1st NATIONAL SEMINAR

AGRI-DIVERSIFICATION AND ECO-REGIONAL FARMING

4-5 March 2025 | ICAR-MGIFRI, Motihari (Bihar), India

COMPENDIUM

Jointly Organized By : **ICAR-Mahatma Gandhi Integrated Farming Research Institute**
Piprakothi, Motihari, Bihar- 845429

Bihar Agricultural Management & Extension Training Institute (BAMETI)
Patna, Bihar

Venue : ICAR-Mahatma Gandhi Integrated Farming Research Institute
Piprakothi, Motihari, Bihar- 845429

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सत्यमेव जयते

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Chairperson
Standing Committee on Defence
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24 फरवरी, 2025

संदेश

मुझे यह जानकर सुखद अनुभूति हो रही है कि भाकृअनुप– महात्मा गांधी समेकित कृषि अनुसंधान संस्थान (MGIFRI), पिपराकोठी, मोतिहारी, बिहार और बामेती, पटना के संयुक्त प्रयास से 04–05 मार्च 2025 को ष्कृषि – विविधीकरण और पारिस्थितिकीय क्षेत्रीय खेतीष विषय पर एक महत्वपूर्ण राष्ट्रीय संगोष्ठी का आयोजन किया जा रहा है। यह पहल भारतीय कृषि के विकास में नई संभावनाओं को तलासने, जलवायु परिवर्तन की चुनौतियों से निपटने और कृषि विविधीकरण को बढ़ावा देने के लिए एक प्रभावी मंच प्रदान करेगी।

भारत विविधताओ का देश है अतः कृषि में भी विविधिकरण और पारिस्थितिकीय स्थानीय खेती सचमुच में एक उचित विकल्प है. बिहार जैसे राज्यों में जलभराव, बाढ़ और कृषि की बदलती परिस्थितियों के मद्देनजर समेकित कृषि प्रणाली (ष्ै) जैसे नवाचारों की भूमिका और अधिक महत्वपूर्ण हो जाती है। सरकार द्वारा कृषि उत्पादकता और किसानों की आय वृद्धि के लिए विभिन्न योजनाएँ चलाई जा रही हैं, और यह संगोष्ठी इन प्रयासों को और अधिक प्रभावी बनाने में सहायक होगी। किसानों की समस्याओं को समझना और उनके समाधान की दिशा में ठोस रणनीतियाँ विकसित करना हमारी प्राथमिकता होनी चाहिए।

कृषि उत्पादकता में वृद्धि, जलवायु परिवर्तन के प्रभाव को कम करना और संसाधन उप्योग दक्षता को बढाना देश की खाद्य एवम पोषण सुरक्षा सुनिश्चित करने और 2047 तक विकसित भारत के लक्ष्य को प्राप्त करने के लिये महत्वपूर्ण है. कृषि में विविधीकरण न केवल किसानों की आय बढ़ाने का माध्यम है, बल्कि यह जलवायु–उपयुक्त प्रौद्योगिकियों, संसाधन संरक्षण, और बाजार अनुकूल कृषि मॉडल को भी बढ़ावा देता है। मुझे विश्वास है कि यह संगोष्ठी किसानों, वैज्ञानिकों, नीति–निर्माताओं और कृषि उद्यमियों को एक साझा मंच प्रदान करेगी, जिससे नई तकनीकों और संभावनाओं पर सार्थक चर्चा होगी।

मैं इस महत्वपूर्ण आयोजन की सफलता की शुभकामनाएँ देता हूँ और आशा करता हूँ कि यह संगोष्ठी भारतीय कृषि को एक नई दिशा देने में महत्वपूर्ण भूमिका निभाएगी।

(राधा मोहन सिंह)

सत्यमेव जयते

डॉ. हिमांशु पाठक
DR. HIMANSHU PATHAK
सचिव (डेयर) एवं महानिदेशक (आईसीएआर)
Secretary (DARE) &
Director General (ICAR)

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कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद्
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली–110 001

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION (DARE)
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH (ICAR)
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MESSAGE

I am happy to know that the ICAR-Mahatma Gandhi Inteqrated Farminq Research Institute (MGIFRI), in collaboration with the BAMETI, Patna is orqanizinq National Seminar on **Agri-Diversification and Eco-Regional Farmings** in Hybrid mode durinq March 4-5, 2025 at ICAR-MGIFRI, Motihari, East Champaran, Bihar.

The theme of the seminar resonates deeply with the current qlobal imperative for farminq systems diversification in relation to climate chanqe mitiqation and eco-reqional farminq. Sustainable farminq system throuqh aqri-diversification is the key to achievinq Sustainable Development Goals (SDGs), particularly for the country like India. Agricultural diversification is needed to reduce risk for farmers by spreadinq their production across multiple crops or livestock types, which helps mitjqate the impact of weather fluctuations, market price swinqs, and pest outbreaks, ultimately leadinq to more stable income and improved food security. Conventional farminq system in unsuitable ecoreqions, however, has qenerated several environmental problems such as depletion of qround water, pollution of air, deqradation of soil and aqqravation of climate chanqe. To achieve the sustainable and environment-friendly farminq practices, the crop diversification should be carried in the reqion where its environmental footprint is the minimum. This can be accomplished with ecoreqional approach. Aqricultural diversification and eco-reqional farminq emerqe as pivotal strateqies to address these challenqes, offerinq sustainable solutions tailored to specific ecoloqical and socio-economic contexts. I hope that the deliberations will lead to practical and implementable recommendations, which will be useful for farmers, policymakers and other stakeholders.

I wish the National Seminar a qrand success.

Dated the 18th February, 2025
New Delhi

(Himanshu Pathak)

प्रो. संजय कुमार सिंह
उप महानिदेशक (बागवानी विज्ञान)

Prof. S. K. Singh
FNAAS, FIAHS, FDBT
Deputy Director General (Horticultural Science)

भारतीय कृषि अनुसंधान परिषद्
कृषि अनुसंधान भवन – II,
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INDIAN COUNCIL OF AGRICULTURAL RESEARCH
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MESSAGE

It gives me immerse pleasure to know that ICAR-Mahatma Gandhi Integrated Farming Research Institute, Motihari and Bihar Agricultural Management and Extension Training Institute, Patn**a are** jointly organizing the 1st National Seminar on "Agri-**diversification** and Eco-Regional Farming", from 04-05 March, 2025 at ICAR-MGIFRI, Motihari, Bihar.

Integrated Panning is a sustainable approach to agriculture that combines various agricultural activities, such as crop cultivation, livestock rearing, aquaculture and agroforestry into a unified system. The goal is to maximize resource efficiency, reduce waste and promote environmental sustainability by using the outputs of one activity as inputs Tor another. Integated farming and agricultural diversification are essential strategies for ensuring sustainable agriculture, especially in the context of climate change, resource scarcity and population growth. They provide farmers with economic resilience, environmental benefits and food security. One of the best ways to reduce risk, boost agricultural output and in prove farmers' incomes is to encourage crop diversification. Eco-regional Farming is a broader, landscape-level approach that aligns farming practices with the unique ecological characteristics of a specific region. It focuses on sustainable agicultural practices that are tailored to the local environmental conditions, biodiversity and socio-economic factors. It is having advantages, such as reduced ecological degradation, thus promoting environmental conservation, increasing the resilience of farming systems to climate extremes, encouraging the use of safe region-specific crops and sustainable practices, "educing dependency or external inputs.

The topic of the Seminar "Agricultural Diversification and Eco regional

Fanning" is highly relevant in the current global context, addressing critical challenges in agriculture, environmertal sustainability. livelihood and food security.

I extend my best wishes to the organizers and participants for the grand success of the Seminar.

(Sanjay Kumar Singh)

डॉ० पुन्यव्रत सुविमलेन्दु पाण्डेय
कुलपति

Dr. Punyavrat Suvimalendu Pandey
Vice-Chancellor

डॉ० राजेन्द्र प्रसाद केन्द्रीय कृषि विश्वविद्यालय
पूसा, समस्तीपुर (बिहार) – 848125
Dr. Rajendra Prasad Central Agricultural University
Pusa, Samastipur (Bihar) - 848 125

MESSAGE

This is a matter of great pleasure that ICAR-Mahatma Gandhi Integrated Farming Research Institute, Motihari, Bihar and BAMETI, Patna is jointly organizing 1st National Seminar cum Exhibition on **"Agri-diversification and Eco-regional Farming"** during 4-5th March 2025.

We have achieved a lot with concerted efforts of Indian Council of Agriculture Research however, under changing climatic conditions, lifestyles and other Global demanding situations it is need of the hour to provide sustainable technological solutions for food, nutritional and environmental security. In this context the theme of the seminar 'Agri-diversification and Eco-regional farming" is strongly matching and certainly come out with strategies to address these challenges particularly for Eastern India.

India, a land of diversity, also requires agricultural diversification and Eco-regional farming to combat the farming risk, outbreak of pests, high price fluctuations of produce and degrading natural resources. The diverse and rich agroecological zones and landscapes of Bihar and neighboring regions requires identification of local constraints, possibilities and available resources to develop farming systems with unique ecological characteristics to maximize resource efficiency, reduce environmental footprints and livelihood security.

This seminar will bring together experts, scientists, farmers, students, entrepreneurs and other stakeholders at one platform for knowledge exchange and network for problem solving. With legacy of advance technologies, leading experts, researchers and professionals our seminar cum exhibition will come out with very good recommendations to address the contemporary challenges in agriculture.

I on behalf of ICAR-MGIFRI extend my warm greetings and best wishes to all distinguished dignitaries and participants. Wishing all the best for grand success of the seminar.

(P. S. Pandey)

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डॉ० बिजेन्द्र सिंह
कुलपति
Dr. Bijendra Singh
Vice-Chancellor

आचार्य नरेन्द्र देव कृषि एवं प्रौद्योगिक विश्वविद्यालय
कुमारगंज, अयोध्या – 224 229 (उ.प्र.) भारत
Acharya Narendra Deva University of Agriculture & Technology
Kumarganj, Ayodhya-224 229 (U.P.) India

MESSAGE

I am very delighted to know that ICAR-Mahatma Gandhi Integrated Fanning Research Institute, Piprakothi, Motihari, Bihar and Bihar Agricultural Management & Extension Training Institute (BAMETI), Patna, Bihar arc jointly organizing "National Seminar on Agri-diversification and Eco-Regional Farming" on 04-05 March 2025 (hybrid mode). Indian agriculture is the backbone of the nation's economy, supporting nearly half of the population and contributing significantly to food security, employment, and rural development.

Diversification in agriculture is one of the key elements of the expansion of the economy. Through the transition of the traditional agricultural product mix to high-quality items that have a high potential for boosting output rate, traditional agriculture is being turned into a dynamic and commercial sector. Changes in technology, consumer demand, commerce, or governmental policies, as well as advancements in irrigation, transportation, and other infrastructure, all assist agricultural diversification. A sustainable method of farming, ceo-regional farming maximizes output while protecting the environment by taking into consideration the distinct biological, climatic, and cultural traits of particular areas. Eco-regional farming encourages methods that arc socially inclusive, economically feasible, and environmentally benign by emphasizing the inherent advantages and disadvantages of a given location.

The National Seminar on Agri-Diversification and Eco-Rcgional Farming is highly relevant in today's context as it addresses critical challenges and opportunities in sustainable agriculture. Such a seminar brings together researchers, policymakers, farmers, and stakeholders to exchange knowledge and explore solutions to pressing agricultural issues.

I express my warm wishes to the organizers and participants for the grand success of national seminar.

(Rajendra Singh)

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श्री धनंजय पति त्रिपाठी
निदेशक

Shri Dhananjay Pati Tripathi
Director

MESSAGE

It is my privilege to extend warm greetings to ICAR-Mahatma Gandhi integrated Farming Research Institute, Motihari and Bihar agricultural management and extension training, Patna on the occasion of national seminar on Agri-diversification and eco-regional farming being organized at ICAR-MGIFRI during 04-05 March 2025.

The need for agri-diversification in Indian agriculture is critical for achieving sustainable growth, addressing socio-economic challenges, and improving resilience to climate change. Agriculture Diversification helps to either a change in cropping pattern or the fatmers opting for other non- farming options like poultry farming, animal husbandry, etc. This practice allows farmers to expand the production, which helps generate a higher level of income. The demand for high-value crops is increasing in India, and this paves the way for farmers to experiment with several cropping combinations. Apart from that, some other reasons make diversification an excellent choice for small and marginal farmers of India. It helps in reducing risk factors as it ensures that the farmers do not lose all of their resources if the weather does not favor the crop production. Agridiversification can reduce income uncertainty caused by price volatility in staple crops. Integrating high-value crops (e.g., spices, medicinal plants, horticulture) or allied activities like poultry, dawy farming, or aquaculture can enhance farmers' income.

The seminar will provide a platform to share knowledge, innovation and strategies that integrate advanced technologies with traditional wisdom for sustainable crop production. I hope that recommendations emerging from this seminar will significantly contribute to safeguarding our crops, empowering our farmers and shaping a sustainable future for Indian agriculture.

I wish the seminar a grand success.

(Dhananjay Pati Tripathi)

22 February 2025

भाकृअनुप–कृषि प्रोद्योगिकी अनुप्रयोग अनुसंधान संस्थान, जोन–IV
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ICAR-Agricultural Technology Application Research Institute, Zone-IV
(India Council of Agricultural Research, Ministry of Agricultural Farmers Welfare
Garbbuchak, Jagdeopath, Patna - 800014 (Bihar)

MESSAGE

It gives me immense pleasure to note that 1st National Seminar on Agri-Diversification and Eco-Regional Farming, will be jointly organized by ICAR-Mahatma Gandhi Institute for Integrated Farming Research (MGIFRI), Motihari, and Bihar Agricultural Management & Extension Training Institute (BAMETI), Patna, Bihar from March 4-5, 2025 at the auspices of ICAR-MGIFRI, Motihari. It is quite heartening to know that distinguished guests, eminent scientists, researchers, policymakers, and progressive farmers will be gracing the occasion during the national seminar.

Bihar's agricultural landscape is significantly shaped by recurring floods and waterlogging, posing serious challenges to farming communities. However, agri-diversification and eco-regional farming offer transformative solutions to enhance productivity, climate resilience, and sustainable livelihoods. I am hopeful this seminar will provide a platform for experts to share innovative strategies, climate-smart technologies, and adaptive farming models tailored to Bihar's unique agro-ecological conditions.

May this seminar serve as a beacon of inspiration, igniting new research avenues and innovative farming practices for a more sustainable and prosperous agricultural future.

Best wishes to the organizing team for a fruitful and successful seminar!

26/1/25
(Director)

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RAXIT PATEL
Director
INNOVAC BIOSCIENCE PVT LTD.

INNOVAC
Bioscience Pvt. Ltd.

MESSAGE

Agriculture is a heart of India as it is a main source of Food, Various industries and Growing Economy. Revolution and development are the endless factor of agriculture. Now the time has come that the whole world has a hope from India for wellness, healthy and wealthy human society development. And so, we have more responsibility to improve the agriculture revolution and diversification. The National seminar on Agri-Diversification and Eco-Regional Farming on 4-5th March 2025 at ICAR -MGIFRI will result in the awareness and sustainability of Agriculture. Implementation of New technologies, Scientific values and practices are necessary for soil health, human health, environmental health. As well as Economic health of farmer and country. With the joint effort of MGIFRI, BAMETI, Government, Farmer and Agro industries we can control the problems and achieve the goals.

I am thankful to MGIFRI and BAMETI to hold this Mega event and wishes best for the success of this conference.

(Raxit Patel)

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भाकृअनुप–महात्मा गाँधी समेकित कृषि अनुसंधान संस्थान
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डॉ० सुशील कुमार पूर्वे
निदेशक
Dr. Sushil Kumar Purbey
Director

MESSAGE

This is a matter of great pleasure that ICAR-Mahatma Gandhi Integrated Fanning Research Institute, Motihari, Bihar and BAMETI, Patna is jointly organizing 1st National Seminar cum Exhibition ou **"Agri-diversification and Eco-regional Farming"** during 4-5* March 2025.

We have achieved a lot with concerted efforts of Indian Council of Agriculture Research however, under changing climatic conditions, lifestyles and other Global demanding situations it is need of the horn to provide sustainable technological solutions for food, nutritional and environmental security. In this context the theme of the seminar Agri-diversification and Eco-regioiial fanning" is strongly matching and certainly come out with strategies to address these challenges particularly for Eastern India.

India, a land of diversity, also requires agricultural diversification and Eco-regional fanning to combat the fanning risk, outbreak of pests, high price fluctuations of produce and degrading natural resources. The diverse and rich agroecological zones and landscapes of Bihar and neighbouring regions requires identification of local constraints, possibilities and available resources to develop farming systems with unique ecological characteristics to maximize resource efficiency, reduce environmental footprints and livelihood security.

This seminar will bring together experts, scientists, fanners, students, **entrepreneurs** and other stakeholders at one platform for knowledge exchange and network for problem solving. With legacy of advance technologies, leading experts, researchers and professionals our seminar **cum** exhibition will come out with **very** good recommendations to address the contemporary challenges in agriculture.

I on behalf of ICAR-MGIFRI extend my warm greetings and best wishes to all distinguished dignitaries and participants. Wishing all the best for grand success of the seminar,

Director

Dated: 25.02.2025

ACKNOWLEDGEMENTS

The ICAR - Mahatma Gandhi Integrated Farming Research Institute (MGIFRI), Piprakothi, Motihari, Bihar, India expresses its sincere gratitude to the Indian Council of Agricultural Research (ICAR), New Delhi, Bihar Agricultural Management & Extension Training Institute (BAMETI), Patna, Bihar, Dr. Rajendra Prasad Central Agricultural University (Dr.RPCAU), Pusa, Samastipur, Bihar, ICAR Research Complex for Eastern Region (ICAR-RCER) Patna, Bihar, ICAR Agricultural Technology Application Research Institute (ATARI), Patna, INNOVAC Bioscience Pvt. Ltd. Savli, Vadodara, Gujrat, ATMA East Champaran, Motihari, Bihar, IFFCO, Patna, Bihar, A. K. Stationers, Motihari, Bihar for their generous sponsorship and financial support for this seminar.

Furthermore, we extend our heartfelt appreciation to the following institutions for their valuable cooperation and support: Furthermore more, the organizers offers thanks to Krishi Vigyan Kendra, Piprakothi, ICAR National Research Centre on Litchi (NRCL), Muzaffarpur Bihar ICAR National Research Centre for Makhana Darbhanga Bihar, ICAR Indian Institute of Farming Systems Research (IIFSR), Modipuram Uttar Pradesh, ICAR National Institute of Secondary Agriculture, Ranchi ICAR Central Institute of Fisheries Education Motipur Bihar for their assistance in the successful execution of this seminar.Lastly, the organizers sincerely appreciate the dedicated efforts of the staff at ICAR-MGIFRI, Piprakothi, Motihari, Bihar, and all supporting personnel, whose commitment and hard work were crucial in organizing this national seminar.

Organizers

भा.कृ.अनु.प.-महात्मा गाँधी समेकति कृषि अनुसंधान संस्थान
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National Seminar on Agri-Diversification & Eco-Regional Farming

4-5 March, 2025. ICAR-MGIFRI, Motihari, Bihar

Lead papers

Strategies and techniques to promote agri-diversification and eco-regional farming in flood prone and waterlogged ecosystems

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1. Introduction

There has been spectacular achievements in India in the agricultural sector during post-independent period, specifically with the advent of green revolution (GR) in the 1960's. Commencing with GR, the country has ushered in the eight revolutions in agriculture and allied sectors during the last about 60 years: green revolution in crops starting with wheat, white revolution in milk, blue revolution in fish, yellow revolution in vegetable oils, golden revolution in Horticulture & honey, silver revolution in egg production, brown revolution in coffee, grey revolution in wool, pulses revolution and sugar revolution. Considering the account of food grains (cereals and pulses), their production in total increased from a mere 50.83 million tonnes in the year 1950-51 to 332.30 million tonnes in 2023-24 (ESE&D, 2024). The primary source of livelihood is the agriculture and allied sectors; about 70% of the rural population still depend on these sectors. About 68.45% of total land holdings belong to marginal (1-2 ha land) and 17.62% to small category (up to 1 ha land) of landholders, i.e., small and marginal combined (landholding up to 2 ha) occupies about 86% of all landholdings. The Indian Council of Agricultural Research (ICAR) and the country has shown its excellence in this sector through innovative research and development. The ICAR has made a remarkable contribution towards agricultural research, education and extension in the country, and farmers welfare.

However, the natural resources, on which the agricultural production systems depend, are either dwindling or could not be managed always sustainably befitting to land degradation, water stress, excess water, changing climate, and other adverse situations. Out of those, floods and waterlogging are the most challenging with respect to natural resource management in the country. The cyclic anaerobic-aerobic soils have different nutrient availability and soil health than short-term waterlogging soils. This situation has increased over time due to both natural and anthropogenic factors. Therefore, it is the need of the hour to provide technology solutions to those challenging ecoregions i.e. flood-prone and water-congested areas. This is particularly important in the context of UN's SDG 2.0 i.e. to achieve 'Ending hunger, achieving food security, improving nutrition, and promoting sustainable agriculture by the year 2030. The present Director General, ICARemphasised, among several other R&D thrust areas and actions areas, there is urgent need to take up appropriate actions on '*demand & outcome based research*' in the '*cropping to farming system'*mode, under the thrust areas viz. '*diversification and eco-regional farming*', By this way the national priorities and targets can be achieved in a specified timeline viz. increasing farmer's income by 200%, improving nutrition security by 100%, reducing fertilizer and water usage by 50%, with 50% use of renewable energy in agriculture sector, and reducing GHG intensity by 45%.

2. Occurrence of floods and waterlogging situations

Floods and waterlogging cause huge impacts on the agricultural lands. The natural resource management is very challenging in those areas. The situation of the problem of waterlogging in some areas has increased over time due to both natural and anthropogenic factors. Floods cause damage in vast areas, and destruction to the infrastructure, human settlements, public life, and the economy. India is particularly prone to floods and the major flood-prone area is about 40 million ha (Fig. 1), which is about 12.15% of 329 million ha of the geographic area as per a reliable estimate (FAAAI, 2023). It is a misery to about 113 million people i.e., about 9% of the population in India.

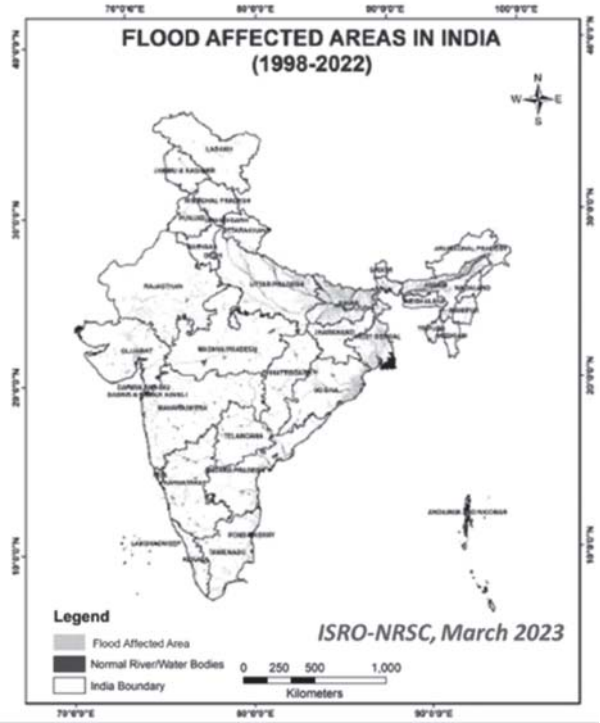


Fig. 1. Spatial distribution of flood affected area in India, Source: FAAAI, NRSC 2023

Major flood-prone states in the country are Bihar (3.977 million ha), Assam (2.465 million ha), West Bengal (1.969 million ha) and Odisha (1.424 million ha) (Fig. 2). Flood hampers agricultural and forest lands, crops and livestock, and human life. Floods frequently occur owing to high rainfall (i.e., fluvial floods), riverine floods and flash floods (i.e., pluvial floods). The damage from a river flood is extensive as in Bihar, as the runoff disturbs smaller rivers in downstream. The degree of riverine flood is increased due to continuous rainfall and with high intensity in the river catchment areas. Coastal flooding (i.e., storm surge) is also a frequent occurrence in coastal areas in the country. Vast stretches of coastal area get flooded by seawater interference due to powerful windstorms, high tide, and different concentrations of cyclones.

On average, floods of different types cause waterlogging (perennial and seasonal) in about 11.6 million ha in the country. The low-lying areas are mostly affected. There is a need to probe into the adverse effects of waterlogging ecosystems due to the occurrence of floods, a sustainable land

management solution with special reference to eastern Indian states viz. Bihar, West Bengal and Odisha. In Bihar, out of 38 districts, 28 flood-prone, 15 extremely flood-prone. The north Bihar rivers have originated from the Himalayas over Tibet and Nepal. Those have steep slopes in upper parts, trellis and dendritic pattern of drainage in the terrain having uniform lithology or physical condition. During the monsoon, those rivers carry higher volume of discharge and sediments, which cause disastroussituation in north Bihar. In the shifting course process, rivers form ox-bow lakes (locally called '*chaur'*), and '*maun'*. Of course those areas are potentially productive. The cyclic anaerobic and aerobic soils have different nutrient availability and soil health than short-term waterlogging soils, which needs to be taken into consideration.

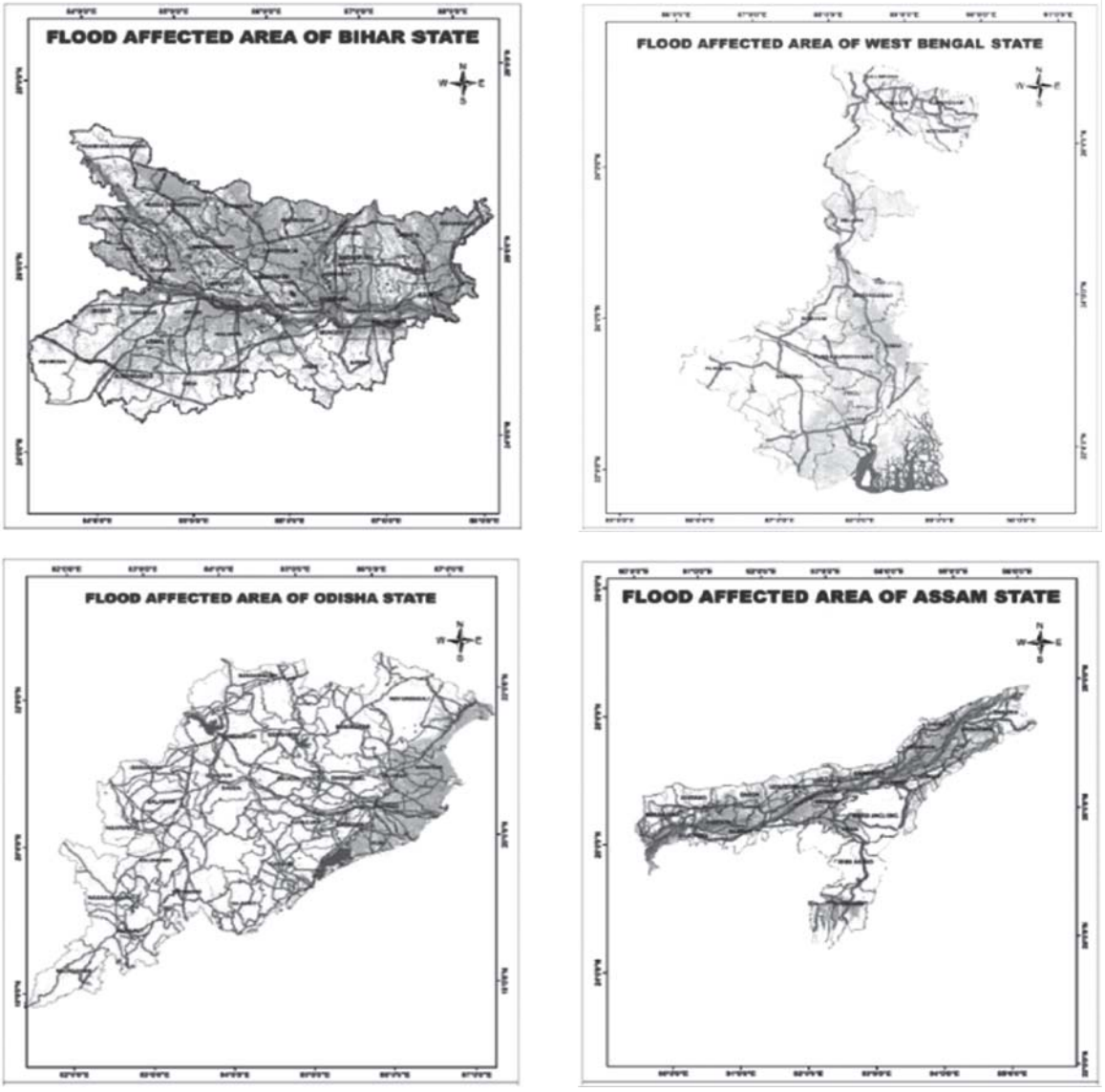


Fig. 2. Spatial distribution of flood affected area in Bihar, west Bengal, Odisha and Assam state
Source: FAAAI, NRSC 2023

A vast area in the country is the flood affected states in India, as indicated in the Table 1 with number of districts affected by flood during 1998-2022. There is a need to provide technology solutions for the waterlogging ecosystems. There is a need for concerted efforts, different approaches like land shaping techniques for crop diversification, water conservation and storage in farm ponds and adoption of site-specific pond-based farming systems, diversified systems and eco-regional farming with crop-fish-animal components, rice-fish coculture systems, post-flood efficient water management for increasing cropping intensity and enhancing the productivity of agricultural lands.

Table 1. State-wise flood-affected area in India (average of 25 years, 1998-2022)

Sl. No.	States in India	Flood-affected area (ha)	Districts affected (No.)
1	Andhra Pradesh	738200	24
2	Arunachal Pradesh	3373	5
3	Assam	2464958	35
4	Bihar	3976861	38
5	Chhattisgarh	12029	12
6	Delhi	5848	7
7	Gujarat	517770	16
8	Haryana	67852	9
9	Jammu & Kashmir	43022	10
10	Jharkhand	2966	2
11	Karnataka	280156	26
12	Kerala	79377	10
13	Madhya Pradesh	210809	30
14	Maharashtra	233590	20
15	Manipur	88352	9
16	Meghalaya	8787	2
17	Odisha	1424313	23
18	Punjab	142692	15
19	Rajasthan	155144	10
20	Tamil Nadu	552010	24
21	Telangana	102318	14
22	Uttar Pradesh	2662942	72
23	Uttarakhand	7604	2
24	West Bengal	1969750	20
	India	15750723	435

Source: Flood Affected Area Atlas of India (1998-2022), NRSC, 2023

3. Agri-diversification

Agricultural diversification is the process of expanding the variety of crops, livestock, and other agricultural commodities and activities within a farming system to optimize resource use, increase income, and reduce risks over monoculture associated with adverse climatic conditions, market fluctuations. It involves integrating farming enterprises such as crops, livestock, fisheries, forestry,

and agro-processing to create a more sustainable and resilient agricultural system. To achieve sustainable and environment-friendly farming, the agri-diversification would be required to follow. Agri-diversification can be accomplished in different fragile eco-regions. The key strategies include: identifying suitable crops and livestock based on local climate and soil conditions, implementing crop rotation systems, integrating agroforestry practices, promoting value-added products, fostering farmer training and knowledge sharing, supporting market linkages for diverse produce, and utilizing conservation tillage methods to protect the environment while optimizing agricultural output. As the interest and attraction grows in high-value crops, driven by concerns over biodiversity loss and environmental health, there is a need for comprehensive information on how crop diversification can support agricultural sustainability.

The accelerating impacts of climate change, adverse effects of pest and diseases, and unstable market conditions demand significant adaptations to secure food supplies, ensure environmental sustainability, and maintain economic stability (Table 2). It has been enumerated, as example from global evidence, how the monocultures adversely inflicts soil depletion, insect-pests and diseases infestation, climate change, food insecurity and market risks. To ensure its effectiveness, diversification must be guided by key principles and approaches that align with ecological, economic, and social sustainability. Sustainability and environmental protection are fundamental principles of agricultural diversification aimed at maintaining long-term productivity, conserving natural resources, and reducing negative ecological impacts. Ensuring that diversification enhances soil fertility, conserves biodiversity, and reduces environmental degradation. Similarly, resource optimization and efficiency aim at effective use of available resources, such as land, water, soil nutrients, energy, and labourto maximize productivity while minimizing waste and environmental degradation (Mihrete and Mihrete, 2025). In agricultural diversification, resource efficiency ensures sustainable growth by integrating multiple farming components to complement and support each other.

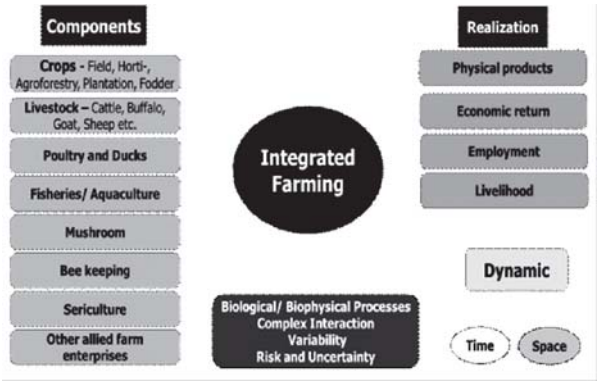
Table 2. Challenges to agriculture and the mitigating role of agricultural diversification

Challenge	Supporting Data	Impact	Mitigating Role of agricultural Diversification
Soil depletion	Global soil degradation: Over 33% of the world's soils are degraded, affecting 1.5 billion people (Gomiero, 2016) Nutrient loss: Monoculture can reduce crop yields by up to 20% due to nutrient depletion (Singh, 2020).	Reduced soil fertility and water retention lead to lower productivity and higher risk of crop failure	Diversification helps maintain soil health by improving nutrient cycling and reducing erosion
Disease and insect-pest and pressure	Economic impact: Huge annual losses due to crop pests and diseases, Increased pest resistance: Monocultures can heighten pest problems and foster resistance to chemical controls by repeatedly exposing pests to the same chemicals (Raman, 2024).	Increased crop losses and severe pest outbreaks affect yields and food availability.	Crop diversification reduces pest pressure and resistance by disrupting pest habitats and life cycles

Food insecurity	Global food insecurity: nearly 828million people are undernourished, and 2.3 billion suffer from food insecurity. Impact of monoculture: reliance on single crops can lead to food system vulnerabilities (Wudil et al., 2022)	Poor nutrition and stunted growth from mono-diets reduce productivity and economic potential, perpetuating poverty and affecting future generations' health.	Diversification improves food security by increasing production stability and dietary variety.
Climate change	Climate eff ects: Global temperatures have risen by approximately 1.1 °C since the pre-industrial era (Wang et al., 2018)	Altered growing conditions and increased frequency of extreme weather events threaten crop yields	Diversification can increase resilience to climate variability by spreading risk across different crop types suited to varying conditions
Market price volatility	Price fluctuations: Agricultural commodity prices can fluctuate by over 30% annually (Xie and Wang, 2017).	Unstable prices lead to income uncertainty for farmers and can influence food affordability for consumers	Diversification reduces economic risk by spreading income sources and reducing dependence on a single crop's market performance.

4. Integrated farming systems in waterlogging ecosystems

Waterlogging possesses not a very congenial environment for growing many field crops. However, any successful farming system interventions under these conditions integrate the field crops as a key component to cater to the diverse food requirements of farm households, with diversified agriculture activities which may help resource-poor farmers to generate additional income, gainful employment and improve their livelihoods by following the resource management strategy in achieving economic and sustainable agricultural production, preserving the resource base and ensuring high environmental quality (Fig. 3). It would be essential to study the variations in natural resource base i.e., land situations, water resources- it's excess and limited availability during post-rainy seasons, resource endowments available with farmers, nutrient flow in the agro-ecosystems and soil sickness, water pollution, climatic variability and extremes, group farming or partnership approach, Government incentives and schemes, market intelligence and farmer's own choice of crops and enterprise development etc. (Mandal et al., 2021).



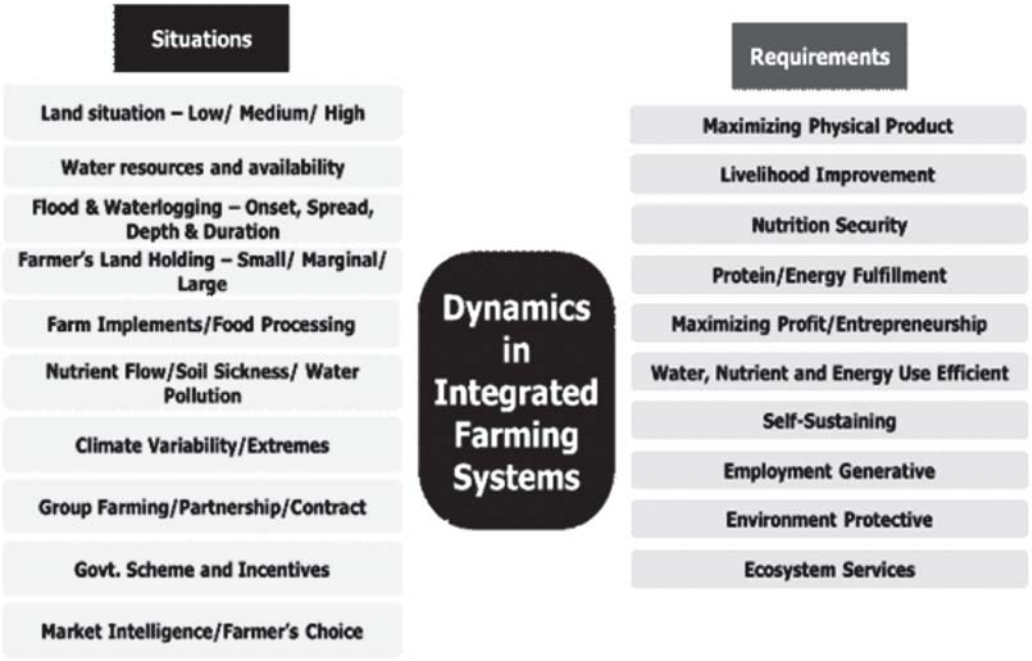


Fig. 3. Dynamic nature of integrated farming system

5. Strategies and technology options to promote agri-diversification and eco-regional farming for flood-prone and waterlogged ecosystems

i) Land shaping enabling diversification and site-specific farming

Land shaping technique includes modification of the land surface primarily for harvesting of rainwater and creating a source of water for irrigation, reducing drainage congestion and growing of multiple and diversified crops round the year, and efficient use of stored water. By these land modification techniques, there is ample scope of growing fruit and seasonal vegetable crops on the raised beds and the pond dykes, and fish culture in the sunken water body of different depths and in ponds. Rice is the principal crop during *kharif* season in eastern India. In waterlogged situations, either rice is grown in shallow water depths, or there is failure of even rice crop in case of deep waterlogged conditions. However, diversification is possible through land modification or land shaping techniques, where raised beds will provide an aerobic environment to grow crops other than rice, and the excavated area will be suitable for water conservation and retention even after the recession of floods. Fish and aquatic crop cultures are possible in those sunken and ponded area. By that the alternate raised and sunken bed is a land management system where both rice and other crops can be grown in the same *kharif* season.

ii) Fish culture and farm pond-based integrated farming

Pond-based farming holds promise in waterlogged areas. Pond management with fish, poultry, on-dyke horticulture and vegetables has proved to be an excellent approach for sustainable production, income and employment generation for the resource-poor rural households. The addition of organic fertilizers like poultry litter to a fish pond, that is integrating poultry farm with fish, increases the water nutrients for better production of fish by resolving the problem of fish feed. A poultry house can be constructed from locally available materials after the excavation of a fish pond.

The walls of the house may be made from eucalyptus wood and plastered with mud. The roof of a poultry house can be constructed with thatch, plastic sheet or corrugated tin sheets.

iii) Rice-fish co-culture

In waterlogged areas, rice-fish coculture is a potential option. It is practiced in Arunachal Pradesh, Tripura, Assam, West Bengal, Bihar, Andhra Pradesh, Tamil Nadu and Kerala; but further improvement would be required. In the eastern region of the country with plenty of rainfall from June to September, rice is the predominant crop during the monsoon. Integration of fish with rice proves beneficial with some minor interventions like the creation of micro watershed-cum-fish refuge in 10-20% area, raising of strong and wide dykes all around the field to protect the micro-environment and to accommodate the integration of different components like vegetables, fruit crops, birds, livestock, agroforestry, mushroom, floriculture, apiculture etc. Evidence shows that, in irrigated rice ecosystems, a refuge area of 9% of rice field resulted in the highest return (4.22 to 4.55 t REY ha^{-1} REY, rice equivalent yield) without using any pesticide (Mohanty and Mishra, 2003; Mohanty et al., 2004). There is huge potential for rice-fish farming in north Bihar which is rich in water resources comprised of rivers, *chaurs*, ox-bow lakes or *mauns*, reservoirs, ponds and tanks etc. Fish productivity of floodplain wetlands of Bihar is reported to be only 50-220 kg/ha/year, which can be increased several folds through scientific interventions (Ayyappan et al., 2017).

iv) Horticulture-based integrated farming

Horticultural crops under a horti-based farming system plays an important role in the farming systems, for example litchi or mango based. The integrated system increases nutritional security, employment and sustainable development in any agroecosystems, and waterlogged ecosystems are not the exception. Various problems which small and marginal farmers face are solved by adopting the horticulture-based integrated farming systems. Surface drainage by land modification technology and recycling of drainage water seem to be feasible in waterlogged ecosystems. Rainwater harvesting and its recycling can increase productivity and diversify agricultural systems including remunerative agricultural and horticultural crops, and pisciculture in an integrated manner(Das et al., 2014).In some cases, under waterlogged areas, despite surface drainage, excess water cannot be drained out due to land topography. The groundwater level of those lands is so near to the surface that water cannot be drained out to main drains. In those cases, restoration of seasonally waterlogged lands is possible through the integration of various techniques of land shaping i.e., pond-cum-raised bed system and pond system. The ratio of pond-cum-raised bed system depends on location and landscape.This approach and practice would ensure nutrition security to farmers, employment generation round the year, and enhancing the productivity of the whole land-water water. A multi-enterprise integrated farming (apiculture, mushroom cultivation, vermicomposting, medicinal and aromatic crops) would also be possible in waterlogged areas.

v) Livestock-based integrated farming system

Livestock is an important component of integrated farming, and is considered in some sites central to the livelihood of farmers. Income and employment generation both are greatly associated with livestock-based farming. Black Bengal goat farming needs promotion. This would fetch considerable earning through *Champaran meet*, as is prevalent in North Bihar. Livestock is an important natural capital asset for the poor, which can be used by them to maintain a livelihood in times of crisis. The use of local resources should be prioritized. Different components of the farming system work together in an integrated farming system resulting in higher total productivity. The output from one enterprise, thus improving the resource use efficiency. Due to fragmentation in the landholding of farmers, it is necessary to integrate land-based enterprises like fishery, poultry and horticultural crops within the bio-physical and socio-economic conditions of the farmers to make farming more profitable and dependable.

vi) Growing of aquatic crops

These aquatic crops are cash crops and provide nutritional and livelihood security to a considerable section of the population in the region. Makhana (*Euryale ferox*) and water chestnut(*Trapa bispinosa, T. natans*) cultivation are popular among the fisherman communities in waterlogged ecosystems of north Bihar, especially in the Darbhanga district. Makhana and water chestnutare widely utilized in India as non-cereal diets and have great demand on the occasion of festivals and ritualistic fasts. In lowland areas of Darbhanga district in Bihar where cultivation of other crops is not possible due to waterlogging, integration of makhana with fish and water chestnut; and field-based system of makhana cultivation is found very beneficial (ICAR-RCER, 2014).

vii) Add-on benefit from ecotourism associated with diversification in pond-based systems

Ecotourism is based on the natural resource attraction or a combination of natural and eco-friendly man-made resources or interventions. Eco-tourism, short form of ecological tourism, is a potential option to increase the ecosystem services (ES) of wetland and waterlogged eco-systems. There could be a fine symbiosis out of the combination of recreation and tourism with the opportunity of human-nature relationships. This would give benefits to both the human and the ecosystems in a long-period sustainability. A schematic example of a farm-pond based integrated farming and a wetland ecosystem depicts the ecotourism and ES (Fig. 4 & 5). In Bihar, most of the waterlogged or wetland areas are having a shape of half-moon which is typical shape majorly found in this location (Fig. 5). Using this waterbody, ecotourism can be developed which will harness cultural ecosystem services. Evolving an ecosystem services (ESS) based ecotourism approach necessitates a concurrent natural science and social science methodology, i.e. a multi-disciplinary perspective. Using the excess water of flood, a fish pond can be constructed, which can add multiple ecosystem services.On the pond dyke, different vegetation mainly flowers, fruits, shady tress can be planted which will enhance the beauty of the area to a large extent. The pond water can be better used by cultivating different fish species, water loving crops like water chestnut, makhana which will produce more economic return.

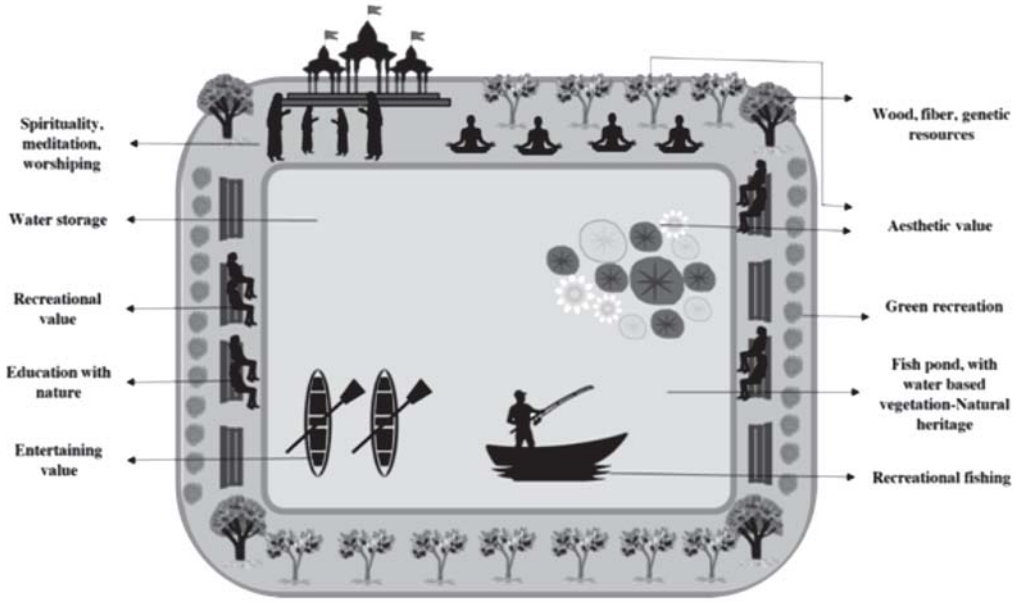


Fig.4: Schematic diagram of ecotourism- a better way to extract cultural services from wetland ecosystems (Source: Mandal et al., 2024)

Additionally, fishing activities can be done which will add entertaining aspect of the cultural services. People generally prefer temple worshiping, meditation, spiritual practices near the water body, this will add spiritual aspect of cultural services. Additionally, boating facilities can be provided for the visitor of the eco-park. By this way, better ecosystem services can be obtained from a waterlogged ecosystem.

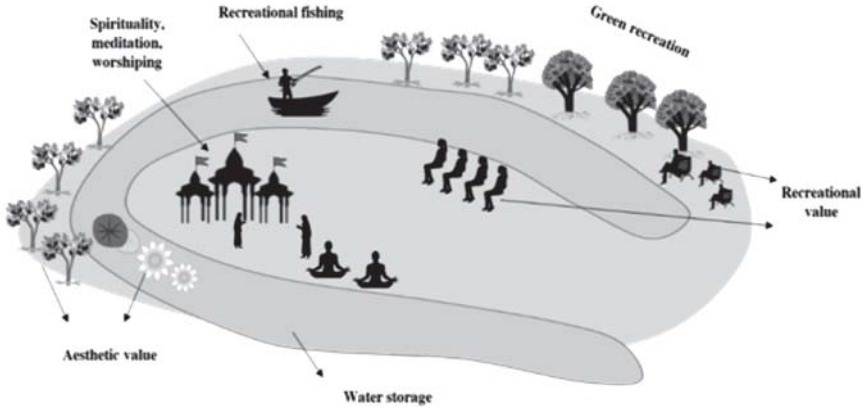


Fig. 5. Conceptual framework for ecotourism in a typial half-moon shaped wetland ecosystems of north Bihar (Source: Mandal et al., 2024)

6. Conclusion

Promoting agricultural diversification and eco-regional farming requires a multi-stake holders and dimensional approach involving farmers, policymakers, researchers, and market stakeholders. By adopting climate-smart strategies, optimizing resource use, and strengthening market access, these approaches can ensure sustainable agriculture, food security, and rural economic development. An integrated farming system is an effective option for marginal and small farmers of north Bihar and elsewhere. Those may be site and situation-specific. It is very essential to develop sustainable land management and diversification system for farmers in flood-prone and waterlogged situations. It is also required to have proper delineation, situation analysis, and mapping of flood-prone, flood-affected and waterlogged areas; need for shifting from cropping to a farming system approach. This will ensure food and nutrition security, and increase farmers' income. Infrastructure development will be required concomitantly; if possible, it should be with low-cost technology and with local resourcesfor the ease of adoption by resource-poor farmers, especially in waterlogged areas. There is a need for the convergence of different line departments of the central and state Governments for appropriate interventions and farmers' welfare.

