OP2

Larval and nursery performance of hatchery-produced *Metapenaeus monoceros* under diverse salinity regimes

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The current exclusive reliance of exotic white shrimp calls for species diversification in shrimp farming. In this context, *Metapenaeus monoceros* forms an ideal species due to its hardy nature and high demand in domestic market. As salinity adaptation of shrimp is worth investigating to devise location-specific technology, a short-term and long salinity stress study on the post-larval and nursery stages of *M.monoceros* was carried out. In short-term stress, the effect of salinity acclimatization on critical postlarval stages (PL 4 and PL12) was attempted under 3, 25, and 45 ppt. The PL

recorded 100 % survival in 25, 3 ppt and 93% in 45 ppt whereas PL 12 recorded 100 % survival in all the groups. During nursery phase shrimps attained 0.41±0.03, 0.67±0.01, 0.61±0.11 g body weight, respectively in 3, 25, and 48 ppt. Osmolality study revealed that serum osmolality varied from 378 to and 1573 milliosmol kg^{-1}against medium osmolarity. Strong hypo and hyper osmoregulatiory responses by the shrimp shows *M.monoceros* has excellent osmoregulatory mechanism and can be one of the best native shrimp for climate resilient aquaculture. The outcome from the study can be used to devise location specific farming techniques under diverse geographical locations in India.

S2-OP3

Community development of fisherfolk through coastal water cage culture in Karwar: A success story

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Community development of fisherfolk from Nagnathwada, Karwar was carried out through demonstration of coastal water cages. Initially training and awareness programmes were taken up on coastal water cage culture. Demonstration of Asian seabass farming in fixed cage and box type floating cage were carried out initially for technology dissemination. After attaining confidence, coastal water cage culture was taken up in commercial scale by the fisherfolk with the technical support from ICAR-CMFRI and financial assistance from National Fisheries Development Board, Hyderabad. Fisher folk were benefited from the cage farming and continuing the activities for better livelihood. Issues such as seed and feed availability for farming and natural calamities need to be addressed for sustaining the farming practices.The present status and future prospects of the community development programme has been evaluated.

Keywords: Asian Seabass, Fixed cage, Box cage, Karwar.

S2-OP4

Understanding virulence and siderophore system of luminescent bacterial pathogen *Vibrio campbellii*

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Luminescent vibriosis is a major challenge in Indian shrimp hatcheries. Our earlier work suggested that *V. campbellii* is mainly responsible for luminescent vibriosis. Many virulence mechanisms such as quorum sensing, toxins production, type III secretion system, lysogenic phages, biofilm formation, haemolysin, proteases, chitinase, iron sequestering siderophore molecules, etc. have been reported to play a crucial role in the pathogenesis of *Vibrio* spp. In the present study,

several virulence factors including siderophore system were investigated The pathogenicity study in *Penaeus* (*Litopenaeus*) *vannamei* juveniles revealed a huge variation with Cox proportional hazard ratio ranging 5.4 to 32.4 among the strains. Detailed investigation suggested that this difference in virulence behaviour was partly explained by metalloprotease production and vital mutation in virulence regulator ToxR. The presence of glutamine at 150th position (Q150) in ToxR is crucial for the pathogenicity of *V. campbellii*. Iron is one of the most critical nutrients required for microbial growth and expression of virulence. Bacteria resolve iron scarcity issues by secreting an iron chelator called siderophore which transports iron inside a bacterial cell. We characterised the genome of *V. campbellii* and found the presence of anguibactin homologue. This was supported from thin layer chromatography and LC-MS analysis of intermediary metabolites. The presence of anguibactin homologue is expected to provide upper edge to *V. campbellii* compared to related pathogens *V. harveyi* in hatchery environment.

S2-OP5

How healthy is River Godavari? Assessment of the river health using fish as ecological indicator

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River Godavari is the largest of the peninsular rivers and the second longest river in India next to Ganga with a total length of 1,465 km. As Indian rivers are facing tremendous anthropogenic pressures, despite their ecological, economic and cultural relevance in the country, an effort was done to identify the major environmental stressors on the ecosystem of this very important river and to assess the ecological health of the river stretches using fish-based index of biotic integrity (F-IBI). The ecological stressors impacting the system were identified and prioritized ranking of the identified stressors were done based on key informants' perception and also on the researchers' understanding. The F-IBI with metrics to reflect the impacts of identified stressors considering the ecological and ichthyofaunal characteristics, were adopted to assess the ecosystem health as fishes being excellent indicators of river health. The study on fish faunal diversity and abundance studies in river Godavari indicated that despite all of its ecological stresses, the river still supports rich fish diversity yet there is notable shift in the fish assemblage pattern, with respect to the ecological stressors such as river fragmentation and pollution. The upper stretches of the river traversing through Maharashtra were mostly under Severely impaired integrity class, the Telangana stretch in Moderately Impaired class and Andhra Pradesh stretch was a mix of Moderately and Slightly Impaired integrity classes. The rivers are germplasm reserves of native fish fauna and immediate measures are to be taken to conserve the declining fish diversity. There should be efforts to improve upstream/downstream accessibility of migratory fishes; it should be ensured that the rivers have at least the minimum required environmental flow of water after the river water gets diverted by various projects.

S2-OP6

Assessment of coastal wetland ecological and fisheries vulnerability and mitigation strategy for fisheries management in changing climate: A field study

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Climate induced changes in temperature and rainfall pattern has been experienced globally, consequently alter the functionality of coastal wetlands and their fisheries. Dynamics of coastal wetlands has impacted fisheries and ecology of coastal ecosystem need greater attention. In order to mitigate the impact of climate change, essential to understand the processes of alteration in services provided by these ecosystem and quantification of major factors. To assess the ecological and fisheries vulnerability in respect of climatic events stakeholders' perception in combination of physical field expert data were used. We observed, in our study area climate impact of coastal wetlands, broadly depends on two factors anthropogenic and local climate condition. We have concentrated our study in three aspects that impacted the functionality of coastal wetlands: change in extreme climate events, intensity of water salinity changes and impact on fisheries. Many coastal wetlands could adjust the climate change but extreme climate events such as flood, storm, cyclone in combination with anthropogenic impact has significantly impacted the coastal wetland ecosystem. Therefore, vulnerability of living organism intensify and reduce the adaptability of organisms to changing functions of wetlands. The management of such coastal wetlands, needs multiscale understanding, balancing between the ecology and anthropogenic activities to mitigate the impact of climate change and reduce the vulnerability of these biocomplex coastal ecosystem. The impact of climatic events can be reduced by paying due attention to the local meteorological information, assessment of historical extreme environmental and geological data. In our study, we have used combination of approach questionnaire based rapid filed level vulnerability assessment tools, local stakeholder's knowledge and past data of coastal changes of studied region to find potential mitigation strategy to be adopted to reduce the vulnerability. The appropriate managementwithclimate smart approach is recommended by involving both stakeholders of local user and the government.

Keyword: Climate change, Coastal wetland, Fisheries, Ecology, Vulnerability assessment

S2-OP7

Development of low volume low cost cage culture of seabass and pearlspot in creeks as an alternate livelihood activity for mangrove based coastal fisher folks of Maharashtra

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ICAR-CIBA, Chennai and Mangrove Foundation, Maharashtra had initiated demonstrations of low volume low cost brackishwater cage culture of seabass and pearlspot in mangrove areas for provision of additional livelihood option for fisher folks as well as to enhance brackishwater aquaculture production of Maharashtra. In 2018-20, a total of 113 cages of size 4 x 4 x 2m (32 m^3) were fabricated using GI pipes and allotted to 28 SHGs units (339 beneficiaries) of Sindhudurg, Maharashtra. CIBA provided scientific guidance on cage farming to selected SHGs with funding support from Mangrove Foundation. Whole cage structure is kept afloat with help of six HDPE barrels (210 L) and anchored in creek with use of 85-100 kg anchors. Pre-grow out net (4 x 4 x 2m; 10 mm hexagonal mesh for 6-10 g seed),grow out nets (4 x 4 x 2m; 30 mm hexagonal mesh for 50-80 g) and outer protection HDPE cage nets (5 x 5 x 2.5m; 40 mm mesh) were used for culture. Seabass is carnivorous fish in nature and hence to avoid cannibalism, net cages with internal partition of 2 x 2 x 2 m were used in pre-grow out cage culture. This facilitated re-stocking of two different size group seabass fishes in each compartment. Seabass seed (3-4") procured from Andhra Pradesh were stocked in cages @ density of 1000nos/cage and fed with floating feed (40-45% protein) @ 3-10% of body weight twice a day. Seabass attained growth of 300-550g with survival ranging from 10-70%. Pearlspot seed (1-2") stocked in cages at density of 3000 nos/ cages and fed with floating feed (30-35% protein) @ 5-10% of body weight twice a day. The fishes attained growth 50-100g with survival ranging from 40-70%. The culture was harvested in June 2020 and sold to local vendor @₹100-450 per kg. Demonstration work resulted in a cumulative revenue generation of ₹36.84 lakhs to SHGs beneficiaries of Sindhudurg, Maharashtra (including COVID-19 Pandemic) and establishment of total 292 cages in Sindhudurg, Ratnagiri, Raigad and Palghar districts of Maharashtra in 2020-21.

Keywords: Seabass, Pearlspot, Cage Culture, Self-help Group, Livelihood

S2-OP8

Economic evaluation of ecosystem services in Terekhol, a small tropical Indian estuary using a hybrid approach

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In this study, we evaluated the primary ecosystem services (ES) of Terekhol (TRE), a small tropical estuary along the west coast of India. The key ES identified were provisional- fish and shellfish, crops and mangroves, raw materials (sand and salt), water for navigation; regulating-carbon sequestration, disturbance regulation and water quality control, erosion control; supporting- breeding grounds for fish and biodiversity and habitat; recreational, tourism, cultural and information services. We used a hybrid approach to evaluate these ES using primary and secondary sources of information and scientific literature. The provisioning, regulating, supporting, recreational, cultural, and information services yielded annual economic values of US$4894018.7, US$2523095.4, US$14248456.6, US$61571.4, US$35520, and US$628777, respectively. The perception of key stakeholders (fishers/farmers/tourism operators/researchers and student's /biodiversity management committee members) of the TRE were assessed and documented. The majority of stakeholders (75-90%) believed that TRE is essential for ferry service, raw materials, biodiversity and species, fish/shellfish, recreation, science, and education. Only 10-15% indicated that the estuary is important for the ES, such as water quality control, sediment erosion control, and carbon sequestration. This knowledge could play a vital role in policy formulation and decision-making process to manage and conserve the ecosystem of TRE.

Keywords: Estuary, Ecosystem service, Economic valuation, Terekhol, West coast of India

S2-OP9

Novel feeding approach for Asian seabass *(Lates calcarifer)* growout culture with glass fish *(Ambassis ambassis)*: Initial observations

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Aquaculture and fisheries reflect about 0.5% of the total global carbon emissions. Energy conservation in aquaculture is wise to avoidwasteful use of fossil fuels, electricity resulting in reduction of carbon emissions. Higher carbon footprint in aquaculture products mainly results from use of feed, feed preparation mechanics, and mechanical aeration. Here, development of an alternative feeding method for Asian seabass foraging on *Ambassis ambassis* (Burrato) has been experimented. Commonly known as the Asiatic glassfish is one of the commonest fish of Goa and found widely

in fresh, brackish, and coastal marine waters. Three treatments of salinities were studied [T1 (10 psu), T2 (5 psu) and T3 (0 psu)] and a control of 15 psu with a tank volume of 400 liters and two replications each. Each tank was stocked with two nos. of Asian seabass (mean weight: control: 705 ± 5.00 gm, T1: 710 ± 0.00 gm, T2: 710 ± 0.00 gm, and T3: 705 ± 5.00 gm). Total experiment period of 30 DOC with the feeding of glassfish (mean weight: 5.5 gm, mean body depth: 3.66 cm) @ 4% per day was carried out. During the total DOC, feed utilization by seabass for glassfish observed for control, T1, T2 and T3 were 8-9%, 7-8%, 4-5% and 1-2% respectively, and, the survival percentage was 1-2%, 2-3%, 5-6% and 8-9%, respectively. The species can be used as a foraging fish in saline to low-saline culture systems for Asian seabass grow-out culture (after 700 g).This will be a better alternative to the pelleted feeding method to save upon the cost of production, achieving faster growth, better yield, and quality fish production, and leading to a sustainable and eco-friendly culture system.

Keywords: Asian Seabass, *Ambassis ambassis*, Feeding, Survival, Growth, Grow Out Culture

S2-PP1

Nursery rearing of milkfish using different substrates for periphyton growth in hapa based system and optimization of substrate area for reduced feed input

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Milkfish, *Chanos chanos* is one of the potential candidate species for brackishwater aquaculture, due to its fast growth rate and lower cost of production. It is desirable to rear milkfish fry in nursery rearing systems to obtain appropriate fingerling size for growout ponds for better growth and survival. Therefore, experiment was carried out to evaluate growth performance of milkfish in hapas provided with different substrates for periphyton growth. A total of 4000 no's hatchery produced milkfish fry (2.68±0.06 cm &0.160±0.02) were randomly distributed in five experimental groups viz. T1 (Sugar cane bagasse), T2 (Split bamboo substrate), T3 (coir rope), T4 (sugar cane bagasse+ split bamboo+coir rope), T5 (no substrate). During the 45 days of experimental period fish were fed with CIBA nursery feed @ 8 % body weight twice a day. The results revealed highest mean total length 9.76±0.13 cm and bodyweight 7.73±0.12 g, percentage weight gain 473.33±33.24, specific growth rate (8.61±0.06) was observed in the treatment provided with substrate combination of (sugar cane bagasse + split bamboo strips + coir rope) ($p<0.05$). Survival rate of milkfish ranged from (95.36 - 96.74 %) in all the treatments ($P>0.05$). From the overall results, it is concluded that combination of (sugar cane bagasse + split bamboo strips +coir rope) substrate ideal for nursery rearing of milkfish. (Experiment -2) Periphyton based nursery rearing of milkfish in hapas with reduced feed inputs. At the end of 60 days of experiment. The highest mean total length (10.51±0.10 cm) and bodyweight (9.66±0.12 g) of milkfish was observed in treatment with periphyton +100 % feeding ($P<0.05$). However, milkfish fingerlings reared with (Periphyton + 50

% feed reduction) attained fingerling size with mean total length and body weight (9.20±0.14 cm & 8.24±0.19 g) with 95 % survival rate. Based on economical point of view, Milkfish reared in (periphyton + 50 % feed reduction) considered ideal for nursery rearing in hapas provided with 40 % substrate area (0.80 m^2) for periphyton growth to reduce feed cost upto 50 %.

Keywords: Milkfish Fingerlings, Periphyton, Substrates, Growth, Survival

S2-PP2

Influence of salinity and microalgal diet on the production of a newly isolated live feed *Colurella* sp. (Rotifera: Lepadellidae)

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Live feeds are the most important basic diet for the larvae of marine finfishes and shellfishes, owing to their small size and nutritional characteristics. These living capsules of nutrition are essential for newly hatched larvae, soon after the exhaustion of yolk for their development and survival. Rotifers are one of the most commonly used live feeds in marine hatcheries and can be cultured in high density with minimum effort compared to all other live food organisms. *Brachionus* spp. are the most popular and widely used live feed in marine hatcheries. Size of all the strains of *Brachionus* spp is mostly above 100µm. So these cannot be used as the first feed of larvae of many marine fishes like groupers, snappers, rabbit fishes and damsels. This prompted us for the search of another species of rotifer which has a size range around 50 µm. Here we have isolated and developed pure culture of a potential species of rotifer with size range (40-50 µm) belonging to genus *Colurella* from coastal waters of Karwar region. Genomic DNA was isolated using the phenol/chloroform method and COI sequencing showed a genetic divergence of 8.83% from *C. adriatica*. Species confirmation work is progressing. For standardising its basic culture parameters, we have investigated the effect of 4 salinities *viz.* 12 ppt, 22 ppt, 32 ppt, 42 ppt on the density of the isolated rotifer *Colurella* sp. and the effect of 3 different microalgae *viz. Isochrysis galbana*, *Chlorella marina*, *Nannochloropsis oculata* at a concentration of 10^7 cells/ml was also studied at the most suitable salinity obtained from the first trial. Among the different salinities tested, maximum density (3042±565 nos/ml) of *Colurella* sp. was at 22 ppt salinity on the 14^{th} day of culture. Among the microalgal feed tested, maximum density of *Colurella* sp. was (10090±1456 nos/ml) obtained for rotifer fed with *C. marina* followed by *I. galbana* (5220±1074 nos/ml) and lowest in rotifer fed with *N. oculata* (3300±1541nos/ml) after 14 days of culture. *Colurella* sp. is much smaller in size than other rotifer species commonly used in hatcheries and can also be produced at a higher density like all other popular rotifers. Hence this species can be utilized in marine fish hatchery as an ideal live feed for smaller fish larvae.

Keywords: *Colurella*, Rotifer, Live Feeds, Microalgae, Salinity

S2-PP3

Otolith morphology: An aid to species variation of fishes of family Leiognathidae

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Fish otoliths a calcium carbonated structure was used as an aid to differentiate allied species from ten species of the family Leiognathidae along the coast of Maharashtra from October 2018 to February 2019. The seven genera were differentiated on the basis of otolith morphology using otolith atlas (Tuset et al 2008) and shape indices (Lleonart et al 2000). Significant difference was observed in circularity, ellipticity, rectangularity, form-factor and roundness (p<0.05) with highest F ratio 253.434 and 268.564 for Ellipticity and Roundness respectively. The canonical discriminant analysis based on shape indices indicated 100 percent variability which were validated using Jackknife classification. The first two discriminant functions of the CDA performed with shape indices accounted for 94.15 variance with all the species significantly differentiated except for *Karalla dussumieri* and *Eubleekeria splendens* overlapping around 40 percent. The Jackknife classification ranged from 18.8 % to 94.4 %, with 58.6% correct classification.

Keywords: Leiognathidae, Maharashtra, Otolith Morphology

S2-PP4

Reproductive biology and length-weight relationship of speckled shrimp, *Metapenaeus monoceros* in the Bay of Bengal.

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Reproductive biology of *Metapenaeus monoceros*, a potential species for diversification of coastal aquaculture in India, was evaluated. A total of 107 broodstock of *M. monoceros* was obtained from the southeast coast of India. The average body weight of female and male broodstock was 29.36 ± 1.15 g and 23.7 ± 1.97 g respectively, whereas total length ranged between 14.48 ± 0.16 cm in female and 14.34 ± 0.33 cm in males and carapace length measured an average of 3.87 ± 0.06 (2.90 - 5.40) cm in females and 3.64 ± 0.097 (3.30 – 4.00) cm in males respectively. Five ovarian maturation stages were recognized including immature/spent stage: Gravid (14%), third (16%), 2 nd (26%), 1st (21%) and immature/spent (23%). The average gonadosomatic index varied between 1.32 ± 0.22 (immature/spent animals) and 6.324 ± 0.3 (gravid spawners). The average Hepato Somatic Index was 3.33 ± 0.36 for gravid females and 3.97± 1.36 for spend females. The total length-weight analysis of the broodstock recorded a positive allometric growth rate with regression equation, $Y=0.06X^{3.15}$.This study advances the knowledge of reproductive biologyof *M. monoceros*, and provides basic information for hatchery production of this species.

S2-PP5

Characterization of water masses related to pelagic fish shoals of South Konkan coast of Maharashtra, India.

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Continuous dynamic variations occur in the ocean influencing the recruitment, survival and growth of fish, and the biological activities. To observe the hydro-biological effects on the pelagic fish distribution, this study was conducted along the South Konkan coast of Maharashtra, India (September 2019 to February 2020), and correlated important environmental parameters (sea surface temperature, salinity, pH, secchi depth, dissolved oxygen, chlorophyll-a, phytoplankton and zooplankton) along with the pelagic fish catch from operations of purse-seine net fishery. The hydro-biological parameters and pelagic fish catch were recorded for all the operations which were conducted by purse-seine boat named as 'Saraswati'. The pelagic fish catch consisted of Indian mackerel, horse mackerel, shrimp scad, lesser sardines, squids, seer fish, ribbon fish, silver and black pomfrets, anchovy and big-eye tuna. ANOVA analysis showed no significant correlations between the independent variables (months, sea surface temperature, salinity) and all the other remaining dependent variables. The total pelagic fish catch showed no significant correlation with hydro-biological parameters. Indian mackerel and horse mackerel were the major pelagic fish caught. A longer duration study along with the total catch landings from all purse-seiners along the South Konkan coast may help us to give a nearly correct picture of correlation with the environmental parameters which are studied for suggesting future measures for the exploitation of pelagic fishes.

Keywords: Correlation, Hydro-Biological Parameters, Konkan Coast, Pelagic Fish Catch, Purse-Seine Fishery

S2-PP6

Problems faced by guppy breeders in Kerala

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The pet market in Kerala boomed after the covid -19 pandemic .Because of the lock down the standed human beings earned for any affection they can find turned into the exponential growth in the pet market. This wave also affected ornamental fish breeding in kerala . The absence of a regulatory body caused the price of the fishes increased to two fold . The present study was conducted as a survey collecting data from 30 guppy breeders from different district of kerala to explain the sustainability of this growing market. There was an increase in the number of new breeders. Due to the increase of large number of breeds there is a high demand for specialist practitioners veterinary medicine in these aquatic animals .The lack of expertise by the new breeders increased the mass mortality of fishes . The increase in damand has stabilized a bit but it is still higher than that of prepandemic levels.

S2- EP1

Viral nervous necrosis: An issue of concern in seabass *(Lates calcarifer)* hatchery production and farming

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Fish culture is an important sector as a source of global food security and livelihood choice contributing to poverty alleviation in low income countries. Thus fish production is gaining prominence worldwide. Further, finfish is a viable option for species diversification in aqua farming. The culture of fish species like Asian seabass (*Lates calcarifer*) is gaining impetus in India due to its high commercial value and food delicacy. ICAR- CIBA has standardised hatchery technology for seabass production and seabass farming is being taken up in many coastal states in India. However, expansion and intensification of aquaculture practices predisposes it to disease emergence especially due to viral pathogens. Viral nervous necrosis (VNN) is an important viral disease that affects brackishwater food fishes like seabass, caused by the *Nervous Necrosis Virus* is a *betanodavirus*, usually results in acute mortality of larval and early juvenile fish and carrier status is reported in adult fish. In India, NNV was reported in the year 2005 in Asian seabass (*L.calcarifer*) larvae by ICAR-CIBA, subsequently detected in few more inland fish species. Generally VNN is considered as primary pathogen of larvae. However during the period 2015 to 2022, disease investigation on incidence of VNN in seabass nurseries and grow out farms in Andhra Pradesh and Tamil Nadu revealed up to 10 % occurrence. The virus accounted for nearly 30 - 40% mortalities in seabass culture which will be significant in terms of estimated production and economic loss to farmers. The focus studies carried out on RT-PCR disease diagnostics, vaccines and health management practices which are essential for prevention of disease occurrence are discussed.

Key words: Seabass, VNN, Diagnostics, Vaccines

S2- EP2

Biological clues from a skewed sex ratio in an exploited population of the neglected ocellate octopus in the southeast Arabian Sea

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The neglected ocellate octopus, *Amphioctopus neglectus* (Nateewathana and Norman, 1999), is distributed in the Indo-Pacific region from the Taiwan Province of China to the west coast of India, along the eastern Arabian Sea. It is one of the major commercial cephalopod species in India, commonly caught in bottom trawls, in depths ranging from 30 to 100 m, typically between 50 to 80 m. There have been a few studies on the benthic octopuses of the southeast Arabian Sea (SEAS), despite their importance in commercial fisheries. This study details the scale of commercial harvest of the resource from the southeast Arabian Sea, the size composition in the

fishery, the male to female proportions in the catch and the stock status. Analysis indicated that the production in SEAS ranged from 1,252 t in 2009-10 to 3,911 t in 2018-19. The sex ratio of the neglected ocellate octopus in the fishery samples was significantly skewed towards males. The sex ratio is suggested as a critical pointer in resource assessment. Understanding the causes of sex ratio patterns and how this variation is relevant for the assessment and management of species of commercial value are discussed.

Keywords:*Amphioctopus neglectus,* Skewed Sex Ratio, Eastern Arabian Sea

S2- EP3

Best-bet Policies for Fishing Harbour at Karaikal in Union Territory of Puducherry

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Fishing harbour is located at coastal village named Karukkalacherry in Karaikal district of Union Territory of Puducherry, India. It is a platform for livelihood of over eight thousand five hundred fishermen and traders who sell their fishing for export and inland trading. It was established on an area of eight acres along Arasalar River in 2012. It accommodates three hundred and twenty marine fishing boats, two auction halls, net mending shed, dry dock, sloping hard, diesel station and four ice plants are functional.The study focused on improving the functioning of the said harbour and found the following relevant policies to be considered by the territorial administration.The said harbour needs expansion. Adequate lighting and drinking water needed. Food court can be very helpful at odd hours. Need to maintain high standards of hygiene. Levelling the land required to prevent water stagnation. Intervention from marine college or universities needed for improving application of technologies in fishing and allied operations. Cold storage structure for preservation is necessary. Deepening the shore, eradicating weed infestation for easy birthing and better quality of roads were found direly essential.

S2- EP4

Optimization of biomass density of the green seaweed, *Enteromorpha intestinalis* for environmental remediation and improved performances of fed species in brackishwater integrated multi-trophic aquaculture (BIMTA) system

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A 60-day experimental trial was performed to evaluate the effect of different biomass densities of seaweed, *Enteromorpha intestinalis* as an inorganic extractive species on environmental

remediation and performances of milkfish (*Chanos chanos*) and Pacific white-leg shrimp (*Penaeus vannamei*) in a BIMTA system. Seaweed at three biomass densities, 0.5 (T1), 1.0 (T2) and 1.5 (T3) kg/m^3 as the test variable, was stocked in 1000 L tanks containing milkfish and shrimp at 25 and 50 no./m^3, respectively, whereas, there was no seaweed in control tanks containing milkfish and shrimp similar to other treatments. A common diet (30% crude protein) was applied at 5% of biomass daily to feed milkfish and shrimp. Nitrogenous and phosphorus compounds, particulate organic matter, and chlorophyll-*a* contents decreased significantly in all three BIMTA systems in comparison to control ($P<0.05$). The highest percentage weight gain of milkfish (294.67±3.76%) and shrimp (311.39±7.38%) was obtained in T3 and T2, respectively. There was no variation in milkfish survival, whereas, the highest survival of shrimp was in T3 (85.0±1.7%). This trial suggested that *E. intestinalis* at the biomass density of 1 or 1.5 kg/m^3 can be an effective inorganic extractive species and bio-remediator in BIMTA system for better productivity and economic return.

Keywords: BIMTA; Inorganic Extractive Species; *Enteromorpha Intestinalis*; Milkfish; Shrimp, Bio-Remediation

S2- EP5

Sea ranching – an effective technique for augmentation of commercially important species in aquaculture

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Sea ranching entails bulk releases of juveniles that feed and grow on natural prey in the marine environment before being recovered and contributing biomass to the aquaculture, as well as broodstock development, larval and nursery rearing, and effect monitoring of the released stock. Ranching is mostly done to improve seed quality and quantity in bays, lagoons, shallow water bodies, and protected environments. The artificial recruitment system has some advantages. The energy-saving exploitation of natural populations is reliant on biomass availability and abundance. The cultured population could create biomass for commercial purposes, but it would need a lot of energy, feed, labour, and capital to do so. Artificially recruited population, on the other hand, allows for population growth in the natural environment without consuming a lot of energy, food, or labour. The evaluation of the impact of ranching on stock improvement necessitates the production and release of a massive amount of seed. This necessitates adequate infrastructure, such as hatcheries and associated inputs, nursery and transportation facilities, the identification of suitable release sites, and facilities for continuous stock monitoring. To overcome the seed production of commercially important species, proper technology, such as selective breeding programmes, is required.

Keywords: Sea Ranching, Seed, Biomass, Selective Breeding, Aquaculture, Stock

S2- EP6

Prediction of Fish Production in Tamil Nadu Reservoirs Using Artificial Neural Network (ANN)

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Fish is nutritious, cheap and healthy source of protein. Fishery sector plays a very important role for nation building by providing nutritional health security. India has very vast inland resources like rivers and canals, reservoirs, floodplain wetlands, estuaries and ponds and tank and also fourteen million inland farmers are getting employment and livelihood support from these resources. Among Inland resources, reservoirs are considered a main resource both in terms of surface area and offer immense scope for increasing fish production. More than 3 million ha of manmade reservoirs in the country has a potential for increase the fish production. Estimation of reservoir yield is a critical component for fisheries managers to adopt suitable scientific management practices to enhance the fishery production in these resources. This study demonstrated prediction of fish production using back propagation algorithm using Artificial Neural network with environmental, biotic and aboitic parameters. The ANN model performed well with low RMSE and MAE and high R^2 values as compared to MLR models. The R_{ratio} values are near to one (i.e. 0.977). Artificial Neural Network gave better estimation compared to MLR models and helps to understand behaviour of the reservoir to formulate appropriate regional specific management practices to improve fish production in reservoir.

Keywords: Artificial Neural Network, Inland Fisheries, Reservoir

S2- EP7

Innovative farm pond-cage integration fish farming model for the sustainable aquaculture and livelihood enhancement of farmers of Maharashtra

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Aquaculture is an important component of rural development as its better source of protein and generates additional revenue for farmers in salt affected areas. The farm ponds are constructed by farmers with intention to store water for irrigation of the agricultural crops and livestock. Recently these farm ponds are being utilized by many farmers for fish culture. As far as the management is taken into consideration, there are certain problems in the culture of fish in farm ponds due to more depth of farm ponds. The most important amongst all management aspects is fish harvesting due to depth of pond and sloppy nature of plastic lined farm ponds. In order to overcome this problem farm pond-cage integration fish farming model was developed at Khar Land Research Station, Panvel under DPDC, Raigad funded project. This model was successfully demonstrated

on a farmer's field at Khandpe, Karjat to culture Pangasius fish. The yield of 12.96 tons of Pangasius was harvested from the 10 cages. The said technology was successfully demonstrated at five different locations in the Raigad district of Maharashtra. Now the said model is being followed and replicated by many farmers in the Maharashtra state. The details of the model and the work carried out will be presented and discussed in the symposium.

Keywords- Cage culture, Farm ponds, Pangasius, Success story

S2- EP8

In silico design of antimicrobial peptide: AMPs journey from nature to the laboratory

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In the present study, we have designed a short and compositionally simple peptide incorporating the common properties of naturally occurring antimicrobial peptide (AMP). The peptide consists of only three types of amino acids which were selected for their unique properties. The designed peptide is cationic and also forms amphipathic structure in helical wheel projection. The peptide was found to interact strongly with important proteins of bacteria in molecular docking studies. The peptide was synthesized in the laboratory using Fmoc chemistry and purified by RP-HPLC. *In vitro* antimicrobial assay revealed that the peptide was effective against different fish bacterial and fungus-like pathogens, including antibiotic-resistant bacteria. The lowest minimum inhibitory concentration of the peptide was found to be below 1 μM. The peptide is thermostable and active in the presence of salts and serum. The peptide is least toxic to fish RBC even at high concentration. In gel retardation assay, the peptide was found to interact with genetic material of bacteria indicating its possible inhibitory role in bacterial DNA replication. The peptide disrupts the bacterial membrane integrity as observed in live dead assay. The findings of this study suggest *in silico* methodology can be followed to generate more potent AMPs.

Keywords: Antimicrobial peptides, *In silico* design, Bacteria, Antimicrobial activity, Molecular docking

S2- EP9

Water quality, microbial and production parameters of shrimp farms during the summer and monsoon crop

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Shrimp farming during the monsoon is influenced by the incessant rain water that causes changes to the water quality and production parameters, which are not properly understood. Water quality, microbial and production parameters were assessed from commercial *Penaeus vannamei*

farms operational within the Navsari region, Gujarat during the summer (March to July, n=6) and monsoon (July to November, n=6) season. The data obtained from the farms during the same crop were pooled and compared with the other using a two-sample t-test. The monsoon season crops resulted in significantly lower ($p<0.05$) water temperature, salinity, total alkalinity and hardness as compared to the summer crops. pH trends are dependent on plankton dynamics rather than rainfall. The total heterotrophic bacteria, total and opportunistic *Vibrio* were higher ($p<0.05$) during the monsoon crop, whereas pathogenic *Vibrio,* dissolved oxygen and TAN did not vary significantly indicating their variation related to local pond conditions, rather than the rainfall. The ionic concentrations and their ratios (Mg^{2+}/Ca^{2+}) were significantly affected between the crops. Survival rate during the monsoon and summer crops varied from 52-98% and 68-83% respectively, though mean survival was similar between the groups, and monsoon crop resulted in numerically lower production parameters. These observations suggest that production parameters are more dependent on factors like seed quality, husbandry, etc., rather than changes in water quality due to seasonal variations; however, this understanding shall dictate the husbandry practices to be followed.

S2- EP10

Development of customised modular recirculatory egg hatching units and its efficacy in shrimp hatcheries

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The aim of the present study to develop a modular recirculatory egg hatching unit in shrimp hatcheries to reduce excess use of seawater and, to improve the hatchability and quality of the nauplii during hatchery cycle. The RAS unit comprised of 4 cylindrical units (5L) fitted inside FRP tank (500L) which is connected to RAS unit comprised of biological filter and 2 unit of cartridge filter connected in series (5 and 1µm) respectively followed by 2 unit of UV sterilizer unit in series (36W each). Wild caught sexually matured *Penaeus indicus* (Stage IV) collected from Kalpakkam screened for OIE listed pathogen and disease free brooder used for the study. There is a significant difference ($p<0.05$) in hatching percentage was observed in the RAS unit (91.3%) compare to conventional tank systems (74.8%) and also significant reduction in microbial load was observed in the RAS unit. Percentage survival of *P. indicus* assessed during each life stages includes nauplius, zoea, mysis and post larvae. Highest post larval survival (53.5±3%) was recorded from the groups raised from RAS hatching unit compared to control (42±2.1%). The study directs recirculatory egg washing units can be better option in terms of water budgeting and produce healthy post larvae during the hatchery cycle.

S2- EP11

Coliphage consortia: An alternative strategy to combat the Biofilm in health and food sectors

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Biofilms persisting in the hospital settings pose difficulty to eliminate bacteria and demands about 100-1000 times higher concentration of antibiotics for complete eradication. Simi-

larly, biofilm is the most serious issue in the food processing unit that needs a very high dose of sanitiser application on food contact surfaces. Biofilm persists on infinitesimal areas of the utensils and are nearly impossible to remove from the in the utensils. To combat the biofilm problem, bacteriophages are considered to be a promising alternative to antibiotics. Considering the drawbacks of the single phage treatment, a coliphage consortia of 10 coliphages ($10^{12\text{ -}17}$ pfu/mL) that have wide range of lytic activities against a maximum of 17 *E. coli* hosts was formulated in the current investigation. The formulated coliphage consortia was tested on one moderate and high two very strong biofilms to estimate the minimum biofilm inhibitory concentration (MBIC) and minimum biofilm eradication concentration (MBEC). It was found that the MBIC ranged between 1:100 dilution to 1:10000 dilution of the coliphage consortia; similarly, the MBEC ranged between 1:10 to 1:100 dilution. The dilution of 1:100 ($10^{10\text{- }15}$ pfu/mL) was chosen to suppress the biofilm *E. coli*, and it was evaluated on 40 different unknown biofilm producers of *E. coli* isolated elsewhere and found that the formulated coliphage consortia inhibited 9 biofilm producers *i.e.,* was able to inhibit nearly 22% of the unknown biofilm producing *E. coli*, indicating that the coliphage consortia would be a potential strategy for eradicating biofilm in health and food processing facilities.

Keywords: Bacteriophage, Biofilm, E. coli, nanoparticles, MBIC, MBEC

S2- EP12

Pathological changes associated with multiple infestation in cage-farmed barramundi: A case study

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In present study, an outbreak of concurrent parasitic infestation was observed with 100% prevalence in cage farmed Asian seabass (*L. calcarifer*, n=16) in low saline water cage culture system during the month of October,2021 without any mortality. External examination revealed dark colored body and fin rot along with scale loss. Marine leaches were found attached to the tongue region of the mouth. Intestine was filled with yellow color fluid. Many helminth parasites were found attached to the peritoneal layer of the intestine near anal region. Histopathology changes included intestinal mucosal erosion, fibrosis and chronic inflammation. Cellular response of Asian seabass to against enteric parasites included increase in numbers of eosinophilic leucocytes. Marine leach and helminth parasites were identified through wet mount in microscopy. In present study water temperature (21±1°C) with low oxygen levels (6.3±0.76ppm) lead to more susceptible towards parasitic infection followed by secondary bacterial infection. Bacterium isolated only from the gill, identified by specific media and biochemical test confirmed the presence of *Vibrio* spp., *Vibrio paraheamolyticus.* This study offers useful information to better understanding associated diseases in fish farmed in low salinities.

S2- EP13

Seafood Consumption Behaviour at Selected Fish Markets of South Andaman, India

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Consumer's preference for a particular group of fish is relevant in the present scenario from the marketing and trading point of view and also for policy makers and planners at macroeconomic level. Present study have focused on 101 consumers from different fish markets and landing centres of South Andaman. The Frequency, Rank Based Quotient (RBQ) and Garrett ranking techniques have been used to analyse the consumer preference and constraints faced by them. Purchase behaviour of the consumer does indicate that the Islanders included fish in their regular diet (34%). Highest preference recorded was for marine fishes although the species consumption pattern varied widely with the ethnicity. Fresh water fishes like Tilapia, Roopchanda, Pangasius, and Indian Major carps have good demand among the Bengali population of the Islands. Majority of the marine landings were consumed in the fresh or dry forms. The islanders preferred species of anchovies, perches, mackerel, sardines and carangids. Identifying the huge potential of the marine resources of the islands, there is tremendous scope for value addition of many underutilised catches.

S2- EP14

Ghost fishing capacity of lost mackerel gillnets: An experimental study from coastal waters of Arthungal, Alappuzha, Kerala

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Lost fishing gears/parts continue to catch fishes and other organisms' even though fishers no longer have control over those gears. These lost gears designated as abandoned, lost or otherwise discarded fishing gears (ALDFG) continue to entangle and kill target organisms and non-target species such as turtles, birds and mammals, a phenomenon defined as ghost fishing. Ghost fishing is most problematic in gillnets and other passive fishing gear types, where the capture process relies on the movement of organisms into the gear. The fishing capacity of nets after they have been lost or abandoned should be examined to assess the impact of these lost gears. Such studies are limited from Indian waters. The present study attempts to assess the fishing capacity of lost mackerel gill nets in the nearshore waters at Arthungal, Alappuzha, Kerala using intentionally abandoned gillnets during January-May 2020. The experimental gillnets (52mm) were allowed to fish continuously and were monitored at frequent intervals. Catches showed a negative exponential decreasing trend over time. Fish catches (mainly *Rastrelliger kangurta*) dominated till 15th day, thereafter Crustaceans dominated. Catching capacity of nets decreased below 50% within 10 days, however the nets continued fishing till 90th day. State of catch showed decaying stages of fishes as the days advanced. The data generated from the present study will be beneficial to assess the range and importance of unaccounted or incidental mortality associated with ghost fishing nets.