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Strengthening India's Sustainable Food System: The Role of Farmer Producer Organizations (FPOs) and Financial Institutions (FIs)

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1. Introduction

Financial institutions play a pivotal role in transforming the agricultural sector by providing the necessary financial support and tools to enhance productivity, sustainability, and resilience. They boost investment by offering capital for sustainable practices such as organic farming, precision agriculture, and renewable energy integration, which improve soil health, reduce environmental impact, and increase long-term productivity. Additionally, they fund infrastructure development like cold storage and processing units, reducing post-harvest losses and improving market access. By offering affordable credit, financial institutions enable small and marginal farmers to invest in high-quality seeds, fertilizers, and irrigation systems, leading to higher yields with fewer resources. Microfinance and self-help groups further cater to the specific needs of smallholder farmers, helping them build capacity and improve livelihoods. To mitigate risks, financial institutions provide insurance products and risk management tools, protecting farmers from crop failures due to climate change, pests, or market fluctuations. Innovative weather-based insurance ensures quicker relief, allowing farmers to recover and replant promptly. Financial institutions also promote the adoption of advanced technologies like drip irrigation, solar-powered pumps, and AI-based farming tools, which reduce resource use and improve efficiency. Digital platforms and mobile payment systems enhance access to financial services, particularly in remote areas.

Beyond funding, they offer training programs to educate farmers on best practices, financial literacy, and technology use, often partnering with agri-tech companies to accelerate innovation. Furthermore, they facilitate market linkages by connecting farmers to buyers, reducing reliance on middlemen, and enabling fair pricing. Warehouse receipt financing allows farmers to store produce and sell it when market conditions are favorable, maximizing income. Through these multifaceted efforts, financial institutions drive the transformation of agriculture toward sustainability, resilience, and improved livelihoods, particularly for smallholder farmers who are most vulnerable to economic and environmental shocks.

A sustainable food system refers to a framework that ensures the production, distribution, and consumption of food in a way that is environmentally sound, economically viable, and socially equitable. It aims to meet the nutritional needs of the present without compromising the ability of future generations to meet their own needs. In India, agriculture is the backbone of the economy, contributing significantly to the GDP and employing nearly half of the country's workforce. It not only ensures food security for the nation's vast population but also supports the livelihoods of millions of farmers and rural communities. Economic Survey says that the Indian agriculture sector provides livelihood support to about 42.3 per cent of the population and has a share of 18.2 per cent in the country's GDP at current prices. The sector has been buoyant, which is evident from the fact that it has registered an average annual growth rate of 4.18 per cent at constant prices over the last five years and as as per provisional estimates for 2023-24, the growth rate of the agriculture sector stood at 1.4 percent.

Economic Survey states that the Investment in agriculture research and support of enabling policies have contributed substantially to food security. It is estimated that for every rupee invested in

agricultural research (including education), there is a payoff of ₹13.85. In 2022-23, ₹19.65 Thousand Crore was spent on agriculture research.

However, the sector faces challenges such as climate change, resource depletion, and market volatility, which threaten its sustainability. To address these challenges, financial institutions like Primary Agricultural Credit Societies (PACS), Commercial Banks (CBs), Regional Rural Banks (RRBs), Self-Help Groups (SHGs), and Farmer Producer Organizations (FPOs) play a pivotal role in enabling sustainable food systems.

2. Role of financial institutions in sustainable food system

These institutions provide critical financial support through institutional credit, which is vital for farmers to meet their working capital needs, such as purchasing seeds, fertilizers, and irrigation equipment, as well as long-term investments in sustainable practices like organic farming, precision agriculture, and renewable energy integration. By offering affordable credit, they empower small and marginal farmers, including farm women, to adopt advanced technologies and improve productivity while reducing resource use. Additionally, they facilitate risk mitigation through insurance products and risk management tools, protecting farmers from crop failures due to climate change, pests, or market fluctuations. This financial safety net encourages farmers to invest in sustainable practices without fear of losing their livelihoods.

Moreover, institutions like SHGs and FPOs promote financial inclusion and collective empowerment, particularly in rural areas. They enable farmers to access markets, negotiate better prices, and reduce dependency on middlemen, thereby improving income and economic resilience. By fostering collaboration and capacity building, these institutions also educate farmers on sustainable practices and financial literacy, ensuring the adoption of environmentally friendly and efficient farming methods. Together, these efforts contribute to the creation of a sustainable food system that balances productivity, environmental stewardship, and social equity, ensuring the long-term growth and development of India's agricultural sector and the broader economy.

The Kisan Credit Card (KCC) scheme has been a game-changer, with 772.49 lakh operative KCCs disbursing ₹9,80,404 crore as of 2024. Uttar Pradesh leads with 109.17 lakh KCCs and ₹1,38,621 crore disbursed, followed by Rajasthan and Madhya Pradesh. Marginal and small farmers rely heavily on PACS for short-term credit, while CBs dominate medium- and long-term credit. Coming to the risk mitigation, Pradhan Mantri Fasal Bima Yojana (PMFBY) has provided crop insurance to 2.28 crore farmers in 2022, with premiums reduced to ₹1,54,826 lakh. The scheme has also promoted horticulture, with coverage increasing from 57 crops (2018) to 60 crops (2022). With respect to financial inclusion, Pradhan Mantri Jan Dhan Yojana (PMJDY) has brought 54.03 crore unbanked individuals into the formal banking system, with 55.7% of accounts belonging to women and 66.6% in rural/semi-urban areas. However, dormant accounts and limited financial literacy hinder the scheme's full potential. SHGs have also played a transformative role, with 144.22 lakh SHGs covering 17.8 crore families and disbursing ₹2,09,285.87 crore in loans. Women-centric SHGs have empowered farm women by providing microcredit, fostering entrepreneurship, and promoting collective decision-making.

SHGs and CBs have been instrumental in providing skill development and entrepreneurship opportunities to farm women. SHGs train women in agricultural practices, handicrafts, and small-scale industries, while CBs offer tailored credit products for women entrepreneurs. These initiatives have not only improved livelihoods but also empowered women to become active participants in rural economies. SHGs provide a platform for women to voice their concerns, participate in community development, and gain confidence. Additionally, PMFBY ensures that women farmers are covered under crop insurance, reducing their vulnerability to agricultural risks. These efforts have contributed to the social empowerment of farm women, enabling them to play a more

significant role in decision-making processes.

The Pradhan Mantri Fasal Bima Yojana (PMFBY), India's flagship crop insurance scheme, aims to provide financial protection to farmers against crop losses due to natural calamities, pests, and diseases. However, the scheme faces several challenges that hinder its effectiveness. One major issue is the delayed pay-outs and denial of claims, with farmers often receiving compensation that is less than their actual losses and experiencing payment delays of up to 18 months. Data collection is another significant challenge, as the poor availability of accurate crop-cutting experiment (CCE) data, which is crucial for assessing yield loss, requires substantial manpower and resources. Additionally, the scheme has imposed a fiscal burden on states, as they are required to share a significant portion of the premium subsidy, leading some states to opt out. Implementation issues further complicate matters, with farmers struggling to upload documents and claim damages due to poor network connectivity in rural areas. Moreover, the scheme's implementation has been scaled back compared to previous versions, reducing its reach. Grievance redressal mechanisms are also inadequate, with only 15 states and union territories having notified Grievance Redressal Committees (GRCs) at the state and district levels, leaving farmers with limited recourse in case of disputes.

To address these challenges, the government can adopt several measures. Replicating the Beed Model, implemented in Maharashtra, could be a viable solution. This model caps insurance company pay-outs at 110% of the premium collected, with the state government bridging any additional claims, thereby preventing windfall gains by insurers. Enhancing technology can improve data collection, streamline claim settlement processes, and strengthen overall scheme implementation. Strengthening grievance redressal mechanisms by establishing functional GRCs at all levels will provide farmers with a platform to resolve disputes effectively. Additionally, increasing awareness through targeted campaigns can educate farmers about the scheme's benefits, coverage, and procedures, ensuring greater participation and utilization. By addressing these challenges, the PMFBY can better achieve its goal of safeguarding farmers' livelihoods and promoting agricultural resilience.

3. Role of FPOs in sustainable food systems

Farmer Producer Organizations are collective entities formed by farmers to enhance their bargaining power, access to markets, and achieve economies of scale. These organizations are typically registered as legal entities under the Companies Act, 2013, or the Cooperative Societies Act. By pooling resources, FPOs enable small and marginal farmers to share risks, access better inputs, technology, credit, and markets. They help farmers reduce production costs, improve product quality, and negotiate better prices for their produce, thereby increasing their income and sustainability.

FPO formations in India track back to some consecutive policy initiations with regard to the empowerment of farmers through collective action. The movement of this concept gained momentum when the inclusion of the Companies Act, 1956, allowed farmers to register themselves as producer companies. In 2002, the Government of India introduced the 'Small Farmers' Agribusiness Consortium' with the aim of promoting the creation and scaling up of FPOs. Subsequently, in the year 2013, the introduction of the Companies (Amendment) Act further facilitated structured growth for FPOs through a regulatory framework. In that process, it also aimed at addressing the fragmentation of landholdings, reducing middlemen exploitation, and raising efficiency at agricultural value chains. The Ministry of Agriculture and Farmers' Welfare reported over 10,000 registered FPOs in India as of 2023. To be precise, it calculates the formation of 10,000 new FPOs by 2027 as per the "Formation and Promotion of 10,000 FPOs" scheme.

- **NABARD's Role**: NABARD has been a key player in promoting FPOs through its Producer

Organization Development Fund (PODF), which provides financial support for the formation and capacity building of FPOs. NABARD also facilitates credit linkages and technical assistance to help FPOs become self-sustainable.

- **SFAC's Role**: SFAC, under the Ministry of Agriculture, has been instrumental in promoting FPOs through its Equity Grant and Credit Guarantee Fund schemes. These initiatives provide financial support to FPOs, enabling them to access credit and invest in infrastructure.
- **State Governments**: Several state governments have also launched initiatives to promote FPOs. For example, the Maharashtra government has been actively supporting FPOs in the horticulture sector, while the Odisha government has focused on promoting FPOs for paddy and millet farmers.

Government of India (GOI) started is supporting the promotion of FPOs during the 12th five-year plan (2012-2017) (GOI, 2013). GOI has approved and also launched a new flagship scheme for the establishment of FPOs called "Formation and Promotion of 10,000 Farmer Producer Organizations (FPOs)" with a total budget of Rs.6865 Cr by the end of 2027-28. The formation and promotion of FPO can be done on the basis of two approaches they are the produce-cluster area approach and the specialized commodity-based approach. When applying the cluster approach, the composition of the break-even point will focus on "one domain - one product" to develop product characterization (PIB Delhi, 2021).

In recent years, the landscape of Indian agriculture has witnessed a significant transformation propelled by the emergence and proliferation of Farmer Producer Organisations (FPOs). These entities, formed by small and marginal farmers, have garnered attention as pivotal agents of change within the agricultural sector. The government has been actively promoting the formation and strengthening of FPOs, recognizing them as crucial vehicles for driving agricultural growth, enhancing farmers' income, and ensuring socio-economic development in rural areas. In this context, the culmination of the 10,000 FPO programme presents FPOs with the challenge of sustaining and expanding their operations independently. However, this transition also heralds a new era of empowerment, where FPOs have the opportunity to assert their autonomy and carve out their niche in the agricultural landscape.

3.1 Government Initiatives to Promote FPOs

India has proposed several initiatives to promote the formation and strengthening of FPOs, considering the role of FPOs in transforming the agriculture sector. Among them are:

✓ **SFAC (Small Farmers' Agribusiness Consortium):** Small Farmers' Agribusiness Consortium is a federation entrusted to coordinate the formation and support for FPOs. It provides financial and technical support for FPOs across the country.

NABARD (National Bank for Agriculture and Rural Development)

✓ NABARD provides finance, grants for capacity building, and marketing support under various schemes for FPOs.

✓ **The Scheme for Formation and Promotion of 10,000 FPOs:** This Scheme was announced in 2020 with an objective of creating and promoting 10,000 new FPOs by 2027. The scheme contemplates financial support for FPO formation, infrastructure development, and capacity building.

Credit Guarantee Fund

✓ The government has provided a credit guarantee fund for enhancing the creditworthiness of FPOs and thereby making access to credit from financial institutions easier.

Pradhan Mantri Kisan Sampada Yojana (PMKSY)

- ✓ Assistance under PMKSY on setting up food processing units is assisting FPOs in value addition and thus securing better prices for their produce.

Farmer Producer Organizations have been registered across India under various agencies, including the Small Farmers' Agri-Business Consortium (SFAC), NABARD, and the Central Sector Scheme (CSS) for the formation and promotion of 10,000 FPOs. Among these, 898 FPOs have been established under SFAC, while 3,904 FPOs have been registered through NABARD's initiatives. Additionally, 2,257 FPOs have been formed under the CSS scheme, which aims to promote and strengthen farmer collectives across the country.

3.2 Services and Objectives of FPO

Services provided by Farmers' Organizations are marketing services (input supply, output marketing, processing, market information), financial services (savings, loans, and other forms of credit), technology services, education services, and welfare services.

Generally, FPOs works with the following objectives in providing their services:

- ✓ Production of same agricultural produce by all members of FPO (one organization one product)
- ✓ Procurement of all the agricultural produce in one place for bulk allocation
- ✓ Harvesting, grading, and processing of the primary agricultural produce
- ✓ Effective marketing of the primary agricultural produce
- ✓ Selling or export/import activities concerning the main agricultural produce

FPOs provide several benefits to farmers, including improved bargaining power, better access to markets, increased income, and access to credit and financial services. The Government of India launched a scheme in 2014 to form and promote 10,000 new FPOs by 2024. As of June 30, 2023, 6,319 FPOs have been registered, with 3,681 in the process of registration. The government provides financial assistance to FPOs, including up to ₹18 lakh per FPO for three years and a matching equity grant of up to ₹2,000 per farmer member. Additionally, a credit guarantee fund has been established to help FPOs access credit from banks. State Level Consultative Committees (SLCCs) and District Level Monitoring Committees (D-MCs) have been constituted to oversee the development and functioning of FPOs, providing guidance and support.

3.3 *Challenges Faced by FPOs*

- ✓ Access to Capital: Despite their better positioning than individual farmers, FPOs face problems in accessing adequate and timely credit. Most financial institutions are too wary to give credit to the FPOs for reasons of perceived risks.
- ✓ Governance Issues: Effective management and governance form key constituent elements for the progress of the FPO. Lack of leadership and management skills among members leads to ineffective decision-making and operational inefficiencies.
- ✓ Market Linkages: Appropriate and viable market linkages are hardly developed. FPOs normally lack market intelligence and networks to competitively function in wider markets.
- ✓ Training and Capacity Building: Inability or lack of professional management skills and technical expertise among members hinders growth and sustainability within the FPO.
- ✓ Policy and Regulatory Challenges: The regulatory environment is complex, entailing compliance requirements and bureaucratic processes that are difficult to handle.
- ✓ Infrastructure Constraints : Inadequate infrastructure on storage, transportation, and processing reduces the scope of FPOs in improving farm incomes.

The agricultural and rural financial ecosystem in India faces several challenges that hinder its effectiveness in supporting farmers, particularly marginal and smallholders, as well as women.

One major issue is credit accessibility, with marginalized groups often struggling to secure long-term credit for sustainable agricultural practices. Awareness gaps further exacerbate the problem, as many farmers and Self-Help Group (SHG) members remain uninformed about institutional schemes and their benefits. Regional disparities in credit distribution and SHG penetration create uneven access to financial resources across states, while a significant portion of Pradhan Mantri Jan Dhan Yojana (PMJDY) accounts remain dormant, The issue of dormant accounts under the Pradhan Mantri Jan Dhan Yojana (PMJDY) further limits the impact of financial inclusion efforts. A significant portion of these accounts remain inactive, either due to lack of awareness, insufficient funds, or limited access to banking services. This inactivity undermines the scheme's potential to provide a safety net for rural households. Similarly, the PMFBY, which aims to protect farmers from crop losses, faces challenges such as delayed claims settlement. Farmers often experience long delays in receiving compensation, and disputes over claim amounts are common. These issues erode trust in the insurance system and discourage farmers from participating in the scheme.

To address these challenges, a multi-pronged approach is essential. Enhancing awareness through targeted campaigns can educate farmers and SHG members about available institutional schemes and their benefits. Strengthening SHGs by providing training, technology, and market linkages will improve their effectiveness and empower rural communities. Expanding long-term credit access for marginal farmers and women is crucial to ensure inclusivity and sustainability. Leveraging technology can streamline processes, such as faster claims settlement under PMFBY and efficient loan disbursement through Kisan Credit Cards (KCC). Promoting financial literacy will enable farmers and women to make informed decisions about savings, credit, and insurance products. Simplifying regulatory frameworks and reducing bureaucratic hurdles can provide greater support to FPOs, enabling them to thrive. Finally, fostering state collaboration to strengthen implementation at the grassroots level will ensure equitable credit distribution and address regional disparities. By implementing these recommendations, India can build a more inclusive, resilient, and sustainable financial ecosystem for its agricultural sector.

4. Conclusion

Institutions like PACS, CBs, RRBs, SHGs, and FPOs have played a transformative role in supporting farmers and empowering farm women in India. From providing credit and insurance to promoting financial inclusion and entrepreneurship, these institutions have significantly contributed to agricultural growth and rural development. However, challenges such as credit accessibility, awareness gaps, and regional disparities need to be addressed. By leveraging technology, enhancing awareness, and fostering collaboration, these institutions can further strengthen their impact, ensuring sustainable development and prosperity for India's farmers and farm women. The progress of SHGs and FPOs reflects the pivotal role of institutions in driving farmer welfare and gender empowerment, paving the way for a more inclusive and resilient agricultural sector to stabilize the food systems in the country.

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Agri-diversification through integrated farming system for diverse ecologies of Bihar

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1. Introduction

The Integrated Farming System (IFS) is a sustainable and self-regulating agricultural production approach rooted in ecological principles. It harmoniously integrates diverse landscape elements and biological interactions to optimize resource use efficiency and enhance productivity. IFS offers a solution to counter the adverse effects of intensive agricultural practices and unsustainable soil management, which contribute to environmental issues such as reduced air and water quality, soil erosion, depletion of soil organic matter, and the emergence of pesticide-resistant weeds, pests, and pathogens. Moreover, it helps maintain soil health and agrobiodiversity.

IFS promotes agri-diversification by supporting crop diversification through crop rotation, cover crops, multiple cropping, and intercropping. These practices are complemented by low-input management strategies, including conservation agriculture, organic farming, and natural or eco-farming. By adopting IFS, agricultural systems can sustain productivity while enhancing long-term resilience against environmental stresses.

Bihar, with its rich natural resources, fertile soil, and abundant river water, has significant potential to support a diversified cropping system. The state is divided into three agro-climatic zones:

1. Zone I: North/North-West Alluvial Plain
2. Zone II: North-East Alluvial Plain
3. Zone III (A and B): South Bihar Alluvial Plain

The Ganga River bifurcates the state, creating contrasting agro-ecological conditions. Northern Bihar, nourished by Himalayan rivers, is prone to floods, while southern Bihar, dependent on central Indian rivers, faces drought risks. The fertile alluvial plains across these zones provide immense potential for agri-diversification.

In Bihar, over 90% of farmers are small and marginal landholders. Therefore, successful implementation of IFS requires tailoring agri-diversification strategies to suit the small average landholding sizes prevalent in the state. This approach can enhance livelihoods, promote sustainable agricultural practices, and contribute to the overall resilience of Bihar's agricultural economy.

2. Crop diversification scenario of Bihar

The decadal (2000-01 to 2009-10 and 2010-11 to 2019-20) crop diversification scenario in Bihar was studied by Roy *et al.* (2023) based on Simpson's Index of Diversification (SID), which is given by the formula:

$$SID = \sum_{i=0}^{n} \frac{A_i}{GCA^2}$$

where, A_i= Area under i^{th} crop and GCA= Gross Cropped Area.

Simpson' index of diversification varies from 0 (perfect specialization) to 1 (perfect diversification). It was estimated that SID in Bihar varies from 0.33 to 0.40 and there was no

significant decadal variation. It was also revealed that horticulture sector is more diversified as compared to agriculture sector because, share of the rice and wheat to the total area of the agriculture sector estimated to be more than 70% which makes that the rice and wheat farming as a specialized one. Among the horticultural crops, marginal and small farmers allocate the area in the range of 60-75% for the vegetable crops and 5-7% for fruit crops to the total area under horticulture crops.

1. IFS and its determinants

Integrated Farming System is an approach that considers whole farm as a system and driven by 1) the inter-dependencies between the components under the control of household members and 2) interaction of these components with each other in respect of physical, biological and socioeconomic factors not under the household's control. Uncertainty of weather parameters compel farmers mix-up of agricultural enterprises like dairy, poultry, pigeon, fishery, sericulture, apiculture etc., suited to their agro-ecological and socio-economic condition. The major determinants of the components of IFS are: size of landholdings, topography of land, availability of waterbodies, occurrence of drought or flood, infrastructure for post-harvest storage and processing, social acceptability and demand for a particular commodity, transport and market facilities.

Behera and France (2016) out lined the key determinants of IFS components, *viz* external and internal. The main exogenous (external) factors influencing the development of farming systems are policies, institutions, public goods, markets, and information and indicated technologies governing the nature of production and processing as well as natural resources are largely endogenous (internal) factors and are therefore indicated within the boundary of the farming system.

2. Agro-climatic zones of Bihar for selection of IFS components

Based on the agro-climatic zones the possible IFS module for the different zones of Bihar may be summarized as follows:

Table1 : Zone-wise delineation of IFS components in Bihar

Name of the zone & Districts	Ecologies	Dominant cropping system	Livestock scenario	Constraint	Possible IFS components
Zone-I: *(Darbhanga, East Champaran, Gopalganj, Madhubani, Muzaffarpur, Saran, Sitamarhi, Shivhar, Siwan, Vaishali and West Champaran*	Flood prone, low land	Rice-Maize fb rice-wheat	High population of cattle (85-125/Km^2), buffalo (60 -90 /Km^2), goat and pig (15-20/Km^2) due to plenty of grazing land	Lack of proper recycling of resources, high cost of cultivation, meagre net income, high labour migration	Crop Fish, Crop Dairy, Crop + Horticulture, Crop+Fish+Makhana
Zone-II: *(Araria, Begusarai, Katihar, Khagaria, Kishanganj, Madhepura, Purnia, Saharsha and Supaul*	Flood prone, low to medium land	Rice-Maize/ Rice-fallow	High to medium population of cattle.	Water stagnation, low cropping intensity, less diversity, inefficient utilization of resources.	Crop+ Horticulture + Bee Keeping, Crop + Horticulture +Livestock and Crop +Fish+ Livestock

Zone-III: ***(****Aurangabad, Banka, Bhagalpur, Bhojpur, Buxar, Gaya, Jamui, Jehenabad, Lakhisarai, Munger, Nalanda, Nawada, Patna, Rohtas and Shekhpura)*	Drought prone Medium to upland	Rice-wheat/Rice-fallow	Low population of livestock.	Water scarcity in post -rainy season, low input use efficiency	Crop + Horticulture, Crop + fish, Crop + Dairy, Crop + Goat, Crop + Goat + Poultry and Crop + Horticulture + fish .

Source: Kumar et al. (2014)

Table 2: Detailed IFS options for diverse ecologies/landholdings/farmer type of Bihar

IFS System	Crop/ cropping sequence	Livestock	Fish	Fruits/ Flowers	Vegetables	Allied enterprises
Irrigated low and medium land (Small and marginal farmers)						
Rice-fish	Rice-wheat/winter maize/lentil/ gram/mustard	Honey bee				Mushroom/ apiculture
Solo crop/Fish +Duckery+ apiculture	-Do-	Goat, Duck, Honey bee	Carp culture	Banana, papaya	Elephant foot yam/okra/ sweet potato/leafy vegetables/cucurbits-beans/tomato/ potato/cole crops	
Irrigated low and medium land (Medium and large farmers)						
Rice/fish+ Dairy	Rice-wheat/winter maize/lentil/ gram/mustard, fodder	Buffalo /Cattle or both	Carp culture	Banana, papaya, mangoes	Elephant foot yam/Colocasia/ okra/ sweet potato/leafy vegetables/cucurbits-beans/tomato/ potato/cole crops/onion/chilli	
Crop+ Dairy+ Fish+ Poultry+ Duckery+ Vegetables+ Fruits+ Flowers	Rice-wheat/winter maize/lentil/ gram/mustard/rye/ fodder	Buffalo/ cattle or both, Duck, Poultry	Composite fish culture	Mango, jackfruit, guava, banana, lemon, litchi, marigold, gladiolus, cut flowers	Elephant foot yam/Colocasia/ okra/ sweet potato/leafy vegetables/cucurbits-beans/tomato/ potato/root crops/onion/chilli	

Irrigated uplands (Small and marginal farmers)						
Crop+ fish+ duck+ vegetables/ fruits	Rice/maize/sugarcane-wheat/winter maize/lentil/gram/mustard	Duck, pig/goat	Composite fish culture	Mango, jackfruit, guava, banana, lemon, litchi, phalsa, papaya	Seasonal vegetables	Mushroom
Irrigated uplands (Medium and large farmers)						
Crop + fish +Dairy +vegetables + fruits/ flowers	Rice-wheat/winter maize/lentil/ gram/mustard/fodder (Jowar, oat, berseem, cowpea)	Buffalo/ cattle or both	Composite fish culture	Mango, jackfruit, guava, banana, lemon, litchi, phalsa, papaya	Seasonal vegetables, gourds, Colocasia, sweet potato, leafy vegetables, cucurbits, melons - beans tomato, potato cole crops root crops, onion, chili	
Crop + Dairy + fish +poultry +Goatery + +Duckery + vegetables + fruits + flowers	Rice-wheat/winter maize/lentil/ gram/mustard/fodder (Jowar, oat, berseem, cowpea)	Buffalo/ cattle or both, Duck + poultry	Composite fish culture	Mango, jackfruit, guava, banana, lemon, litchi, marigold, gladiolus, cut flowers	Elephant foot yam, Colocasia, sweet potato, leafy vegetables, cucurbits, melons - beans tomato, potato cole crops root crops, onion, chili	
Rainfed areas (small and marginal farmers)						
Crop + fish + pig + goat/poultry/sheep/ vegetables/fruits	Rice-wheat/winter maize/toria	Pig/ goat, sheep	Composite fish culture	Mango, jackfruit, guava lemon, litchi, phalsa and papaya	Seasonal vegetables	
Crop + fish + pig + goat/poultry/sheep/ vegetables/fruits	Rice, pigeonpea, soybean-wheat/winter maize/ potato/mustard	Pig/ goat, sheep	Composite fish culture	Mango, jackfruit, guava lemon, litchi, phalsa and papaya	Seasonal vegetables	

Rainfed areas (Medium and large farmers)						
Crop + Dairy + fish +vegetables/fruits	Rice, wheat, maize, pigeon pea, mustard toria, soybean, mung, sweet potato, sesame.	Buffalo/ cattle/ both	Composite fish culture	Mango/ guava/ Lemon/litchi/custard apple/jack fruit	Seasonal vegetables	
Flood prone areas (Small and marginal farmers)						
Crop+ rice+ fish +poultry	Deep water rice/jute/sugarcane (BO 91), Rice+mung/maize+soybean-Grass pea/lenti/sweet potato/wheat/boro rice	Poultry	carp	Water chestnut, makhana, mango, litchi, water melon	On bunds seasonal vegetables	
Makhana/water chestnut+fish+dairy+bamboos+vegetable/fruits	Deep water rice/jute/sugarcane (BO 91), Rice+mung/maize+soybean-Grass pea/lenti/sweet potato/wheat/boro rice		Air breathing carp	Water chestnut, makhana, mango, litchi, water melon	On bunds seasonal vegetables	
Flood prone areas (Medium and large farmers)						
Crop+ Makhana/ water chestnut+ fish+dairy+bamboos +vegetables/fruits	Deep water rice/jute/sugarcane (BO 91), Rice+mung/maize+soybean-Grass pea/lenti/sweet potato/wheat/boro rice		Air breathing carp	Water chestnut, makhana	On bunds seasonal vegetables	
Crop+ Makhana/ water chestnut+ fish +piggery/goatery+vegetable/fruits	Deep water rice/jute/sugarcane (BO 91), Rice+mung/maize+soybean-Grass pea/lenti/sweet potato/wheat/boro rice	Pig, goat	Air breathing carp	Water chestnut, makhana	On bunds seasonal vegetables	

1. Development of IFS models for low and medium land situations in Bihar

Kumar et al. (2021) proposed two IFS models, having diversification of different components for different land situations of Bihar as follows:

IFS model-I (Area: 2.0-acre, low land, Patna, Bihar)

❖ **Model at a glance**

Main enterprise: Crop + Livestock (2 no.) + Fishery

Allied enterprise: Duckery, composting, vermicomposting

❖ **Details of components**

(1) Cereal crops (50% area)

Kharif: Rice

Rabi: Wheat/Maize/Gram/Mustard

(2) Horticultural crops (Fruits + vegetables): 12.5% area

Vegetables:

Kharif: Cucurbits/Brinjal/Okra

Summer: Onion/Brinjal/Cowpea/Okra/Bitter gourd/Cucumber etc.

Rabi: Tomato, cabbage, Broccoli, French bean

Fruits:

Papaya (On pond's dike and field bunds)

Banana (On pond's dike)

Lemon (On pond's dike and Horticultural block)

Guava (On pond's dike and Horticultural block)

(3) Boundary plantations (4% area)

Fodder-cum-green manure: Drumstick, Dhaincha; Cucurbits/ pigeonpea/soybean along bund fencing for protein supplement in diet.

4) Fish + Duck integration (17.8% area)

(a) Mix carp culture: Rohu (20% as column feeder), Catla (30% as surface feeder), Mrigal/common carp (50% as bottom feeder)

(b) Duck (Khaki Cambell): 40-45/1000 m^2 water area. A thatched hut of 10 x 15' size is optimum for 40 ducks above the water or on the pond's dike.

(5) Livestock (1.80% area) + Bio- gas unit- 2 cows+ 2 calves.

(6) Fodder production (12.5% area)

Kharif: M.P. Chari/Sudan grass/ Napier/Maize

Summer: Boro/Lobia/Maize/Sudan grass

Rabi: Berseem/Oat/Maize etc.

(7) Spices : In the sheds or where light intensity is less like orchards, spaces between the huts etc. turmeric, ginger or guinea grass are being taken.

(8) FYM/vermicomposting pits: (1.4% area)

Optimal sizes pits (9' x 3') for preparation of FYM (3 pits) and Vermicompost (4 pits) has been made.

IFS model-II (Area: 1.0-acre, medium land, Patna, bihar)

❖ **Model at a glance**

Main enterprise: Crop + Goat + Poultry

Allied enterprise: Mushroom, vermicomposting

❖ **Details of components**

(1) Cereal crops (50% area)

Kharif: Rice

Rabi: Wheat/Maize/ Lentil/Til

(2) Horticultural crops (Fruits + vegetables): 22.5% area

Vegetables:

Kharif: Cucurbits/Brinjal/Okra

Summer: Brinjal/Cowpea/Okra/ Bitter gourd/Cucumber etc.

Rabi: Tomato, Cauliflower, spinach

Fruits :

Banana (On field bund)

Lemon (In Horticultural block)

Guava (In Horticultural block)

(3) Boundary plantations (4% area)

Fodder-cum-green manure: Karunda, Drumstick, Dhaincha; Cucurbits/ pigeonpea/soybean along bund fencing for protein supplement in diet.

(4) Livestock (Goat): 2.5% area

A size of 20 female goat + 1 buck. A thatched hut of 20' X 30' with sufficient fenced paddock space (to move goats freely as goats have to kept on stall feeding) is sufficient for above number of animals.

(5) Poultry (200 birds)

200 birds (broiler) are being reared in an area of 225 sq. ft. by making a thatched hut.

(6)Mushroom

Year-round mushroom production is being done in an area of 25' x 20' by making a thatched hut for optimum return.

March - September: Straw/Paddy/Milky mushroom

October- February: Oyster/ Button mushroom.

(7) Fodder production (12.5% area)

Kharif: M.P. Chari/Sudan grass

Summer: Boro/Lobia/Maize/Guinea grass

Rabi: Berseem/Oat/Maize etc.

(8) Spices : In the sheds or where light intensity is less like orchards, spaces between the huts etc. turmeric, ginger or guinea grass are being taken.

(9) FYM/vermicomposting pits: (1.4% area)

Optimal sizes pits (9' x 3') for preparation of FYM (3 pits) and Vermicompost (4 pits) has been made.

IFS model-III (Sabour, Bhagalpur)

Developed of Integrated Farming System Model for Livelihood Security of Small and Marginal Farmers of Bihar.

IFS Model experimental area (m^2): 10,000

Table 3: Distribution of area of 1.0 ha under different components

Enterprises identified	**Number**	**Net area allocated** (m^2)
Field crops	Cereals, pulses, oilseeds, fodder & vegetables	7,806
Cross breed Cows	2 Cross breed cows + 2 calves	70
Goat unit	Black Bengal (10 female + 1 male)	80
Duckery	25 Nos.	24
Fishery + Fruits	800 Nos.	1420
Vermi-compost unit	3 Nos.	100
Area under Bunds, Farm shed ,channels &Loafing area		300
Farm Boundary plantation	125 numbers of Subabool (*Leucaena leucocephala*) and 50 nos. of Moringa plants were planted along the boundary of field in 200m^2 .	
TOTAL		**10,000**

1. Evaluation of different farming systems

Kumar et al. (2011) evaluated seven IFS models of 2.0 acre (0.8 ha) each in ICAR Research Complex for Eastern Region, Patna, Bihar during 2007-10 for productivity and profitability under lowland condition. Crop+ fish + duck + goat emerged as the best integrated farming system (IFS) in terms of productivity, net returns (1,59,485/yr) and income sustainability index (SI) for net returns (80%) (Table-3 and 4), where SI can be calculated by the formula:

$$SI = \frac{\text{Net return of any model} - \text{Standard deviation of all models}}{\text{Maximum Net ret ret return of all models}}$$

Under field crops (FC), rice-maize sequence produced maximum RGEY (9.2 t ha^{-1}) gross return (92.0 × 10^3 ₹ ha^{-1}), net return (41.5 × 10^3 ₹ ha^{-1}) and benefit cost ratio of 1:8

Table 4 : Area allocation, productivity of each component and system productivity of different IFS models in terms of rice grain equivalent yield (RGEY)

Treatment/ Farming system		Area (ha)	Component productivity (RGEY t ha^{-1})		System productivity (RGEY t ha^{-1})
Field Crop (FC)	FC	0.66	FC	9.23(100)	9.23
FC+ Fish +Poultry*	FC	0.66	FC	12.3(66.1)	18.6
	Fish	0.12	Fish	1.81 (9.7)	
	FYM +VC Pit	0.02	Poultry	4.5 (24.2)	
FC +Fish +Duck*	FC	0.66	FC	12.0(78.1)	15.4
	Fish	0.12	Fish	1.81(11.8)	
	FYM +VC Pit	0.02	Duck	1.56(10.1)	
FC + Fish+ Goat	FC	0.54	FC	12.2(62.1)	19.6
	Fish	0.12	Fish	1.81(9.2)	
	Goat	0.02	Goat	5.6(28.7)	
	Fodder area	0.1			
	FYM +VC Pit	0.02			

FC + Fish +Duck* + Goat	FC Fish Goat Fodder area FYM +VC Pit	0.54 0.12 0.02 0.1 0.02	FC Fish Goat Duck	12.2(57.5) 1.81(8.5) 5.6(26.6) 1.56(7.4)	21.2
FC + Fish + Cattle	FC Fish Cattle Fodder area FYM+ VC Pit	0.54 0.12 0.02 0.1 0.02	FC Fish Cattle	12.0(57.1) 1.81(8.5) 7.3(34.4)	21.2
FC + Fish + Mushroom	FC Fish Mushroom FYM +VC Pit	0.64 0.12 0.02 0.02	FC Fish Mushroom	12.4(81.1) 1.81(11.8) 1.1(7.2)	15.3

* Sheltered over fish pond; FC= Field crop; figures in parenthesis indicate percent contribution to the total system productivity; RGEY= rice grain equivalent yield

Table 5: Economics of different IFS models

Treatment/ Farming system	Production cost ($\times 10^3$ ₹ ha^{-1})	Net returns ($\times 10^3$ ₹ ha^{-1})	Net returns ($\times 10^3$ ₹ day^{-1})	Income susceptibility index
Field Crop (FC)	48.0	62.8	172	19.3
FC + Fish+ Goat	83.9	151.6	415	75.1
FC + Fish +Duck* + Goat	94.9	159.5	437	80.0
FC + Fish + Cattle	125.6	128.5	352	60.6
FC + Fish + Mushroom	70.8	127.9	350	60.2
SD	24.1	31.9	87	
CV (%)	29.2	25.3	25.1	

SD= Standard deviation, CV = Coefficient of variation

7. Conclusion

It can be concluded that, IFS is a sustainable self-regulating agricultural production system which optimizes resource utilization under different components based on input-output relations. In Bihar there is a vast scope of agri-diversification through IFS, owing to its ecological diversity and decadal stagnated level of diversification. IFS has the potential to at least double the system productivity of a farm, promote subsistence to farm families through food and nutritional security and improve livelihood of farmers through employment and income generation.

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Perspective of horticulture based Integrated Farming System in waterlogged and flood prone areas

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1. Introduction

Agriculture prosperity particularly in term of horticulture production in India is evidenced by almost fivefold increase in production in last few decades and is estimated to be 352.23 Million Tonnes, surpassing the total food grain production of 332.0 Million Tonnes during the year2023-24 **(**MA&FW, Govt. of India, PBI, New Delhi**).** This needs to be enhanced further to cope up with increasing demand of population and that too in the wake of challenges like climate change, degradation of land and water resources, shrinking of land, low farm income coupled with increasing malnutrition and nutritional security. Majority of the farmers in India are small and marginal. They often follow a monoculture approach which leads to low farm income from agriculture/horticulture/aquaculture to run their families. Presently, most of the farmers are concentrating mainly on crop production, which is subjected to a high degree of risk and uncertainty in income due to crop failure by various factors. Per capita total land availability was 0.32 ha in 2001 (world average of 2.19 ha), and expected to have 0.23 ha in 2025, and 0.19 ha in 2050. (*DAC, Agriculture Census Division 2010-11*). The gradual degradation of resources has become a problem of major concern and calls for location specific measures to optimize crop productivity on sustained basis (Kumar *et al.* 2012). In these circumstances it is imperative to integrate the enterprises such as dairy, piggery, goatery, fishery, poultry, apiary along with field and horticultural crops so as to make farming more remunerative, reliable and sustainable. There is other various problems which the farmers, particularly the small and marginal are facing which will be can solve in single units like by adopting the horticulture based integrated farming systems (IFS) (Kumar *et al*. 2015). The cultivation of horticultural crops under Horticulture based farming system **(**HBFS**)** will play an important role in prosperity of farmers along with nutritional security, health, employment and sustainable development.

In India, huge stretches of different kinds of wastelands such as salt-affected land, waterlogged areas, gullied/ravinous lands etc. has been developed over the years due to biotic and abiotic pressures. As per the estimate of Wasteland Atlas Map, 2019 a substantial area (162715 and 519945 ha permanent and seasonal type in India and (69465 and 86940 ha permanent and seasonal type, respectively) in Bihar is under waterlogged and marshy condition and majority of the area falls under those districts which are suitable for horticultural crops cultivation. In low lying area, water is available in the surface of the land and stands seasonally for 4-5 months during monsoon season or even for most part of the year. This condition prevails usually in lands located in plain areas associated with the drainage congestion. The water logging problem in India is mainly confined to deltaic region with sub-humid to humid tropical climate. In general, in this region by and large three types of excess water situations are encountered viz, (i.) High rainfall associated within very short period with inadequate drainage resulting into flood that extends over large areas, (ii.) Accumulation of water over prolonged period in sporadic localized topographical depressions and (iii.) Intrusion of brackish or sea water in deltaic areas. Due to uncontrolled excess water situation even rice growing

areas are often subjected to waterlogging and flash flood. But, this type of land situation is also not preferred for growing of most of the horticultural crops due to water-logging, un-decomposed organic matter and swampy condition.The major problems associated with this wasteland are poor drainage and water accumulates only due to high rains during monsoon months resulting in crop failure in cultivated field. Some parts of India remain waterlogged (> 1m surface water) for 4-5 months and become unproductive during *kharif* and very low utilization in *rabi* season too.

2. Horticulture-Based IFS: A Sustainable Approach

Management of waterlogged areas by growing of waterlogging resistant paddy varieties, floating rice, growing aquatic crops like water chestnut, swamp taro and makhana is one option. By integrating fish into this eco-system, the overall productivity of the zone could be increased tremendously which would meet the food grain as well as nutritional requirement of growing population of our country. But, surface drainage, land modification technology and recycling of drainage water seem to be feasible in these areas. Efficient rainwater harvesting and recycling may provide new livelihood options for the resource poor farmers. Rainwater harvesting and its recycling can increase productivity and diversify agricultural system including remunerative agricultural and horticultural crops, pisiculture in integrated manner(Das *et al.* 2014).In some cases in waterlogged area in spite of surface drainage, excess water cannot be drained out due to land topography. The ground level of those lands is so low that water cannot be drained out to main drains. In those cases restoration of seasonal waterlogged lands is possible through integration of various techniques of land development (land shaping) i.e. (i) pond cum raised bed system and (ii) only pond system. The ratio of pond cum raised bed system depends on location and landscape.Land shaping technique includes modification of the surface of the land primarily for harvesting rain water for creating source for irrigation, reducing drainage congestion and growing of multiple and diversified crops round the year and efficient use of stored water. Further the harvesting of excess water through suitable land shaping involves modifying the surface of the farm land for conservation of excess rain water and making the land surface suitably shaped for successful cultivation of fruit along with seasonal vegetable crops on pond dyke and fisheries in pond through integrated approach of farming system. Sustainable development through horticulture based integrated farming system has been emerged as a viable way of improving farmers income with rational utilization of resources and environmental protection without hampering economic growth. Keeping in view, a multi-enterprise horticulture based integrated farming (apiculture, mushroom cultivation, vermicomposting, medicinal and aromatic crops) systems will enable food security, nutritional security (Provide balance food), higher productivity and enhanced farm income per unit area, employment generation, recycling of resources and minimize environmental pollution. Various studies has shown that sustainable development through horticulture based integrated farming system has been emerged as a viable way of improving farmers income with rational utilization of resources and environmental protection without hampering economic growth.

In waterlogged ecosystem an integrated aquaculture has an integral and sometimes pivotal role in integrated resources management (IRM).Integrated aquaculture can be classified into three major systems with twelve major models. The most popular models preferred in India and suitable for waterlogged ecosystem are mainly pond-dyke integration, fish-rice-duck/poultry-vegetable, fish-water chestnut/makhana-vegetables and fish-cow/pig-duck/poultry vegetableAn on farm study conducted by IIWM, Bhubaneswar applying pond cum raised system in Kudra district of Odisa found 20 to 40 percent more on raised bed than that in the prevailing low land cultivation system for different crops (Sahoo *et al*, 2006).The above study of comparative economics between pond cum raised bed system and low-lying adjoining land reveals that benefit cost ratio (B: C) in the improved

system is 2.45 where as in the low lying system (original condition) it is only 0.7. Similarly, Patel *et al*, (2020) in their study of horti-based IFS model comprising of four pond-dyke model namely(model I: Two row of litchi and banana + seasonal crops, model II: Two row of litchi and papaya + seasonal crops, model III: Two row of litchi + banana in between two litchi plants + seasonal crops, model IV: Two row of litchi + papaya in between two litchi plants + seasonal crops) along with traditionally existing cropping system practiced in low lying area (fallow-mustard-moong) to compare with different models found that highest SVI, total system productivity and economic efficiency (0.78, 25.49 and 116.15) in model 1, respectively as compare to crop based existing system which was almost double than the crop based existing system Table 2.Five vegetable-based cropping sequences on raised beds and six rice-based sequences on sunken beds were tested and compared with rice monocropping (control) under an organic production system. On raised beds, tomato–okra–French bean gave highest rice equivalent yield (REY; 44.7 t ha^{-1}) followed by carrot–okra–French bean (42.5 t ha^{-1}). Rice (cv. Shahsarang 1)-pea (cv. Prakash) gave highest REY (17.3 t ha^{-1}) on sunken beds (www.icarneh. gov.in).

Table: 1 Yield and Economics of pond and raised bed system

Season	Crop	Crop yield (q/ha)	Gross return (Rs)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)
Kharif	Ladies finger	2.08	2496.00	543.00	1953.00
	Brinjal	3.00	3000.00	271.00	2729.00
Rabi	Tomato	1.20	1200	302.00	898.00
	Ladies finger	2.08	2496	543.00	1953.00
Summer	Chilli	2.00	1800	1357.00	443.00
Bund plantation	Pumpkin	0.50	200	50.00	150.00
	Papaya	3.00	900	150	750.00
	Banana	9 bunch	1350	81	1269.00
	Cowpea	0.5	250	15	235.00
	Green leaf	0.05	50	10	40.00
Pond	Bitter gourd	0.62	620	35.00	585.00
	Fingerling	1200 nos.	1200.00	450.00	750.00
	Big fish	0.75	3150.00	950.00	2200.00

Source : Sahoo *et al.* 2006

Table 2 Productivity of different components in various farming system models (pooled of 3 years)

Farming system	Component productivity			Total system productivity in terms of LEY (t/ha)	Relative Economic Efficiency	Sustainable value index
	Fruit	Seasonal crop	Fish			
Model 1	0.32 (1.26)	0.24 (0.94)	24.93 (97.80)	25.49	116.15	0.78
Model 2	0.27 (1.07)	0.29 (1.15)	24.64 (97.78)	25.20	110.54	0.76
Model 3	0.27 (1.07)	0.34 (1.35)	24.57 (97.54)	25.19	82.98	0.63

Model 4	0.10 (0.39)	0.28 (1.11)	24.80 (98.49)	25.18	67.64	0.56
Existing system (Fallow - mustard - moong)	-	4.05 (100)	-	4.05	0.00	0.25

Figure in parenthesis indicate per cent contribution to the total system productivity, LEY: Litchi equivalent yield

3. Integrated Aquaculture-Horticulture System

Plantation of litchi on ridges is recommended in low-lying areas in order to prevent water logging in Philippines (Rachell C. Sotto, Litchi production in the Philippines,

Table: 3 On-Station Farming Systems Developed IFS Models (with Horticulture as a component) in Various Regions of India

Sl. No.	*NARP Zone (Location of Centre)*	*Details of Farming System*	*Area (ha)*	*Mean Production (Rice equivalent yield) (t)'*	*Mean net returns (Rs in lakhs) **	*Area Allocation under Horticulture (%t)*	*Percentage Share of Horticulture to Total Net Returns*
I. Western Himalaya							
1	Pantnagar (Uttarakhand)	Cropping systems (0.52 ha) + dairy (2 cows) + horticulture (0.19 ha) + agro-forestry (0.23 ha) + vermicompost (0.005 ha)		30.2	2.21	19	18
		II. Eastern Himalaya					
2	Umiam (Meghalaya)	Cropping systems (0.70 ha) + horticulture (0.20 ha) + poultry (600 broilers + 50 layer) + piggery (3 Nos.) + fishery (0.05 ha)	1.00	20.6	1.64	20	6
III. Lower Gangetic Plains							
3	Kalyani (West Bengal)	Cropping systems (0.42 ha) + dairy (2 cows) + horticulture (0.11 ha) + fishery (0.09 ha) + vermicompost (0.018 ha)	0.66	14.4	1.09	16	18

IV. Middle Gangetic plains							
4	Varanasi (Uttar Pradesh)	Cropping systems (0.81 ha) + dairy (6 cows) + horticulture (0.06 ha) + fishery (0.10 ha) + poultry (200 Nos.) + vermicompost (0.004 ha) + mushroom (0.002 ha)	1.00	43.4	3.64	6	4
5	Patna (Bihar)	Cropping systems (0.40 ha) + dairy (2 cows) + horticulture (0.10 ha) + fishery (0.12 ha) + duck (35nos.) + vermicompost (0.01 ha) + biogas (2 m^3)	0.80	21.5	1.56	12	13
6	U.P.	Orchard-based IFS-model	1.5	41	4.29	0.8	57
V. East Coast Plains and Hills							
7	Bhubaneswar (Odisha)	Cropping systems (0.32 ha) + horticulture (0.19 ha) + dairy (2 cows) + fishery (0.33 ha) + poultry (380 Nos.) + duck (20 Nos.) + agro-forestry (0.094 ha) + vermicompost (0.0033 ha) + mushroom (0.010 ha) + biogas (0.0048 ha) + apiary (2 boxes)	1.25	29	1.58	16	20
VI. Upper Gangetic plains							
7	Modipuram (Uttar Pradesh)	Cropping systems (0.38 ha) + dairy (2 buffaloes + 1 cow) + horticulture (0.30 ha) + vermicompost (0.01 ha) + biogas (1.5 m^3) + mushroom (0.002 ha)	0.70	23.0	2.28	42	37

VII. Eastern Plateau and Hills						
Raipur (Chhattisgarh)	Cropping systems (0.60 ha) + dairy (2 cows) + horticulture (0.22 ha) + fishery (0.072 ha) + poultry (0.003 ha) + vermicompost (0.003 ha)+ biogas (1.5 m^3) + mushroom (0.003)	1.00	18.32	1.44	22	33

*Mean of 5 years

http://www.fao.org/docrep/005/ac684e/ac684e0b.htm#Top Of Page).The over-all design of litchi orchards should be established according to topography. The raised-bed model in the lowlands and contour making in steep land are the two main designs practiced in Vietnam (Vu Manh Hai and Nguyen Van Dung, Litchi production in Vietnam, ttp://www.fao.org/docrep/ 005/ac684e/ ac684e0d.htm# TopOfPage).

In the lowlands of the Central Plain Samut Songkhram and adjacent provinces of Thailand, the raised-bed or ridges are used for growing litchi as well as other crops. Each bed is 4 m (sometimes 6 m) wide alternating with a 2 m wide ditch. The water level is kept constantly at 50 cm and controlled by an outer dyke. Irrigation and chemical sprays are employed by boat through the ditches all over the orchard. Coconut, pomelo, banana and other crops are planted along with the main litchi trees. (Ravie Sethpakdee, Head, Department of Horticulture, Faculty of Agriculture, Kasetsart University, Kamphaengsaen Campus, Nakhon Pathom, Thailand . Litchi production in Thailand, Title: Lychee production in the Asia-Pacific region. (http://www.fao.org/docrep/005/ac684e/ac684e0c.htm).

In China, litchi is often planted on the banks of ponds and streams. In low wet land situation, ditches of 10 to 15 ft (3-4.5 m) wide and 30 to 40 ft (9-12 m) apart, using the excavated soil to form raised beds on which they plant litchi trees, so that they have perfect drainage but the soil is always moist. (http://chamkarkhmer.com/lychee-fruits, Morton, J. 1987. Lychee. p. 249–259. In: Fruits of warm climates. Julia F. Morton, Miami, FL.).

Selected case studies of family farming models and horticulture-based farming system models is discussed for their role in farming systems suiting to local climatic needs particularly suitable for waterlogged ecosystem (DARE News, 2015). Out of IFS models developed at different locations, the percentage area allocation to horticulture component varied from 6 to 42 per cent (Table 3) depending on suitability of location, while the share of income from horticulture component to net income of the system varied from as low as 2 to 57 per cent depending on type of fruits or vegetables as well as whether it was the main crop or intercrop or boundary crop (Table 3).

Study of different existing farming systems in different parts of the country are reveals that naturally existing crop + dairy system being practiced by close to 85 per cent house-holds is able to provide only Rs. 37,614/ha/year, which is very low for the marginal and small holders to sustain their livelihood, while coconut + banana + cocoa + pineapple + nutmeg gives return of Rs. 1.27 lakhs/ha/year (Panwar *et al.* 2016). Several authors have reported that diversified systems having the

components of horticulture, fisheries, apiculture, poultry and goat rearing are able to provide higher income as compared to farming systems having without horticulture enterprises. Different farming systems developed at various locations across the states, either as horticulture-based systems or at least horticulture as one of the components of the farming system for wetland ecosystem have been described in Table 3. It can be inferred from the Table 1 that Horticulture is one of the key component of the major farming system developed in different states of the country and is playing a significant role in enhancing productivity and profitability to the farmers of the region.

4. Conclusion

In several areas of eastern India's the waterlogging is quite seasonal. It is mainly rainfed depending on the frequency and extent of annual .rainfall. Hence the vegetable cops can be grown when the water level reduces periodically in *rabi* season under post flooded situation. However, suitable crops are to be selected which perform favorably under *rabi* season like okra, tomato and brinjal. Cultivation of bio-drainage trees could be used to manage shallow water table and salinity problem. The clear impact of lowering of water table is evident even within 10 years of establishment of vegetation. The approach is relatively cheaper, sustainable and ecologically compatible depending on natural capability of vegetation to transpire water. Few important profusely transpiring trees as promising bio-drainage candidate like eucalyptus, casuarinas, Lucerne, Kalmi sag (*Ipomoea aquatic*), Thankuni sag (*Hydocotyl asiatica*), aquatic medicinal plants viz. brahmi, keshori, Ipomea, etc.

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Climate smart agricultural practices for increasing productivity under flood prone and waterlogged ecosystem

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1. Introduction

Floods have an adverse effect on the Indian economy every year. On an average, every year around 7 million hectares of farm lands get affected by floods, around 3.2 million people are affected to varying degrees, and more than 1600 human lives and 89,000 cattle are lost due to floods. The annual damage to property amounts to Rs 18 billion and is rising each year. 88% of the current year, based on the report by the Centre for Science and Environment (CSE) and Down to Earth published on 1st November India witnessed extreme weather events – such as heatwaves and floods, caused by the changing climate. Between January 1 and September 30, such events claimed the lives of 2,755 people, and affected 1.8 million hectares of crop area across the country much of the above damages occurs in a particular geographical region. The Ganga-Brahmaputra-Barak basin areas in the states of Assam, West Bengal, (North) Bihar and (Eastern) Uttar Pradesh, face the brunt of floods every year. Hence, these areas may be termed as recurrent flood prone areas along with waterlogging problems. These areas have high population density and rank low on human development index. In general, Bihar is one of the most poverty-stricken States in India. High incidence of poverty relates to high population density, low per capita availability of agriculture land, low agriculture productivity and illiteracy. Bihar is also the most flood-prone State in India. About 70% of its geographical area is affected by flood. The plains of North Bihar has been witnessing flood for last several years. Most of these floods occur due to breach of artificial embankments constructed as a part of river training and flood control measures by the State Government. In August 2008, there was a major flood in North Bihar due to breach of embankment on River Kosi resulting in huge loss of life, crops and livestock. All these events in some way connected to changing pattern of the climate. Climate is emerging as a prominent issue in the world nowadays. The climate has changed, is changing and will continue to change regardless of what investments in mitigation are made. Climate change is a significant variation in weather patterns occurring over periods ranging from decades to millions of years (Reyes et al 2015). Changing climatic conditions most severely affect agriculture because it depends on local climatic parameters like temperature, rainfall, humidity, etc. Climate change directly affects agricultural production as the sector is inherently sensitive to climatic conditions and is one of the most vulnerable sectors to risk and impact of global climate change. Under flood and water logged condition, excess water is available on the earth surface, use of this excess natural resources could be done by recycling approach. Resource recycling is one of the major option practiced under integrated farming system (IFS) approach. Where output from one sub system can be used as input to another component in the IFS system. Pond based IFS model including fishery/ poultry/ and horticultural components has been found quite effective in managing and recycling resources for obtaining better output. Climate smart agricultural practices is another option to address the issue of flood prone and water logging condition. Thus, current topic will focus on possible agricultural practices for managing this problematic situation.

2. Flood prone and water logged ecosystem

India is the worst flood-affected country in the world after Bangladesh and accounts for one fifth of global death count due to floods. Around 40 million hectares of land in the country are subject to floods according to National Flood Commission, and an average of 18.6 million hectares of land is affected annually. The annual average cropped area affected is approximately 3.7 million hectares. The most flood-prone areas in India are the Brahmaputra and Ganga River basins in the Indo-GangeticBrahmaputra plains in North and Northeast India, which carry 60 per cent of the nation's total river flow. The other flood prone areas are the north-west region of west flowing rivers such as the Narmada and Tapti, Central India and the Deccan region with major east flowing rivers like Mahanadi, Krishna and Cauvery. Like flood, waterlogging is another problem and a menace to a large category of people. Water-logged environment is found in the areas where soil remains saturated with water (Mihrete et al 2025). The word "waterlogged" is used as an adjective referring to soil that is saturated with water and thus cannot keep oxygen between its particles (Raman 2024). Waterlogged area is generally defined as an area having ground water level from 25 cm to 300 cm on the surface of the land for few months or for whole year. Waterlogged areas are classified in three categories i.e. (1) shallow: having water level upto 45 cm on the surface of land (2) medium: having water level from 45 cm to 120 cm and (3) deep: waterlogged area having water level above 120 cm land surface. Similarly, Floodplains are land areas adjacent to rivers and streams that are subject to recurring inundation. Owing to their continually changing nature, floodplains and other flood-prone areas are need to be examined in the light of how they might affect or be affected by development. Flooding is a natural and recurring event for a river or stream. Flooding is a result of heavy or continuous rainfall exceeding the absorptive capacity of soil and the flow capacity of rivers, streams, and coastal areas (Mohanty et al 2024). This causes a watercourse to overflow its banks onto adjacent lands. Floodplains are, in general, those lands most subject to recurring floods, situated adjacent to rivers and streams. Floodplains are therefore "flood-prone" and are hazardous to development activities if the vulnerability of those activities exceeds an acceptable level. The National Commission on Agriculture assessed that an area of about 6.0 million hectare was waterlogged in the country. Out of this, an area of 3.4 million hectare is affected due to surface water stagnation and 2.6 million hectare due to rise in water table. The Ministry of Agriculture estimated that an area of 11.6 million hectare was suffering from the problem of waterlogging. The Working Group of MOWR (1991) estimated that about 2.46 million hectare area in the country was affected by waterlogging in various irrigation commands. The extent of waterlogging is on rise in eastern part of India.

3. Climate smart agriculture

Climate change is turning the lives of farmers upside down. Unpredictable weather patterns, shorter growing seasons, floods, heavy rainfall events, droughts, extreme temperatures, and increased exposure to pests and crop diseases pose daunting problems to smallholder farmers around the world—especially in the tropics, where people tend to be more reliant on natural resources. Climate-smart agriculture techniques can help farmers adapt to and prepare for impacts in order to preserve—and even improve—their livelihoods.Climate-smart agriculture (CSA) is an integrated approach to managing landscapes—cropland, livestock, forests and fisheries—that addresses the interlinked challenges of food security and accelerating climate change. CSA aims to simultaneously achieve three outcomes: 1) increasing productivity, 2) enhancing resilience, 3) reducing emission.

Climate-smart agriculture isn't distinct from sustainable agriculture; rather it's a way of combining various sustainable methods to tackle the specific climate challenges of a specific farming community. Once an assessment of climate impacts and risks has been conducted, climate-smart strategies tailored to a particular landscape, farming community, or even individual farm can be

determined.Climate-smart agriculture is not a new agricultural system, nor a set of practices. It is an innovative approach for charting development pathways that can make the agriculture sectors more productive and sustainable and better able to contribute to climate change adaptation and mitigation.

4. Increasing productivity under water congested ecology through climate smart practices

Several strategies can be followed to address this issue. Integrated farming system approach combining water component, fishery, horticulture, and crop component provides efficient use of resources. Some of the following strategies could be followed for increasing productivity

4.1 Pond based IFS model

Excess water during heavy rainy period can be stored by excavating pond. This excess water then can be used for fish cum duck based faring system. We can also grow horticultural crops like lemon, guava, mango, and banana at the pond dyke. By this way, better productivity can be obtained.

4.2 Animal based IFS model

In this practice, we can incorporate animal part like dairy animals e.g., cow, goat, sheep, and poultry birds with the fishery component. Excreta from the animal component can be recycled by using them in fish feed. Additionally, leguminous fodder crops can be grown on the dyke area, which can use pond water as irrigation and excreta of animal component as fertilizers. Thus better return may be possible through this part only.

4.3 Resource conservation technology

Water as a natural resource show high variability in its availability in different location. Somewhere, water is available more than sufficient and somewhere, it is not available at all. Thus, proper conservation of this resource is necessary. Excess water can be stored by excavating pond/ tank/ and creating big storage structure at village level. This stored water can be used during lean period or during water scarcity period for irrigating the crop, for feeding the farm animals, and rearing fish (Tittonell et al 2012). Crop residue management and soil moisture conservation using mulching technique are also some of the option can be followed in RCT.

4.4 Water conservation

Agriculture accounts for 70% of the world's freshwater consumption. As global temperatures rise, water shortages—already a critical issue in many regions—are expected to worsen. One effective strategy to mitigate water scarcity is rainwater harvesting, which allows farms to store and utilize rainfall efficiently.Communities can construct ponds lined with bamboo to enhance water retention, while individual farms have several options for collecting rainwater. Simple methods include placing barrels outdoors, while more advanced systems involve channeling rain from roofs into storage barrels through gutters and pipes (Srivastava et al 2023).Traditional irrigation methods can also help reduce water stress on farms. While watering cans are labor-intensive and inefficient—especially on dry soil that struggles to absorb large amounts of water—low-tech solutions such as bamboo sticks or water-filled bottles placed next to plants can enable slow-drip irrigation, delivering moisture directly to the roots over time.By integrating rainwater harvesting and sustainable irrigation techniques, farms can become more resilient to water shortages, ensuring long-term agricultural productivity and resource conservation.

4.5 Contingency crop planning

Contingency cropping is growing of a suitable crop in place of normally sown highly profitable crop of the region due to aberrant weather conditions. In dryland agriculture, contingency of growing another crop in place of normally grown crop arises due to delay in the onset of monsoon. Depending upon the date of receipt of rainfall, crops are selected. It is assumed that the rainfall for the subsequent

period is normal and depending upon the economic status of the farmer, certain amount of risk is taken to get good profits if season is normal or better than normal. For early season break in monsoon, gap filling or re-sowing of crop is suggested. For mid-season break in monsoon, different moisture and nutrient conservation practices are mostly recommended so that the standing crop gets proper nutrition and moisture to complete its life cycle. For terminal water stress which happens due to early withdrawal of monsoon, early sowing of *rabi* crop of supplemental irrigation is generally recommended. Irrespective of these, for delayed monsoon, sowing of short duration, drought tolerant crop is commonly followed. Few other contingent practices are given as follow:

- Direct seeded rice in most paddy growing states
- Community paddy nurseries at village level
- Double transplanting of overage seedling in paddy in Bihar and West Bengal
- Promotion of crop diversification with maize in rice wheat cropping states
- Promotion of intercropping of millets, pulses and oilseeds
- Broad bed furrow and ridge furrow planting for soybean in Madhya Pradesh
- Pest and disease management in all states
- In season monitoring mechanisms at district and state HQ are established
- Funds for meeting contingency situations from state plans apportioned in Bihar
- Allocation of fund from ongoing Govt. Schemes to meet contingency situations

Apart from above, few commonly used management practices are also given below.

1) **Water distribution**

Floods may vary in intensity and duration, from a few hours to a period of months, and may also at times be forceful and unpredictable. Improving water distribution, by putting in place water control structures, can allow better control of water and reduce erosion, water logging and other risks.Dividing the floodwater into smaller portions, and avoiding steep slopes where water can pick up speed, can help safely steer water. Other relevant flow diversion structures can be put place, including drop structures (to transition between levels), flood bed stabilizers (to prevent uncontrolled runoff) and water-spreading weirs (to reduce erosion).

2) **Field water management**

Being able to manage the rise and drainage of floodwater within a field is also essential to be able to use the water productively. Several mechanisms can help in this matter: Dikes and soil bunds can help protect fields from unexpected floods and they can also allow farmers to drain or retain water as needed; drainage ditches can be used to channel away excess floodwaters; and reuse agreements can enable farmers to take turns using water from the same source.

3) **Groundwater use**

In most area where flood-based farming can be practiced, groundwater is will be shallow. This means that potential exists to access and use groundwater to extend the cropping season.Several approaches can be considered, including accessing groundwater through hand-drilled tube wells, which can be established for low costs and using only local labor. Other groundwater-lifting technologies include rope pumps, treadle pumps, motor pumps and solar-powered pumps. Most importantly in assessing and mapping groundwater resources to avoid overexploitation.

4) **Agronomic practices**

Introducing improved crop varieties and changing agricultural practices can also help realize potential production gains. Some crop varieties are better suited for flood-based farming systems,

such as for example very fast growing floating rice varieties, which are grown in areas as varied as Mali and Myanmar.

5) **Multi-functional use**

The productivity of flood-based farming systems can also be boosted by considering the multiple ways that floodplains provide benefits, such as through fishery, flood pastures, fuel wood collection and water supply. For example, fishponds and aquaculture can supply local communities with protein, while requiring fewer inputs than other agricultural practices.

6) **Internal governance**

Flood-based farming systems are underappreciated and poorly understood by governments, donors and development agencies. To realize the full potential, governance must be improved, including by familiarizing policy makers, extension workers, academics and other water professionals with the potential for and benefits of floods-based farming.

5. Conclusion

Climate change majorly affects the poor and marginal farmers who make their livelihoods from agriculture. Technology and smart practices can help mitigate risks caused by climate change, among others. India is constantly making efforts to formulate and implement policies to make agriculture more sustainable. Climate-smart agriculture (CSA) can help transform agri-food systems in a responsive manner and mitigate the devastating effects of climate changes while producing food and energy in a sustainable manner. Farmers in India are gradually realizing the benefits of CSA. CSA is an integrated approach of managing cropland, livestock, forest, and fisheries. CSA also addresses the interconnected challenges of food security and rapid climate change.

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Empowering Rural Youth through Agri-preneurship : Functionality of ARYA Project

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1. Introduction

Empowering youth in agriculture is not just an investment in the present; it is an investment in a resilient, prosperous, and food-secure future for generations to come. Today, the focus has shifted from merely increasing farm production to ensuring higher returns on agricultural investments. However, multiple challenges hinder the growth of the agricultural sector in India, including low farm productivity, limited access to inputs and markets, land fragmentation, natural resource degradation, climate change, non-remunerative prices, and limited surplus for value addition. On one hand, there is an urgent need to diversify agriculture and enhance its profitability through value addition and processing. On the other hand, rural youth are increasingly moving away from agriculture as a profession. Youth play a vital role in the anticipated transformation of Indian agriculture. According to the National Youth Policy, individuals aged 15-35 are classified as young. Currently, 35% of India's total population falls within this age group, with approximately 75% residing in rural areas. Alarmingly, around 45% of rural youth are migrating to cities, and only about 5% are engaged in agriculture.

India had 45.6 crore migrants in 2011 compared to 31.5 crore migrants in 2001. While the population grew by 18% between 2001 and 2011, the number of migrants increased by 45%. Internal migration accounted for 99% of total migration, while immigrants comprised just 1% (Census, 2011). The growing urban population, has raised concerns about retaining youth in agriculture. Many young individuals perceive agriculture as lacking long-term career prospects and prefer urban employment opportunities. In developed nations, the skilled workforce constitutes between 60% to 90% of the total workforce, whereas in India, only 5% of the workforce aged 20-24 years is classified as skilled. This highlights the urgent need for initiatives that empower youth by improving their skills and providing opportunities to remain engaged in agriculture as a sustainable livelihood. Developing successful economic models in rural areas is essential to inspire and energize young individuals to become entrepreneurs and guide their communities toward agricultural sustainability.

Creating interest and building confidence among rural youth in agriculture is a challenge, but not an impossible task, as evidenced by numerous successful agri-based enterprises. Retaining youth in agriculture is intrinsically linked to making the sector more rewarding and viable. India, with its predominantly agrarian economy, depends on the active involvement of young people to ensure sustainable agricultural development, address food security challenges, and uplift rural communities.

Recognizing the critical role of rural youth in agricultural development, particularly for ensuring national food security, ICAR launched the 'Attracting and Retaining Youth in Agriculture (ARYA)' project in 2015-16. This initiative aims to engage rural youth below the age of 35 by creating income-generating opportunities within the agricultural sector. Special efforts are being made to train and

empower youth, enabling them to serve as role models by showcasing the potential of agri-based enterprises. Through skill development and entrepreneurship training, rural youth are regaining confidence in farming as a viable profession. Additionally, the initiative is generating employment opportunities in secondary agriculture and service-related rural activities.

2. Importance of Youth in Agriculture

Young farmers play a critical role in ensuring food security when they are actively engaged in farming and provided with adequate support to overcome challenges. Youth are more open to adopting innovative ideas and modern agricultural technologies, making them ideal change agents in transforming the agricultural sector. Agricultural extension services should focus on empowering young farmers by providing them with knowledge, training, and access to resources to enhance productivity and sustainability.

Additionally, young farmers can help reshape the perception of agriculture, particularly in rural areas, by demonstrating that it is a viable and profitable career path. Their ability to embrace new ideas, concepts, and technology makes them key drivers in modernizing the sector. By improving the skills and capacities of young individuals, we can shift the outdated narrative that farmers are "uneducated and unskilled." Encouraging rural youth participation in agriculture is essential for fostering economic growth, enhancing livelihoods, and improving overall quality of life. Their involvement in the development process can bring about significant socio-economic transformation in rural communities, ensuring a resilient and prosperous future for the agricultural sector.

3. Concept of ARYA

India has implemented several youth-targeted programs such as the National Service Scheme (NSS) for student youth, Nehru Yuva Kendra (NYK) for non-student youth, Training of Rural Youth for Self-Employment (TRYSEM), Women and Youth Training Extension Program (WYTEP), and Nehru Yuva Kendra Sangathan (NYKS). Recognizing the critical role of rural youth in agricultural development and food security, the Indian Council of Agricultural Research (ICAR) launched the Attracting and Retaining Youth in Agriculture (ARYA) program.

4. Overview of ARYA

The ARYA project is being implemented in 25 states through Krishi Vigyan Kendras (KVKs), selecting one district per state. In each district, 200-300 rural youth are identified for skill development in entrepreneurial activities and the establishment of micro-enterprise units such as: apiary (beekeeping), mushroom cultivation, seed processing, soil testing, poultry farming, dairy farming, goat rearing (goatry), carp hatchery, vermicomposting etc. The ARYA project provides training, financial assistance, and market linkages to rural youth for establishing enterprises in mushroom production, poultry farming, food processing, goat farming, fish farming, and beekeeping. Key components of the initiative include:

- Skill development programs
- Facilitating access to financial resources
- Establishing sustainable marketing linkages with local markets and Farmer Producer Organizations (FPOs)
- Encouraging horizontal expansion through Self-Help Groups (SHGs) and cooperatives

KVKs collaborate with Agricultural Universities and ICAR Institutes as technology partners. Additionally, KVKs establish enterprise units to serve as training hubs for farmers.

5. Achievements of Krishi Vigyan Kendra, Piprakothi, East Champaran

The ARYA project has witnessed significant growth in rural entrepreneurship. The number of sustainable enterprises established, training sessions conducted, and youth engaged in profitable ventures have increased manifold. Major achievements include:

- Expansion of enterprises in multiple agricultural domains
- Increased revenue generation for rural entrepreneurs
- Enhanced market accessibility through FPOs and SHGs
- Establishment of food processing units with FSSAI certification

Since its inception under ARYA, KVK, Piprakothi has achieved remarkable outreach and expands its operational area by covering 25 out of 27 blocks, reaching a total of 337 villages, established FPOs and SHGs supporting agricultural enterprises and provide market accessibility through structured supply chains. Considering sector-wise entrepreneurial units, KVK, Piprakothi established215 mushroom units in 57 villages (supported by 4 FPOs), 162 poultry units in 34 villages (backed by 5 FPOs),**:** 54 food processing units in 13 villages aided by 7 FPOs, 97 goat farming units in 31 villages supported by 2 FPOs,103 fish farming units in 36 villages (assisted by 3 FPOs), 213 beekeeping units in 77 villages strengthened by 3 SHGs.

Table 1:Significant impact of ARYA in horizontal dimension by KVK Piprakothi

Indicators	Mushroom Production	Poultry	Food Processing and Value Addition	Goat Farming	Fish farming	Bee Keeping
FPOs and SHGs associated	4	5	7	2	2	3
Units established after success of this unit	315	245	98	218	195	180
Press release /TV or Radio talk, etc.)	12	14	6	4	3	7
Banded products	Yes	-	Yes	-	-	Yes

1. Success Stories of ARYA Entrepreneurs:

Several entrepreneurs have emerged as successful role models under the ARYA initiative. Notable examples include :

1. Mushroom Production:

- Mr. Satyananda Tiwari (Parshurampur, East Champaran) began with 450 bags of Oyster Mushrooms and expanded to processing dry mushrooms, earning a monthly profit of Rs. 17,000-18,000.

- Mrs. Sangita Devi (Piprakothi, East Champaran) started with 60 bags and now cultivates 350 bags of Oyster Mushrooms and 200 bags of Button Mushrooms, generating Rs. 11,000 per month.

2. Food Processing:

Mrs. Lovely Devi (Mehsi, East Champaran) established a food processing unit and formed the Saraswati Swayam Sahayata Samuh SHG. She packages and sells value-added products, earning Rs. 17,000 monthly.

3. Poultry Farming:

Mr. Rohit Kumar (Khodadpur, East Champaran) started with 200 chicks and expanded to two poultry farms with 3,500 birds. His annual net profit increased from Rs. 59,050 to Rs. 2,76,500.

4. Goatery Farming

Priyanka Kumari (Bairiya, Motihari) initially started with 10 numbers of goats, now she owns 32 goats at her farm. Initially she earned net profit of Rs. 30000. After increasing number of goats to 32, she got annual net profit of Rs. 1,15,000.

5. Bee Keeping

Vijay Kumar (Koirigawan, Mehsi) had registered around 600 boxes under National Bee Board, New Delhi.He is considered as pioneer and flag bearer of bee-keeping in this district by forming 'Jay Mata Di Madhumakhi Palan Kalyan Samiti' which comprises of around 200 bee-keepers and running in a successful manner.

6. Recognition and Awards:

ARYA's impact has been acknowledged at national and regional levels:

- Luvkus Agro Producer Company Ltd. received the Best Outstanding FPO Award-2022 at the Outlook Agri-tech Summit.
- Mrs. Zainab Begum was honored with the "Millionaire Farmer Award" at ICAR, New Delhi, in 2023.
- Sri Vikas Kumar (Mushroom Grower) and Shri Vijay Kumar (Beekeeper) received the Innovative Farmer Award.
- Mrs. Sabya Devi (Food Processing) was felicitated at the National Review Workshop on ARYA.

7. Conclusion

The ARYA project is an effective initiative that promotes rural youth engagement in agriculture and allied enterprises, ensuring economic stability and rural development. By providing skill training, entrepreneurial opportunities, and networking, the program aims to transform agriculture into an attractive and profitable career option for young Indians. The convergence of multiple youth-oriented programs further strengthens its impact, making rural youth key contributors to India's food security and agricultural growth.

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Unlocking the potential of integrated farming systems in low-lying areas of Eastern Uttar Pradesh

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1. Introduction

India has the second-largest arable land (141.0 Mha), yet the average per capita landholding remains only 1.1 ha. Smallholder farmers (<1.0 ha) constitute over 86% of the farming community, facing resource constraints and risk-prone conditions. The challenges are even more severe in eastern Uttar Pradesh, where vast low-lying areas experience water stagnation, seasonal flooding and soil-related constraints, further limiting farm productivity. While intensive rice-wheat cultivation has ensured food security, it has also led to resource degradation, yield stagnation and declining profitability. However, these low-lying areas offer opportunities for sustainable Integrated Farming Systems (IFS), which integrate crops, livestock, fisheries, agroforestry and horticulture to enhance productivity, profitability and environmental sustainability. The IFS approach has been reported to improve productivity by 2–3 times, create employment, conserve resources and ensure household nutritional security. This article explores the potential of IFS in low-lying areas of eastern Uttar Pradesh and its role in promoting sustainable agricultural growth, farm income and employment opportunities.

2. Scope of IFS in low-lying areas

1. Efficient Land Use: Low-lying areas often remain underutilized due to water stagnation and poor drainage, limiting their suitability for conventional farming. The Integrated Farming System (IFS) optimizes land use by integrating multiple agricultural enterprises such as crops, livestock, fisheries and horticulture. By strategically utilizing waterlogged and elevated zones, farmers can maximize productivity while maintaining ecological balance.

2. Diversification for Risk Reduction: Dependence on mono-cropping in flood-prone areas makes farmers vulnerable to crop failure and income loss. IFS promotes diversification by incorporating multiple components like aquaculture, livestock and agroforestry alongside traditional cropping. This multi-enterprise approach not only mitigates economic risks but also ensures a steady income stream throughout the year.

3. Water Resource Utilization: Persistent water stagnation in low-lying regions can be converted into an advantage through integrated water-based enterprises. Aquaculture, duck farming and rice-fish farming offer sustainable solutions for utilizing waterlogged areas. Such interventions enhance productivity while reducing the negative impacts of seasonal flooding on conventional cropping systems.

4. Nutrient Recycling and Sustainability : The integration of crops, livestock and fish farming facilitates efficient recycling of nutrients within the farming system. Crop residues can serve as feed for livestock, livestock manure can be used as organic fertilizer for crops and fishpond sediment can enrich soil fertility. This closed-loop nutrient cycle minimizes dependency on external chemical inputs, thereby promoting sustainable and eco-friendly farming practices.

5. Employment Generation : The multi-enterprise nature of IFS creates diverse employment opportunities for rural communities. Activities such as fish farming, poultry rearing, beekeeping and

agro-processing generate additional income streams, benefiting smallholders, landless farmers and rural youth. By engaging multiple family members in various enterprises, IFS enhances livelihood security and reduces rural unemployment.

6. Climate Resilience: Climate variability poses significant challenges to conventional farming, particularly in flood-prone lowlands. The diversified nature of IFS enhances resilience by reducing dependence on a single crop. Enterprises like fish farming and duck rearing can sustain productivity even in flooded conditions, ensuring economic stability despite climatic uncertainties. Additionally, agroforestry components help in soil stabilization and water conservation, further strengthening climate adaptability.

3. Key interventions for successful IFS implementation

1. Water management strategies: Effective water management is crucial for optimizing productivity in low-lying areas prone to waterlogging and seasonal flooding. Constructing small ponds, bunds and check dams helps regulate water flow, store excess rainwater and ensure year-round availability for irrigation and aquaculture. Integrating micro-irrigation techniques, such as drip or sprinkler systems in elevated areas, further enhances water-use efficiency, ensuring that different farm components receive adequate moisture without excessive wastage.

2. Soil health improvement: Maintaining soil fertility is essential for the long-term sustainability of IFS. The use of organic amendments such as green manuring, biofertilizers, compost and farmyard manure improves soil structure, enhances microbial activity and boosts nutrient availability. These practices reduce dependency on chemical fertilizers, mitigate soil degradation and contribute to better crop yields. Additionally, conservation practices like mulching and cover cropping help in moisture retention and soil erosion control, particularly in flood-affected zones.

3. Technology integration: The adoption of modern agricultural technologies enhances the efficiency and productivity of IFS. Climate-smart agricultural techniques, such as drought- and flood-tolerant crop varieties, precision farming tools and sensor-based irrigation systems, help optimize resource use. ICT-based advisory services provide real-time weather updates, pest management strategies and market information, enabling farmers to make informed decisions. Mechanization, such as small-scale farm machinery for land preparation and harvesting, further reduces labour dependency and operational costs.

4. Capacity building: Strengthening farmers' knowledge and skills is fundamental for the successful adoption of IFS. Organizing regular training programs, farmer field schools and exposure visits allows farmers to learn from successful IFS models and implement best practices. Demonstrations on integrated crop-livestock-fishery management, efficient resource recycling and enterprise diversification empower farmers to adopt innovative approaches tailored to their local conditions. Farmer cooperatives and self-help groups also play a significant role in knowledge dissemination and collective decision-making.

5. Financial support: Access to institutional credit, subsidies and government incentives is essential for small and marginal farmers to adopt IFS. Financial assistance can facilitate investments in infrastructure, such as fish ponds, polyhouses, vermicomposting units and dairy sheds, which are critical for enterprise integration. Government schemes supporting sustainable agriculture, such as subsidies on organic inputs, machinery and alternative livelihood activities, ensure the economic viability of IFS and encourage wider adoption.

6. Market Linkages and value addition: Establishing strong market linkages ensure better price realization for IFS-based products. Strengthening rural cooperatives and farmer producer organizations (FPOs) helps in collective bargaining, reducing exploitation by intermediaries. Direct

marketing channels, contract farming and e-commerce platforms provide farmers with improved access to consumers and agribusinesses. Additionally, value addition through processing, packaging and branding of farm produce—such as dairy products organic vegetables and fishery products—enhances profitability and expands income opportunities.

4. Case studies on IFS in eastern Uttar Pradesh

1. Integrated crop and fish based IFS in Gorakhpur: A farmer (Mr Ashfaque Khan, Nayagaon, Jungle Kaudiya, Gorakhpur) adopted crop and fish based IFS in 1.9 ha, comprising 2000 m^2 for fish production pond, 40 m^2 for fish hatchery pond, 12000 m^2 for crop production, 2000 m^2 for horticultural crops, 2000 m^2 for fodder crops, 35 goats, 2 milking cows and 1600 poultry birds, leading to net income of Rs.7 lakh annually. The system improved soil fertility, reduced pest infestation and provided year-round earnings.

2. Integration of makhana cultivation: A cooperative of farmers utilized flood-prone lands for fish and makhana cultivation, leading to a sustainable livelihood model with high profitability.A target of 180 hectares of fox nut production in identified district (Lucknow, Varanasi, Gorakhpur, Ayodhya, Prayagraj, Sitapur, Sultanpur, Pratapgarh, Jaunpur, Ghazipur, Basti, SantKabir Nagar, Siddharth Nagar, Ballia, Kushinagar, Maharajganj, Mirzapur and Bareilly) in Uttar Pradesh.

3. IFS for enhanced productivity in Siddharth Nagar : An Integrated Farming System (IFS) model was implemented on 1.6 ha in Siddharth Nagar with KVK's intervention to overcome drainage challenges caused by surrounding ponds and a mango orchard. The fish pond was deepened, and the excavated soil was utilized to raise land levels for other farming activities. With technical guidance and input support, including improved seed varieties and planting material, complementary enterprises such as fisheries, dairy, and poultry were integrated. This synergistic approach reduced production costs, maximized returns, and increased the farmer's net income to ₹5.26 lakh (Table 1).

Table 1:IFS for enhanced productivity in Siddharth Nagar

Component	Breed	Number/ Area	Cost of production (Rs)	Gross return (Rs)	Net return (Rs)
Dairy (Buffalo)	Murrah	03 animals	120000	216000	96000
Poultry	Kuroiler	2000 birds	240000	360000	120000
Fisheries	Mixed species	0.2 ha	200000	350000	150000
Crop Production	Paddy- wheat & field pea	0.8 ha	130000	240000.0	110000
Fodder	Napier, Berseem,	0.1ha	-	-	-
Orchards	Mango+ Turmeric	0.2 ha	9500	20000	10500
Agribusiness	-	-	70000	130000	60000
Total	-	1.6 ha	769500	1316000	546500

Multi-enterprise IFS for sustainable agriculture in Azamgarh

A Multi-enterprise IFS model was implemented on 3.10 ha of cultivated land in Azamgarh, incorporating diverse components such as fisheries, beekeeping, Kamdhenu dairy, crop cultivation, fruit and vegetable production, backyard Karaknath poultry, vermicomposting, BGA and Azolla

production, market linkages, transport facilities, and a sales counter. These interconnected enterprises complemented each other, utilizing by-products as inputs within the system. This integration reduced production costs and maximized returns, enhancing overall farm sustainability and profitability. The IFS model transformed farmer's livelihood by tripling his income and now he is a role model for farmers. His success has attracted exposure visits organized by various line departments for wider adoption.

4. Conclusion

Low-lying areas of Eastern Uttar Pradesh face challenges like waterlogging and declining farm productivity. Integrated Farming Systems (IFS) offer a solution by integrating crops, livestock, fisheries, horticulture, and agroforestry, optimizing land use, reducing risks, and ensuring year-round income. Key interventions include water management, organic soil enrichment, technology adoption, financial support, and market linkages. Case studies highlight significant income gains and sustainability benefits. Developing region-specific models and supportive policies can promote wider adoption, improving land productivity, food security, and economic sustainability for small and marginal farmers.

Integrated Farming Systems: A Pathway to Resource Efficiency and Sustainability in the Indo-Gangetic Plains

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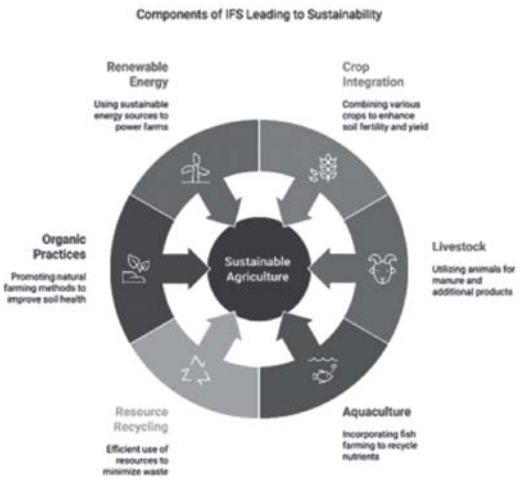
1. Introduction



Eastern India, where small and marginal farmers constitute nearly 70% of the agricultural workforce (Gill et al., 2010), faces persistent economic and environmental challenges. Limited landholdings and scarce resources make smallholder farmers highly dependent on seasonal crops, which often fail to provide adequate sustenance. Additionally, the region's agroclimatic conditions—marked by erratic rainfall, soil degradation, and temperature fluctuations—exacerbate farming uncertainties. Over the past five decades, technological advancements in agriculture, including high-yielding crop varieties, mechanization, and intensive use of chemical inputs, have significantly boosted productivity (Biswas et al., 2013). However, these gains have come at a cost, leading to soil nutrient depletion, reduced farm profitability, and environmental degradation. Addressing these challenges necessitates a transition towards more resilient and resource-efficient farming models. Integrated Farming Systems (IFS) provide a viable solution by harmonizing multiple agricultural enterprises such as crop cultivation, livestock rearing, aquaculture, poultry, beekeeping, and horticulture. This approach optimizes resource utilization, promotes ecological balance, and enhances farm sustainability (Kumar et al., 2018). By integrating various components, IFS enables nutrient recycling, minimizes waste, and reduces dependence on external inputs. Additionally, it diversifies income sources, strengthens food security, and enhances farm resilience against climate variability. Given the semi-humid climate of Eastern India, conventional monoculture systems struggle to ensure sustainable agricultural growth. Soil degradation, fluctuating yields, and economic vulnerabilities continue to challenge smallholder farmers. IFS addresses these issues by fostering synergy between different farm enterprises, ensuring efficient resource use, and creating a more profitable and environmentally sustainable farming model. With minimal investment, IFS emerges as an economically viable, ecologically sound, and socially acceptable strategy for ensuring long-term agricultural sustainability in the region (Babu et al., 2019).

2. Goals of Integrated Farming Systems (IFS)

- Maximize productivity and ensure stable farm income.
- Enhance resource-use efficiency and ecological balance.
- Reduce dependency on chemical inputs, promoting pollution-free, nutrient-rich production.
- Improve resilience to climate variability and economic uncertainties.

Factor	Integrated Farming System	Traditional Farming
Productivity & Profitability	Enhances per-unit yield through diversified enterprises.	Limited income from seasonal crops.
Sustainability	Organic recycling sustains soil health and reduces external inputs.	Heavy reliance on chemical inputs depletes soil fertility.
Nutritional Security	Ensures year-round availability of diverse food products.	Monoculture limits dietary diversity.
Resource Recycling	Waste from one component serves as an input for another.	Wastes are often discarded, leading to inefficiencies.
Income Stability	Multiple revenue streams from crops, livestock, and allied activities.	Seasonal income dependent on single-crop harvests.
Environmental Benefits	Reduces pollution through efficient waste utilization.	Excessive pesticide use degrades ecosystems.
Employment Generation	Year-round labor demand in various IFS components.	Seasonal employment with long idle periods.
Technology Adoption	Regular income allows investment in advanced practices.	Financial constraints limit adoption of new technologies.
Energy & Fuel Security	Utilization of biogas and agroforestry reduces reliance on fossil fuels.	Heavy dependence on external energy sources.
Forest Conservation	Reduces deforestation by supplementing timber and fuelwood needs.	Unregulated harvesting contributes to forest degradation.

3. Research on IFS at ICAR-RCER, Patna

Field experiments (2016–2024) at ICAR-RCER, Patna, integrated crops, horticulture, livestock, poultry, fishery, and mushroom to develop sustainable Integrated Farming System (IFS) models. A five-year study assessed interactions among components for resource efficiency and income enhancement. Seven IFS models were tested on farmers' fields in Patna, Nalanda, and Motihari (2018–2023) and compared with existing cropping systems: (i) Rice-wheat, (ii) Rice-maize, (iii) Rice-maize-moong, and diversified models integrating crops with livestock, fishery, poultry, duckery, and mushroom. Organic wastes (pond silt, FYM, compost, vermicompost, and manures) enriched soil fertility, contributing 56.5 kg N, 39.6 kg P, and 42.7 kg K through nutrient recycling.

4. Conclusion

Integrated Farming Systems (IFS) offer a sustainable solution for small farmers in Eastern India byintegrating crops, livestock, and aquaculture. The crop + fish + duck + goat model proved mosteffective, yielding 19.41 t/ha, Rs. 156,320 net income, and improved soil health (10.3 g/kg organiccarbon) with low greenhouse gas emission (0.320). IFS enhances resource efficiency, diversifiesincome, and reduces environmental impact while improving soil fertility. By promoting organicpractices and renewable energy, IFS strengthens farm resilience. Policy supports and capacity-building can drive its widespread adoption, ensuring sustainable agricultural growth.

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List of selected Abstracts

SESSION-1
Theme : Strategies and techniques to promote agri-diversification and eco-regional farming

NS-T1-01

SUPPRESSIVE EFFECT OF MANURING WITH VERMICOMPOST PREPARED FROM COW DUNG ALONE OR MIXTURE OF COW DUNG + OILCAKES ON FACUNDITY IN RED SPIDER MITE (*TETRANYCHUS UTRICAE* KOCH.) ON OKRA PLANT

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Suppressive effect of manuring with different vermicomposts on each of the three biological parameters viz., fecundity, hatchability and adult emergence in Red spider mite showed variation depending upon the type of vermicompost. The extent of reduction in fecundity of the female mite varied widely from 6.26 to 28.91 per cent over unmanured control, maximum being due to the manuring with vermicompost from cow dung + neem cake (4:1) at 1.0kg pot $^{-1}$ and minimum in case of the vermicompost from cow dung alone. The extent of reduction in hatchability due to manuring ranged from 4.66 to 39.51 per cent, over unmanured control. It was maximum in case of manuring with cow dung + neem cake (4:1) at 1.0kg pot $^{-1}$ and minimum due to manuring cow dung based vermicompost at 0.5kg pot $^{-1}$. Manuring with vermicompost from cow dung + neem cake (4:1) at 0.5kg pot $^{-1}$ proved the second-best treatment in affecting the hatchability of eggs in *Tetranychus utricae.* It was closely followed by manuring with vermicompost from cow dung + neem cake (4.5:0.5) at 1.0 kg pot $^{-1}$ its lowerdose at 0.5 kg pot $^{-1}$ and that from cow dung + karanj cake (4:1) at 1.0kg pot $^{-1}$. Reduction in adult emergence was maximum (40.36%) on Okra plant manured with vermicompost from cow dung+ neem cake (4:1) at 1.0 kg pot $^{-1}$, while vermicompost from cow dung alone at 0.5 or 1.0 kg pot $^{-1}$ proved least effective by recording minimum adult reduction in adult emergence (< 10.0%). Mixing of neem cake with cow dung in 4:1 or 4.5: 0.5 ratios at application dose of 0.5 or 1.0 kg pot $^{-1}$ showed clear cut superiority over other oilcake in terms of reduction in adult emergence.

Keywords: Oilcake, vermicompost, fecundity, hatchability, adult emergence, Okra and *Tetranychusutricae.*

NS-T1-02

ECONOMICS AND ENERGETICS OF MODERN FARMING, ORGANIC FARMING AND NATURAL FARMING IN FRUIT CROP-BASED CROPPING SYSTEM

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A field experimentation titled "Economics and energetics of modern farming, organic farming and natural farming in fruit crop-based cropping system", comprising 3 treatments of types of farming *viz*., modern farming, organic farming and natural farming has been conducted in two consecutive years (2022-23 and 2023-24) laid in Randomized Completely Block Design with seven replications at IIHR, Bengaluru. Inter-crops

grown in the interspace of fruit crops were tomato, French bean, marigold and china aster. System productivity was significantly affected by the farming method, with modern farming achieving the highest tomato equivalent yield (45707 kg/2400 m²), followed by organic farming (31315 kg/2400 m²), while natural farming recorded the lowest productivity (12317 kg/2400 m²). The increased productivity in modern farming was attributed to effective biotic stress management, rapid nutrient release, and intensive input use. Economic analysis revealed that modern farming generated the highest gross returns (₹4,57,067/2400 m²) and net returns (₹2,61,689/2400 m²), along with the best benefit-cost ratio (2.34). Organic farming followed with gross returns of ₹3,75,780/2400 m² and a benefit-cost ratio of 1.88, whereas natural farming had the lowest returns (₹1,84,757/2400 m²) and a benefit-cost ratio of 1.81. Organic farming incurred the highest cultivation cost (₹1,99,815/2400 m²), while natural farming had the lowest (₹1,02,290/2400 m²). Energetic analysis showed that modern farming recorded the highest total energy output (69328 MJ/2400 m²) and net energy balance (37095 MJ/2400 m²). Organic farming had the lowest specific energy requirement (0.63 MJ/kg), indicating better energy efficiency, while natural farming exhibited the highest specific energy (0.88 MJ/kg). Overall, modern farming proved to be the most productive and economically viable, while organic farming demonstrated superior energy efficiency. These findings suggest that modern farming is optimal for maximizing yield and profitability, with organic farming offering sustainable energy advantages.

Keywords: Modern farming, natural farming, organic farming, system economics, system energetics.

NS-T1-03

GRIDLING TECHNIQUE: AN APPROACH TOWARDS MANAGEMENT OF ALTERNATE BEARING IN LITCHI CV. CHINA

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Irregular bearing at young stage of the plant in all litchi cultivars is a phenomenonal constraint in general and alternate bearing in cultivar of China group in particular. Alternate bearing occurs due to genetic characteristics of the plant, growth conditions, endogenous hormonal level, crop load and impact of other particular annual variables related to carbohydrate storage and mobilization**.** The yield gets affected severely due to erratic flowering owing to irregular bearing which has subsequent impact on a in the yield level with a high yield ("ON" year) and a low yield ("OFF" year) in the following year. Litchi is one of the important fruit crops in Samastipur district of Bihar, where Shahi and China cultivars of litchi are grown in particular. Due to the phenomenon of alternate bearing in China cultivar, farmers are facing huge crisis particularly in 'OFF' year with very poor yield and very low income in OFF year. In an attempt to combat the effect of alternate bearing, Girdling technique was practiced at farmer's field through On Farm Trial. In this trial, Girdling was performed on 50% primary branches in an area of 2mm diameter (T_1), as well as on 50% primary branches in an area of 03 mm diameter (T_2), with a control plot (with no practice of Girdling) during two consecutive 'On' and 'Off' year in Litchi cv. China at Samastipur District of Bihar during 2022-2023 and 2023-2024.Results revealed significant enhancement of flower induction percentage (34.78%) in T_1 as compared to farmer's practice (04.26%) during Off year. Improved yield was recorded in girdled trees (18.41-21.68 kg/tree) as compared to farmers practice (05.09kg/tree) which ultimately impacted B:C ratio (1.16-1.54) against B:C ratio of 0.37 in field with no practice of girdling during 'Off' year. Study revealed that Girdling has no much significant improvement in flowering induction performance as well as yield during 'On' year. Girdling technique can serve as an innovative approach towards induction of higher flowering percentage with more profit during Off year in litchi cv. China.

Keywords - Gridling technique, Litchi, Bihar, fruit crop

NS-T1-04

EVALUATION OF BIODIVERSITY OF AONLA (*EMBLICA OFFICINALIS* GAERTN.): FROM DIFFERENT DISTRICTS OF M.P

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Aonla trees have a significant socio-economic impact across all parts of the country. They contribute notably to the economic upliftment of farming communities through commercial orcharding, nursery production, and the processing of herbal products. Due to the predominance of seedling propagation, India possesses rich biodiversity in cultivated and wild relatives of Aonla. However, genetic erosion of these resources remains high due to severe deforestation, natural calamities, and the adoption of a few popular cultivars in select regions. Despite this, substantial variability in Aonla remains unexploited, necessitating focused efforts on exploration, collection, and conservation to preserve its genetic biodiversity. The experiment was conducted at ICAR-Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow, UP, India focused on identifying and characterizing aonla accessions for alkaline conditions, high yield, and improved fruit biochemical quality. Among the 11 genotypes evaluated, CISH-Aonla-1 and CISH-Aonla-2 exhibited superior fruit yield per plant (50-55 kg/tree and 45-50 kg/tree, respectively), indicating their better adaptability to alkaline soils. Additionally, these genotypes are very rich in biochemical attributes such as total soluble solids (9.50 ºB and 9.250 ºB), acidity (3.22% and 2.90%), ascorbic acid (504.08 mg/100g and 417.48 mg/100g), total sugar (8.18% and 7.59%), reducing sugar (3.81% and 3.72%), total phenol (1.31 g/100g GAE and 1.68 g/100g GAE), and total ferric reducing antioxidant power (FRAP) (233.64 mg/g and 228.65 mg/g). These promising genotypes (CISH-Aonla-1 and CISH-Aonla-2) have the potential to improve horticulture diversity and can be well adopted in alkaline soils in subtropical areas of India and other similar environments. This study finds promising aonla accessions that can adapt to alkaline soils, providing opportunities for developing climate-resilient cultivars with improved fruit yield and quality.