Keywords: Ghost Fishing, Gillnets, Catch, Mortality

S2- EP15

The pandemic impact on the coastal fishing practices of the Nicobar traditional communities in Car Nicobar, Nicobar archipelago

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The COVID-19 pandemic has invariably affected the global fishing sector leading to a decline in landings, loss of income, employment, and associated livelihood constraints. Nicobar traditional communities in Andaman and Nicobar archipelago engage in traditional fishing activities with simple fishing techniques aimed at their subsistence needs. Their fish catches were mainly constituted by small tunas, groupers, snappers etc using common fishing gears such as gill nets, hand lines, cast nets, gleaning of shallow water resources etc. We hereby report the impact of the pandemic on the remotely located Car Nicobar Island which was predominantly inhabited by the Nicobar traditional communities. We studied the impact through personal interviews with the Nicobarese community (N=95) and women fish vendors (N=3) of Car Nicobar Island. The interviews were undertaken with the prior permission and consent of the Chief captain, the Car Nicobar tribal council. Our surveys revealed that in the post-pandemic conditions there was a significant reduction ($p<0.001$) in the average monthly income and fish catches when compared to the pre-COVID times. Garrett ranking method used to rank the issues revealed the issues such as limitations in inputs, fuel issues, transportation problems etc. Rank-based quotient analysis was used to rank the assistance required in the form of subsidies, awareness, advisories, and infrastructure. Car Nicobar being a remotely located Island mainly relies on the supplies from Andaman Island which in turn relies on the mainland supplies. Strengthening infrastructure, generation of awareness, real-time advisories and technological backstopping can sustainably develop the marine fisheries sector in the remotely located Car Nicobar Island.

Keywords: Coastal Fishing, Pandemic, Livelihood, Employment, Subsidies, Infrastructure

S2- EP16

Utilization potential of ragged sea hare Bursatella *leachii* Blainville, 1817

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Sea hares are large sea slugs belonging to the phylum Mollusca (Opisthobranchia: Anaspidea). These organisms are soft bodied, with reduced or no internal shell in addition to the two tall rhinophores in their heads. They are distributed in the shallow coastal waters and approximately 400 species are known to occur in Indian waters and 190 species are reported from west coast of India. Regular surveys were conducted in the coastal waters along Karnataka coast to understand the diversity and distribution of various marine organisms including sea hare. A recent survey in the estuarine stretches of river Netravathi in Mangalore, revealed the breeding ground and sea-

son of ragged sea hare, *Bursatella leachii* Blainville, 1817. The organism was observed to create menace for the local fishers in the region. The paper discusses in detail the distribution, breeding ground, breeding season and commercial utilization potential of ragged sea hare in Indian context.

Keywords: Anaspidea, Netravathi Estuary, Breeding ground, Potential uses

S2- EP17

Physico- chemical parameters and phytoplankton abundance that influencing fish larval abundance along the coastal waters of Dakshina Kannada, South west coast of India

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Capture fisheries is highly widely seasonal and is dependent on biotic as well as abiotic factors among which, among which relative abundance of fish larvae which determine the intensity of recruitment into the exploitable stock is by far the most important . Studies of fish larvae can also indicate relative size classes and abundance of spawning fish stocks and therefore help with management decisions pertaining to fisheries and conservation. But insufficient knowledge on the correct identification of the larval stages has greatly hampered detailed investigations on their survival and recruitment.The present study attempts to study the physico chemical parameters that influence the fish larval distribution along the coastal waters of Dakshina Kannada, which includes two near shore stations Surathkal and Chitrapur stations, three stations from the Netravati-Gurupura Estuary - Kudroli, Taneer Bavi and Kulur and one station from Mulki-Pavanje estuary.Pronounced monthly variations in the primary production, phytoplankton standing stock (chlorophyll a), physio chemical parameters such as water temperature, pH, salinity, dissolved oxygen and nutrients were observed at the selected stations. Standard analytical methods (APHA, 1981) were used for the estimation of physio chemical parameters. A one way analysis of variance (one way annova) and was conducted to evaluate the null hypothesis that there is no variations in the physico chemical characteristics within the stations during the period (36 months). To test the differences in physico chemical parameters between stations each parameters were tested using a one-way ANOVA, and a post-hoc Fisher Least Significant Difference (LSD) analysis performed to identify significantly different mean values. The one way Anova showed significant variations for the physiochemical parameters such as AT, phosphate concentrations, Dissolved oxygen and chlorophyll c ($p< 0.05$) and highly significant variations in pH, salinity, dissolved carbon dioxide, Chlorophyll a, nitrate, ammonia and silicate concentrations. This was followed by the multivariate comparisons (Tukey HSD) to know the variation in the physico chemical parameters within the stations. The results clearly showed the marine and estuarine stations distinctly with respect to the physico chemical parameters. Stations Chitrapur and Surathkal varied from other estuarine stations such as Kudroli, Kulur , Taneer Bavi and Mulki for pH, Salinity, Nutreint concentrations such as nitrate, silicate , ammonia and Chlorophylla a concentrations ($p<0.05$). Kulur and Mulki also showed a distinct variations with respect to ph, salinity, nitrate, silicate, ammonia and chlorophyll a concentration ($p<0.05$). This is because, Kulur being the upstream station is high-

ly influenced by freshwater influence and anthropogenic activities like sand mining and effluent water discharge. Mulki belongs to another estuary Mulki-Pavanje estuary which is rich in natural mangroves and is influenced by the tides. Fish larvae collected from these stations were sorted out from the zooplankton samples and identified up to the family level by referring to literature and fish larvae identification guides.

S2- EP18

Variations in diversity and distribution of zooplankton in different depths off Mumbai, Maharashtra

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A study was conducted to assess depth wise and seasonal changes in diversity and distribution of zooplankton in near shore waters of Mumbai from January 2015 to May 2017. Monthly sampling at two depths 20m and 40 m was done onboard mechanized fishing boat by oblique surface hauls using Heron Tranter net (mouth area 0.25m^2 and mesh size of 100 micron) fitted with TSK flow meter. Except in the month of April Zooplankton density was lower at 40 m station than 20m depth. There was a gradual decrease in density after the peak observed in January. Second peak was observed in October. Zooplanktons comprised of 27 genera and 37 species with Copepods being the dominant group followed by Hydrozoans, Chaetognaths and Lucifers. Species Richness 'd', Shannon Weiner 'H' were higher at 20 m depth stations in Post-Monsoon and Pre-monsoon seasons. SIMPER analysis was done for identification of species responsible for similarity between two depth locations. The average similarity between 20m and 40m locations is 50.64. Major groups responsible for similarity were copepods followed by Tintinids, Fish eggs and Chaetognaths. The study indicates high density and diversity values of zooplankton at 20 m depth than 40 m which could be attributed to high organic load in near shore waters.

S2- EP19

Variations in phytoplankton community composition in coastal waters off Ratnagiri, Maharashtra, West Coast of India

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Spatio-temporal variations in phytoplankton were studied for a period of three years during 2014-2017 off Ratnagiri Maharashtra. A total of 75 phytoplankton species were recorded, which was dominated by 60 diatom species followed by, 14 dinoflagellate and a blue green algae. Overall

phytoplankton cell density was comparatively higher at 20 m depth station (Mean 7.79±0.60 X 10^4 cells l^{-1}) than at 40 m depth (Mean 1.84±0.18 X 10^4 cells l^{-1}). Total cell density of phytoplanktons, diatoms, dinoflagellates and blue green alga at 20 m and 40 m depth stations was significantly different. Maximum average cell density was recorded during post-monsoon season than pre-monsoon and monsoon seasons during the present study. *Chaetoceros curvicetus*, *Skeletonema costatum*, *Trichodesmium erythraeum*, *Chaetoceros lorenzianus*, *Ditylum brightwellii* were ubiquitous off Ratnagiri throughout the year. Dinoflagellate, *Noctiluca scintillans* was abundant during pre-monsoon season and absent during monsoon season. Shannon – Wiener diversity index (H') and Margalef's Species Richness (d) were higher at 20 m depth during post-monsoon season. ANOVA revealed significant difference among nutrients (phosphate, nitrate, nitrite), ammonia and biochemical oxygen demand in the two depth stations. Phytoplankton cell density was positively correlated with chlorophyll and nutrients (phosphate, nitrate, nitrite) and phytoplankton diversity was high at 20 m depth during post-monsoon season.

S2- EP20

Medical application of fishery by-products: A review

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The seafood processing industry produces a large number of underutilized by-products annually. Researches have been initiated to investigate those discarded materials and has identified several bioactive compounds including bioactive peptides, collagen and gelatin, oligosaccharides, fatty acids, enzymes, calcium, water-soluble minerals, and biopolymers. Bioactive peptides derived from fish by-products have shown various biological activities including antihypertensive and antioxidant activities and hence may be a potential material for biomedical and food industries. Collagen and gelatin are currently used in diverse fields including food, cosmetic, and biomedical industries. Other than that, they are promising drug carriers for the treatment of cancer. Many studies have reported that chitin, chitosan, and their derivatives possess biologically active polysaccharides and hence they are potential agents for many applications. Further, those compounds have also shown potential activities such as antioxidant, antibacterial, antiviral, antihypertensive, anticancer, etc. Hence, seafood by-products are valuable natural resources that show the range of functionalities and hence potential materials for biomedical and nutraceutical industries. Chitosan is a natural pseudo cationic polymer, and due to this character, it is suitable in cosmetic applications, especially for hair care concerning its electrostatic interactions. Moreover, chitosan and its derivatives are potential agents for pharmaceutical and medical applications due to their characteristic features.

Keywords: Seafood, By-Product, Bioactive Peptides, Anticancer

S2- EP21

Sexual maturity, spawning activity, sex ratio and fecundity of *Seriolina nigrofasciata species* dwelling the South-East Arabian Sea

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The reproductive biology of *Seriolina nigrofasciata* was studied by examining 627 individuals collected between August 2017 and May 2018 from the south-west coast of India. The population had a significantly higher proportion of females than males. Using a logistic regression, it was determined that the length at 50% maturity were 36cm for males and 39cm for females. *S. nigrofasciata* spawned from November to March, with a peak in December, based on the monthly proportions of macroscopic gonadal maturity stages and monthly variations in the gonado-somatic index. The fecundity ranged from 1,92,295 to 7,60,248 eggs with an average 5,02,906 eggs per individual. The fecundity of *S. nigrofasciata* increased linearly with the standard length, body weight and ovary weight of fish. The ova diameterranged from 0.01 to 0.5mm. According to the size distribution of oocytes, S.*nigrofasciata* appeared to show a unimodal distribution indicating that this fish is a total spawner.

Keywords: *Seriolina nigrofasciat*a; Sexual maturity; GSI; Spawning; Arabian Sea

S2- EP22

Quality loss of fishes during gillnet operation: Observations from Meenkara reservoir, Palakkad, Kerala

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Quality loss is the decrease in quality attributes of fishes without physical loss, however, the potential value of the fish is reduced. The quality loss of fish during fish capture has significant food-security implications, besides affecting fishing economies and fisheries-based livelihoods. The present study has been carried out to assess the quality loss of fish during gillnet operation in the Meenkara reservoir, Palakkad, Kerala. Two grades of fish were caught during gillnet operations. Grade 1 is the fresh quality fish and grade 2 is the spoiled fish. A total of 1.02% loss in value of the total fish captured were observed. About 2.43% loss in value was observed for *Catla catla*, 1.49% for *Labeo rohita*, 2.32% for *Cirrhinus mrigala,* 0.09% for *Oreochromis* sp., 18.99% for *Clarias gariepinus*, and 1.63% *for Etroplus suratensis*. The main reason identified for the quality loss of fish was the extended soaking time of gillnets in the reservoir. Reducing the soaking time will shorten the time lapse between the first caught fish and the hauling of the net, thus improving fish quality. The information obtained during the study will help to formulate new strategies and identification of appropriate tools for reducing the quality loss of fish in small-scale fishing operations.

S2- EP23

Integrative taxonomic characterisation of *Plicomugil labiosus* (Valenciennes 1836) (Mugiliformes: Mugilidae) from the Lakshadweep Islands, Western Indian Ocean

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The hornlip mullet, *Mugil labiosus* was described by Valenciennes in 1836, from the Red Sea, and subsequently assigned to a new monotypic genus *Plicomugil* in 1953.This species is currently known to be distributed in the Indo-West Pacific, from the Red Sea to the Philippines. Though forming part of its wider distribution range, very few verifiable records of *Plicomugil labiosus*, backed by voucher specimens are available from India. Here, we provide a detailed description of *P. labiosus* based on five specimens (89.86–123.17 mm SL) collected in July 2018, from Agatti Island in the Lakshadweep archipelago. Using an integrated taxonomic approach incorporating morpho-meristic data with mitochondrial cox1 gene, this is the first systematic characterization of the species from the Indian waters. *Plicomugil labiosus* can be identified by a number of morphological characteristics including the presence of a conspicuous deep blue or black spot on the pectoral fin, broad and thick upper lip, lower lip with a symphyseal knob, and meristic counts including 34 lateral line scales with three to four small scales on the caudal fin, 10 longitudinal scales, 16 circum-peduncular scales, 15-16 caudal-fin rays, and 14 pectoral-fin rays.

Keywords: Hornlip mullet, Morpho-meristics, Cytochrome oxidase I, Agatti Islands

Technical Session 3

Augmenting productivity of horticultural crops

Keynote address

Innovative technologies for improving productivity of Horticultural crops in Coastal Ecosystems

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Abstract

Horticulture plays a pivotal role in the Indian economy by securing direct and indirect livelihood of most of the Indians. Indian horticulture has witnessed great transformation with technological interventions. The coastal region is most important because it includes both land and marine resources besides intense interactions between various natural processes and human activities that take place which are important factors for development. Horticulture development plans may provide for research, extension marketing and adequate infrastructure to develop and promote particular activities and technologies in coastal areas such services may be used to encourage the farmers to adopt better soil conservation practices or to use energy sources that do not deplete the natural resources. There is a wide scope of diversification of farming practices such as manure, water, pest management and also generation of rural employment and sustainable livelihood outcomes. The imminent efforts should be to promote coastal horticulture by increasing capacity building of the farmers through interventions of government, research organizations and NGOs for high margin crops. Effective coordination is particularly important in coastal areas. Interventions will be effective only if the people are involved. Improving the productivity of horticultural activities in favourable areas and development of alternative areas that are suitable for horticulture production. Recommended practices resulting from research and extension activities must be relevant to farmers objectives, farming systems from broader economic and social environment perspective.

Introduction

India with diverse soil and climate comprising several agro-ecological regions provide ample opportunity to grow a variety of horticultural crops which forms a significant part of total agricultural production in the country comprising of fruits, vegetables, root and tuber crops, flowers and other ornamentals, medicinal and aromatic plants, spices, condiments, plantation crops and mushrooms. The agricultural paradigm is already undergoing a shift with focus from cereal production to diversified horticulture farming. India has witnessed an increase in horticulture production over the last few years. Significant progress has been made in area expansion resulting in higher production. Total horticulture production in the year 2021 is estimated at 326.58 MT, an increase of 5.81 MT over 2020.

India has one of the world's longest coastlines, characterized by varied landforms and ecosystems. India has a long coastline (7500 km) of about 5422 km excluding islands which includes 8 states and 3 union territories (Table 1). In India, agriculture and allied sectors share 15.87% of total Gross Value Added (GVA) and employ 59% of the total workforce (Ministry of Statistics and Programme Implementation, 2020), of which 0.91% and 5.23% GVA comes from fisheries and coastal agriculture and allied sectors respectively. The area along the vast coastline of India has diversified

conditions related to soil, rainfall, water resource, agriculture, horticulture and forest crops, fisheries etc. the area is rich in diversified natural resources but the people are the poorest in the country.

Table 1: Coastal line of India

State /UT	West coastline (km)	State/UT	East coastline (km)
Gujarat	1214.70	Tamil Nadu	906.9
Maharashtra	652.60	Pondicherry	30.60
Goa, Daman and Diu	160.5	Andhra Pradesh	973.70
Karnataka	280.00	Orissa	476.40
Kerala	569.70	West Bengal	157.50
Total	**2877.50**		**2545.10**

Coastal areas are commonly defined as the interface or transition areas between land and sea, including large inland lakes. Favourable biophysical and climatic conditions, together with ease of communication and navigation, have encouraged human settlement in coastal areas since prehistoric times. They are also important ecologically, as they provide numerous environmental goods and services. The coastal areas contain both critical terrestrial and aquatic habitats, particularly in the tropics.

Horticultural sector is still organized by crop production groups: fruit, vegetables, floriculture, ornamental horticulture, herbs, medicinal, and spices. However, increased sophistication of production in the developed world has resulted in enormous increases in yield and efficiency reducing the number of growers and increasing the size of operations. Postharvest horticulture has become increasingly important, as horticultural products are shipped from coast to coast and continent to continent. Horticulture plays a key role in the local economy, either through the production of food or by providing raw materials to industry which is established in these areas to make the best use of port facilities and thus has strategic significance.

The coastal areas often provide excellent soil and climatic conditions for horticulture, which has been practised for thousands of years and plays an important role in the economy of coastal areas. Therefore, coastal horticulture, in addition to benefiting from favourable environmental conditions with generally good land, also benefits from sea communications for trade and for development of industry and tourism in coastal areas, which may provide markets for horticulture products, livelihood support for coastal populations, including cities, and opportunities for establishment of horti-based sectors.

Agro-climatic conditions of coastal regions

- The climate of most of the coastal sub-regions in India falls under the hot and humid or sub-humid condition with limited variations.
- The soils of coastal areas are deep to very deep, imperfectly to poorly drained, sandy to fine loamy to fine in texture.
- The sandy shores are covered partly with water during high tides and stormy periods.
- The soils are calcareous, slightly to moderately saline and alkaline.
- Heavy exploitation of groundwater coupled with changes in land configuration in many coastal areas has resulted in seawater intrusion and development of high soil salinity.

- As a result, this has become one of the impediments for improving farm production even though the agro-climatic condition is suitable for different crops and farming systems.

Technologies for promotion of coastal horticulture

i. Crops

The coastal ecosystem offers vast scope for commercial use not only for a wide variety of fruit and vegetable crops, but also plantation crops, spices and medicinal plants. Plantation crops, like coconut, areca nut, oil palm, cashew, coco, spices ginger, turmeric, and seed spices like cumin, coriander, fennel, fenugreek are high-value commercial crops and coastal regions have a great scope to cultivate commercially for all those crops. Both cashew and black pepper are good foreign exchange-earners. India has emerged as the largest producer of coconut in the world, and coconut coir industry is a well-established business. Cashew is cultivated mostly in the coastal areas. Release of improved varieties in all these crops and improved production technology has brought significant improvements in the production of these crops. Medicinal and aromatic plants play important role in Indian traditional medicines. It is reported that over 2000 native plant species have curative properties, and another 1300 species are known for their aroma and flavour are native to coastal ecosystem. Medicinal and aromatic plants, like isabgol and opium poppy are produced on commercial scale. Vegetable seed production is also a potential area in this region. Oil palm (*Elaeis guineensis* Jacq.) is recognised as the highest edible oil yielding crop, producing 4-6 tonnes of oil per tree in 25 Years. Total potential area identified for growing oil palm is mainly along the coastal belt.

Vegetables: Amaranth, taro (*Colocasia*), elephant foot yam, brinjal, cassava, drumstick, Indian spinach, okra, potato, beans, water spinach, yam.

Fruits and Nuts: Jackfruit, mangosteen *(Garcinia mangostana),* papaya, pineapple, sapota, toddy palm (*Borassus flabellifer*)

Spices and Condiments: Black pepper, cardamom, cinnamon, clove, ginger, Malabar tamarind, nutmeg, turmeric, vanilla

Plantation Crops: Areca nut, banana, cashew nut, cocoa, coconut, coffee, oil palm, rubber

Medicinal and Aromatic Plants: Jatamansi or muskroot, turmeric (Curcuma spp.), lemon grass, Rauvolfia, *Piper longum*

Ornamental Crops: Chrysanthemum spp., lily, doum palm (*Hyphaene thebaica*), ginger lily, ixora (*Ixora coccinea*), jacaranda, jasmine, lotus, palms.

ii. Cropping systems

Almost the entire coastal area is grown with rice, mostly rainfed, under different land situations depending upon level of soil salinity, topography, and depth to waterlogging often subjected to floods.

Important crops and cropping systems in coastal ecosystems of different stats of India (Saha *et al*., 2008)

State	Wet season	Dry season
Andhra Pradesh	Rice, cotton, sugar cane, tobacco, groundnut	Black gram, green gram, groundnut and chilli
Odisha	Rice, jute, sugar cane	Rice, black gram, green gram, chilli, groundnut and sunflower
Tamil Nadu	Rice, sugar cane, sorghum, pearl millet, tapioca	Rice, groundnut and cotton
West Bengal	Rice and jute	Rice, barley, lathyrus, sunflower, sugar beet, chilli and watermelon

iii. Integrated farming Systems

For coastal areas, the integrated farming system combining crop production with sericulture, apiculture, dairy, poultry, duckery, aquaculture, agroforestry, *etc.* has a scope. In India, coconut contributed about R 10,707 crore in crop output in 2019-20, and the coconut industry directly or indirectly employs about 12 million people. Coconut is a major plantation crop in coastal regions of Kerala, Tamil Nadu, Karnataka, and Andhra Pradesh. These top four producers accounted for 90% of total production and about 89.5% of total production acreage in the country in the year 2019-20.

Integrated Farming for Sustainability:

India is rich in livestock (with 15, 58, 18, 7 and 5 per cent of world's cattle, buffalo, goat, sheep and poultry birds' population, respectively) and fishes (6.3 per cent of global fish production), which contribute significantly to India's agrarian economy under diverse production systems. Therefore, sustainability of future horticulture would require integrated farming practices, leveraging the principle of cyclic resource use.

Agri-horti production system

The coastal areas in countries like India are endowed with abundant sunshine, solar as well as wind energy, precipitation, diverse soils, physiography, climate, etc. and therefore, have tremendous opportunities for supporting a host of perennial and annual crops like trees, fruit plants, cereals, root crops, pulses, oilseeds, commercial crops, vegetables, etc. In addition, prospects for fishery, poultry, animal husbandry, sericulture, mushroom cultivation, bee-keeping and dairying are also enormous. Rice-based cropping systems are more dominant in the coastal plain tracts.

A study on deep poorly drained alluvial soil in Balipatna Block in Orissa having average annual rainfall of 1480 mm, a modified soil physical environment through 5m x 30m alternate raised and sunken beds for seven different cropping systems revealed that the highest rice equivalent, water expense efficiency, net water productivity, net returns, and B/C ratio were achieved with rice-fish in the sunken bed and pointed gourd + snake gourd in the raised bed system (Yadav, 2008).

Certain plantation crops, especially coconut, arecanut and cocoa have received major attention in the coastal areas. Mixed and intercrops in the coconut and arecanut based cropping systems have helped in augmenting overall production capacity as well as in improving economic returns of the farmers in a sustainable manner. The coconut-based farming system comprising coconut, grass, dairy, poultry and fishery has proved more economical and sustainable.

Several benefits relating to sustainability and profitability accruing from diversified and integrated farming are as under (Yadav, 2008).

(i) Efficient conservation and optimization of natural resources.

(ii) Productive recycling of organic wastes among different components of farming system.

(iii) Enhancement of soil health including organic carbon status and microbial activity.

(iv) Prevention/minimization of soil erosion and other land degradation hazards.

(v) Improvement of soil productivity capacity.

(vi) Reduction in use of external inputs and hence, less crop production cost.

(vii) Increased environmental and ecological safety.

(viii) Meeting multiple demands relating to fodder, feed, food, fibre, fertilizer, fuel, timber, medicine, etc.

(ix) Greater employment, livelihood and nutritional opportunities.

(x) Regular flow of higher-income leading to poverty alleviation.

(xi) Insulation of farmers against risks arising from calamities, such as drought, weather aberrations, pest virulence, etc.

(xii) Security of greater self-reliance among farming community.

(xiii) Ecological and biological stability of natural resources as well as productivity.

Coconut based industries

An off-shoot from the mainstay coconut sector, the coir industry in India contributes significantly to employment creation and the economy at large, mainly in coastal areas in India (Karun *et al*., 2021). Approximately seven lakh persons find employment, both direct and indirect, in this industry. The industry is also significant in terms of exports. In 2019-20, India exported 9.9 lakh MT of coir and coir products, earning R 2,758 crore in export revenues. It is also noteworthy that, the exports of coir and coir products have increased at an annual growth rate of 11.1% during the last five years (2016-2020). The domestic revenue earned is double the export revenue. India accounts for more than two-thirds of the global production of coir and coir products, including 60% of the total global supply of white fibre. Sri Lanka is the second-largest producer accounting for 36% of the total global supply of golden fiber. Currently, the global annual production of coir fiber is about 3.5 lakh metric tonnes. The coir industry assumes significance because it is agro-based, has a large presence in rural areas, and involves a large proportion of women workers (80%) belonging to the economically and socially disadvantaged sections. India currently exports about 14 coir products, including coir pith, coir fiber, tufted mats, handloom mats, geotextiles, coir yarn, curled coir, handloom matting and rubberised coir. Currently, only 40% of the coconut husk is utilised by the coir industry, and there is potential for further development.

Designing varieties suitable for coastal zones:

The multifaceted abiotic stresses in coastal areas (high salinity and other soil problems, submergence, stagnant flooding, and drought), mean that most areas are monocropped with rice during the monsoon season. Local horticultural varieties have some level of tolerance for these conditions, including water stagnation, but their productivity is very low. During the rest of the year, the area remains fallow due to high soil and water salinity and lack of good quality irrigation water. Our long term goal is to develop resilient varieties combining tolerances to major abiotic stresses prevailing in coastal areas, through the development of effective breeding tools that can help dissect and incorporate tolerance into modern varieties and breeding lines adapted to these areas. Combing the use of varieties with broader tolerance to these stresses, with proper and affordable management options, can ensure higher and stable food production in coastal areas.

- Mango: Arka Arunika -Export purpose, Pusa Arunima (Export quality), Pusa Surya (Long self-life), Arunika (Anthracnose resistant)
- Papaya: Arka Prabhat - Better storage life
- Coconut: Kalpa Sankra, Kalpa Raksha, Kalpa Shree – Resistant to root wilt
- Tomato: Arka Samrat & Arka Rakshak-Triple resistance to ToLCV+BW+EB, Arka Abhed-Multiple Resistance to ToLCV+BW+EB+LB
- Onion: Bhima Super, Bhima Subhra- Kharif season
- Carrot: Arka Suraj -Resistant to powdery mildew and tolerant to nematode
- French bean: Arka Anoop – Resistant to bacterial blight
- Watermelon: Arka Madhura-Seedless type
- Potato: Kufri Chipsona-3, Kufri Chipsona-4, Kufri Himsona- Chip making and Kufri Frysona-French fries, Kufri Pukhraj (High yield and input efficient),
- Taro: Jhankari, Sonajuli – Tolerant to blight, drought and salt
- Aonla – Goma Aishwarya (Early maturity)
- Guava – Lalit (Pink pulp)
- Litchi: Swarna roopa : Cracking tolerant

iv. Use of digital science for transforming coastal horticulture

Digital science through information and communication technology has the potential in providing technological support by way of assisting in information dissemination related to crop and input selection, pest and disease advisories, weather advisories, credit and insurance, real-time data on market intelligence, post-harvest processing in a need-based and user-friendly mode (Seth

and Ganguly, 2017). The application of digital technologies which include remote sensing (satellites and drones), wireless sensors, internet of things (IoTs), geographical information systems for crop and soil health monitoring, livestock and farm management is expected to be the future in providing newer solutions to the problems faced by the farmers (Gill *et al*., 2017).

v. Digital Solutions and Artificial Intelligence (AI)

Using Big Data Analytics, we can create decision support systems at various levels, including weather forecasting and efficient management of water, pest, and nutrient. Linked with satellite imagery, this can also help in future predictions of produce and price. Importance of ICT for marketing, sales, and pricing as seen in the response to e-NAM, is expected to attract and retain youth in horticulture. Comprehensive and reliable data resources are conducive to augment AI that can bring a paradigm shift by developing smart farming practices using IoT (internet of things) to address the uncertain issues with utmost accuracy that will enable farmers to do more with less, and also provide new business opportunities to youth as well. AI can also be used for high throughput plant phenotyping, monitoring of natural calamities and crop residue burning.

vi. Use of renewable energy resources

Renewable energy is also called "clean energy" or "green power" as is does not pollute the environment (Bharathi *et al.,* 2019). Sunlight can be converted directly into electricity using photovoltaic (PV) systems. Wind power is the conversion of the kinetic energy of the wind into a useful form of energy, such as using wind turbines to make electrical power, windmills for mechanical power or wind pumps for water pumping or drainage (Khare *et al.,* 2013).

vii. Precision Agriculture

Precision agriculture, which exploits modern tools, technologies and innovations, including genetically enriched seeds, nanotechnology, artificial intelligence (AI), drones, sensors, robots etc. is the way forward to achieve environmentally sustainable Evergreen Revolution. The approach recognizes site-specific differences within fields and adjusts management actions accordingly adopting the concept of "doing the right thing in the right place at the right time". Moving forward, this will be the new norm, addressing: (i) increased land and labour productivity by means of gender-neutral technologies, (ii) intensification, diversification (iii) institutional arrangement to equitable rights, and (iv) balanced agroecological settings compatible with minimum risk (Gatzweiler and Von Braun, 2016).

viii. Genetic Resource Management and Crop Improvement

The importance of rich genetic resources in crop variety improvement cannot be overemphasized. Germplasm enhancement/pre-breeding using wide gene pools and molecular breeding techniques are to be given higher credence in evolving high yielding, nutritive, biotic and abiotic stress-resistant, widely adapted and climate-resilient crop varieties/hybrids suited for diverse agro-ecologies. Immediate steps are needed to characterize and evaluate the vast germplasm repository available in national institutes and use the same for genetic improvement.

ix. New Models for Capacity Building

Application of many new innovations may require a new set of skills or up-gradation of the existing ones. Indian youth, including the rural population, are fairly tech-savvy and eager to learn. The first and foremost requirement for adoption of innovative precision technologies is training of local youth in vocational skills.

x. Application of Biosensors in horticulture and Allied Fields

With growing concerns about air, water and soil pollution, effective diagnosis of pathotypes, rapid, precise and cost-effective analysis, and monitoring of food and other agricultural products are assuming greater salience. Biosensors (analytical devices that convert a biological response into an electrical signal, including enzymes, antibodies, nucleic acids, microorganisms etc.), in this way are being used in medicine and healthcare. It may be considered for a wide array of applications in agriculture and allied industries.

xi. Solar Power for Sustainable horticulture

Use of renewable energy sources, particularly solar power is vital in horticulture. Though these are being promoted for a very long time, their use is limited and localized due to the high initial investment and lack of affordable and efficient power storage systems (power grid and batteries). The costs of panels have come down substantially, but India is still tech-dependent on other countries for affordable battery manufacturing.

xii. Mulching

Mulching is the application of layers of organic residues or other permitted materials on the surface of the soils to reduce the impact of splash erosion, rate of evaporation and increases the infiltration capacity of the soil besides suppression of weed growth. It becomes essential in coastal areas where it rains heavily and luxuriant growth of weeds occurs. In this region, coir waste, coconut husk, farm waste, dried leaves, dried grasses, sugarcane trash, paddy straw and groundnut husk can be used as mulching materials.

xiii. Bio-fertilizers

Micro-organisms convert the unavailable form of nitrogen, phosphorus and potash present in the vicinity of plant roots and atmosphere into available form. They also enrich the crops with vitamins, amino acids and growth promoters. Generally, seeds are treated with bio-fertilizers or applied to the soil after mixing with farmyard manure. In case of legumes, suitable *Rhizobium* sp. is applied as seed inoculants. In the transplanted crops, *Azospirillum* is inoculated through seed, seedling root dip and soil application methods. For direct sown crops, *Azospirillum* is applied through seed treatment and soil application. Phospho-bacteria is inoculated through seed, seedling root dip and soil application methods as in the case of *Azospirillum*. Phospho-bacteria can also be mixed with *Azospirillum* and *Rhizobium*.

xiv. Multiple cropping

In the coastal region, coconut as a monocrop does not fully utilize the basic resources such as soil and sunlight available in the garden. Adoption of multiple cropping practices in coconut gardens ensures better utilization of basic resources and higher production. This includes multistoried cropping and intercropping which utilize the vertical and horizontal unutilized spaces. Organic farming techniques provide ample scope for the practice of multiple cropping in the coastal plains. Multistoried cropping refers to the cultivation of three or more crops having different morphological characteristics so as to intercept solar radiation at different levels and exploit different soil zones. The required nutrients can be met by effective recycling of the plantation and animal wastes within the farm. Once the palms attain a height of 5 to 6 m perennials like cocoa, pepper, cinnamon, clove and nutmeg can be grown.

Mixed / intercropping increases the level of light interception about 95 per cent. A variety of intercrops like pineapple, banana, groundnut, chillies, sweet potato and tapioca can be raised in coconut gardens upto 8-10 years. Intercropping also leads to increased availability of organic matter for recycling.

In addition, the interspaces of plantation crops can be effectively used for growing vegetables and legumes to augment production. Besides, 25 tonnes of organic wastes are also made available per ha which can be mixed with animal waste for efficient recycling and supply of nutrients to plantation crops by vermicomposting.

xv. Protected cultivation

Protected cultivation holds the key in the future for the production of high-value crops, especially for efficient use of land and water.

The main benefits are,

- Protected structure increases the yield of several crops up to 5 to 8 times and saves water up to 50% compared to open field flood irrigation.
- Crop grows consistently, is healthier, produces good quality fruits and matures fast.
- Early maturity results in higher and faster returns on investment.
- Undulating terrains, saline, waterlogged, sandy and hilly lands can also be brought under protected cultivation.

xvi. Innovative Post-Harvest Technologies for Extended Shelf Life and Value Addition

Innovative primary processing, dehydration and pasteurization technology at the farm gate, for extending shelf-life of farm produce, specially fruits and vegetables, milk and fish using solar power and low-cost storage facilities; advance processing technologies for value-added and ready-to-use products and nutraceutical development, are some other vital areas that hold promise to increase value from horticulture both in domestic and export markets, as well as providing nutrition security.

xvii. Indigenous Technical Knowledge (ITK)

Indigenous Technical Knowledge (ITK) has immense value in innovation and plays significant role in horticulture growth in coastal areas. The knowledge inherently acquired by the indigenous communities in different ecosystems is valuable for climate adaptation, natural resource management, processing/preservation, storage, and medicinal value. Traditional knowledge of farmers in conserving and identifying useful biological material, embodied in biotechnological innovations, offers an effective strategy for achieving sustainable food security (Blakeney and Siddique, 2020).

xviii. Changing cropping patterns in India

Agricultural diversification is an important instrument for economic growth. Diversification largely depends upon the opportunities and responsiveness of farmers to technological breakthroughs, consumer demand, government policy, trade arrangements and development of irrigation, roads and other infrastructure. Changes in cropping patterns are responsive to these factors. The aggregate cropping patterns of the country are represented by the gross cropped area allocation among different crops and commodity groups. India has experienced a considerable degree of crop diversification in term of changes in the area under various crops since the Green Revolution which was largely in favour of food grains to meet the objective of self-sufficiency and country's food security. In the past one decade, the changes in production patterns are more towards the horticulture sector.

xix. Higher Export Earning Potential

Fruits and vegetables have been shown to earn 20-30 times more foreign exchange per unit area than cereals due to higher yields and higher prices available in the international market. In spite of the large scale production, India's fresh produce has not made major dent in the international trade so far, except for spices, cashew nut and recently grapes. This is primarily due to the fact that horticultural crops were treated as one of the several means of land use of secondary importance, with food grain crops receiving prime attention and consequently heavy investments.

Research needed

- Integrated nutrient management
- Resource conservation
- Need for alternative to gypsum
- Harnessing synergy from modern science
- Bio- and phyto-remediation
- Bio-saline agriculture
- Micro-irrigation for enhanced resource use efficiency
- Achieve technology-led development in Horticulture.
- Post harvest& value addition in horticulture crops.
- Modified atmosphere packaging for long storability & transportation of fruits & vegetables.
- Insect pollinators for improving productivity and quality of the crops.

- Development of varieties for cultivation in non-traditional areas.
- Nutrient dynamics and interaction.
- Bioenergy and solid waste utilisation to make horticulture more efficient and ecofriendly.
- Plan, coordinate and monitor R&D programmes at national level as well as serve as knowledge repository in Horticulture sector.

Opportunities for coastal horticulture

- Road, port and airport construction: Increased labour supply and demand for horticulture produce, access to new land and produce markets.
- Rural electrification: employment, local processing, local service industries, expanded range of technological options, area more attractive to skilled staff.
- Industrial development: employment, infrastructure development, increased demand for horticulture food products.
- Development of climate-resilient varieties
- Development of stress-resistant varieties.
- Plan upland farm layouts to respect natural drainage patterns.
- Encourage sustainable intensification of horticulture on suitable land to reduce pressure on unsuitable drylands.
- Promote crops that are compatible with wetlands.
- Implement soil and water conservation practices to control cropland erosion and surface water runoff
- Prioritization of research based on farmers' needs
- Creation of real-time database and impact assessment
- Utilize fertilizers and pesticides in a manner that will minimize their loss and transport towards coastal areas.
- Whenever feasible promote organic fertilizers, biological pest control and non persistent biocides.
- Promotion of the horticulture research, extension and marketing with adequate infrastructure.

Conclusion:

Coastal region is agro ecologically the most important region as it includes both land and marine resources besides intense interactions between various natural processes and human activities which are the important factors for development. India has a long coastline of about 5422 km excluding islands which includes 8 states and 3 union territories. This region assumes its importance because of high productivity of its ecosystems, concentration of population, exploitation of natural resources, development of various industries, discharge of waste effluent increasing load on harbours and above all petroleum exploration activities. This region offers plenty of scope for horticulture. To address the large and systemic challenges, inclusiveness and rapid conversion of knowledge into needed and commercial products will be the key to innovative and affordable solu-

tions. Generating new technologies and innovations to meet the emerging challenges by the public and private sectors needs to be encouraged through commensurate policies. Professionals, farmer producer organizations (FPOs), farmer producer companies (FPCs), self-help groups (SHGs), cooperatives and NGOs are to be effectively involved in scaling innovations with easy access to technology, policy and financial support and hand-holding from the research institutions. Thus, financing on easy terms, risk management, and incentives from state administration will attract entrepreneurs to establish successful start-ups in coastal areas.

References

Anonymous. 2020. Area and Production of Horticulture Crops. National Horticulture Board.

Bharathi, S., Cheryl, A., Uma, A., Ahilan, B., Aanand, S. and Lingam, R.S.S. 2019. Application of Renewable Energy in Aquaculture. Aqua International March Issue: p. 48, 50, 52 & 54.

Blakeney, M. & Siddique, K.H.M. eds 2020. Local Knowledge, Intellectual Property and Agricultural Innovation. Springer Nature Singapore Pvt. Ltd., 247p

Gatzweiler, Franz W.& von Braun, Joachim. 2016. Technological and Institutional Innovations for Marginalized Smallholders in Agricultural Development. Springer International Publishing, Switzerland AG. ISBN 978-3-319-25718-1; XV, 435p.

Gill, S. S., Chana, I., and Buyya, R. 2017. IoT based agriculture as a cloud and big data service:the beginning of digital India. Journal of Organizational and End User Computing. 29(4):1-23.

Karun, A., Jayasekhar, S. and Muralidharan, K. 2021. Coconut based cropping systems for enhancing profitability, ensuring sustainability and transcending towards nutritional security. *Indian Horticulture*, 66(5).

Khare, V., Nema, S. and Baredar, P. 2013. Status of solar wind renewable energy in India.Renewable and Sustainable Energy Reviews. 27:1-10.

Saha Sanjoy, Singh DP, Sinhababu DP, Mahata KR, Behera KS and Pandey MP. 2008. Improved rice based Production systems for higher and sustainable yield in eastern coastal plain in India. Journal of Indian Society of Coastal Agricultural Research 26(2) (Special Issue): 74-79.

Seth, A. and Ganguly, K. 2017. Digital Technologies Transforming Indian Agriculture. In: The Global Innovation Index 2017: Innovation Feeding the World, Dutta, S, B Lanvin and S Wunsch-Vincent (eds.), Cornell University, INSEAD, and WIPO, Ithaca, Fontainebleau and Geneva. pp. 105-111.

Yadav JSP. 2008. Sustainable management of coastal ecosystem for livelihood security: a global perspective. *Journal of Indian Society of Coastal Agricultural Research* 26(1) (Special Issue): 5-11.

Lead Paper

Technological Advancements to Improve Vegetable Production in Coastal India

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Introduction

Coastal areas are commonly defined as the interface or transition areas between land and sea, including large inland lakes. The global coastline is about 440,000 km long (Ouillon, 2018). More than 600 million people live in coastal areas that are less than 10 meters above sea level. Nearly 2.4 billion people live within 100 km of the coast. India has a coastline of 7516.6 km-5422.6 km of mainland coastline and 1197 km of Indian islands. Indian coastline touches nine states and two union territories. It is noted that in India, the coastal ecosystem covers an area of 10.78 million ha along coastline. There is a total of 71 districts in these states in the coastline. All the districts together cover about 3.99 lakh square km of the area to form the coastal ecosystem of the Country with an estimated population accounting for about 17% of the total population of the country (Vision 2050, 2015). The inhabitant of this region depends primarily on coastal and marine habitats for food, building sites, transportation, recreational areas, and waste disposal. The unique coastal ecosystem provides immense opportunities for food and livelihood security, economic development and environmental protection. At the same time, there are a number of challenges to be addressed to optimize sustainable benefits from the system and improve the livelihoods of millions who depend on these resources.

Coastal zones are extremely dynamic and fragile, with wide variation in soils, water and land uses, and with significant long-term and seasonal changes. Natural disturbances are common in these areas and are further aggravated by climate change adversities; making them highly unstable. Livelihood sources in coastal tropical zones are quite diverse and are dominated by agriculture and aquaculture activities. The people of these zones depend mainly on low productive agriculture due to constraints such as prolonged water logging after the wet season, saline soils, and scarcity of good quality irrigation water in the dry season. Coastal land salinity problems are attributed to the phenomenon of saltwater intrusion. Changing rainfall patterns and increased frequency of extreme events attributed to climate change are inciting added vulnerabilities to livelihoods and resources in the region. With 520 cyclones between 1891 and 2018, the east coast has been more vulnerable than the west coast with 126.

Farming in Coastal areas

Agriculture

The people of coastal zones depend mainly on low productive agriculture. In the coastal areas adoption of several farming system like, floating garden, embankment cultivation, etc. need to be adopted for mixed cropping system that encompasses vegetables, fruits, plantation crops, spices, herbs, ornamental and medicinal plants as well as livestock that can serve as a supplementary source of food and income. Agricultural activities in the watersheds with drastic impacts on coastal ecosystems are: eutrophication of coastal waters by riverine fluxes of sediments (Hedges and Keil, 1995; Beusen et al., 2005) and the attendant plant nutrients (e.g., N, P, K) leading to anoxia (Selman et al., 2008) through inputs of fertilizers, herbicides, pesticides, and heavy metals

(Nobi et al., 2010); wetland drainage; and deforestation and adoption of plow-based agriculture. Hence, it is urgently required to develop awareness as well as different models to utilize the available resources in scientific method for producing fresh vegetables and fruits to meet up the food and nutritional security of the farmers of the coastal areas. The farmers primarily grow low-yielding long-season traditional varieties of rice during the wet season and much of the land lies fallow during the dry season.

Vegetable farming in India and costal areas.

Vegetables

Around 400 species contribute to global vegetable crop diversity (Arora, 2003). Over 97 species of higher plants are thought to have been cultivated and used as vegetables in India (Pareek et al., 2000; Nayar et al., 2003). Farmers and home gardeners grow nearly 60 vegetables commercially and in-home gardens for fresh consumption (Arora, 1991; Kochhar, 1998). Over 20 different families of higher plants have contributed to vegetable crops in India. India is home to a wide variety of veggies and vegetables accounts for 59 percent of all horticultural production in India. By having 380 g of vegetables available per capita, India has met its objective for vegetable output, which surpasses the daily recommended quantity of 250 g of vegetables. India is the second largest producer of vegetables in the world next only to China with an estimated production of about 193.6 million tonnes from an area of 10.29 million hectares at an average yield of 18.8 tonnes per hectare. India shares about 16.5 % of the world output of vegetables from about ~5.25% of cropped area in the country. India is the largest producer of ginger and okra amongst vegetables and ranks second in production of potatoes, onions, cauliflowers, brinjal, Cabbages (NHB, 2018). By and large vegetable research has been carried out in India by Public Institutions. However, in recent years there has been an effort to start R & D activities by some private companies independently and some with foreign collaboration. Till date a total of 553 vegetable varieties in 30 vegetable crops have been recommended for cultivation in various agro-climatic zones of the country. This includes 329 O.P. varieties, 168 hybrids and 56 O.P./ hybrids resistant to different biotic and abiotic stresses. However, the vegetable varieties suitable for costal areas are very less. Development of multiple stress tolerant (salinity, submergence and mineral toxicity) varieties for coastal saline areas should be the focus. Of the total of 6.73 million ha of salt effected area, 2.56 million ha is reported to exist in coastal areas, accounting for about 30 percent of the total salt affected soils of India. Majority of the vegetable crops, such as bean, carrot, celery, eggplant, lettuce, muskmelon, okra, pea, pepper, potato, spinach, and tomato, have very low salinity threshold (EC_t, which ranged from 1 to 2.5 dS m^{-1} in saturated soil). Salinity-induced oxidative stressed in vegetables could affect the qualitative and quantitative value of vegetables as this oxidative stress could lead to a plethora of biochemical and physiological changes in plants (Kashyap et al., 2020, 2021). ICAR-Goa has developed some cultivars of vegetables suitable for cultivation in the costal areas such as in cowpea; Goa Cow pea-3, Brinjal; Goa Brinjal 1, 2, 3 and 4 and amaranth; Goa Tambdi Bhaji-1. Vegetable varieties were also released for cultivation in the different states of the coastline, however the specifically adapted to coastal environment are only a few.

Mitigation of stress in costal vegetable farming.

Traditional ways of mitigating the stress

The pertinent question arises here that, what can farmers do to effectively respond to salinization and ensure farm production is maximized? There is a solution— massive promotion of Good Agricultural Practices including the use of tolerant varieties in cultivation in coastal saline

environment among farmers up to a level that has achieved significant and wider strategic adoption. Farmers have to implement adaptation practices by improving the yield through application of fertilizers and switching from local varieties with long growth duration to high yield varieties with shorter growth duration. Recently, many new varieties were released for commercial production that have tolerance to salinity and flash flooding, along with the adjustments on the cropping calendar to avoid the drought-salinity intrusion cycles that can led to an increased production during autumn and winter seasons. A prudent strategy of sustainable management of coastal ecosystems involves reducing land-based pollution by adoption of conservation-effective measures include conservation agriculture (Lal, 2015), regenerative agriculture (Lal, 2020), agroforestry, and complex farming systems which create a positive soil/ecosystem, carbon budget (Lal, 2004). These measures would reduce runoff and soil erosion, minimize non-point source pollution, and decrease fluxes of plant nutrients and other pollutants.

Grafting for mitigating the salinity stress

Improving the productivity of vegetable crops is a challenge under salt-affected soil or water. Hence, increasing salt tolerance in vegetable crops will have a greater impact in nutritional and economic security, particularly where salinity in soil and water are widespread (Singh et al., 2020). Traditional breeding programs have been attempted to improve salt tolerance in crop plants (Borsani et al., 2003), but the commercial success is limited due to the trait's complexity. Currently, major efforts are being directed toward genetic transformation in plants to increase their tolerance, and despite the trait's complexity, the transfer of a single gene or a few genes has resulted in claims of improved salt tolerance, such as the expression of genes involved in the control of Na^+ transport (Gaxiola et al., 2001). However, the transgenics are highly regulated by the Indian government. Unless a full proof practical and faster breeding tool comes in vogue, a well-proven fast and eco-friendly technique "vegetable grafting" can be deployed to increase tolerance to stresses in vegetables. Vegetable grafting, in fact, has emerged as an efficient tool to sustainably increase vigor and yield of commercial cultivars under challenged growth environment by mechanically attaching with resistant root genotypes. In grafting, some rootstocks may have better performance than the others, though their response may change depending on level of salt concentration in the growth medium (Singh et al., 2020; Bayoumi et al., 2021). Numerous reports have demonstrated the ameliorative response of grafting to salinity stress in cucurbitaceous crops (e.g., melon, watermelon, and cucumber) involving the Cucurbita interspecific hybrid rootstocks (Goreta et al., 2008; Rouphael et al., 2012). The agronomic performance of pepper cv. "Adige" under natural salinity condition was clearly evident with 75% higher yield and with 31% lesser fruit damage (blossom end rot) when it was grafted onto a salt-tolerant accession "A 25" as rootstock in comparison with non-grafted control plants (Penella et al., 2016). Eggplant ("Suqi Qie") grafting onto the rootstock of wild eggplant (*Solanum torvum* cv. "Torvum vigor") provided salinity tolerance by minimizing the yield reduction under saline stress (Wei et al., 2009).

Modern approaches.

Tremendous advances have been made in understanding the genetic control of salinity tolerance, which has provided molecular tools for developing salt-tolerant varieties for the coastal regions. A number of quantitative trait loci (QTLs) for salinity tolerance have been identified using efficient single nucleotide polymorphism (SNP) genotyping methods. These QTLs provide useful targets for marker assisted backcrossing of large-effect loci to increase tolerance in breeding lines. In cucumber mapping of salinity stress QTLs have been successfully achieved by Kere et al. (2017). They mapped QTLs associated with relative leaf numbers (RLN14) of plant and in terms of

assessing salt tolerance (TOL) on chromosome number 3. More recently, Liu et al. (2021) mapped a highly reproducible QTL (*qST6.1*) for salt tolerance on chromosome 6 using a RIL population.

Transgenic technology for salt stress tolerance has been reported as one of the most crucial tools in developing the stress-tolerant vegetable crops (Kumar et al., 2017). For example, to avoid salt tolerance in plants, genes encoding for proteins like Na^+ "exclusion" (PM-ATPases with SOS1 antiporter, and HKT1 transporter), vacuolar compartmentalization of Na^+, V-H^+, ATPase and V-H-PPase with NHX antiporter, and also other genes encoding proteins such as aquaporins and dehydrins that are involved in mitigation of water stress during salinity have been transferred and/or overexpressed in tomato or Arabidopsis through transgenic technology (Kotula et al., 2020). Many osmoprotectant genes like *P5CS, mtlD*, and *AtBADH* have been transferred to potato, which significantly improves the salt tolerance under salt stress (Karthikeyan et al., 2011; Rahnama et al., 2011; Zhang et al., 2011). In tomato far salt stress tolerance, osmoprotectants genes like *BADH-1*, *ToOsmotin*, *Ectoine* (*ectA, ectB*, and *ectC*), and *coda* gene have been transformed in tomato, which reduces the impact of salt stress by encoding osmoprotectant solutes (Moghaieb et al., 2000, 2011; Goel et al., 2010; Wei et al., 2017). In water melon *HAL1* transferred which encodes for 32 kDa water soluble proteins which protects from salt induced osmotic stress (Bordas et al., 1997). Park et al. (2014), Han et al. (2015), and Kim et al. (2015) transformed bottle gourds with *AVP1* which encodes vacuolar H^+-pyrophosphatase, which regulate the proton pump and ultimately maintains the cellular acidity to avoid salt stress. The cole crops are very sensitive to the salt stress, and different genes like *CodA*, *PgNHX1*, *OsNASI*, *BnSIP1-1*, *APX*, *SOD*, and *LEA41* have been transferred to sustain salt stress (Park et al., 2005; Wang et al., 2010; Kong et al., 2011). At the same time, new biotechnology tools are now available using CRISPR/Cas9 for precise gene editing, which can enable validation of candidate genes through gene knockouts, as well as providing a means for allele replacement as a fast-track method for testing natural allelic variation. Machine learning can also be used to accurately predict the location and severity of floods.

References

Arora R.K. (1991) Plant diversity in the Indian Gene centre. In: Plant genetic resources - conservation and management (eds Paroda RS and Arora RK), Intern. Board for Plant Genetic Resources, Regional Office for South Asia and South East Asia and National Bureau of Plant Genetic Resources Campus, New Delhi, pp 25-54.

Arora R.K. (2003) Genetic resources of underutilized vegetables and their regions of diversity. Veg. Sci. 30(1): 1-9.

Bayoumi, Y., Abd-Alkarim, E., El-Ramady, H., El-Aidy, F., Hamed, E.-S., Taha, N., et al. (2021). Grafting improves fruit yield of cucumber plants grown under combined heat and soil salinity stresses. Horticulturae 7:61.doi: 10.3390/horticulturae7030061

Beusen, A.H.W., Dekkers, A.L.M., Bouwman, A.F., Ludwig, W. and Harrison, J. (2005). Estimation of Global River Transport of Sediments and Associated Particulate C, N, and P. Global Biogeochemical Cycles 19, no. 4 (December 1). https://doi.org/10.1029/2005GB002453.

Bordas, M., Montesinos, C., Dabauza, M., Salvador, A., Roig, L. A., Serrano, R., et al. (1997). Transfer of the yeast salt tolerance gene *HAL1* to *Cucumis melo* L. cultivars and in vitro evaluation of salt tolerance. Transgenic Res. 6, 41–50. doi: 10.1023/A:1018453032336

Borsani, O., Valpuesta, V., and Botella, M. A. (2003). Developing salt-tolerant plants in a new century: a molecular biology approach. Plant Cell Tiss. Org. Cult. 73, 101–115.doi: 10.1023/A:1022849200433

Gaxiola, R. A., Li, J. S., Undurraga, S., Dang, L. M., Allen, G. J., Alper, S. L., et al. (2001). Drought- and salt-tolerant plants result from overexpression of the *AVP1* H^+- pump. Proc. Natl. Acad. Sci. U.S.A. 98, 11444–11449.doi:10.1073/pnas.191389398

Goel, D., Singh, A. K., Yadav, V., Babbar, S. B., and Bansal, K. C. (2010). Overexpression of osmotin gene confers tolerance to salt and drought stresses in transgenic tomato (*Solanum lycopersicum* L.). Protoplasma 245, 133–141. doi: 10.1007/s00709-010-0158-0

Goreta, S., Bucevic-Popovic, V., Selak, G. V., Pavela-Vrancic, M., and Perica, S. (2008). Vegetative growth, superoxide dismutase activity and ion concentration of salt-stressed watermelon as influenced by rootstock. J. Agric. Sci. 146, 695–704.doi: 10.1017/S0021859608007855

Han, J. S., Park, K. I., Jeon, S. M., Park, S., Naing, A. H., and Kim, C. K. (2015). Assessments of salt tolerance in a bottle gourd line expressing the Arabidopsis H^+-pyrophosphatase *AVP 1* gene and in a watermelon plant grafted onto a transgenic bottle gourd rootstock. Plant Breed. 134, 233–238.doi: 10.1111/pbr.12253

Hedges, J.I., and Keil, R.G. (1995). Sedimentary Organic Matter Preservation: An Assessment and Speculative Synthesis. Marine Chemistry 49 (2): 81–115.

Karthikeyan, A., Pandian, S. K., and Ramesh, M. (2011). Transgenic indica rice cv. ADT 43 expressing a 1-pyrroline-5-carboxylate synthetase (P5CS) gene from *Vigna aconitifolia* demonstrates salt tolerance. Plant Cell Tis. Org. Cult. 107, 383–395.doi: 10.1007/s11240-011-9989-4

Kashyap, S. P., Kumari, N., Mishra, P., Moharana, D. P., Aamir, M., Singh, B., et al. (2020). Transcriptional regulation-mediating ROS homeostasis and physiobiochemical changes in wild tomato (*Solanum chilense*) and cultivated tomato (*Solanum lycopersicum*) under high salinity. Saud. J. Biol. Sci. 27, 1999–2009. doi: 10.1016/j.sjbs.2020.06.032

Kashyap, S. P., Kumari, N., Mishra, P., Moharana, D. P., and Aamir, M. (2021). Tapping the potential of Solanum lycopersicum L. pertaining to salinity tolerance: perspectives and challenges. Genet. Res. Crop Evol. 68, 2207–2233. doi: 10.1007/s10722-021-01174-9

Kere, G.M., Chen, C., Guo, Q., Chen, J., (2017). Genetics of salt tolerance in cucumber (Cucumis sativus L.) revealed by quantitative traits loci analysis. Sci. Lett. 5 (1), 22–30.

Kim, B. O., Han, J. S., Park, K. I., Jeon, S. M., and Kim, C. K. (2015). Absence of AVP1 transcripts in wild type watermelon scions grafted onto transgenic bottle gourd root stocks. J. Plant. Biotec. 42, 13–18.doi: 10.5010/JPB.2015.42.1.13

Kochhar SL (1998) Economic botany in the tropics. II edn. Macmillan India Ltd., New Delhi.

Kong, F., Mao, S., Du, K., Wu, M., Zhou, X., Chu, C., et al. (2011). Comparative proteomics analysis of *OsNAS1* transgenic *Brassica napus* under salt stress. Chin. Sci. Bull. 56, 2343–2350.doi: 10.1007/s11434-011-4585-x

Kotula, L., Garcia Caparros, P., Zörb, C., Colmer, T. D., and Flowers, T. J. (2020). Improving crop salt tolerance using transgenic approaches: an update and physiological analysis. Plant Cell

Environ. 43, 2932–2956.doi: 10.1111/pce.13865

Kumar, J., Singh, S., Singh, M., Sri vastava, P. K., Mishra, R. K., Singh, V. P., et al. (2017). Transcriptional regulation of salinity stress in plants: a short review. Plant Gene 11, 160–169. doi: 10.1016/j.plgene.2017.04.001.

Lal, R. (2004). Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. Science 304, no. 5677 (June 11): 1623–1627.

Lal, R. (2015). A System Approach to Conservation Agriculture. Journal of Soil and Water Conservation 70, no. 4 (July 1): 82A-88A.

Lal, R. (2020). Regenerative agriculture. Journal of Soil and Water Conservation 75: doi:10.2489/jswc.2020.0620A

Liu, D., Dong, S., Bo, K., Miao, H., Li, C., Zhang, Y., Zhang, S., Gu, X., (2021). Identification of QTLs Controlling Salt Tolerance in Cucumber (Cucumis sativus L.) Seedlings. Plants 10 (1), 85

Moghaieb, R. E. A., Tanaka, N., Saneoka, H., Hussein, H. A., Yousef, S. S., Ewada, M. A. F., et al. (2000). Expression of betaine aldehyde dehydrogenase gene in transgenic tomato hairy roots leads to the accumulation of glycine betaine and contributes to the maintenance of the osmotic potential under salt stress. Soil Sci. Plant Nutr. 46:3.doi: 10.1080/00380768.2000.10409153

Moghaieb, R. E., Nakamura, A., Saneoka, H., and Fujita, K. (2011). Evaluation of salt tolerance in ectoine-transgenic tomato plants (Lycopersicon esculentum) in terms of hotosynthesis, osmotic adjustment, and carbon partitioning. GM Crops. 2, 58–65.doi: 10.4161/gmcr.2.1.15831

Nayar ER, Pandey A, Venkateswaran K, Gupta R, Dhillon BS (2003) Crop plants of India- checklist of scientific names. National Bureau of Plant Genetic Resources, New Delhi.

NHB 2018: Horticultural Statistics at a Glance 2018

Nobi, E.P., Dilipan, E., Thangaradjou, T., Sivakumar, K. and Kannan, L. (2010). Geochemical and Geo-Statistical Assessment of Heavy Metal Concentration in the Sediments of Different Coastal Ecosystems of Andaman Islands, India. Estuarine, Coastal and Shelf Science 87, no. 2: 253–264.

Ouillon S. (2018). Why and How Do We Study Sediment Transport? Focus on Coastal Zones and Ongoing Methods. Water, 10, 390; doi:10.3390/w10040390

Park, B. J., Liu, Z., Kanno, A., and Kameya, T. (2005). Genetic improvement of Chinese cabbage for salt and drought tolerance by constitutive expression of a *B. napus LEA* gene. Plant Sci. 169, 553–558.doi: 10.1016/j.plantsci.2005.05.008

Park, M., Han, J., Ahn, Y., Kim, J., Lee, H., Jang, Y., et al. (2014). Ectopic expression of Arabidopsis H^+-pyrophosphatase *AVP1* enhances drought resistance in bottle gourd (*Lagenaria siceraria* Standl.). Plant Cell Tiss. Org. Cult. 118, 383–389.doi: 10.1007/s11240-014-0490-8.

Penella, P., Landi, M., Guidi, L., Nebauer, S. G., Pellegrini, E., Bautista, A. S., et al. (2016). Salt-tolerant rootstock increases yield of pepper under salinity through maintenance of photosynthetic performance and sinks strength. J. Plant Physiol. 193, 1–11.doi: 10.1016/j.jplph.2016.02.007

Rahnama, H., Vakilian, H., Fahimi, H., and Ghareyazie, B. (2011). Enhanced salt stress tolerance in transgenic potato plants (*Solanum tuberosum* L.) expressing a bacterial *mtlD* gene. Acta Phys. Plant 33, 1521–1532.doi: 10.1007/s11738010-0690-8

Rouphael, Y., Cardarelli, M., Rea, E., and Colla, G. (2012). Improving melon and cucumber photosynthetic activity, mineral composition, and growth performance under salinity stress by grafting onto Cucurbita hybrid rootstocks. Photosynthetica 50, 180–188.doi: 10.1007/s11099-012-0002-1

Selman, M., Sugg, Z., Greenhalgh, S. and Diaz, R. (2008). Eutrophication and Hypoxia in Coastal Areas. Washington, D.C.: World Resources Institute. https://www.wri.org/publication/eutrophication-and-hypoxia-coastal-areas.

Singh, H., Kumar, P., Kumar, A., Kyriacou, M. C., Colla, G., and Rouphael, Y. (2020). Grafting tomato as a tool to improve salt tolerance. Agronomy 10:263. doi:10.3390/agronomy10020263

Vision 2050: ICAR-Vision-2050 document of ICAR-Central Coastal Agricultural Research Institute (CCARI), Goa (2015). Published by ICAR, New Delhi.

Wang, Q. B., Xu, W., Xue, Q. Z., and Su, W. A. (2010). Transgenic *Brassica chinensis* plants expressing a bacterial *codA* gene exhibit enhanced tolerance to extreme temperature and high salinity. J. Zhejiang Univ. Sci. B 11, 851–861. doi: 10.1631/jzus.B1000137

Wei, D., Zhang, W., Wang, C., Meng, Q., Li, G., Chen, T. H., et al. (2017). Genetic engineering of the biosynthesis of glycinebetaine leads to alleviate salt-induced potassium efflux and enhances salt tolerance in tomato plants. Plant Sci. 257, 74–83. doi: 10.1016/j.plantsci.2017.01.012

Wei, G., Yang, L., Zhu, Y., and Chen, C. (2009). Changes in oxidative damage, antioxidant enzymes activity and polyamine contents in the leaves of grafted and non-grafted eggplant seedlings under stress by excess of calcium nitrate. Sci. Hortic. 120, 443–451.doi: 10.1016/j.scienta.2008.12.009

Zhang, N., Si, H. J., Wen, G., Du, H. H., Liu, B. L., and Wang, D. (2011). Enhanced drought and salinity tolerance in transgenic potato plants with a *BADH* gene from spinach. Plant Biotech. Rep. 5, 71–77.

Lead Paper

Technological advancements to improve cashew productivity in coastal regions

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Introduction

Cashew (Anacardium occidentale L.) has progressively gained importance as a beneficial horticultural crop and its cultivated area is gradually increasing in the traditional coastal regions of Maharashtra, Goa, Karnataka and Kerala on the West Coast and Tamil Nadu, Andhra Pradesh, Odisha and West Bengal on the East Coast. This has been possible due to the untiring efforts of the developmental government agencies, extension activities of SAUs as well as promotion of cashew by various NGOs. Cashew cultivation has been well received and is spreading speedily in non-traditional areas such as Bastar region of Chhattisgarh and plains regions of Karnataka, Gujarat, Jharkhand and in Nagaland, Meghalaya, Tripura and Manipur states under the NEH region. Due to increasing affordability by the domestic consumers, its high nutritional value being appreciated by health-conscious public and comparatively lesser cultivation costs; the demand for cashew kernels continues to increase both in domestic and international market. During 2020-21, total production of raw cashewnuts (RCN) in the country was 7.78 lakh tonnes from 12.20 lakh ha of land with a productivity of 637.00 kg/ha. Noticeably, the mean productivity of raw cashewnut in India is very low. There is a wide gap between potential productivity and current productivity. The major factors for low productivity are: the large plantations under seedling origin, low levels of soil fertility, intense water stress during cropping season, poor orchard management practices and severe / sporadic pest incidence and climatic variations leading to significantly low fruit set and raw nut yields. Hence, it is imperative to adopt effective scientific technologies to boost the productivity of cashew. The recent advances in various disciplines of cashew production technology; which have been the outcome of research at the ICAR–Directorate of Cashew Research leading to higher cashew nut production for enhancing the farmers' income are presented hereafter.

Varieties Released

Nationwide adoption of grafts for planting has brought about a spectacular change in the uniformity of crop growth and harvesting season; however, there is a felt need for region specific varieties and premium nut varieties in both the domestic and international market. The recent breeding efforts were directed to attain this need. The efforts of hybridization programme in 1999-2000 yielded laudable success in obtaining several high performing hybrids. This Directorate has recently released two bold nut cashew varieties; Nethra Ganga(H-130) and Nethra Jumbo (H-126) and one dwarf variety, Nethra Vaman.

Nethra Ganga(H-130)

Among hybrids generated, H-130 of the combination has desirable features such as precocious bearing, high yield with bold nut, high shelling percentage, positive response to pruning and thereby it is amenable for both high density and ultra-density planting.

The plants have sparse canopy with extensive branching behavior with flushing from October–November onwards and fruiting continues till April to May. This has mixed flowering phase, in which more than 100 bisexual flowers/inflorescence were observed. Final fruit retention was 8-10 nuts per inflorescence. The average nut weighs around 10-14 g. The yield performance of H-130 was significantly higher in comparison with commercial varieties such as; Bhaskara and NRCC Sel.-2 at three different spacings for three harvests. The hybrid H-130 recorded the highest yield in all the three different spacings of planting viz.,, 2.5 X 2.5 m (2432 kg/ha), 5 X 5 m (1212 kg/ha) and 7.5 X 7.5 m (723.9 kg/ha) over other two commercial varieties. At 2.5 X 2.5 m planting H-130 recoded 3 times higher yield than the NRC Sel. 2 and 15 times higher than Bhaskara variety.in the 4th year.

H-130 fruits at harvestable stage

Kernels of H-130 (W150-W180)

Nethra Jumbo (H-126)

The hybrid, H 126 is recommended on account of its uniform sized jumbo nuts (12g nut weight), with premium grade kernel (W130), higher nut yield over the released check varieties; Bhaskara and NRCC Selection-2 and cluster bearing nature with 5- 6 fruits per panicle while the bearing starts from second year after planting, the annual flowering occurs between 1st week of December to 1st week of March, having medium flowering duration (64 days)

The recorded nut yield of this hybrid was 7.4 kg/plant (7th harvest) with an average productivity of 1.02 t/ha. Under identical evaluation conditions, it yielded 60% higher yield than Bhaskara and 110% higher yield than NRCC Selection-2. The hybrid recorded an appreciable apple weight of 102g with a juice content of 72% with a TSS of 13 degree brix rendering it suitable for cashew-apple value added products.

Fruiting bunch of H-126

Cluster bearing in H-126

Nethra Vaaman

The natural growth habit of cashew is generally tall and vigorous with wide spreading branches, farmers manage the canopy up to a height of 15 feet by annual pruning when planted at 8m x 8m. In high density planting systems (3 m x 3m, 4 m x 4m), plants need to be managed within 5-6 ft by annual pruning. In this context, for the first time, the Directorate has identified a dwarf cashew variety named Nethra Vaaman from the seedling progenies planted out of imported bulk nuts samples of Brazil. Upon characterisation and evaluation, its slow growth and dwarf character was confirmed. This was evaluated for ten years and recently it is released and recommended for cultivation. The yield parameters are as follows; nut weight being 5.5-6.0gm, apple weight 50.0 g with nut yield of 1.0 to 1.5 kg in the 4th year.

	
Fruiting bunch of Nethra Vaaman	Fruits of Nethra Vaaman

Soil & Water Conservation Techniques

Cashew is typically grown as a rainfed crop; hence, adoption of soil and water conservation techniques constitutes an essential part of successful cashew production technology. Cashew is generally grown in slopy areas where the top soil is eroded; which needs to be re-generated and surface runoff during the monsoons has to be conserved. Adoption of soil and water conservation measures significantly reduces the surface runoff, checks soil loss and nutrient loss and appreciably increases the soil moisture content and replenishes groundwater level. Water deficit during fruiting season ranges from 59 to 183 mm in West Coast (from March to May) whereas, in East Coast it is 90 to 155 mm (from March-April).

Following in situ soil and water conservation is one of the effective methods for harvesting the pre-monsoon and post-monsoon precipitation and make it available to the cashew plant during this critical period. There is a prospect of increased production of cashew by adopting soil and water conservation measures along with high yielding varieties of cashew. The effective S&W measures found to be effective at ICAR – DCR are enlisted below.

Normal tree base terrace at 2 m radius around the plant or reverse terrace

Providing a terrace at 2 m radius around the plant within three years of planting is beneficial in conserving soil moisture. Terrace (2 m radius) should be taken up around each plant by cutting soil from the upper portion of the slope and filling the lower portion so that soil around the plant is

flattened. Terrace should be in such a way that the upper side of the slope should have a depression or a catch pit measuring 2.0 m length, 0.30 m width and 0.45 m depth. Reverse terraces of size 2.0 m length and 2.0 m width by cutting soil sloped towards the gradient from the upper portion and filling the lower portion to a considerable height (30 to 50 cm) was also found effective in conserving moisture and increasing nut yield by 30 to 45%.

Individual tree base terrace with crescent bund at 2 m radius

Forming terrace at 2 m radius at the base of the plant and making a semi-circular / crescent bund of size 6.2 m length, 1.0 m width and 0.5 m height around each plant on the upstream side of the slope; so that a trench of size 6.2 m length and 0.5 m depth will be formed on the upstream which can store around 800 to 1000 litres of water during pre-monsoon and post-monsoon showers.

Soil and water conservation measures such as modified crescent bund along with coconut husk burial treatments increased the growth of cashew plants and cumulative cashew yield indicating 32 to 35% increase in yield. These treatments reduced the annual surface runoff (20 and 22% of the annual rainfall compared to 37% of the annual rainfall in control) and soil loss (47 and 49% of control), increased the mean soil moisture content (15.6% and 15.8 % dry basis compared to 11.6% dry basis in control during March), and also led to higher nutrient content of the soil and leaf of cashew plants in the water conservation plot.

Coconut husk burial around cashew plants for improving water holding capacity

Coconut husks are to be buried in trenches of 1m width, 0.5m depth and 3.5m length opened across the slope between two rows of cashew. Three to four layers of coconut husks are to be buried one above the other with convex side of the first layer of the husks touching the ground After spreading a layer of litter / chopped weed growth and a thin layer of soil (around 2 cm) on the first layer of husks, the second layer of husks are to be laid in the same fashion as that of first layer The last layer of husks should be inverted so that convex side is facing the upper side. Finally, a thick layer of soil up to 10 cm thickness needs to be spread over this. Implementing coconut husk burial enhances soil and moisture conservation and serves as a supplementary source of potassium.

In East coast, cashew is mostly grown in plain area where the soil is sandy loam, red sandy loam or laterite soils. Hence, digging the basin area or ploughing the ground between two rows of cashew before summer rains enhances percolation and higher absorption of rain water. Availability of soil moisture during peak flowering and fruiting seasons retains more fruits resulting in higher yields. It was recorded that 25-30 % increased yield could be obtained by adopting soil and water conservation measures in cashew in different field trials.

Ultra High-Density Planting System

The present level of domestic RCN production is not sufficient to fulfill the processing requirement of cashew industries in the country (i.e, 20.0 lakh tonnes). Most of the cultivated cashew area is in degraded, non-fertile soils of east coast and west coast and hilly regions of the country and consequently the canopy spread is not covering the total ground area even after 5 to 8 years. With this background to enhance the productivity of cashew nut and thereby increasing income of cashew farmers a planting system of 'Ultra high density' planting in cashew was evaluated at the Directorate. Ultra-density planting in cashew recommends planting of 1111 to 1600 plants per ha, along with maintenance of productive canopy by timely regular pruning. Traditionally the spacing for planting was recommended at 8M x 8M (150 plants/ha) and up late recommendation of high density at the rate of 4M x 4M (625 plants/ha) but due to lack of effective canopy management technique a gradual nut yield decline was observed till recently.

	
View of 2nd year of orchard growth in ultra density planting in cashew	Well maintained ultra-density planted cashew plot

The canopy management can be done as follows: allow the graft to grow straight without any side sprouts up to 0.25 to 0.50 m, later the apical branch has to be cut to force primary branching and subsequent lateral branches can be trained on them. The cashew varieties having precocious flowering and positive response to pruning such as VRI-3, NRCC Sel-2, Ullal-1, Ullal-4 were found to be most suitable for ultra-high-density planting. It is noticed that highly precocious cashew varieties will set fruit during the 1st year of planting and in some situations from 2nd season onwards. Once the first harvest is completed (usually during May-June); first pruning at 1.0 m height from ground level needs to be taken up and subsequently annual pruning at same height shall be adopted every year.

The complete allotted space can be covered in 3rd year of planting and potential yield of the unit land can be realized from 3rd to 4th year of orchard life onwards. The yield in farmers' plot harvested in this method was up to 3 kg/plant after 3 years of planting which was much superior over existing orchards having National Average nut yield of less than 750 kg/ha. The technology is well taken by the farmers and growers and more than 100 farmers in various growing regions in Karnataka, Kerala and Tamil Nadu.

Conservation Of Pollinators

Though cashew inflorescence bears both male and hermaphrodite flowers; self-pollination does not occur because of the arrangement of male and female reproductive parts in the flowers. Further, cashew pollen grains are sticky in nature; indicating that wind has no role in pollination. This makes cross pollination by insects inevitable for the nut set in cashew. Low nut set and productivity in cashew orchards is due to lack of adequate pollination. Cashew flowers are visited by an array of bees, ants, wasps, butterflies, flies and moths which have been reported as pollinators in different cashew growing regions of the world.

Among the flower visitors, 13 bee species including three species of honey bees and 10 species of wild bees are considered as pollinators of cashew. The common pollinators include honey bees (Indian bee-Apis cerana indica, little bee - Apis florea) and native bees including viz.,Braunsapis picitarsis, Braunsapis mixta, Pseudapis oxybeloides, Ceratina hierogyphica, Lasiolossum sp. and Seledonia sp. Peak foraging period of these pollinators occurs during 11.00 am – 1.00 pm. avoiding spraying of insecticides during that period helps to prevent poisoning of pollinators. Increasing the activity of bees in cashew ecosystem through honey bee colonies and

different bee flora for the wild bees can be helpful to cashew farmers. Maintenance of suitable local bee flora was found to help in conserving the resident bee populations.

Artificial nesting sites nests have been developed for conservation of native bees. Artificial nesting sites can be prepared by drilling holes of 2.0 - 5.0 mm dia. into wooden pieces. These drilled wooden blocks and thin sticks of bamboo, lantana, Johnson grass, mussanda, etc., can be placed in a wooden shelter in which wild bees and also different wasps (excellent predators of several pests) to promote nesting and breeding.

*Arrows indicate wild bees (Braunsapis spp.) have successfully occupied the holes.

Homestead Processing Machinery

ICAR-Directorate of Cashew Research has developed several cashewnut processing machinery technologies suitable for small scale / homestead processing. These processing contraptions are designed to suit different agro-climatic requirements; enhance processing efficiency; reduce drudgery of processing personnel and to standardize the primeval roasting-type processing. Adequate emphasis is given for improving efficiency and quality of cashewnut processing

Concentric drum type rotary sieve grader for raw cashewnuts

In the raw cashewnut processing, the cashewnuts need to be graded based on size before processing to ensure an increase in the efficiency of shelling, peeling and grading processes. This can also enhance labour efficacy and ensure a higher wage-output ratio. Four different sizes of nuts irrespective of the varieties can be segregated using this appliance developed at ICAR-DCR. This technology is appropriate for ensuring profitability of medium to large scale cashewnut processing units.

Dual mode dryer for raw cashewnuts:

Raw cashewnuts are normally dried under the sun after harvest to reduce the moisture content to 8% which is the safest level for storage. Early onset of monsoon in Southern states and coincidence of rains and cashewnut harvest in North-Eastern hills of India will adversely affect the quality of raw

cashewnuts, thus fetching a lower price in the market. Therefore, in this context it was envisaged to develop a dual mode dryer for raw cashewnuts which can be operated by either electricity or locally available biomass such as cashew shell cake (CSC), pruned wood; crisscross branches cleared for light penetration etc. This dryer can also be alternatively used for drying of any farm commodities such as spices, arecanut etc.

Rotating drum roasting machine for raw cashewnuts

Cashew kernels obtained by drum roasting mode of processing imparts an unique taste and flavour which is domestically preferred over the steam boiled processed kernels. This is due to caramelization of sugars in the kernels. Traditionally drum roasting of raw cashewnuts is being followed in certain parts of Tamil Nadu, Andhra Pradesh, Kerala and also North Eastern states. However, these traditional methods are labour oriented where continuous activity and crucial attention of processing workers is needed for feeding the nuts, rotating the drum, regulating the fire below the drum and to remove the roasted cashewnuts aptly from drum. These activities are accomplished automatically by the rotating drum roasting machine developed by ICAR-DCR, which not only reduces cost of processing but also ensures higher quality of the roasted cashew nuts. Another important feature of this machine is that the chimney has been redesigned to lessen the release of smoke generated during roasting process.

Radial Arm type Cashew Kernel Extracting Machine

In this modified kernel extractor, cutting of the cashew nut shells and splitting of steam boiled cashewnuts is enabled in a single operation by pressing the foot-pedal. This machine is operated in a seated posture, which reduces back and shoulder strain faced by workers during shelling of raw cashewnut. This enhances the overall work efficiency and also kernel production rate is improved by using this shelling unit. This technology is suitable for small scale cashewnut processing units.