Keyword: Alkaline soil, antioxidant, aonla, ascorbic acid, total phenol content

NS-T1-05

KALAHANDI TYPE GOAT: A SUSTAINABLE LIVELIHOOD OPTION FOR THE WESTERN UNDULATING AGRO ECOLOGICAL ZONE OF ODISHA

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Tribal communities in the Western Undulating Zone of Odisha continue to engage in rice and cotton farming alongside livestock rearing, particularly goat farming. The region's climate is highly conducive to goat rearing, leading to a growing preference for this practice as a reliable source of income. Their ability to thrive in resource-limited environments makes them an attractive option for livelihood diversification. This study aimed to evaluate the suitability of the native Kalahandi type goat as an ideal species for livelihood diversification in the Western Undulating Zone of Odisha. The study was conducted in Kalahandi and Nuapada districts, selecting four blocks from each district. From each block, four villages were randomly chosen, and ten goat farmers per village were surveyed using a pre-validated structured questionnaire. The findings revealed that 90% of the surveyed farmers reared Kalahandi type goats under a semi-extensive system. Most kids had a birth weight between 2-3 kg (80.62%). The litter size increased with parity, and 85.93% of respondents reported that their goats attained sexual maturity between 8-10 months. Male kids were typically sold between 7-8 months of age. A significant rise in goat prices was observed during the Chatar Parab festival, contributing to an annual

income of approximately Rs. 100,000 from goat sales. Kalahandi type goats exhibit strong climate resilience, high twinning rates, and adaptability to extreme conditions, making them a valuable asset for livelihood diversification in the region.

Keywords: Kalahandi type goat, livelihood diversification, goat farming, semi-extensive system

NS-T1-06

INTEGRATION OF HORTICULTURAL CROP PRODUCTION THROUGH SUSTAINABLE METHODS PROVIDING OPPORTUNITIES AND PROSPECTIVE OF INTEGRATED DEVELOPMENT OF HORTICULTURE

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The incorporation of sustainable methodologies within horticultural crop production is paramount for effectively confronting the contemporary challenges associated with agriculture, including climate change, resource depletion, and food security. This investigation delves into the avenues and potentialities of embedding sustainable practices within the evolution of horticulture. It underscores the significance of implementing environmentally-friendly strategies such as organic farming, integrated pest management, and the preservation of soil health to augment crop productivity while mitigating environmental repercussions. Sustainable horticulture provides a holistic framework for production, ensuring the judicious utilization of resources such as water and nutrients. Strategies including drip irrigation, rainwater harvesting, and the application of organic fertilizers contribute to the reduction of environmental degradation and the promotion of enduring soil fertility. Moreover, the study accentuates the pivotal role of biodiversity in sustaining ecological equilibrium and enhancing resilience against pests and diseases. This integration not only fosters environmental sustainability but also yields substantial socio-economic advantages. By advocating for value-added products, minimizing post-harvest losses, and enhancing market accessibility, sustainable horticultural methodologies can elevate farmers' income and generate new employment opportunities. Additionally, the transition towards organic and sustainable agricultural techniques facilitates access to premium markets and international certifications, thereby augmenting competitiveness. The research concludes that the integrated progression of horticulture via sustainable practices represents a promising trajectory for attaining food security, environmental preservation, and economic advancement. This paradigm nurtures a more resilient, productive, and sustainable horticultural sector, benefitting farmers, communities, and the overarching agricultural landscape.

Keywords: Sustainable, horticultural, environmental, productivity

NS-T1-07

EFFECT OF MAIZE RESIDUES ON THE GROWTH AND PRODUCTIVITY OF SUBSEQUENT CROPS IN MAIZE-BASED CROPPING SYSTEMS

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Maize residues play a crucial role in influencing the growth and productivity of subsequent crops in maize-based cropping systems. Retaining or incorporating maize residues into the soil can enhance soil health by improving soil organic matter, moisture retention, and nutrient cycling. However, their effect varies based

on management practices, climatic conditions, and the characteristics of the following crop. This study examines the impact of different maize residue management strategies—removal, incorporation, and surface retention on soil fertility, microbial activity, and the yield performance of subsequent crops such as wheat, legumes, and other cereals. The decomposition of maize residues contributes to nitrogen immobilization in the short term but enhances soil fertility over time by increasing nitrogen mineralization and organic carbon content. Surface retention improves soil moisture conservation and reduces erosion, benefiting drought-prone areas. Conversely, excessive residue accumulation may harbour pests and diseases, potentially affecting crop establishment and growth. Field trials and controlled experiments indicate that maize residue incorporation significantly enhances the yield of subsequent crops by improving soil structure, microbial biomass, and nutrient availability. Legume-based rotations particularly benefit from residue retention due to nitrogen fixation synergy. However, site-specific residue management practices are necessary to optimize productivity while mitigating challenges like allelopathic effects and nutrient lock-up. In conclusion, sustainable maize residue management can enhance soil health and improve the productivity of subsequent crops in maize-based systems. Integrating residue management with conservation agriculture principles can ensure long-term soil fertility and resilience to climate variability. Future research should focus on optimizing residue management strategies under diverse agro-ecological conditions to maximize benefits for sustainable cropping systems.

Keywords: Maize residues, soil fertility, nutrients recycling, conservation agriculture, cropping systems

NS-T1- 08

CLUSTER FRONTLINE DEMONSTRATIONS: PROGRESSIVE APPROACH FOR ADVANCING OILSEED PRODUCTION AND ENHANCING LIVELIHOODS

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Mustard is one of the key oilseed crops grown during the Rabi season in East Champaran district, Bihar. In Rabi 2023-24, Krishi Vigyan Kendra, Parsauni, East Champaran-II, conducted a Cluster Front Line Demonstration (CFLD) program on mustard to assess its impact on yield and income gaps through the adoption of scientific cultivation practices. Fields were selected from various villages and clusters across the district. A total of 40 hectares were covered under the CFLD program, with 102 demonstrations using the variety RH-761 of mustard. Farmers followed the full package of practices, including proper seed rates, seed treatment, ZT/Line Sowing, Sulphur, Boron, Micronutrient, and Imidacloprid. Observations on key parameters of both demonstration and control plots were recorded. The study revealed that the average yield in the CFLD plots was 14.83 q/ha, which was significantly higher than the yield from farmer's practices. Additionally, the technology gap, extension gap, and technology index were found to be 10.17 q/ha, 5.41 q/ha, and 40.68%, respectively. The average gross income in the demonstration field was in the tune Rs. 80,823/ha, compared to Rs. 51,339/ha in the farmer's field. Similarly, the average net income in the demonstration field was recorded Rs. 53,523/ha, while it was Rs. 27,939/ha at farmer's holdings. The benefit-cost ratio for the demonstration field was 2.96, higher than the 2.19 observed in farmer's practices. The significant yield improvement suggests that the adoption of improved varieties and scientific practices under the CFLD program has contributed to increased mustard production and productivity in East Champaran district.

Key words: Cluster front line demonstration, mustard, demonstrations, yield, B:C ratio

NS-T1-09

EFFECT OF RICE RESIDUES ON THE GROWTH AND PRODUCTIVITY OF SUBSEQUENT CROPS IN RICE-BASED CROPPING SYSTEMS

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Rice-based cropping systems play a crucial role in global food security, but sustainable residue management remains a challenge. This study investigates the effects of rice residue incorporation on the growth and productivity of subsequent crops in rice-based cropping systems. Rice residues, when managed properly, can improve soil health, enhance nutrient availability, and influence crop performance. However, improper handling may lead to nitrogen immobilization, pest infestation, or allelopathic effects. Field experiments were conducted to assess the impact of different rice residue management practices, including full incorporation, partial incorporation, and residue removal, on the growth and yield of subsequent crops such as wheat, maize, and legumes. Key parameters evaluated included soil organic matter, nitrogen mineralization, microbial activity, plant growth characteristics, and final crop yield. Results indicated that residue incorporation significantly improved soil moisture retention, organic carbon content, and microbial diversity, leading to enhanced crop growth and yield. Particularly, wheat and legumes exhibited higher biomass accumulation and grain productivity under residue retention treatments compared to residue removal. However, early-stage nitrogen immobilization was observed, necessitating appropriate nitrogen supplementation. The study concludes that sustainable rice residue management can enhance soil fertility, improve productivity in rice-based systems, and reduce environmental concerns associated with residue burning. The integration of optimized residue decomposition techniques, including microbial inoculants or cover cropping, may further maximize benefits. Future research should focus on site-specific recommendations for residue management to achieve long-term agricultural sustainability.

Keywords: Rice residue, cropping systems, soil health, nitrogen immobilization, crop productivity

NS-T1-10

ENHANCING PRODUCTIVITY AND PROFITABILITY OF RICE-WHEAT CROPPING SYSTEMS THROUGH DIFFERENT TILLAGE AND CROP ESTABLISHMENT METHODS IN SOME MIDDLE GANGETIC PLAINS OF BIHAR

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In the recent years increase in average annual temperatures and water stress condition have significant implication on crop production and productivity in the middle Gangetic plains of Bihar. To combat these challenges, Indian Council of Agricultural Research, New Delhi launched a project entitled "National Innovations in Climate resilient Agriculture" in 2011 and as a part this project also started in Saran district of Bihar through Krishi Vigyan Kendra of RPCAU, Pusa. Under this project an experiment was established on

different tillage and crop establishment methods in rice-wheat cropping. The data presented for two cropping cycle of rice-wheat cropping during 2019-20 and 2020-21. The study performed under completely randomised block design involved seven replication of three different tillage and crop establishment *viz*., zero tillage rice with *Sesbania aculeata* brown manuring - zero tillage wheat without residues (ZTRBM-ZTW-R), Green manuring rice-conventional tillage wheat (GMR-CTW), Puddled transplanted rice-conventional tillage wheat-farmer practice (PTR-CTW). Results of two years impact analysis of different tillage and crop establishment methods had significant effect on productivity and profitability of both crops. Irrespective of the treatments, ZTRBM-ZTW-R improved rice-wheat system productivity by 21.0% compared to PTR-CTW after completion of second year cropping. Similarly, system (rice + wheat) water productivity was also the highest (0.026 kg m^{-3}) in ZTRBM-ZTW-R followed by GMR-CTW and PTR-CTW after completion of two cycle of rice-wheat cropping. The higher productivity associated treatment well reflected to the higher profitability in rice-wheat cropping system. Therefore, the highest system profitability was incurred by Rs.123259 ha^{-1} and Rs. 140924.6 ha^{-1} during two respective years (2019-20 & 2020-21) in treatment ZTRBM-ZTW-R. Impact analysis of particular crop shows green manuring treatment produced the highest productivity of rice closely followed by zero tillage brown manuring rice. In contrast, the highest productivity of wheat obtained in zero tillage wheat without residues retention followed by conventional tillage wheat after green manuring rice (GMR-CTW) and absolute conventional tillage (PTR-CTW) during both the years of study. Rice-wheat system productivity under ZTRBM-ZTW-R was equivalent to that of GMR-CTW. The study revealed that to sustain rice-wheat system under zero tillage and green/brown manuring practice could be more feasible options for farmer clientele of Bihar.

Keywords: Rice-Wheat cropping system, zero tillage, green manure, brown manure, production, productivity

NS-T1-11

CLIMATE-RESILIENT AGRICULTURAL PRACTICES IN BIHAR

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Bihar, an agriculture-dependent state, is highly vulnerable to climate change impacts such as erratic monsoons, frequent floods, droughts, and rising temperatures. To counter these challenges, climate-resilient agricultural practices have been introduced to help farmers adapt and sustain productivity. One of the key strategies includes the adoption of drought- and flood-resistant crop varieties like swarna Sub-1 (flood-tolerant rice) and terminal heat tolerable wheat (DBW 187). Conservation agriculture practices, such as zero tillage, crop rotation, and intercropping, improve soil health and water retention while reducing dependency on chemical inputs. Efficient water management techniques, such as drip and sprinkler irrigation, rainwater harvesting, and farm ponds, help optimize water use during dry spells. Agroforestry and integrated farming systems promote biodiversity, combining tree plantations with crops and livestock to enhance soil fertility and provide additional income. Soil and nutrient management is strengthened through organic farming practices, including the use of biofertilizers, vermicomposting, and green manuring, which improve soil health while reducing chemical dependency. Integrated Pest and Disease Management (IPDM) minimizes crop losses by promoting biopesticides and disease-resistant crop varieties. Technology-driven solutions, like climate information services and digital tools, provide farmers with real-time weather forecasts, market trends, and best farming practices via mobile applications and SMS alerts. From this context, KVK, Piprakothi is promoting climate resilient technologies in nearly 350 ha in each season in three villages, which resulted in ~21% higher yield and economical benefit. These technologies are being transferred via capacity building, exposure visit and demonstration By promoting these climate-resilient agricultural practices, Bihar aims to

build a more sustainable and adaptive farming system, ensuring food security, protecting rural livelihoods, and mitigating the adverse effects of climate change in the long run.

Keywords: Climate resilient agriculture, zero tillage, crop diversification

NS-T1-12

CLIMATE-RESILIENT CROP ESTABLISHMENT TECHNIQUES AND CROP DIVERSIFICATION TO MITIGATE SUSTAINABILITY ISSUES IN RICE-WHEAT CROPPING SYSTEM OF NORTH-WEST BIHAR

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The conventional paddy-wheat cropping system in the North-west Bihar is experiencing sustainable issues viz. fluctuating yield, moisture stress, and uneven fertilizer usage, specifically under changing climate scenario. Scientists are taking initiatives to boost sustainability and productivity by implementing tillage and crop establishment techniques (TCET) within this cropping pattern and also incorporating one leguminous crop in it. Current research was carried out at the Climate Resilient Agriculture (CRA) adopted village in the East Champaran district of Bihar. The purpose was to compare five distinct TCETs utilization in the present rice–wheat cropping system by incorporating summer green gram. The study highlighted that the ZTDSR-ZTW-ZTG resulted in the highest system yield, with 16-21% higher rice yield, 22-26% higher wheat yield, and 18–23% higher green gram yield over other TCET. Moreover, ZTDSR-ZTW-ZTG provided 22% larger net returns after adopting conservation agriculture (CA)-based interventions in existing cropping system as compared to the conventional tillage. Outcome of current research advocate that CA-based TCETs overcame conventional approaches in terms of achieved yield and monetary returns and overall efficiency.

Keywords: Climate resilient agriculture, crop establishment techniques, crop diversification, zero tillage

NS-T1-13

LAND SHAPING FOR AGRI-DIVERSIFICATION AND PRODUCTIVITY IMPROVEMENT IN WATERLOGGED ECOSYSTEMS

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On average, 11.9 million ha land in India is under various kind of waterlogging. These waterlogged areas have been developed over the years due to extreme climatic rainfall events, poor drainage, cyclonic floods, flash floods, breaching of river embankment and biotic & abiotic factors must be looked upon for sustainable land and water productivity. The waterlogged areas can be brought under cultivation by intervention of deep-water paddy cultivars, aged seedlings of paddy, sole water chestnut etc. But, the unpredictability of the extent of waterlogging does not allows for strategic crop planning for augmenting the land and water productivity. Under such condition the harvesting and reuse of excess water can be done effectively through suitable shaping of the farm land, which not only involves harvesting of excess rain water but also making the land surface suitably shaped for adoption of improved cultivation of diversified crops and multi-enterprise integrated farming for nutritional security to farmers, employment generation round the year, and enhancing productivity of the

waterlogged areas. Some of the popular land shaping techniques which were found beneficial under waterlogged situations are pond-dyke, paddy-fish-duck system, pond-cum-raised bed system, shallow furrow & medium ridge, etc. By this land modification techniques, there is ample scope of growing diversified fruit and seasonal vegetable crops on the raised beds and on the pond dykes, whereas fish and aquatic crops like water chestnut and makhana in water body of different depths and duration. The land shaping studies for integrated farming system at ICAR-MGIFRI, Motihari, Bihar has shown highly significant improvement of productivity and net income of waterlogged land as compared to non-land shaped waterlogged areas. The land shaping techniques would be very viable option for Agri diversification and productivity improvement of land and water in waterlogged areas of India.

Keywords: Agri-diversification, aquatic crops, integrated farming, land shaping, productivity, waterlogging

NS-T1-14

STUDIES ON GENETIC AND BIOCHEMICAL BASIS OF *IN SITU* GERMINATION IN ADVANCE BREEDING LINES OF GROUNDNUT (*Arachis hypogaea* L.)

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A field experiment was undertaken at the Main Agricultural Research Station, Dharwad during *kharif* seasons of 2022 and 2023. The thirty-three advance breeding lines were tested for *in situ* germination / pre harvest sprouting trait. This experiment was irrigated after crop maturity and evaluated for *in situ* germination and other productivity traits at weekly interval. Analysis of variance revealed significant differences among genotypes, confirming their genetic diversity. High heritability coupled with high genetic advance over the mean was observed for traits like *in situ* germination, pod yield per plant, and seed yield per plant, suggesting substantial genetic variability in the advance breeding lines.Eight advance breeding lines Dh 281 × Dh 8-4, Dh 256 × GM 6000-F5-RII-15, Dh 256 × Dh 257-3, Dh 256 × Chico-3, Dh 281 x Dh 8-1, Dh 281 x Dh 8-2, Dh 256 × Dh 8-2, G2 52 X Dh 8-1 were identified as *in situ* tolerant lines with superior performance compared to tolerant check Dh 8. Tolerant lines exhibited lower electrical conductivity, reduced total dehydrogenase activity, and higher phenol content. Higher abscisic acid (ABA) and lower GA_3 levels were observed in *in situ* tolerant genotypes, such as TMV 2 NLM (125.63 ng/g), indicating strong dormancy regulation. Conversely, Higher levels GA_3 were noted in sensitive genotypes like Dh 86 (70.52 ng/g). Notably, *in situ* germination sensitive ABL Dh 86 × Dh 256-2 showing the lower ABA and higher GA_3 (23.91 and 29.20 ng/g) and *in situ* germination tolerant ABL Dh 281 × Dh 8-3 showing the higher ABA and lower GA_3 (34.94 and 1.32 ng/g).

Keywords:*In situ* germination, pre harvest sprouting, Advance breeding lines, Phytohormones, Phenol content

NS-T1-15

SITE SPECIFIC NUTRIENT MANAGEMENT AND ITS EFFECT ON PRODUCTIVITY OF MAIZE

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Site-Specific Nutrient Management (SSNM) is an advanced agricultural practice that tailors nutrient application to the specific needs of a field, considering variations in soil properties, crop requirements, and environmental conditions. This approach aims to optimize nutrient use efficiency, reduce input costs, and enhance crop productivity. The study explores the impact of SSNM on the productivity of maize, a staple crop in many regions. The research was conducted in maize-growing areas with diverse soil types and nutrient

levels. Various SSNM strategies were implemented, including precision soil testing, real-time monitoring of nutrient uptake, and customized fertilization schedules. The study concluded that SSNM not only boosts maize productivity but also promotes sustainable farming practices by improving nutrient use efficiency, reducing environmental pollution, and enhancing the economic benefits for farmers. The findings underscore the importance of adopting site-specific approaches to nutrient management to meet the growing global demand for food while maintaining environmental integrity.

Keywords: Nutrient management, maize productivity, fertilizer efficiency, soil health, sustainable agriculture

NS-T1-16

BIOCHAR-NANOPARTICLE COMPOSITE- AN INNOVATIVE APPROACH FOR ARSENIC REMEDIATION

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In order to remediate as toxicity, we have developed and characterized Rice Husk Biochar (RHB)-Nanoparticle composite using nano zero valent iron (nZVI) and nano silicon dioxide ($nSiO_2$). The composites were prepared using two different approaches, firstly by combining rice husk and nanoparticles in a pyrolysis chamber. In the second method, biochar was prepared first, then nanoparticles were added to it. In both the methods, different ratios of biochar/rice husk and nanoparticles (biochar and rice husk: nZVI:: 10:0.25, 10:0.5, 10:1 and biochar and rice husk: $nSiO_2$ :: 10:0.5, 10:1, 10:2) were used for preparation of composite. SEM image clearly showed porous surface of biochar-nanoparticles composite. EDX data confirmed the attachment and loadings of nanoparticles to the biochar. BET surface area and pore volume were significantly higher in nanoparticles composites as compared to RHB. In the adsorption study, the maximum as sorption and removal were observed in both composites made using the first approach with the lowest ratios of nanoparticles as compared to only RHB. It has been found that both RHB-nZVI and RHB-$nSiO_2$ removed approximately 4.5 times more As(III) and As(V) as compared to RHB. So, these products can be novel solution to As menace in both soil and water.

Key words: Arsenic, biochar, nanoparticle composite,toxicity,

NS-T1-17

WEED MANAGEMENT TECHNOLOGIES ADOPTED BY DSR FARMERS IN WEST CHAMPARAN, BIHAR

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The different weed management technologies adopted by DSR Farmers in West Champaran; Bihar are manual weeding by Khurpi Mechanical weeding by power weeder. The field performance of different weeding tools/implements viz. Khurpi (hand hoe), grubber, wheel hoe, and power weeder were carried out at the rice growing by DSR farmers' field of West Champaran, Bihar. Results revealed that actual field capacity of 0.0035±0.002, 0.0076±0.0002, 0.0129±0.0003 had associated with Khurpi, grubber, wheel hoe and power weeder, respectively. Khurpi had recorded the maximum weeding efficiency (98.9%) and lowest in case

grubber (74%). Similarly, power weeder contributed to higher plant damage (0.4%). Operational cost of Khurpi had recorded maximum (Rs.6793/ha). The energy consumption observed was more in manual weeding followed by Grubber, cone weeder and Power weeder. The highest yield was observed where Power weeder was operated i.e. 46.5 q/ha and was less in weeding with Khurpi i.e.43 q/ha.

Keywords: Mechanical weeding, filed capacity, weeding efficiency& operational cost

NS-T1-18

ENHANCING AGRICULTURAL PRODUCTIVITY AND LIVELIHOOD SECURITY: IMPACT OF THE FARMERS FIRST PROGRAMME IN THE EAST CHAMPARAN REGION

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Agriculture remains the primary livelihood for nearly 75% of Bihar's population, with key crops including rice, wheat, maize, sugarcane, cauliflower, and jute. However, productivity remains low due to challenges such as inefficient land tenure systems, poor seed replacement rates, limited access to quality inputs, and adverse climatic conditions, including frequent floods and droughts. The Tetaria block in East Champaran, a region particularly vulnerable to these constraints, also struggles with low farmer literacy, small landholdings, and inadequate extension services, making agriculture largely subsistence-based. To address these issues, the Farmers FIRST Programme was implemented to promote improved agricultural practices and integrated farming system (IFS) models in four villages Ujhilpur, Hasanpur, Narha Panapur, and Balbhadarpur of district East Champaran of Bihar. Field demonstrations of high-yielding paddy varieties, including Swarna Unnat, Swarna Smriddhi, Swarna Shreya, and Swarna Purvi Dhan 3, showed significant productivity gains of 19.3% to 24.2% over local varieties. Among them, Swarna Unnat recorded the highest yield (5.05 t/ha), while net returns in demonstration plots ranged from ₹36,390 to ₹43,263 per hectare, compared to ₹26,952 to ₹34,069 under traditional practices. Similarly, the wheat variety DBW 187 demonstrated an average yield of 6.2 t/ha, compared to 4.8 t/ha under conventional methods, with net returns rising from ₹72,046/ha to ₹90,531/ha. Wheat variety DBW 187 is gaining popularity in the adopted and nearby villages. Initially, the farmers were reluctant to accept this variety but within a short time span, DBW 187 has gained momentum owing to better adaptability. Farmers are now harvesting reasonable crop yields ranging from 4.5- 6.5 t/ha as against the earlier average of 2.5-3.5 t/ha. The project also implemented four IFS model demonstrations, combining crops, livestock, fisheries and horticulture, to boost farm productivity and income. The fish-crop-goat, fish-crop-goat-cow, fish-duck-goat and fish-crop-goat-vermicomposting models promoted ecological sustainability through organic waste recycling. These models significantly increased farming incomes ₹3,18,182/ha to ₹6,16,800/ha.

Keywords: Agricultural productivity, sustainable agriculture, diversified farming, high-yielding crop varieties

NS-T1-19

ENHANCING SUSTAINABILITY AND RESILIENCE IN AGRICULTURE THROUGH CLIMATE-RESILIENT AND CLIMATE-SMART PRACTICES

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The increasing significance of climate-resilient agriculture (CRA) and climate-smart agriculture (CSA) is crucial in mitigating the effects of climate change on agriculture. CRA is primarily focused on adapting

agricultural systems to changing climatic conditions, ensuring food security by effectively managing vital resources such as water and land. By integrating strategies like risk assessments and adaptive practices, CRA aims to improve resilience in farming systems, helping them withstand the uncertainties brought by climate change. On the other hand, CSA is a holistic approach that not only addresses the immediate challenges of climate change but also works towards enhancing agricultural productivity, resilience, and long-term sustainability. CSA achieves this by incorporating both adaptation and mitigation measures, including reducing greenhouse gas emissions, enhancing soil fertility, and supporting biodiversity. These practices are particularly important in promoting social sustainability by improving livelihoods and empowering marginalized groups, including smallholder farmers and women. Furthermore, CSA focuses on the environmental aspect by ensuring reduced environmental degradation and promoting sustainable land management. To achieve success, both CRA and CSA require access to financial services, extension support, and climate information. These tools enable farmers to implement these approaches effectively, ensuring long-term resilience and sustainable agricultural systems that can face the challenges of climate change.

Keywords: Climate-resilient agriculture (CRA), Climate-smart agriculture (CSA), Sustainability, Food security

NS-T1-20

ASSESSMENT OF GROWTH PERFORMANCE OF AMUR CARP IN COMPOSITE FISH CULTURE SYSTEM

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The Composite fish culture or polyculture, is a highly efficient aquaculture practice that involves raising multiple compatible fish species in the same pond. This method aims to maximize fish production by utilizing all available ecological niches within the water body. This study investigates the viability and efficiency of integrating Amur carp into existing composite fish culture systems, evaluating its growth rate and overall contribution to yield. The study was conducted in across the 7 different locations of West Champaran district of Bihar. The treatment- T_1- composite fish culture system with ratio 3:4:3 (Catla +Rohu + Common carp) stocking with stocking density @8000/ha, the treatment- T_2 composite fish culture system with ratio 3:4:3 (Catla +Rohu +Amur carp) stocking density @8000/ha. The control was composite fish culture system with indiscriminate ratio of stocking of fingerlings of Catla+Rohu+Mrigal. The parameters were assessed average body weight gain (kg), total yield (q/ha), cost of culture (Rs. /ha), gross return (Rs. /ha), net return (Rs. /ha), and benefit-cost (BC) ratio. Results indicated that the treatment with Amur carp, stocked at a ratio of 3:4:3 (Catla: Rohu: Amur) with a density of 8000/ha, exhibited superior growth performance, achieving an average body weight gain of 1.20 kg and a total yield of 4720 kg/ha, compared to the control (TO_1) using Common carp (0.95 kg/fish and 3925kg/ha). Both treatments were recorded a 70% survival rate. Economic analysis revealed a significantly higher BC ratio of 2.40 for TO2, compared to 1.86 for TO1 and 1.50 for the control. These findings suggest that replacing Mrigal carp with Amur carp in a 3:4:3 composite culture system at a stocking density of 8000/ha (TO2) offers a more profitable and efficient approach for aquaculture in the region.

Keywords*:* Amur carp, composite fish culture, profitability, yield

NS-T1-21

EFFECT OF DIFFERENTIAL RICE RESIDUAL LOAD AND NITROGEN SPLITTING ON ZERO TILLED WHEAT (*Triticum aestivum* L.)

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Among the sustainability issues of the Rice-Wheat Cropping System (RWCS), riceresidue management is a crucial issue for sustainable crop production as well as environmental security. Approximately 16% of total crop residues are being burnt out of which 62% is contributed by rice and wheat. Considering the narrow sowing window for subsequent rabi crops, wheat in particular, the majority of the farmers burn rice residues in the field which leads to huge nutrient loss besides deteriorating environmental quality and human health. In this context, Conservation Agriculture (CA) is considered as a viable option which considers sustainable crop production in one hand and the environmental security on the other. CA is showing its potential in yield enhancement, improved water productivity, climate resilience, reduced cost of cultivation, and lower environmental footprints in RWCS. The nutrient management, nitrogen in particular, assumes huge importance in wheat grown under zero tillage with varying residue load as nutrient management practices for wheat under ZTwith varied levels of surface residues are poorly understood. Hence, the timing of nitrogenous fertilizer application is one of the low cost strategies that can may reduce nutrient losses through proper synchronization with plant demands. There is little information available on N management options for ZT wheat sown with differential rice residues. Through different splitting of N fertilizers, we have tried to optimize N scheduling in ZT wheat grown under differential rice residue load. The initial results are supportive of maintaining an optimum residue load with proper splitting of N fertilizers could maximize wheat yields with proper nutrient balance.

Key words: Conservation agriculture, zero tillage, wheat, rice residues, rice-wheat cropping system

NS-T1-22

SELF-SUSTAINING GOAT FARMING MODEL FOR LIVELIHOOD IMPROVEMENT OF SMALL AND MARGINAL FARMERS

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Goat is a multipurpose animal that produces milk, meat, fiber, kids, and manure. India has 148.88 million goats (according to the 20th Livestock Census), making it the 5th largest goat population in the world. Goats contribute 27.8% of India's total livestock population. There has been a progressive growth in the goat population, with an increase of 10.14% compared to the previous Livestock Census Report of 2012. Goat farming has tremendous potential for employment generation and poverty reduction, particularly for small, marginal, and landless farmers in rural areas. Goat meat has no religious taboos and is in high demand across all communities due to its lower fat content and higher protein. Goat meat also commands higher prices in the market. Additionally, goat manure and urine are rich sources of nitrogen, potash, and phosphorus.Despite the high demand and favorable market price for goats, there are several production constraints hindering the growth of goat farming. The availability of grazing land is the biggest concern in goat farming. Moreover, the decrease in grazing resources, both in terms of quality and quantity, the increased grazing pressure due to the growing goat population, the unavailability of labor for grazing, and the high cost of labor are major challenges in goat farming. An increase in the cost of feed and fodder also raises input costs. Abiotic stresses such as heavy rains, heat and cold stress, and nutritional stress due to insufficient rainfall adversely affect both the productive and reproductive performance of goats.To mitigate the effects of climate change on goat production systems

and achieve sustainable production and income, self-sustaining goat farming was developed by integrating the Osmanabadi goat breed, a climate-smart housing system, and sustainable livestock feeding and management practices. The study was conducted over a one-year period. The goats were feed with different fodder shrubs grown on the boundary of fields, with drip irrigation. The total recurring cost of production for a (6+4) animal goat unit was Rs. 38,070, and the gross income was Rs. 105,512, with a B:C ratio of 2.77, without the supplementation of concentrate feed. The net income obtained was Rs. 6,744 per goat per annum in our study. This goat farming model has the potential to generate employment for rural youth and landless farmers in a sustainable manner. Farmers can earn a sustainable income with less land and limited water resources by adopting this model.

Keywords: Goat farming, IFS model,livelihood improvement,small and marginal farmers

NS-T1-23

HARNESSING AGROFORESTRY FOR SUSTAINABLE DEVELOPMENT IN BIHAR: A COMPREHENSIVE ANALYSIS OF LAST FEW YEARS OF DATA, BENEFITS, AND FUTURE DIRECTIONS

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Agroforestry has emerged as a critical strategy for sustainable agricultural development in Bihar, India. The integration of trees with crops and livestock offers a multifaceted approach to enhancing ecological resilience, economic stability, and rural livelihoods. This paper provides a comprehensive analysis of the current status of agroforestry in Bihar, focusing on its extent, species diversity, benefits, challenges, and future directions. As of 2021, Bihar's tree cover outside forests was reported at 3.11%, reflecting a significant increase from 2,003 sq km in 2019 to 2,341 sq km in 2021. The adoption of agroforestry practices is accelerating, with 6,900 farmers planting 3.51 lakh saplings under various agroforestry schemes in 2024, supported by an investment of ₹8.75 crore. Key species such as poplar (*Populus deltoides*), mango (*Mangifera indica*), and bamboo (*Bambusa spp.*) are commonly integrated with staple crops like wheat, maize, and pulses, enhancing soil fertility through nitrogen fixation and organic matter enrichment. This has led to an estimated 20–30% increase in crop yields. Beyond improving agricultural productivity, agroforestry contributes to biodiversity conservation by creating habitats for diverse flora and fauna and supporting ecosystem services such as pollination and pest control. However, despite its potential, agroforestry in Bihar faces several challenges, including climate change-induced temperature fluctuations and unpredictable precipitation patterns, which adversely impact agricultural productivity. Additionally, farmers struggle with limited market access due to inadequate infrastructure and insufficient market information, hindering the effective commercialization of agroforestry products. To overcome these barriers, a comprehensive approach is required, encompassing targeted research, robust policy frameworks, and capacity-building initiatives. Strengthening stakeholder collaboration and promoting sustainable agroforestry practices can unlock its full potential, fostering ecological stability and improving livelihoods in Bihar's farming communities. This research underscores the importance of Bihar as a model for sustainable agricultural practices, providing insights for similar initiatives in other regions facing comparable challenges.

Keywords: Agroforestry, sustainable agriculture, bihar, tree cover, climate resilience, rural livelihoods

NS-T1-24

GROWTH AND REPRODUCTIVE PERFORMANCE OF LOCAL GOATS REARED UNDER INTEGRATED FARMING SYSTEM IN EAST CHAMPARAN DISTRICT OF BIHAR

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The study was aimed to evaluate the performance of local goats reared under integrated farming system (IFS) in East Champaran district of Bihar. The goats were raised in goat based IFS with Model-I: goat-crop integration and model-II: goat-crop-fishery integration. The total area allocated for goat-crop integrated model was one acre. The area allocation for goat housing and its associated structure like open fencing, manure pits, fodder unit development was 20 percent of the total area allocated under this model. The remaining 80.0 percent (3200 sq.) was allotted for crop production which included field crop (45 percent of total) and vegetables (35 % of the total land under this model). In model-II, the area allotted for field crop production, vegetable and fish production was 35%, 25% and 20% of total area of project, respectively. The average monthly body weight (kg) of goats at 8th month (initial month) for Model-I and model-II was 11.18± 1.21 and 11.34± 1.18, respectively. The body weights of goats at initial month and consequent months were non-significant between the two models. The average daily intake of green fodder, dry fodder, concentrate mixture for Model-I and model-II were 2.18, 0.21, 0.26 and 2.23, 0.23,0.25 kg, respectively which were non-significant to each other. Similar, trend was also observed for water intake and dung output. All animals were allowed for grazing on the dyke and side by roads for 3- 4.5 hour daily depending upon the season. The average body weights of goats at the time of first kidding was 17.57± 0.09 and 17.88± 0.10 for Model-I and model-II, respectively. The average litter size varied from 1.65 to 1.8 over the years during the study period. The performance of goats in both the models were found non-significant to each other.

Key word: Growth, Integrated farming, Litter size, Water intake

NS-T1-25

INTEGRATION OF POULTRY WITH AGRICULTURE AND ALLIED SECTORS: A SUSTAINABLE STRATEGY FOR AGRI-DIVERSIFICATION

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Poultry farming has played a very significant role in India's livestock sector, contributing largely to egg and meat production. As per the census of BAHS (2023), India ranks 3rd worldwide in egg production, reaching 138.38 billion eggs in 2022-23, with a 6.77% annual growth. Per capita egg availability stands at 101 per annum, with Andhra Pradesh, Tamil Nadu, and Telangana leading production. Poultry meat constitutes 51.14% of the country's total meat output, growing at 4.52% annually. While commercial poultry dominates production, backyard poultry remains crucial for rural livelihoods and nutritional security. In Bihar, where agriculture often faces recurring floods and excessive waterlogging, the need for resilient and diversified farming systems is even more vital. About 70% of the state's geographical area is flood-prone, particularly in North Bihar, where poor drainage and embankment failures worsen waterlogging issues. These challenges recurrently interrupt agricultural activities, leading to crop losses, livestock mortality, and large-scale migration. Integration of poultry with agriculture in vulnerable regions can put forward a sustainable livelihood approach by ensuring continuous income, enhancing farm productivity with improved food security. This

approach is particularly crucial for Bihar, where frequent floods and waterlogging upset traditional farming, leading to financial instability and migration. Given its economic and nutritional importance, poultry integration also promotes resource utilization. Poultry waste serves as valuable organic manure thus reducing dependence on chemical fertilizers and improving soil fertility. In addition, diversified farming optimizes land use, ensures year-round productivity, and minimizes risks associated with monoculture.

Keywords: Poultry farming, integrated farming, sustainable agriculture, Bihar, flood resilience, Agri-diversification, rural livelihoods

NS-T1-26

ASSESSMENT AND SCOPE OF FLORICULTURE FORESTRY IN BIHAR

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In Bihar, natural forests are being conserved primarily for the environmental benefits, climate moderation and wildlife conservation. Efforts are being done to plant large number of trees outside forest under Social/ Extension/Agroforestry programme to increase the tree cover and fulfill demand of various forest produce required by the people and forest-based industries. Agricultural fields are one the potential area where large scale planting of trees can be taken up along with agricultural crops. Agroforestry models adopted by farmers in Bihar are highly lucrative. One of the area which is missing is floriculture Forestry which may attract the farmers, forester/horticulturist in a big way. This area has a great export potential, recreation as well as regular supply of flower to the devotees. Floral wealth of Bihar is rich and varied. So this is an attempt to describe the floral forest trees which flowers are great demand in the present floriculture market, first choice of devotees and also have great export potential. These species are *Grevillea pteridifolia , Nerium oleander, Plumeria alba, Plumeria obtusa, Plumeria rubra, Plumeria acutifolia, Millingtonia hortensis, Magnolia champaca, Magnolia sieboldii, Michalia champaca, Magnolia soulangeana, Magnolia denudata, Magnolia x alba, Callinandra eriophylla, Saraca ashoka, Couroupita guianensis, Cassia javonica, Kokia cookie, Caesalpinia pulcherima, Ipomoea quamoclit,Allamanda cathartica, Tecoma castanifolia, Bauhiniax blankeana, Bougainvillea glabra, Prosopis chilensis, Butea monosperma, Hibiscus syriacus, Hibiscus rosa sinenensis, Bixa orellana, Peltaphorum pterocarpum, Cassia fistula, Albizia julibrissin, Artabotrys siamensis Helecteres isora, Melaleuca viminalis,Laburnum anagyoides, Phanera vahlii, Bombax ceiba, Cassa javanica , Peltophorum dubium, Tabebuia rosea, Malvaviscus arboreus,Barringtonia racemosa, Hibiscus mutabilis, Thespesia populnea, Passiflora incarnate, Passiflora racemosa, Passiflora foetida, Pterospermum acerifolium, Combretum indicum, Hamelia patens, Bauhinia purpurea, Gloriosa superba.*

Keywords: Floriculture forestry, export potential, floral tree

NS-T1-27

COMPARATIVE ANALYSIS OF NATURAL FARMING VS CONVENTIONAL METHODS: EFFECTS ON SOIL HEALTH AND RICE YIELD

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Exploration of sustainable alternatives to conventional rice farming, is the need of the time. By examining the beneficial effects of natural farming practices on soil health, and increase crop productivity, natural farming

practices which is also known as eco-friendly farming, focus on reducing chemical inputs while enhancing the biodiversity and overall health of farming ecosystems may be a tool for the future. An experiment is being conducted at RPCAU, Pusa, Bihar with the aim to examine the effect of natural farming practices on soil health in rice based cropping system (Rice-Wheat-Greengram) started with Greengram crop (var. Virat) in April, 2022 followed by Rice (var. *Rajendra Bhagwati*) and wheat (var. HD 2967) laid in Randomized Block Design with nine treatments replicated thrice. The treatments were T_1 - Control, T_2 - Natural farming using Beejamrit, Jeevamrit, Ghanajivamrit, and natural plant protection measures, T_3 - T_2 + Irrigation at critical stages, T_4 - T_3 + Intercropping, T_5 - T_4 + Mulching, T_6 - Organic farming package, T_7 - 100% Organic source Nitrogen, T_8 – INM, and T_9 - 100% RDF. The experimental soil was alkaline in reaction, low in organic carbon, available nitrogen, and potassium, with medium levels of available phosphorus. The critical evaluation of observations recorded during two years, showed that the biological yield of rice was highest in T_8, followed by T_9, T_6 and T_5. The soil organic carbon content was highest in T_6, which used organic farming methods, followed by T_5. The highest available nitrogen was observed in T_7, while the highest levels of phosphorus and potassium were found in T_8. The highest dehydrogenase and alkaline phosphatase activity were recorded in T_5, followed by T_6 and T_7. It has been observed that the natural farming practices significantly improve soil health and rice productivity. Among the treatments, Integrated Nutrient Management (T_8) showed the highest biological yield, while natural farming practices and organic practices (T_6 and T_5) contributed to better soil organic carbon and enhanced enzymatic activity. These findings highlighted the potential of natural farming methods in promoting sustainable rice cultivation, improving soil fertility, and reducing dependence on synthetic inputs.

Keywords: Enzymatic activity**,** natural farming**,** rice productivity**,** soil health

NS-T1-28

REVIEW ON POTENTIAL AND PROSPECTS OF SUSTAINABLE MANGO-BASED FARMING IN FLOOD-PRONE AREAS OF NORTH BIHAR

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Mango (*Mangifera indica* L.) is a major fruit crop in Bihar, occupying 1.6 lakh hectares with an annual production of 15.49 lakh tonne. Despite its economic importance, mango cultivation faces several challenges, challenges like irregular bearing, fruit drop, and pest attackswhich contribute to lower yields and profitability. Additionally, old mango orchards in the region are inefficiently spaced at 8–10 m, leaving valuable land underutilized. This provides an opportunity for crop diversification by integrating short-duration or filler crops in the interspaces, maximizing resource use. Moreover, waterlogging affects nearly 51% of the central districts in North Bihar, making fruit cultivation difficult. Implementing land shaping and establishing site-specific farm ponds within mango orchards while ensuring adequate space for root growth and canopy development can help manage excess rainwater through rainwater harvesting. Utilizing harvested rainwater for supplemental irrigation via drip systems reduces dependence on erratic rainfall, ensuring a stable water supply during critical crop growth stages. Efficient water management, coupled with proper irrigation scheduling, enhances soil moisture conservation, nutrient availability, improves drainage and overall crop performance. Additionally, integration of mulching with organic or synthetic materials can further improves moisture retention, suppresses weeds, and boosts yields. Integrated Farming Systems (IFS) offer a holistic approach to addressing these challenges. Integrating short-duration crops like turmeric, ginger, and vegetables between mango trees can enhances land productivity and farm income. Furthermore, combining mango cultivation with livestock and fisheries under IFS can also improves sustainability and resilience. This approach can transform mango orchards into resource-efficient and profitable farming models for flood-prone areas of North Bihar.

Keywords: Mango-based system, rainwater harvesting, intercropping, flood-prone regions

NS-T1-29

IMPACT OF FARMING PRACTICES ON SOIL MICROBIAL ACTIVITIES IN SUGARCANE BASED INTERCROPPING SYSTEMS

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The soil health is an important indicator of soil productivity which is largely influenced by soil microflora and soil enzyme activities. In this view a field experiment was carried out at Agricultural Research Station, Hukkeri, Belagavi (Dist), Karnataka during 2019-20 on medium black clay loam soils to study the effect of different farming practices, planting row arrangement and intercropping systems on soil microbial activity in sugarcane rhizosphere. Experiment was laid out in split-split plot design with three farming practices such as recommended package of practices (RPP: M_1), organic farming (OF: M_2) and natural farming (NF: M_3) in main plots; in sub plots two planting row arrangement *viz*., paired row planting (60-180-60 cm × 60 cm: S_1) and wide row planting (240 cm × 60 cm: S_2) and in sub-sub plots three intercropping systems were taken *viz*., sugarcane + onion - turmeric (I_1), sugarcane + onion + cowpea + coriander + green chilli (I_2) and sole sugarcane (I_3). The results indicated that different farming practices and intercropping systems influenced significantly on soil microbial activities in sugarcane rhizosphere. Organic farming practice recorded higher general microflora *viz*., bacteria, fungi and actinomycetes and beneficial microflora *viz*., N- fixing bacteria and phosphate solubilizing microorganisms at 180 DAP and at harvesting stage as compared to recommended package of practices (RPP), whoever it was found on par with natural farming practices for microbial activity. Microbial population found to be non-significant between two spacings. Among the intercropping systems, sugarcane + onion – turmeric (I_2) intercropping system recorded significantly higher general and beneficial microbial population as compared to other two intercropping systems.

Keywords: Intercropping, natural farming, organic farming, PSM, N-fixers, ZBNF

NS-T1-30

GRAPES: A HIGH VALUE OPTION FOR CROP DIVERSIFICATION IN FARMING SYSTEM

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Grape (*Vitis vinifera* L.) has proven its adoptability to different agro-climatic i.e. temperate, tropical and sub-tropical and grown for wine, juice and table purpose. In India, grapes are produced on 175.93 thousand hectares with a production of 3,896.46 thousand tonnes with export growth CAGR of 9.26% in quantity and 17.45% in value. Grapes are being grown successfully in different pockets of country stretching from North (i.e. Ladakh, Kashmir, Punjab, Madhya Pradesh) travel to South (i.e. Karnataka, Andhra Pradesh, Tamil Nadu) from there to West (i.e. Maharashtra) and to East and Northeast (i.e. West Bengal, Mizoram, Nagaland and Arunachal Pradesh). This shows its potential adoptability to diverse eco-regional conditions. Location specific canopy management practices (single pruning-single cropping; double pruning-single cropping), new varieties, PGR, nutrition and irrigation schedule and disease and pest management modules, training and advisories via social media are the triggers for its successful cultivation in different pockets of the country. Climate suitability map developed by the ICAR-NRCG; Pune helps in identification of suitable area for its

cultivation. Base on the output of the climate suitability map the production constraints were identified and suitable GAP was disseminated among the growers. Apart from commercial vineyards, growing of grapes in kitchen garden is quite popular in NEH region of India, where it is grown for wine and juice purpose on existing pendal/bower made from bamboo/stone/iron poles and wires generally used for raising cucurbits, kiwifruits etc. Thus, to achieve the goal of Vikshit Bharat, grapes is a viable option for crop diversification in existing farming system.

Keywords: Grapes, diversification, GAP, climate suitability map

NS-T1-31

IMPACT OF ORGANIC SUBSTRATES ON MICROBIAL DYNAMICS AND ENZYMATIC ACTIVITIES DURING COMPOSTING

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The continuously rising population and increasing urbanisation has resulted in massive increase in consumption and subsequently increased waste materials generation with a great assortment of organic solid wastes. Managing solid waste in an open environment is a growing problem in the modern world, especially in developing countries like India. Many of these wastes are nutrient-rich, and improper disposal leads to the loss of significant untapped nutrients. There is a need for scientific and hygienic disposal of organic waste, which should be managed effectively. This can be achieved through residue recycling, including composting and vermicomposting of farm, urban, and agro-industrial waste. As a biological process, composting/vermicomposting involves a myriad of microorganisms and all biochemical reactions during composting are catalysed by enzymes, so, their composition and magnitude are quite important. Monitoring enzyme production and microbial population changes during composting/vermicomposting helps understand the transformation dynamics and enhances composting efficiency. Hence, taking this in to consideration an experiment was conducted during the year 2021 and 2022 at vermicompost production unit, RPCAU, Pusa with an objective to monitor the effect of four different food materials *i.e.,* temple waste, food waste, household waste and agricultural waste in combinations with cow dung (65:35) and cow dung alone as fifth one in presence and absence of the epigeic earthworm *Eisenia fetida*microbial dynamics and enzymatic activities during different decomposition stages. The experiment was conducted in Completely Randomized design (factorial) replicated thrice. Results indicated an increasing trend in microbial population and enzymatic activity (dehydrogenase, acid and alkaline phosphatase, β-Glucosidase, cellulase and fluorescein diacetate)over the course of the composting process up to 60 DAI for all the treatment combination, with the exception of fungal population and cellulase activity, which gradually decreased after 90 DAI. The results also indicate that incorporating organic waste with cow dung for composting leads to higher microbial buildup and greater enzymatic activity compared to using cow dung alone. Additionally, vermicomposting consistently shows significantly higher values than regular compost, regardless of the substrates used.