Hydraulic type cashew apple juice extractor

Currently usage of cashew apple is being given prime importance to augment the income of the cashew farmers. Extraction of juice is an essential operation in the preparation of cashew apple-based beverages such as RTS and Cashew Apple Cider. In order to minimize pulp fibers mixing in the juice leading to cloudiness; and ensure higher extraction of clear juice from cashew apple, a hydraulic juice extractor was developed. This juice extractor has an efficiency of extracting about 80-85% of juice

in the first pass and about 60-65% of the residual juice can be extracted in the second pass. This technology is suitable for cashew apple processing units and NGOs involved in value addition.

Cashew Apple Value Addition:

Cashew apple is a juicy fruit that can be an additional income source for cashew farmers. Due to lack of suitable technologies in handling cashew apple during harvest and post-harvest management; normally about 4-6 tonnes of cashew apple per hectare goes waste without utilization. The cashew apples are rich source of vitamin-C and also possess anti-bacterial properties. In spite of having high nutritional value, neither the fresh cashew apples nor the juice is preferred for consumption due to astringency. ICAR-Directorate of Cashew Research has developed several cashew apple technologies which are free from astringency and helpful to get additional income to cashew farmers and create employment opportunities in cashewnut growing areas of the country.

Cashew apple RTS (Cashlime):

The fresh cashew apple juice is blended with lime juice around 5.0 per cent and the unfermented beverage labelled "Cashlime" is a blended RTS suitable for consumption preferably chilled. This nutrient rich drink can be stored under refrigerated conditions for five months with full retention of nutrients and biochemical quality.

Cashew apple Cider:

Cashew apple juice is a good candidate for fermented beverage due to its high TSS content. Cashew apple cider is a less known fermented beverage with an alcohol content of 3.5-6.0%. However, traditional cashew apple fermented beverage i.e. Feni from Goa has alcohol content of 42% which may have adverse effect on health. Whereas cashew apple cider with several minerals and vitamins can have certain beneficial effects.

Cashew apple Jam:

For a longer shelf life and ensuring larger levels of utilization of the cashew apple it was felt desirable to standardize cashew apple based jam recipes. Cashew apple jam is an antioxidant rich functional food. ICAR-Directorate of Cashew Research has standardized a protocol for astringency free cashew apple jam, which could be stored for 6 months at room temperature. This preparation has added pectin from guava pulp and has good smearing texture.

Cashew apple Jelly:

Cashew apple jelly is yet another product which has been very well received; it is an attractive semisolid translucent product of cashew apple juice and sugar. Jelly making is a good approach to preserve fruit flavors which is relished by most consumers. It is also an easy-to-prepare value added product without the need for any specialized processing equipment.

Lead Paper

Sustainable development of plantation crops in the coastal region

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In the emerging agricultural scenario with the escalation in the cost of inputs and labour, deterioration in production environment and impacts of climate changes, enhancing agricultural productivity through sustainable use of natural resources and high use efficiency of inputs gain greater importance. Production system management through efficient use of resources assumes great significance to achieve higher productivity, profitability and sustainability in plantation crops. Technological advancements made in development of production technologies involving perennial tree crop based cropping and farming systems, integrated nutrient management, organic farming and bio-resource management, water management and soil and water conservation and harvesting technologies have been proved to be important to increase the sustainability of the crops. Studies conducted at CPCRI indicated that high density multi species cropping and integrated farming (involving animal husbandry enterprises) are more dependable in production and more sustainable in terms of resource conservation, ecological and socio-economic advantages than simple monoculture. Enhanced yields in diverse cropping systems were resulted from a variety of mechanisms such as more efficient use of resources (light, water, nutrients) improved microclimate and soil properties (physical, chemical and biological) and reduced pest damage. Crop diversification complimented with recycling of crop residues improved the soil quality and productivity and reduced inorganic fertilizer input.

Increased use efficiency of inputs has been achieved through integrated soil fertility management with balanced inorganic inputs and nutrient substitution with green manure legumes, vermicompost and bio-fertilizers. Among the various methods tried, drip irrigation has proved successful in exhibiting high water productivity by saving irrigation water to the extent of 34% in coconut when compared to conventional methods of irrigation. Fertigation schedule for coconut and arecanut has been standardized which reduces the fertilizer requirement by 50% and 25% apart from the savings in irrigation water. Protocol for organic production of coconut has been standardized through crop residue recycling by vermicomposting, *in situ* generation and incorporation of N_2 fixing leguminous green manures, bio-fertilizers and drip irrigation. An increase in coconut yield to the extent of 275% under coastal sandy soil was achieved with improved technologies over the conventional methods. Similarly arecanut yield increase was to the extent of 75% over conventional technologies.

Precision farming should receive greater attention to identify critical nutrient information for site specific management to improve input use efficiency and soil health. Carbon sequestration in the below ground in form of organic carbon and microbial dynamics in cropping systems should receive adequate attention. More focus is required on the use of bio-fertilizers, biological N fixers and other microbial agents for achieving sustainability and higher resource use efficiency.

S3-OP1

Prioritization of research and development issues for vegetable seeds in India

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Seeds being the repository of the genetic potential of crop species are the primary basis for human sustenance. Seed is recognized to be the cheapest source, yet the most critical single input for enhancing vegetable productivity up to 15–20%. The Indian vegetable seed sector is established with tremendous potential to grow beyond the boundaries of the domestic market. Being high value per unit weight, the vegetable seed segment has a significant share in the overall seed market in monetary terms. Besides these opportunities, the Indian seed sector has several issues and challenges such as the price of vegetable seeds in the market being exorbitantly high, farmers are facing problems of spurious seed, low germination percentage, unavailability of quality seeds on time, poor and faulty storage of seeds. Currently, the Indian seed sector comprises formal and informal systems where the formal system supplies only 30% of seeds while the informal system fulfils 70% of seed demand. The formal system includes public sector agencies and private seed companies. The public sector is mainly dealing with seed production of low value and high-volume crops (cereals and pulses) to meet the food security of the country while private companies are focused on high value and low volume crops like vegetables, hybrids and Bt-cotton etc. Research and development interventions are required to overcome these problems. The research priorities in the vegetable seed sector which have been identified should be considered for research coordination and to be informed research managers for policymaking in a sustainable manner.

S3-OP2

Compatibility of entomopathogenic fungi and botanicals against sucking pests of brinjal: an ecofriendly approach

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Eggplant, *Solanum melongena* Linn., is one of the most popular conventional vegetable in India. In the present context of environmental change, the infestations of sucking insect pests, especially whitefly, *Bemisia tabaci* and jassid, *Amrasca biguttula biguttula* occurred thorough out the crop growth period in the region. Various entomopathogenic fungi (EPF) *viz*., *Metarhizium anisopliae*, *Beauveria bassiana* and *Lecanicillium lecanii* were evaluated individually and their 1:1 mixtures with botanicals like neem seed oil against these nefarious sucking insects pests and juxtaposing to commonly used chemical insecticide Imidacloprid 17.8% SL as check treatment under open field conditions during 2020 and 2021. Amongst the three EPF tested, minimum jassids (1.77, 2.33 leaf^{-1}) and whiteflies (1.41, 1.63 leaf^{-1}) populations were observed in experimental plots sprayed with *L. lecanii* during both the years. Half of the approved doses of *L. lecanii* and neem

seed oil combination registered the lowest jassids and whiteflies population along with the highest reduction over control which was at par with Imidacloprid 17.8 SL. Furthermore, all these microbial insecticides and their blending with neem seed oil were noted relatively safe to the associated predators (*Menochilus sexmaculates, Coccinella septempunctata, Micraspis discolor,* and spiders) and similar to untreated control. In a paradox, Imidacloprid 17.8 SL was established as the toxic most amongst the treatments having the least number of predatory fauna in the eggplant ecosystem. Blending half of the recommended doses of popular EPF *viz*., *B. bassiana*, *M. anisopliae* and *L. lecanii* with botanicals like neem seed oil may be a feasible eco-friendly avenue in managing the sapsuckers of eggplant, accompanied with the upkeep of associated predators.

S3-OP3

Drumstick: an alternative for nutritional security and climate resilience through agri-entreprenuership

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Drumstick (*Moringa oleifera* L.) is a tropical plant grown for its nutritious leafy greens, flower buds, tuberous roots and green pods. It is a drought tolerant plant and adapts easily to varied agro-climatic conditions, ranging from small-scale backyard home gardens to large scale commercial production has proven to be boon in many ways. As it is economical and reliable alternative for good nutrition, medicinal use, animal feed and fodder, plant supplement and soil reclamation; it can be touted as a miracle plant. Owing its high nutritive values, wider adaptability, a variety namely Thar Harsha have been developed which, produces about 314 fruits in a year, and its yield potential is 53-54.7 t/ha. It is rich in protein, Vitamin A and Vitamin C content. It also have high antioxidants contents and activity *viz*. total phenols, total flavonoids, DPPH, FRAP and CUPRAC in pods as well as leaves. The variety Thar Harsha recorded highest dry matter, protein, potassium, Calcium, Sulphur, Iron, Zinc, Manganese and Copper in leaves in comparison to checks. Diverse potentiality of drumstick in context to antioxidants and nutrients can be included in diets to supplement our daily nutrient needs to overcome the global pandemics like COVID-19 by boosting and strengthening our immune system, nutritional security, climate resilience and sustainable livelihood.

Keywords: *Moringa oleifera* L*,* Antioxidants, Nutrients, Thar Harsha, Nutritional Security, Climate Resilience

S3-OP4

South Asian medicinal beverage from *Cassia auriculata* under high density cultivation for resource conservation and livelihood generation

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Multi-purpose legume perennials are increasingly appreciated as playing a major role in agricultural diversification, livelihood security, land quality improvement, climate risk management and mitigation, improved resource conservation and other ecosystem benefits. *Cassia auriculata* (Caesalpiniaceae) is an amazing rejuvenating South Asian beverage medicinal plant to revitalize the entire biological system which was proven by several pharmacological studies. An experimental study conducted with *Cassia auriculata*-elite genotype (CA-4) for high-density planting was established under six different treatments viz., T_1- Single row Cassia without SCT, T_2- Single row Cassia with SCT, T_3-Double row Cassia without SCT, T_4- Double row Cassia with SCT, T_5- Triple row cassia without SCT and T_6- Triple row Cassia with SCT at ICAR-IISWC, Research centre, Kota-Rajasthan during 2019-2021. The study result of high-density plantation with CA-4 genotypes of *Cassia* under different treatments had shown considerable variability in growth and yield production. In that, T_4 - Double row Cassia with SCT treatment has significant superiority on plant flower yield (1.260 kg/plant/annum), annual dry pod yield of (2.98 kg/plant/annum) compare to other treatments. High primary branching behaviour of 14 secondary branches /plant and 12 number of flower head/plant was recorded under T_4 which valued high soil conservation potential as vegetative contour hedges/ barrier benefits in the non-arable lands. It can also fit into agroforestry, soil reclamation programmes as a legume-based woody plant. Thus, marginal land cultivation and value-added green tea product development aspects would contribute to the rural livelihood generation and would be helpful to land quality improvement towards resource conservation and ecosystem benefits.

Keywords: *Cassia auriculata*, Legume, Perennial, High density, Resource conservation, Livelihood generation, Marginal lands

S3-OP5

Influence of Storage Conditions and Containers on Seed Storability of Jamun Seeds *(Syzigium cumini)*

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A comprehensive laboratory experiment was conducted to study the influence of storage conditions and containers on seed storability of Jamun (*Syzigium cumini*) in college of Forestry, Sirsi, UAS, Dharwad. The study was conducted with two factors completely randomized design (CRD) with 3 replications for each treatment. The cleaned seeds are equally divided into 8 parts,

four samples were stored in ambient condition and other four samples were stored in refrigerated condition along with different containers *viz* open bowl, cloth bag, airtight container and polythene bag, respectively. The samples were drawn at fourthnight intervals and sown in the nursery bed. For each replication 100 seeds were sown to explore the effect of storage conditions and containers on seed germination. The jamun seeds responded highly to cold temperature due to arrest of metabolic activity at low temperature. Storage of jamun seeds under refrigerated condition gave 73.88% germination and was maintained up to 75 days from the date of harvest. Seeds stored in airtight jar have shown the best performance by recording maximum germination of 74.44 % when compared to all other containers. The speed of germination has shown a gradually decreasing trend during the storage period in jamun. Seeds stored in refrigerator condition found significant and recorded maximum root and shoot length and seedling vigor index compared to ambient condition. Airtight container was the best for seed storage container in jamun, as it acts as impermeable and keeps moisture at constant level by which seed viability can be restored up to 3 months. In general, as advancement in seed storage in jamun leads to decline in seed germination.

Keywords: Storage, Containers, Germination Root Length And Vigour Index

S3-OP6

Ecosystem services from Horticultural crops in coastal India

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Coastal agroecosystems offer numerous ecosystem services to humans which remain scientifically unexplored. The current report covers the case studies of palms, vegetable amaranths, and noni. Provisioning services: The coconut crop in 59 Indian mainland coastal districts contributed to 0.073% of the country's GDP. Major coconut growing coastal districts of Kerala and Karnataka with significant contribution (more than 0.0045% to state or 0.00032% to National GDP) to the economy. Cultural services are received when ornamental crops such as anthurium, jasmines and crossandra is grown as intercrop in coconut. *Jasminum pubescens* performed well as intercrop in coconut garden. Spice based agro-ecotourism unit form a major initiative in Goa, India. Supporting services: Nutrient cycling patterns are analysed in six coconut based cropping system models and five banana cultivars in arecanut based cropping systems. The study indicates that potassium mining was a major constraint when both main crop and intercrop requirements of potassium are high. Biodiveristy of Lakshadweep islands indicates endosperm mutant and very small fruit type in coconut. Biodiveristy studies of Noni in coastal Maharastra and Goa resulted in 19 accessions representing unique traits. Date palm seed length recorded lowest diversity 0.00 in yellow dates to 06.9 in Red date fruit types from Gujarat. Four local coconut cultivars of Goa (Benaulim, Calangute, Rivona, Canacona, Gaodongri) and one local arecanut cultivar of Uttar Kannada Karnataka were collected and characterized. A submergence tolerant cassava germplasm was collected from flood-affected Ernakulam District Kerala and was screened for field-level submergence. Vegetable amaranth germplasm collected from Goa gave one pigment rich germplasm and a root-knot nematode trapping germplasm.

Keywords: Biodiversity, Nutrient mining, Share to GDP, Coastal Horticulture

S3-PP1

Pre-harvest fruit bagging technology for development of quality traits

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During growth and development, fruits undergo several physico-chemical changes and damages resulting in yield and economic losses for which several good agricultural practices (GAP) are becoming popular. Also, alternative techniques for improving quality of fruit and reducing infestations are being developed. Among these, pre-harvest fruit bagging has emerged as an effective approach in different parts of the world. It is a physical protection technique, commonly applied to many fruits, which not only improves their visual quality by promoting peel colouration and reducing the incidence of fruit cracking and russeting, but can also change the micro-environment for fruit development which can have multiple effects on internal fruit quality. Pre-harvest bagging with different types of bags at 30 days after fruit set in cv. Alphonso, modified fruit retention, period required for harvesting, physico-chemical composition, shelf life, occurrence of spongy tissue and pest incidence in mango. In climatic aberrations bagging provide microclimate for fruit development and act as a barrier to prevent the abiotic and biotic stress. Also, in case of high-density planting and rejuvenated orchards where farmers can easily reach to their produce, pre-harvest bagging become a grower-friendly technology for getting quality fruits.

S3-PP2

Evaluation of coconut-based cropping models in Goa

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Perennial palm crops like coconut, arecanut are cultivated in plantations. In coconut plantations, intercropping is practiced for efficient utilization of resources and enhancing income generation and employment. The study by ICAR-All India Coordinated Research Project on Palms at ICAR-CCARI, Old Goa where six coconut-based intercropping treatment models were evaluated from 2016 to 2021. An adult coconut garden of 28 years old main crop planted at 7.5m × 7.5m spacing was intercropped with intercrops viz., coconut + papaya + drumstick, coconut + heliconia, coconut + banana + lemon, coconut + pineapple + passion fruit, coconut + soursop, coconut + crossandra, and coconut monocrop as control. The models were analyzed for coconut equivalent yield, total gross return, the net return, and benefit: cost (B:C) ratio by taking the average for the five years. The highest net return was recorded by the coconut + pineapple + passion fruit model (1,30,270/-) with a B:C ratio of 1.99 followed by coconut + heliconia (1,24,700/-) with a B:C ratio of 1.90. The lowest net return was recorded by coconut + papaya + drumstick (57,439/-) with B:C ratio of 0.88. The net return for coconut monocrop was only 60,220/- with B:C ratio of 1.21. Intercropping with pineapple and passion fruit in coconut plantation gave an additional 8605 coconut equivalent yield of over monocrop with 10982 nuts per hectare.

Keywords: Coconut, Goa, Cropping System, Pineapple, Passion Fruit

S3-PP3

Significance of multi-storied cropping system in horticulture

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Multi-storied cropping system is one in which crops are accommodated mainly based on the different heights, root systems and canopy patterns to maximum utilization of nutrients, land and sunlight which ultimately helps in fetching more crops or yield per unit area. This helps in sustainable productivity and maximum returns per unit area of land by maintaining soil fertility. This system is practiced in places where there is space constraint and more popular in Western Ghats. Agriculture, horticulture and silviculture based cropping system is usually practiced here. It provides crop diversification, increasing productivity, higher use efficiency of resources, intensive input use and sustainable productivity. Multi-storied cropping system increases per unit area income, minimum risk of crop yield, effective use of resources, improve soil health and reduces soil erosion, enrich the biodiversity and reduces the incidence of weed, pest and diseases. Among horticultural crops mostly plantation and fruit crops are being used in this type of cropping system and also some of the medicinal and aromatic crops, spices and vegetable crops. Here the plants used in this type of cropping system should be tall, wider spacing, slow-spreading growth, shade-loving, tolerance to pests and diseases etc.

Keywords: Multi-storied, Cropping system, Horticulture

S3-PP4

Changes in leaf pigment and water content of mango varieties at vegetative and flowering stages

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Leaf pigment and relative water content of four mango varieties *viz.,* Amrapali (V_1), Alphonso (V_2), Kesar (V_3) and Mankurad (V_4) were evaluated at vegetative and flowering stages. During the vegetative stage, chlorophyll 'a' content was the highest in Amrapali (1.81 mg/100 g) and chlorophyll 'b' content was the highest in Mankurad (3.14 mg/100 g). Total chlorophyll content and leaf carotenoid content had no significant difference among the varieties during the vegetative stage. Relative water content was the highest in Amrapali (76.58%) and Mankurad (72.54%). During the flowering stage, Alphonso had the highest chlorophyll 'a' content (2.02 mg/100 g) which was on par with Amrapali and Mankurad. Chlorophyll 'b' was also highest in Alphonso (1.21 mg/100 g) in the flowering stage. Total chlorophyll was the highest in Alphonso (3.33 mg/100 g) which was on par with Mankurad (2.82 mg/100 g). Leaf carotenoid content was 1.18 mg/100 g (Alphonso) which was on par with Amrapali and Mankurad. Relative water content was the highest in Amrapali (69.59%) which was on par with Alphonso (64.96) and Kesar (64.79%).

S3-EP1

Fertilizer phosphorus prescription for chilli under STCR-IPNS in Inceptisol of Puducherry

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The field experiment was conducted at farmer's holding of Karikalampakkam village in Nettapakkam commune of Puducherry district, U.T. of Puducherry during 2020 by using STCR approach. The study area comes under coastal alluvial plain, classified as fine, mixed isohyperthermic, Typic Ustropept. The result of the experimental field revealed that the soil is sandy clay loam in texture, neutral (pH-7.21) and non -saline (EC-1.17 dSm^{-1}) with cation exchange capacity of 20.8 cmol (p^{+}) kg^{-1}. The fertility status of the soil was low in $KMnO_4$ – N (212 kg ha^{-1}), medium in Olsen - P (20.6 kg ha^{-1}) and NH_4OAc - K (196 kg ha^{-1}). Soil test data, Chilli (hybrid-VNR 145) fruit yield and NPK uptake by chilli crop were used for obtaining four important basic parameters *viz*., nutrient requirement to produce one quintal of chilli fruit (NR), contribution of nutrients form fertilizers (Cf), contribution of nutrients from soil (Cs) and contribution of nutrients from organic matter (Cfym). Making use of these basic parameters the fertilizer prescription equation was developed for P for chilli crop and is given below.

$$FP_2O_5 = 0.84\ T - 4.82\ SP - 0.84\ OP$$

The perusal of estimate showed that when NPK alone was applied for a soil test value of 20 kg ha^{-1} of P_2O_5, the doses of fertilizer P_2O_5 required for desired yield target of 260 and 270 q ha^{-1} were 121 and 130 kg ha^{-1}, respectively. While the doses were 95 and 103 kg ha^{-1}, respectively for combined addition of NPK plus FYM applied @ 12.5 t ha^{-1} recording 21.5 and 20.0 per cent reduction of fertilizer P_2O_5 doses over NPK alone. When NPK applied with FYM @ 25 t ha^{-1} the doses were 69 and 77 kg ha^{-1} with a per cent reduction of 43.0 and 40.8, respectively over NPK alone. Using the fertilizer prescription equation under IPNS, the extent of saving of inorganic P fertilizer with the application of FYM@ 25 t ha^{-1} with 30 per cent moisture and 0.30 per cent of P_2O_5 was 52 kg ha^{-1}.

S3-EP2

Assessment of the suitability of ornamental plant species for green walls based on APTI

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Creating green spaces by way of green walls or vertical gardens can serve as a solution to reduce air pollution, one of the most pressing issues confronting the modern world. The study investigated the ability of eighteen ornamental species in vertical landscape plans for their pollution mitigating ability. The main aims were to evaluate different ornamentals for their performance in

vertical landscape systems and to estimate the tolerance level of plant species on green walls to air pollution using Air Pollution Tolerance Index (APTI). The highest total chlorophyll content was observed in *Syngonium podophyllum* 'Maria Allusion' (1.86 mg/g) and 'Pink Allusion' (1.83 mg/g) whereas the lowest in *Peperomia* (0.08 mg/g). A higher level of leaf-extract pH was observed in *Syngonium podophyllum* 'Cream Allusion' (7.74) and 'Maria Allusion' (7.71) whereas the least was observed in *Philodendron* (5.37). Maximum relative water content was observed in *Peperomia* (92.63%) and *Syngonium podophyllum* 'Maria Allusion' (89.28%). The ascorbic acid content in the present study varied from 0.40 in *Philodendron scandens* to 3.99 in *Peperomia.* Study shows that the inclusion of ornamentals having pollution mitigating ability in vertical landscape plan will serve the dual purpose of making our living environment green and pollution-free in the long run.

S3-EP3

Terrace gardening: Achieving nutrition and livelihood security

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With the increasing urbanization and migration of people from rural areas, the pressure on land resources have increased tremendously. Owing to the indiscriminate use of fertilizers and chemicals most of the agricultural and horticultural commodities have become unsafe for consumption. Hence, people are now looking more towards growing of these essential commodities using green / organic cultivation practices. In the urban areas with limited space or land availability, terrace and balcony cultivation of vegetables, fruits, flowers and herbs is also gaining popularity and it has now become more of a necessity than merely a hobby. Besides making use of unused / wasted space to grow food, the terrace garden also provides additional benefits like aesthetic benefit, temperature control, hydrological benefits, architectural enhancement, habitats for birds and pollinators, recreational opportunities etc. The involvement of the whole family in gardening also helps in relieving stress and improves mental wellness. Vegetables like beans, peas, gourds, cucumber, tomatoes, chilly, moringa, brinjal; leafy vegetables like palak, methi, coriander, lettuce, mint; fruits like papaya, strawberry, passion fruit; flowers like hibiscus, jasmine, rose, tuberose, chrysanthemum, gaillardia, marigold, aster; spices like seed spices (coriander, fennel, methi, dill), ginger, turmeric; herbs like tulsi, coleus, brahmi, centella, mints, pippli, etc. can be easily grown in terraces / balconies. These can be grown either in soil or in soilless media (cocopeat, vermiculite, rockwool, pumice, wood residues, barks etc.) by using either rain water or waste water generated from RO unit. The entire garden can be manured using properly segregated and composted kitchen waste efficiently. Successful cultivation of crops in terrace/balcony garden also opens up entrepreneurial opportunities for the homemakers by turning it into an enterprise incorporating various vertical garden models where they can get additional yield and additional income by selling purely organic and safe products. Hence, growing plants by effectively utilizing the available space in the terrace/balcony/indoor can not only help to achieve health and nutritional security of the household but also provide entrepreneurial opportunities.

S3-EP4

Studies on the influence of combined application of both organic and in-organic sources of nutrients in high density arabica coffee (*Coffeea arabica L.*)

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Arabica coffee prefers higher altitudes (1000-1500 m msl) and cool weather. It is being cultivated in the higher altitudes in the coffee-growing regions of India. The higher the altitude, the higher will be the rainfall and nutrients lost through topsoil erosion. Hence, it is worth that the supply of the essentially required nutrients through both the organic and inorganic sources during the differential growth could result in the progressive and positive development in the crop production. Application of hundred per cent recommended dosage of inorganic fertilizers along with the twenty five per cent N through goat manure has resulted in the significantly higher plant height (113.37 cm), number of primaries (13.37), number of secondary branches (11.0) stem girth (5.03 cm), number of leaves per branch (15.33), total number of nodes per branch (11.0), crop bearing nodes (10.67), bush spread (118.56 cm), length of the longest primary (118.25 cm),number of berries per node (21.0) and clean coffee yield1605.08 kg ha^{-1} followed by the application of seventy five per cent of recommended dosage of fertilizers along with fifty per cent N through goat manure and the rest of the treatments recorded on-par observations with the differential combinations of recommended dosage of fertilizers, goat manures and dried leaf compost, however the control(only hundred per cent RDF) has registered the significantly lower yields (1275.21 kg ha^{-1}) then the best treatment in high density Arabica coffee planting designs.

Keywords: Arabica coffee, Clean coffee (CC), Dried leaf compost (DLC) Goat manure (GM), High density planting (HDP), Recommended dose of fertilizers (RDF)

S3-EP5

Variability for double kernels in almond cultivars growing in north western Himalayan region of India

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Almonds being a unique matrix of nutrients are consumed world-wide since the ancient times. Besides being consumed as whole nuts, they are ingredients in snack food including desserts, chocolates, baking items etc. Although the almond is one of the oldest crops used by humans, its specific environmental requirements have restricted its commercial production to specific areas of the world. However, the demand for the almonds has been steadily increasing owing to enhanced health-consciousness among masses. Certain almond cultivars exhibit double kernels i.e. two kernels developing in one shell with one side of double kernel being flat or concave. The

presence of double kernels in almond is considered a negative trait and fetches lower prices due to challenges around blanching or slicing the odd shape. This phenomenon varies across the cultivars and years. We studied the double kernel phenomenon in almonds cultivars growing in Kashmir, falling within North-western Himalayan region of India. A four year study using ten almond cultivars revealed that "Merced" cultivar exhibited highest number of double kernels while "IXL" exhibited least number of double kernels. The local almond cultivars like Makhdoom, Shalimar and Waris also show high tendency for double kernels. We also studied the association of double kernels with weather parameters. Monthly average temperatures during the month of February revealed a highly significant association with the number of double kernels.

S3-EP6

Diversity assessment and trait-specific genotype identification in intraspecific breeding lines of roselle (*Hibiscus sabdariffa* L.).

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Roselle (*Hibiscus sabdariffa* L.) is one of the most important commercial fibre crop after Cotton and Jute, mainly cultivated in the eastern and southern states of the country. Roselle fibre has more or less same physical and chemical properties as jute fiber and, therefore, in many value-added applications, it satisfactorily acts as a jute substitute. In spite of its potential economic importance, area under the crop has reduced drastically and national fibre productivity has attained a plateau. Biotic/abiotic stresses coupled with limited genetic variation in the cultivated gene pool are cited as the major factor limiting fibre production and productivity at national level. Assessment of genetic diversity within the advanced breeding population helps in parents' diversification and identification of trait-specific genotype. In the present study an intraspecific hybrid breeding program involving five crosses, HS-7910 × AMV-4, GR-27 × JRR-07, AMV-5 × GR-27, GR-27 × HS-7910 and AHS-160 × NONBRIS-4 followed by pedigree selection, resulted in isolation of 75 advance breeding lines. These genotypes along with two commercial varieties were evaluated for fibre yield and associated traits. A significant genetic diversity was observed among the genotypes, distributed in 3 broad clusters. Of these, cluster I was largest with 38 genotypes followed by cluster III with 36 genotypes and cluster II harboring only three genotypes. Plant height and green biomass yield are the two traits contributing maximum to the total divergence. Promising roselle genotypes were identified for each trait can be successfully utilized in future breeding program for the development of high fibre yielding cultivar.

S3-EP7

Identification of elite germplasm of Malabar tamarind for promoting cultivation in the Andaman Islands

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Malabar tamarind (*Garcinia gummi-gutta*) is a tropical fruit-bearing species native to the Western Ghats region of India. Though it has been traditionally used in culinary preparations, its

increasing importance in the recent past has been due to the presence of hydroxycitric acid, an anti-obesity compound. To explore the possibility of cultivating it under island conditions, it was introduced in the Andaman Islands. As seedling progenies of Malabar tamarind were used for planting, considerable variability was recorded for morphological and biochemical attributes from 2015 to 2022. Two promising selections were identified for promoting the cultivation of this crop in the islands. Selection GG-05 is characterized by early flowering habits as it starts maturing from mid-May onwards in the islands. Further, the presence of a thin rind could reduce the labour requirement for its processing. This selection is a prolific bearer and has closely arranged shallow groves on the fruits with narrow leaves. Another elite selection is a large-fruited one with prolific bearing habit. Fruits have wider ridges and deeper groves with broader leaves. Biochemical analysis of the selections including hydroxycitric acid content and phenolic acid profiling were also carried out using LC-MS.

S3-EP8

Effect of varying levels of NPK and growing media on growth, yield and quality of red cabbage grown in open and polyhouse soilless cultivation

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An open and polyhouse experiments were conducted to study the effect of different NPK levels and growing media on growth, yield and quality of red cabbage under soilless cultivation. The study was carried out with four NPK levels and seven replications in a completely randomized design. Silpaulin grow bags of size 4×1×1feet were filled with Arka Fermented Cocopeat (AFC) and soil separately and three red cabbage seedlings were transplanted in each bag. One set of grow bags was placed in a temperature-controlled polyhouse with fan and pad cooling system. Another set of grow bags was maintained in open conditions for comparison purposes. Nutrient levels of 185 ppm N-NO_3, 41 ppm P and 210 ppm K recorded maximum stem diameter (25.71 mm), number of leaves (24.82), head diameter (36.79 cm), head length (14.64 cm), average head weight (972.25 g/plant) and yield (54.01 t/ha). Best NPK levels under protected conditions are found to register maximum growth and red cabbage yield in open conditions as well. Between open-field and polyhouse soilless cultivation of red cabbage, maximum plant height (25.71 cm), head diameter (33.7 cm), head length (12.9 cm), average head weight (817.8 g/plant) and yield (45.43 t/ha) was recorded with polyhouse conditions. However, the maximum stem diameter (22.5 cm) and number of leaves (28.1) were recorded under open-field conditions. With respect to growing media, red cabbage raised on soil registered maximum stem diameter (24.9 mm), number of leaves (28.3), head diameter (36.8 cm), head length (13.7 cm), average head weight (977.8 g) and yield (54.32 t/ha) compared to Arka Fermented Cocopeat (817.8 g and 45.43 t/ha, respectively). Nevertheless, AFC grown cabbage recorded maximum plant height (25.7 cm) than soil-grown cabbage (24.5 cm).

Keywords: Soilless Cultivation, Red Cabbage, NPK Levels, Substrate, Growth and Yield

S3-EP9

Proficiency of different hydroponic subsystems in an affordable rainbow trout - lettuce aquaponic system

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An experimental trial to study the proficiency of different hydroponic cum bio-filter sub-systems i.e. river stone bed, crushed stone bed and deep water culture (DWC) system were carried out in a cost-effective low-tech rainbow trout (*Oncorhynchus mykiss*)-lettuce (*Lactuca sativa*) recirculatory aquaponics system based on their yield and nutrient transformation. Some of the components of the system were designed for multifunction so as to minimize space and cost. After seed germination in plastic and egg trays, the plantlets were randomly transplanted among different treatments following a specific planting interval. Rainbow trout juveniles were stocked in experimental tanks with different HLRs following particular density and were fed @ 3-5% of their body weight whereas the plant yield was simply based on the generated fish waste. Fish growth was better in the higher HLR group and three crops of lettuce were harvested within one crop cycle of rainbow trout. The TAN, nitrate and phosphate removal including lettuce performance varied significantly and follow the order, DWC > crushed stone > river stone. So, the DWC can be a fruitful technique in the aquaponic production of rainbow trout and lettuce but the area/volume proportion of fish tank, plant bed and bio-filter may be optimized.

Keywords: DWC, Crushed stone, River stone, Rainbow trout, Lettuce

S3-EP10

Integrated nutrient management in coconut for sustainable agriculture

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An experiment was conducted for five years in a 45 years old coconut garden of East Coast Tall variety planted with a spacing of 7.5 m × 7.5 m to evaluate the nutrient management in coconut based cropping system of Thanjavur region during 2013 - 2018. The coconut based cropping system comprises of Coconut (ECT) + Black pepper (Panniyur 1) + Banana (G9) + Cocoa (F1 hybrid)) in East Coast region of Tamil Nadu with four nutrient management treatments viz., T1 – 75% of recommended NPK + 25% of N through organic recycling with vermicompost, T2 – 50% of recommended NPK + 50% of N through organic recycling with vermicompost + vermiwash + biofertilizer +*in situ* green manuring, T3 – Fully organic 100 % of N through organic recycling with vermicompost + vermiwash + biofertilizer + *in situ* green manuring + green leaf manuring (*Glyricidia* leaves) + composted coir pith husk incorporation (once in 3 years) and mulching with coconut leaves, T4 – Control (recommended NPK and organic manure). The number of nuts of coconut, cocoa, pepper and banana yields were significantly influenced by the inorganic and or-

ganic nutrient management in coconut based cropping system. The mean nut yield of 118 number of nuts palm^{-1}, dried cocoa beans 230.20 kg ha^{-1}, fruit yield of banana 23,345 kg ha^{-1} and dried black pepper 39.80 kg ha^{-1} were registered in treatment T2– 50% of recommended NPK + 50% of N through organic recycling with vermicompost + vermiwash + biofertilizer + *in situ* green manuring with the highest net income of Rs. 354244/-. The mono crop of coconut registered the lowest net income of Rs. 1,18,645/-. The study indicated the nutrient management with 50% inorganic fertilizer and 50% organic recycling are suitable for coconut based cropping system.

S3-EP11

Vegetable grafting: a climate resilient technique for vegetable production

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Grafting is emerged as a potential tool and environment-friendly approach which is used to control soil borne diseases and increasing the yield of susceptible cultivars. This technique ensures sustainable vegetable production by using resistant rootstock and in turn reduces dependence on agrochemicals. Grafting is also used to induce tolerance to abiotic stresses *viz*. flooding, drought and salinity. Grafting is nowadays regarded as a rapid alternative to the relatively slow methodology of breeding for increased environmental-stress tolerance of vegetables. Vegetable grafting is gaining more popularity in the world in the case of cucurbits, tomato, eggplant and chilli using vigorous and disease resistant rootstocks to ensure adequate yields. Grafting aids to promote plant growth, fruit yield and quality, reduce viral, fungal and bacterial infection, strengthen tolerance to thermal or saline stress and increase nutrient and mineral uptake. Presently, grafting technology is rapidly expanding all over the world to develop resistance or improve tolerance against the broad spectrum of biotic and environmental stresses in various vegetable crops, specifically solanaceous and cucurbitaceous vegetables

S3-EP12

Palmyrah: A Crop for coastal region of Tamil Nadu

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Palmyrah palm (*Borassus flabellifer* L) belongs to the family Arecaceae and is native to tropical Africa. In India, it is grown naturally throughout the country. It is monocotyledonous, dioecious plant in almost all parts viz., root leaves, seed and fruit of the palm are used in different ways. It is underutilized palm and grown naturally in forest and barren lands. The importance of the palm is not still recognized by the people. Palmyrah Palm (*Borassus flabellifer* L.) is also known as toddy palm, tal, panai, etc. It is third important palm next to coconut and date palm. The centre of origin of Palmyrah palm is Tropical Africa and distributed from India through South-

East Asia to New Guinea. According to Literature, it is believed that *B. flabellifer* is a selection from the more diverse Borassus aethiopum Mart. Of Africa. Globally, it is grown in Sri Lanka, India, Myanmar, Cambodia, Indonesia, etc., In India is found naturally in forest and community land of Tamil Nadu, Andhra Pradesh, Odisha, West Bengal, Bihar, Karnataka, Gujarat and Maharastra. In Tamil Nadu 5.1 crore population of Palmyrah is distributed especially in southern parts of state. It is a large tree up to 30 m high and the trunk may have a circumference of 1.7 m at the base. It is also recognized as the state tree of Tamil Nadu in 1987. It is multipurpose, evergreen plant. All the plant parts of this palm are useful for the welfare of human in different ways. It is a good source of nutrition, especially for tribal people. It also provides good opportunity for employment and source of income for resource-poor people of panchmahal tribes. Recently it is grown in orchard form as sole, mixed with fruit crops, boundary plantation and multistory cropping systems.

S3-EP13

Seed enhancement through biopriming and micronutrient priming on seed quality and yield in Chia (*Salvia hispanica* L.)

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Chia (*Salvia hispanica* L.) is a herbaceous plant that belongs to the *Lamiaceae* family, Chia grows up to one meter in height and has oppositely arranged leaves. Chia produces white or purple small flowers (3 to 4 mm) with smaller corolla. The seed colour of chia varies from grey, black and black pointed to white and the shape is oval with the sizes ranging from one-two mm (Bresson *et al.,* 2009). A chia seed contains protein (15 – 25 %), fats (30 – 33 %), and high dietary fibre (18 – 30 %), It is also containing a higher number of antioxidants (Ixtaina *et al*., 2008). Chia seeds are rich in Omega (ω) -3 and ω - 6 fatty acids which are the essential polyunsaturated fatty acids containing Alpha linolenic acid and linoleic acid. Seed priming is the most significant advance in facilitating rapid and uniform seed germination and the emergence and increasing the seed tolerance to adverse environmental conditions (Heydecker *et al.*, 1973; Harris *et al.,* 1999). The potential of micronutrient seed priming for improving crop growth and grain nutrient enrichment can be utilised in increasing the productivity of chia. The work was conducted to know the seed priming duration in chia during 2020-21. 20 minutes of seed hydropriming recorded higher germination (91.75 %), seedling length (13.53 cm) and seedling dry weight (1.03 g/ 10 seedlings),) compared to control and the effect of bio and micronutrient priming on quality and yield parameters in chia at ARS, Bagalkot. Seed priming with Zinc (1.5 %) recorded higher germination (95.25 %), seedling length (16.33 cm), seedling dry weight (1.260 g/10 seedlings), and plant height (91.73) followed by *Azospirillum brassiliense* (20 %). Seeds primed with Zinc (1.5 %) showed higher yield attributing traits *viz.,* a number of spikes per plant (18.53), spike length (16.30 cm), yield per plant (15.68 g), yield per hectare (752.38 kg ha^{-1}) and 1000 seed weight (1.332 g) followed by PSB (20 %) over control. Hence, it can be concluded that seed priming with Zinc (1.5 %), *Azospirillum brassiliense* (20 %) and PSB (20 %) enhances the quality, growth and seed yield in Chia.

S3-EP14

Speciation of chromium in various parts of *Ipomoea aquatica*

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Though Cr is generally stated as toxic, a trivalent form of chromium is important for glucose metabolism and is also utilized as medicine for diabetic persons. Hence by assessing the speciation of Chromium in food materials, their utility could be explored. In this study, water spinach (*Spinacea oleracea*) a semi-aquatic crop was investigated for assessing Cr accumulation in soil spiked with Cr(VI) up to 150 mg kg^{-1} in red and black soil. The content of Cr(VI) in the plant parts increased with the increase in the content of Cr added to both the soils. The Cr(VI) in root ranged from 0.053 to 0.188 ppm in red soil and 0.070 to 0.192 ppm in black soil. The lowest Cr(VI) content was recorded in the leaves of the plant grown in both the soils. There was no detection of Cr(VI) from all the parts of plants cultivated in soils added with 0 to 25 mg kg^{-1}. Chromium accumulation was in the order of Root > Stem > Leaf. The content in plants ranged from 0.018 to 0.172 ppm in red soil and 0.021 to 0.141 ppm in black soil, respectively. However, the total Cr extracted by triacid digestion was higher over other fractions especially at higher levels of Cr added to the soil for root, stem and leaf.

S3-EP15

Growth and yield of ginger (*Zingiber officinale Rosc.*) as influenced by plant growth regulators

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Ginger (*Zingiber officinale* Rosc.) is cultivated in India for the underground stems called rhizomes, which are used both as a fresh vegetable and dried spice. Due to scarcity of land and also urbanization, growing ginger in grow bags has been initiated but the yield is found to be less due to poor partitioning of dry matter to rhizomes. Better growth, yield and partitioning of the dry matter in ginger have been reported with the use of synthetic growth regulators. Hence an experiment was conducted during 2020-2022 to study the effect of four different plant growth regulators at four different concentrations on the growth and yield of ginger variety IISR Varada. Polybags of size 40 x 40 were filled with a potting mixture consisting of soil, farmyard manure, sand and farmyard manure in 2:1:1 proportion and the ginger rhizomes weighing 25g were planted in these bags. Nutrients were provided as per the POP recommended by ICAR-IISR as per schedule. The experiment consisted of four growth regulators 6-benzyl adenine purine (6-BAP), cycocel (Chlormequat chloride), gibberellic acid (GA3) and paclobutrazol (PBZ), as the main plot treatments and five concentrations viz. control (water spray) as control, 50 ppm, 100 ppm,150 ppm and 200 ppm as the subplot treatments with three replications laid out in split-plot design. Growth regulators were applied 4 months after planting by foliar application. Observations were recorded 5 months after planting and at the time of harvest. Results of pooled data over two years revealed that the number of tillers, secondary rhizomes, tertiary rhizomes, length, diameter of rhizomes and yield (245.13 g/

plant) were maximum in the treatment of 100ppm 6-BAP whereas maximum height was noticed in plants sprayed with 150ppm GA3. The study highlights the need for foliar application of 6-BAP at 100ppm for augmenting yield in potted ginger.

Keywords: Cycocel,6-BAP, GA3, Paclobutrazol, Growth, Yield

S3-EP16

Effect of phytodesalination with *Sesuvium portulacastrum* on growth and yield of Marigold under saline soils

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Fresh water availability for agriculture is reduced drastically over the decades, hence utilization of wastewater as an irrigation source could be a viable alternative. While the irrigation with paper and pulp mill effluent results in salt buildup in the soil matrix and increase in soil ESP. Hence a field experiment was conducted with a coastal halophyte '*Sesuvium portulacastrum*' as phytoremediant for a period of 90 days after which a test crop African marigold was cultivated. The uptake of ions by *S. portulacastrum* followed an order of Cl > Na > Ca > K > SO_4> Mg. The highest uptake of Cl (293 kg ha^{-1}) and Na (250 kg ha^{-1}) by *S. portulacastrum* was in plots applied with Pressmud compost, which prevented the 1.6 times increase in EC and 70.1 per cent increment in ESP. The highest increase in biomass (11.4 %) and flower yield (4.2 % higher than control) was observed in the plot where halophyte was cultivated as first crop. Based on the results, *S. portulacastrum* cultivation along with calcium rich organic manure application could be used to prevent the increase in soil ESP when irrigated with paper and pulp mill effluent.

Keywords: Effluent irrigation, Salinization, Phytoremediation, Halophyte, Marigold.

Technical Session 4

Animal resources, production and health management

Lead Paper

Animal Biodiversity conservation and improvement in coastal regions

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India is rich in terms of biological diversity; a central principle of natureand the country possesses diversified ecosystems. India has only 2.5 per cent of the total land mass of the world and harbours about 7.8 per cent of the world's known plant and animal species.Biological diversityis the basis for the continuous evolution of species and ecosystems.Ecological security is the maintenance of the diversity of ecosystems and habitats; the diversity of species, subspecies/varieties, populations and communities; the interactions between species, populations, communities and their habitats and ecosystem; their integrity including biological productivity of ecosystems and taxa; the evolutionary potential of natural and agricultural systems; and critical ecosystem services. This refers to both wild and domesticated biodiversity.Livelihood security is the security of human communities and individuals critically dependent on biological resources, including guaranteed access to, and control over such biological resources and related knowledge.Both ecological and livelihood security are eroded and continue to be threatened. Thereis an urgent need to take comprehensive measures to reverse this trend and two basic goals need to be achieved to reverse this trend:

- Conservation of biodiversity
- Sustainable use of biological resources (http://nbaindia.org).

The 20th Century was marked by growing concerns about the status of conservation of the world's biological diversity. The threat and erosion of animal bio diversity lead to the establishment of the 1992 United Nations Convention on Biological Diversity in 1992. FAO brought out the first global assessment of livestock biodiversity in 2007 "The State of the World's Animal Genetic Resources for Food and Agriculture" (FAO, 2007). The FAO has identified 7,616 livestock breeds of which 20 per cent were classified as at risk (FAO, 2012).

Animal Genetic resources of India

India is bestowed with rich animal diversity spreading across the species. The total number of animal species reported from India is about 89,451. India possesses little more than 7 per cent of the total animal species of the world and the percentage is higher than that of the plant species. Out of total animal species insects alone comprise 68.32 per cent and Chordates only 5.70 per cent(http://nbaindia.org).

Livestock sector plays an important role in sustaining the agricultural production of our country. Livestock products are the major source to ensure food and nutritional security to millions of people and help farmers to generate self employment and income. Livestock and poultry provide milk, meat, egg, fibre, wool, leather, work power and organic fertilizers to agriculture and employment to rural masses apart from draught power and manure. Livestock also help to generate biogas from manure.

Farm animals is the term used to designate the domestic animal species that are used for food, fibre and agriculture. About forty animal and poultry species have been domesticated so far to fulfil various food and agricultural needs. At present, cattle, sheep, goat, pig and chicken are termed as "Big Five or global species" that are distributed globally, whereas, others like buffalo, horse,

donkey, dromedaries and Bactrian camel, llama, alpaca, reindeer, yak, duck, geese, mithun, guinea fowl, ostrich, quail and turkey are either restricted to a continent or region or distributed very thinly across the continents. The man-made selection, targeted for fulfilling his different needs was the most important determinant for developing large-scale genetic diversity among the farm animals. FAO defined the breed as "a sub-specific group of domestic livestock with definable and identifiable external characteristics that enable it to be separated by visual appraisal from other similarly defined groups within same species". At present, the world possesses more than eight thousand livestock and poultry breeds, evolved from only few founder populations and catering various needs of human society around the world. The various breeds of the different livestock species have acquired unique characteristics such as heat tolerance, disease resistance, thriving on lower plane of nutritional support, etc. to adapt to their diverse environmental conditions. It is widely assumed that a large number of the livestock and poultry breeds have been developed during last five to ten centuries.

Indian subcontinent remained as a major hotspot for the domestication of a number of farm animal species and the country possess 536 million population of 10 livestock species – cattle, buffalo, sheep, goat, pig, horse, donkey, camel, yak and mithun and 852 million poultry species distributed over a large range of geographical, ecological and climatic regions (https://www.nddb.coop/information/stats/pop). India stands second in total livestock population in the world including first in buffalo comprising about half of the buffalo of the world, second in cattle and goat. As per an estimate by FAO, there may be about 275 livestock breeds in the country. There is one breed per million animals in the world, whereas, our country possesses one breed in 3.5 million livestock population (0.28 breed/million), which is much lower than world average. At present, the total number of registered and gazette notified indigenous breeds of livestock and poultry in the country is 202, which include 50 for cattle, 19 for buffalo, 34 for goat, 44 for sheep, 7 for horses & ponies, 9 for camel, 10 for pig, 3 for donkey, 1 for yak, 19 for chicken, 2 for duck, 1 for geese and 3 of dog.

Table 1. Farm animal genetic resources of India (FAO, 2007 and ICAR-NBAGR, 2021)0

Species		Number of breeds			
	Local	Regional Trans-boundary	International Trans-boundary	Total	ICAR-NBAGR*
Buffalo	17	4	2	23	19
Cattle	52	6	6	64	50
Goat	28	3	3	34	34
Sheep	58	4	0	62	44
Yak	5	0	0	5	1
Pig	7	1	0	8	10
Horse	6	1	0	7	7
Ass	3	0	0	3	3
Camel	10	0	0	10	9
Rabbit	3	0	0	3	-
Chicken	23	1	4	28	19
Duck	4	0	2	6	2
Quail/Geese	2	0	0	2	1
Total	218	20	17	255	199

Source: SOW-AnGR, FAO, 2007 with addition of some more breeds and deletion of duplication/ synonyms.

**ICAR-NBAGR*

The details of registered and gazette notified breeds within each farm animal and poultry species along with their accession number are given below.

Table 2. Registered breeds of Buffalo (ICAR-NBAGR, 2021)

Sr. No.	Breed	Home Tract	Accession Number
1.	Bhadawari	Uttar Pradesh & Madhya Pradesh	INDIA_BUFFALO_2010_BHADAWARI_01003
2.	Jaffarabadi	Gujrat	INDIA_BUFFALO_0400_JAFFARABADI_01006
3.	Marathwadi	Maharashtra	INDIA_BUFFALO_1100_MARATHWADI_01009
4.	Mehsana	Gujarat	INDIA_BUFFALO_0400_MEHSANA_01004
5.	Murrah	Haryana	INDIA_BUFFALO_0500_MURRAH_01001
6.	Nagpuri	Maharashtra	INDIA_BUFFALO_1100_NAGPURI_01007
7.	Nili Ravi	Punjab	INDIA_BUFFALO_1600_NILIRAVI_01002
8.	Pandharpuri	Maharashtra	INDIA_BUFFALO_1100_PANDHARPURI_01008
9.	Surti	Gujarat	INDIA_BUFFALO_0400_SURTI_01005
10.	Toda	Tamil Nadu	INDIA_BUFFALO_0018_TODA_01010
11.	Banni	Gujarat	INDIA_BUFFALO_0400_BANNI_01011
12.	Chilika	Orissa	INDIA_BUFFALO_1500_CHILIKA_01012
13.	Kalahandi	Odisha	INDIA_BUFFALO_1500_KALAHANDI_01013
14.	Luit (Swamp)	Assam and Manipur	INDIA_BUFFALO_0212_LUIT_01014
15.	Bargur	Tamil Nadu	INDIA_BUFFALO_1800_BARGUR_01015
16.	Chhattisgarhi	Chhattisgarh	INDIA_BUFFALO_2600_CHHATTISGARHI_01016
17.	Gojri	Punjab and Himachal Pradesh	INDIA_BUFFALO_1606_GOJRI_01017
18.	Dharwadi	Karnataka	INDIA_BUFFALO_0800_DHARWADI_01018
19.	Manda	Odisha	INDIA_BUFFALO_1500_MANDA_01019

Table 3. Registered breeds of Cattle (ICAR-NBAGR, 2021)

Sr. No.	Breed	Home Tract	Accession Number
1.	Amritmahal	Karnataka	INDIA_CATTLE_0800_AMRITMAHAL_03001
2.	Bachaur	Bihar	INDIA_CATTLE_0300_BACHAUR_03002
3.	Bargur	Tamil Nadu	INDIA_CATTLE_1800_BARGUR_03003
4.	Dangi	Maharashtra and Madhya Pradesh	INDIA_CATTLE_1104_DANGI_03004
5.	Deoni	Maharashtra and Karnataka	INDIA_CATTLE_1108_DEONI_03005
6.	Gaolao	Maharashtra and Madhya Pradesh	INDIA_CATTLE_1110_GAOLAO_03006
7.	Gir	Gujrat	INDIA_CATTLE_0400_GIR_03007
8.	Hallikar	Karnataka	INDIA_CATTLE_0800_HALLIKAR_03008
9.	Hariana	Haryana, Uttar Pradesh and Rajasthan	INDIA_CATTLE_0520_HARIANA_03009
10.	Kangayam	Tamil Nadu	INDIA_CATTLE_1800_KANGAYAM_03010
11.	Kankrej	Gujarat and Rajasthan	INDIA_CATTLE_0417_KANKREJ_03011
12.	Kenkatha	Uttar Pradesh and Madhya Pradesh	INDIA_CATTLE_2010_KENKATHA_03012
13.	Kherigarh	Uttar Pradesh	INDIA_CATTLE_2000_KHERIGARH_03013
14.	Khillar	Maharashtra and Karnataka	INDIA_CATTLE_1108_KHILLAR_03014
15.	Krishna Valley	Karnataka	INDIA_CATTLE_0800_KRISHNAVALLEY_03015
16.	Malvi	Madhya Pradesh	INDIA_CATTLE_1000_MALVI_03016
17.	Mewati	Rajasthan, Haryana and Uttar Pradesh	INDIA_CATTLE_1705_MEWATI_03017
18.	Nagori	Rajasthan	INDIA_CATTLE_1700_NAGORI_03018
19.	Nimari	Madhya Pradesh	INDIA_CATTLE_1000_NIMARI_03019
20.	Ongole	Andhra Pradesh	INDIA_CATTLE_0100_ONGOLE_03020
21.	Ponwar	Uttar Pradesh	INDIA_CATTLE_2000_PONWAR_03021
22.	Punganur	Andhra Pradesh	INDIA_CATTLE_0100_PUNGANUR_03022
23.	Rathi	Rajasthan	INDIA_CATTLE_1700_RATHI_03023

24.	Red Kandhari	Maharashtra	INDIA_CATTLE_1100_REDKANDHARI_03024
25.	Red Sindhi	On organized farms only	INDIA_CATTLE_0000_REDSINDHI_03025
26.	Sahiwal	Punjab and Rajasthan	INDIA_CATTLE_1617_SAHIWAL_03026
27.	Siri	Sikkim and West Bengal	INDIA_CATTLE_2221_SIRI_03027
28.	Tharparkar	Rajasthan	INDIA_CATTLE_1700_THARPARKAR_03028
29.	Umblachery	Tamil Nadu	INDIA_CATTLE_1800_UMBLACHERY_03029
30.	Vechur	Kerala	INDIA_CATTLE_0900_VECHUR_03030
31.	Motu	Orissa, Chhattisgarh and Andhra Pradesh	INDIA_CATTLE_1526_MOTU_03031
32.	Ghumusari	Orissa	INDIA_CATTLE_1500_GHUMUSARI_03032
33.	Binjharpuri	Orissa	INDIA_CATTLE_1500_BINJHARPURI_03033
34.	Khariar	Orissa	INDIA_CATTLE_1500_KHARIAR_03034
35.	Pulikulam	Tamil Nadu	INDIA_CATTLE_1800_PULIKULAM_03035
36.	Kosali	Chhattisgarh	INDIA_CATTLE_2600_KOSALI_03036
37.	Malnad Gidda	Karnataka	INDIA_CATTLE_0800_MALNADGIDDA_03037
38.	Belahi	Haryana and Chandigarh	INDIA_CATTLE_0532_BELAHI_03038
39.	Gangatiri	Uttar Pradesh and Bihar	INDIA_CATTLE_2003_GANGATIRI_03039
40.	Badri	Uttarakhand	INDIA_CATTLE_2400_BADRI_03040
41.	Lakhimi	Assam	INDIA_CATTLE_0200_LAKHIMI_03041
42.	Ladakhi	Jammu and Kashmir	INDIA_CATTLE_0700_LADAKHI_03042
43.	Konkan Kapila	Maharashtra and Goa	INDIA_CATTLE_1135_KONKANKAPILA_03043
44.	Poda Thurpu	Telangana	INDIA_CATTLE_3600_PODATHURPU_03044
45.	Nari	Rajasthan and Gujarat	INDIA_CATTLE_1704_NARI_03045
46.	Dagri	Gujarat	INDIA_CATTLE_0400_DAGRI_03046
47.	Thutho	Nagaland	INDIA_CATTLE_1400_THUTHO_03047

48.	Shweta Kapila	Goa	INDIA_CATTLE_3500_SHWETAKAPILA_03048
49.	Himachali Pahari	Himachal Pradesh	INDIA_CATTLE_0600_HIMACHALIPAHARI_03049
50.	Purnea	Bihar	INDIA_CATTLE_0300_PURNEA_03050

Table 4. Registered Goat breeds (ICAR-NBAGR, 2021)

Sr. No.	Breed	Home Tract	Accession Number
1.	Attapady	Kerala	INDIA_GOAT_0900_ATTAPADYBLACK_06001
2.	Barbari	Uttar Pradesh and Rajasthan	INDIA_GOAT_2017_BARBARI_06002
3.	Beetal	Punjab	INDIA_GOAT_1600_BEETAL_06003
4.	Black Bengal	West Bengal	INDIA_GOAT_2100_BLACKBENGAL_06004
5.	Changthangi	Jammu and Kashmir	INDIA_GOAT_0700_CHANGTHANGI_06005
6.	Chegu	Himachal Pradesh	INDIA_GOAT_0600_CHEGU_06006
7.	Gaddi	Himachal Pradesh	INDIA_GOAT_0600_GADDI_06007
8.	Ganjam	Orissa	INDIA_GOAT_1500_GANJAM_06008
9.	Gohilwadi	Gujarat	INDIA_GOAT_0400_GOHILWADI_06009
10.	Jakhrana	Rajasthan	INDIA_GOAT_1700_JAKHRANA_06010
11.	Jamunapari	Uttar Pradesh	INDIA_GOAT_2000_JAMUNAPARI_06011
12.	KanniAdu	Tamil Nadu	INDIA_GOAT_1800_KANNIADU_06012
13.	Kutchi	Gujarat	INDIA_GOAT_0400_KUTCHI_06013
14.	Malabari	Kerala	INDIA_GOAT_0900_MALABARI_06014
15.	Marwari	Rajasthan	INDIA_GOAT_1700_MARWARI_06015
16.	Mehsana	Gujarat	INDIA_GOAT_0400_MEHSANA_06016
17.	Osmanabadi	Maharashtra	INDIA_GOAT_1100_OSMANABADI_06017
18.	Sangamneri	Maharashtra	INDIA_GOAT_1100_SANGAMNERI_06018
19.	Sirohi	Rajasthan and Gujarat	INDIA_GOAT_1704_SIROHI_06019
20.	Surti	Gujarat	INDIA_GOAT_0400_SURTI_06020
21.	Zalawadi	Gujarat	INDIA_GOAT_0400_ZALAWADI_06021
22.	Konkan Kanyal	Maharashtra	INDIA_GOAT_1100_KONKANKANYAL_06022

23.	Berari	Maharashtra	INDIA_GOAT_1100_BERARI_06023
24.	Pantja	Uttarakhand and Uttar Pradesh	INDIA_GOAT_2420_PANTJA_06024
25.	Teressa	Andaman & Nicobar	INDIA_GOAT_3300_TERESSA_06025
26.	KodiAdu	Tamil Nadu	INDIA_GOAT_1800_KODIADU_06026
27.	Salem Black	Tamil Nadu	INDIA_GOAT_1800_SALEMBLACK_06027
28.	Sumi-Ne	Nagaland	INDIA_GOAT_1400_SUMINE_06028
29.	Kahmi	Gujarat	INDIA_GOAT_0400_KAHMI_06029
30.	Rohilkhandi	Uttar Pradesh	INDIA_GOAT_2000_ ROHILKHANDI _06030
31.	Assam Hill	Assam and Meghalaya	INDIA_GOAT_0213_ ASSAMHILL _06031
32.	Bidri	Karnataka	INDIA_GOAT_0800_ BIDRI _06032
33.	Nandidurga	Karnataka	INDIA_GOAT_0800_ NANDIDURGA _06033
34.	Bhakarwali	Jammu and Kashmir	INDIA_GOAT_0700_ BHAKARWALI _06034

Table 5. Registered Sheep breeds (ICAR-NBAGR, 2021)

Sr. No.	Breed	Home Tract	Accession Number
1.	Balangir	Orissa	INDIA_SHEEP_1500_BALANGIR_14033
2.	Bellary	Karnataka	INDIA_SHEEP_0800_BELLARY_14019
3.	Bhakarwal	Jammu & Kashmir	INDIA_SHEEP_0700_BHAKARWAL_14001
4.	Bonpala	Sikkim	INDIA_SHEEP_2200_BONPALA_14034
5.	Changthangi	Jammu & Kashmir	INDIA_SHEEP_0700_CHANGTHANGI_14002
6.	Chokla	Rajasthan	INDIA_SHEEP_1700_CHOKLA_14008
7.	Chottnagpuri	Jharkhand	INDIA_SHEEP_2500_CHOTTANAGPURI_14035
8.	Coimbatore	Tamil Nadu	INDIA_SHEEP_1800_COIMBATORE_14020
9.	Deccani	Andhra Pradesh &Maharashtra	INDIA_SHEEP_0111_DECCANI_14021
10.	Gaddi	Himachal Pradesh	INDIA_SHEEP_0600_GADDI_14003
11.	Ganjam	Orissa	INDIA_SHEEP_1500_GANJAM_14036
12.	Garole	West Bengal	INDIA_SHEEP_2100_GAROLE_14039

13.	Gurez	Jammu and Kashmir	INDIA_SHEEP_0700_GUREZ_14004
14.	Hassan	Karnataka	INDIA_SHEEP_0800_HASSAN_14022
15.	Jaisalmeri	Rajasthan	INDIA_SHEEP_1700_JAISALMERI_14009
16.	Jalauni	UttarPradesh& Madhya Pradesh	INDIA_SHEEP_2010_JALAUNI_14010
17.	Karnah	Jammu and Kashmir	INDIA_SHEEP_0700_KARNAH_14005
18.	Kenguri	Karnataka	INDIA_SHEEP_0800_KENGURI_14023
19.	Kilakarsal	Tamil Nadu	INDIA_SHEEP_1800_KILAKARSAL_14024
20.	Madras Red	Tamil Nadu	INDIA_SHEEP_1800_MADRASRED_14025
21.	Magra	Rajasthan	INDIA_SHEEP_1700_MAGRA_14011
22.	Malpura	Rajasthan	INDIA_SHEEP_1700_MALPURA_14012
23.	Mandya	Karnataka	INDIA_SHEEP_0800_MANDYA_14026
24.	Marwari	Rajasthan and Gujarat	INDIA_SHEEP_1704_MARWARI_14013
25.	Mecheri	Tamil Nadu	INDIA_SHEEP_1800_MECHERI_14027
26.	Muzzafarnagri	UttarPradesh &Uttarakhand	INDIA_SHEEP_2024_MUZZAFARNAGRI_14014
27.	Nali	Rajasthan	INDIA_SHEEP_1700_NALI_14015
28.	Nellore	Andhra Pradesh	INDIA_SHEEP_0100_NELLORE_14028
29.	Nilgiri	Tamil Nadu	INDIA_SHEEP_1800_NILGIRI_14029
30.	Patanwadi	Gujarat	INDIA_SHEEP_0400_PATANWADI_14016
31.	Poonchi	Jammu and Kashmir	INDIA_SHEEP_0700_POONCHI_14006
32.	Pugal	Rajasthan	INDIA_SHEEP_1700_PUGAL_14017
33.	Ramnad White	Tamil Nadu	INDIA_SHEEP_1800_RAMNADWHITE_14030
34.	Rampur Bushair	Himachal Pradesh	INDIA_SHEEP_0600_RAMPURBUSHAIR_14007
35.	Shahbadi	Bihar	INDIA_SHEEP_0300_SHAHBADI_14037
36.	Sonadi	Rajasthan	INDIA_SHEEP_1700_SONADI_14018
37.	Tibetan	Arunachal Pradesh	INDIA_SHEEP_2300_TIBETAN_14038
38.	Tiruchi Black	Tamil Nadu	INDIA_SHEEP_1800_TIRUCHIBLACK_14031
39.	Vembur	Tamil Nadu	INDIA_SHEEP_1800_VEMBUR_14032
40.	Katchaikatty Black	Tamil Nadu	INDIA_SHEEP_1800_KATCHAIKATTYBLACK_14040

41.	Chevaadu	Tamil Nadu	INDIA_SHEEP_1800_CHEVAADU_14041
42.	Kendrapada	Odisha	INDIA_SHEEP_1500_KENDRAPADA_14042
43.	Panchali	Gujarat	INDIA_SHEEP_0400_PANCHALI_14043
44.	Kajali	Punjab	INDIA_SHEEP_1600_KAJALI_14044

Table 6. Horse and donkey breeds (ICAR-NBAGR, 2021)

Sr. No.	Breed	Home Tract	Accession Number
1.	Bhutia	Sikkim and Arunachal Pradesh	INDIA_HORSE_2223_BHUTIA_07005
2.	Kathiawari	Gujarat	INDIA_HORSE_0400_KATHIAWARI_07002
3.	Manipuri	Manipur	INDIA_HORSE_1200_MANIPURI_07003
4.	Marwari	Rajasthan	INDIA_HORSE_1700_MARWARI_07001
5.	Spiti	Himachal Pradesh	INDIA_HORSE_0600_SPITI_07004
6.	Zanskari	Jammu and Kashmir	INDIA_HORSE_0700_ZANSKARI_07006
7.	Kachch-hi-Sindhi	Gujarat and Rajas-than	INDIA_HORSE_0417_KACHCHHISIND-HI_07007

Donkey breeds(ICAR-NBAGR, 2021)

Sr. No.	Breed	Home Tract	Accession Number
1.	Spiti	Himachal Pradesh	INDIA_DONKEY_0600_SPITI_05001
2.	Halari	Gujarat	INDIA_DONKEY_0400_HALARI_05002
3.	Kachchhi	Gujarat	INDIA_DONKEY_0400_KACHCHHI_05003

Table 7. Camel and Yak breeds (ICAR-NBAGR, 2021)

Sr. No.	Breed	Home Tract	Accession Number
1.	Bikaneri	Rajasthan	INDIA_CAMEL_1700_BIKANERI_02001
2.	Jaisalmeri	Rajasthan	INDIA_CAMEL_1700_JAISALMERI_02002
3.	Jalori	Rajasthan	INDIA_CAMEL_1700_JALORI_02004
4.	Kutchi	Gujrat	INDIA_CAMEL_0400_KUTCHI_02007
5.	Malvi	Madhya Pradesh	INDIA_CAMEL_1000_MALVI_02008

6.	Marwari	Rajasthan	INDIA_CAMEL_1700_MARWARI_02003
7.	Mewari	Rajasthan	INDIA_CAMEL_1700_MEWARI_02005
8.	Mewati	Rajasthan and Haryana	INDIA_CAMEL_1705_MEWATI_02006
9.	Kharai	Gujarat	INDIA_CAMEL_0400_KHARAI_02009

Yak breeds(ICAR-NBAGR, 2021)

Sr. No.	Breed	Home Tract	Accession Number
1.	Arunachali	Arunachal Pradesh	INDIA_YAK_2300_ARUNACHALI_16001

Table 8. Registered Pig breeds (ICAR-NBAGR, 2021)

Sr. No.	Breed	Home Tract	Accession Number
1.	Ghoongroo	West Bengal	INDIA_PIG_2100_GHOONGROO_09001
2.	NiangMegha	Meghalaya	INDIA_PIG_1300_NIANGMEGHA_09002
3.	AgondaGoan	Goa	INDIA_PIG_3500_AGONDAGOAN_09003
4.	Tenyi Vo	Nagaland	INDIA_PIG_1400_TENYIVO_09004
5.	Nicobari	Andaman & Nicobar	INDIA_PIG_3300_NICOBARI_09005
6.	Doom	Assam	INDIA_PIG_0200_DOOM_09006
7.	Zovawk	Mizoram	INDIA_PIG_2700_ZOVAWK_09007
8.	Ghurrah	Uttar Pradesh	INDIA_PIG_2000_GHURRAH_09008
9.	Mali	Tripura	INDIA_PIG_1900_MALI_09009
10.	Purnea	Bihar and Jharkhand	INDIA_PIG_0325_PURNEA_09010

Table 9. Registered Poultry Breeds (ICAR-NBAGR, 2021)

Chicken

Sr. No.	Breed	Home Tract	Accession Number
1.	Ankaleshwar	Gujarat	INDIA_CHICKEN_0400_ANKALESHWAR_12001
2.	Aseel	Chhattisgarh, Orissa and Andhra Pradesh	INDIA_CHICKEN_2615_ASEEL_12002

3.	Busra	Gujarat and Maharashtra	INDIA_CHICKEN_0411_BUSRA_12003
4.	Chittagong	Meghalaya and Tripura	INDIA_CHICKEN_1319_CHITTAGONG_12004
5.	Danki	Andhra Pradesh	INDIA_CHICKEN_0100_DANKI_12005
6.	Daothigir	Assam	INDIA_CHICKEN_0200_DAOTHIGIR_12006
7.	Ghagus	Andhra Pradesh and Karnataka	INDIA_CHICKEN_0108_GHAGUS_12007
8.	Harringhata Black	West Bengal	INDIA_CHICKEN_2100_HARRINGHATABLACK_12008
9.	Kadaknath	Madhya Pradesh	INDIA_CHICKEN_1000_KADAKNATH_12009
10.	Kalasthi	Andhra Pradesh	INDIA_CHICKEN_0100_KALASTHI_12010
11.	Kashmir Favorolla	Jammu and Kashmir	INDIA_CHICKEN_0700_KASHMIRFAVOROLLA_12011
12.	Miri	Assam	INDIA_CHICKEN_0200_MIRI_12012
13.	Nicobari	Andaman & Nicobar	INDIA_CHICKEN_3300_NICOBARI_12013
14.	Punjab Brown	Punjab and Haryana	INDIA_CHICKEN_1605_PUNJABBROWN_12014
15.	Tellichery	Kerala	INDIA_CHICKEN_0900_TELLICHERY_12015
16.	Mewari	Rajasthan	INDIA_CHICKEN_1700_MEWARI_12016
17.	Kaunayen	Manipur	INDIA_CHICKEN_1200_KAUNAYEN_12017
18.	Hansli	Odisha	INDIA_CHICKEN_1500_HANSLI_12018
19.	Uttara	Uttarakhand	INDIA_CHICKEN_2400_ UTTARA_12019

Duck breeds(ICAR-NBAGR, 2021)

Sr. No.	Breed	Home Tract	Accession Number
1.	Pati	Assam	INDIA_DUCK_0200_PATI_11001
2.	Maithili	Bihar	INDIA_DUCK_0300_MAITHILI_11002

Geese breeds(ICAR-NBAGR, 2021)

Sr. No.	Breed	Home Tract	Accession Number
1.	Kashmir Anz	Jammu & Kashmir	INDIA_GEESE_0700_KASHMIRANZ_18001

Animal Genetic Resources of Coastal Regions

In coastal region of the India livestock resources are diverse and plenty in number. Coastal region of the India, which constitutes for the 14.2% of total Indian landmass, possesses the 19.5% of the livestock population of total Indian livestock population. The East Coast of the country is more affluent in both population and the genetic diversity in livestock resources than the west coast. The vast population and diversity of livestock in the coastal India could prove to be a vital asset for the country and unlike many other natural resources which will deplete over the years, a sustainable livestock production system will continue to propel coastal agriculture. Milk is available in abundance and the presence of vibrant Dairy co-operatives in the coastal districts of the country boosts the dairy industry in this region.There is better availability of power and communication infrastructure due to presence of major and minor ports.

Table 10. Animal Genetic resources of coastal region of India(*in millions*)

Region	Cattle	Buffalo	Sheep	Goat	Pig	Poultry	Duck
West Coast	7.39	3.93	1.05	4.22	0.26	18.03	1.73
East Coast	28.78	7.61	12.11	10.17	23.39	40.02	3.32
Coastal	36.17	11.55	13.16	14.39	2.36	58.05	5.05
Total India	199.07	85.74	71.56	140.54	11.13	617.73	27.64

Conservation of animal genetic resources

The 20th livestock census gave some indications about the population of the livestock breeds. Presently a number of registered breeds have very low population, which include all the species. Beside these breeds, some of other livestock populations, which are yet registered, are also declining. The reasons behind the decrease of most of the indigenous populations vary but most evident are: decreasing utility, increasing pressure for production, low productivity. Consistently high demand with changing production scenario has derived the preference for highly specialized breeds, which has attributed to the loss of genetic diversity of the livestock in general, and of indigenous breeds in particular. Low productivity of indigenous livestock can be adjudged as biggest reason for threatening of a breed.

During last 50 years, the genetic diversity of indigenous farm animals started declining. Although, the trend is not endemic, however, it is observed that in most of the countries specifically developing. Mechanized agricultural and transport led the down-numbering of the farm animal breeds needed for draught, ploughing and utility as a pack animal. Even most of the draft purpose cattle breeds useful for agricultural works and breeds of camel and horse, un-described populations of donkey and yak utilized for packing and transportation have been declined significantly and seemingly most of them under threat. Preserving each and every germplasm should be our utmost priority at National level, where different stakeholders' agencies should participate in coordination. Multi-pronged strategies including documenting maximum diversity their unique traits of known breeds, identifying new populations, adopting different conservation strategies, improving such populations through developing societies and cooperatives may be some improvement strategies to preserve and sustainably use the precious germplasm for present and future generations.

Challenges

The updated list of mammal species/subspecies reflects a shocking picture of extinction of three species/subspecies from the entire territory of India (FAO 2012). One-third of the total is on the threshold of extinction (Critically Endangered + Endangered: 42 out of 144) and further another set of about 42 (30%) species/subspecies figuring in Near Threatened/Lower Risk-Near threatened IUCN category, which are knocking on the door of threatened species. Interestingly, there is a noticeable number of species, which could not be assessed due to poor quality of data Deficient or not evaluated species are equally important, since they also fall under the category of conservation status at either National level Indian Wildlife (Protection) Act Schedule I or International level Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendices I. Attention needs to be given to such species to gather maximum input to formulate appropriate corrective measures for the protection of these species.

Indian mammal species/subspecies with higher conservation status listed under Indian Wildlife (Protection) Act, 1972 Schedules (about 88%) out of 144 listed species have been offered full protection under Schedule I Part I and Schedule II, Part II of Indian Wildlife (Protection) Act and any kind of offense carries capital punishment. However, there are 14 species (about 10%) not featuring in the Wildlife Act Schedules, but they do carry higher conservation status of IUCN and/or CITES. Efforts should be made to assess these species critically in light of the provisions under the Act, which has been amended from time to time.

Key drivers of the loss of animal genetic diversity

- Marginalization of traditional production systems and local breeds.
- The growing concentration of meat, milk and egg production with high yielding breeds and strains. The ease of transportation of animal genetic material along with production technologies and required inputs
- Disease and epidemics or other natural calamities such as drought or floods significantly reduced the animal genetic resources and breeds.
- Policy frameworks within the livestock sector

(www.fao.org)

Global Plan of Action for Animal Genetic Resources

The member states of the FAO adopted the 2007 Interlaken Declaration on Animal Genetic Resources and associated Global Plan of Action for Animal Genetic Resources. The declaration "recognizes the essential role and values of animal genetic resources for food and agriculture, in particular, their contribution to food security for present and future generations." In response, Member States committed themselves "... to achieving the sustainable use, development and conservation of animal genetic resources for food and agriculture." Furthermore, Member States committed themselves "to facilitating access to these resources and the fair and equitable sharing of the benefits arising from their use..." with the objective of enhancing world food security, improving human nutritional status and contributing to rural development (FAO, 2007).

Objectives

- To promote the sustainable use and development of animal genetic resources, for food security, sustainable agriculture, and human wellbeing in all countries;
- To ensure the conservation of important animal genetic resource diversity, for present and future generations, and to halt the random loss of these crucial resources;
- To promote a fair and equitable sharing of the benefits arising from the use of animal genetic resources.
- To meet the needs of pastoralists and farmers, individually and collectively, within the framework of national law, to have nondiscriminatory access to genetic material, information, technologies, financial resources, research results, marketing systems, and natural resources, so that they may continue to manage and improve animal genetic resources, and benefit from economic development;
- To promote agro-ecosystems approaches for the sustainable use, development and conservation of animal genetic resources;
- To assist countries and institutions responsible for the management of animal genetic resources to establish, implement and regularly review national priorities for the sustainable use, development and conservation of animal genetic resources;
- To strengthen national programmes and enhance institutional capacity in developing countries and countries with economies in transition – and develop relevant regional and international programmes; such as education, research and training to address the characterization, inventory, monitoring, conservation, development and sustainable use of animal genetic resources;
- To promote activities aimed at raising public awareness and bringing the needs of sustainable use and conservation of animal genetic resources to the attention of concerned governments and international organizations.

(www.fao.org)

Conservation protocols

In situ: Conservation of the live animals under its own habitat. The animals are conserved as closed species without intermixing of the other related animals. As a best preferred method of conservation, In-situ conservation oflivestock through involving livestock keepers in the production system should be adopted to maintain a breed ina dynamic state.

Ex situ: Two approaches are practiced for ex situ conservation of animals. Ex situ-in vivo is the conservation of

live animals in the controlled farm conditions and Ex situ -in vitro method is the cryo-preservation of ova, embryo, semen, somatic cells, PGCs, DNA etc. It is more useful in the conservation of endangered or threatened animals.

Genetic Improvement of animals

Genetic improvement of livestock and poultry species is carried out for the improving the productivity of animals. Generally, the improvement is done through traditional selection breeding methods. Characterization and documentation of the lesser known livestock populations will be an

important step towards planning the organized breeding program for their genetic improvement, conservation strategies and sustainable utilization. Breed registration will help in preparation of an inventory of the genetic resources that will enable to take systematic efforts for the genetic improvement. Establishment of breeding farms for different livestock species will help in the genetic improvement of animals.

The following methods will help in the genetic improvement of farm animals:

- Inbreeding
- Selective breeding
  - Mass selection
  - Independent culling levels
  - Index selection
  - Marker Assisted selection
  - Genome wide Associated Selection
- Out Breeding
  - Cross breeding
  - Out crossing
  - Grading up
  - Species hybridization

- Transgenesis/GMOs
  - Gene silencing
  - Gene knock out
  - Gene editing, etc.