Keywords: Microbial dynamics, enzymatic activities, organic substrates

NS-T1-32

INTEGRATED FARMING SYSTEM: IMPORTANT DIVERSIFICATION IMPORTANT STRATEGY FOR FARMING COMMUNITIES

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The integration of various agricultural enterprises, such as animal husbandry, fishing, and forestry, has enormous potential in the agricultural economy. These businesses not only enhance farmers' incomes, but also give job opportunities for family members. The integrated farming system strategy entails altering farming techniques to enhance crop yield and resource utilization. This technique repurposes farm waste for productive use. A mix of agricultural operations like as dairy, poultry, piggery, fisheries, sericulture, and so on, tailored to agro-climatic conditions and farmers' socioeconomic situation, can produce farming prosperity. Agriculture mixed with animal husbandry generates additional income and year-round job options. Livestock excreta utilized as manure saves fertilizer costs, preserves soil fertility, and boosts crop yields. Crop residues used as livestock feed reduce feed costs. Agriculture combined with fodder and azolla production, along with animal husbandry, provides more benefits. The data were recorded and interpreted from progressive farmer's field. Incorporation of major components of integrated farming systems for diversified agriculture (Rice, Wheat, Sugarcane, Mustard, Mango, Makhana cultivation, Dairy, Fisheries/ Prawn farming- Rohu, Katla, Mrigal, Grass carp, Common carp, Silver carp, Prawn) was the main tool in sustainability of farmer's income. After establishing the integrated farming system, his net income increased to Rs. 2685600 /-annually from 27-acre land. The overall average production growth and net income was 48.31 and 114.40 per cent more over previous baseline period.

Keywords:IFS, diversification, agricultural economy, baseline period

NS-T1-33

STUDIES ON GROWTH AND SURVIVAL OF STUNTED AND NON-STUNTED FISH FINGERLINGS: SUSTAINABLE PRACTICES IN AQUACULTURE

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Aquaculture plays a significant role in national economies; however, its productivity and sustainability could be enhanced through the application of advanced technological practices. The present study carried out in nine earthen ponds of East Champaran, Bihar with three distinct experimental treatments: T1, involving the stocking of IMC fingerlings at a density of 3000 per acre with an average body weight of 10-20g; T2, stocking of advanced fingerlings at a density of 3000 per acre with an average body weight of 50g; and T3, stocking of stunted yearlings at a density of 3000 per acre with an average body weight of 50-100g. The research aimed to assess the growth, survival and economic parameters of stunted and non-stunted fish fingerling in composite fish culture practices. The results revealed that T3 exhibited the highest fish yield, survival, growth, and benefit-cost (BC) ratio compared to both T1 and T2 treatments, suggesting that the use of stunted yearlings enhances both growth rates and survival in grow-out ponds, thereby boosting fish production. Furthermore, the implementation of multiple stocking and harvest represents a cost-effective strategy to augment both fish

production and pond productivity. It is recommended that farmers adopt improved management practices and sustainable aquaculture techniques, such as the use of stunted fingerlings, to enhance productivity, improve livelihoods, and reduce the environmental and social impacts associated with aquaculture practices.

Keywords: Aquaculture, economic, growth rate, stunted fingerling, sustainable

NS-T1-34

MORINGA-BASED AGROFORESTRY: A SUSTAINABLE SOLUTION FOR FOOD SECURITY, RURAL LIVELIHOODS, AND CLIMATE RESILIENCE IN BIHAR

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Agroforestry is a key strategy for sustainable agriculture, integrating trees with crops and livestock to improve farm productivity and environmental resilience. Among agroforestry species, Moringa (Moringa oleifera) stands out due to its high nutritional value, rapid growth (3–5 meters per year), and ability to thrive in drought-prone areas. This thesis explores Moringa's role in Bihar's agroforestry systems, analyzing its ecological, economic, and social benefits. Moringa leaves contain 25–30% protein, 7 times more vitamin C than oranges, 4 times more calcium than milk, and 3 times more potassium than bananas, making it a crucial food source for combating malnutrition. Additionally, Moringa trees improve soil fertility through nitrogen fixation, reduce erosion, and enhance groundwater recharge. The economic viability of Moringa is significant, as one hectare can yield 10–15 tons of fresh leaves per year, generating annual revenues of ₹80,000–₹1,50,000 for smallholder farmers. The seed oil, valued at ₹2,000–₹3,000 per liter, adds another income stream. A comparative analysis with Poplar, Bamboo, and Eucalyptus highlights Moringa's advantages, such as shorter maturity (6–8 months for leaf harvest, 2–3 years for full yield), higher nutritional value, and multiple revenue sources. However, limited market access, inadequate farmer awareness, and weak policy support hinder large-scale adoption. Government initiatives like the National Agroforestry Policy and Bihar's Hariyali Mission have provided subsidies and technical training, but further interventions are needed. This study recommends strengthening supply chains, creating farmer cooperatives, expanding research on high-yielding varieties, and integrating Moringa into mid-day meal programs. By addressing these challenges, Moringa-based agroforestry can enhance food security, rural livelihoods, and climate resilience, making it a transformative solution for Bihar's agricultural sector.

Keywords: Moringa, Agroforestry, climate resilience,rural livelihoods

NS-T1-35

SMART CROP MANAGEMENT SYSTEM TO MITIGATE THE RISKS IN FLOOD PRONE AREAS

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Rice- wheat is the dominant cropping system in Eastern U.P. Rice is the is the main kharif crop in Eastern U.P. and Eastern part of India while wheat is the most popular crop in during rabi in EUP.. Rice productivity in E.U.P. is low and mostly affected due to late onset of monsoon followed by flood at vegetative growth stage. Farmers of Eastern U.P. start planting after onset of monsoon hence there nursery get old and flood in the latter stage damage the crop which resulted some time no yield and some very low yield. Selection of crop in flood affected NICRA village based on the situation can help in increase the income of the farmers. Keeping in View these facts the most important proven technologies were selected for demonstration in flood prone NICRA

Village Mahopar, Tighra and Giradharpur. The Technology selected for Demonstration were early sowing using Stale bed technique and submergence tolerance variety Swarna Sub-1, short duration vegetable crops after flood damaged the crop. Cropping system using the best bet crop were developed and demonstrated on farmers field during 2022-23 and 2023-24 at 30 farmers field of Village selected in NICRA Project. The Demonstration led out at Farmers Field with their exiting rice production technique for comparison, number of Farmers Considered as replication. Data reveals that in flood prone area crop sequence onion(leafy) – veg. pea – okra recorded highest rice equivalent yield (563.94 q/ha) and net return Rs. 951108/ha followed by crop sequence Onion(leafy) – wheat using best bet practice (table -1). Crop sequence spinach – spinach –radish and spinach –veg. pea also registered higher REY and net return than the rice –wheat of NICRA farmer and non NICRA farmer. Rice – mustard crop sequence also recorded higher REY (109.63 q/ha) and net return Rs. 171111/ha over rice – wheat crop sequence with best bet practice and non NICRA farmer (Traditional practice). Results of demonstration also showed that inclusion of veg. crop in crop sequence after flood, recorded a better option for higher net return and REY. Highest net return with less cost of cultivation and better marketing demand was recorded with onion (leafy) crop followed by spinach and radish as individual short duration crop.

Keywords: smart crop management system, flood prone areas

NS-T1-36

AGRO-DIVERSIFICATION THROUGH NUTRITION GARDENS: INFLUENCE OF OPINION LEADERS IN RURAL COMMUNITIES

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This study examines the role of opinion leaders in disseminating agricultural information in rural communities, with a specific focus on the adoption of nutrition gardening as a strategy for agro-diversification. Conducted in three villages in Punjab, India, the research employed a quasi-experimental design with a non-equivalent control group. Opinion leaders were identified using sociometric techniques, and their influence was measured through social network analysis (SNA). The study also utilised Propensity Score Matching (PSM) to account for selection bias and logistic regression to evaluate the impact of opinion leaders on the diversification of agricultural practices. The findings reveal that opinion leaders significantly enhance the dissemination and adoption of nutrition gardening, which serves as a critical tool for agro-diversification by integrating a variety of nutrient-rich crops into farming systems. This increase was not observed in the second experimental group or the control group, highlighting the importance of targeted interventions. By fostering diversified cropping patterns, nutrition gardens contribute to enhanced food security, improved soil health, and reduced dependency on monoculture. The study underscores the potential of leveraging opinion leaders in agricultural extension services to accelerate the transition towards agro-diverse farming systems, ultimately ensuring long-term sustainability and resilience in resource-poor settings.

Keywords: Opinion leadership, agro-diversification, nutrition gardening, social network analysis, agricultural information dissemination

NS-T1-37

ALLANBLACKIA IN AGROFORESTRY: A GAME CHANGER FOR SUSTAINABLE LAND USE AND RURAL PROSPERITY

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Allanblackia (*Allanblackia* spp.) is an emerging agroforestry species with immense ecological, economic, and industrial potential. Native to tropical Africa, it produces oil-rich seeds highly valued in the food, pharmaceutical, and cosmetic industries. Beyond its commercial applications, Allanblackia enhances biodiversity, improves soil fertility, and plays a vital role in carbon sequestration. However, despite its promising attributes, large-scale adoption remains limited due to slow maturation (6–12 years), lack of improved cultivars, and underdeveloped value chains. This study examines Allanblackia's viability in agroforestry systems, focusing on its productivity, economic feasibility, and key challenges.A mature Allanblackia tree yields 10–50 kg of seeds annually, with an oil content of 50–60%. The extracted oil commands a premium price of ₹1,500–₹3,000 per liter, offering a high-value income stream for smallholder farmers. When integrated with crops such as cocoa, coffee, or banana, Allanblackia improves soil moisture retention, optimizes shade management, and enhances overall farm productivity. Additionally, its byproducts, such as seed cake, serve as nutritious livestock feed or organic fertilizer, further promoting sustainability. Despite its benefits, Allanblackia's expansion faces constraints, including prolonged juvenile phases, limited genetic improvement programs, and weak market linkages. This study highlights the need for strategic interventions such as advanced breeding programs, farmer training initiatives, and supportive policies to incentivize cultivation. Strengthening supply chains through certification, cooperative models, and public-private partnerships will be critical in scaling its commercial adoption. Integrating Allanblackia into agroforestry systems can significantly enhance rural livelihoods, promote climate resilience, and contribute to sustainable land management. This research provides a foundation for future studies and policy recommendations to unlock Allanblackia's full potential as a transformative agroforestry species.

Keywords: Allanblackia,agroforestry, game changer, rural prosperity

NS-T1-38

EFFECT OF FEEDING DIFFERENT HYDROPONIC FODDER ON GROWTH PERFORMANCE OF THE GOATS

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The present study was conducted on the organized goat's farms at Jehanabad. The general and breeding history and animals, presented for health checkup were recorded in respect of age of animal, body weight gain, conception rate and mortality rates. Animals observe to be after feeding of Hydroponic fodder grass along with open grazing. A total of 40 goats selected at the same age group of 7th months and its divided into four groups each groups 10 goats for On farm trail at Jehanabad district. TO I : Hydroponic fodder of wheat along with open grazing , TO II Hydroponic fodder of maize along with open grazing , TO III Hydroponic fodder of oats along with open grazing and in TO (control group) feeding only open grazing. The highest body weight gain after feeding of hydroponic maize and oats fodder grass along with open grazing (9.7Kg) at the age of 8 to 9

months in TO I &TOII.as comparison to TOI and control groups (9.5Kg) The conception rate of goats was found 100% in both groups.

Key words: Hydroponic, fodder, goats, breeding

NS-T1-39

BACKYARD POULTRY FARMING: RURAL ENTERPRISE

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Indian agriculture sector contributes 28 per cent to the gross domestic production income (GDP) in India, among which 17% of income from poultry. The population of land less in Jehanabad District, Bihar is predominantly schedule tribal in nature. Non-vegetarian food pattern is huge demand for meat and egg but the production is poor due to rearing of livestock is traditional method. On the basis need, high production potential poultry bird, Vanaraja & Grampryia, has been introduced and popularized as a sustainable livelihood for rural and schedule areas.Selection of six villages in the Jehanabad district and each village 20 farmers were selected on the basis of skill based trained of backyard poultry farming. Participants enriched with sound knowledge were distributed with 25 Vanaraja & Grampriya chicks per person free of cost under front line demonstration mandate of KVK, Jehanabad. Vanaraja & Grampriya chicks for distribution among farming community were procured from Poultry. Periodical visits were made to beneficiaries units for health check-up as well as to collect information on growth performance and egg production potential of Vanaraja & Grampriya chicks breed. In this present study was found most significantly variation in sexual maturity of different groups of poultry birds. Vanaraja matures at the age of 141.62 days,Grampriya at 158.32 days and Desi bird at 186.47 days. The higher body weight gain and early age of sexual maturity in crosses compare to indigenous birds may be because of genetic inheritance of Vanaraja birds prevailing in crosses. Egg production and egg weights determine the success of poultry enterprise. The pullet egg weight of Vanaraja, Desi and Grampriya were 38.75 g,30.82 g & 34.94 g,Egg weight at 40 weeks of age were 55.87g,42.89 g & 51.26 gand increase in egg weight were 17.12g, 12.07g & 15.42 g, respectively. Egg weight at first lay and at 40 weeks of age was significantly ($p < 0.05$) varied in crosses compare to their parents. The concluded that the Vanaraja & Grampriya as compared to Desi birds are characterized by faster growth, a greater number of bigger sized eggs, thrives well under low input system, resistance to most of the diseases, and requires small space, minimum labour force and investment and aid to self-employment and income generation.

Keywords: Backyard poultry farming, livestock, traditional method

NS-T1-40

SUGARCANE SETTLING TRANSPLANTING TECHNIQUE WITH INTERCROPPING FOR SUSTAINABLE DOUBLING OF FARMERS INCOME

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Intercropping is growing of two or more crops simultaneously on the same piece of land with a definite row pattern. The main concept of intercropping is to get increased total productivity per unit area and time, besides equitable and judicious utilization of land resources and farming inputs including labour. Many successful intercropping systems have been evaluated through out of the world, to get maximum production from the small land holdings. Mono-cropping is less economical to meet the farmers need. Doubling of farmers' income, the flagship programme of the present government, can be achieved by increasing the productivity and reducing the cost of cultivation. Transplanting sugarcane single-bud/ bud-chip settlings can save seed cane requirement up to 80 per cent besides providing healthy plants and good field establishment. It is less expensive

and labour saving in comparison with conventional sett planting. This method also reduces the initial water requirement of the crop and reduces crop duration in main field. Transplanting sugarcane settlings in wider row spacing provides more space and sunlight for a longer duration which increases cane productivity, and also facilitates intercropping and mechanization of sugarcane agriculture from transplanting to harvesting. The data were recorded from farmer's field. Progressive farmers adopted sugarcane settling transplanting technique with intercropping of sugarcane + potato, sugarcane + field pea, sugarcane + lentil and sugarcane + wheat for higher production, income and their livelihood security. He also adopted other package and practices with proper insect-pest and disease management as per suggestion of KVK scientists. He harvested 5250 qt production of sugarcane including intercropped yield from 15-acre lands during 2020-21. He also harvested 79 qt. produce (paddy and wheat) during 2020-21. Farmers received net returns of Rs. 978750/- and Rs. 80700/- from sugarcane STT with intercropping and paddy and wheat, respectively during 2020-21. It was 312.11 and 54.60 per cent more over previous baseline period. The outcome of these new technology for higher sugarcane production inspired the farming communities to replace their conventional method of transplanting/sowing technique with resistance high yielding varieties which are being cultivated. The partner farmers and neighboring farmers were fully convinced about sugarcane settling transplanting technique (STT) with intercropping of short duration and short statured crop like potato, field pea, lentil and wheat.

Keywords:Sugarcane, intercropping, doubling farmers' income

NS-T1-41

INTERCROPPING WITH VEGETABLE CROPS ON INCIDENCE OF SHOOT BORER, *CHILO INFUSCATELLUS* IN SUGARCANE

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Sugarcane (*Saccharum officinarum* L.) is one of the important commercial crops in the world and holds a prominent position as a cash crop. Sugarcane is grown in subtropical and tropical regions of the world in a range of different climates from hot dry environment to cool and moist environment at higher elevations. Sugarcane producers take advantage of this by growing various short-duration crops such as spices, pulses, vegetables, and so on as intercrops to provide intermediate returns, as tiny sugarcane growers cannot wait a long time to get a financial return from a single sugarcane crop. Sugarcane is an important commercial crop around the world and is ideal for intercropping. Intercropping is a strategy for increasing diversity in an agricultural ecosystem. Intercropping systems promote ecological balance, resource usage, product quantity and quality, and reduce insect, disease, and weed damage. The most common varieties of intercropping include row, mixed, strip, and relay. Intercropping improves crop output by promoting faster growth, reducing weeds, pests, and diseases, and maximizing resource utilization. Intercropping reduces insect and disease damage compared to pure cropping due to the second crop species attracting pests and pathogens. Additionally, intercropping crops have a complementing effect and help control weeds. The use of leguminosae plants in intercropping promotes soil fertility due to the increased amount of biological nitrogen fixation. The data were recorded from farmers' participatory demonstrations of sugarcane intercropping with garlic, onion and coriander, it reduced the incidence of shoot borer (*C. infuscatellus*) on sugarcane from 8.20 to 9.50%. In general all the intercrops gave suppressing effect on dead hearts due to shoot borer and percent incidence. Lowest percent incidence of dead hearts due to shoot borer was recorded in sugarcane + garlic followed by sugarcane + onion and sugarcane + coriander. Highest cane yield of 950.50 q/ha was recorded in sugarcane + coriander plots followed by sugarcane + onion (880.80 q/ha) and sugarcane + garlic (775.60 q/ha).

Keywords:shoot borer, vegetable, intercropping

NS-T1-42

SUGARCANE INTERCROPPING WITH AUTUMN PLANTED VEGETABLE CROPS: A WAY TOWARDS SUSTAINABILITY OF FARMERS' INCOME

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Intercropping is the practice of cultivating two or more crops on the same plot of land in a specific row arrangement. The primary goal of intercropping is to maximize total productivity per unit area and time while also utilizing land resources and farming inputs, including labor, in an appropriate and judicious manner. Many successful intercropping systems have been examined around the world to maximize productivity from tiny landholdings. Transplanting sugarcane settlings in wider row spacing provides more space and sunlight for a longer duration which increases cane productivity, and also facilitates intercropping and mechanization of sugarcane agriculture from transplanting to harvesting. The intercrops and cultivars selected should be of dwarf type with compact canopy and short duration. In general, the optimal row spacing for autumn-planted sugarcane is 90 cm, which is extensively used by farmers, while larger row spacing is an option. The sugarcane settling transplanting technique manually with normal planting spacing of 5 x 2 feet (row x plant) distance in a paired row and zig-zag (5000 settling/acre) and also at 4 x 1.5 feet (row x plant) distance in a single line (8000 settling/acre) is followed by farmers for intercropping. Wider row spacing allows for intercropping without reducing cane production, increasing the system's total productivity and profitability. Because of the scarcity of manpower in sugarcane farming, wider row spacing has become an important agronomic concern when using mechanization. Cane sown in the autumn season germinates before the start of winter and remains in the field without much development until spring arrives. During this period, there is little need for cane as a growth resource. This allows for the cultivation of any *rabi* crop as an intercrop with autumn-planted sugarcane. Several progressive farmers of district West Champaran, Bihar is being adopting sugarcane settling transplanting technique with intercropping of sugarcane + potato, sugarcane + field pea, sugarcane + cauliflower and sugarcane + coriander for higher production, income, enhance natural resources use efficiency and their livelihood security also. The data were recorded by KVK technocrats from farmer's field it was found that significantly higher numbers of tillers were recorded under the combination of sugarcane + potato, sugarcane + cauliflower, sugarcane + vegetable pea and sugarcane + coriander when compared with over base year data and sole crops also. The farmer used to get higher production and income i.e. 50 - 86.04% to 73.43 - 75.72% with sugarcane + potato crop, 80-100% to 150.50- 258.33% with sugarcane + coriander and 60.00-84.37% to 42.50-66.66% with sugarcane + vegetable pea, respectively as compare to base year data. Intercropping in sugarcane crop has indicated more benefits in terms of net profits mainly resulting reduces cost of cultivation, reduction of incidence of insect pests and diseases and greater resource utilization and fulfils the diversified needs of the farmers.

Keywords:sugarcaneintercropping, sustainability, autumn

NS-T1-43

INTERCROPPING POTATOES AND MAIZE: A SUSTAINABLE PEST CONTROL STRATEGY FOR CLIMATE-RESILIENT FARMING

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Climate change is one of the most significant threats to the agricultural sector's productivity and long-term growth in Bihar, owing to moderate to severe water stress, droughts, and temperature fluctuations. Climate change may increase the prevalence of insect pests and illnesses, which reduce crop yield. Chemical controls

are the only approach now used by farmers, who rely on synthetic organic insecticides to manage insect pests and illnesses in crops. This raises the likelihood of environmental contamination, biodiversity loss, health risks, natural enemy extinction, and the development of insecticide resistance. To prevent the negative impacts of chemical pesticides, eco-friendly techniques such as intercropping and strip cropping are helpful for insect and disease management in crops. Intercropping of potato with maize has demonstrated by KVK, Narkatiaganj in an area of 30 acre in two villages of district West Champaran, Bihar under the Climate Resilient Agriculture programme. Intercropping of potato with maize play an important role to reduces the potato tuber moth population by increasing several natural enemies including parasitoids (e.g., *Copidosoma koehleri* Blanchard; *Diadegma pulchripes* (Kokujev); *Temelucha decorate* (Gravenhorst); *Bracon gelechiae* Ashmead) and predators (e.g., *Coccinella septempunctata* Linnaeus; *Chrysoperla carnea* Stephens;*Orius albidipennis* (Reuter). The practice of intercropping of potato with maize markedly reduces the incidence and rate of disease development of bacterial wilt (*Pseudomonas solanacearum*) and Rhizoctonia rot (*Rhizoctonia solani*) in the potato crop due to the effect of increased distances between individual potato plants, their spatial arrangement and the presence between potato plants of root systems of other plant species, all of which resulted in a reduction in plant□to□plant transmission, via the roots. Intercropping also minimizes the chances of total crop failure while ensuring income from some crops in the event of catastrophic weather occurrences. It also decreases soil, water, and nutrient loss through effective ground cover, hedge growth, and blocking of runoff during heavy rains. Thus, intercropping provides a long-term adaptation to climate change, particularly to extreme weather events such as temperature increases, floods, and droughts, for small-scale farmers.

Keywords: Potatoes, Maize, climate-resilient farming

NS-T1-44

NATURAL RESOURCE MANAGEMENT UNDER AGRI-DIVERSIFICATION AND ECO-REGIONAL FARMING

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Natural Resource Management (NRM) is essential for sustainable agriculture, promoting Agri-diversification and eco-regional farming. Agri-diversification integrates multiple crops, livestock, and agroforestry systems to enhance productivity, resilience, and ecological stability. Eco-regional farming tailors agricultural practices to specific environmental conditions, optimizing resource use while minimizing environmental degradation. These approaches help conserve biodiversity, improve soil fertility, and enhance water retention, reducing reliance on chemical inputs and mitigating climate variability. A key component of sustainable agriculture is the use of locally adapted seed varieties and Indigenous Technical Knowledge (ITKs). Indigenous seed varieties have evolved over centuries to adapt to local conditions, offering benefits such as climate resilience, biodiversity preservation, minimal resource requirements, and high nutritional value. In contrast, improved seed varieties—developed through selective breeding, hybridization, or genetic modification—offer advantages such as higher yields, disease resistance, and better market value. ITKs, passed down through generations, play a crucial role in resource management, sustainable farming practices, and environmental conservation. Traditional techniques like mixed cropping, intercropping, organic pest control, soil conservation, and water-saving methods contribute to sustainable food production and ecological balance. By integrating NRM, Agri-diversification, eco-regional farming, indigenous seed varieties, and ITKs, sustainable agriculture can be strengthened, ensuring food security and long-term environmental stability. This approach supports enhanced livelihoods, resilience to climate change, and a balanced ecosystem for future generations.

Keywords: Natural resource management, agri-diversification, eco-regional farming, indigenous seed varieties, sustainable agriculture.

NS-T1-45

INTEGRATED FARMING SYSTEM FOR A SUSTAINABLE FUTURE AND ENHANCED LIVELIHOOD

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Integrated farming system (ifs) is a holistic farming approach that combines crop production, animal husbandry, aquaculture, and horticulture to enhance agricultural productivity, sustainability, and profitability. this study focuses on an ifs model established in 2018 at the kvk campus, designed to support small and marginal farmers. the model, implemented on one hectare, integrates crops, fish rearing, poultry, dairy, and fruit and vegetable cultivation. the ifs system aims to provide practical training, demonstration, and research opportunities for farmers. the results from the study indicate that goat farming within the ifs model provided the highest benefit-cost (b:c) ratio, yielding the maximum net income, followed by fish rearing. the dairy unit, however, showed the lowest b:c ratio among livestock systems. among the vegetable crops, those grown within the ifs system showed a higher b:c ratio compared to traditional crop production. overall, the ifs system resulted in a net income of rs. 5.27 lakh with a b:c ratio of 2.8 and an operational cost of rs. 8.06 lakh after four years of establishment. additionally, the ifs system serves as a resource conservation and waste recycling mechanism. dairy waste water (98,400 litres per year) is used to enhance fish pond productivity, while solid waste (1.3 tons/year) and crop residues (0.8 tons/year) are converted into vermicompost to improve soil health for crop and vegetable production. the findings highlight the economic and environmental benefits of ifs, suggesting its potential as a sustainable and profitable farming model for rural development.

Keywords: Integrated farming system, sustainability, benefit-cost (b:c) ratio, profitable farming model

NS-T1-46

VEGETABLE-BASED CROP DIVERSIFICATION FOR AGRICULTURAL RESILIENCE AND FOOD SECURITY

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Crop diversification is increasingly recognized as a sustainable strategy for addressing the challenges of modern agriculture, including climate change, declining soil fertility, and economic instability among farmers. A well-diversified cropping system enhances resilience by reducing dependence on a few staple crops and mitigating risks associated with climate change and market fluctuations. Vegetable crops have emerged as a crucial component of diversification due to their high economic returns, short growing cycles, and significant contribution to nutritional security. Integrating vegetables into traditional cereal-based systems can enhance farm profitability, optimize resource use efficiency. Furthermore, vegetable cultivation plays a vital role in enhancing food security by improving the availability of micronutrients essential for a balanced diet. The rising demand for fresh vegetables, both domestically and internationally, presents opportunities for smallholder farmers to engage in export-oriented production, thereby increasing rural income. However, the adoption of vegetable crops in diversification strategies faces challenges, including price volatility, perishability, and inadequate storage and transportation facilities. Strengthening extension services, providing financial

incentives, and improving supply chain management are critical for maximizing the benefits of vegetable-based diversification. Overall, crop diversification through vegetable cultivation offers a sustainable approach to achieving economic stability, food security, and environmental sustainability. Policies supporting diversified farming systems can play a significant role in ensuring the long-term resilience of agricultural production.

Keywords: Diversification, resilience, food security, vegetable

NS-T1-47

IMPACT OF CLIMATE CHANGE ON RICE CULTIVATION: ABIOTIC STRESSORS, CHALLENGES, AND ADAPTIVE STRATEGIES

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Abiotic stressors that climate change would exacerbate include heat (high temperatures and humidity), drought, salinity, and submersion in rice cultivation. In order to overcome production losses, each stress is examined in light of the present understanding of the mechanisms causing harm to rice plants as well as potential advancements in crop management methods and germplasm. There are two main ways that higher temperatures can negatively impact rice yields: (i) high maximum temperatures that, when combined with high humidity, cause spikelet sterility and negatively impact grain quality, and (ii) higher nighttime temperatures that may lessen assimilate accumulation. However, because some rice cultivars are cultivated in extremely hot conditions, a vast genetic pool for this characteristic can be captured by developing rice germplasm with enhanced heat resistance. The review includes a comparative analysis of rice in relation to other climate-related crops. Because of its semiaquatic evolutionary background, the rice crop has several special characteristics in terms of vulnerability and adaptation to the effects of climate change. The majority of the world's rice comes from irrigated systems, which are somewhat protected from the immediate consequences of drought. However, the type and condition of the individual irrigation system will determine the buffer effect of irrigation against the effects of climate change. The planned adoption of water-saving irrigation technology will improve rice producing systems' ability to withstand future droughts.We come to the conclusion that while climate change poses significant dangers to rice production, the creation of the required adaptation choices can benefit from the vast array of rice production systems found in a wide range of climates as well as from promising advancements in recent studies.

Keywords: Climate change, abiotic stressors, heat resistance, drought management and water-saving irrigation

SESSION-2

Theme: Integration of modern tools and techniques for problem solving approaches in agri-diversification

NS-T2-01

MACHINE LEARNING-BASED DROUGHT PREDICTION USING SPEI IN AGRA AND BUDAUN DISTRICTS OF UTTAR PRADESH

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Drought prediction is crucial for effective water resource management and agricultural planning. This study employs the Standardized Precipitation Evapotranspiration Index (SPEI) to analyse drought conditions in Agra and Budaun districts of Uttar Pradesh. The SPEI values at different timescales (SPEI-1, SPEI-3, SPEI-6, SPEI-9, and SPEI-12) were computed using the SPEI R package in R-Studio. To enhance drought prediction accuracy, machine learning models, including Random Forest (RF), Support Vector Machine (SVM), and Long Short-Term Memory (LSTM), were applied. The performance of these models was assessed using statistical indicators to determine their suitability for drought forecasting. The results indicate that Random Forest outperformed the other models in predicting SPEI across different timescales. For Agra district, RF achieved the highest coefficient of determination (R^2) values: SPEI-1 = 0.70, SPEI-3 = 0.73, SPEI-6 = 0.70, SPEI-9 = 0.61, and SPEI-12 = 0.99. Similarly, for Budaun district, RF yielded R^2 values of 0.70, 0.68, 0.65, 0.62, and 0.71 for SPEI-1, SPEI-3, SPEI-6, SPEI-9, and SPEI-12, respectively. These findings demonstrate the capability of Random Forest in accurately modelling drought conditions compared to SVM and LSTM. By leveraging machine learning techniques, this study provides valuable insights into drought prediction in the Indo-Gangetic Plains, emphasizing the potential of RF for improving forecasting accuracy. The outcomes can aid policymakers and stakeholders in implementing timely drought mitigation strategies, ensuring sustainable agricultural practices and water resource management in the region.

Keywords: Drought Prediction, Standardized Precipitation Evapotranspiration Index (SPEI), Machine learning, Water Resource Management.

NS-T2-02

SITE SPECIFIC NUTRIENT MANAGEMENT AND ITS EFFECT ON PRODUCTIVITY OF WHEAT

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Wheat is a vital staple crop worldwide, facing significant production challenges, including soil degradation and nutrient deficiencies. Efficient nutrient management practices are necessary to optimize yields, reduce environmental impact, and ensure sustainable production. SSNM involves tailoring nutrient applications to specific soil and crop conditions, optimizing productivity by reducing soil degradation, improving nutrient use efficiency, and promoting sustainable practices. Analysis reveals a positive impact on

soil health and environmental sustainability. SSNM significantly improves wheat yields, quality, and profitability. SSNM's benefits on yields, quality, and profitability are evident, and its effects on soil health and environmental sustainability are analyzed, highlighting its value for sustainable wheat production. SSNM can play a crucial role in addressing wheat production challenges, promoting sustainable agriculture practices, and ensuring food security. By adopting SSNM, wheat producers can optimize yields, reduce environmental impact, and ensure long-term sustainability. The research concludes that Site Specific Nutrient Management (SSNM) in wheat production offers numerous benefits, including improved yields, quality, and profitability. SSNM promotes sustainable agriculture practices, reduces environmental impact, and ensures long-term sustainability. Its adoption can address wheat production challenges, ensure food security, and provide a valuable solution for wheat producers worldwide, contributing to a more sustainable and productive farming system, with significant implications for global food production.

Keywords: Site Specific Nutrient Management, Wheat productivity, Nutrient use efficiency, Sustainable agriculture.

NS-T2-03

EVALUATION OF SPECTRAL INDICES AND CORRELATION BETWEEN CLIMATIC FACTOR WITH LAND DEGRADATION IN BALLIA DISTRICT OF UTTAR PRADESH

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Soil, essential for ecosystems and agriculture, faces severe degradation due to natural and anthropogenic factors. Unregulated land use, industrial expansion, and unsustainable farming alter its physical, chemical, and biological properties, accelerating degradation. This study investigates the spatio-temporal dynamics of land degradation in Ballia district, Uttar Pradesh, India, using multi-temporal satellite remote sensing and GIS techniques. Landsat satellite imagery spanning 26 years (1994–2019) was analyzed to assess soil degradation trends. Specifically, Landsat Thematic Mapper (TM) data from 1994 and 2004, along with Landsat Operational Land Imager (OLI) data from 2016 and 2019, were utilized. These ortho-rectified satellite images were acquired from the United States Geological Survey (USGS) repository. Additionally, topographic maps from the Survey of India (SOI) at a 1:50,000 scale were used for field validation and sample collection. Key remote sensing indices Normalized Difference Vegetation Index (NDVI), Salinity Index (NDSI), and (Water Index) (NDWI) were analyzed using Landsat imagery and CHIRPS data to assess vegetation health, soil salinity, and water distribution. The results indicate increasing land degradation from 1994 to 2019, with NDVI declining in Murli Chhapra (0.119), Bariya (0.135), and Hanumanganj (0.146), while NDSI values increased, highlighting progressive soil deterioration. A decrease in water content leads to increased vegetation cover from 2004 to 2019, as indicated by the inverse relationship between NDVI and NDWI, where NDVI decreased (e.g., Murli Chhapra: 0.119, Bariya: 0.135, Hanumanganj: 0.146) with increasing NDWI values (63.58, 68.71, 59.58), while Nagra showed the highest NDVI (0.449) with higher rainfall (86.12). The findings underscore the critical role of remote sensing in monitoring soil degradation dynamics and informing sustainable land management strategies. The integration of multi-temporal satellite datasets with GIS-based spatial analysis offers a robust framework for assessing land degradation and supporting climate-resilient agricultural practices.

Keywords: Land degradation, Remote sensing, Landsat Operational Land Imager, Thematic Mapper, Normalized Difference Vegetation Index (NDVI).

NS-T2-04

DEVELOPMENT AND FIELD EVALUATION OF A MOTORIZED GIRDLING TOOL FOR LITCHI CULTIVATION

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Litchi (Litchi chinensis S.), a subtropical evergreen fruit tree, holds significant economic importance in India, the world's second-largest producer after China. In 2022-23, India achieved an annual litchi production of 743,000 tons from 100,000 hectares. Despite its commercial value and export potential, the national average yield remains suboptimal, primarily due to the reliance on traditional, labour-intensive practices. Girdling, a critical operation in litchi cultivation, involves the selective removal of bark strips to improve fruit size, yield, and quality. However, conventional girdling methods using serrated knives are time-consuming, labour-intensive, and lack precision, limiting efficiency and profitability.To address these challenges, a motorized girdling tool was developed at ICAR-Central Institute of Agricultural Engineering, Bhopal. The tool features a 12 V battery-operated motor, a circular blade, a safety cover, and an ergonomic handle. Field trials demonstrated that the tool achieves a girdling depth of 2-3 mm and a width of 3-4 mm, meeting the specific requirements of litchi cultivation. The motorized tool reduced the time for a single girdling operation to 2-4 minutes, compared to 10-12 minutes required with traditional methods. Additionally, it saved two-thirds of the operation time, reduced labour requirements by 60%, and decreased drudgery by 67%. Mechanization in litchi cultivation has faced challenges due to fragmented landholdings, limited infrastructure, and low farmer awareness. However, adopting tools like the motorized girdling device can enhance productivity, reduce costs, and improve farmer incomes.

Keywords: Litchi cultivation, mechanization, girdling tool, motorized tool, fruit yield improvement.

NS-T2-05

INTEGRATED ASSESSMENT OF WATER QUALITY IN VARANASI REGION USING MCDM TECHNIQUES

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A comprehensive analysis of water quality is crucial for assessing the suitability of water for various uses, such as drinking, irrigation, and recreation. Qualitative water is a critical importance for public health, ecological balance, and economic development. It encompasses physical, chemical, and biological parameters that define the state of water in a given environment. Quality of water is detreating due various factor such as pollution, industrial discharges, agricultural runoff, and climate change significantly influence water quality, making its monitoring and management a global priority. To effective evaluation of water quality need to develop water quality index. A Water Quality Index (WQI) serves as a valuable tool for simplifying complex water quality data into an easily interpretable format. It consolidates the multiple parameters value into a single numerical value or categorical classification. The categorization of water quality help in decision-makers, stakeholders, and the general public to quickly assess the health of a water body and also help in tracking changes in water quality over time, identifying pollution sources, and formulating effective management strategies. Multi-Criteria Decision-Making (MCDM) techniques have become essential tools in the formulation of WQIs, facilitating the incorporation of complex datasets and diverse water quality parameters. This study explores the integration of subjective and objective MCDM approaches to enhance the robustness

and adaptability of WQI development. Subjective MCDM technique, such as Analytical Hierarchy Process (AHP) and fuzzy logic, preferences to assign weights to water quality parameters. These approaches provide valuable insights into region-specific or use-specific water quality concerns. Conversely, objective methods, such as Entropy weighting, derive parameter weights from intrinsic data variability. In the research subjective and objective based water quality was evaluated and classified which are best to evaluating water quality for specific purposed. The hybrid WQI model is validated through a case study application, demonstrating its ability to produce reliable and context-sensitive water quality assessments. Key findings highlight the advantages of integrating subjective prioritization with objective rigor, ensuring transparency, adaptability, and broader acceptance of the developed index. The leveraging both subjective and objective MCDM techniques, the proposed methodology offers a versatile and reliable approach for WQI development, adaptable to diverse geographic and environmental contexts. The outcomes of this study the subjective approach gives better evaluation of water quality then objective based MCDM technique. This will help to policymakers and environmental managers seeking to improve water resource management strategies.

Keywords: MCDM, AHP, Fuzzy-AHP and Entropy.

NS-T2-06

TRANSFORMING AGRICULTURAL PRACTICES THROUGH ARTIFICIAL INTELLIGENCE

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With the increase in human and animal population, the need for commensurately increased availability of food grains and fodder is urgently being felt all across the world, besides providing large-scale employment and contribution to national incomes. With this in the background, coupled with the need for providing food and nutritional security to the billions of mankind, newer and advanced technologies are being searched and applied for improving productivity on the one hand and controlling crop loss due to biotic and abiotic factors. Artificial Intelligence (AI), with the essential concept of adaptability, rapid performance, precision and cost-effectiveness creates machines that have the inherent capability of learning, reasoning and subsequently behaving like humans, and is exceedingly and quite successfully being applied to the field of agriculture, among others, be that in crop and soil monitoring, disease detection, monitoring and control, precision fertigation through predictive analysis based on the usage of machine vision, machine learning, deep learning and robotics, resulting in improved productivity and concurrently reduced crop loss with reduced human interference and drudgery. AI using historical and big data helps in crop and soil management through systematic study of weather patterns and soil mineralogy with regards to prediction of ideal sowing time, crop spacing, planting depth and the like. It also uses Hyperspectral Imaging (HSI) and Multispectral Imaging (MSI) for real-time monitoring and solutions provisioning of crop health, soil quality including texture, water content and pH, precision farming including need-based irrigation, fertilizer and pesticide application, yield estimation and stress detection, and smart sorting. AI with Convolutional Neural Network (CNN), ML algorithms and DL models with Internet of Things (IoT) based sensors usage allows precise diagnosis of plant diseases, pest infestation and malnutrition on farm assisting in faster and effective decision-making for intelligent and precise application of pesticide and other disease control mechanisms, thereby reducing crop loss. It helps in informed automated data-driven pest detection and quarantine protocols getting applied in real-time. In effect, AI in agriculture has undoubtedly proved itself possessing the potential to transform traditional agriculture to high value agriculture through modern agricultural revolution making it an economically sought after occupation and eco-friendly sustainable enterprise.

Keywords: Artificial Intelligence, Agriculture, IoT, Machine Learning, Deep Learning

NS-T2-07

STUDIES ON OVARIAN FOLLICULAR DYNAMICS AS MODERN TOOLS AND TECHNIQUE FOR IMPROVEMENT OF REPRODUCTIVE EFFICIENCY IN THE INDIGENOUS CATTLE

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The indigenous cattle breeds such as Bachaur, Gangateri, and Sahiwal are medium-sized, dual-purpose breeds primarily found in the northern regions of India. The conservation of these indigenous breeds is essential, and initiatives should be implemented to enhance their reproductive efficiency and productivity. Hence, the present study was designed to study the follicular development pattern, behavioral estrus pattern and intensity, duration of estrus in normal cycling cows as well as using novel estrus synchronization protocols. The total of twelve (n=12) cycling healthy indigenous cattle four cows (n=4) from each breed aged between 3 to 5 years maintained at Centre of Excellence on Indigenous Breed cattle farm, Piprakothi were taken for study. The follicular dynamics studies were done using ultrasonography with trans rectal probe (5.0-7.5 MHz). The behavioral estrus signs, duration and intensity were studied in normal cycling cows and as well as cows treated with novel synchronization protocols like Doublesynch vs Ovsynch protocol. Behavioural estrus signs were observed and recorded in the morning and evening in all the animals under study. In the present study, most common and appreciable physical sign was recorded was vulval swelling (86.7%). However, frequent urination and mucus discharge was observed in more than 70% of the indigenous cows. The other estrus parameters like sniffing, licking, restlessness, reduction in milk yield, hyperemia of vulva and bellowing was also observed as minor signs. Presence of large palpable, medium and small follicles on the ovary was observed in normal cycling cows as well as treated with synchronization protocols.

Keywords: Indigenous cow, Behavioural Estrus, Synchronization protocol, Follicular dynamics

NS-T2-08

APPLICATIONS OF DRONES AND ROBOTICS IN SOIL SCIENCE

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The integration of drones and robotics has revolutionized soil analysis, mapping, and management by providing high-precision, cost-effective, and real-time data. These technologies have significantly enhanced agricultural productivity and soil health monitoring. Drones equipped with multispectral and hyperspectral sensors improve soil property assessment. A study in **China** used UAV-mounted cameras over **200 hectares**, achieving **85% accuracy** in predicting soil organic matter while reducing soil sampling costs by **40%**. Similarly, in **Iowa, USA**, a drone-based soil texture classification across **1,500 acres** attained **93% accuracy**, optimizing fertilization and reducing nitrogen use by **18%** without affecting yield. Drones and robotics also support **Variable Rate Application (VRA)**, optimizing fertilizer and irrigation use. In **Brazil**, NDVI mapping over **500 hectares** of soybean fields enabled site-specific fertilizer application, reducing fertilizer use by **22%** while increasing yield by **10%**. In **India**, robotic soil sensors deployed across **700 hectares** of rice fields monitored real-time moisture and nutrient levels, reducing water use by **30%** and boosting yield by **12%** through automated irrigation. Drones with LiDAR sensors efficiently assess soil erosion and compaction. A **Spanish study** covering **1,200 hectares** identified erosion-prone zones with **95% accuracy**, leading to soil conservation measures that reduced topsoil loss by **27%**. Similarly, in **Germany**, automated penetrometers analyzed compaction in **600 hectares**, improving root growth by **15%** and wheat yield by **9%** through

Controlled Traffic Farming (CTF). Robotic soil sampling systems enhance efficiency and accuracy. An **AgBot in Australia** processed **100 samples per hour** over**300 hectares**, reducing analysis time by **65%** and labor costs by **50%**. In **the Netherlands**, robotic systems achieved **90% accuracy** in real-time soil pH and nitrogen assessments, optimizing fertilizer application and increasing vegetable crop productivity by **13%**. These advancements demonstrate how drones and robotics are transforming soil science, making agriculture more precise, sustainable, and efficient.

Keywords: drones, robotics,topsoil loss, UAV

NS-T2-09

SPATIOTEMPORAL DYNAMICS OF CRY TOXIN EXPRESSION AND LARVAL INFESTATION PATTERNS OF PINK BOLLWORM IN Bt COTTON

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Pink bollworm (PBW) poses a significant threat to cotton cultivation, particularly in the context of *Bacillus thuringiensis* (Bt) cotton, where resistance to Bt cotton has led to outbreaks of PBW in various regions across India. An experiment was conducted at the Agriculture Research Station (ARS) in Dharwad during the 2021-2022 rabi season to elucidate the relationship between PBW larval population and Cry toxin expression in different parts of the cotton plant, along with meteorological factors. Cry1Ac toxin levels were measured in different plant parts, indicating higher concentrations in leaves followed by squares, seed bits, and boll rind. The peak expression was recorded at 80 days after sowing (DAS), gradually decreasing at 100, 120, and 140 DAS. The decreasing trend in toxin content over time indicates a dynamic regulation of Cry1Ac toxin expression in both vegetative and reproductive organs of Bt cotton. Despite the impact of Cry1Ac toxin on PBW larvae, challenges persisted due to increased larval infestation around 90 DAS as Cry toxin levels declined. Field experiments revealed two distinct peaks in larval population at 49th and 50th Standard Meteorological Week (SMW), coinciding with specific weather conditions after 140 DAS, with a negative correlation observed between larval infestation and maximum and minimum temperatures. Notably, no significant negative correlation was found with humidity and rainfall. The observed relationships between Cry toxin levels, PBW larval population, and meteorological factors signifies the need for an integrated pest management (IPM) approach in Bt cotton cultivation. IPM strategies that consider the complex interactions between the crop, pest, and environmental factors can help optimize pest control and ensure sustainable crop production.

Keywords: Bt cotton, Cry protein, Larval population, Pink bollworm, Toxin expression

NS-T2-10

EMBRYO TRANSFER TECHNOLOGY AND IVF IN SAHIWAL COW

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India is top milk producer of the world with 240 MMT of milk production in 2024. Contribution of milk from indigenous cow is low. Farmer preference of indigenous cow is low because of low milk production. But, since last decade demand of milk of indigenous cows has increased and farmers are getting premium price for

indigenous cow milk. Indigenous cow are having good tolerance towards heat stress. Out of fifty-five registered cattle breeds in India, Sahiwal, Gir, Red Sindhi and Tharparkar are dairy breeds of cattle. These indigenous dairy cattle breeds have evolved in arid or semi-arid zone of the country, have physical and physiological adaptation of heat tolerance thus survive and flourish even at high ambient temperature. On other hand, crossbred Holstein Friesian and Jersey cattle don't have such adaptation as they are originated in temperate climate. Keeping in view the above facts Rashtriya Gokul Mission (RGM) projects with the latest advance assisted reproductive technologies (ART) like Embryo transfer and in-vitro fertilization was started for faster improvement and conservation of indigenous bovine breeds and to meet growing demand of milk in domestic and International market. This work is being carried out in RGM Piprakothi, East Champaran centre established under Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar. For Embryo Transfer selected elite donor Sahiwal cows were subjected for superovulatory protocol using FSH hormone (Stimufol inj) Artificial Insemination was done forty eight hours later. Flushing of embryo was done non-surgically on 7th day of Artificial Insemination for retrieval of embryos. Embryos were searched, collected and graded in the laboratory using suitable media. They were transferred in synchronized surrogate cows. A total of 59 embryos were retrieved and were transferred in 50 recipient cows on different dates. Nine Sahiwal calves has been bour using Embryo transfer Technology. Under IVF, donor were super ovulated using Stimufol and oocytes were retrieved from ovaries using ultrasound guided trans-vaginal oocyte aspiration needle. Retrieved oocytes were searched, graded and matured in trigas CO_2 incubator in IVF lab. Actual invitro fertilization was done in matured oocytes and fertilized oocyets were cultured to get 64 cell embryo. Four fresh IVF embryos were transferred in synchronized surrogate cow. Pregnancy was confirmed in two cows. Thus, the IVF technology has been successfully standardized and ready to use for the farmer's field.

Keywords: embryo transfer technology, IVF, Sahiwal

NS-T2-11

OPTIMIZING PHENOLIC EXTRACTION FROM POTATO PEEL USING ULTRASOUND-ASSISTED TECHNIQUE: A RESPONSE SURFACE AND GENETIC ALGORITHM APPROACH

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Potato peels, often considered a waste product during potato processing, are rich in phytochemicals, particularly phenolics. These compounds, known for their antioxidant and antimicrobial properties, offer valuable potential for the food industry. In this study, phenolics were extracted from potato peel using ultrasound-assisted extraction, where key variables such as sonication time (5-25 min), ethanol concentration (0-100%), and extraction temperature (25-65°C) were optimized using a central composite design (CCD). The extraction process was fine-tuned with response surface methodology (RSM) followed by a genetic algorithm (GA) approach to maximize total phenol content (TPC). The optimized conditions for the highest recovery of phenols (621.27 mg/100g dry weight) involved 22.032 minutes of sonication, 61.818°C temperature, and 99.99% ethanol concentration. Ultrasound-assisted extraction proved to be significantly more efficient than conventional solvent extraction, yielding 2.84 times more phenolic compounds. The optimized extraction conditions, along with the predictive model, open up promising opportunities for the food industry, providing products with notable health benefits.

Keywords: phenolic extraction, genetic algorithm

NS-T2-12

USE OF MODERN TECHNIQUES FOR PROCESSING AND VALUE ADDITION TO MAKHANA IN BIHAR.

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Agriculture is crucial to India's economy, contributing significantly to GDPand employing nearly half the workforce. Bihar, a key agrarian state, has shown growth in crop production, especially paddy, maize, and vegetables, but faces post-harvest losses due to limited processing facilities. Makhana (fox nuts) holds economic importance in Bihar, contributing to agriculture and food processing. As a leading producer, Bihar can enhance profitability and support rural livelihoods through value addition. Modern techniques like automated roasting, vacuum packaging, and freeze-drying extend shelf life, reduce waste, and increase market appeal. Value-added products such as flavoured snacks, energy bars, and makhana powder are gaining traction both domestically and internationally. Cultivated mainly in Mithila, makhana farming uses traditional pond-based methods, supporting thousands of farmers. Recent advancements like mechanized harvesting and sustainable water management have boosted productivity and lowered labor costs. Rich in antioxidants, fiber, and magnesium, and potassium, makhana promotes heart health, digestion, and weight management. According to the National Research Center for Makhana, Darbhanga (ICAR), makhana cultivation covers 15,000 Ha, yielding 120,000 MT of seeds and 40,000 MT of pops, with a production value of Rs. 250 Crore at the farmers' end and Rs. 550 Crore at the trader's level. With rising demand for packaged makhana, nitrogen packing is essential to maintain crispness and prevent contamination. Embracing modern processing techniques and expanding market networks can boost farmers' incomes and strengthen makhana's position in the global health food market.

Keywords: Agriculture, Indian economy, Post-harvest losses, Crop production, Mechanised Harvesting

NS-T2-13

EVALUATION OF SPECIALLY DESIGNED GOAT FEEDING MANGERFOR BETTER UTILIZATION OF VALUABLE FEED AND ENHANCING INCOME OF GOAT FARMERS IN WETLAND ECOSYSTEM OF NORTH BIHAR

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The goat farming in north Bihar is very popular among a large section of farming communities belonging to small and marginal categories. The feed of goat comprises of green fodder, dry fodder and concentrate mixture. Apart from grazing, most of the farmers feed their goats on the floor or fixed type of manger similar to large animals. However, by this practice, there is possibility of wastage of valuable feed resource due to soiling by goat manure and browsing habits while feeding. Keeping in view to reduce the feed wastage and promote scientific feeding, a self-standing linear (SSL) feeding manger was designed with a dimension of 5 feet length, 1.5-2 feet width and 2.5 to 3 feet height for group feeding to goats. An experimental trial was conducted to evaluate the SSL goat feeding manger for proper utilization of feed and reducing the feed wastage. A total of 20 goats (adult and growers) were divided equally in two groups viz. group-1: feeding with feeding manger (T) and group-II: without feeding manger. From the study it was found that feed utilization efficiency (%) by goats for green, dry and concentrate mixture using especially designed SSL feeding manger was 80.9, 76.5 and 94.2, respectively. The utilization efficiency in control group was 49.04, 51.5 and 58.77, respectively. The added advantage of using specially designed feeding manger over the control group for reducing feed wastage was 31.9, 25, and 35.4 percent for the respective category of ration i.e. green, dry and concentrate mixture. The total

saving of feed cost was Rs. 1130/goat/year, which can enhance profitability of goat farmers in wetland ecosystem of north Bihar.

Keywords: Concentrate feed, feeding manger, goat rearing, Waterlogged ecosystem

NS-T2-14

MAPPING SOIL QUALITY: A COMPREHENSIVE SQI MODEL FOR KARIJIRAHALLI MICRO-WATERSHED

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The present study aimed to evaluate soil nutrient quality and assess the spatial variability of soil fertility parameters in the Karijirahalli micro-watershed of the Naganahalli sub-watershed, located in Nagamangala taluk, Mandya district, Karnataka, using geospatial techniques during 2023–24. Analytical data were interpreted, and statistical parameters such as range, mean, and standard deviation were calculated for each parameter. The soils were found to be moderately to strongly alkaline and non-saline. Organic carbon content ranged from low to medium, while available nitrogen and phosphorus were at medium levels. Available potassium was high, whereas available sulphur ranged from low to medium. Among the DTPA-extractable micronutrients, zinc and iron were deficient in 50% of the samples, while copper and manganese were present in sufficient amounts. The results indicated that available N, P, S, Zn, and Fe are key soil fertility constraints. Principal Component Analysis (PCA) was used to identify the Minimum Data Set (MDS) from the analyzed soil fertility parameters. The major variables influencing soil quality were pH, available nitrogen, and boron. Two principal components with eigenvalues greater than 1 were significant, explaining 70% of the variance, with Soil Quality Index (SQI) values ranging from 0.15 to 0.84. The study concluded that the SQI, measured using regular grid sampling at a 320 m scale, effectively captured spatial dependence through the ordinary kriging technique, allowing the generation of thematic maps for efficient soil management strategies at the micro-watershed level. The SQI map of the Karijirahalli micro-watershed indicated that 32.82% of the area fell under the low to very low category, 9.14% under the medium category, and 58.03% under the high category.

Keywords: Indicators, Principle component analysis, Remote sensing, Soil quality and Micro-watershed

NS-T2-15

IMPACT OF LASER LAND LEVELLERS IN THE WEST-NORTH REGION OF BIHAR

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In 2022, laser-assisted land levelling (LLL), a precision agriculture-based resource-conserving technology (RCT), was introduced by Krishi Vigyan Kendra (KVK), Gopalganj in the Gopalganj District, West-North region of Bihar, India, to address challenges in the intensive rice-wheat cropping system. This study aimed to assess the potential benefits and impacts of LLL conducted on 300 acres of farmers' fields across five different villages viz. Sipaya, Barraipati, Khemmathiniya, Bishunpura, and Tiwarimathiniya over three consecutive years. The climate resilient agriculture program is being run by KVK Gopalganj in theses villages. Land levelling is a key mechanical input in intensively irrigated farming, improving crop stand, saving irrigation water, and enhancing input use efficiency. A total of 120 farmers from each village (300 farmers per treatment) participated, with each practicing either Traditional Land Levelling (TLL) or Laser Land Levelling (LLL) on a 0.5-acre plot. The on-farm trials showed that LLL significantly led the productivity of the rice-wheat system by 12%, while achieving water savings of 18-20%. These findings highlight the superiority of

LLL over traditional land level ing methods, particularly in enhancing crop yields and optimizing water use. Moreover, the study also identified several barriers to the adoption of LLL, shedding light on the challenges farmers face in implementing this technology. Overcoming these obstacles is essential for promoting widespread adoption and maximizing the environmental and economic benefits of LLL in sustainable farming practices.

Keywords: Laser Land Levelling, Resource Conserving Technology, Crop Productivity, Water Saving

NS-T2-16

BIO-EFFICACY OF UAV (DRONE) FOR MANAGEMENT OF SUCKING PESTS IN WHEAT AND MUSTARD CROP.

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A comparative study was conducted in different crops to study the bio-effectiveness of different insecticides through UAV (Drone) spraying and conventional spraying. The flying height of drone was calibrated at 1m above the crop canopy and flying speed at 4ms^{-1}. The target pest species were wheat Aphid (*Macrosiphum miscanthi)* and mustard aphid (*Lipaphis erysimi*). Three systemic insecticides were undertaken for comparative study of bio-efficacy through drone and knapsack sprayer in two consecutive years. The results revealed that the population of aphids in Wheat was recorded lowest in plots where spraying was done through drone and treated with Spirotetramat 11.01 % + Imidacloprid 11.01 % SC i.e (1.56 nymphs/tiller)(pooled),while in Mustard the plots where spraying methodology was through drones and usage of Thiamethoxam 25% WG had shown lowest aphid population i.e (1.89 nymphs/apical shoot).The efficacy of the insecticides was found to be significantly at par with conventional method as well as other parameters such as time taken, water usage and labour usage was also found to be significantly at par in spraying made through drone.

Keywords: UAV(Drone), sucking pests, bio-effectiveness, conventional spraying, aphid

NS-T2-17

INNOVATIVE TECHNOLOGY AND SOLUTIONS FOR WASTE MANAGEMENT

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Waste Management is a global issue due to fast urbanization, industrialization, and population growth. Traditional waste management options like incineration or land filling causes environmental pollution and

resource depletion. Such a framework is required with modern technologies and sustainable solutions to manage waste effectively. To combat these challenges there are need of investigating groundbreaking methods such as the use of the Internet of Things and artificial intelligence in smart waste management systems and waste sorting, as well as microbial technologies in bio-waste treatment. The waste is being handled in a circular economy and sustainable way with the aid of a developing range of technologies & solutions. The Internet of Things allows for the real-time monitoring of waste levels in smart bins the optimization of collection routes, and engaging citizens by issuing open data through web or mobile applications. In present era waste management also adopts modern approaches like plasma gasification, and microbial fuel cells. Block chain technology is being signalled as a revolutionary instrument that may provide the necessary transparency and traceability throughout the waste management lifecycle, and hence increase accountability and efficiency. The newer methods include plasma gasification, pyrolysis, and chemical recycling, and are assessed for their ability to treat waste to create useful resources like energy and building blocks. Different case studies from urban and rural contexts illuminate how collaboration between the public and private sectors, policy frameworks, and community involvement catalyse innovation. Data incorporation through these avenues leads to improved systems, optimized to serve society, which can sometimes play a role in producing a cleaner and greener future. In future adoption of smart technologies, IoT, and block chain in waste management may be lead in a new era of efficient, transparent, and sustainable waste practices, addressing the global issue of waste management while advocating for environmental sustainability.

Keywords: Waste Management, innovative technologies, sustainable solutions, resource recovery

NS-T2-18

MULTIPLE USE OF WATER MODEL: A SUSTAINABLE APPROACH FOR ENHANCING WATER PRODUCTIVITY AND CLIMATE RESILIENCE IN EASTERN INDIA

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India faces severe water stress, with just 4% of the world's freshwater resources supporting 17% of the global population. Agriculture accounts for 70-85% of water usage, mainly for rice-wheat systems, leading to rapid groundwater depletion and declining surface water availability. Inefficient irrigation methods and low crop-water productivity further threaten sustainable agriculture. In Eastern India, the challenges are particularly acute due to high dependence on monsoonal rainfall and frequent droughts and floods, necessitating innovative water management solutions to enhance agricultural productivity and resilience. To address these challenges, ICAR Research Complex for Eastern Region, Patna, implemented a 'Multiple Use of Water' (MUW) model at its research farm. The model integrates several key components to optimize water use and improve agricultural sustainability. Water harvesting structures, such as ponds, capture and store rainwater, ensuring its availability during dry spells and contributing to groundwater recharge. Smart irrigation systems, including drip and sprinkler technologies, enhance water-use efficiency, reducing wastage while maintaining crop productivity. Composite fish farming maximizes the productivity of stored water, providing an additional income source for farmers. Crop diversification and agro-aqua land configurations, such as integrating short-duration crops with fish farming, enhance income stability and reduce risk. The model also emphasizes resource conservation practices like reduced tillage and residue management, which improve soil health and minimize greenhouse gas emissions. Renewable energy solutions, particularly solar pumps, ensure sustainable and cost-effective water extraction. Additionally, climate-resilient cropping systems are promoted to enhance productivity under varying climatic conditions. This integrated approach not only addresses water scarcity and waterlogging issues but also ensures year-round productivity, income generation, and climate resilience. The MUW model serves as a replicable strategy for sustainable agricultural intensification and water resource management in eastern India.

Keywords: Multiple Use of Water, Water harvesting, Smart irrigation, Composite fish farming, Sustainable agriculture.

NS-T2-19

STUDY OF STRUCTURAL PROPERTIES OF MAGNETIC WATER THROUGH SCANNING ELECTRON MICROSCOPE **SEM AND** X-RAY DIFFRACTION **IMAGE**

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The structural properties and crystallography of water samples with electrical conductivities of 1 dS m^{-1} and 4 dS m^{-1}, in both non-magnetized and magnetized water states, were investigated. Using a Scanning Electron Microscope (SEM) to capture images generated from the intensity of back-scattered electrons at different resolutions (30 µm, 3 µm, and 1 µm) for non-magnetized and magnetized saline irrigation water at both conductivity levels, it was observed that the magnetic field induced a change in the surface morphology of magnetized saline water, resulting in a smoother surface compared to non-magnetized saline water. In the X-Ray Diffraction analyses, observed that after passing the water through a magnetic field led in to a high resonance effect, causing water molecules to collide and break, thereby reducing the size of the water particles. The water particles exhibited a crystalline nature, with the majority being smaller in size compared to non-magnetized water samples at both conductivity levels of 1 dS m^{-1} and 4 dS m^{-1} in both non-magnetized and magnetized water states. The use of this magnetized water for irrigation in agriculture helps in improving the soil heath along with quality and increasing in production of agricultural produce.

Keywords: X-Ray Diffraction, SEM, electrical conductivity

NS-T2-20

PERFORMANCE OF HERBICIDE APPLICATION THROUGH AGRICULTURAL DRONES AND ITS EFFECT ON GROWTH AND PRODUCTIVITY OF WHEAT

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The integration of agricultural drones for herbicide application has revolutionized modern farming by enhancing efficiency and precision. This study evaluates the performance of drone-based herbicide application and its impact on the growth and productivity of wheat (*Triticum aestivum*). A comparative analysis was conducted between conventional ground spraying and drone-based spraying methods, focusing on herbicide efficacy, weed control, crop health, and yield improvement. Field trials demonstrated that drones provided uniform coverage with reduced chemical usage, minimizing environmental contamination and promoting sustainable weed management. The targeted application reduced herbicide drift and ensured optimal absorption by the weeds, leading to improved control of invasive species. Additionally, drone application significantly lowered soil compaction, preserving root aeration and water retention, which are critical for wheat growth. Growth parameters, including plant height, tillering, and biomass accumulation, showed notable improvements under drone-sprayed conditions. Moreover, wheat grain yield and quality were enhanced due to reduced crop stress and optimized weed suppression. The cost-effectiveness of drone-based spraying was evident through reduced labour and input costs, making it a viable alternative for large-scale farming. This study highlights the potential of drone technology in precision agriculture, demonstrating its effectiveness in increasing wheat productivity while promoting environmental sustainability. The findings support the adoption of drone-based herbicide application as a transformative approach to modern wheat farming. Further research on optimizing spray parameters and integrating AI-driven decision-making can enhance its efficiency and applicability across diverse agro-climatic conditions.

Keywords: Agriculture drones, Herbicide, Precision Agriculture, Wheat Management, Sustainability.

NS-T2-21

PERFORMANCE OF HERBICIDE APPLICATION THROUGH AGRICULTURAL DRONES AND ITS EFFECT ON GROWTH AND PRODUCTIVITY OF RABI MAIZE

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The adoption of precision agriculture technologies, including agricultural drones, has revolutionized modern farming practices. This study evaluates the performance of herbicide application using agricultural drones and its effects on the growth and productivity of rabi maize (Zea mays L.). A field experiment was conducted to compare drone-sprayed herbicides with conventional spraying methods in terms of weed control efficiency, crop growth parameters, and yield performance. Key parameters such as weed suppression, plant height, leaf area index, chlorophyll content, and grain yield were analyzed. Results indicated that drone-based herbicide application provided uniform spray coverage with reduced herbicide drift and higher weed control efficiency compared to conventional methods. The improved precision in herbicide application contributed to enhanced plant health, increased nutrient uptake, and improved physiological traits of rabi maize. Additionally, drone application reduced labour requirements, minimized herbicide wastage, and promoted environmental sustainability by reducing excessive chemical runoff. The study also observed a significant increase in maize grain yield under drone-sprayed herbicide treatment, attributed to better weed suppression and optimized crop growth conditions. Furthermore, operational efficiency, cost-effectiveness, and time savings associated with drone technology make it a promising alternative to traditional herbicide application methods. In conclusion, the findings suggest that agricultural drones can enhance the efficiency of herbicide application, leading to improved growth and productivity of rabi maize. Widespread adoption of this technology could contribute to sustainable agriculture by optimizing chemical inputs, reducing manual labour, and improving overall farm profitability. Future research should focus on refining drone-based spraying techniques for different agro-climatic conditions and crop varieties.

Keywords: Agricultural drones, herbicide application, rabi maize, weed control, precision agriculture, crop productivity.

NS-T2-22

INTEGRATION OF MODERN TOOLS AND TECHNIQUES FOR PROBLEM SOLVING APPROACHES IN AGRI-DIVERSIFICATION

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Agricultural diversification is vital for ensuring food security, economic resilience, and environmental sustainability in the face of climate change, resource limitations, and market fluctuations. The integration of advanced technologies has revolutionized diversification strategies, optimizing resource utilization, improving yields, and enhancing resistance to biotic and abiotic stresses. This study examines the role of precision agriculture, remote sensing, artificial intelligence (AI), biotechnology, and data analytics in driving agricultural diversification. Precision agriculture, enabled by GPS-guided machinery and IoT-based monitoring, optimizes inputs such as water, fertilizers, and pesticides, reducing waste and enhancing productivity. Remote sensing and geographic information systems (GIS) facilitate soil health analysis, climate monitoring, and the identification of optimal cropping patterns. AI-powered decision support systems process large datasets to provide real-time recommendations for crop selection, pest management, and yield forecasting. Additionally, biotechnology innovations, including genetically modified crops and tissue culture, expand agricultural options and improve resilience against pests, diseases, and environmental

stresses.Blockchain technology and smart supply chain solutions enhance market access, ensuring transparency and efficiency for diversified farming systems. Financial tools such as digital payment platforms, crop insurance, and climate-smart investments further promote economic sustainability. Moreover, these technological interventions support sustainable agricultural practices like agroforestry, intercropping, and organic farming, contributing to biodiversity conservation and ecological balance. Despite these advancements, barriers such as high implementation costs, digital illiteracy, and inadequate infrastructure hinder widespread adoption, particularly among smallholder farmers. Addressing these challenges through policy support, capacity-building initiatives, and public-private partnerships can facilitate the transition toward a technology-driven, diversified agricultural economy. This study underscores the transformative potential of technology in agricultural diversification, advocating for an integrated approach that merges innovation, policy reforms, and farmer participation to achieve sustainable and resilient food systems.

Keywords: Agricultural diversification, precision agriculture, remote sensing, artificial intelligence, blockchain, sustainability, food security, climate resilience, smart farming.

NS-T2-23

DESIGN AND DEVELOPMENT OF LOW-COST EQUIPMENT AND MACHINERY FOR WATERLOGGED FARMING CONDITIONS

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Waterlogged conditions in agriculture, particularly in lowland rice ecology, pose significant challenges to mechanization. To address this issue, our study focuses on the development of solar-powered and battery-operated agricultural equipment, enhancing efficiency and sustainability in farming.A solar-powered seed drill was designed with a 24V, 350W DC motor, 100W solar panel, 24V 30Ah battery, and an MPPT solar charge controller, ensuring optimized power utilization. Field trials in Piprakothi recorded an energy conversion efficiency of 33.55%, with a charging time of 6–8 hours under prevailing solar radiation. The seed drill demonstrated effective seed placement with minimal manual intervention, making it a viable mechanized alternative for small farmers.Additionally, a battery-operated weeder was developed using a 24V DC motor and a chain and sprocket transmission system to facilitate weed removal in submerged conditions. Performance evaluations confirmed its reduced power consumption, improved operational efficiency, and enhanced field coverage, making it a promising solution for weed management in waterlogged fields.The adoption of such low-cost, renewable-energy-powered machinery can significantly improve farm productivity, reduce labor dependency, and promote sustainable mechanization in North Bihar's waterlogged agricultural landscapes. This research contributes to the broader goal of advancing climate-resilient and resource-efficient farming technologies for marginal and small-scale farmers.

Keywords: Solar-powered seed drill, battery-operated weeder, lowland rice ecology, mechanization, sustainable farming, waterlogged conditions

SESSION-3

Theme: Natural Resource Management under agri-diversification and eco-regional farming

NS-T3-01

EFFICACY OF HERBICIDES ON CHICKPEA (CICER ARIENATUM) PRODUCTION

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Chickpea is one of the important legume crops occupying an area of more than 44 countries across five continents. An experiment was conducted at Research Farm of Birsa Agricultural University, Ranchi, and Jharkhand during Rabi, 2021-2022 to quantify the response of pre and post emergence herbicides with the main emphasis to find out the effect of herbicides on growth, yield, weed dynamics and economics of chickpea. The experiment was laid out in randomized block design (RBD) and replicated thrice with the variety Birsa Chana-3 under irrigation condition. The treatments consists of oxyfluorfen 150 g/ha (T_1), oxyfluorfen 250g/ha (T_2), quizalofop-p-ethyl 100g/ha at 21 DAS (T_3), Propaquizafop 100g/ha at 21 DAS (T_4), topramezone 20.6g/ha at 21 DAS (T_5),oxyfluorfen 150g/ha (PE) fb quizalofop-p-ethyl 100g/ha at 15-20 DAS (PoE) (T_6),oxyfluorfen 150g/ha(PE) fb propaquizafop 100g/ha at 15- 20 DAS (PoE) (T_7), oxyfluorfen150g/ha (PE) fb topramezone 20.6g/ha at 14-21 DAS (PoE) (T_8), imazethapyr 60 g/ha (PoE) at 21 DAS (T_9),Manual Weeding (Weed free) at 25 DAS and 45 DAS (T_{10}),Weedy Check(T_{11}).The soil was clay loam, acidic in reaction(5.7),low in available nitrogen (247.4kg/ha), medium in available phosphorous(18.92kg/ha),medium in available potassium(145.30kg/ha),medium in organic carbon(4.5g/kg soil),low in available Sulphur (22.5kg/ha). Experimental field was infested with two categories of weeds i.e., narrow leaved weed and broad-leaved weeds covering four families. Altogether 8 weed species were recorded. Among narrow-leaf, *Cyanodon dactylon*, *Avena fatua and Phalaris canariensis and in broad-leaf, Digera arvensis, Portulaca oleraceae, Phyllanthus niruri, Melilotus indica, Amaranthus virdis* weeds were dominant. Results revealed that the application of oxyfluorfen 150 g /ha (PE) fb topramezone 20.6 g/ha at 14-21 DAS exhibited significantly lowest total weed density at 30 and 60 DAS (220.66 and 481.11/m^2 respectively), total weed dry matter (6.65 and 25.30g/m^2), highest weed control efficiency (59.19 and 66.11%) among herbicides and was significantly similar to two manual weeding at 25 DAS and 45 DAS. Similarly, application of oxyfluorfen 150g/ha (PE) fb topramezone 20.6g/ha at 14-21 DAS recorded highest growth parameter of chickpea viz. plant height (59.33 cm), dry matter accumulation at 90DAS (305.00g/m^2), maturity (409.81g/m^2),crop growth rate during 30-60DAS (5.36 g/m^2 /day),yield attributes viz. Number of branches/plant (21.77) and number of pods/branch(1.74),number of seeds/pod(1.78 seeds),number of pods/plant(36.98 pods),1000 seed weight (290.5g),grain yield (19.15q/ha),straw yield (25.27q/ha) and net return (Rs.63691/ha) among herbicides and was significantly similar to two manual weeding at 25 and 45 DAS.On the basis of one year of experimentation, it may be concluded that, application of Oxyfluorfen 150g a.i/ha (PE) fb Topramezone 20.6g a.i/ha at 14-21 DAS proved to be effective in suppressing weeds and recorded maximum grain yield (19.15q/ha) and net return (Rs. 63691/ha) with B: C ratio (1.80) of chickpea under medium land situation in irrigated condition (3 irrigations) of Jharkhand.

Keywords: Herbicides, Chickpea

NS-T3-02

CLIMATIC VARIABILITY AND TRENDS OF EXTREME WEATHER INDICES IN NORTH-WESTERN PLAIN AGRO-CLIMATIC ZONE

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The daily weather data (1970- 2020) of minimum temperature, maximum temperature and rainfall was used to study climatic variability, dry & wet spell probability analysis and extreme weather indices in North-western plain agro-climatic zone. Modified Mann-kendall test was performed for trend analysis in R software (package "climdex.pcic"). Eight rainfall indices namely the Very wet days (R95p), Max 1-day precipitation amount (RX1day), Max 5-day precipitation amount (RX5day), Number of heavy precipitation days (R10), Number of very heavy precipitation days (R20), Consecutive dry days number of (CDD), Consecutive wet days (CWD) and Simple daily intensity index (SDII) were selected from those listed by the World Meteorological Organization Expert Team on Sector-specific Climate Indices (WMO ETSCI, http://www.wmo.int/pages/prog/wcp/ccl/opace/opace4/ET-SCI-4-1.php). The annual minimum temperature varied from 16.4– 19.5 ^{o}C from northern to southern part of the study area and showed significant increasing trend. The annual maximum temperature varied from 27.5-31.6 ^{o}C and showed significant increasing trend in north and north eastern part of the study area. There is high variability in rainfall was observed & it varied from 650-1400 mm. the p value showed no significant increasing or decreasing trend in rainfall in most parts of the study area. However, three district namely, Bareily, Gautam Budh Nagar, Bulandshar showed significant increasing trend. The analysis of consecutive dry and wet spell revealed that there were 80% chances that four consecutive dry days would occur first 23 weeks of the year. The maximum chances of four consecutive wet days (50-90%) were maximum from 24th week to 38th week. Thereafter from 37-38th week onwards again there were 90% probability of occurrence of four consecutive dry days were observed. In case of extreme temperature indices, the significant increasing trends were found for summer days, tropical nights and warm nights. Significant decreasing trends were noticed for cool nights, diurnal temperature range and cold spell duration indicator. In case of extreme rainfall trends, significant decreasing trends were observed for consecutive wet days for most of the districts. The heavy rainfall evets also showed significant decreasing trends.

Keywords: Climate, Extreme weather indices, trend analysis

NS-T3-03

CLIMATE – SMART STRATEGY FOR SUSTAINABLE FOOD PRODUCTION USING TRADITIONAL AGRICULTURE

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Sustainable food production is a critical challenge in the 21st century due to climate change, population growth, and resource depletion. While the Green Revolution increased food production, its reliance on high-input farming led to soil degradation, biodiversity loss, and greenhouse gas emissions. The excessive use of fossil fuels, agrochemicals, and mechanization has compromised agroecosystem integrity, necessitating a transition to climate-resilient agricultural practices. Traditional agriculture, rooted in indigenous knowledge

and region-specific practices, is gaining recognition for its role in climate change mitigation and adaptation. Studies indicate that methods such as agroforestry, integrated crop-livestock systems, crop rotation, cover cropping, and organic composting enhance soil health, biodiversity conservation, and carbon sequestration while reducing synthetic inputs. These practices not only strengthen ecosystem resilience but also improve food security and support rural livelihoods by lowering input costs and promoting self-sufficiency. Integrating climate-smart agriculture (CSA) with traditional farming systems offers a viable pathway toward sustainable food systems. However, policy gaps, market limitations, and knowledge barriers hinder large-scale adoption. Policymakers must design frameworks that incentivize agroecological approaches, strengthen farmer education, and bridge traditional knowledge with modern innovations. Further research is needed to quantify the climate resilience of traditional farming across agroecological zones. By leveraging indigenous wisdom alongside scientific advancements, agriculture can acheive a sustainable, resilient, and climate-adaptive model, ensuring food security while preserving ecological integrity.

Keywords: agroecology, climate-smart agriculture, sustainable food Systems, traditional agriculture.

NS-T3-04

ANALYSIS OF BROWNTOP MILLET-BASED INTERCROPPING SYSTEM IN THE NORTHERN TRANSITION ZONE OF KARNATAKA

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A field experiment was carried out at the Main Agricultural Research Station, UAS, Dharwad, during the *kharif* season of 2021-22 to evaluate the performance of browntop millet intercropped with legumes. The study was designed in a randomized complete block design with thirteen treatments, each replicated three times. The treatments included intercropping of browntop millet with groundnut, soybean, green gram and black gram in 4:2 and 2:1 row ratio, along with sole crops of each species. The results indicated that the sole browntop millet was recorded significantly higher grain yield (973.61 kg ha^{-1}), while among intercropping systems, browntop millet + groundnut of 4:2 row ratio was recorded the higher grain yield (674.31 kg ha^{-1}). The sole groundnut recorded significantly higher browntop millet equivalent yield (BMEY) of 3689 kg ha^{-1}, however, browntop millet + groundnut (4:2) recorded the highest BMEY (2326 kg ha^{-1}) among intercropping systems. Intercropping of browntop millet + black gram (4:2) showed the highest values for land equivalent ratio (1.192), area time equivalent ratio (1.13), and system productivity index (1159.49). Browntop millet exhibited a negative trend in case of aggressivity, indicating lower competitiveness. The intercropping of browntop millet with groundnut of 4:2 row ratio was recorded the highest relative crowding coefficient (18.12). Economically, sole groundnut generated the highest gross returns (₹1,13,438 ha^{-1}), net returns (₹72,934 ha^{-1}) and benefit-cost ratio (2.80). Among intercropping systems, browntop millet + groundnut (4:2) achieved the highest gross returns (₹72,397 ha^{-1}), net returns (₹37,971 ha^{-1}), and benefit-cost ratio (2.10).

Keywords: Browntop millet, Economics, Intercropping indices, Intercropping system, Yield.

NS-T3-05

CLIMATE CHANGE EFFECTS ON HORTICULTURAL CROPS

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Climate change presents considerable obstacles to the production of horticultural crops, influencing their growth, yield, and overall quality. The predominant climatic variables that affect horticulture include rising

temperatures, modified precipitation patterns, and an increased occurrence of extreme weather events. Elevated temperatures may induce heat stress, which subsequently diminishes fruit set, accelerates the maturation of crops, and disrupts the physiological processes within plants. Moreover, alterations in precipitation patterns, encompassing both drought and flooding, may jeopardize water availability, resulting in either water stress or oversaturation, both of which adversely affect crop vitality. The transition in climatic conditions further affects the dynamics of pests and diseases, as warmer temperatures and modified humidity levels foster conducive environments for the proliferation of pests and pathogens. This escalation heightens the risk of crop losses and necessitates the implementation of more rigorous pest management strategies. In addition, the phenology of horticultural crops is subject to alteration, with modifications in flowering and harvesting periods that may disrupt established agricultural calendars and market dynamics.Furthermore, the phenomenon of climate change exerts significant influences on soil health by modifying nutrient availability and altering the structural composition of soil, which in turn impacts the productivity of crops. Horticultural crops, recognized for their high economic value and heightened sensitivity to fluctuations in climatic conditions, exhibit particular susceptibility. The qualitative characteristics of fruits and vegetables, encompassing dimensions, pigmentation, and nutritional composition, may be adversely affected as a result of stress induced by climate variability. Implementing adaptive strategies, which encompass the creation of climate-resilient crop varieties, the enhancement of irrigation methodologies, is imperative to alleviate the detrimental consequences of climate change. Addressing the repercussions of climate change on horticultural crops is of paramount importance for the assurance of food security, the sustenance of livelihoods, and the preservation of the economic viability of this essential agricultural domain.

Keywords: Climate Change, Horticultural Crops, Water Stress, Dynamics of Pests and Diseases, Qualitative Characteristics, Sustainable Agricultural, armers' awareness

NS-T3-06

IMPACT OF CLIMATE CHANGE, ADAPTATION AND MITIGATION STRATEGIES FOR FIELD CROPS

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Climate change is a significant concern for India, where agriculture is a cornerstone of the economy. The sector is highly vulnerable to changing weather patterns, including more frequent droughts, floods, and heatwaves, which negatively impact crop yields. Key crops like rice, wheat, and maize are particularly affected, and the country's reliance on rainfed agriculture exacerbates these challenges. To address this, both adaptation and mitigation strategies are crucial. Adaptation focuses on enhancing the resilience of agricultural systems to climate impacts, while mitigation seeks to reduce agriculture's role in climate change. In India, adaptation measures include developing climate-resilient crop varieties capable of surviving drought, heat, and flooding. For instance, drought-resistant rice varieties such as "Swarna-Sub1" are already helping farmers in flood-prone regions. Practices like crop diversification, agroforestry, and intercropping are encouraged to improve soil health and reduce vulnerability. Water-saving techniques, including drip irrigation, rainwater harvesting, and precision farming, help optimize water usage and enhance yields. Mitigation efforts aim to lower the agricultural sector's carbon footprint through practices like reduced tillage, organic farming, and carbon sequestration with cover crops. Additionally, zero-budget natural farming (ZBNF) is promoted to reduce dependence on chemical inputs, thereby decreasing greenhouse gas emissions. The Indian government has implemented programs such as the National Action Plan on Climate Change (NAPCC) and the Pradhan Mantri Fasal Bima Yojana (PMFBY) to support farmers facing climate-related risks. However, challenges such as limited access to technology, financial constraints, and inadequate extension services remain. Overcoming

these barriers through improved research, policy support, and farmer involvement is critical for long-term success in adapting and mitigating climate change's impacts on agriculture.

Keywords: Climate change, Adaptation and Mitigation strategies, resilient crops, Diversification, Intercropping and Precision farming.

NS-T3-07

DEVELOPMENT OF A SOIL QUALITY INDEX FOR SOILS OF GANASANDRA MICRO-WATERSHED OF NAGAMANGALA TALUK, MANDYA DISTRICT KARNATAKA

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The present study aimed to evaluate soil nutrient quality and assess the spatial variability of soil fertility parameters in the Karijirahalli micro-watershed of the Naganahalli sub-watershed, located in Nagamangala taluk, Mandya district, Karnataka, using geospatial techniques during 2023–24. Analytical data were interpreted, and statistical parameters such as range, mean, and standard deviation were calculated for each parameter. The soils were found to be moderately to strongly alkaline and non-saline. Organic carbon content ranged from low to medium, while available nitrogen and phosphorus were at medium levels. Available potassium was high, whereas available sulphur ranged from low to medium. Among the DTPA-extractable micronutrients, zinc and iron were deficient in 50% of the samples, while copper and manganese were present in sufficient amounts. The results indicated that available N, P, S, Zn, and Fe are key soil fertility constraints. Principal Component Analysis (PCA) was used to identify the Minimum Data Set (MDS) from the analyzed soil fertility parameters. The major variables influencing soil quality were pH, available nitrogen, and boron. Two principal components with eigenvalues greater than 1 were significant, explaining 70% of the variance, with Soil Quality Index (SQI) values ranging from 0.15 to 0.84. The study concluded that the SQI, measured using regular grid sampling at a 320 m scale, effectively captured spatial dependence through the ordinary kriging technique, allowing the generation of thematic maps for efficient soil management strategies at the micro-watershed level. The SQI map of the Karijirahalli micro-watershed indicated that 32.82% of the area fell under the low to very low category, 9.14% under the medium category, and 58.03% under the high category.

Key words: Indicators, Principal component analysis, Remote sensing, Soil quality and Micro-watershed

NS-T3-08

ITKs IN BIHAR FOR SOIL AND WATER CONSERVATION AND ITS EFFECT ON CROP PRODUCTION AND PRODUCTIVITY.

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Indigenous Technical Knowledge (ITKs) in Bihar for Soil and Water Conservation and Its Effect on Crop Production and Productivity Indigenous Technical Knowledge (ITKs) plays a crucial role in sustainable soil and water conservation in Bihar, where traditional farming practices have evolved to suit local agro-climatic conditions. This study explores various ITKs employed by farmers in Bihar to manage soil fertility, conserve water, and enhance agricultural productivity. Key soil conservation ITKs include the use of organic mulching with crop residues and green manure to improve soil moisture retention and fertility. Farmers also practice ridge and furrow systems to control erosion and optimize water use. Traditional water conservation methods such as Ahars and Pynes, which are community-based irrigation systems, have been effective in managing

water resources, particularly in drought-prone areas. Additionally, intercropping, crop rotation, and agroforestry techniques are widely practiced to maintain soil structure and nutrient balance. The impact of these ITKs on crop production and productivity has been significant. Studies indicate that fields managed with traditional mulching and organic amendments exhibit higher water retention, improved soil microbial activity, and better yield stability, especially under erratic rainfall conditions. Similarly, traditional irrigation practices have enhanced water availability, leading to increased productivity of staple crops like rice, wheat, and maize. These methods contribute to cost reduction by minimizing reliance on chemical fertilizers and external irrigation sources. This paper highlights the importance of preserving and integrating ITKs with modern agricultural techniques for sustainable farming in Bihar. The adoption of such practices can lead to resilient agricultural systems, ensuring food security and environmental sustainability while maintaining productivity in the face of climate variability.

Keywords: Indigenous Technical Knowledge (ITK), Soil Conservation, Water Conservation

NS-T3-09

PHYSIOLOGICAL CHARACTERIZATION OF BAEL GENOTYPES UNDER SUB-TROPICAL REGION OF UTTAR PRADESH FOR COLD HARDINESS

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Bael (*Aegle marmelos* Correa), considered sacred, is an underutilized indigenous Indian fruit tree with significant medicinal value. It is renowned for its ability to aid digestion, alleviate, gastrointestinal disorders, and assist in diabetes management. A study was conducted during 2022– 2024 for identification and characterization of bael accessions for cold hardiness, high yield and better fruit quality at ICAR-Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow, (UP). Twenty six accessions (10-clonally propagated, 10-seedling population and 6-popular cultivars viz. CISH B-1, CISH B-2, CISH B-3, Pant Aparna, Pant Shivani and NB-5) were collected from different biodiversity region of Indian Subcontinent *i.e*., UP, Bihar, Jharkhand, Chhattisgarh and Odisha. These accessions showed lot of variability among bael accessions based on physiological, biochemical and quality traits. Genotype *viz*. T-33, T-34, CISH B-1 and S-4 have higher chlorophyll (total) content and photosynthetic rate as compared to other accessions which provides the basis for their better adaptability for cold temperature. Based on membrane stability index which was higher in CISH B-1, T-33, T-34 and S-4 as compared to other bael accessions, seems to be cold tolerant than the others evaluated genotypes. Furthermore, total yield was also higher in these accessions (55.61, 33.25, 47.56 and 30.73 kg/tree, respectively). Additionally, fruit quality traits like total sugar, Vitamin 'C' and TSS was also found higher in T-33, T-34, CISH-B-1 and S-4. The study concluded that a significant diversity among bael accessions for their cold tolerance and fruit quality traits. Notably, accession T-33, T-34, S-3, S-4, and CISH-B-1 exhibited superior physiological traits such as MSI, high maintenance of chlorophyll content and *Pn* rate that related to cold hardiness. Additionally, T-34, S-4, and CISH-B-1 showed higher levels of fruit quality traits like Vitamin 'C' and pulp content, indicating their overall superiority compared to other accessions studied.

Keyword: Bael, Fruit quality, Physiological traits, Variability

NS-T3-10

CHARACTERIZATION OF MAJOR DISEASES OF ONION AND EVALUATION OF IMPORTANT BIOCONTROL AGENTS.

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Onion (*Allium cepa* L.), recognized as the earliest vegetable incorporated in culinary practices and fresh salads, belongs to the monocot family of herbaceous plants within the Asparagales order. Karnataka being the second largest producer of onion after Maharashtra are facing many challenges from various pests and diseases. This study mainly focusses on characterizing major diseases of Onion in southern Karnataka and evaluating fungal and endophytic bacterial biocontrol agents against the major pathogens such as *Alternaria Colletotrichum, Fusarium*. Diseased samples and biocontrol agents were collected and isolated from southern Karnataka districts such as Bengaluru and Chitradurga. Pathogens were isolated by standard protocol and biocontrol agents were isolated using specific media. Morpho-molecular characterisation of both pathogen and biocontrol agents were carried out and the sequences were submitted in NCBI database to get accession number. All the pathogens were evaluated against 13 biocontrol agents which involve both fungus and bacteria. The major diseases that are prevalent in southern Karnataka are found to be purple blotch (*Alternaria porri*), twister disease (*Colletotrichum gloeosporioides*), and fusarium basal rot *Fusarium oxysporum* f. sp. *cepae*. 8 Trichioderma spp. and 5 Bacillus spp. found to have significant biocontrol activity against all the three pathogens.*Trichoderma harzianum* isolate TH6showed highest percent inhibition of 72.57% against *Colletotrichum gleosporoides*. The same isolate TH6 showed highest growth inhibition with 72.33% against *Fusarium oxysporum*. Against *Alternaria* TH13 *T.harzianum* showed highest percent inhibition of 89%. In case of endophytic bacteria against Colletotrichum, isolate GREB 13, *Paenibacillus polymyxa* showed highest inhibition of 47.77% followed by GREB5 isolate with 36.11%. Against fusarium GREB13 has highest growth inhibition of 42.73% followed by GREB5with 36.46%.

Keywords: Onion, Biocontrol, *Alternaria Colletotrichum, Fusarium, Trichoderma, Bacillus*

NS-T3-11

IndigenousTraditional Knowledge: A Study of Folk Medicinal Plants

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The traditional use of medicinal plants forms the backbone of primary healthcare for many rural communities. In developing countries, 80% of the population relies on traditional medicine, as estimated by the World Health Organization (WHO). This study focuses on documenting indigenous knowledge about medicinal plants and their applications in the Mokama block of Patna district, Bihar, India. A survey was conducted with 45 respondents, including local healers, elders, and women, to collect information about the medicinal uses of plants. A total of 40 plant species from 27 families were identified and documented.Prominent families included Apiaceae, with four species, and Asteraceae and Poaceae, with three species each. Various plant parts—roots, leaves, bark, stems, flowers, and fruits—were used to treat ailments such as diabetes, fever, kidney stones, skin disorders, and digestive issues. Common methods of preparation included decoctions, pastes, and juices, often created using traditional tools like pestle and mortar. The findings underscore the critical role of indigenous knowledge in preserving biodiversity and promoting sustainable healthcare. However, factors such as deforestation, urbanization, and overexploitation threaten this traditional knowledge. The study emphasizes the urgent need to document and conserve these practices to ensure their survival for future generations. Integrating traditional knowledge with modern healthcare systems could provide affordable and sustainable solutions for various health challenges.

Keywords: Indigenous knowledge, medicinal plants, rural healthcare, traditional medicine, biodiversity conservation.

NS-T3-12

BIOCHAR AMENDMENT OF POND SEDIMENT ENHANCES SOIL HEALTH AND REDUCES SEEPAGE LOSS OF WATER

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Sustainable aquaculture" plays a crucial role in meeting the growing global demand for low-cost protein food while minimizing the environmental impact. Under climate change scenarios, pond productivity is decreasing and soil health and water quality are deteriorating. Farmers use chemicals like fertilizers, pesticides, and antibiotics in the culture system to maximize production within minimum periods. These chemicals are enhancing the production but degrading the environment in the long run. In such a scenario, biochar from agro-waste emerges as a sustainable option to incorporate in aquaculture systems to maximize production without affecting the environment. The biochar nutrient composite was applied @ 2 t ha-1 in the fish pond, and Penaeus vannamei was stocked at 45 juveniles/m2. Compared to the control the sediment physico-chemical and biological parameters was significantly improved where biochar was used as an amendment in sediment. Organic carbon, potassium content and water holding capacity of the sediment was significantly higher as compared to control. The SGR (2.38±0.05 % day-1) weight gain (%), and survival (96.1±2.0 %) in biochar treatment were found to be the highest at the end of the experiment. When biochar was mixed with sediment in the inland saline system, an improvement was seen in both the water and sediment quality and growth characteristics of Penaeus vannamei. Biochar amendment to sediment also reduces the seepage of the water (13.01%) as compared to the control, and saves the potassium requirement by 30% as compared to the control. Biochar application to an aquaculture system improves the sediment health, improves water quality, controls seepage loss of the water and nutrients, builds up carbon content in the soil, and enhances the productivity. Thus agro-waste, a green, sustainable, and easily available source will provide sustainability beyond our expectations in aquaculture when applied in biochar form.

Keywords: Soil health Management, aquaculture, Biochar, Seepage control, Sustainability

NS-T3-13

EXPLORING THE IMPACT OF AGRO-ECOLOGICAL PRACTICES ON VEGETABLE NUTRIENT DENSITY

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Agro-ecological practices, which emphasize sustainable and ecologically sound farming methods, have gained significant attention for their potential to enhance food quality and environmental resilience. This study explores the impact of agro-ecological practices on the nutrient density of vegetables, focusing on how these methods influence the concentration of essential vitamins, minerals, and phytochemicals. By comparing conventional farming systems with agro-ecological approaches such as crop diversification, organic fertilization, and integrated pest management, the research aims to identify practices that optimize nutrient content while maintaining soil health and biodiversity. A meta-analysis of existing studies and field experiments was conducted, analyzing nutrient profiles of commonly consumed vegetables like spinach,

tomatoes, and carrots. Preliminary findings suggest that agro-ecological practices significantly increase the levels of key nutrients, including vitamin C, iron, and antioxidants, compared to conventional methods. This improvement is attributed to enhanced soil microbial activity, reduced chemical inputs, and improved plant resilience under agro-ecological systems. Furthermore, the study highlights the role of farmer knowledge and local adaptation in maximizing nutrient density outcomes. The results underscore the potential of agro-ecological practices to address both nutritional security and environmental sustainability, offering a viable pathway for improving public health and reducing the ecological footprint of agriculture. This research contributes to the growing body of evidence supporting agro-ecology as a transformative approach to food production, emphasizing its dual benefits for human nutrition and ecosystem health.

Keywords:

Nutrient density, sustainable agriculture, vegetable quality, biodiversity, organic farming, phytochemicals, food security.

NS-T3-14

STUDY OF ARSENIC ADSORPTION BY ALLUVIAL SOILS OF VARANASI

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In this study arsenic (As) adsorption was done with 2.0 g of silicate (Si), sulphate (S) and phosphate (P) deficient alluvial soils as adsorbent with As concentrations ranging from 2.5 to 50 ppm. Results showed that, the amount of As adsorbed by Si, S, and P deficient soil was 0.233, 0.244, and 0.296 µg g^{-1} at initial 30 minutes of adsorption period and increased significantly upto 0.343, 0.427, and 0.494 mg g^{-1} at 24 hours and beyond this, no significant changes were record. The adsorption of As was very much pH dependent and the highest adsorption was happened at pH 6. With the increased in pH from 7.0 to 12.0, the equilibrium As adsorption by all the soils decreased from 0.350, 0.420, and 0.490 mg g^{-1} to 0.016, 0.021, and 0.061 mg g^{-1}, in Si, S and P deficient soil respectively. The highest amount of arsenic adsorption, 0.496 mg g^{-1}, was seen in P deficient soil, followed by 0.429 and 0.341 mg g^{-1} in soil that was deficient in S and Si, respectively. In this study, the Sips model, a hybrid of the Langmuir and Freundlich models, was the best fitted model for As adsorption isotherm for all the soil types. The capacity of As adsorption was in the order Si deficient soil < S deficient soil < P deficient alluvial soil.

Keywords: Adsorption, Alluvial soil, Arsenic

NS-T3-15

DELINEATION AND MAPPING OF FLOOD-PRONE AREAS OF BIHAR AND WEST BENGAL USING SENTINEL-1 SAR FOR DEVELOPING INTEGRATED FARMING MODELS

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In recent decades, floods have become increasingly destructive due to increased impervious surfaces, climate change, and global warming. Remote sensing technologies have been widely used in risk analysis. In this study, mapping of flood-affected areas is done using Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) with the Sendai Framework Terminology on Disaster Risk Reduction

(United Nations, 2023) as a standard directly applicable to assessing flood impacts. Sentinel-1 Synthetic Aperture Radar (SAR) GRD: C-band image data (HH and VH), having a spatial resolution of 10m and temporal resolution of 6-12 days, were acquired both before and after the flood occurrence. Extent of the flood affected area was delineated by differencing the after and before flood images. Later, the mask was applied to remove permanent water bodies, isolated pixels, and steppe areas. A pixel is classified as a flood pixel if the difference is more than the threshold value, while, a permanent water pixel is classified when the pixel value is less than the threshold value for that pixel. Based on this principle, permanent/ semi-permanent water bodies and flood-inundated areas were delineated for Bihar and West Bengal from 2017-2023 using the Google Earth engine platform. Form the study it was found that Darbhanga was the most affected district due to the flood in August 2017. Apart from this, the eastern part of Samastipur, Khagaria, Katihar, Purnia, Bhagalpur, East Champaran, Munger, East Champaran and Muzaffarpur were affected by floods in 2017. Similarly, for West Bengal, districts like Malda, Murshidabad, Birbhum, Dakshin Dinajpur, Uttar Dinajpur, Bardhman East, West Midnapur, Hoogly, North 24 Parganas, South 24 Parganas were found affected during 2017-2023. Heavy rainfall due to tropical depression in the Bay of Bengal, water release from various dams by DVC led to widespread flooding in WB The availability of excess water in the identified flood-prone districts presents a significant opportunity for establishing fish-based integrated farming system models. These districts can serve as potential sites for implementing sustainable agricultural practices that utilize waterlogged conditions effectively. This study plays a crucial role in identifying the extent of flooding, enabling better planning and decision-making for risk reduction and flood management. By integrating these insights, policymakers and farmers can adopt adaptive strategies to enhance productivity and resilience in flood-affected regions.

Key words: Flood, Sentinel -1, SAR, Eastern India

NS-T3-16

Use of diversity of indigenous seedling mango and minor fruits of Bihar and its probable ITKs

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Farmers in Bihar play crucial role for conserving state's diverse mango heritage, actively contributi n g to the evolution and *in-situ* conservation of the unique local varieties. This extensive study across 13 key mango-growing districts in Bihar sought to identify custodian farmers employing Indigenous Technical Knowledge (ITK) to conserve >10 mango varieties (including seedling origin) within their orchards. District-wise analysis unveiled a concentration of custodian farmers, with *Darbhanga* and *Samastipur* district orchardist's dedication to maintaining the highest number of traditional varieties/unique seedling mango. *Bhagalpur* district emerged as a notable area where custodian farmers dedicated significant orchard space to mango cultivation. Some of the ITKs identified as growing pummelo for *Chhat* puja, maintaining multispecies and multi-varietal orchard as backyard plantations are tool for maintaining diversity of fruit species. The application of pummelo peel in rice field during vegetative stage repels insects and peels contain organic matter that can enrich the soil. Smoking under mango tree at the time of flowering, wastes of fish are placed below citrus plants as natural insect repellents. The Jamun pulp is used to prepare Vinegar by folk people and consumption of seedling mango inhibiting digestive problems and bark of mango being used for the control of diarrhoea. The Bael powder is used for alleviation of diabetes, headache, vomiting, toothache, diarrhoea, dysentery and swelling on intestine etc. *Madhubani* district have taken centre stage as primary sources for traditional varieties, highlighting their pivotal role in supporting *in-situ* conservation efforts. This emphasizes the synergy between custodian farmers and local nurseries, both rooted in ITK practices. The study identified a strong correlation emphasizing that the number of traditional varieties significantly contributes to *on-farm* conservation, underscoring the importance of preserving mango diversity. This research illuminates the proactive measures taken by Bihar farmers, providing insights with potential implications for sustainable agriculture and biodiversity conservation.