References

1. FAO (2007) The State of the World's Animal Genetic Resources for Food and Agriculture. Edited by Rischkowsky B, Pilling D Rome: Food and Agriculture Organization.
2. FAO (2012) Status and Trends of Animal Genetic Resources - 2012. Intergovernmental Technical Working Group on Animal Genetic resources for Food and Agriculture, Rome, 24-26 October, 2012 (CGRFA/WG-AnGR7/12/Inf.4).
3. http://www.fao.org/docrep/meeting/026/ME570e.pdf
4. https://nbagr.icar.gov.in/en/new-breeds-lines/
5. www.fao.org
6. https://nbagr.icar.gov.in/en/registered-buffalo/
7. https://nbagr.icar.gov.in/en/registered-cattle/
8. https://nbagr.icar.gov.in/en/registered-goat/
9. https://nbagr.icar.gov.in/en/registered-sheep/

10. https://nbagr.icar.gov.in/en/registered-horse/
11. https://nbagr.icar.gov.in/en/registered-donkey/
12. https://nbagr.icar.gov.in/en/registered-camel/
13. https://nbagr.icar.gov.in/en/registered-yak/
14. https://nbagr.icar.gov.in/en/registered-pig/
15. https://nbagr.icar.gov.in/en/registered-chicken/
16. https://nbagr.icar.gov.in/en/registered-duck/
17. https://nbagr.icar.gov.in/en/registered-geese/

Lead Paper

Innovative Strategies to make Coastal Regions Self Reliant in fodder

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Livestock husbandry in India is mainly sustained on crop-residues. Diverse cropping enables livestock to get crop-residues of varied kinds. However, in many agro-ecological situations in the country cropping pattern is dominated by tree species, residue of which cannot be used. The realised fact is that organic manure is must to make agriculture sustainable. Organic manure is more crucial in places where leaching of nutrients prevail. Coastal areas with high rainfall are more prone to such condition. The situation gets worst in coastal belts as it also has undulating terrain. Livestock are valued more in such areas not for milk but for manure. Regular application of farm yard manure is essential to sustain the yield of agriculture crops in coastal regions. They are plagued with regular leaching of soil nutrients due to heavy rainfall and typical sloppy terrain. Besides demand for land for non-agricultural use in these regions due to spurt of secondary and tertiary sector literally poses challenge for agriculture development as land available for cultivation is already limited. Maintenance of fertility of available agriculture land becomes thus essential. Earlier pulses occupied a prominence in coastal regions. But over the years the pulse area drastically declined to less than 0.1 per cent of the net sown area. Natural reclamation of soil through pulse cultivation is thus affected leading to nutrient leaching.

Livestock by farm families as mentioned earlier are reared mainly for obtaining cow-dung to prepare farm yard manure. However, the range of crops cultivated in the region do not really produce crop residues having fodder value. Coconut, cashew, mango, rubber, tea, coffee, pepper, cardamom, arecanut, ginger, nutmeg, cinnamon are the crops cultivated at large in the coastal regions. We need to understand that farm families in our country sustain livestock mainly on crop residues. This particular region, due to cultivation of plantation and spice crops (as listed above) is devoid of adequate quantities of crop residue for livestock. Paddy is grown in the state to large extent and it becomes very crucial to make best use of paddy straw for feeding livestock though it forms a very poor feed from quality perspective. However, dry fodder is valued more in the state than green fodder as is required to keep the body of animal warm especially in rainy season. This typical condition of the state with respect to livestock rearing calls for systematic and scientific interventions of fodder technologies to ensure adequate fodder availability.

Parts of Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Bihar, Orissa, West Bengal and some north eastern states have coastal zones. Besides Pondicherry, Lakshadweep and Andaman and Nicobar Islands belong to coastal belt. In the present paper, fodder scenario and strategies for enhancing fodder production by taking Goa state as an example for coastal belt is discussed. In Goa state, the annual requirement of concentrate, green fodder and dry roughages is about 1.23, 10.08 and 1.67 lakh tons, respectively. In terms of supply, the deficiency percentage is highest in concentrate at 93%, followed by 49% in green fodder and 50% in dry roughages. The feed resources available from existing agricultural practices meet roughly 40 per cent of the livestock requirement of green and dry fodder. With increased cross-breeding, the physical stature of dairy animals has improved considerably and their body weight now is in the range of 325-350 kg as against earlier body weight of around 150 kg. As a result, the demand for feed and fodder has further increased.

The major constraints in production of green fodder are small land holding or unavailability of land for fodder cultivation, scarcity of water or saline water, labour required for cultivation (sowing, earthing up, weeding, harvesting etc.), requirement of manure and fertilizer, more growth time (approx. 45-60 days), non-availability of consistent quality of fodders round the year, fencing to prevent fodder crop from wild animals and natural calamities etc.

Land use pattern of Goa indicates negligible area under permanent pastures and grazing lands. However large area is available under forests and cashew nut and coconut crops. If this land is put under fodder production using available inter-row spaces, then state can address the issue of fodder deficiency. In Table 1, estimation of green fodder production by different land use is computed and presented.

Table 1: Estimation of green fodder production potential of non competitive lands in Goa

Niche	Area (000 ha)	Estimated GF production (MMT/year)	Estimated Livestock sustainable for 3 months ('000 no)	Estimation rate
Forest area	125	187.5	75	GFY 1.5 t/ha/year
Permanent pastures and grazing lands	1	5	2	GFY 5 t/ha/year
	Total A	192.5	77	
Cashew nut	56735	2269400	907.76	GFY 40 t/ha/year
Coconut	25608	1027250	411.008	GFY 40 t/ha/year
	Total B	3296.92	1395.768	
	Grand total (A+B)	3489.42	1472.768	20 kg GF/ACU as sustenance feed
	Total bovines in state		89000	

MMT: Million metric tons or Million tons

Suitable forage technologies for enhancing fodder production in coastal region

1. Introducing improved fodder crops in orchards and plantation: This intervention helps to use inter-row spaces of fruit and plantation crops which otherwise left unutilised. Coastal regions have large area under plantation crops. If this area is put to use for cultivation of perennial fodder crops, green fodder requirement of ruminants for three months can be met exclusively from the fodder produced from this intervention. Specially some of the legume species like *Stylosanthes guianensis* are suitable for cultivation in high rainfall area and under tree canopy. Besides providing fodder, they also act as cover crop suppressing other weeds.
2. Forage based crop diversification and intensification: Range of very high yielding fodder crops suitable for cultivation in coastal regions are available. The crops like bajra napier hybrid (DHN-6), guinea grass (BG-2), grazing guinea, *Brachiaria ruziziensis*, fodder maize*, Clitoria* sp, *Stylosanthes hamata and S. guianensis* etc are suitable for cultivation in coastal belt. These crops being perennial in nature, once planted regularly provide fodder for 3-4 years. Every year land preparation, seed cost could be avoided by cultivating these perennial crops besides ensuring round the year green fodder.

3. Fodder shrubs and trees: Chaya, *Sesbania* spp., *Gliricidia*, Subabul, *Sauropus androgynus* (Chakramuni/Katuk), *Desmanthus virgatus* etc are some of shrub and tree species which need to be promoted all along field boundary in coastal regions. They are easy to manage and cheap protein sources for livestock. Leaf meal prepared from these trees and shrubs act as feed reserve.

4. Azolla as a green feed supplement: Azolla can be fed to livestock either in a fresh or dried form. It can be given directly or mixed with concentrates to livestock. As fresh azolla is highly perishable, it is advisable to dry it immediately when there is a surplus. Azolla is usually dried in the shade and stored, for example in a plastic bin, for later use.

5. Pineapple fruit residue silage: Pineapple is one of the important crop of high rainfall region. In Pineapple fruit, only 30% is consumed and remaining 70% is a waste. Nearly 1.3 million tons of this non-edible residue is available annually and is being wasted in the country. The Pineapple Fruit Residue is chaffed into pieces of 1–2 inches and compacted in plastic drums/bags of 50 kg capacity at a moisture content of about 65% with 4:1 ratio (w/w) of pineapple leafy crown and fruit peels, and kept under airtight condition (see video for the process of silage preparation). In a period of 20 days, good quality silage is prepared with average pH and lactic acid content of 4.2 and 6–7%, respectively. Nutritive value of the PFR silage on dry matter basis (total sugars 52.0%, crude protein 7.50%, neutral detergent fibre 56.04%, acid detergent fibre 19.76%, total digestible nutrients 72%, calcium 0.61%, and phosphorus 0.30%) is better than the conventional maize green fodder.

6. Hydroponics: Under hydroponics system, from one kg of maize seed, about 5-6 kg of fresh fodder can be produced, which is more nutritious than the conventional maize fodder in terms of available organic matter, crude protein, ether extract and nitrogen free extract content and the cost of production of the hydroponics maize fodder was approximately Rs. 4-4.50/- per kg on fresh basis in Goa condition. A case study under field conditions revealed that by adopting this technology and feeding 10 kg hydroponics fodder maize per cow, 1.0 kg concentrate mixture per cow/day could be saved and boosted milk yield from 8 litres to 9 litres per cow per day with an additional income of Rs 10/animal/day. Four cows, which were repeat breeder conceived after incorporation of hydroponics green fodder maize in their ration. The young calves fed with 1-2 kg hydroponics fodder gained higher body weight (350g vs. 200g) with better skin coat.

7. Paddy straw enrichment and bales: Paddy straw is the only crop residue available in the state. Paddy straw can be enriched with urea treatment as urea is relatively safe chemical and is easy to store and dissolve in water (Singh and Schiere, 1995). An amount of 4 kg of urea (equivalent to 2.2% ammonia) to treat 100 kg of air dry straw has been found to be an optimum level. Levels lower than 3.5 kg may not produce sufficient ammonia for effective treatment, and levels above 4 kg have not further increased straw quality. Higher levels result in higher digestibility in *in vitro* trials. In practical *in vivo* work however, where it is the combination of increased digestibility and intake that counts, no beneficial effect of higher urea levels is found. A farmer can weigh the 4 kg of urea in a bucket or a cup once, mark the level and subsequently use that measure for further weighing. Only one week treatment time is required in coastal area as generally it has temperature above 30^0 C.

The different methods of stacking or storing urea sprayed straw have their relative merits and demerits, but the bottom line about all these methods is that the better the compaction and air tightness of the stack, the better will be the quality of the treated straw.

Further paddy straw can be baled and stored. This requires less space without affecting its quality and making it prone for fungal infection. Mobile type hay densification machines are available which can be hired by farmers on custom basis for getting their paddy straw baled and preserved. This saves considerably on space to stack fodder, transportation of paddy straw besides saving labour.

8. Use of feed troughs: Several farmers place paddy straw on the ground, leading to very high wastage. Studies have shown that use of troughs reduce wastage by 20–30%. Promotion of improved feed troughs brings many benefits to farmers. They no longer had to spend time to rearrange fodder around the animals to prevent trampling and soiling, and less soiled fodder to clear out from the cattle sheds. Besides, clean fodder, free of urine and dung reduces the risk of infections (especially respiratory problems) for the animals.

9. Awareness and training on use of area specific mineral mixture: Minerals are required by dairy animals for their metabolic functions, growth, milk production, reproduction and health. Animal cannot synthesize minerals inside its body and usually feeds and fodders fed to the dairy animals do not provide all the minerals in the required quantity. Therefore, animal should be supplemented with adequate amount of good quality mineral mixture in their ration. For all the coastal districts, area specific mineral mixture recommendations as per BIS standards are available. Popularising them through awareness programs and conducting training programs in high livestock density districts would help to improve feed utilisation as well as animal production.

10. Brewers' grain as livestock feed: Brewers' spent grains (BSG) are the by-products of the brewing industries, obtained during the preparation of cereal malt beverages. The BSG primarily consist of the residues of the grains (barley alone or a mixture of barley and other cereal grains or grain by-products) used in the brewing process. In Goa, about 6000 tons of BSG are produced annually of which 50% is used in this state and the rest is being exported to the neighbouring state. The cost of the BSG is approximately Rs. 2/- per kg on fresh basis. Use of BSG as an alternative feed for livestock reduce the cost of production. The fresh BSG contain about 80% moisture and after drying the dried brewers' grains (BDG) contain approximately 25% crude protein, 5% ether extract, 17 crude fibre, 7.5% total ash and 1.5% acid insoluble ash on dry matter basis. Due to high moisture content, it cannot be preserved as such for long time (not more than 4-5days). However, after sun drying, it can be preserved for long duration. In dairy animals, the BSG can be fed both as fresh brewers' grains and brewers' dried grains (BDG). It is suggested that on fresh basis BSG can be fed @ 2% of the body weight of the dairy animal replacing up to about 2 kg of concentrate mixture daily, which saves the feed cost approximately Rs. 20/- per animal per day. The BDG can be included in the diet of the dairy cows up to 28% replacing the rice polish without any adverse effect on the performance of animals, which reduces the cost of the concentrate mixture by approximately Rs. 3/- per kg.

Some of the major constraints, a development professional faces in promotion of fodder innovations are related to forage extension and forage seed. Challenges of forage extension are many. Hybrid napier, guinea, signal grass, hamata etc are the names of forages which do not sound famil-

iar to several farmers unlike food crops like paddy, wheat, jowar etc. They are not close to and fit in their native vocabulary. They simply sound new to them and the things with the tag 'new' have initial inertia of change. The challenge of forage extension begins thus with making farmers familiar with very name of these forage crops. These crops are not found to be seen in the vicinity of farmers' habitation. Getting farmers see these crops is important to make them familiar with these new set of crop vocabulary (names) and to the other multiple benefits they bring to these farmers. Off campus training method of extension system thus becomes less relevant here as farmers need to see these crops in the field and experience them by using as many sensory organs (touch to feel softness, taste them to know the extent of sweetness, see them to understand the level of hairiness, recognise and remember them). On campus training method becomes inevitable to break the initial inertia of change among farming community. Learning becomes easier if basic information of the innovation is made known to the learner. Teaching on an entirely new area demands certain level of creativity on the part of the trainer to ensure that interest among learners is generated and knowledge that is passed on sinks maximum into their mind. Creativity ought to be also vital when farmers are less willing to spare more time for the crops having no direct and immediate benefits.

In the country, forage seeds are produced and sold mainly by the public sector. Besides, there is no adequate information available about the demand for forage seed. Inadequacy in the availability of quality seed is one of the major constraints in forage promotion and enhancing livestock productivity in the country. Sowing a new pasture or improving an existing natural pasture requires a reliable source of seed or vegetative material of species recommended and adapted for the area. Quality forage seed production is a specialized activity and is a relatively recent phenomenon in India. Because of limited experience and expertise, organized forage seed production and delivery systems are almost non-existent at the required niches. For the propagation of improved fodder varieties coupled with production technologies, it is essential that quality seed should be made available to the farmers so that the benefits of breeding and research efforts could percolate to the end users. By and large forage crops are poor seed yielders because they are basically bred for forage yield. Other factors are genetic limitation of seed setting, non synchronized flowering/maturity, and abscission causing flower, pod and seed drop and the physiological drift during seed development (Singh *et al*., 2009). Seed yield is negatively correlated with forage production. Majority of the forage crops are shy seed yielders with poor synchrony. Seed production in these crops is a specialized and location specific activity requiring skill, intimate knowledge of flowering, seed maturation and seeding behaviour of a species.

The seed production of forage crops is considered secondary in importance, because the economic product is the vegetative growth which is cut for animal consumption before the seed matures. Thus the new and high-yielding forage crops and their varieties will not be adequate unless the forage seed of the right quality and in the right quantity is made available to the growers at the right time and in the right place and above all at a reasonable price which a farmer can afford to pay. With the development of improved and high-yielding varieties in forage crops, it has been realized that truthful labelled (TFL) and certified seed should be supplied to the farmers. Shortage of improved technologies in the field of seed production of forage crops has to be overcome by launching a participatory seed production programme or through bringing up new entrepreneurs in seed production of these crops. Apart from the seed production techniques, seed processing and handling techniques need to be developed for maintaining the quality of forage seeds. The demand of quality seed of these crops is increasing day by day. Hence, to meet out the ever increasing demand of the seed, one need to identify the high seed-producing forage crop varieties, location and through participatory programme of researchers, farmers, NGOs and seed growers.

Fodder technologies listed in the paper which if promoted and adopted by the stakeholders can considerably reduce the fodder scarcity of coastal region and the region can become self sufficient in fodder resources. The efforts of promotion of fodder technologies need to be backed by adequate availability of forage seed. It is advised that adoption of combination of technologies based on the basis of resource mix of stakeholders would help to meet varied nutritional requirements of the animals.

S4-OP1

Influence of fertilizer dosages and seed setting chemicals on seed yield and quality of *Brachiaria ruziziensis* grass

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Brachiaria grass is an important cultivated fodder crop used extensively for fodder purposes in tropical parts of the world. It is a very palatable crop with overall digestibility of 55–75 per cent. Because of its high fodder potential, it is mainly grown in southern parts of the country, *viz.,* Karnataka, Kerala, and Tamil Nadu. Due to its perenniality and good persistence, this grass can be profitably grown as a component of agro-forestry and plantation cropping systems. Establishment through root slips is highly successful and commonly practiced. But it is uneconomical due to higher labour requirements and substantial transportation costs. Hence, propagation through seed is cheaper, easy and convenient. However, seed germination is very poor due to the non-availability of a suitable package of practices for seed production. Hence, the present study was undertaken at IGFRI, SRRS, Dharwad from 2019-to 2022. The experiment was laid out in a factorial design comprising three fertilizer doses and four foliar spray treatments. The results revealed that with an increase in the application of fertilizer doses increased the plant height and number of branches per plant. Application of 25 % more RDF recorded maximum plant height (86.8 cm) at 30 DAP in $T_{12.}$ In comparison, the plant height was maximum (168.9 cm) in T_{11} at 60 days after the first cut. The number of branches per plant also exhibited a similar trend; it was significantly maximum in treatment T_{10} (141.5). The seed yield per plot was significantly highest (323.3 g) in treatment T_{10} (25 % higher RDF + foliar spray with IAA @ 100 ppm). The control (RDF + No spray) recorded the lowest seed yield per plot (177.3 g). Similarly, the seed quality parameters viz., seed germination, seedling length and seedling vigour index were also highest in the treatment combination of 125 % RDF + foliar spray with IAA @ 100 ppm.

Keywords: Fertilizer, Fodder, Seed Yield, Seed Quality

S4-OP2

Genetic polymorphism of HSP90 gene in Shweta Kapila cattle of Goa

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Heat stress proteins are essential factors in protecting the cells of animals and humans against environmental stress leading to cellular homeostasis. Zebu cattle are well known for the prevalence of novel mutations responsible for heat tolerance. Hence, the study was carried out to identify single nucleotide polymorphisms (SNPs) in the 3'-untranslated region (3'UTR) of inducible 90kDa heat shock protein (HSP90AA1) gene in Sahiwal, Gir and Shweta Kapila cattle breeds raised in the hot and humid coastal climate of Goa, India. Genomic DNA was extracted from whole blood in EDTA using the ReliaPrep™ Blood gDNA Miniprep system (Promega). The 3'UTR of HSP90AA1 gene of genomic DNA was amplified using designed oligonucleotide primers and sequenced. Custom sequencing results revealed three SNPs at loci g.G4733C, g.C4765A and g.A4848G in 3'UTR of HSP90AA1 gene in all three breeds. Moreover, SNPs g.G4733C and g.C4765A resulted in amino acid substitutions as Cysteine to Serine and Glutamine to Cysteine, respectively. This is the first study of mutations in the HSP90AA1 gene in selected indigenous cattle breeds of India adapted to the hot and humid coastal climate. Further studies with a large sample size are necessary to genotype the loci for their significant effect on thermotolerance in cattle which can be used as a molecular marker for thermotolerance.

Keywords: Cattle, Heat Shock Protein, HSP90AA1 Gene, SNP

S4-OP3

Comparative analysis of broad host range coliphages infecting AMR *E. coli* for virulence and resistance potential: A whole genome approach

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Antimicrobial resistance (AMR) is creating havoc in the health sector and its menace has percolated into the food production systems. To combat this, bacteriophages find use as a potential alternative to antibiotics. However, using broad host range phages that kill multiple strains of bacteria would be more beneficial, as it is supposed to be equivalent to a broad-spectrum antibiotic. In the present study, three broad host range coliphages viz., ϕEC-S-21, ϕEC-S-24 and ϕEC-11-5 isolated from aquatic systems of Kerala and Andhra Pradesh were subjected to whole-genome sequencing using Illumina platform. The genome annotation, genome analysis, and function prediction were carried out using different bioinformatic software. Determination of lytic or lysogenic lifecycle was performed based on PHACTS and the coding sequences (CDS) were obtained by

PHASTER and Prokka software. The CDS were annotated and gene ontology was determined using Blast2Go tool. Phage genomes were compared to other genomes in NCBI using MAUVE and BRIG (Blast Ring Image Generator) tools to visualize the similarities and differences. The phages ϕEC-S-21and ϕEC-11-5 belonged to *Myoviridae*, and phage ϕEC-S-24 belonged to *unclassified Kayfunavirus* of *Autographivirdae*. The phage genomes ranged between 24 kb and 145 kb in size, with a G+C content varying between 37% and 51%. Coding sequences ranged between 30 and 251 amino acids length. The CDS were annotated and categorized into different modules *viz*., structural proteins, DNA replication and modification, cell lysis, packaging, and uncharacterized proteins. There existed a diversity between the phages in proteins associated with infection and lysis. Pertinently, the phage genes did not harbour any toxin genes or resistance genes, thus making these phages as desirable candidates to be exploited in phage therapy.

Keywords: Bacteriophages, Whole-genome sequencing, Genome analysis, Genome comparison.

S4-OP4

Effect of Supplemental mineral mixture fed varying levels of protein on growth performance and blood biochemical profile of Black Bengal goats

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An *in vivo* study (3 months) was conducted to assess the effect of a proteinaceous diet along with mineral mixture on nutrient utilization, blood biochemical profile and growth performance of Black Bengal goats under a semi-intensive system. Twelve male kids (6-7 months) were randomly divided into 3 groups of 4 in each based on body weight. Three types of diets containing T_1- Conventional/farmers' practice (CM-I: low protein and low mineral), T_2- T_1 + mineral (CM-II: low protein and high mineral) and T_3- T_2+ protein-rich oil cake based feed (CM-III: high mineral and high protein) were provided to animals. Fodder (HN-IGFRI-6) was provided to the animals as per requirement on daily basis maintaining a concentrate: roughage ratio at 40:60 level. Total DM intake was higher ($P<0.05$) in T_3(588) than T_1 (520) and T_2 (545). Nutrient digestibilities of DM, CP, EE, fibre were higher ($P<0.05$) in T_3 was higher than T_1 and T_2 which were at par. The haematobiochemical indices and mineral profile of goats i.e hemoglobin, glucose, protein, Ca, P, Cu, Fe, Mn, Zn level in T_3 was higher ($P<0.05$) than T_1 and T_2. The average daily gain (ADG; g/day) was also higher ($P<0.05$) in T_3 (59.12) than T_1 (34.45) and at par with T_2 (45.23). The voluntary feed intake (g/day) of concentrate was higher ($P<0.05$) in T_3 (223.5) than in T_1 (194.5) and T_2 (207.6). The voluntary feed intake (g/day) of roughage was the similar and total dry matter was higher in T_3 as compared to T_1 but at par with T_2. The feed gain ratio was better ($P<0.05$) in T_3 (9.19) than in T_1 (14.82) and T_2 (11.7). It was concluded that growth performance was higher in protein feed supplemented animals along with mineral mixture showing the synergistic effect of protein with mineral due to better nutrient utilization at the tissue level.

S4-OP5

Sero cytokine biomarkers for Ethnopharmacological Assessment of Nicobari Tribal Ethno Veterinary practices

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Ethno-veterinary medicine (EVM) system, an indigenous knowledge on animal health is re-emerging as a holistic animal health care and has an important role in one health programme. Indigenous remedies and clinical practices are being preferred at present for the virtue of their cost-effectiveness and ease of accessibility to treat and prevent animals' diseases rather than the use of modern synthetic drugs and in a view of residue-free livestock and poultry production. However, due to the lack of proper documentation and pharmacological evaluation, EVM is restricted to a few herbal healers in our society. Andaman & Nicobar Islands is the hot spot for medicinal plants and works on documentation of EVM were initiated. The present study was conducted by using medicinal plants (*Tabernamontana crispa, Psidium gujava and Lee indica*) collected from the tribal farming community of Car Nicobar. The pharmacological efficacy of these plants were evaluated in poultry by using sero-cytokines as biomarkers. A biological experiment was carried out on the efficacy of aqueous extract of herbal formulation. The herbal decoction was prepared. Experimental birds were divided into three groups. The first group was given with only water without any additives. The second group was given an antibiotic (oxytetracyclin) and the third group was given a polyherbal formulation @ 3 ml per bird twice a week. Results showed that both antibiotic and polyherbal extract supplemented groups have better body weight as compared to the control group. The higher serum growth-promoting hormone (0.3 to 0.4 ng/ml) was observed in the polyherbal supplemented group, which was well correlated with better growth performance during the starter phase. On the 22nd day, all the birds were injected with lipopolysaccharide of *E. coli* @ 100 mg per kg body weight. The preliminary parameters such as total intestinal bacterial count, antioxidant property in terms of Thiobarbituric Acid Reactive Substances (TBARS) and serum growth-promoting hormone, cytokines (Major Histo-compatibility complex, Interleukin – 6 and Interferon ɤ were studied. Lower values of TBARS with supplementation of antibiotics and polyherbal indicated a reduction in stress and better antioxidant properties. Compared to antibiotics, polyherbal showed a significantly higher antioxidant properties. Polyherbal supplementation reduced total intestinal and caecal bacterial count and is on par with antibiotic growth promoters. Lower serum levels of IL-6 (279.78± 34.42 pg/ml) and a higher level of IFN-ɤ (771.91± 66.8 pg/ml) and MHC (2.091± 0.077 ng/ml) with a decoction of polyherbal additive, enhanced the anti-inflammatory effect, improved immunity, and maintained innate immune homeostasis.

S4-OP6

Effect of betaine supplementation on post-partum reproductive health and ovarian activity of crossbred cows during heat stress condition

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The objective of the study was to investigate the effect of supplementation of betaine on reproductive attributes of crossbred dairy cows calved during the period of heat stress. A total of 18 pre-parturient cross-bred cows of 2nd to 5th parity were categorized into two groups as control (n=9) and other as treatment (n=9) in which 50 gm betaine anhydrous was supplemented daily. The temperature-humidity index of the experiment shed was calculated. Reproductive parameters studied were incidence of clinical metritis, assessment of cervical and uterine involution, scoring of vaginal mucus for endometritis, ovarian activity, and concentrations of plasma progesterone. Results of environmental variables indicated THI >72 throughout the experimental period i.e. all animals were under heat stress conditions. Results of reproductive parameters indicate a lower incidence of metritis, significantly (P<0.05) rapid involution of the reproductive tract, the increased average number of small-sized follicles (2.40 ± 0.34 vs. 1.05 ± 0.19), the reduced interval from calving to the day of first ovulation (28.64 ± 2.50 vs. 39.5 ± 4.61 days) and increased concentrations of plasma progesterone (4.12 ± 0.31 vs. 2.71 ± 0.64 ng/ml) in the treatment group as compared to control. It can be concluded that supplementation of betaine improves post-partum reproductive health and ovarian activity of dairy cows during the period of heat stress. This technology has the potential to be used in coastal animal husbandry to improve reproductive performance.

Keywords: Betaine; Heat stress; Ovarian activity; Reproductive health; THI

S4-OP7

Sperm morphometric characterization of Agonda Goan breed of indigenous pig

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The present study was carried out to evaluate and characterize important sperm morphometric parameters and indices of Agonda Goan breed of an indigenous pig reared in its native tract. Semen ejaculates from mature boars were collected by gloved hand technique, a total of thirty-six ejaculates were screened and sperm rich fractions of ejaculates were used for detailed sperm morphometric analysis. Eosin-Nigrosin stained smears were evaluated for morphometric characterization of the sperm head and tail using Olympus BX41 microscope equipped with multi-scan and semi-automated image analysis software (MagnusPro x86, version 3.7). Sperm head dimensions including length and width of the sperm head, head area, perimeter, and tail length were measured

and these basic morphometric parameters were also used to calculate additional derived morphometric indices characterizing the sperm head *viz*. Ellipticity, Elongation, Rugosity, Form, and Regularity. The mean length of the boar sperm head was 11.06±0.06 µm whereas the total sperm length was averaged as 69.31±0.26 µm. Other recorded basic parameters were Mean head width (6.01±0.05 µm), head area (59.62±0.42 μm^2), head perimeter (29.24±0.15 µm), and tail length (58.25±0.26 µm). Rugosity or roughness, which specifies the amorphous shape of the sperm head, was 0.817±0.003 $\mu m^2/pixel^{2,}$ and regularity index, indicates the symmetry of sperm head, was 0.91±0.007. Other derived sperm head morphometric indices were Ratio (0.546±0.006), Ellipticity (1.854±0.020), Elongation (0.296±0.005) and Form (817.46±2.85 $\mu m^2/pixel^2$). The findings of the study indicate that detailed sperm morphometry employing derived morphometric indices can characterize the sperm head shape more precisely and can be used as a supportive tool for the characterization of boar semen morphology and sperm classification.

Keywords: Agonda Goan, Indigenous Pig, Sperm Morphometry, Morphometric Characterization

S4-OP8

Respiratory disease outbreak with concurrent infection of *Mycoplasma gallisepticum, M. synoviae and Avibacterium paragallinarum* in a poultry flock in Goa

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Backyard poultry farming is one of the important components of agriculture in rural India providing additional income and a source of nutrition to the rural poor. Respiratory diseases are a major cause of morbidity and mortality in poultry flocks leading to serious economic loss due to death, reduced egg production, slow weight gain, and cost of medication. There are numerous bacterial, viral, and fungal pathogens associated with respiratory disease in poultry and the climate is also an important factor, which has serious effects on the occurrence of diseases in birds. This report presents an outbreak of respiratory disease in a poultry farm located in the North Goa district. Huge mortality in chicken, guinea fowl, and turkey was reported on this farm from the last week of January to the first week of February 2022. The affected birds showed signs like conjunctivitis, swelling around the eyes, nasal discharge, thick mucus in the oral cavity, diarrhea, sudden falling, and death. On post-mortem examination, varying lesions were observed like congestion of tracheal mucosa and lungs, mild air sacculitis, deposition of caseous material over tracheal mucosa, and enteritis in most of the birds and in addition peritonitis was seen in a few birds. The samples were collected aseptically and inoculated in suitable media for the isolation of suspected bacteria. DNA and RNA were isolated from oropharyngeal and cloacal swabs. PCR/ Reverse Transcription PCR was carried out for detection of *Mycoplasma gallisepticum* (MG), *M. synoviae* (MS), *Avibacterium paragallinarum* (AP) and New Castle disease Viral (NDV) RNA. No bacteria could be isolated on blood agar from lungs spleen and liver. The samples from chicken showed positive for MG, MS and AP and were negative for NDV. *Avibacterium paragallinarum* the causative agent of Infectious coryza and *Mycoplasma gallisepticum* responsible for Chronic Respiratory Disease are important pathogens causing respiratory

diseases in poultry. Both these pathogens are also reported with mixed infection with other bacterial or viral pathogens which possess a major challenge in prevention, accurate diagnosis, and control of infection. The hot humid weather of the coastal area will exert additional environmental stress on the birds and other factors like poor immunity, overcrowding, build-up of ammonia in poultry sheds, etc. will predispose the birds to infection with respiratory pathogens. Hence preventive measures like vaccination, biosecurity measures, proper bird-area ratio, and housing management should be followed in poultry farming in the coastal area to minimize loss due to diseases.

S4-OP9

Estimation of genetic parameters and factors influencing re(production) performance in crossbred pigs

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Pig farming is the most economically viable option for resource-poor rural farmers in India. A study was carried out to analyze the effect of various genetic and non-genetic factors on the growth and reproductive performances of crossbred pigs (75% LWY and 25% Agonda Goan). Weights were recorded at birth, weaning and monthly intervals till ten months of age. Litter size and weights at birth, weaning, and age at first farrowing was also recorded. Least-square means of body weights were estimated considering the effects of generation, sex, litter size at birth, parity, season and period of birth. Heritability and correlations for different traits were estimated by REML WOMBAT software. A significant difference ($p<0.01$) in weights was observed among generations, with a maximum on the fifth-generation indicating ideal selective breeding in the herd. In the fifth generation, the average weight at birth, weaning and eight months (marketing) was 1.07±0.03kg, 8.25±0.35kg, and 77.22±2.092kg, and the mean litter size at birth and weaning was 8.23±0.87 and 7.62±0.29, respectively. Heritability estimate of weaning weight was 0.45, and higher heritability values were observed for all body weights. Genetic as well as phenotypic correlations were moderate to high among growth traits. The findings indicated that 75% of crossbred pigs thrived well in the prevailing hot-humid coastal climate.

Keywords: Crossbred Pigs, Body Weights, Litter Traits, Genetic Parameters

SP-OP10

Constraint analysis and strategic interventions on strengthening technical capacities of small-holder poultry farms in the west coast region

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A study was undertaken to document the current status, constraint analysis and strategic interventions in managemental aspects for small-holder poultry farmers. A total of 150 small-holder

poultry farmers of Goa and Karnataka were selected randomly and interviewed with a structured questionnaire to study the socio-technical parameters. Analysis of primary data revealed that 70% of farmers were male, and more than 90% preferred to have dual-purpose breeds followed by layers and indigenous/native birds. By adopting backyard poultry feeding practices, it was found that 84% of farmers were supplementing poultry feed while 98% provided night shelter and followed biosecurity and herd health measures. Chick production and recycling were only adopted by 60% of farmers, while others faced this as a constraint. On surveillance, predominant diseases of poultry flock were identified as Ranikhet disease, Coccidiosis, Fowl pox, diarrhoea and parasitic infections. Employment generation through family poultry farming was a minimum of 182 to a maximum of 548 man-days per year for male farmers, while a minimum of 91 to a maximum of 821 man-days per year for female farmers. Significant constraints faced by poultry farmers were high feed cost, inadequate financial and departmental support, non-availability of replacement stocks, adverse effects of climate change, non-availability of skilled labourers and predator attacks. Hence, need-based technological interventions were made by demonstrations and interactions in feeding aspects by introducing herbal feed additives, larvae and various feed formulations, breeding strategies like propagation of flock through flock mating and good hatchery practices. These strategies aid in improving the technical competence of small-holder poultry farmers and farm productivity.

Keywords: Adoption Practices, Backyard Poultry, Small-holder Farmer, Technical Competence, West Coast

SP-OP11

Reproductive and productive characterization of Shweta Kapila breed of indigenous cattle reared under western coastal climate

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The coastal region along the Goa state and adjoining the Konkan region is the native breeding tract of the recently registered Shweta Kapila breed of indigenous cattle. A study was carried out to characterize important reproductive and productive attributes of Shweta Kapila cattle reared in its native tract under tropical hot and humid western coastal climate. This breed is characterized by short stature, white body coat and is known for climate resilience, disease resistance, relatively low feed intake and is ideal for rearing under low-input and eco-friendly production systems. Productive and reproductive records of apparently healthy female cattle, aged between three and eight years, were screened and data over a period of five years were analysed to determine different parameters of overall reproductive efficiency and production attributes. Major reproductive attributes recorded were age at puberty (25.6±0.32 months), age at first service (34.1±1.24 months), age at first calving (41.3±1.65 months), and mean service period (92.3±1.83 days). The average length of oestrous cycle was 20.5±0.18 days and the average duration of oestrus period was 18.4±0.26 hours. Mean gestation period was recorded to be 284.18±7.22 days, whereas inter-calving interval

was 392.4±8.62 days. Daily milk yield ranged from 1.6 to 3.7 kg with an average of 2.95±0.17 kg, and lactation milk yield ranged from 130 to 680 kg with a mean yield of 304.78±32 kg. Lactation length ranged from 134-238 days, with a mean length of 218.88±9.7 days. Mean birth weight was 13.35±0.23 kg, and calves showed a daily weight gain of 0.21±0.01 kg/day. Most of the reproductive and productive parameters were comparable to other indigenous dwarf breeds of the coastal region. Overall production attributes were improved over the period, possibly due to selective breeding and good management practices. The study also revealed that Shweta Kapila cattle reared under coastal climate had relatively shorter age at puberty and calving interval suggestive of apparently favourable reproductive potential of this indigenous breed.

Keywords: Shweta Kapila, Indigenous Cattle, Reproductive Characterization

S4-PP1

Comparative phylogeny of langurs of Western ghats

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Langurs of Western Ghats comprise mainly Nilgiri langur (*Trachypithecus johnii*) and Common langur (*Semnopithecus sp*.). The current study was done to ascertain the phylogeny of langurs based on the mitochondrial cytochrome B gene (*CYTB*). Briefly, DNA was isolated from fecal samples of 13 langurs of Western Ghats using HiPurA™ Stool DNA Purification Kit (Himedia, India). The 1140 bp mitochondrial *CYTB* was amplified using polymerase chain reaction and later sequenced using Sanger's di-deoxy method. Phylogenetic analysis was performed using the maximum likelihood method in MEGA X. The analysis has shown that Common langurs of Wayanad wildlife sanctuary are clustered separately, whereas Nilgiri langurs sampled from Thiruvananthapuram zoo clustered as a separate clade. Nilgiri langur samples from South Wayanad forest division and Parambikulam tiger reserve were also found to be of an independent clade.

Keywords: Nilgiri langur, mitochondrial CYTB, Phylogeny

S4-PP2

Environmental enrichment to abate aggressive biting incidence in weaned piglets

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The effect of environmental enrichment on aggressive biting behaviour was studied in weaned Large White Yorkshire (LWY) piglet. Forty-eight LWY weaned piglets were selected and

divided into eight groups, each with six piglets. T_1, T_3, T_5 and T_7 piglets were weaned at 35 days old, indicating control, area reduction, and straw and balls enrichment treatments. T_2, T_4, T_6 and T_8 piglets were weaned at 45 days old representing control, area reduction, straw and balls enrichment treatments, respectively. It was found that the frequency of biting was lowest in T_5 and T_6 ($P<0.01$), followed by T_7 and T_8 ($P<0.01$), respectively. However, the frequency of the biting behaviour was found to be highest in T_3 and T_4 ($P<0.01$), respectively.

Keywords: Environmental Enrichment, Straw, Balls, Biting Behaviour, Large White Yorkshire

S4-PP3

Effect of dietary energy and methionine levels on performance and economic values of meat-type ducks

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A 2×4 factorial experiment was conducted to determine the effect of dietary metabolizable energy (ME) and methionine (Met) levels on growth performance and techno-economics of meat-type ducks from 1 to 56 days of age. A total of 120 one-day-old meat-type ducklings (Vigova Sper M) were randomly assigned into eight groups (three replicates in each group and five ducklings in each replicate). The basal diet was formulated as per BIS (IS:1374; 2007) recommendations. The experimental diet was formulated with two levels of energy (basal diet level and 10 per cent less than basal diet) and four levels of methionine (basal diet level, 10 per cent more, 20 per cent more, and 10 per cent less than basal diet). Better performance was observed in the G7 group during the pre-starter and starter period; however, less feed intake, better body weight gain, and feed efficiency were observed in the G2 group during the finisher period. The profit per kg live weight was more in G2 groups supplemented with 10 per cent DL-Methionine at BIS level metabolizable energy (ME). It concluded that supplementation of DLM up to 10 per cent level is beneficial in meat-type ducks.