Keyword: Custodian farmer, Diversity, Mango, Nursery, Seedling mango, Traditional mango variety.

NS-T3-17

SUSTAINABLE FISH-BASED INTEGRATED FARMING FOR ENHANCED PRODUCTIVITY AND ECONOMIC VIABILITY OF FLOODPLAIN WETLANDS IN BIHAR, INDIA

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India comprises 0.35 million ha of floodplain wetlands mainly in eastern India. Rice and fish farming are major farming practices in floodplains, and their productivity is lesser than the national average productivity of rice and fish. The fish-based integrated farming can play a vital role in increasing the productivity and economic efficiency of floodplains in Bihar. High-density fish-poultry-on dyke fruit crops (IFS-1) and fish-poultry-duck-on dyke fruit crops (IFS-2) models were assessed. The fish fingerlings were stocked @ 10000 nos. ha-1 of an average body weight (ABW) 30.5±0.8 g comprised of *Catla catla* (30 %), *Labeo rohita* (20 %), *Ctenopharyngodon idella* (20 %) *Cirrhinus mrigala* (15 %) and *Cyprinius carpio* (15 %). The supplementary fish feed was supplied daily at the rate of 1 % of fish biomass. In the IFS-1, poultry birds (vanraja) were integrated @ 800 number ha^{-1} yr^{-1}, and on-dyke fruit crops (banana, lemon and guava) were grown. In the IFS-2, Khaki Campbell duck, poultry (vanraja) and on-dyke fruit crops were integrated with fish. After a culture period of one year, in IFS-1, minimum and maximum ABW was recorded as 362.5±37.9 g of *C. mrigala* and 632.5±35.5 g of *C. catla*. In the IFS-2, the minimum and maximum ABW were recorded as 362.5±35.9 g of *C. mrigala* and 624.5±35.3 g of *C. catla*. The survival rate of fish was found to be 84.0 % in IFS-1 and 85.6 % in IFS-2. The fish equivalent yield was recorded as 5.8 t ha^{-1} yr^{-1} from IFS-1 and 6.1 t ha^{-1} yr^{-1} from IFS-2. The cost-benefit ratio was estimated to be 1:1.60 and 1:1.65 in IFS-1 and IFS-2, respectively. The energy use efficiency was higher (0.69) in the IFS-2 model than IFS-1 (0.60). Such IFS can play a significant role in sustainable utilization of the floodplain wetland resources, and in turn, the livelihood and nutritional security of the farmers will be improved.

Keywords: Floodplain, Fish, Poultry, Duck, Fruit Crops, Cost-Benefit Ratio, Energy Use Efficiency

NS-T3-18

ORGANIC MANURE AMENDED SULPHUR FOR ENHANCING FERTILITY STATUS AND YIELD IN MUSTARD-RICE CROPPING SYSTEM

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Modernisation of agriculture involving high input and output activity necessitated the importance of sulphur and now-a-days sulphur is called as the fourth major plant nutrient as most crops absorb sulphur in quantity equivalent to phosphorus. However, with the increased use of high analysis S-free fertilizers, lower use of organic manure and very low rate of application or practically no application of sulphur fertilizers, the reserves of sulphur in soil have started depleting and are limiting the soil productivity. Sulphur is best known for its role in balanced fertilization and consequently in crop production. It is essential nutrient for the formation of

amino acid, synthesis of chlorophyll, oil in oilseeds and improvement in the nutritive quality of crops. An experiment was conducted to evaluate the direct effect of different level of sulphur alone or in combination with organic manures on mustard and residual effect on rice crops in calcareous soil of north India. The experimental site was sandy loam in texture, slightly alkaline in reaction, low in organic carbon, available N, P, K and S. The treatment consisted of seven level of sulphur (0, 20, 40, 60, 80, 100 and 120 kg S ha^{-1}) alone or along with organic manures and were replicated thrice in randomised block design. Source of S-Phosphogypsum (1 % P_2O_5 and 14 % S), Source of organic manure-FYM/ Biogas slurry (5.0 t ha^{-1}). Two test crops Mustard (var. Varuna) and rice (var. Rajshree) were grown successively to see the direct and residual effect of sulphur alone or along with organic manure Sulphur application significantly increased the yield of mustard as well as rice, S concentration and its uptake by mustard (seed+stover) as well as available –S content in post- harvest soil samples after mustard and rice. The optimum level of S was worked out to be 60 kg S ha^{-1} for mustard seed and stover production. However, with regards to total S uptake, the optimum dose appeared at 100 kg S ha^{-1}. The beneficial effect of organic manure was evident in enhancing the seed and stover production, S-concentration in seed, S-uptake (Seed+Stover) by mustard and available-S content in post-harvest soil samples from 9.8 to 10.7 q ha^{-1}, 37.5 to 40.5 q ha^{-1} , 0.779 to 0.821 per cent, 20.39 to 32.47 kg ha^{-1} and 25.7 to 86.5 mg kg^{-1}, respectively and the grain yield, S-content in grain, straw, total S-uptake (grain + straw) and available S content in post-harvest samples of rice from 47.2 to 49.8 q ha^{-1}, 0.088 to 0.098 per cent, 0.123 to 0.175 per cent, 13.83 to 17.98 kg ha^{-1} and 24.2 to 37.9 mg kg^{-1} , respectively.Organic carbon content varied from 3.5 to 5.2 g kg^{-1} with application of sulphur alone or along with organic manure. Organic manure was found to enhance the level of organic carbon in the soil significantly where BGS was more effective than FYM. Among the organic manures, biogas slurry (BGS) proved to be better source in enhancing seed yield, stover/straw yield, S-uptake, and available-S in post-harvest soil samples after mustard and rice. The residual effect of higher level of S along with BGS proved more effective with respect to S nutrition to rice.

Keywords: organic manures, mustard, residual effect, rice, sulphur

NS-T3-19

CARBON FRACTIONS AND ITS SEQUESTRATION IN CALCAREOUS SOIL INFLUENCED ON INCORPORATING CROP RESIDUE AFTER 23 RICE- WHEAT CROP CYCLE

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The study was carried out in the alluvial calcareous soils of Bihar, India. The experiment was designed as a split plot with two main factors: crop residue level (0%, 25%, 50%, and 100%) and initial zinc application level (0, 2.5, 5.0, and 10 kg ha^{-1}). After the 23rd wheat crop was harvested, post-harvest surface soil samples were collected and analyzed. The findings revealed that increasing the amount of crop residue significantly enhanced the oxidizable organic carbon fractions in the soil. Specifically, the organic carbon content increased by 7.18%, 20.22%, and 34.21% in plots receiving 25%, 50%, and 100% crop residue, respectively, compared to plots with no crop residue. Additionally, the non-labile carbon fraction made up 46.6% of the total organic carbon. After 23 years, 100% crop residue incorporation sequestered 5.41 Mg ha^{-1} carbon in soil. Furthermore, incorporating 100% residues along with chemical fertilizer resulted in a 41.84% increase in rice yield and an 11.03% increase in wheat yield compared with those of plots with no crop residue incorporation. The mean weight diameter, percentage of water-stable aggregates, and volumetric water content were highly significantly correlated with soil organic carbon and its fractions, while soil pH, bulk density, and calcium carbonate content

showed a strong negative correlation. The crop residue management in the rice-wheat cropping system demonstrates its potential to reduce atmospheric carbon levels by enhancing carbon sequestration in soil along with enhancement in crop productivity.

Keywords: Calcareous soil, carbon fraction, crop residue, total organic carbon, yield.

NS-T3-20

SCREENING OF MANGO GERMPLASM SUITABLE FOR PROCESSING IN BIHAR

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Mango is the most liked, juicy, nutritious and luscious fruit of India. For year round consumption processing of mango is very necessary. For this suitable variety for processing needs to be identified. For this purpose a trial is ongoing at Pandit Deendayal Upadhay College of Horticulture & Forestry, Piprakothi since 2024-2025 to identify specialty mango germplasm suitable for processing in Bihar. Under this 6 germplasms were identified and analysed biochemically. max^{m}TSS (20^{o}B) was found in Parorba which showed least acidity (0.24%) also. Kala Pahad expressed max^{m} firmness (12.75N), max^{m} Vitc-content (45.16mg/100g pulp), max^{m} antioxidant (6.23 umol TE/g.) max^{m} Phenol (512.3 ug GAE/100g), max^{m} total carotenoid (8.9 mg/100g pulp) and max^{m} storage life (15 days). Threshold firmness for consumption is fixed at 5 N. Therefore it may be concluded that Kala Pahad may be utilized for further processing purpose.

Keywords: mango,screening

NS-T3-21

ENHANCING MICROBIAL HEALTH THROUGH THE SYNERGY OF LONG-TERM MANURING AND NITROGEN FERTILIZATION IN SEMIARID ENVIRONMENTS

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The soil's biological health is an important aspect in sustaining crop production in arable soils. However, in intensive cropping systems in semi-arid tropical regions, determining the optimal rate of manure application to maintain soil quality while avoiding financial and environmental losses is a major challenge. The impact of the long-term application of graded doses of farmyard manure (FYM) and its integration with mineral nitrogen (N) on soil biochemical properties was investigated in a pearl millet-wheat system. The study involved four levels of FYM (0, 10, 20 and 30 Mg ha^{-1}) and two N levels (0 and 120 kg ha^{-1}) and the effects were assessed soil N availability, microbial activity and N cycling enzymes activities in 0-15 and 15-30 cm soil depths. The results showed a significant increase (p< 0.05) in soil available N with addition of FYM and N and it ranged from 169-328 kg ha^{-1} in surface soil and 132-238 kg ha^{-1} in subsurface soil. The soil microbial biomass carbon (MBC) and nitrogen content was significantly increased with increasing FYM and N levels, where MBC ranging from 162-1189 mg g^{-1} (0-15 cm) and 91-852 mg g^{-1} soil (15-30 cm) soil depth. The substrate-induced respiration and soil microbial quotient was also reported to increase with FYM and N application irrespective of soil depths. The soil urease activity was increased by 227% in surface soil and 323% in subsurface soil with increased FYM

level from 0 to 30 Mg ha^{-1}. The activity of arginine deaminase ranged from 4.36-10.3 µg $NH_4^+ g^{-1}$ soil hr^{-1} in 0-15 cm. Thus, the study emphasizes the importance of FYM and N fertilization for enhancing MBC, enzymes activity and N availability in semiarid environment, all of which support better soil health and sustainable crop production.

Keywords: Long-term fertilization, Soil Health, Microbial Biomass Carbon, Soil Microbial Quotient, Substrate Induced Respiration, Farm Yard Manure, Soil Urease, Arginine Deaminase

NS-T3-22

IMPACT OF ZINC AND CYTOKININ ON THE GROWTH, YIELD AND QUALITY IN BAJRA (*Pennisetum glaucum*).

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An experiment entitled "Impact of Zinc and Cytokinin on the Growth, Yield and Quality in Bajra (Pennisetum glaucum)" was carried out at the Agricultural Farm of Lovely Professional University, Phagwara, Punjab, from April to August 2022. The experiment comprised a total number of 8 treatments and replicated thrice consisting of T0 (Control), T1 (60 ppm Zinc), T2 (75 ppm Zinc), T3 (90 ppm Zinc), T4 (60 ppm Zinc + 10 ppm Cytokinin), T5 (75 ppm Zinc + 20 ppm Cytokinin), T6 (90 ppm Zinc + 30 ppm Cytokinin) and T7 (30 ppm Cytokinin). The experiment was conducted in randomized block design with three replications taking the variety 'SBH-100' as a test crop. Crop management practices were performed per the standard package and practiced 40 kg N/ha, 24 Kg P2O5/ha as RDF. Among these treatments, growth and yield attributes were significantly higher with T6 (90 ppm zinc + 30 ppm cytokinin), followed by T5 (75 ppm zinc + 20 ppm cytokinin) cut at 65 DAS and 130 DAS. The higher physiological attributes were recorded in the treatment T6 (90 ppm zinc + 30 ppm cytokinin) and followed by T5 (75 ppm zinc + 20 ppm cytokinin). Treatment T6 (90 ppm zinc + 30 ppm cytokinin shows higher biochemical attributes and is followed by T3 (90 ppm zinc).
Keywords: Zinc, Cytokinin, Bajra, Physiological Attributes, Biochemical Attributes

NS-T3-23

STUDIES ON SUSTAINABLE RESOURCE MANAGEMENT FOR CLIMATE SMART IFS MODEL

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Studies on sustainable resource management for climate smart 0.4 ha IFS model was taken under all India coordinated research project on integrated farming system, College of Agriculture Rewa during 2021 to 2022 and 2022 to 2023. The study reveals that 0.4 hectares size of IFS model gave 131 .24 q rice equivalent yield, gross return Rs.271531, Net profit Rs.130090 And B:C ratio 1.91. The net profit from 0.36 hectares cropping systems was Rs.36727 and REY 41.80 q. The dairy component with two cows gave net profit Rs.86933 and B:C ratio 1.92. Among different cropping systems okra – garlic gave B:C ratio 2.23 and net profit of Rs.8066 from 0.02 ha area. The employment generation was 36 labour man days in June to 51 labour man days in October. Total employment generation was 513 labour man days per year. Flow of year-round income was varied from Rs.2501/ month in June to Rs.29913 in April. Self-reliance status from IFS model was 89%, green fodder, 27.39% dry fodder and 41.87% concentrates for cattle. Vermicompost and compost unit gave 36.1% of total nitrogen, 46.26 %of total phosphorous and 95 % need of total Potassium.

Keywords: - IFS, Garlic, Employment Generation, Climate Smart IFS

NS-T3-24

ECOFRIENDLY METHOD FOR MANAGING SOIL AND SEEDBORNE DISEASES IN VEGETABLES CROPS THROUGH SEED BIOPRIMING

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Seed is an important initial investment in agriculture and a healthy seed can lead for enhancement in production with good quality of farm produces. It is estimated that 30% diseases are of seedborne nature and can be simply managed through the using of disease-free seeds for sowing. The losses due to seed-borne diseases in developing countries are estimated to be 60-80% higher than in industrialized countries. Conservatively estimated, seed-borne diseases cause losses in the order of 50 million tonnes of food annually. Similarly soilborne pathogens such as *Fusarium* spp., *Sclerotium rolfsii*, *Sclerotiniasclerotiorum*, *Rhizoctonia* etc. also possess a major threat to crop production on a global scale all over world. These phytopathogens cause highly devastating diseases which affect crop since germination hence an early protection in form of seed biopriming will provide advantage to crop for uniform, swift & higher stand establishment. Seed biopriming enables controlled seed hydration and active colonization of AIMs i.e. *Trichoderma* spp., *Pseudomonas fluorescent,Bacillus* spp.etcon seeds thereby activating its metabolism without substantial germination and augmented establishment of the biocontrol agent prior to pathogen infection. Besides, it also assists in rapid germination, as well as enhances resistance to both biotic & abiotic stress conditions. Further, seed biopriming also provides greater protection from foliar diseases through various biocontrol mechanisms and induced systemic resistance (ISR). In this context, seed biopriming prove to be a promising, ecofriendly and economical technique in comparison to seed treatment, soil application & foliar spray, thereby providing a significant contribution to sustainable agriculture.

Keywords: Seed biopriming, Bio control agent, *Trichoderma,* Soil and seedborne disease.

NS-T3-25

SURVEY AND MANAGEMENT OF EARLY BLIGHT DISEASE OF TOMATO CAUSED BY *ALTERNARIA SOLANI* (ELLIS &MARTIN) JONES AND GROUT

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Early blight is a major disease of tomato that significantly reduces fruit yield. To know the severity of the disease, a detailed field survey was conducted during the Rabi, 2020-21 and 2021-22 in major tomato-growing areas of Prayagraj, Varanasi, Mirzapur, Kanpur Dehat and Kanpur Nagar districts of Uttar Pradesh. The survey report revealed that tomato crops were infected with early blight at all surveyed locations. The disease intensity varied from 26.90 to 42.84 percent and 20.55 to 45.29 percent during Rabi, 2020-21 and Rabi, 2021-22 cropping season respectively. To manage early blight, different treatments were evaluated under field conditions, including three fungicides (Indofil M-45, Saaf, and Contaf Plus), one bio-agent (Trichoderma harzianum) and a plant extract (Datura leaf extract) both alone and in combination. Among all treatments, the best result was observed with the combination of seed treatment using T. harzianum (@5g/kg seeds, one foliar spray of Datura leaf extract (@15% and two foliar sprays of Indofil M-45 (@ 0.25%. This treatment recorded the lowest disease intensity (13.94%), highest disease control (65.91%) and maximum fruit yield (17.31 t/ha) based on pooled data from both cropping seasons. These findings suggest that an integrated approach using bio-agents, plant extracts and fungicides can effectively reduce early blight disease and increases tomato yield.

Keywords: Alternaria solani, fungicide, percent disease intensity, tomato and yield

NS-T3-26

EXPLORING THE POTENTIAL OF BAMBOO FROM CULTIVATION TO POST-HARVEST TREATMENT: AN APPROACH FOR STRENGTHENING LIVELIHOODS

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Bamboo, known as the "poor man's furniture," holds immense potential for rural economies. The East Champaran district is ideal for cultivating *Bambusa balcoa* (Bheema Bamboo), *Bambusa tulda*, *Babossa bamboos*, and *Bambusa strictus*. Bamboo's versatility and economic viability position it as green gold commerce, driving rural entrepreneurship and sustainable development. As a sustainable alternative to wood, bamboo is widely used in furniture, handicrafts, utensils, and textiles, creating employment opportunities and reducing labour migration. In East Champaran district, the farmers had started cultivating bamboo since 2018, where the inference drawn is noted as with proper cultivation, 333 plants per hectare can yield 1,500–2,000 culms per hectare after six years with farmers harvesting the produce from the third year, fetching them ₹1.4 lakh/ha in the fourth year, ₹1.67 lakh/ha in the sixth year, and an expected income of ₹15–18 lakh over fifteen years. Furthermore, with the treatment of produced bamboos under full sleeve process enhances its shelf life up to 4–5 years outdoors and 15–20 years indoors. Bamboo-based furniture and handicrafts offer attractive profit margins yielding a B:C ratio of 1.25 for Sofa and centre table and 3.3 for bed. A treated bamboo trellis lasts three years, compared to one year for untreated bamboo, saving ₹78,000 over three years.

Key Words: Bamboo, poor man's furniture, employment opportunities, sustainable alternative, Bamboo-based furniture, treated bamboo

NS-T3-27

EFFECT OF ESTABLISHMENT METHODS OF RICE ON BIOLOGICAL PROPERTIES OF SOIL

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A field experiment was conducted in split-plot design at Research Farm, Pusa, Bihar. Main-plot treatments included three crop establishment methods, viz. dry direct-seeded rice (DSR-dry), wet direct-seeded rice (DSR-wet) and puddled transplanted rice (TR). In sub-plots, five nutrient management methods T1- 100% STCR Based Dose of Fertilizer + ZnSO4 @ 25 kg ha-1 (DF), T2-75% DF + 25% STCR based Recommended Dose of Nitrogen (RDN) through Vermicompost, T3-100% STCR based RDN through Vermicompost, T4-100% DF + 50% STCR based RDN through Vermicompost and T5- 50% DF + 25% STCR based RDN through Vermicompost. The post-harvest soil was analysed to evaluate the effect of different nutrient management methods on soil microbial biomass Carbon (SMBC), Microbial population and Dehydrogenase Enzyme (DH) activity under the three different establishment methods. The results indicated that fungal and bacterial population was higher in transplanted rice while actinomycetes population was higher in DSR-dry. The microbial population count was highest under T3 followed by T4. The DH and MBC recorded higher values of 28.74 µg TPF g-1 hr-1 and 292.6 mg kg-1 respectively under transplanted rice whereas, DSR-dry recorded

lower value. The DH and SMBC were significantly influenced by the application of T3 which recorded 33.64 µg TPF g-1 hr-1 & 317.1 mg kg-1 respectively while significantly lower value was recorded with T1 (20.12 µg TPF g-1 hr-1 and 249.1 mg kg-1 respectively. Therefore, it may be concluded that addition of organics (vermicompost) led to improvement of microbial as well as enzymatic activity which was more pronounced in DSR-wet and Transplanted rice.

Keywords: Rice, Nutrient Management, DSR, Transplanting

NS-T3-28

MANAGEMENT OF SHOOT & FRUIT BORER IN BRINJAL (*LEUCINODES ORBONALIS*)

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Brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* is a serious insect pest of brinjal (*Solanum melongena* L.). It is the serious pest in Gorakhpur district for brinjal crop. Different insecticides were evaluated for the control of BSFB in a field study under On Farm Trial (OFT) at Bansgaon and Khajani block in Gorakhpur district during kharif season. The study was carried out using Sangro S 704 variety of brinjal which is very popular in Gorakhpur. Transplanting of nursery was done on 01, July, 2023 and 4 july 2024 Pheromone trap were installed on 01, August,2023 and 4 August 2024 @ 15-30 per hactre. Trichogramma card was released @ 75000 per hectare after one month of transplanting. The experiment was laid out in a Randomized Block Design having ten replications. Each plot had four rows at 75 cm and plant to plant was 75 cm. Insecticides used were Neem oil 1500 PPM @ 4.0 ml per liter of water at 55-60 DAT and Emamectin Benzoate 5 % SG @ 0.5 gm per liter of water at 80-85 DAT. Insecticides were sprayed as per treatment. All infested fruits were picked from plots one day before insecticide application. Infected shoots were marked by tying a ribbon to all drooping shoots one day before spray. Fruit and shoot infestations were recorded 07 and 14 days after insecticide application from plants in the middle two rows of each plot. All treatments reduced the shoot and fruit infestation significantly as compared to the control. However, Pheromone trap, Trichogramma card and Neem oil 1500 PPM treated plots had the least shoot infestation. For control of the borer in fruits, Emamectin Benzoate 5 % SG proved to be the most effective insecticide and highest yield of 509 q/ha in the Brinal crop.

Keywords: Shoot & Fruit Borer, Brinjal

NS-T3-29

ESTIMATE OF GENOTYPIC AND PHENOTYPIC CORRELATION AND PATH COEFFICIENTS IN CHILLI (*CAPSICUM ANNUUM* L.)

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The significant positive correlation of phenotypic and genotypic performance as well as path correlation of crops helps in selection of the superior cultivars. Based upon important significance of these estimates, it was applied in our research. For this an experiment was conducted on different genotypes of chilli during winter season of 2021-22, with the aim of estimate correlation coefficient among the growth and yield traits and elucidate the direct and indirect effect of different traits on yield through path coefficient analysis. The

experimental material for the study consisted of 40 genotypesincluding one check (Kashi Anmol), laid in Randomized Complete Block Design with three replications. Observations were recorded on thirteen quantitative characters. The most important trait fruit yield per plant had exhibited highly significant and positive phenotypic correlation with average fruit weight (0.925), no. of fruits per plant (0.595) and fruit circumference (0.464). Path coefficient analysis revealed that average fruit weight (0.835) and no. of fruit per plant (0.385) were identified as most important traits which had positive direct on fruit yield per plant. The higher magnitude of negative direct effect on fruit yield per plant was exerted by fruit circumference (-0.018) followed by secondary branches per plant (-0.011). While maximum positive indirect effect on total fruit yield per plant shown by fruit circumference (0.448), followed by no. of fruit per plant (0.216). while negative indirect effect shown by secondary branches per plant (-0.143) followed by plant height (-0.127) and days to mature red ripe stage (-0.124). Thus, it can be inferred from the data above that selecting for these qualities will effectively enhance the crop for increased production and contributing traits.

Keywords: Chilli (*Capsicum annuum* L.**)** correlationgenotypic, phenotypic, path coefficient, quantitative trait.

NS-T3-30

GENETIC DIVERSITY STUDIES IN DOLICHOS BEAN (*Lablabpurpureus* L.)

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The genetic diversity among 45 genotypes of Dolichos bean (*Lablab purpureus L.*) was assessed for twenty-one quantitative and qualitative traits including disease-pest incidence. The experiment was conducted during the Kharif season 2021-2022at the Experimental farm of Department of Horticulture, Ranchi Agriculture College, BirsaAgricultural University, Kanke, Ranchi, India with four check entries [SwarnaUttakrisht (C-1), Swarna Rituvar (C-2), LC-1 (C-3) and LC-2(C-4)] in an augmented design using three blocks. A substantial variability among the accessions forquantitative traits, and pod borer infestations, except for the number of branches perplant, was documented. The estimates of heritability were high for all the traits studied. The phenotypic and genotypic coefficients of variation, which reflect the averageinter-accession differences, were moderate. However, these are useful statistics to understandvariability among the accessions. The germplasm was grouped into four clustersfollowing Wards minimum variance clustering approach with significant deviationsamong clusters. The intra-cluster distance was lower compared to inter-cluster distance. The results could be used to adopt suitable strategies for breeding Dolichos beanaimingat improved productivity. Dolichos bean (Lablab purpureus L.) 2n=2x=22, 24 is an important leguminous vegetable crop grown throughout the country and is commonly knownasSem and it is member of Fabaceae family. The present investigation was carriedout during the Kharif season 2021-2022 at the Experimental farmof Department ofHorticulture, Ranchi Agriculture College, Birsa Agricultural University, Kanke, Ranchi. Total forty-five genotypes of dolichos bean and four checks [Swarna Uttakrisht (C-1), Swarna Rituvar (C-2), LC-1 (C-3) and LC-2(C-4)] were taken for present investigation. Observations were recorded on twenty-one quantitative and qualitativetraits including disease-pest incidence under this study in an augmented designusingthree blocks. High PCV and GCV was found for 10 pod weight and number of pods perplant. High heritability in broad sense was recorded for the traits no. of pods per plant, 10 pod weight and yield per hectare. High heritability coupled with highgeneticadvance as per cent of mean was observed for number of flower per cluster suggestedthat selection of this trait may be effective as heritability is most likely due toadditivegene effects. Yield per plant was negatively correlated and highly significant withnumber of pods per plant. It was also found that the yield per plant was positivelycorrelated and highly significant with dry seed weight. The qualitative traits flowercolour, seed colour and seed testa texture were able to distinguish dolichos beangenotypes and thus can be used for germplasm characterization in chickpea as perguidelines of DUS test.

Keywords: Dolichos bean,genetic diversity

NS-T3-31

BONDING PERFORMANCE OF MIXED SPECIES HARDWOOD CROSS LAMINATED TIMBER

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Over the past few decades, cross-laminated timber (CLT) has emerged as a sustainable building material and replacing the traditional materials like steel and concrete for high-load bearing constructions. Despite the mechanical strength of most hardwoods, EN 16351 only recognizes poplar for CLT preparation. One of the main contributing factors is the challenge of creating a solid and durable adhesive bond in hardwood CLT panels, which is brought on by cross-lamination. The purpose of this study is to examine how the manufacturing pressure affects the bonding properties of three-layer hybrid CLT that consists of outer maple and core poplar layers, and vice versa. The three-layered CLT panels were prepared by using one-component polyurethane (PUR) adhesive without edge gluing with two different manufacturing pressure of 0.6 MPa and 1 MPa. For each test, forty CLT samples were assessed in accordance with EN 16351:2015, and the percentage of wood failure was calculated. According to the results, delamination and bond shear strength were both significantly affected by the manufacturing pressure. Bond shear strength was lower and delamination was higher for lower manufacturing pressure. According to the study, specimens that were bonded as outer poplar with core maple had a 70% failure rate in the delamination test. On the other hand, specimens that had outer maple layers with core poplar pass both the bond shear test and the delamination test because the core layer had densified. The study confirms that a manufacturing pressure of 1 MPa or greater is required for bonding hardwood CLT.

Keywords: Bond shear, Cross Laminated Timber (CLT), Delamination, Maple, Poplar.

NS-T3-32

GROWTH PERFORMANCE OF THREE FAST-GROWING TREE SPECIES AT PRAYAGRAJ, UTTAR PRADESH

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To study the growth performance of *Populus deltoides* (Poplar), *Eucalyptus spp.* (Eucalyptus) and *Casuarina equisetifolia* (Casuarina) tree species under high-density plantation at Prayagraj, Uttar Pradesh. The tree species planted in three different spacing *viz.,* 1m×1m, 1.2m×1.2m and 1.5m×1.5m. The trail was established in July 2021 and data was collected after one year (July 2022) and in second year (July 2023). Current annual increment (CAI) height in first year maximum found in T_2: Eucalyptus (1m×1m) 2.43 m followed by T_5: Eucalyptus (1.2m×1.2m) 2.38 m and minimum in T_9: Casuarina (1.5m×1.5m) 0.97 m whereas in second year the maximum CAI height was found in T_2: Eucalyptus (1m×1m) 4.04 m followed by T_4: Poplar (1.2m×1.2m) 2.98 m and minimum in T_9: Casuarina (1.5m×1.5m) 1.87 m. The maximum average height was found in T_2: Eucalyptus (1m×1m) 3.24 m followed by T_5: Eucalyptus (1.2m×1.2m) 2.63 m and minimum in T_9: Casuarina (1.5m×1.5m) 1.42 m. CAI girth in first year was maximum found in T_2: Eucalyptus (1m×1m) 4.54 cm followed by T_5: Eucalyptus (1.2m×1.2m) 4.24 cm and minimum in T_9: Casuarina (1.5m×1.5m) 1.35 cm whereas the in second year the maximum CAI girth was found in T_4: Poplar (1.2m×1.2m) 6.96 cm followed by T_2: Eucalyptus (1m×1m) 6.65 cm and minimum in T_3: Casuarina (1m×1m) 2.90 cm. The maximum average grith was found in T_2: Eucalyptus (1m×1m) 5.60 cm followed by T_4: Poplar (1.2m×1.2m) 5.45 cm and

minimum in T_3: Casuarina (1m×1m) 2.14 cm. The maximum volume increment was found in T_2: Eucalyptus (1m×1m) 0.0076 m^3 $tree^{-1}$ followed by T_4: Poplar (1.2m×1.2m) 0.0068 m^3 $tree^{-1}$ and minimum in T_9: Casuarina (1.5m×1.5m) 0.0009 m^3 $tree^{-1}$. After two years of experiment the result indicate Eucalyptus (1m×1m) spacing perform best among all treatment.

Keywords: Growth, Increment, High-density Plantation, Volume, Height

NS-T3-33

IMPACT OF NATURAL FARMING AND CONVENTIONAL FARMING PRACTICES ON SOIL HEALTH UNDER LAND USE SYSTEM IN BIHAR

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Green revolution (mid-1960s) increased crop yields but resulted in negative environmental (e.g. soil degradation, greenhouse gas emissions, biodiversity losses), health and economic impacts. The largest alternative farming movement in India, Natural Farming (NF), began as a grassroots social movement, is one such low-input, climate-resilient type of farming that encourages farmers to use low cost locally-sourced inputs, eliminating the use of artificial fertilizers, and industrial pesticides. Thus, in this perspective, the present study was carried out to assess the soil fertility under two farming systems i.e. Natural Farming (NF) and Conventional Farming (CF) in different agro-ecology. The natural farming inputs, soil (0-15 cm) and plant samples were collected from fifteen natural and conventional farming practitioner farmers' field of five districts of Bihar. The results indicate that the different natural farming inputs were alkaline in reaction and loaded with microbes and mineral nutrients. The soil pH under NF was found to decline (1.3%), while the organic carbon (13.7%), available N (12.7%), P (14.4%), K (22.0%), S (22.6), Zn (14.4%), Cu (12.4%), Fe (6.7%), Mn (13.0%), dehydrogenase activity (23.5%), bacteria (3.9%), fungi (20.8%), actinomycetes (10.0%) and soil microbial biomass carbon (3.8%) increased over conventional farming. Thus, the present study indicates that the soil health and nutrient content in crops improved due to adoption of natural farming practices over conventional farming. Also, during initial stage of natural farming, the vegetable crops are more suited one than the cereal crops.

Keywords: Growth, Increment, High-density Plantation, Volume, Height

NS-T3-34

SEASONAL OCCURRENCE OF MAJOR INSECT PESTS OF TEASEL GOURD (MOMORDICA SUBANGULATA SUBSP. RENIGERA) AND SPINE GOURD (MOMORDICA DIOCA) IN EASTERN UTTAR PRADESH, INDIA

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The key objectives of Viksit Bharat-2047 are to significantly enhance farmer incomes, ensure food security and contribute to inclusive economic growth through the adoption of precision agriculture and climate-smart farming practices for farmers. In alignment with these goals, potential crops suited to the eastern regions of India include Teasel Gourd (*Momordica subangulata* Blume subsp. *renigera*) and Spine Gourd

(*Momordica dioca*). A field experiment was conducted at the ICAR-IIVR, Regional Research Station, Sargatia, Uttar Pradesh, during the Kharif seasons of 2023 and 2024 to monitor the seasonal incidence of Hadda Beetle (*Epilachna vigintioctopunctata*) and the Cucurbit Caterpillar (*Diaphania indica*). Pest populations were recorded at seven-day intervals following the initial appearance of pest infestation. Observations were made from five plants per replication, with three replications in total. For each plant, nine leaves were selected where three from the upper, middle and lower parts of the plant for pest counting in both teasel and spine-gourds. *Epilachna* and *Diaphania* were reordered as major pests in the region with significant infestations in both the gourds. As the actual crop standing commences in May-June, peak infestation of *Epilachna* was noticed in July and August, while a severe infestation of *Diaphania* was observed in August and September in teasel gourd. The severe beetle infestation was found in the third week of July (9.20 grubs and adults/plant), while the peak *Diaphania* incidence was documented in the last week of August (6.2 larvae/plant) in teasel-gourd. Similarly, peak *Epilachna* infestation was detected in the third week of July (10.00 grubs and adults/plant), while peak *Diaphania* incidence was documented in the second week of September (2.4 larvae/plant) in spine-gourd. Spine-gourd was found to be more prone to hadda beetle and less prone to cucurbit caterpillar compared to teasel-gourd.This incidence data enables farmers to take timely control measures using integrated pest management strategies.

Keywords: Teasel Gourd

NS-T3-35

EFFECT OF BROWN MANURING ON SOIL HEALTH, WEED CONTROL, AND RICE PRODUCTIVITY IN HIGH RAINFALL AREAS

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On-farm trial conducted during the wet season of 2017-18 at a farmer's field in South Andaman. The experiment was laid out in a randomized block design with four treatments and five replications. At 20 days after transplanting, the highest weed control efficiency of 80.8% was recorded with the application of butachlor at 1.25 kg/ha, followed by hand weeding at 30 DAT. This was followed by intercropping of *dhaincha* with 2-4 D sodium salt at 0.5 kg/ha at 30 DAT, which achieved a WCE of 76.7%. At 40 DAT, the highest WCE of 91.0% was observed with the intercropping of *dhaincha* with 2-4 D sodium salt at 0.5 kg/ha at 30 DAT, which was on par with the application of butachlor at 1.25 kg/ha at 3 DAT, followed by hand weeding at 30 DAT. Significantly higher grain yield (4.6 t/ha) and straw yield (6.15 t/ha) were recorded with the application of butachlor at 1.25 kg/ha at 3 DAT, followed by hand weeding at 30 DAT. This was comparable to the intercropping of *dhaincha* with 2-4 D sodium salt at 0.5 kg/ha at 30 DAT, which resulted in a 40.4% higher grain yield compared to the unweeded check. Furthermore, intercropping of *dhaincha* with 2-4 D sodium salt at 0.5 kg/ha at 30 DAT recorded the highest net return (Rs. 29,375), along with the best benefit-cost ratio of 2.46. Soil nutrient status, in terms of available nitrogen was assessed at harvest, and it was observed that the plot with *dhaincha* incorporation recorded a 35.7% higher available soil N content compared to other weed control treatments.

Keywords: WEED CONTROL

SESSION-4

Theme: Socio-economic approaches and policies to build sustainable food systems

NS-T4-01

EMPOWERING RURAL ODISHA: SELF-HELP GROUPS AS CATALYST FOR SOCIAL ENTREPRENEURSHIP IN KORAPUT DISTRICT

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Social entrepreneurship, characterized by the innovative use of resources to address social issues, has gained significant traction in recent years, particularly in the context of rural development and women's empowerment. This study explores the role of Self-Help Groups which act as a catalyst for social entrepreneurship among rural women in the Koraput district of Odisha, India. SHGs, which emerged in India in the late 1980s, have become a vital mechanism for poverty alleviation, gender equality, and economic empowerment, particularly for marginalized women. By providing financial resources, fostering mutual support, and encouraging entrepreneurial activities, SHGs enable women to achieve financial stability, improve their social standing, and challenge gender inequalities. The study employs discriminant analysis to identify key factors influencing women's participation in SHGs. The empirical evidence from the analysis reveals that financial stability with a discriminant coefficient of 0.224 and women's rights with a coefficient of 0.117 are the most significant motivators for women to join SHGs. These findings are supported by the high canonical correlation of 0.334 and the significant Chi-square value of 102.024, indicating strong discrimination between women who prefer to join SHGs and those who do not. Additionally, the study found that employment generation, gender inequality, and social value creation also play crucial roles in influencing women's affiliation with SHGs. However, the study also acknowledges limitations, including the potential for response bias due to the sensitive nature of the topic. Despite these constraints, the study offers critical insights into the transformative potential of SHGs in fostering social entrepreneurship and empowering rural women. The study suggests that SHGs are not merely financial institutions but are also instrumental in driving systemic social change, particularly in regions marked by poverty and gender disparity. The study highlights that SHGs serve as a powerful tool for sustainable development, offering a scalable model that can be adapted in other rural areas to promote social entrepreneurship and women's empowerment.

Keywords: Social Entrepreneurship, SHGs, Women Empowerment, Rural Development, Financial Stability, Gender Inequality.

NS-T4-02

ENHANCING FARMER WELFARE THROUGH COLLABORATIVE VALUE AND SUPPLY CHAIN MANAGEMENT: THE ROLE OF GOVERNMENT AGENCIES, NGOS, FPOS, AND COOPERATIVES

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Agriculture remains the backbone of many countries, and farmer welfare is critical to ensuring food security, economic stability, and rural development. Government agencies, Farmer Producer Organisations (FPOs), Non-Governmental Organisations (NGOs), and cooperatives play critical roles in improving farmer welfare and increasing value chain management in agriculture. These institutions provide different helps including financial assistance, capacity training, access to technology, and market linkages that lead to increased farmer income and productivity. Government agencies provide regulatory frameworks, subsidies, and infrastructure, whereas FPOs enable small and marginal farmers to bargain collectively.FPOs are essential for combining small-scale farmers' produce and enhancing their ability to connect with the growing modern marketplace. NGOs help by providing training, sustainable farming techniques, and promotion, while cooperatives improve supply chain efficiency through collective marketing and resource management. Together, these institutions contribute significantly trying to close down the gap between production and market access, lowering post-harvest losses, and assuring fair pricing for agricultural commodities. Efficient value and supply chain management is essential for enhancing farmer income while minimising post-harvest losses. These organisations help to establish cold storage facilities, processing units, and efficient transport networks that ensure timely delivery and minimal waste of agricultural products. These agencies' support for digital innovations allows for greater pricing transparency, improved market intelligence, and direct farmer-to-consumer linkages. Furthermore, public-private partnerships play an important role in bridging infrastructure knowledge gaps and focussing on technological advances. Strengthening these institutional frameworks can greatly improve farmers' socioeconomic conditions, which leads to more sustainable and resilient ecosystems for farming.

Keywords- Economic stability, Market linkages, Subsidies, Supply chain, Farmer income.

NS-T4-03

ROLE OF IARI's EXTENSION APPROACHES FOR FARMERS' WELFARE AND TECHNOLOGY OUTSCALING

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Ensuring farmers' welfare and strengthening value chains require effective extension mechanisms to facilitate technology dissemination. This study assessed the effectiveness of three key extension approaches of

the Indian Agricultural Research Institute (IARI) in Uttar Pradesh using an *ex post facto* research design. A stratified multistage sampling method was employed to select 120 farmers and 30 stakeholders for the study. Findings revealed a significant increase in the diffusion of area and seed spread of improved IARI wheat and rice varieties over the past four years. HD 2967 (wheat) and PB 1121 (rice) recorded the highest Estimated Cumulative Spread, Area Diffusion Effect (ADE) and Quality Seed Diffusion (QSD). The change in seed utilization pattern was observed at a medium level, while adoption of technologies like *seed production* and *improved crop varieties* showed positive trends. Among the extension models, farmers exhibited a more favourable attitude towards the IARI-Voluntary Organization (VO) partnership approach, while stakeholders showed a preference for the IARI Model Village (IMV) approach. The IARI-VO approach demonstrated the highest mean overall effectiveness index score, with IARI-NEP and IARI-VO performing significantly better than the IMV model. Despite these successes, challenges such as market constraints and limited seed availability hindered further technology outscaling. To enhance the impact of IARI's extension approaches, strategic interventions such as technology diversification, capacity building, promotion of seed production and leveraging ICT-based agro-advisory services are recommended. Strengthening institutional collaborations with government agencies, FPOs, NGOs and cooperatives can further streamline value chains and improve farmers' access to quality inputs and markets, contributing to a more sustainable food system.

Keywords: Extension approaches, Farmers' welfare, Seed diffusion, Value chain management.

NS-T4-04

LAND GOVERNANCE AND LAND TITLING REFORMS IN KARNATAKA: HISTORICAL EVOLUTION, LEGISLATIVE CHANGES, AND CHALLENGES

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This paper examines the historical evolution of land ownership, legislative changes, and the impact of these reforms on land rights, particularly in Karnataka. The need for structured land reforms arose due to disparities in land distribution, tenancy issues, and the socio-economic impact of ambiguous land rights. This study highlights Karnataka's land governance history, focusing on reforms, institutional arrangements, and the necessity for clear land titling and based on a qualitative analysis of historical land governance structures and policy documents, drawing from legislative texts and academic literature to understand the evolution of land tenure systems in Karnataka. The historical evolution of land governance in Karnataka began with the Raiyatwari system in ancient India, where cultivators held ownership rights but were taxed. During the medieval period, the introduction of intermediary landlords like zamindars impacted direct land ownership. British colonial rule further complicated land tenure by institutionalizing revenue farming systems. Post-independence, significant reforms were implemented to address land inequities. The abolition of intermediaries and the introduction of tenancy laws in the 1950s led to the Karnataka Land Reforms Act of 1961, which granted ownership to tenants and set landholding limits. Subsequent amendments in 1974 and 1976 further strengthened tenancy rights and restricted non-agricultural ownership. Recent initiatives like the Bhoomi e-Governance Project and the Karnataka Valuation and e-Registration Programme (Kaveri) have enhanced transparency and streamlined land transactions through digitization. However, challenges in land titling persist due to inconsistent documentation, informal transactions, and the limited success of land regularization schemes. Socio-economic disparities rooted in historical land inequities further hinder comprehensive land rights. Despite progressive land reforms, challenges remain in achieving comprehensive land rights in Karnataka. Clear land titling is crucial for enhancing agricultural productivity, ensuring social equity, and enabling access to government welfare schemes. Strengthening digital land records and addressing gaps in legal frameworks can contribute to a more efficient land governance system.

Keywords: Land governance, land ownership, Agricultural productivity, Bhoomi e-Governance, Karnataka Land Reforms Act, digitization of land records.

NS-T4-05

INTEGRATED FARMING SYSTEMS IN INDIA: ENHANCING SUSTAINABILITY, PROFITABILITY, AND RURAL LIVELIHOODS

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Integrated Farming Systems (IFS) play a crucial role in enhancing agricultural productivity, ensuring livelihood security, and promoting sustainability across diverse agro-ecoregions of India. Various studies have demonstrated region-specific IFS models tailored to optimize resource use and maximize returns. In the Northern and Central zones, crop-livestock combinations, particularly Crop + Dairy models, have proven to be the most effective. The Eastern zone predominantly benefits from Rice-Fish based systems, while in the Southern and Western zones, horticulture-integrated models yield higher economic returns. The ICAR-AICRP on IFS has recommended zone-wise models that maximize per hectare net returns, with Meghalaya, Bihar, and Mizoram emerging as top performers. A financial feasibility analysis of the IFS model developed by ICAR-IARI, New Delhi, highlights Dairy, Crop, and Horticulture modules as the most profitable, with high NPW and B:C ratios. The model exhibits an overall NPW of ₹27.86 lakh, a B:C ratio of 1.35, and an IRR of 28%, demonstrating economic viability. Scenario analysis over different project lifespans reveals improved profitability over time, with longer durations enhancing returns. However, modules like vermicomposting and biogas require further optimization due to high costs and limited market demand. Despite its benefits, the adoption of IFS faces challenges, including high initial investment, lack of market linkages, skilled labour shortages, and weather-related constraints. Addressing these through targeted interventions can enhance its sustainability. As a climate-resilient approach, IFS mitigates risks, stabilizes farm income, and supports rural livelihoods. Investment in low-cost technologies and assured market access is vital for widespread adoption. Given its economic and environmental advantages, IFS holds immense potential to transform rural agriculture and ensure sustainable livelihoods.

Keywords: Integrated Farming System, Sustainable Rural Livelihood, Financial feasibility analysis, Rural economy

NS-T4-06

LEVEL OF AWARENESS AND WILLINGNESS TO PAY FOR SAFE MILK: A STUDY OF URBAN CONSUMERS IN NORTH INDIA

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Milk adulteration and contamination present significant challenges to the dairy industry. Consumer awareness of food safety plays a crucial role in addressing this issue, particularly in countries with limited regulatory resources. This study evaluates consumer awareness of milk safety and estimates their Willingness to Pay (WTP) for safe milk. Data were collected from 270 milk-consuming households in North India and analyzed using the contingent valuation method, regression analysis, and index construction. The findings indicate an average household milk consumption of 2.6 liters per day, with an overall milk safety awareness index of 0.73. However, 29% of households exhibited low awareness, particularly regarding food safety

regulations, sources of milk contamination, and detection kits for adulteration. Awareness can be improved through targeted campaigns, television, and social media outreach. The study also found that milk safety awareness increased with household income, education level of the household head, and the quantity of milk purchased. Additionally, households with pregnant women and nursing mothers demonstrated higher awareness levels. The marginal WTP for safe milk was estimated at Rs. 6 per liter. Establishing a milk safety certification system could benefit dairy farmers by enabling them to receive premiums for producing clean and safe milk.

Keywords: Adulteration, Contamination, Contingent valuation, Milk Safety Awareness Index, Marginal Willingness to Pay (mWTP)

NS-T4-07

EXPLORING FARMER-LED INNOVATIONS IN ADVANCING ENTREPRENEURSHIP: A BIBLIOMETRIC ANALYSIS

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Farmer-led innovation plays a crucial role in driving sustainable agricultural transformation by offering grassroots solutions that address local challenges and enhance productivity. This study explores the intellectual landscape of farmer-led innovation, focusing on its contribution to entrepreneurship development. A bibliometric approach was employed to analyse authorship patterns, publication sources, institutional affiliations, and keyword co-occurrence networks. Key contributors such as De Carvalho GDG and Gupta AK, alongside leading institutions like Wageningen University and ICAR, were identified as pivotal in advancing this research area. Prominent journals, including Sustainability (Switzerland) and Nutrient Cycling in Agroecosystems, emerged as significant publication platforms. The keyword analysis revealed recurring themes of innovation, sustainability, agriculture, grassroots innovation, and smallholder farming, underscoring the critical interplay between local adaptation, policy frameworks, and technological advancements. Globally, the United States led research contributions, followed by significant outputs from China, India, and the United Kingdom. Citation analysis further highlighted regional disparities and emerging opportunities, particularly emphasizing the influence of developed nations in shaping the discourse on farmer-led innovation.

Keywords: Farmer-led innovation, Sustainable agriculture, Grassroots solutions, Bibliometric analysis.

NS-T4-08

INCOME INEQUALITY IN RURAL INDIA: AN EMPIRICAL ANALYSIS

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This study examines income inequality among agricultural households in India, focusing on factors influencing income diversification and its impact on poverty alleviation. Using data from the National Sample Survey Office (NSSO) Situational Assessment Survey of Agricultural Households, the analysis highlights significant disparities across states and landholding categories. While agriculture remains the primary income

source, off-farm activities—such as wage employment and non-farm businesses—now contribute 45% of total household income. The study finds that crop income is the largest contributor to income inequality, whereas earnings from livestock and wages help reduce disparities. Improving education and skill development for marginal and small farmers is essential for expanding access to off-farm employment, increasing household income, and reducing inequality. Additionally, female workforce participation shows a positive correlation with livestock income, emphasizing the need for women-focused credit programs offering low-interest loans. To estimate the impact of income diversification on household consumption expenditure, we applied Propensity Score Matching (PSM) using nearest neighbour matching, kernel-based matching, and calliper matching, all of which yielded significant results. The findings indicate that increased income diversification not only helps alleviate poverty but also plays a crucial role in reducing income inequality among farmers. Households with greater crop diversification demonstrate higher annual consumption expenditure, reinforcing the importance of policies that support diversified income sources. To bridge economic disparities and enhance rural livelihoods, the study recommends promoting sectors like dairying, construction, manufacturing, and trade, which can generate employment, support income diversification, and reduce inequality.