Keywords: Energy, Methionine, Performance, Economics, Duck

S4-PP4

Effect of supplementation in weight gain of early-weaned piglets

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Effects of supplementing Vitamin E, vitamin C and bamboo leaves extract (BLE) on the growth performance and different climate conditions were studied in early-weaned piglets. Thirty-two early-weaned piglets (21 days) were selected from Pig farm, Instructional Livestock Farm Complex, College of Veterinary and Animal Sciences, Pookode, Wayanad. The piglets were randomly allotted to four treatments (T_1 to T_4) of eight each as per the design of the experiment and maintained under similar housing in different feeding systems. The first group constituted as con-

trol (T1). The second group was offered 40 IU of Vitamin E added in the basal ration in addition to a regular diet (T2). The third group of piglets received 500 mg of vitamin C. The fourth group of piglets received bamboo leaves extract (BLE) 0.5 per cent on a basal diet. All groups were fed with a concentrate diet according to NRC (1998). The feeding of the experimental ration of T_1, T_2, T_3 and T_4 to early-weaned piglets resulted in mean ± **SE of** body weight gain of 2.85, 2.90, 2.95 and 3.27 kg, respectively. There was a significant ($P < 0.01$) increase in body weight gain from the 9^{th} and 10^{th} week of the study. From the present findings, it can be concluded that supplementation of bamboo leaves extract @ 0.5 per cent significantly improved the growth rate by 14 per cent and performance indices with economic profitability in the weaned piglets.

Keywords: Early weaning, Anti-stress Supplements, Vitamin C, Vitamin E

S4-PP5

Iguana: A new frontier in exotic pet farming

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The pet market in Kerala boomed after the COVID-19 pandemic. Because of the lockdown, the stranded human beings earned any affection they could find, which turned into the exponential growth in the pet market. This wave also affected exotic animal breeding in Kerala. One of these new frontiers is Iguana breeding. The absence of a regulatory body caused the Iguanas' price to increase two-fold. The present study was conducted by collecting data in the form of a survey from 15 Iguana breeders from different districts of Kerala to explain the sustainability of this growing market. There was an increase in the number of new breeders too. Due to the rise of many new varieties of pets, there is a high demand for specialist practitioners in veterinary medicine for these animals. The lack of expertise by the new breeders leads to the poor management of iguanas. In our study, it was evident that the reproductive potential of Iguanas was reduced because of the limited knowledge of animal breeding. After lockdown, the increase in demand has stabilized slightly, but it is still higher than pre-pandemic levels.

Keywords: Iguana, Kerala, Exotic Pet Farming

S4-EP1

Increasing income of farm women through family poultry production in a coastal district of Odisha

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Family poultry production represents an appropriate system to contribute to feeding the fast-growing human population and provide income to poor small farmers, especially women. A field study was conducted to study the impact of family poultry rearing on the income flow of farm women in the Puri District of Odisha. Forty (40) farm women were selected and twenty (20) numbers of four weeks straight run chicks of dual-purpose Vanaraja chicks were distributed to each farm woman for rearing in an extensive system. The farm women reared the chicks by allowing them to scavenge outside during the daytime and were provided night shelter (low-cost house).

The performance of the birds was monitored at regular intervals and technical support on feeding and health care was provided as and when required. The farm women were advised to sell the male birds, when they reach around 1.5 kg body weight (at around 10-12 weeks of age) and to retain the females for egg production. The rearing of 20 birds (10 males and 10 females) by the household has increased their net income. Around Rs. 3500 net income was earned by each family through the sale of male birds at 3 months of age. Subsequent rearing of females further increased their income by another Rs 5400 through the sale of eggs. Taking eggs and meat, the net income per household per annum was around Rs. 8500-9000. The higher net income is attributed to the higher price of meat (Rs. 300/kg live weight) and eggs (Rs.10 per egg). If household consumption of eggs and meat are accounted for, net income ranges from Rs. 9800-10000/ per family per annum. It is concluded that family poultry production not only ensures the availability of eggs and meat to cater to the nutritional requirement but also provides additional income to the farm women.

S4-EP2

Rumen microbial diversity, enteric methane emission, and nutrient utilization of crossbred Karan-Fries cattle *(Bos taurus)* and Murrah buffalo *(Bubalus bubalis)* consuming varied roughage concentrate ratio

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Dietary mix and host species have both been shown to have a significant impact on rumen microbial diversity, enteric methane emission, and animal performance. The goal of this study was to see how the roughage concentrate ratio 70:30 (Low concentrate; LC) *vs* 40:60 (High concentrate; HC) and the host species crossbred cattle *vs* buffalo affected rumen microbial diversity, enteric methane emissions, and nutrient utilization. Dry matter intake (kg/d) and dry matter per cent digestibility were considerably ($P<0.05$) higher in the HC ration and buffalo compared to LC ration and crossbred cattle, respectively. Both dietary mix and host species had a substantial ($P<0.05$) impact on the intake of various nutrients, including organic matter (OM), crude protein (CP), ether extract (EE), neutral detergent fibre (NDF), and acid detergent fibre (ADF). Increased concentrate proportion in the ration improved nitrogen balance, resulting in increased average daily gain and considerably reduced methane (g/d) output ($P<0.05$). Furthermore, 16S rRNA genes were sequenced using Oxford Nanopore Technology (ONT) and subsequently annotated using the Centrifuge workflow to uncover ruminal bacterial diversity. *Firmicutes* were considerably ($P<0.01$) greater in the LC diet, whereas, *Bacteroidetes* were higher in the HC ration. Genus *Prevotella* dominated all rumen samples, and buffalo fed LC ration had significantly ($P<0.01$) higher *Oscillospira* abundance. At the species level, simple sugar-utilizing bacteria such as *Prevotella* spp. and *Selenomonas ruminantium* predominated in the crossbred cattle, but fibrolytic bacteria such as *Oscillospira guilliermondii* were statistically ($P<0.01$) more abundant in the buffalo. Overall, dietary mix and host species have both been shown to have a significant impact on rumen microbial diversity, enteric methane emission and animal performance, however, host species remained a major driving force to change ruminal community composition as compared to roughage concentrate ratio under similar environmental conditions.

S4-EP3

Supplementing turmeric rhizome powder in growing Andaman Local Pigs: A conflated approach for therapy evaluation

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This communication elaborates the pluripotent effect of supplementation of turmeric rhizome powder (TRP) (*Curcuma longa*) for 30 days in three different concentrations (0.05, 0.1 and 0.2 %) in growing Andaman local pigs. After 30 days of supplementation, the bodyweight of pigs supplemented with 0.1 % and 0.2 % TRP differed significantly compared to the control group ($p<0.05$) which indicated TRP as a digestive enhancer. Effect of TRP supplementation indicated a protective role on liver and muscle as well as prevention of tissue damage. There was also a decrease in cardiac risk factor (CRF) and atherogenic index (AI) in TRP supplemented groups compared to pigs fed with a basal diet. Further, supplementation of TRP increased the level of antioxidants compared to the control group and proved its beneficial role as a potent antioxidant in growing pigs. The anti-inflammatory potentiality of TRP could also be appreciated since TRP supplementation down-regulated expression of IL-6, IL-1β, and IFNϒ. Therefore, we perceive that this conflated approach is an example of its kind to focus on modification of the health status of pigs for more productivity and as translational research on the utility of turmeric for possible benefits on human health.

S4-EP4

Seasonal effect on physiological and hematological profiles, scrotal circumference, and testicular parameters in indigenous goat bucks under tropical humid island ecosystem

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Andaman local goat (ALG) is a meat animal in Andaman and Nicobar islands (ANI) of India. The present study was conducted to measure the seasonal effect on physiological and hematological profiles, scrotal circumference (SC), and testicular weight during rainy and dry summer seasons in ALG. A total of 10 adult intact ALG bucks (body condition score: 3.0-3.5 and classified as good; 3-4 years) were selected from the goat breeding farm, ICAR-CIARI, Port Blair, ANI, India. Results revealed that these experimental profiles differed significantly ($p < 0.05$) between the seasons. Significantly ($p< 0.05$) higher hematological profiles, SC, and testicular weight were observed during the rainy season than dry summer season whereas physiological profiles such as rectal, skin, and scrotal temperature were higher during dry summer than wet rainy season. The study concluded that the rainy season has significantly greater beneficial effects than the dry summer season on reproduction and artificial breeding programs in semi-intensive management of goats in the present location.

S4-EP5

On-farm evaluation of fodder grass-tree mixtures in a typical small holder farm in Thrissur district, Kerala

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Well-managed silvopasture systems comprising protein bank trees can better answer protein deficit and fodder scarcity in Kerala as compared to traditional grass monoculture approaches. In present two year-study, eight treatments viz; Hybrid Napier-CO5 (HN)+Mulberry (*Morus indica*), HN+-Calliandra (*Calliandra calothyrsus*), Guinea grass (*Panicum maximum*)+Mulberry, Guinea grass+ Calliandra, sole HN, sole Guinea grass, sole Mulberry and sole Calliandra replicated thrice in RBD under the partially shaded farm in Pananchery Panchayat, Thrissur in 2019 to study their productivity and protein yield as compared to sole cropping. Four rows of grasses intercropped with two rows of trees. Inter row spacing for grasses and trees and intra row spacing for HN and trees was 50 cm whereas, intra row spacing for guinea grass was 20 cm. Trees were maintained at 1m height and harvested at the interval of two months during the rainy season and three months during the dry season for two years while grasses were harvested every month and fodder yield and protein yield were recorded. Highest fodder yield obtained for sole HN in first year, while in the second year, the yield for sole HN and HN+Calliandra was comparable. In terms of protein yield, sole Calliandra, Guinea grass+Calliandra, and HN+Calliandra performed better, while in second-year sole Calliandra outperformed all, and intercropping plots performed better than sole grass plots. This study indicated that as trees get established, the productivity of the grass-tree mixture system starts increasing.

Keywords: Silvopasture, Intercropping, Grass-tree mixture, Agroforestry, Fodderbank

S4-EP6

Use of spice and herbs as a seafood biopreservation method

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Consumer demand increases for minimally processed seafood that retains its sensory and nutritional properties after handling and storage. Food preservative additives are natural or artificial compounds that prevent microbial growth, enzyme activity and oxidation from causing food degradation. Synthetic food additives were more commonly used in the past. Consumers have not universally accepted synthetic chemicals in recent years due to their alleged adverse health effects. Therefore, customers' preference for natural ingredients (species and herbs) is growing by the day. Natural preservatives with potent antioxidant and antibacterial characteristics have been extensively researched and adopted as safe alternatives in seafood preparation with the primary objective of enhancing shelf life. There is a strong and growing interest among consumers and manufacturers in products that can be used to improve health and wellness. Due to an increasing interest in creating safe and effective natural food preservation, spices and herbs have gained relevance as potential sources of raw food preservatives in recent years.

Keywords: Seafood, Natural preservatives, Spices and Herbs, Human Health

Technical Session 5

Conservation and improvement of plant genetic resources

S5-OP1

Evaluation of Indian mustard *(Brassica juncea L.)* germplasm for terminal heat stress

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Indian mustard is grown under diverse agro-ecological conditions varied from early/timely to late sown, as a rainfed or irrigated crop. The late sowing after cotton and rice in the month of November-December exposes this crop to high-temperature stress during the reproductive stage, making the heat an important limiting factor for late sown mustard crops. Hence, the present study was carried out to assess the effect of heat stress on Indian mustard. A total of 145 genotypes of Indian mustard were evaluated for terminal heat tolerance, along with six checks (NPJ112, NRCHB 101, CS 56, Pusa Bold, Kranti, PM 26) in augmented block design. Two trials were conducted each under timely sown irrigated and late sown irrigated ecology. Data were recorded on five randomly selected plants for 12 different quantitative traits for each genotype to assess the effect of heat stress on different agro-morphological traits of Indian mustard. Terminal heat stress at the maturity stage of mustard caused a significant reduction in performance of all traits except oil content and fruiting zone length. Seed yield/plant showed the highest reduction (33.92%) followed by 1000-seed weight (21.28%). 1000-seed weight and secondary branches/plant were found associated with seed yield under late sown conditions. Based on yield under stress, yield index, geometric mean productivity, and stress tolerance indices, five lines *viz*., DRMR59, DRMR-2094, DRMR-2129, DRMR-2071, DRMR-2136 were identified as high yielding and terminal heat stress-tolerant. Whereas, based on the heat stress susceptibility index, DRMR-1347, DRMR-1154, and DRMR-1190 were top-performing lines tolerant to terminal heat stress but poor yielder. Selection of high yielding lines under stress conditions could be done using correlated traits like 1000-seed weight and secondary branches/plant. Yield under stress was found significantly correlated with yield stability index, yield index, mean productivity index, stress tolerance index, and geometric mean productivity, suggesting to use of these indices for the selection of high yielding and heat tolerant lines.

Keywords: *Brassica juncea*, Correlation, Indian mustard, Stress susceptibility Index, Terminal Heat Stress

S5-OP2

Evaluation of genetic diversity in bael *(Aegle marmelos Correa.)* using physico-chemical and molecular markers

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An evaluation was carried out on 24 accessions of bael conserved in field gene bank at Indian Institute of Horticultural Research, Bengaluru. Among 24 accessions, 18 accessions are seedling progenies from North Indian type, NB-1 and NB-3 are secondary collections from An-

daman and Nicobar Island and remaining 6 accessions are seedling progenies of South Indian type from Nanjangud region of Karnataka. All the accessions showed variation in terms of DUS characters given by PPV & FR Authority, New Delhi. The analysis of variance revealed a significant difference concerning fruit and quality parameter. The maximum fruit length (10.6 cm), fruit width (11.6 cm), fruit weight (1478.8 g), pulp weight (894.3 g), shell weight (534.1 g), number of fruits (215), shell thickness in (2.7 mm), seed weight (65 g), number of seeds (50), pulp:shell (2.2 %). Quality parameters *viz.,* TSS (36 °B), acidity (1.23 %), vitamin C (98.08 mg/100g), total sugars (25.07 g/100 g), phenols (24.39 mg GAE/g fw), flavonoids (74.63 mg CE/g fw), carotenoids (14.96 **µg/g fw**), moisture content (68.00 %), ash content (4.30 %), antioxidant content DPPH (96.24 mg AEAC/100g), FRAP (150.93 mg AEAC/100g) were recorded during the investigation. The SRAP marker characterization of the accessions revealed that the highest number of bands and PIC value was observed in primer combination (Me3Em3 and Me4Em5). The investigation revealed that among 24 accessions, B-1, B-8 and B-18 were most promising for growth, yield and quality parameters. These accessions can be used either for further evaluation or selection as a commercial cultivar or gene source in bael improvement programme.

S5-OP3

Genetic variability in pole type dolichos bean under rainfed semi-arid conditions

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Sixty pole type dolichos bean genotypes were evaluated for their genetic variability, heritability and genetic advance at the research farm of Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur, Godhra, Gujarat during 2018-2021 under rainfed semi-arid conditions. The analysis of variance indicated the prevalence of sufficient genetic variation among the genotypes from all the characters studied. The high GCV (Genotypic Coefficient of Variation) and PCV (Phenotypic Coefficient of Variation) were observed for number of primary branches, number of pods per plant, pod length, pod weight and green pod yield per plant. The high heritability was observed for all the characters under study. The high heritability coupled with high genetic advance as % mean was observed for plant height, number of primary branches, number of pods per plant, pod length, pod girth, pod weight and green pod yield per plant. Among the genotypes studied, the maximum number of pods per plant was observed in the genotype CHESDB-07 (1600), maximum pod length and pod weight were observed in the genotype CHESDB-50 (17.5cm and 15.2 g) and high green pod yield per plant was also observed in the genotype CHESDB-50 (8-10 kg) followed by CHESDB-07 (7-9 kg), CHESDB-01(7-8 kg), and CHESDB-31 (6-7 kg). For selecting high yielding genotypes emphasis should be given to number of pods per plant, pod weight and pod length. Therefore, these characters should be considered as selection criteria for green pod yield improvement in Indian bean.

Keywords: Dolichos bean, Genetic Variability, Genetic Advance, Heritability, Semi-arid

S5-OP4

Pyramiding of late blight and ToLCV resistance genes in tomato for augmenting the productivity in tomato

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Tomato leaf curl disease (ToLCD) caused by Begomoviruses and late blight caused by *Phytophthora infestans* are important limiting factors for tomato production in the Indian sub-continent. Use of resistant cultivars is among the most effective, economic and environmentally safe strategies. Among late blight resistant genes in tomato, *Ph2* and *Ph3* have been used in late blight resistance breeding. *Ty3* alone or in combination with *Ty2* is working well against ToLCV. To develop tomato lines with ToLCV and late blight resistance, two F_2 populations from P2018 × (LA 3152 × LA 4286) and LA 3152 × VRT-78-2 were used as base material. Marker-assisted selection was employed through generations to select plants with targeted genes. Gene-based markers AW910up-F2R3, Ty3-SCAR and Ph3SCAR were used to select *Ty2*, *Ty3* and *Ph3* genes respectively. dTG422 CAPS markers linked to *Ph2* gene were used to select *Ph2* containing genotypes. Advanced lines with all four genes and in different combinations with good horti-agricultural characters have been developed. The developed lines can be sent to multi-location evaluation and also can be tried as parental lines in hybrid developmental programmes. Developed advanced lines may play a greater role in stabilizing tomato production by minimizing the losses caused by respective diseases.

S5-OP5

Morphological and molecular-based genetic diversity analysis in rice germplasm collections of West Coast of India

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The study assessed genetic diversity among 153 germplasm accessions of rice collected from West Coast of India. The germplasm comprised of improved cultivars, landraces and wild rice were characterized using 37 qualitative and 16 quantitative morphological traits. Furthermore, genetic diversity was assessed using 34 Simple Sequence Repeat (SSR) markers. Based on Shannon diversity index 20 traits were highly diverse, 11 moderately diverse, three with low diversity while four traits were invariable. Among the quantitative traits, grains per panicle (18.5-344.6) showed the highest variability while harvest index showed the lowest variability (0.0-0.5). The heritability estimates ranged from 61.1% to 99.0% whereas genetic advance as per cent of mean ranged from 18.1% to 76.9%. The Principal Component Analysis (PCA) produced ten principal components with Eigenvalue >1, which cumulatively accounted for 71.7% of the total variability among the rice accessions. The molecular characterization was carried out with 34 SSR markers

of which 30 markers were found to polymorphic in nature. Marker RM10871 produced maximum alleles (19) followed by RM474 (10) and RM3867, RM333 and RM180 with eight alleles each. PIC was highest in RM10871(0.92) followed by RM474 (0.83) and RM206 (0.82). Identity map for the rice genotypes was created to find unique identifiers among the 12 chromosomes using GGT2. The unique identifiers were observed to be well distributed in nine out of 12 chromosomes in the studied rice genotypes. Cluster analysis of 153 rice genotypes grouped them into four distinct major clusters which could help in future breeding programs.

S5-OP6

Evaluation of *Garcinia* accessions of ICAR-CCARI, Goa

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ICAR- CCARI, Old Goa has 13 promising accessions of Kokum (*Garcinia indica* Choisy) *viz.,* A1P1, BAN-3, KAS-11, KAS-5, KAS-6, KUR-9, KUR-8, M-16, P-115, P-36, P-38, PED-1and SK-3 collected from different parts of Goa state; tissue culture kokum plants developed by Goa University, Talegaon and CSIR-NCL, Pune; varieties developed by Dr. BSKKV, Dapoli *viz.,* Konkan Amruta, Konkan Hatis; variable types like 'bell Shaped' kokum and 'yellow' kokum and *Garcinia tinctoria*, *Garcinia hombroniana*, *Garcinia mangostana and Garcinia gummigutta*. Among the kokum accessions, KAS11 (104/16) has dwarf stature with 79.00 cm height, 36.00 cm stem girth and 245.00 cm plant spread. It started bearing at the age of four and yielded 14.15 kg with 528 fruits in the year 2021. SDL-54/14 had the highest yield (98.00 kg) followed by SDL-136/14 (75.31 kg) and SDL-43/14 (73.46 kg). SDL-1/14 had the highest mean fruit weight (45.62 g), rind weight (24.93 g) and rind thickness (3.33 mm) and 20.45% fruits under the class I (> 40 g fruit weight). KAS-11 (58/16) had the highest fruit rind TSS (15.44 **° Brix)**, pulp TSS (15.52 °Brix) and acidity were the highest (8.7%).

S5-PP1

Diversification of greengram *(Vigna radiata l.)* Rhizosphere microflora through natural and organic farming practices

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The present study focused on diversification of soil microflora through different farming practices *viz*., natural farming (NF), organic farming (OF), conventional farming (CnF) and chemical farming (CF) in green gram crop rhizosphere during *Kharif* 2021. At both flowering and harvesting stages, bacterial populations were significantly higher in CnF (18.75 and 16.25×10^5 CFU/10 g of soil) followed OF, NF and the lowest population was observed in CF (6.50 and 7.75 $\times10^5$ CFU/10 g of soil). There was no significant difference in fungal population among different

farming practices at both stages, but numerically higher fungal population was observed in NF (4×10^4 CFU/10 g of soil) followed by OF, CnF and CF. At both the stages, actinomycetes populations in NF and OF were on par with each other and higher than CnF and CF. Beneficial microflora such as Nitrogen(N) fixers and phosphate solubilizing microbes (PSM's) were significantly higher in NF (N fixers-22.75 and 17.5×10^5 CFU/10 g of soil and PSM-38 and 28.25×10^4 CFU/10 g of soil) than CnF, OF and CF at both the stages. Natural and Organic farming practices showed higher biological activities and diversification than chemical farming. Hence, it can be adopted in agro-ecotourism model farms.

Keywords: Chemical Farming, Conventional Farming, Greengram, Natural Farming, Organic Farming and Rhizosphere microflora

S5-PP2

DUS Characterization of Traditional Rice Varieties of Northern Kerala

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A study was carried out to characterize traditional rice varieties (TRVs) of Northern Kerala. Fifty TRVs and 4 checks were planted in augmented design during *rabi*-2021 at IF-II, College of Agriculture, Padannakkad, Kerala (12°14′45″ N; 75°8′6″ E). Data were recorded on five randomly chosen plants in each genotype and checked for 56 morpho-metric traits following Distinctness, Uniformity and Stability (DUS) descriptor. Analysis of variance showed highly significant variation for all the quantitative traits. Among morphological traits, leaf anthocyanin coloration (purple-6%; green-94%), color of leaf ligule (white-84%; light purple-4%; purple-12%), flag leaf attitude (erect-12%; semi-erect-66%; horizontal-20%; drooping-2%), panicle curvature (straight-10%; semi-straight-40%; deflexed-14% drooping-36%), panicle awns (absent-84%; present-16%), panicle attitude of branches (erect-26%; erect to semi-erect-34%; semi-erect-4%; semi-erect to spreading-18%; spreading-18%), panicle exertion (partly exerted-18%; mostly exerted-16%; well exerted-66%) and seed colour (white-24%; light brown-46%; dark brown-18%; light red-8%; dark purple-4%) were polymorphic. Polymorphism among these traits could be utilized for future conservation efforts, elimination of duplicates/off-types and registration of farmer's/extant varieties under Protection of Plant Varieties and Farmers' Rights Authority (PPV&FR) Act, 2001. Identification and validation of linked morphological markers with economically important quantitative traits will facilitate marker-assisted selection and future crop improvement programmes.

S5-PP3

Assessing the genetic diversity in cowpea for yield and its component traits

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Cowpea (*Vigna unguiculata* L.) is one of the most important grain legume crop grown in tropical and subtropical regions. It is a rich source of protein and carbohydrates. In the present study, 62 genotypes of cowpea collected from different parts of the country were used to assess the diversity using D^2 statistics and identify the potential diverse parents for hybridisation programme. The analysis of variance revealed significant differences due to genotypes for all the traits indicated the presence of substantial genetic variability in the germplasm. Among the qualitative traits, wide range of variations was observed for flower colour, seed coat colour, seed eye colour and seed shape. Genetic variability analysis revealed very high PCV and GCV for number of clusters per plant followed by number of pods per plant, test weight and seed yield per plant. High heritability coupled with high GAM was observed for test weight followed by number of pods per plant and seed yield per plant. Mahalanobis D^2 analysis showed considerable genetic diversity grouped the 62 genotypes into five clusters. The maximum inter-cluster distance was recorded between cluster III and V. Characters like seed yield per plant, test weight and number of pods per plant contributed maximum towards genetic divergence. Cluster III and V are most diverse in nature and the genotypes constituted in these clusters could be utilized as parents for hybridization programmes. The present study identified diverse promising genotypes based on seed yield and agronomic traits such as IC-257449, GC-3, IC-438362, IC- 257428, KBC-9 and IC-390269 and these diverse genotypes could be utilized in breeding programme of cowpea to generate better transgressive segregants for yield and its attributes.

Keywords: Cowpea, Germplasm, Genetic Diversity, D^2 Analysis

S5-EP1

Influence of land configurations and genotypes on yield and economics of yellow pericarp sorghum under rainfed conditions

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A field experiment to study the effect of land configurations and genotypes on yield and economics of yellow pericarp sorghum was conducted at PJTSAU, Hyderabad, during *kharif*, 2018-19. The experiment was laid out in strip plot design with six land configurations in vertical strip *viz.,* flatbed, ridge and furrow, broad bed and furrow, flatbed + mulch, ridge and furrow +

mulch, broad bed and furrow + mulch (Pongamia leaf mulch @ 6 t ha^{-1}) and four yellow sorghum genotypes were taken in horizontal strip *viz.,* PYPS 101, PYPS 102, PYPS 103 and PYPS 104. Results indicated that significantly higher grain yield (1701 kg ha^{-1}), gross returns (Rs. 95747 ha^{-1}), net returns (Rs. 62101 ha^{-1}) and B:C ratio (2.84) were recorded under broad bed and furrows with mulch which was closely followed by ridge and furrows with mulch. BBF + mulch resulted in an increase in grain yield by 37 per cent over flatbed (control). Correspondingly, PYPS 102 genotype recorded higher grain yield (1585 kg ha^{-1}), gross returns (Rs. 89774 ha^{-1}), net returns (Rs. 57028 ha^{-1}) and B:C ratio (2.74). However, grain yield was on par with PYPS 103 (1507 kg ha^{-1}).

Keywords: Broad bed and furrow, PYPS 102, Pongamia mulch, Ridge and furrow, Yellow pericarp sorghum.

Technical Session 6

Secondary agriculture and policy interventions for self-reliant coastal agriculture

S6-OP1

Policy interventions for doubling farmers' income by promoting social and digital media utilisation: A study from coastal districts of Puducherry

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Digital and Social media turned out to be the great tool for doubling their farm income. Research and extension systems facing great challenges due to lack of manpower and reach the rural population with profitable technologies. In order to propose policy interventions to enhance the social and digital media utilization by the farmers of UT of Puducherry, a study was conducted in the coastal district of UT of Puducherry viz. with a sample size of 200 farmers, with 34.00% of Integrated farming system adopting farmers. The study revealed that farmers had medium level of attitude towards social and digital media usage for their farm development activities. Majority of the farmers use these social and digital media for getting general news (80.00%) followed by entertainment purposes (60.17%) and agricultural purposes (50.34%). WhatsApp, YouTube and Facebook were the mostly used social media. Whereas radio and TV were the most preferred digital media sources by the farmers. The most interacted content on these social media was organic farming, pest management, and disease management. Organic farming, varietal selection, and nursery management were preferred in digital media. Mobile phones were productively used for getting information about input availability. The policy suggestions such as creating block-level content to be posted on social and digital media, developing content in regional dialects, involving research, extension system and farmers in content developing, recognizing the best content creator and participating farmers, promoting media forum among farmers, training rural youth/ward of farmers to help in media accessing. Good internet strength, charges of recharging/subscriptions were the constraints expressed by the farmers.

S6-OP2

Nutritional enrichment and value chains for traditional rice-based foods

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Rice is every food connoisseur's delight apart from being the staple food for a large population in South Asia. It is very apt to say rice is life for a majority of the small holder farmers providing economic and food security and is an integral part of the social, religious and cultural practices in India. Not a feast or celebration is complete without rice-based main course, desserts and finger foods. Time is now to prepare rice-based foods from nutritionally enriched rice varieties. Nutritionally enriched (high zinc, protein) rice varieties have been released by the Indian Institute of Rice Research, the All India Rice Improvement Project and a few State Agricultural Universities. On a pilot basis, traditional foods from rice flour of the high zinc variety, DRR DHAN48 have been prepared and sensory evaluation is under progress. Value chains on a farm-to-fork model for the supply of nutritionally enriched rice-based foods can be formed by SHGs/FPOs. Technical and marketing linkage is the key to value chain development and quality seeds of nutritionally enriched rice varieties can be provided to small holder farmers and low polish rice flour are to be used for preparation of traditional foods. Marketing these niche products labelled as prepared from nutritionally enriched rice is an entrepreneurial avenue.

S6-OP3

Value addition & product diversification in jute fibre: Role of Agri-Business Incubation (ABI) Centre of ICAR-NINFET

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Jute crop plays a significant role in the livelihood generation of the farmers of the coastal districts of West Bengal despite its meagre share in the area coverage and production volume. Moreover, coastal region plays pivotal role in creating market potential for value-added craft products by attracting tourists from various parts of the country and abroad. To have a convergence between the availability of jute, *the golden fibre* and the demand for craft products; there lie immense business opportunities in the area of value addition and product diversification in jute sector. Agri-Business Incubation (ABI) centre of ICAR-NINFET, Kolkata with an aim to promote entrepreneurship identifies potential entrepreneurs and then nurture them to create profitable ventures. Skill development trainings on jute diversified products are imparted on identified un-employed youth for creation of their own enterprises. Moreover, the centre helps them in supplying specialized jute materials for sustainable business round the year. The Institute Sales Counter running under the aegis of this ABI centre also serves as a platform to sell their developed products. Over the years, the centre has succeeded in inculcating the idea of entrepreneurship in rural youth and helping them in honing their skill & acumen in starting up their own enterprises.

Keywords: Incubation, Entrepreneurship, Jute, Handicrafts, Training

S6-OP4

Paper based fish freshness indicator for retail packed Indian mackerel

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Smart packaging is an advanced packaging system with embedded sensor or indicator technology which finds wide application in food, pharmaceutical and other products. In food it is mainly used to monitor freshness and to indicate or display information on quality of product to ensure the safety of consumer. The present study aimed to develop a paper based smart device to indicate the freshness of fish, Indian mackerel (*Rastrelliger kanagurta*) in chilled storage condition (1-2^{0}C). For this, cleaned fish steaks were packed in high density polyethylene trays and ten pH-sensitive dyes were placed on the inner side of sealing film, separately. Care was taken to prevent direct contact of fish with the indicator. Quality changes mainly, volatile bases, lipid quality (oxidative and hydrolytic rancidity) and sensory changes were monitored at regular intervals. TVB-N value increased from initial 7.1mgN_2 100g^{-1} to 36.8 mgN_2 100g^{-1} on 8th day. Peroxide value and free fatty

acid values fluctuated during storage period whereas TBARS value showed an increasing trend. On 8th day TBARS and FFA value of 5.2 mg MA kg^{-1} sample and 12.9 as % oleic acid, were observed, respectively. Sensorily, mackerel samples were acceptable up to 6th day in chilled storage. Of the 10 indicators used for developing freshness indicator only one indicator showed a progressive colour change from bright yellow to red, indicating its effectiveness to use as smart packaging device. The instrumental colour changes of the paper device indicated a decrease in yellowness (b* value and yellowness index) and increase in redness (a* value). The study indicated that the developed smart paper device can be used for monitoring real-time freshness for packed fish.

Keywords: Smart Packaging; Freshness Indicator; Fish; Quality

S6-OP5

An economic analysis of post-harvest loss in green chillies

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Though India is the second-largest producer of vegetables in the world, it is often faced with quite a few challenges in the vegetable sector and one among which is the postharvest loss and food security. Thus, the present study focussed on the marketing analysis of green chillies after duly accounting for the postharvest loss at each level. The primary data required for the study was collected from 65 chilli growers randomly selected from 6 villages which were purposively selected from Siddipet district. In addition, 7 wholesalers, 7 commission agents, 6 organised retailers and 7 unorganised retailers were chosen randomly to collect the primary data required for the study. The findings of the study indicated that the highest monetary value of post-harvest loss was in the case of channel 3 (producer – commission agent – wholesaler – unorganised retailer – consumer) due to the involvement of more number of intermediaries and the lowest found in the case of channel 1 (producer-consumer) as it was the direct marketing channel and did not involve any intermediaries. The study suggested the enhancement of value addition in chilli through encouraging chilli growers for contract farming with processors which would mitigate the losses to some extent.

S6-OP6

Tourism trends in Goa and scope of agro-ecotourism

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Goa is known at a global level in the tourism sector due to its scenic beauty, beautiful beaches, rich flora and fauna as it is located in the Western Ghats range, which is one of the world's biodiversity hotspots. Goa attracts both foreign and domestic tourists every year. To understand the growth dynamics in tourist arrivals to Goa, time-series data on both domestic and foreign tourist arrivals (1985 to 2019, from various issues of Economic Surveys of Goa) and estimates of foreign exchange earnings (2001 to 2019, from various issues of India Tourism Statistics at a Glance) were compiled. Compound growth rates, coefficient of variation and instability indices were estimated for three subperiods (1985 to 1999, 2000 to 2009 and 2010 to 2019) and the overall period (1985 to 2019) for domestic, foreign tourist and total tourist arrivals to Goa. The share of foreign tourists

in total tourist arrivals in Goa was around 12 per cent till 1990 which increased to approximately 23 per cent in 2000 but declined to 12 per cent in 2019. During the period 1985 to 1999, the growth rate in domestic tourist arrivals was 2.22 per cent which increased to 9.00 per cent in the period 2000 to 2009 and 17.55 per cent in the period 2010 to 2019. However, in the case of foreign tourist arrivals, the compound growth rate was 10.45 per cent during the period 1985 to 1999 which declined to 4.14 per cent in the period 2000 to 2009 and rose to 10.44 per cent in the period 2010 to 2019. During 2001, foreign exchange earnings from tourism in India were Rs. 15,083 crores (US$ 3198 million), which grew to Rs. 2,11,661 crores (US$ 30,058) in 2019 with a compound growth rate of 13.31 per cent. Considering these, there is a huge scope for agro-ecotourism in Goa which can generate additional income for farmers and create employment opportunities and lead to increased avenues for value addition. To achieve this expeditiously, branding Goa as one of leading the agro-ecotourism destinations at the Global level is needed.

S6-PP1

Area, production, productivity and economic analysis of coconut sector in Ernakulum district Kerala India

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Coconut is a major crop of the South Indian states. Ernakulam District of Kerala recorded an average of 48943 ha. of area under coconut with average production and productivity of 2624 lakh nuts and 5322.63 nuts/ha respectively (2000-2019). Aim of study was to understand growth trends in area and production, economics of crop for the years from 2000-2019. Population data of district was collected from census of 1985, 1991, 2001 and 2011.Data of value of production of coconut (Rs.) during 2011-2017 was used. Statistical tools like compound growth rates, average annual growth rates and sustainability index were used. Decline in area and production was observed with average annual growth rate of -2.65% and -3.48% respectively from 2000-2019. Productivity showed sustainability index of 0.29 and average annual growth rate of -0.51% during 2000-2019. Value of output (Lakh Rs.) of 18713 and 16899 were recorded during 2011 and 2017 respectively. Compound growth rate of -2.95% for area, -3.92% for production and -1.00% for productivity were recorded (2000-2019). Compound growth rate of -2.95% was recorded for percent area under crop (2000-2019). Urbanisation rate increased from 39.56 % to 68.07% during 1985 to 2011. Sustainability index of 0.37, 0.43 and 0.29 were recorded for area production and productivity respectively (2000-2019).

Keywords: Coconut, District, Ernakulam, Sustainability, Trend Analysis, Urbanisation

S6-PP2

Comparative economics of natural farming practice with conventional, organic and chemical farming practices in ground nut + finger millet intercropping system

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A Field experiment was conducted at College of Agriculture, Hanumanamatti in Haveri district of Karnataka during *kharif* (2019 to 2021) to study the economics of different farming practices in groundnut + finger millet intercropping system. Four farming Practices (T_1: Conventional Farming Practices (CNF), T_2: Organic Farming (OF), T_3: Natural Farming (NF) and T_4: Chemical Farming (CF)) were tested in RCBD with three replications. Pooled data indicated that CNF recorded higher yield of groundnut and finger millet yield (14.13 and 6.82 q/ha) than NF (13.12 and 5.85 q/ha), OF (12.62 and 6.01 q/ha) and CF (11.84 and 5.60 q/ha). Cost of cultivation was comparatively lesser under NF (Rs. 48351/ha) and CF (Rs. 48382/ha) than CNF (Rs. 63354/ha) and OF (Rs. 66404/ha). About 24 and 27% of costs were saved under NF than CNF and OF, respectively. Material cost saved under NF was Rs. 19154/ha (which was about 35% lesser than CNF (Rs. 29251/ha) and about 39 % lesser than OF (Rs. 31440/ha). Without premium price, net return was higher under NF (Rs. 47980/ha) than CNF (Rs. 41401/ha) and OF (Rs. 27906/ha). The higher benefit-cost ratio was under NF (2.00) and CF (1.92) than CNF (1.66) and OF (1.42). With premium prices, again NF registered higher net returns of Rs. 65,416/ha, which was about 58% higher than CNF (Rs. 41401/ha) and about 46% higher than OF (Rs. 44777/ha). The higher benefit-cost ratio was under NF (2.36) than OF (1.68) and CNF (1.66). The above results indicated that cultivation of groundnut along with finger millet is more profitable under NF (even without premium prices) than CNF, CF and OF practices. Hence, natural farming practices can be adopted in groundnut + finger millet cropping system in Eco-tourism adopted farms for eco-friendly and healthy food production.

Keywords: Benefit-cost ratio, CNF, Finger Millet, Intercropping, Natural Farming, Net Return, Organic Farming, Premium Prices

S6-PP3

Natural farming indigenous technical knowledge (ITK's) for entrepreneurship development among farm youth

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Many formulations are prepared by natural farming farmers based on their experiences. Among them, Mr. Maleeshappa G. Biserotti, Dharwad district, Karnataka is a national level darti-mitra organic farming award farmer. He has been practicing Natural Farming since 2005. He started using liquid *jeevamrutha*, but he faced scarcity of water to prepare it. So, he started ex-

perimenting with solid-*jeevamrutha* (*Ghanajeevamrutha*). It is prepared by desi cow-dung and urine, gram pulse flour, native soil and organic jaggery. Gana*jeevamrutha* is directly used at the time of sowing and as top-dressing. It contains 1.96, 0.81, 1.14 % NPK respectively, 4.20, 2.96, 3.93 % Ca, Mg and S, respectively. It also contains micronutrients *viz*., Zn, Fe, Mn and Cu (0.009, 0.001, 0.25 and 0.07 %, respectively). *Ghanajeevamrutha* is consortia of microflora (45.33×10^5, 32.77×10^5 and 39.33×10^5 CFU/g bacteria, fungi and actinomycetes) and beneficial micro-organisms (3.32×10^3 CFU/g PSM and 14.10×10^5 CFU/g N-Fixers). *Ghanajeevamrutha* extract is used as pesticide and growth promoter. He prepares pesticide with 1 kg of carom seeds in 5 litres of water after boiling. He also prepares 200 kg of neem cake with the neem seeds. The farm youths can start entrepreneurship of natural farming products, processing and marketing to the Agro-eco tourists during their visit.

Keywords: Ghanajeevamrutha, ITK's, Jeevamrutha, Microflora and Natural Farming

S6-PP4

Retort processing of traditional chicken *biriyani*, its microbiological quality and sensory evaluation

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Traditional dishes such as chicken biriyani are relished by many and consumed in almost every celebration. The lifestyle changes and rapid urbanisation calls for the development of ready-to-eat processed foods, which are safely processed and neatly packed. Retort processed shelf-stable foods are an alternative to such a demand. In the study conducted, the retort processing conditions of traditional chicken biriyani were standardised and the microbiological parameters, as well as the sensory qualities of the product, were analysed for 0^{th}, 30^{th}, 60^{th}, 90^{th} and 120^{th} days of storage. The study was carried out at Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Pookode and Fish Processing Division, ICAR- Central Institute of Fisheries Technology, Kochi. The product was processed at a Fo 3.5 and the come up time was 5 minutes. The commercial sterility test was satisfactory and the microbiological analysis revealed an absence of bacterial colonies throughout the storage study. A significant decrease in colour, odour, flavour, texture and overall acceptability was recorded during the study period. The highly perishable, traditional product was sterile on all days of storage study and was suitable as a shelf-stable product for mass production.

Keywords*:* Chicken biriyani, Retort processing, Commercial Sterility, Microbiological Parameters, Sensory Quality

S6-EP1

Impact of training on farmers' expenditure on organic fertilizers

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Traditionally, Indian agriculture was driven by indigenous methods using locally re-generable materials for soil fertilization. The advent of chemical fertilizers happened only during the green revolution. Indian farmers' current fertilization practices are heavily skewed in favour of inorganic fertilizers, especially nitrogen. Several fertilizer policies like subsidies have contributed towards this. In the wake of, mounting costs of chemical fertilizer application and, the changing perceptions in favour of environment, there is a need to revisit the current approach of soil fertilization and work for a judicious mix of the modern and traditional technologies for greater sustainability of agriculture in the country. However, lack of proper knowledge and awareness about organic fertilizers restricts its adoption. Among several strategies, providing trainings to farmers on organic fertilizers is a potential one to push the pace of adoption. In this study, we test the impact of farmers' participation in training programmes on their spending on organic fertilizers using data of 400 farmers from the Indo-Gangetic Plains. We analyse the five-point Likert scale data to summarize the farmers' perception on fertilization. Further using Propensity Score matching, we find that the training programs indeed have an effect of increasing spending on organic fertilizers.

S6-EP2

FPO as a method for scaling up profits and improving morale through sense of Agri-entrepreneurship

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Poor mental state of farmers and an increasing number of suicides of farmers is an area that requires immediate attention. A sense of ownership and employment can improve the lives of the farmers. Farmer Producer Organisation (FPO) caters to meet this requirement. Aim of the study was to explore the scope of FPO in improving the mental health of farmers and to see the scalability of farmers' profits. Sixteen registered FPOs, under National Bank for Agriculture and Rural Development (NABARD) and Small Farmers' Agri-Business Consortium (SFAC) in Wayanad, Kerala were contacted. Ten farmers willing to participate were interviewed, which lasted for around 1.15 hours. Interviews were transcribed and thematic analysis was conducted. The analysis projected clear signs of upliftment of farmers' mental health in FPO. The themes identified from the analysis were a sense of ownership, financial security, sense of belongingness, knowledge sharing, risk sharing amongst members of the FPO, and interdependence of members. The analysis also revealed that labour scarcity, climatic changes, knowledge crisis and uncertainty of price were identified as the biggest challenges faced by the farmers. Farmers Producer organisations provide a certain level of security and sense of entrepreneurship, which improves farmers' morale and cater to provide financial security to its members.

S6-EP3

Price behaviour of copra in major markets of Kerala: a time series analysis

Preethi V P

Changes in the price behaviour of copra in major markets of Kerala (Alappuzha and Kozhikode) were analysed for two periods *viz*., Period I (from 1980-01 to 1995-96) and Period II (from 1996-97 to 2015-16) and the variations in price due to trend, cyclical, seasonal and irregular fluctuations were calculated. For copra, these markets were observed to be more synchronised showing signs of better market integration during Period II. In spite of high fluctuations, the copra price moved in the two markets in close association with each other indicating mutual dependencies among these markets. It was observed that the seasonality and irregular variations in the price were more prominent in the primary commodity than the processed commodity like copra.

S6-EP4

Economic analysis of livestock-based farming systems in coastal areas of West Bengal

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The study was conducted in coastal areas of West Bengal comprising the Sundarban area of South 24 Parganas, Parts of North 24 Parganas and Purba Midnapore districts to identify the livestock-based farming systems which provide a livelihood to the marginal and small farmers of these areas. A total of four farming systems were identified, these were S1 (Sheep+ Poultry), S2 (Goat+ Poultry), S3 (Cattle+ Goat+ Crop+ Fish) and S4 (Cattle+ Poultry+ Crops+ Fish). The share of labour was highest (56% to 58%) in total cost in crop enterprises and feed and fodder costs had a major share (53% to 79%) in total cost for livestock enterprises. Due to low maintenance costs, S1 and S2 farming systems have output-input ratios that were close to 2. In case of other farming systems, the output-input ratios were close to 1.5. Among different resources labour, fodder and fertilizer were over-utilized and concentrate and veterinary services were underutilized. Return to scale of farming systems in saline areas was constant (S1 and S2) and decreasing for S3 and S4. Analysis of profit efficiency revealed that households under all the farming systems except S3 were on an average less than 70 per cent efficient. The factors like age, level of education, farming experience, household size, number of animals, land under cultivation, access to credit and access to information had a negative effect on profit inefficiency. Goal programmingwas used to estimate the optimal farm plan, the analysis found that in case of S3 and S4 farming systems the second (maximizing self-financial support) were over-achieved. However, the first goal (maximizing gross margin)and the third goal(minimizing income risk of the farm)were over-achieved in case of all the farming systems.

Technical Session 7

Agro-eco tourism for livelihood diversification and scaling of entrepreneurship among rural youth

S7-OP1

Non-chemical management of aquatic weeds in the water bodies to increase aesthetic value and augment the ecotourism

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Aquatic weeds are undesired plants that grow in water and impair the utility of water bodies for irrigation, aquaculture, drinking water and recreation, as well as obstruct drainage canals, which are essential for flood control and due to eutrophication, the water is unsafe for consumption. The aquatic weeds have the potential to multiply more rapidly than terrestrial weeds. This leads to reducing the effective supply of usable water. The majority of the country's irrigation projects and tourist place lakes are being plagued by a large increase in the number of aquatic weeds. Since, tourism is the main source of livelihood in these places, management of these weeds is highly important. Further, aquatic weeds contribute to a significant water loss as it increases the evaporation rates many times faster than an open surface through evapotranspiration. *Eichhornia crassipes, Ipomoea aquatica, Typhaan gustata, Ceratophyllum demersum, Salvinia molesta, Nelumbo nucifera, Alternanthera philoxeroides, Hydrilla verticillata, Vallisneria spiralis, Chara spp., Nitelia spp., Potamogeton spp*., are among the most prominent aquatic weeds in India. Aquatic weed control is one of the leading global concerns, despite massive financial and human resource expenditures in the implementation of its regulations. Aquatic weeds can be managed by several methods like biological, chemical and physical methods. The goal of this review is to look at the non-chemical aquatic weed management strategies that could be used instead of registered chemical pesticides owing to environmental concerns. Biological, mechanical, and physical control methods, as well as preventive measures, are promising alternatives to chemical methods. Some of the biological control methods are the introduction of insects and sterile grass carp, microbial biocontrol agents, enzymes as well as the addition of organic material. Mechanical control is done by various methods such as harvesting, cutting, shredding, pulling, rolling and diver dredging. Physical control measures comprise shading, aeration etc. In recent decades, successful attempts have been made to control aquatic weeds by insects, plant pathogens, herbivorous fish and cyanobacteria control agents. Under most problematic situations integrating nonchemical weed management approaches are capable of controlling nuisance aquatic species while minimizing potential negative environmental effects.

S7-OP2

Agro-ecotourism through natural farming with sugarcane based multi-tier cropping system and entrepreneurship development

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The present study focused on the diversification of sugarcane through a multi-tier cropping system with 4 farming practices *viz*., natural farming (NF), organic farming (OF), conventional farming (CnF) and chemical farming (CF) in the main plot and 3 cropping systems (I_1: sugarcane

+ soybean - chickpea – turmeric, I_2: sugarcane + onion + cowpea + coriander + green chilli and I_3: sole sugarcane) in sub plot and layout in split plot design during *adsali* planting season of 2019-2020. Significantly higher cane yield (137.8 t ha^{-1}) was observed with CnF than organic (108.1 t ha^{-1}) and natural farming (87.8 t ha^{-1}). The cost of cultivation was saved in natural farming to the extent of 29.48 per cent over CnF and 69.32 per cent over organic farming**.** Among the different intercropping systems, sugarcane + soybean - chickpea - turmeric recorded significantly higher SEY (160 t ha^{-1}), gross returns (₹ 459029 ha^{-1}), net returns (₹ 260258 ha^{-1}) than other intercropping systems. Whereas, a significantly higher B:C ratio was recorded in sugarcane + onion + cowpea + coriander + green chilli (2.41) and it was on par with sugarcane + soybean - chickpea - turmeric (2.38) than sole sugarcane. Hence, sugarcane crop diversification can be done through intercropping and entrepreneurship development activities can be taken with the sale of products of multi-tier cropping systems which provide the opportunities for establishing small scale jaggery processing units (100 kg CPD), sugarcane crusher for juice extraction, small oil extruder. Further, the sale of organic and natural farming products like organic turmeric powder, jaggery, sugarcane juice, soybean oil, onion, fresh coriander herb juice, and tender chickpea pods for culinary purposes can be sold among the tourists in agro-ecotourism concept. The adoption of natural farming with a multi-tier cropping system in agro-ecotourism farms provides opportunities for enhancing farm income and employment generation among the farm youths.

Keywords: Conventional Farming, Crop Diversification, Multi-Tier Cropping System, Natural Farming, Organic Farming, Sugarcane

S7-OP3

Invasive alien parthenium *(Parthenium hysterophorus)* plant: Their impact on agro ecotourism, ecosystem and their sustainable management through bio extracts

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Parthenium hysterophorus L. (Asteraceae) is a poisonous and problematic weed, is now posing a serious threat to crop cultivation and also to human and animal health and affects the aesthetic value of the land. This weed is native to Tropical America and now naturalized in several tropical and subtropical parts of the world and greatly affects agro-ecotourism. Parthenium is one of the most troublesome weeds and figures among the list of invasive species in the Global Invasive Species Database. This invasive plant caused ecological perturbations by the biotic invasion have been identified as a growing threat to global sustainability as a result, biodiversity loss and thereby altering the ecosystem services which leads to negative impact on agro-ecotourism and also reducing the sustainability of the Indian agriculture. Field experiments were conducted during 2018-20 at Tamil Nadu Agricultural University, Coimbatore to develop eco-friendly sustainable Parthenium management through bio extracts. The results of the laboratory study revealed that, application plant extract viz., *Terminalia chebula pods* + 50% acid lime extract and *Terminalia chebula* pods + 25% acid lime extracts on the parthenium seed germination. Higher parthenium control efficiency was recorded with application of POE *Terminalia chebula* pods + 50% acid lime extract on 20 DAS. Hence, from the experiments, it could be concluded that, pre-emergence

or post-emergence application of *Terminalia chebula* pods extracts + acid lime extract either with 25 or 50% resulted in reduced Parthenium seed germination, dry weight and higher Parthenium control efficiency. This approach will lead to an improved ecosystem and scaling up the agri-entreprenership and promoting healthy agro-ecotourism.

S7-OP4

Role of traditional food in destination brand building: Exploring culinary tourism potential of Jaipur City

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Food plays a vital role in drawing travellers to a certain destination because of its reflection of a region's culture and lifestyle. Food has an influence on a traveller's decision when choosing the destination and the contribution of traditional food in attracting tourists is on the uninterrupted rise. Gastronomy has a symbiotic relationship with tourism and is playing a pivotal role in tourism development. Destinations can be distinguished based on indigenous traditional culinary offerings which can have a significant impact on the overall image building of the destination. Owing to increased spending power and disposable income, travellers are spending more than 40% of their total tourism budget on food. The city of Jaipur is recognized in the world of tourism for its majestic forts, palaces, opulent cultural heritage and its colossal gastronomic wealth. Jaipur's rich culinary repository has been unfolded as an outcome of traditional knowledge based on ethnic preferences, religious preferences, agro-climatic conditions, socioeconomic status, and cultural practices, which gives a huge scope for developing culinary tourism in the region. However, within the tourism sector, the culinary potential of Jaipur is not tapped completely and remains an underdeveloped area of investigation. The food of Jaipur has a range of flavours and indigenous ingredients which gives it a huge potential to boost the tourism economy and augment the development of the local economy. Hence, the primary objective of this paper is to investigate the influence and role of traditional foods in attracting travellers enhances the niche segment of consumers for culinary tourism. It is qualitative research where the data will be collected through in-depth interviews with travellers and restaurant/hotel owners. Data will be coded and analysed using NVivo to recognize the themes and derive conclusions. Exploration of the impact of local food consumption as part of the culinary experience in Jaipur with a focus on the destination food image will add value to develop marketing strategies to promote culinary tourism in Jaipur.

Keywords: Culinary Tourism, Food, Gastronomy, Indigenous, Tourism economy, Jaipur, Traditional

S7-OP5

Fodder museum: A potential component for the agro-ecotourism unit

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The number of agro-ecotourism units is increasing and attracting lots of urban tourists. Goa has been a favourite destination for international and domestic tourists, especially for onshore tour-

ism. The dawn of COVID-19 era, social distancing and quarantine protocol has opened up new avenues of offshore tourism and attracted thousands of tourists. The state of Goa also experiences an acute shortage of fodder and imports the deficit from neighbouring states. Goa has around 26,000 ha under coconut cultivation and the interspaces are underutilized. In the present study the interspaces of coconut were utilized to grow 35 different types of fodder grasses, legumes and trees to evaluate their performance as an agroforestry component and to develop it as an agro-ecotourism unit. Among the different fodder crops, the highest green biomass was recorded in bajra napier hybrid CO5 followed by super napier. Maintaining a diverse range of fodder crops supplies different nutritional requirements, ensures nutritional security of the farm animals and also helps in meeting the fodder requirement throughout the year. This plot not only supplies green fodder but also acts as a live demonstration unit for the farmers and tourists. The rich diversity of fodder crops has attracted hundreds of farmers, farm enthusiasts and tourists making it a potential agro-ecotourism hot spot. Further, the availability of green fodder throughout the year has improved animal health and milk yield, reduced the expenditure on concentrates and there is an overall increase in the farm income. The fodder based agro-ecotourism is a win-win situation for both farmers and tourists.

Keywords: Farm Tourists, Green Fodder, Diversity

S7- PP1

Mapping of agro-ecotourism hubs using Geographical Information System (GIS) and remote sensing in Karnataka and Maharashtra

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Agro-tourism is emerging as one of the potential sectors in tourism as well as the agriculture industry. However, the industry is yet to realise its full potential. There are many challenges in making agro-tourism a profitable venture for both farmers and young agro-entrepreneurs, while conserving and nurturing the regional biodiversity. The challenges the sector is facing are lack of organized promotional activities, lack of database of farmers willing to get involved in the sector, lack of accessible information on the agro-tourism hubs to tourists (domestic and international), increasing number of unemployed rural youth, need of conserving the regional biodiversity, etc. leading to the untapped potential of this sector. This study was taken up to map different agro-ecotourism hubs such as crops, cattle breeds, birds, medicinal plants, water bodies, etc. using Geographical Information System (GIS). We collected data from different sources and identified the hubs based on the diversity index estimated. We also over-layered these layers with remotely sensed imagery to visualize the agro-tourism hubs in Karnataka and Maharashtra. The future work will be to extend the GIS maps of agro-ecotourism hubs in the web interface. This study can be used to identify the agronomical and ecological spots which could be the potential Agro-ecotourism hubs.

S7- PP2

Impact of agro-ecotourism on farm households in Karnataka

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The present study was carried out in the Chikkamagaluru and Kodagu districts of Karnataka**.** A purposive random sampling technique was employed for the selection of sample respondents. Data were collected from 40 sample farmers through a personal interview method using a pre-tested well-structured schedule. Income from agro-ecotourism (Rs. 18,72,820) was comparatively higher than income from agriculture (Rs. 8,21,666.70). But the number of days employed in agro-ecotourism among farmers was lesser than in agriculture in both the districts. The working capital of the agro-ecotourism unit was Rs. 6,67,027.90 with an annual fixed cost of Rs. 2,13,274.49. Farmers reaped net returns of Rs. 9,92,517.61 from agro-ecotourism. The net gain per unit was about Rs. 12,05,792.10 which was high when compared to following only agriculture. The area under agriculture had reduced due to the construction of buildings, roads and ponds along with the increase in wastelands and grasslands in 2019 depicting urbanization when compared to 2011. Indebtedness, gender of the respondent, distance, off-farm income and landholding were significantly affecting the establishment of agro-ecotourism by farmers. Cent per cent of farmers believed in the rise of supplementary income and additional employment through agro-ecotourism. Therefore, Government should encourage farmers to adop t sustainable agro-ecotourism in order to double their income.

S7- PP3

Traditional foods and culinary tourism in Tamil Nadu

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This study explores about the food preference and likings of the tourists in Tamil Nadu. As food industry being one of the major contributors of revenue to the state. The various aspects of the traditional food system have been recorded in ancient scriptures, literature and as well as in oral narratives of folk, we may still find new food items in the state of Tamil Nadu. From the public perspective, food assumes a secondary but major role in the tourism industry which is promoted by tourists' words of mouth and now with the use of social media. The objective of the study was to evaluate the preference of food items by sampling tourists and by analysing the impact of food experience during their visit. The study required both secondary and primary data. The secondary data required was collected from prestigious journals and reports the primary data was collected from the respondents by personal review method. The findings revealed that both foreigners and visitors from other parts of India have really enjoyed the food provided by different food centres in the state of Tamil Nadu which suggests the state has already become a culinary tourist destination.

Keywords: Food, Tourism

S7- PP4

Traditional foods and culinary tourism in Kerala

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Traditional foods and culinary tourism refer to a cultural tradition of sharing food, recipes and cooking skills and techniques and passing down that collective insight through generations. The value of this knowledge is hidden in a global food system offering an abundance of commercial convenience foods. Food diversity is an important component of human nutrition and can be an indicator of a bio-cultural region. Food should be consumed for survival and physical strength, but not for pleasure. Fasting is another aspect of the conventional diet. It is meant to purify the mind and the body. These traditional food concepts have been changed drastically in our society because of our contemporary lifestyle. We may find special food items and many dietary varieties in Kerala. The traditional knowledge of food is considered to be the best for particular geographical conditions. Changing food patterns can damage the good health of society. So, it is vital to know the importance of good food habits of our own tradition and balanced diet and the scope of culinary tourism in Kerala.

Keywords: Traditional Foods, Culinary Tourism, Kerala

S7- PP5

Butterfly garden: A potential component of agro-ecotourism and butterfly diversity in Goa

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Agro ecotourism is a symbiotic relationship between tourism and agriculture which provide a positive economic approach to rural development. Planning "butterfly garden" as a component of agro-ecotourism is a wise choice for attracting nature enthusiasts and addressing biodiversity friendly sustainable agriculture. A survey was carried out to record the butterfly diversity of Madei and Netravali Wildlife Sanctuary, Goa. Results shows that, Blue Mormon (*Papilio polymnestar* Cramer), Common Rose (*Pachliopta* spp.), Common Grass Yellow (*Eurema hecabe* Moore), Grey Pansy (*Precis atlites* L.), Malabar Tree Nymph (*Idea malabarica* Moore), Danaid eggfly (*Hypolimnas misippus*), The clipper (*Parthenos sylvia*), Plain tiger (*Dannus* spp). and Common Sailer (*Neptis hylas* Linnaeus, 1758) were found to be the major butterfly species in the selected study areas. In this article, an attempt is made to discuss the important things to be considered before setting up a new butterfly garden like the right location, landscaping, life cycle of butterflies, larval host plants, ways to attract butterflies and understanding butterfly requirements. The results of the study could provide basic information on butterfly gardens and butterfly diversity in Goa.

Keywords: Butterfly Garden, Agro-ecotourism, Butterfly, Goa

S7- PP6

Agri-Api-ecotourism: A new concept to double the farmer's income

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Agriculture is one of the important economic activities in the coastal regions of India. The increase in population density, reduced per capita land availability and seawater intrusion are important challenges faced by agriculture in the coastal region. The scenic beauty and beaches attract millions of tourists every year. After Covid-19 offshore tourism in the name of agro-eco-tourism concept has picked up in Goa, which is attracting tourists, farmers and students. These agro-ecotourism spots also harbour rich biodiversity and attract different birds and insects. In this study, *Apis cerana* (Indian bee) colonies were introduced in the established agro-ecotoursim unit at ICAR-CCARI, Goa. Further honey bee diversity and its impact on crop productivity were studied. The major honey bee diversity recorded was *Apis dorsata*, *Apis florea*, *Apis cerana* and *Tetragonula* sp. The data revealed that there was an increase in yield after the introduction of Indian bee colonies in coconut (21.92 %), arecanut (32.08 %) and Indian hog plum (159.21 %). The major constraints faced in the maintenance of bee colonies are high rainfall, cyclone, pest and diseases. The agri-api-ecotourism concept helps in increasing the farmer's income through improved crop productivity (pollination), honey production and also helps in conserving the wild bee diversity.

Keywords: Honey bees, Coconut, Arecanut, Indian hog plum

S7- EP1

Agro-ecotourism and sustainable livelihood opportunities in Manipur

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Manipur, a state in a remote corner of India, is blessed with abundant biodiversity. However, with climate change threatening the state's biodiversity and consequently threatening the livelihood of those dependent on it, agro-ecotourism provides an alternative source of employment to individuals and communities. Annual festivals of various crops like pineapple, orange, Kachai lemon are organized to encourage agro-ecotourism. These festivals provide a common platform for buyers-sellers while attracting tourists near and far. In addition, colourful gardens and parks with indigenous flora are coming up at various locations within the state. While conserving biodiversity, these parks create recreational spots for visits, picnics and even video shoots and generate income by charging a reasonable fee. An example is the conservation of the flower, *Iris laevigata*, an endemic species at Kombirei Garden (Imphal East district). Meanwhile, many sustainable homestays are coming up in and around the famous Loktak lake (Bishnupur district). They help conserve this Ramsar site while providing an additional livelihood to the people. Hikes, treks and camps are organized to see endemic lilies, Siroy lily (Ukhrul district) and Dzuko lily (Senapati district), which grow only on specific mountain peaks. In Manipur, conserving biodiversity and working in harmo-

ny with nature under the shadow of climate change has boosted tourism and supported many sustainable livelihoods. Therefore, agro-ecotourism may be used to promote sustainable livelihoods, create job opportunities, and improve people's quality of life while conserving biodiversity.

S7- EP2

Unconventional spices from Andaman Islands for supporting agro-ecotourism industry

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Novelty and uniqueness are considered as important attributes in tourism industry in which native commodities, foods and products are considered crucial. To boost up agro-ecotourism based activities in the Andaman Islands, systematic efforts were made to identify potential spices and promote their cultivation. Woody pepper, a wild relative of black pepper, is a unique spice of the islands in which stem pieces are edible. It was identified for cultivation as a novel spice from the islands. Efficient propagation techniques, cultivation models and value added products (dehydrated and steep preserved) have been developed to promote its cultivation. *Curcuma mangga*, a rhizomatous species distributed naturally in the islands, was identified as a suitable crop for rainfed cultivation. Rhizomes were sources of essential oil rich in industrially important Myrcene and Cyclofenchene. Agro-techniques, micropropagation protocol and processed products (paste and dehydrated shreds) were developed. Culantro (*Eryngium foetidum*) is another popular herb for which Dweep ProDhaniya Multi (multi-tier pro-tray cultivation) system suitable for urban hoteliers was developed. Hanging cultivation structure (Dweep HanGreens) has been developed and licensed to island entrepreneur, which can be used for the beautification of walls and surroundings in tourist spots. These crops are being popularized among local farmers, entrepreneurs and hoteliers for serving the tourists with novel flavours.

S7- EP3

Genetic Garden: An integrated approach to promote biodiversity conservation and agritourism

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A genetic garden is an integrated *ex-situ* biodiversity conservation approach for the collection, conservation and utilization of plant genetic resources. Realizing the multidimensional roles of genetic gardens an initiative has been taken at ICAR-NIASM, Baramati to establish a genetic garden for abiotic stress tolerance. It aims to accomplish important tasks by collecting, conserving and maintaining genetic resources for food and agriculture (GRFA) by facilitating basic research for better insights into trait diversity and mechanisms underlying tolerance to abiotic stresses. The genetic garden spreads across more than 10 acres comprising a crop cafeteria for displaying the

climate resilient crop varieties, crops wild species block, diversity blocks of mango and dragon fruit, a butterfly garden, herbarium, fish museum and livestock unit maintaining local cattle breeds and fowls. ICAR-NIASM campus is more than any botanical garden comprising more than 100 native plant species, 3000 germplasm/accessions/wild species of field and vegetable crops, 30-40 fruit crops including diverse dragon fruit clones. All these components and repositories of the genetic garden are major assets for upscaling the agrotourism to facilitate and promote exposure and educational tours for the college students, researchers and farmers to get acquaint with knowledge, research insights and technologies relevant to abiotic stress management in agriculture. Further, ATIC, model farm, IFS unit with agroforestry, fish ponds, medicinal garden and nakshatra garden also attracting features for the general public, school children and the farming community. Another important essence of this genetic garden is to promote and create awareness on biodiversity conservation among the public, students and children by integrating with agritourism.

Keywords: Genetic Garden, Diverse Flora, Butterfly Garden, Fish Museum, Educational Tours, Medicinal Garden

S7- EP4

Agro-Ecotourism for Enhancing Indian Spices Export and Competitiveness

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Most of our spices are exported to West European countries and North American countries. Markov Chain Analysis was used to estimate the direction of trade and Nominal Protection Coefficient (NPC) for analyzing the export competitiveness of Indian spices in the international trade. Four major spices viz., black pepper, chilli, turmeric and ginger were selected for in-depth analysis. The secondary data were collected from the Spices Board, Govt of India. The major countries which import Spices from India were Vietnam, Indonesia , U.S.A, Malaysia, Sri Lanka, U.A.E, U.K and Saudi Arabia. The NPC for black pepper, chilli and turmeric were competitive, whereas, for ginger was very poor. The demand of spices was inelastic. A special tourism package may be developed to invite people from the potential importing countries to show case the supply chain including quality aspects and also untapped countries to enter the market. Therefore, there is a need to regulate production and supply of spices in the country. The Spices Board, DGFT and Dept of Tourism jointly needs to look after the aspects of production, prices and export demands besides creating spice parks as tourism centres. This will generate revenue through export as well as through tourism.

S7- EP5

Income enhancement through establishing agro-tourism centres in river bank of Nalbari district of Assam

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Introducing agro-tourism with organic farming is now becoming popular among the farming community and other stakeholders. Many tourists want to experience the beauty of the nature of the rural environment and prefer living in the village farmhouse. Two case studies were con-

ducted during 2020-21 in two agro-tourism centres based on organic farming of pumpkin situated on the bank of Pagladia river of Nalbari district of Assam *viz.*, Jyoti Krishi Farm and Sankardev jaibik krishi Farm. It partners with farmers in implementing farm tourism ventures. In the study, issues related to agro-tourism operations are discussed in depth. It was mainly focused on scope, challenges and sustainability to get the first-hand information regarding types of service provided like accommodation, food, education, entertainment etc. and sustainability of the centres to get additional income out of the farm activities. Regarding the 1st case Jyoti Krishi Pam which was established in the year 2015. They earned Rs 18,50,000.00 from their farm product. The farm engaged 15 people to work for tourism and farm activities and earning Rs 3,09,000.00 as entry fees, Rs 2,53,000.00 from food and lodging, and Rs 51,500.00 from boating in the river additionally from the innovation of the agro-tourism centre. The 2nd case Sankardev Jaibik Krishi Pam which was established in the year 2011 earned Rs 13,50,000.00 from farm products. They also engaged 12 people for both farm and tourism activities and earned an additional income of Rs 2,06,000.00 from entry fees, Rs 1,83,000.00 from food and lodging and Rs 28,000.00 from boating. In both cases, major constraints are marketing and lack of popularity among urban visitors. Both the centres are taking help from Assam State Tourism Department, District administrations and local media for advertising the centres. Though there are some challenges, it is established from the studies that establishing agrotourism centres on the farm can give handsome additional income and ultimately improved rural livelihood. Dependence on local resources and their sustainable use lowered the cost.

Keywords: Agrotourism, Organic farming, Challenges, Additional income, Sustainability

S7- EP6

Mango agro-eco-tourism: A new path for direct marketing!!!

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The study was undertaken to know the economics of mango agro-ecotourism in the Eastern Dry Zone of Karnataka. Data were collected from 15 farmers practising tourism (FPT), 20 farmers not practising tourism (FNPT), 30 consumers and 25 market intermediaries. The results revealed that, growth in the area (2.58 %) and production (1.56 %) of mango increased while, productivity decreased by one per cent in Karnataka from 2007-08 to 2018-19. The total establishment cost and annual maintenance cost per acre of mango orchard was Rs. 2,21,119 and Rs. 70,613, respectively in FPT whereas, Rs. 2,02,065 and Rs. 58,971 per acre, respectively in FNPT. The net return was more in FPT (Rs. 70,157) compared to FNPT (Rs. 14,116). Returns per rupee of expenditure were 1.85 and 1.21 in FPT and FNPT, respectively highlighting the profitability of mango tourism. Of the six mango marketing channels identified, a higher producer's share in consumer's rupee (96.24 %) and marketing efficiency (25.56) was found in Channel VI (mango tourism). There is a need to promote further mango tourism which not only helps producers in realizing higher prices through the direct sale but also helps consumers by way of providing fresh fruit in the natural environment.

S7- EP7

Assessing customers preferences towards natural features of agri-tourism in Tamil Nadu

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The agricultural landscape is the base for agri-tourism development. This paper focuses on customer preferences for agricultural landscapes, particularly natural features when participating in agri-tourism. The study's prime objective includes identifying the attractive features of agricultural landscapes and comparing those perceptions across a category of customers' gender, marital status, tour frequency, and levels of agricultural attachment. Data were collected in farm resorts located in Coimbatore, Tamil Nadu. Forty customers were randomly selected as respondents in ten resorts with total arrival of 400 respondents. Results showed that customers liked primarily natural features followed by agricultural and cultural features. Native plants and flowers, historical elements, a variety of speciality crops, water resources, wetlands and intensive crop farms were the most preferred features by customers. Multivariate analyses of variance (MANOVA) showed significant differences across selected segments such as gender, marital status, tour frequency, and agricultural attachment, recommending implications for offering agri-tourism. Further, expanding agri-tourism to include more natural features would increase customer participation and allow them to impart knowledge about natural features.

Keywords: Agri-tourism, Customer, Landscape, Preference, Nature

S7- EP8

Kulagar-A traditional agriculture system for agro-ecotourism in the Konkan region of India

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Goa and Konkan regions of Maharashtra and Karnataka are parts of Western Ghats with a huge diversity of flora and fauna. This region is a biodiversity hotspot due to its warm, humid climate and intense rainy season. Farmers of the Konkan region have a conventional, multitier, homestead system of gardening called *Kulagar*. *Kulagar* inherited from their ancestors, to cultivate and converse with the local crop plants near their household. It is an integrated system with the skeletal component as arecanut palms, plantation crops, herbs, fruits, local vegetables, medicinal and aromatic plants and flower crops are among the other crops included in this system. Some of the *Kulagar* farmers have included complimentary enterprises such as dairy, poultry, goat farming etc. *Kulagar* system is also an eco-friendly approach for doubling farmers' income in which the residue generated in the system is recycled through mulching and composting. Furthermore, *Kulagar* systems are climate-resilient and have shown the ability to respond to and mitigate

climate change. In the agro-ecosystem, visitors/tourists especially from the cities, those are not known about the different types of crops, pay to visit and or stay on farms to experience the rural life and learn about different types of flora and fauna and the farming activities. The *Kulagar* system of the Konkan region, has a variety of crops especially palms, spices and fruit crops, where visitors/tourists can learn more about the crops and their importance. Many *Kulagar* farms have been converted to agro-ecotourism. This system has the ample opportunity to attract tourists to visit the farming system and got acquainted with the natural flora and fauna of the region. Not only this, even farmers' income significantly increases with this ventures.

Key words: Agro-ecotourism, Konkan, *Kulagar*

S7- EP9

Tea tourism in wayanad for better livelihood and sustainability

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Wayand is one of the smallest districts in Kerala with stunning greenery and outstanding weather conditions. It is an upcoming tourist place because of its luxuriant forest cover and maximum annual rainfall. This climate is also congenial for growth of different flora and fauna that attract millions of eco-tourists towards this small piece of land. Considering the geographical area and rich bio-diversity, this district did not attain the full-fledged tourism though it is potent. The symmetrical arrangement of tea plants, green lush look with cool climate throughout the year makes the place more aesthetic. From this point of view, there is a large scope for tea tourism which uplifts the livelihoods of the people around the tea plantations and also increases the sustainability of community livelihood. Tea tourism will help to improve the economic conditions of the local community, diversify the opportunities which play a key role in promoting the tea industry which also popularizes the local culture of that particular area. In depth information about the destination has to be provided to visitors to get more interest about the cultivation, harvesting and processing of various types of tea as tourists are eager for unique experiences now a days . This would ensure that the tourist feel revitalized about the tea industry thereby satisfying their curiosity. As tourism had become an important alternative for income generation by increasing the employment for a broad range of people, this also uplifts the heritage of this district. In relation to the above context, practical implication of tea and tourism integration will encourage more local participation and diversify their income and this in turn opens a new gate for increasing the national economy through tea tourism in future.

Keywords: Wayand, Tea tourism, Livelihood Opportunities

S7- EP10

Recycling the organic waste and organic preparations: Eco-friendly and economical components of agro-ecotourism

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The activity of agro-ecotourism (AET) generates biodegradable waste through farm operations and it offers a scope to convert the 'waste to wealth'. Integration of such environment-friendly practices and biodegradable waste recycling is important to augment the income of AET and impart knowledge to visitors. Different components on vermicomposting, organic preparations, azolla cultivation, green manuring, etc. were integrated into the AET unit of the ICAR – Central Coastal Agricultural Research Institute, Old Goa, Goa. Based on the amount of biodegradable waste generated annually, a vermicomposting unit was established to recycle 6 tonnes of biodegradable waste annually. Annually, two cycles of vermicomposting produced 4 tonnes of vermicompost in 232 days (approximately 8 months, 4 months per cycle) with a conversion ratio of 0.65. The gross and net income was Rs. 0.86 Lakhs and Rs. 0.51 Lakhs with a benefit to cost ratio of 2.24. The net income for one cycle of vermicomposting for converting 3 tonnes of biodegradable waste in 116 days was Rs. 0.26 Lakhs. Amount of the nutrients recycled through vermicomposting were 57 kg nitrogen, 3 kg phosphorus and 36 kg potassium. Besides, mulching of the biodegradable waste in the basins of the coconut, arecanut, banana and other crop plants was carried out and exhibited. Similarly, the basins of these plants were sown with the local cowpea '*Alsando*' for biological nitrogen fixation and organic matter addition which added dry biomass of 1.5 kg per basin in 2 months. Cultivation of the gliricidia and green leaf manuring was also incorporated. Use of the Institute technologies, Goa Bio 2 for plant health management in black pepper and seedling production in the nursery was carried out. The organic preparations like Jeevamrut were prepared and demonstrated to the visitors and it was applied to the different crop plants of the AET unit. A small demonstration unit of cultivation of the azolla was also integrated. These practices are eco-friendly and generated additional income. All these green practices enlightened the visitors on how traditional and scientific knowledge can be blended and used for the AET for improved income and profitability.

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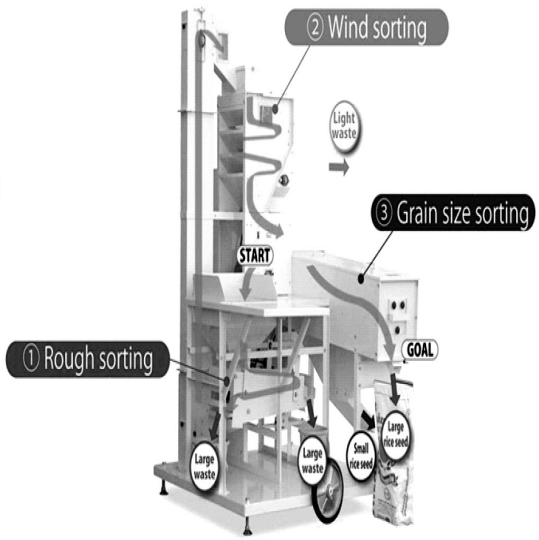

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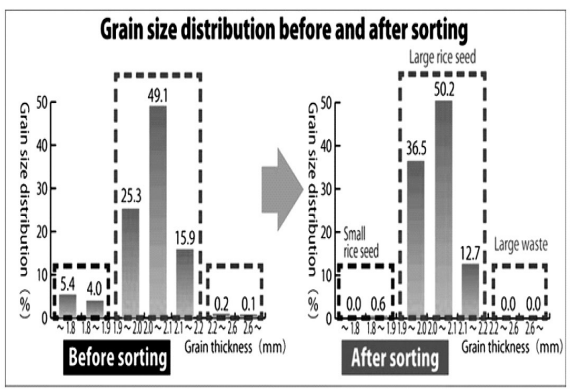

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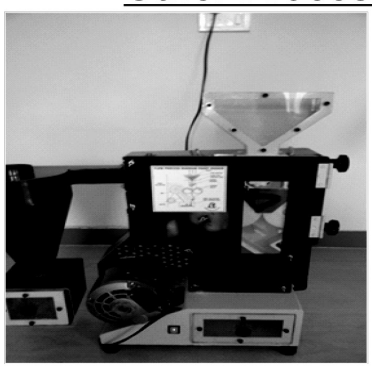

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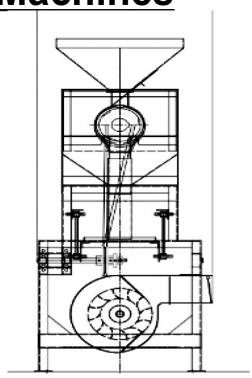

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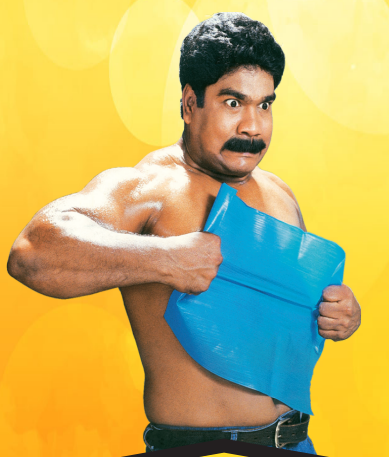

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