Keywords: Empirical analysis, Income inequality.

NS-T4-09

ROLE OF FINANCIAL INSTITUTIONS IN EMPOWERMENT OF FARMERS AND FARM WOMEN

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Farmers, architect of rural developmentand national building, are the backbone of the farm sector which provides food security and ensures livelihood of millions. The financial institutions play an important role in the empowerment of farmers, by providing access to financial services, products and resources, Loans are offered to the farmers at reasonable interest rate by these institutions to enable the farmers to purchase improved seed, chemical fertilizers, manures, insecticides, pesticides, farm machinery and other essential inputs. Farmers suffer heavily due to number of natural hazards viz., flood, cyclone, drought etc. Sometimes, crops are completely failed due to disease incidence or severe pest infestation. Financial institutions empower farmers by providing crop insurance, protecting farmers from crop failures, natural disasters and market fluctuations. Financial institutions encourage farmers to save some of their earnings. Farmers can open their saving bank account and fixed deposits with these institutions. This facility provide access to farmers at the time of any need. Microfinance sources are also provided to farmers especially farm women by the financial institutions, by offering small loans for supporting their farm activities. They also provide farm extension services by offering training guidance and technical support. Thus, they help farmers in enhancing their farm productivity and income by suggesting improved package of practices of various crops. Now, financial institutions are also offering digital financial services such as mobile banking and digital payment. Thus, accessing financial services, receiving payment and making transactions much easier at the tip of the finger. Risks associated with farmers such as weather risks, disease incidence, severe epst infestation, price volatility are reduced to a great extent by financial institutions, as they offer hedging products and other risk management tools. Thus, financial institutions empower farmers for enhancing crop yield and income, improve their livelihoods and well-being, ensuring food and nutritional security, expanding their market access and opportunities and building their resilience to climate change and other uncertainties by providing a critical support to them.

Keywords: Farm Women, Financial Institutions

NS-T4-10

EMPOWERING FARMERS AND FARM WOMEN: THE ROLE OF FINANCIAL INSTITUTIONS IN ADVANCING FINANCIAL INCLUSION

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Financial institutions play a vital role in advancing financial inclusion and empowering farmers and farm women, particularly in rural areas where access to formal financial services remains limited. Financial inclusion ensures the availability of affordable and timely financial services, such as credit, savings, and insurance, which are essential for enhancing agricultural productivity, improving livelihoods, and fostering socio-economic growth. This paper examines how financial institutions contribute to bridging the financial gap for rural communities through innovative schemes and interventions. Key government initiatives, such as the Pradhan Mantri Jan Dhan Yojana (PMJDY), have enabled millions of rural households to access banking services, including zero-balance accounts and insurance coverage. The Kisan Credit Card (KCC) scheme provides subsidized credit for agricultural needs, supporting small and marginal farmers, including women. Additionally, the Self-Help Group-Bank Linkage Program (SHG-BLP), facilitated by NABARD, empowers rural women through collective savings and credit access, promoting entrepreneurship and financial independence. The Pradhan Mantri Fasal Bima Yojana (PMFBY) offers affordable crop insurance, reducing financial risks from natural disasters, while the MUDRA Yojana supports micro-entrepreneurs with collateral-free loans. Digital innovations such as mobile banking, digital payment systems, and fintech platforms have significantly enhanced accessibility, reducing transaction costs and enabling real-time access to financial resources. Partnerships with microfinance institutions (MFIs) and NGOs further strengthen financial service delivery in remote areas. This paper emphasizes the need for collaborative efforts among policymakers, financial institutions, and community stakeholders to address challenges and scale successful models. By leveraging technology and adopting gender-sensitive financial practices, financial inclusion can serve as a powerful tool to empower farmers and farm women, foster rural development, and ensure sustainable agricultural growth.

Keywords: Farm Women, Financial Institutions

NS-T4-11

A PROFITABILITY ANALYSIS OF ORGANIC TURMERIC PRODUCTION IN NORTHERN KARNATAKA

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AnAttempt has been made to study the profitability of organic turmeric, which is widely known as the 'Golden Spice of India', in major turmeric producing districts, Bagalkot and Belagavi, in Northern Karnataka, India. A multistage purposive sampling technique was employed for the selection of sample respondents. Applied cost concepts and factor share analysis were the tools used to analyse the data. The findings of this study revealed that, hired human labour (34.82 %), cost of seeds (31.80 %) and farm yard manure (FYM) and vermicompost (12.31 %) were the major costs in Belagavi district, while these were 35.46 per cent, 33.43 per cent and 10.27 per cent, respectively for Bagalkot district. The per hectare cost of cultivation (Cost-C_3) and the cost of production per quintal of organic turmeric for organic turmeric was higher in Belagavi district compared to Bagalkot district. Collectively across both the districts, cost of cultivation of organic turmeric was Rs.

4,15,838.52/ha while the per quintal cost of production of organic turmeric was Rs. 5,569.60/q. It is also found that the organic turmeric production is economically viable (Returns per rupee of expenditure – 1.86), with positive net returns (Rs. 3,58,269.66/ha). The human labour emerged as the predominant factor in organic turmeric production across these districts, followed by factors such as seeds, farm yard manure and vermicompost *etc*. The study provides the inputs to policymakers, considering return on investment, to strengthen research and development for higher yields and extension services for mode adoptability among the farmers.

Keywords: Applied cost concepts, net return, resource optimization, Human labour

NS-T4-12

ENHANCEMENT OF FARMERS' LIVELIHOODS AND INCOME DIVERSIFICATION THROUGH FINANCIALLY FEASIBLE SANDALWOOD AGROFORESTRY

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Santalum album is a culturally and commercially important plant species. Due to its extensive depletion in natural habitats and continuously rising demand, there is a severe demand-supply gap in the global sandalwood market. The domestication of sandalwood through agro-silvicultural practices presents a viable solution to enhance its supply while ensuring sustainable cultivation. In this context, the present study was conducted in Karnataka using the snowball sampling method by collecting primary data from 200 farmers practicing sandalwood-based agroforestry models (AFMs). The study identified 24 distinct AFMs, integrating sandalwood with primary and secondary host plants that facilitate its growth as sandalwood is a hemi root parasite. The most commonly practiced models were AFM-I (*Santalum album - Cajanus cajan - Melia dubia*) (23.85%), followed by AFM-II (*Santalum album - Cajanus cajan - Mangifera indica*) (14.68%), AFM-III (*Santalum album - Cajanus cajan - Punica granatum*) and AFM-IV (*Santalum album - Morus alba - Mangifera indica*) (9.17% each). A financial feasibility analysis, based on indicators such as Net Present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate of Return (IRR) at 12 per cent discount rate over the economic life period of 15 years, revealed that AFM-II was the most profitable model with an NPV of ₹ 25,56,803 per hectare and the highest BCR (2.27). AFM-IV and AFM-III followed with NPVs of ₹ 23,56,381 and ₹ 23,47,685 per hectare, respectively. AFM-II also had the highest IRR (23.57%), making it the most financially viable model. The findings indicate that regions suitable for *Mangifera indica* (mango) cultivation may benefit from adopting AFM-II, as it provides the highest economic returns. Promoting financially feasible agroforestry models can encourage sustainable sandalwood cultivation and enhance farmers' livelihoods through the diversification of income sources, benefiting from the high-value sandalwood crop as well as the regular income from secondary host plants.

Keywords: Sandalwood, agroforestry, financial feasibility, farmers' livelihood, income diversification.

NS-T4-13

SCOPE AND OPPORTUNITIES OF MUSHROOM CULTIVATION IN WEST CHAMPARAN, BIHAR

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Mushroom cultivation presents a promising opportunity for agricultural diversification and rural entrepreneurship in West Champaran, Bihar. The region's favourable climatic conditions, with moderate temperatures ranging from 15-38°C and high humidity (75-85%), make it suitable for year-round production of commercially viable mushrooms such as Oyster (*Pleurotus* spp.), Button (*Agaricus bisporus*), and Milky (*Calocybe indica*). The abundance of agricultural residues like paddy straw, wheat husk, and maize stover provides a cost-effective substrate, reducing input costs and enhancing profitability. Additionally, the support from government schemes, NABARD funding, and KVK Madhopur has created a conducive ecosystem for mushroom cultivation in the region. Economically, mushroom cultivation offers a high return on investment, with production costs ranging from ₹50-70 per kg and market prices reaching ₹150-200 per kg, resulting in profit margins of over 185-209%, depending on the mushroom type. A small-scale farmer producing 100 kg per cycle can generate a net profit of ₹8,000-15,000 per cycle, with an estimated annual income of ₹1,50,000-3,00,000 when multiple cycles are conducted. Furthermore, value addition through mushroom processing, dehydration, and pickling can enhance profitability and expand market opportunities. Despite its potential, mushroom cultivation in West Champaran faces challenges such as limited awareness, inadequate market linkages, pest and disease management issues, and post-harvest losses. Addressing these constraints through KVK-led training, formation of groups and educating people for importance of mushroom cultivation and its value addition can significantly enhance the sector's sustainability. Strengthening supply chain networks, digital marketing platforms, and cooperative farming models will further ensure that small and marginal farmers benefit from this emerging enterprise. West Champaran holds immense potential for income generation, employment creation, and sustainable agricultural development. By integrating technological advancements, market-driven strategies, and institutional support, the district can emerge as a leading hub for mushroom production in Bihar.

Keywords: Mushroom, Bihar

NS-T4-14

A PRINCIPAL COMPONENT ANALYSIS OUTLOOK ON CONTRIBUTION OF INDIA'S GDP CONSTITUENTS

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The attempt has been made to study the application of principal component analysis (PCA) to analyze the extent of contributions of components to India's Gross Domestic Product (GDP) spanning from 1950–51 to 2022–23. PCA is meticulously chosen to mitigate challenges like multicollinearity and spurious regression. Two principal components, explaining 99.72% of the overall variation, were identified through eigenvalue approach and scree-plot analysis. The study revealed the significant roles of consumption, government spending, investment, exports, and imports in driving India's economic growth, with consumption and investment being the primary drivers of GDP. The study also highlighted the balanced contribution of

components to Indian GDP in the post-liberalization, unlike the pre-liberalization period, affirming the success of the 1991 reforms in fostering balanced growth across sectors. Higher contribution of Government's fixed capital formation stimulated economic expansion, while exports and imports bolstered international trade and competitiveness. These findings highlight the transformative impact of policy interventions, shaping India into a strong global economy. In addition, the study also validated PCA's effectiveness in tackling multicollinearity and found that the PC regression model outperformed the conventional multiple linear regression in terms of predictive accuracy.

Keywords: Eigenvalue approach, Liberalization, Multicollinearity, Principal Component Regression, Scree-plot.

NS-T4-15

CLUSTER FRONTLINE DEMONSTRATION ON LENTIL IMPROVES YIELD AND PRODUCTION ECONOMICS IN EAST CHAMPARAN, BIHAR

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Second most important rabi pulse crop in India as well as Bihar. However, lack of technological interventions, cultivation under rainfed conditions limits its production. From the view point of food and nutritional security of our nation scientific cultivation of lentil is very much esstial. Being a leguminous crop It also improves soil quality specially under cereale-based cropping sequence by fixing atmosphereic nitrogen through symbiotic fixation and helps in N cycling within the ecosystem. From this context, Cluster frontline demonstrations on lentil were conducted by Krishi Vigyan Kendra, Piprakothi, East Champaran during rabi season from 2019-20 to 2022-23. A total number of 133 front line demonstrations were conducted on lentil in 50 ha area by the active participation of the farmers with improved technologies of lentil (seed treatment, IPM, INM etc.). The results of the demonstrations observed that on an average yield of lentil under improved technology ranged from 10.34 to 12.35 q/ha with a mean of 11.65 q/ha; which was 24.8 per cent more yield as compared to farmer's practices (9.34 q/ha). Moreover, recorded average demonstration yield was also surplused over district (9.85 q/ha) and State (9.65 q/ha), respectively. Current study also highlighted that technology gap and technology index were reduced over the four year span from 816 to 615 kg/ha and from 44.1% to 33.24%, respectively for the demonstrated HUL- 57 and IPL 220 variety of lentil. Farmers also get benefitted form production economics point of view as they fetched the average mean net return of Rs. 38341/ha with mean B: C ratio of 2.57 in comparison to farmers' practices (Rs. 26131/ha). The present study resulted to convincing the farming community of East Champaran for demonstration of new improved technologies of lentill for higher productivity and returns.

Keywords: Cluster Frontline demonstrations, lentil, Technology gap, Technology index, East Champaran

NS-T4-16

ADOPTION AND CHALLENGES OF BACKYARD POULTRY FARMING AMONG RURAL SCHEDULED CASTE FARMERS OF SIWAN DISTRICT OF BIHAR

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Backyard poultry farming plays a crucial role in enhancing the livelihoods of rural and landless families in India. It requires minimal investment yet offers high returns, serving as a valuable source of supplementary income. Easily managed by men, women, children, and the elderly, it provides affordable, protein-rich meat and eggs, improving household nutrition. This study examined the adoption and challenges of backyard poultry farming among 30 Scheduled Caste farmers in Siwan District, Bihar. Findings revealed that 92% of farmers exhibited low adoption levels, while only 8% had a medium level of adoption. Key constraints included the absence of secure poultry shelters, limited vaccination facilities, unavailability of improved breeds, and summer feed shortages. Additional challenges were inadequate poultry sheds (90%), disease outbreaks (68%), restricted market access (78.67%), lack of information (71%), medicine scarcity (67%), and a shortage of veterinary doctors (61%). The study highlights the need for awareness programs on scientific poultry management to address these constraints, improve productivity, and promote sustainable backyard poultry farming.

Keywords: Backyard Poultry Farming

NS-T4-17

RESOURCE USE EFFICIENCY OF RICE -WHEAT CROPPING SYSTEM AND ITS DIVERSIFICATION OPTIONS IN INDO-GANGETIC PLAIN (IGP)

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Since the Green Revolution, the adoption of high-yielding crop varieties, mechanization, and assured market prices has significantly increased the combined area under rice and wheat cultivation as a share of the total gross cropped area. In Haryana, this proportion rose from 25.45% to 58.68%; in Punjab, from 31.18% to 83.34%; in Uttar Pradesh, from 37.70% to 59.48%; and in Bihar, from 50.04% to 71.98%, whereas in West Bengal, it declined from 70.18% to 55.68%. Over the past two decades, the growth rate of human and animal labour hours in the Indo-Gangetic Plain (IGP) declined, while mechanization increased, as reflected in rising machine labour use. Fertilizer and herbicide application also exhibited a continuous upward trend. However, total factor productivity (TFP) growth stagnated, with rice at 1.2% and wheat at 3%. This study aimed to analyse resource use efficiency and diversification options for the rice-wheat cropping system (RWCS) to enhance agricultural sustainability in the IGP. The analysis utilized secondary data from the 77th Situational Assessment Survey of Agricultural Households (NSSO, 2021), the Cost of Cultivation of Principal Crops, and Land Use Statistics. The findings revealed that the marginal productivity of irrigated land in RWCS was highest in Punjab and Haryana compared to Bihar and Uttar Pradesh. However, the marginal value product (MVP) of electricity expenditure per hectare was negative in Punjab and Haryana, indicating its adverse impact on total revenue. Additionally, excessive chemical fertilizer uses in these states led to unsustainable agricultural

practices. In contrast, Bihar and Uttar Pradesh exhibited underutilization of seed expenditure, suggesting that adopting higher-quality seeds could enhance revenue. The RWCS in the IGP exhibited decreasing returns to scale (except in Punjab), where a 1% increase in input costs led to less than a 1% increase in total revenue. Diversification with rabi maize or sugarcane improved profitability by 28% and 68%, respectively, due to assured prices, whereas diversification with masur/gram and rapeseed-mustard reduced profitability by 13% and 15% due to price realization below the minimum support price (MSP).

Keywords: Rice -wheat Cropping System

NS-T4-18

WOMEN ENTREPRENEURS AND INCOME-GENERATING ACTIVITIES: EMPOWERING WOMEN THROUGH ENTREPRENEURSHIP

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This paper explores the role of income-generating activities as a tool for women's economic empowerment, focusing on the diverse entrepreneurial ventures undertaken by women globally. In particular, it highlights how women entrepreneurs contribute to their families, communities, and economies through various business activities such as agriculture, handicrafts, beauty and wellness services, food processing, online businesses, and more. The research examines the factors that drive women to start their own businesses, the challenges they face, and the socio-economic impact of their ventures. Additionally, it investigates how income-generating activities not only provide financial independence but also empower women to challenge societal norms, access new opportunities, and contribute to sustainable development. Through case studies, qualitative surveys, and secondary data analysis, the paper sheds light on successful models of women entrepreneurship and the ways in which they overcome barriers like lack of access to credit, education, and resources. Ultimately, the research for policy interventions that support women in entrepreneurship, with an emphasis on creating inclusive ecosystems and providing the necessary resources to help women entrepreneurs thrive.

Key words: Economic empowerment, business activities, financial independence, entrepreneurship

NS-T4-19

EMPOWERING FARMERS AND FARM WOMEN: STRENGTHENING COMMUNITIES THROUGH AGRICULTURAL DEVELOPMENT

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This research paper explores the role of agricultural development in empowering farmers, particularly farm women, and how this empowerment leads to the strengthening of rural communities. The study emphasizes the importance of access to resources, education, training, and technology for farmers, with a particular focus on women who are involved in farming activities. Despite the significant contributions of farm women to agriculture, they face unique challenges, including limited access to land, credit, technology, and decision-making power. Through case studies, field surveys, and secondary data analysis, the paper identifies the strategies and initiatives that have proven successful in enhancing the capacity of farmers and farm women. These include training programs, agricultural cooperatives, access to financial resources, gender-sensitive

policies, and innovative technology adoption. This research also highlights the socio-economic benefits of empowering farm women, such as increased household income, improved food security, and better overall community development. it may be concluded that recommending policy interventions that can support the empowerment of farmers and farm women, ensuring that agricultural development is inclusive, equitable, and sustainable.

Key words: Empowering, farmers and farm women, gender-sensitive, strategies, financial resources

NS-T4-20

FRAMEWORK FOR SUSTAINABLE LIVELIHOOD OF LIVESTOCK FARMERS IN FLOOD PRONE AREAS OF ODISHA: EXPLORATORY RESEARCH STUDY

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Livestock rearing is an integral part of land scarce farmers for generating income and a means of providing a living. Livestock farmers in flood affected state of Odisha have been facing multifaceted impact on their livelihood which is a mammoth challenge to overcome. The research was carried out in the purposively selected state of Odisha because of the recurrent occurrences of flood. Thus, to ensure sustainable livelihood of livestock farmers faced with floods; exploratory research was taken to gather in-depth understanding of problems and construct a framework of suitable strategies with the active participation of stakeholders. Disaster specific strategies were formulated for flood prone area farmers for better livestock management and ensuring improved productive and reproductive performance. The formulation of strategies was a participatory exercise which involved four steps– stakeholders' selection, meeting with the stakeholders, identification and prioritization of problems and development of the framework. A total of four focus group discussion was carried out in the selected flood prone districts of Jagatsinghpur and Ganjam. Framing sound policies to address the vulnerability of livestock farmers in flood prone areas is crucial which this research study aims to fulfil.

Keywords: Flood, Framework, Livelihood, Livestock Farmer, Strategies

NS-T4-21

Comparative Economics of Natural and Conventional farming in Sugarcane cultivation in Belagavi district of Karnataka

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This study assesses the economic benefits of natural versus conventional sugarcane farming in Belagavi district of Karnataka for the time period of 2023-24. Amid India's economic ambitions and the critical role in agriculture played during the COVID-19 pandemic, natural farming methods, particularly Zero Budget

Natural Farming (ZBNF) advocated by Shri Subhash Palekar are examined. The research, involving 120 sample farmers including 60 practicing natural farming and 60 conventional farming for the analysis total cost method was employed. The results reveal that in conventional farming yield was more sugarcane per hectare and provides higher gross returns, natural farming proves more cost-effective. Natural farming's total cost of cultivation was Rs. 2,24,544.71 per hectare, when compared to conventional farming (Rs. 2,55,587.89). This difference is largely due to lower variable costs and more efficient input use in natural farming. Although natural farming has lower yields but it fetches a higher price per tonne (Rs. 3,300 versus Rs. 2,900), contributing to higher net returns of Rs. 2,07,633 compared to Rs. 1,81,532 from conventional methods. The cost of production per tonne is also higher in natural farming (Rs. 1,715) compared to conventional farming (Rs. 1,696), whereas, the overall returns per rupee of expenditure was better in natural farming (1.92) than the conventional farming (1.71).The findings highlights the natural farming's potential for economic sustainability and reduced dependence on costly inputs, despite its lower yields. The study suggests that, with increased awareness, government support and incentives natural farming practices could gain broader adoption in the study area. This not only benefit farmers economically but also promote long-term sustainability and resilience in agriculture.

Keywords: Variable and fixed costs, Natural farming and conventional farming

NS-T3-22

ASSESSING THE EFFECTIVENESS OF WATER USER ASSOCIATIONS IN IRRIGATION MANAGEMENT: A CASE STUDY FROM KARNATAK

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India's irrigation system plays a crucial role in sustaining agricultural productivity and ensuring food security. Recognizing the need for decentralized water management, Participatory Irrigation Management (PIM) was introduced in the 1980s, leading to the establishment of over 85,000 Water User Associations (WUAs) managing 14.5 million hectares across 24 states. These institutions are playing a crucial role in involving farmers in water planning, distribution, and management. However, irrigation systems in India, whether large or small, face challenges at the grassroots level, necessitating effective institutional mechanisms. This study evaluates the effectiveness of WUAs under different irrigation systems in Karnataka, focusing on their group dynamics and overall functionality.The research was conducted in the command area of the Rameshwar Lift Irrigation Project in Karnataka, implemented by Karnataka Neeravari Nigam Limited in 2016. A total of 360 farmers were surveyed, with 120 farmers each from the head (Gokak), middle (Ramdurga), and tail (Saundatti) regions, representing eight different WUAs. The study employed a Group Dynamics Effectiveness Index (GDEI) to assess institutional efficiency, incorporating ten key parameters. Farmers in head region irrigation WUAs rated most GDEI parameters highly, except for social support. In contrast, WUAs in the middle region exhibited higher effectiveness, while those in tail irrigation systems reported weaknesses in participation, decision-making, group atmosphere, empathy, interpersonal trust, and social support. GDEI values ranged between 6.28 and 6.82 on a scale of 0 to 10, indicating differential effectiveness influenced by spatial and temporal variations in irrigation command areas.The findings highlight the need for strengthening institutional capacity, enhancing participatory decision-making, and addressing regional disparities in WUA performance. Policies should focus on empowering WUAs through capacity-building programs, financial support, and adaptive governance strategies to ensure equitable and efficient water resource management, ultimately contributing to sustainable irrigation and agricultural development.

Keywords: Effectiveness of Water, Irrigation Management

NS-T4-23

ARYA: EMPOWERING RURAL YOUTH THROUGH SECONDARY AGRICULTURE BY REVITALIZING MUSHROOM CULTIVATION

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Mushroom cultivation is one of the integral secondary agriculture components which has potential for boosting rural economy and enhancing livelihoods. Attracting and Retaining Youth in Agriculture (ARYA) project, initiated by ICAR at KVK Piprakothi, Bihar, has significantly boosted mushroom production in East Champaran by empowering rural youth with training and entrepreneurial support. Since inception of ARYA, 18 training programs were imparted benefiting 427 youth, of whom 407 established their own mushroom farming enterprises, with 374 running them sustainably. Additionally, 78 entrepreneurial groups were formed, with 77 successfully operating. The initial size of enterprise is 60 bags, generating employment for 1,104 youth over five years. This initiative has led to a 124.65% rise in income, with average annual earnings increasing from ₹36,500 to ₹82,000. Furthermore, 4 FPOs and SHGs are associated with the project, leading to the establishment of 315 new mushroom units in nearby villages. Awareness has also been raised through 12 press releases, TV, and radio talks, contributing to market expansion. A branded product has also emerged from this initiative. ARYA has successfully transformed mushroom farming into a profitable and sustainable enterprise, promoting rural employment, entrepreneurship, and economic growth while reducing youth migration to cities.

Keywords: Attracting and Retaining Youth in Agriculture, secondary agriculture, mushroom production,

NS-T4-24

A STUDY ON REGIONAL VARIABILITY IN INDIGENOUS TECHNICAL KNOWLEDGE AMONG DAIRY FARMERS IN NORTH INDIA

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Indigenous Technical Knowledge (ITK) plays a crucial role in traditional dairy farming practices across North India. As north zone is bestowed with huge cultural and livestock diversity from plain to hilly and temperate agro-climatic regions and the livestock farmers have been using traditional skills and practices (ITKs) related to livestock management. This study aims to explore the regional variability of ITKs among dairy farmers in different states of North India, viz., Punjab, Himachal Pradesh, Uttarakhand Jammu & Kashmir to understand the prevalence of ITKs and its dynamics of usage across the region. Data was collected from the dairy farmers by the associated Animal Scientists from KVKs with the help of focus group discussions guided by interview schedule and checklist. For recording the adoption pattern from each state, six villages were selected and from each village 20 farmers were selected. Therefore, out of 24 villages total 480 farmers were selected for the study purpose. A total 82 ITKs were identified and categorized into two groups namely health and management and out of them few promising ITKs were studied for region specific variation on the basis of 5 key informants. Out of the total ITK documented, the maximum adoption of ITKs was obtained in HP

(33%) followed by UK (26%), J&K (23.1%) and least in Punjab (18.2%). 75% ITK constitute the Ethnoveterinary practices and rest are under other managemental practices. Easily availability of medicinal plants locally along with farmers having embedded expertise of ITKs were the key factors that determine the adoption of ITK by the dairy farmers. However, attractive nature of modern practices and high labor and skill requirement needed for using ITKs are the major perceived constraints in adoption of ITK by the dairy Farmers. Cross regional analysis of location specificity of different ITKs, similarities and variation in ingredients usage and researchable issues in ITKs would help in further promoting its widespread usage. The study reveals that regional variations in ITKs are shaped by environmental constraints, availability of natural resources, and socio-economic factors. While some ITKs align with scientific dairy practices, others require validation and refinement. Large inter-regional variation in the ITK usage warrants a scope to popularize the validated ITKs among the dairy farmers of other regions where these are not being practiced. These findings aim to highlight the relevance of ITKs in modern dairy farming and their potential integration into scientific livestock management.

Key words: Indigenous technical knowledge, dairy, adoption

NS-T4-25

AN EXPLORATORY STUDY ON SOCIO-ECONOMIC PROFILE OF DAIRY FARMERS IN CENTRAL PLAIN OF PUNJAB

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Dairying is a crucial occupation that sustains the livelihoods of a large proportion of the population in India, including farmers in Punjab. This study aimed to examine the socio-economic profile of dairy farmers in the central plain zone of Punjab. Three districts were purposively selected from the zone, and two blocks were chosen randomly from each district. Six villages were selected from the two blocks in each district for the study, and from these villages, 10 livestock farmers were randomly selected for the interviews. The total sample size for this study was 180. The inclusion criteria required that dairy farmers must have at least one lactating dairy animal at the time of the investigation. Data was collected using a pre-tested structured interview schedule through personal interviews. The collected data was then analyzed using appropriate statistical tools. The results indicated that the majority of the farmers were in the middle-age group, with an average age of 45 years, and most had an education level up to high school. Category-wise, 30.5% of respondents had medium-sized land holdings and an average of 10 years of experience in dairy farming. A significant difference ($P<0.01$) was found across districts regarding the distribution of dairy animals, with more than 50% of the animals being buffaloes, followed by 24.4% crossbred cows, and the remaining non-descript animals, most of which were in lactation. Regarding milk production, consumption, and sale, significant differences were observed between districts, with an average production of 13 litres per day per household from buffaloes. In conclusion, the socio-economic characteristics of the farmers play a crucial role in the effective implementation of projects and policymaking decisions. The study revealed that more than half of the farmers involved in dairy farming were middle-aged and belonged to medium-income groups.

Key words: Punjab, dairy, milk production

NS-T4-26

SUSTAINABLE LIVELIHOOD TO ENHANCE HOUSEHOLD FOOD SECURITY THROUGH KITCHEN GARDEN IN RURAL AREAS OF SHEOHAR DISTRICT

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Kitchen gardening contributes to household food security by providing direct access to food that can be harvested, prepared and feel to family members, often on a daily basis. Generally, kitchen gardening refers to the cultivation of a small portion of land which may be around the household or within walking distance from the family home. Kitchen garden is a realistic solution as in rural area to solve the nutritional insecurity adequate nutrition is very important during all the stages of life as life cannot be sustained without adequate nourishment. Deficiency disease caused by micro nutrient is one of the serious problems. Micro nutrients deficiencies are most prevalent in rural area where the habitual diet lacks variety and people cannot afford to diversify their diets or unable to include fruits and vegetables in their diet. To fulfill the objectives of the present study the purposive study was planned. The study was conducted in two blocks i.e. Sheohar and Tariyani were selected for this study. From each block two villages were selected purposively for the study. Among each village 30 farm women were selected randomly. Hence, total sample size was 120 women the data were collected through personal interview method with the help of structured schedule having area near the house of $100m^2$, $150m^2$ and $200m^2$. It was found that area available for kitchen garden is most of farm families in cultivated area near the house (55.32%) followed by useless land near the house (35.37%) which were not used due to awareness. The majority of the respondents were having no knowledge about variety of seeds and stages of irrigation followed by manure and fertilizer, transplanting distance and sowing time of vegetables seeds. It was also found that from $150m^2$ of kitchen garden fulfilled the requirement of vegetable in daily diet for small family of five members. It was also observed that after introducing kitchen garden people save money and use fresh and organic vegetables so, that health problems also reduce due to use of balance dose of vegetables in daily diet.

Keywords: - Kitchen Garden, House Hold Food Security, Rural Area.

NS-T4-27

CONSTRAINTS AND STRATEGIES IN ADOPTION OF BEEKEEPING IN SHEOHAR DISTRICT OF BIHAR

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Apiculture is an ideal absorbing instructive and economically profitable hobby. It is especially suitable for women because it does not involve heavy physical work, allows time flexibility, provides gainful employment near to their house and ultimately provides financial security. It solves problem of unemployment if adopted on Commercial scale or as cottage industry. It can generate self-employment to over 15 million rural and tribal families and can produce annual income of over Rs 4.5 billion by producing 150000 tons of honey (Shende, 1992). The study was conducted in two block of Sheohar district in Bihar, out of five block two block selected namely Tariyani and Piprahi. Total sample of 80 rural entrepreneurs was selected as respondents. Constraints faced by beekeeping entrepreneurs in setting up beekeeping enterprise were grouped in four categories viz. socio - personal, economic, technological and communicational constraints. Low level of consumer awareness and motivation, poor access to finance, irregular and ineffective training programme for upgrading the know-how and skill and inadequate access to training programme were the major constraints for beekeeping entrepreneurship development. The following strategies are suggested not only to remove the bottlenecks

rationed above but also to strengthen the adoption of beekeeping enterprise by entrepreneurs were creation of proper consumer awareness for enhancing motivation provision of institutional finance on reasonable interest improving access and effectiveness of training programme in beekeeping enterprise.

Keywords - Constraints analysis, strategies, Beekeeping entrepreneurs and effectiveness of training programme.

NS-T4-28

ADDITIONAL INCOME GENERATE OF MUSHROOM CULTIVATION UNDER ARYA PROJECT

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Attracting and Retaining Youth in Agriculture (ARYA) project of ICAR is going on at Krishi Vigyan Kendra, Belipar Gorakhpur since 2019-20. In this project entrepreneurial trainings are being given to unemployed rural youth so that they can start their own Enterprises. He is involved in button mushroom production from last year being a beneficiary of ARYA Project. He obtained 18.7 q button mushroom last year, which was sold to nearby market @ 120/kg. He earned Rs. 163000 as net income by selling of total harvest of mushroom. He is also interested in production of milky and oyster mushroom. He has also created employment opportunity to two members in future his planning to start value addition in terms dried mushroom powder and other value added products. To make agriculture sustainable, the price of agricultural commodities must be sufficient but variations in price may occur depending on market demand. So, by adopting mushroom production at rural level farmers may minimize the price gap by price of their mushroom and ultimately people get good quality of mushroom and mushroom based products like pickle at rural level. This sets good example and also increases extra income from the agriculture at rural level by youth. 50 Educated and unemployed rural youths trained year 2024-25 of ARYA Project and 19 youth started commercial farming of mushroom and 31 farmer start personnel use. Rural youth gets benefited by the interventions as facilitated by Krishi Vigyan Kendra, Belipar Gorakhpur, like trainings, demonstration, farm advisory service for Button, Oyster and Milky mushroom production, value added product and marketing of these products under ARYA project. The spawn of mushroom, chemical, net bags, polythene bags and other accessories were provided among 50 rural youths for this enterprise under ARYA project. Farmers are receiving good prize of mushroom and its value added products by selling it to different enterprises. They also reduced storage and handling cost for surplus extra and sell their products to consumers and this enable increase of extra income. From the findings it may be concluded that mushroom production through scientific and technical support of KVKs may raise the extra income of the rural youths and farm women.

Keywords: MUSHROOM, ARYA PROJECT

NS-T4-29

STUDY ON VEGETABLES AND LIVESTOCK BY PRODUCT EFFECT OF MALNUTRITION AND LIVELIHOOD

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The present experiment was conducted on the "Eradication of malnutrition" was carried out at Village-Gorsur, Block- Ghosi District- Jehanabad, Bihar from August, 2023 to June, 2024. Information related to the

study was collected by survey as well as PRA at100 schedule caste (SC) family and total population 831(average children age 10-15 years, women 4o-45 years and man 45-50 years) are selected for malnutrition. In order to obtain relevant information, the survey sources include face to face interviews with the heads of households through a pre-tested interview schedule by a questionnaire because many households heads were either illiterate or had low literacy levels. The results obtained in the present investigation are summarized like Detailed characteristics of households, Demographic details of households, Family structure, Occupational profile of the households, Monthly income of the households, Households' status of livestock, Number of households engaged in income generation from livestock, Households' land holding details, Existing nutri garden practices of households Area under nutri-garden practice, vegetable in daily food habitat, dairy byproducts (milk, panner, curd, tea etc.) in daily food habitat, poultry (eggs & chicken) in daily food habitat, goat meat and health check-up of children's/man/women and animal health check-up. The Krishi Vigyan Kendra, Jehanabad, first of all provided awareness programme(25) for it and conducted health check-up of children's/man/women (height, weight, anaemia, haemoglobin, blindness, blood pressure, etc.), animal health check-up (vaccination, deficiency of calcium, minerals) then after given under front line demonstration (FLD) kitchen garden kit (chili, carrot, brinjal, palak, coriander, tomato, cauliflower, pea, reddish, methi, onion, spinach, pumpkin, bottle guard, cluster bean, okra, mask melon, cowpea; seedling plants (jackfruit, mango, guava, lemon, moringa, papaya, pomegranate etc.); for backyard poultry farming (Sonali, Karaknath, Grampriya and Vanraja poultry chicks); vaccination of PPR in goat; and distribution of mineral mixture for dairy cattle. The results of the study have revealed that majority of the respondents in the study area were of middle age, illiterate, unemployed and having very low income. All are belonged to scheduled caste and farming as well as livestock rearing was their main source of livelihood. The KVK, Jehanabad also organized health camp at Referral Hospital, Gorsur, Ghosi, Jehanabad for testing of height, weight, blood profile like haemoglobin, blood presser. The results are found that the slightly increase average children haemoglobin percent(7-8%), women haemoglobin percent(9.2%), man haemoglobin percent(11.3%); average children weight(26kg), women weight(39.3kg), man weight(55.5kg); and average children height(4.5 ft), women height(4.8ft), man height(5.1ft) and average children body mass index (BMI)(7.91), average women BMI(9.49) and average man BMI(11.23).

Keywords: - Malnutrition, health check-up, vegetable, animal by product, kitchen garden kit, livelihood, scheduled caste and FLD

NS-T4-30

EMPOWERING FARMERS OF EAST CHAMPARAN, STRENGTHENING PULSE SEED CHAIN THROUGH CREATION OF SEED HUBS FOR INCREASING INDIGENOUS PRODUCTION OF PULSES IN INDIA

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The Pulse Seed Hub Programme, launched by the Indian Council of Agricultural Research (ICAR) under the National Food Security Mission (NFSM) in 2016-17, aims to increase indigenous pulse seed production through participatory seed production. KVK Piprakothi has played a key role in enhancing seed availability, promoting improved varieties, and boosting farmers' incomes across multiple villages of East Champaran. Since its inception, KVK Piprakothi has cultivated lentil, pigeon pea, and green gram on a large-

scale accounting to production of a total of 173.70 tonnes and covering an area of 375 hectares approximately. This programme has increased seed replacement rates (SRR), improved pulse productivity, and enhanced financial sustainability. The seed replacement ratio of East Champaran in Pigeon Pea, Lentil and Green gram was 17.43 %,13.46% and 21.35 % respectively in the year 2023-24. The initiative continues to empower farmers, improve food security, and strengthen community-driven seed production in East Champaran. The pulse seed chain thus established in East Champaran has not only improved the availability of pulse seed but also has improved socio-economic condition of the farmers through the participatory mode. Key Words: Pulse Seed Hub, participatory seed production, community-driven seed production.

Keywords: -SEED CHAIN, National Food Security Mission

NS-T4-31

FARMER PRODUCER ORGANIZATIONS AND AGRO-PROCESSING IN INDIA: STATUS, PERFORMANCE, AND GROWTH FORECAST

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Farmer Producer Organizations (FPOs) play a vital role in empowering small farmers by improving market access, bargaining power, and profitability. They are crucial in agro-processing, value addition, and reducing post-harvest losses. Despite policy support from the Central Govt., SFAC and NABARD, many FPOs face challenges like inadequate capital, fragmented supply chains, and limited technical expertise. However, success stories from Maharashtra, Tamil Nadu, and Madhya Pradesh showcase their potential in building sustainable agribusinesses. This study employs predictive analytics and *Grey modeling* to forecast FPO growth in India until 2040. Key drivers include digitalization, climate-smart practices, and private-sector collaboration, supported by government schemes like PM-FME and PMKSY. By 2040, FPO-led collectives are expected to boost India's agri-GDP and increase farm gate prices by 30–40%. However, challenges like climate change, policy shifts, and evolving consumer preferences persist. Addressing these through technology adoption, skill development, and integrated value chains is crucial. Long-term policy stability, financing reforms, and cooperative models will be essential for FPOs to drive rural prosperity and agricultural sustainability in India.

Keywords: FPOs, Value addition, Challenges, Policy support

NS-T4-32

AN ECONOMIC ANALYSIS OF MILK PRODUCTION: EVALUATING PROFITABILITY ACROSS MARKETING CHANNELS

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Milk production plays a crucial role in the agricultural economy, contributing significantly to rural livelihoods and food security. However, the profitability and sustainability of dairy farming are influenced by the efficiency of marketing channels. This study analyzes the economic aspects of milk production, focusing on different marketing channels, including direct sales, cooperatives, and private vendors. The research examines production costs, revenue generation, and the price margins across these channels to identify the most

profitable and sustainable distribution models.The marketing structure of the study area revealed that the produce's share in consumer's rupee was estimated comparatively high in case of channel-I, followed by channel-II, channel- III and channel-IV. Thus, channel-I was most appropriate and profitable from the viewpoint of the producer's share. The findings suggest that in this channel, direct contact of milk producer with consumer of milk provides maximum share of consumer price to the producer of milk but it require better infrastructure and market access. It ensures better price realization for farmers, while private vendors often offer quick liquidity but at lower margins. To enhance profitability, policies should focus on strengthening dairy cooperatives, improving cold chain logistics and ensuring fair price mechanisms.The study highlights the need for improved infrastructure, price transparency, and policy support to enhance dairy farmers' economic returns. Overall, a well-structured and transparent marketing system is essential for maximizing farmers' income and promoting sustainable dairy farming.

Keywords: Consumers, Dairy farmers, Fair price mechanism, Marketing channels, Milk production,Producer's share in consumer's rupee, Profitability, Sustainability

NS-T4-33

ASSESSMENT OF FLD ON MUSHROOM CULTIVATION IN SHEOHAR DISTRICT OF BIHAR

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Mushroom is one of the promising Agri-enterprises that has immense potential to increase the livelihood of poor people, and one can become a successful agri-entrepreneur with large-scale commercial mushroom cultivation. Particularly in Bihar, where most of the farmers possess marginal land holdings, mushroom cultivation is one of the best substitutes for an improved year-over-year income with low investment and input costs coupled with mushroom growing skill and technology. Therefore, more than 250 farmers were trained in KVK, Sheohar, for mushroom cultivation through rural youth training programs during the year 2022–23 and 2023–24. After providing training to the farmers, a simultaneous FLD program was also conducted for validating the profitability and ease of choosing oyster/milky or button mushroom cultivation over one another in the respective years. The mushroom cultivation kits composed of mushroom spawn, low density polythene bags and other miscellaneous items were distributed to the trained farmers and its impact was assessed in terms of production and BC ratio. During the FLD period, oyster, milky and button mushroom cultivation kits were distributed to 99 (no.), 64 (no.) and 65 (no.) farmers respectively. As a result, 7.43 q, 4.82 q and 3.90 q of average yields were recorded in oyster, milky and button mushroom respectively. It was evident from the calculation of BC ratio viz. 3.41:1 in oyster, 2.89:1 in milky, and 2.05:1 in button mushroom that oyster and milky mushroom cultivations were very promising in Sheohar district with significant production supported by high BC ratio. While button mushroom cultivation was started first time in the district so, adoption rate was in its early phase and availability of quality compost was the main constraint in the button mushroom cultivation which was being addressed by KVK, Sheohar. These findings indicate that there is a huge potential in mushroom cultivation that can really help farmers and rural youth to become self-reliant.

Keywords: Mushroom, FLD

NS-T4-34

GOAT FARMING FOR INCOME AND EMPLOYMENT GENERATION IN DIFFERENT KVKS UNDER ARYA PROJECT

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Goat farming in India is a growing sector that contributes significantly to the country's animal husbandry industry. The industry is thriving due to high returns on investment and the increasing demand for goat meat, milk, and leather. India is one of the largest consumers of goat meat, making it a profitable enterprise for farmers. Research and development efforts are being made to enhance breed quality, improve nutrition, and improve shelter management practices. Goat farming is crucial for India's rural economy, providing employment and income generation for small-scale and landless farmers. The adaptability of goats to different climates and low maintenance costs makes it a viable option for sustainable livelihoods. The industry also supports the leather and dairy sectors, further contributing to India's economy. Government and non-governmental initiatives are being introduced to support farmers through training and infrastructure development, such as the ARYA project, which encourages youth participation in profitable agricultural enterprises like goat farming. Through these training programs, a total of 100 rural youth was trained, leading to the creation of employment opportunities and generating 455 man-days of work. Additionally, 252 viable goat farming units were established, resulting in a total production of 36 goats. The economic impact of these efforts was substantial, with a net benefit of ₹1,51,220/- and an impressive benefit-cost ratio (BCR) of 5.00, highlighting the profitability of goat farming in the region. Goat farming in India offers numerous economic and social benefits, including high return on investment, consistent income, and low initial investment and maintenance costs. It is accessible to farmers with limited financial resources, and government subsidies enhance its profitability. Goat farming has contributed to the upliftment of rural communities by providing sustainable employment opportunities and encouraging agricultural entrepreneurship. However, challenges such as disease outbreaks, lack of access to quality breeds, inadequate veterinary care, and fluctuating market prices need to be addressed collaboratively. Continued research, technical support, and training programs are essential for enhancing productivity and profitability. Investments in infrastructure, disease control measures, and efficient supply chain management are crucial for long-term sustainability. Strengthening the industry through improved breeding techniques, better disease management, and efficient marketing strategies will ensure long-term growth and prosperity for farmers, making it a cornerstone of India's agricultural economy.

Keywords: Employment, Goat farming, Training, Rural Youths

NS-T4-35

Rice-fish integration: Performance and potential under flood-affected waterlogged ecosystems in North Bihar, India

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Nearly 13% of the country's total geographic area is susceptible to flooding, with approximately 11.6 million hectares affected by waterlogging annually. Bihar is one of the most flood-prone states, where extensive cultivable lands remain submerged, restricting crop cultivation to rice during the kharif season. Additionally, rising groundwater levels post-monsoon further limit the viability of high-value crops. Rice-fish

integration presents a sustainable approach that enhances both productivity and profitability by creating a mutually beneficial system. Fish excreta improve soil fertility, leading to increased rice growth and yield, while fish contribute to pest and weed control, soil aeration, and reduced input costs. In return, rice fields provide a suitable habitat and food sources for fish.A field experiment conducted on farmers' fields evaluated rice-fish farming under three nutrient management treatments: organic, organic + inorganic, and inorganic sources of nutrients. Results showed significantly higher rice grain yields in organic + inorganic and organic treatments compared to inorganic and traditional farming practices. The highest fish survival rate (96%) was recorded in the organic + inorganic treatment, followed by inorganic and organic treatments (90%). After 100 days, fish yield, including L. rohita, C. catla, C. mrigala, and C. carpio, was highest in the organic + inorganic treatment. Water quality parameters such as pH, temperature, and dissolved oxygen remained within the optimal range, except for alkalinity and hardness. The system also supported diverse phytoplankton and zooplankton populations.For effective implementation, minor modifications like micro-watershed-cum-fish refuge areas and strong dykes are required, allowing integration with crops, livestock, and agroforestry. Despite its potential, adoption in northern Bihar remains low due to technical knowledge gaps, socio-economic barriers, and policy limitations. Developing region-specific models and supportive policies can promote wider adoption, improving land productivity, food security, and economic sustainability for small and marginal farmers.

Keywords: Rice-Fish Farming System, Waterlogging, Flood, Food and Nutritional Security, North Bihar

NS-T4-36

ASSESSMENT OF WATER-SAVING IRRIGATION TECHNIQUES FOR WINTER MAIZE IN THE RICE-MAIZE CROPPING SYSTEM OF NORTH BIHAR

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Efficient water management is crucial for food security and poverty reduction, ensuring global sustenance. Bihar is India's third-largest maize-producing state, contributing about 14% to the national output. Maize farming provides livelihoods for nearly 1.3 million farmers in Bihar, most of whom are small and marginal. In North Bihar, maize is cultivated in all three seasons, with rabi having the largest area, followed by kharif and spring. With its humid subtropical climate, North Bihar plays a crucial role in global food security. After the kharif season or during non-monsoon periods, groundwater becomes the primary source of irrigation for rabi and summer crops, as rainfall is absent and stream flows decline to minimal levels. Maize is sensitive to both water stress and excessive moisture, proper irrigation management is essential for maximizing yield. A field study was conducted in Motihari, Bihar, during the winter seasons of 2021–2022, 2022–2023, and 2023–2024 to assess the impact of irrigation techniques and levels on winter maize. Results indicated that alternate furrow irrigation (AFI) with a 30 cm furrow depth reduced seasonal crop water use (CWU) by 36.5%, 33.6%, and 31.3%, while AFI with a 15 cm furrow depth saved 35.1%, 31.3%, and 30% CWU at 100%, 80%, and 60% irrigation levels, respectively. AFI with 60% ETc irrigation was found to be the most effective for conserving water, enhancing crop water productivity, and improving maize yield in North Bihar.

Keywords: Winter maize; Water-saving techniques; Alternate furrow irrigation; North Bihar; Crop water use.

NS-T4-37

INNOVATIVE AGRICULTURAL PRACTICES FOR CLIMATE RESILIENCE: THE IMPACT OF ZERO TILLAGE ON WHEAT FARMING IN WEST CHAMPARAN, BIHAR

Abhishek Ranjan, Abhishek Pratap Singh, Jagpal

KVK, Madhopur, West Champaran, Bihar

Policy-makers are increasingly recognizing the largely untapped potential of the Western Indo-Gangetic Plains (IGP) to contribute to state- and national-level food security in India. Zero tillage (ZT) technology has emerged as an effective method for improving wheat productivity while simultaneously reducing production costs in this region. This approach is widely acknowledged within the framework of Conservation Agriculture (CA), which involves minimal soil disturbance, maintaining organic soil cover using crop residues or cover crops, this approach is widely acknowledged within the framework of Conservation Agriculture (CA). These practices enhance input efficiency, improve resource utilization, and contribute to climate change mitigation by reducing greenhouse gas (GHG) emissions. Under the Climate resilient agriculture (CRA), efforts were made to introduce zero tillage technology in three villages (Jhakhra, Gahiri and Telua) under the Nautan block of West Champaran district, Bihar. The results indicate that farmers in these villages are increasingly adopting zero tillage for wheat cultivation, recognizing its potential to enhance income and promote sustainable farming. This technology allows rice-wheat farmers to directly drill wheat seeds immediately after rice harvesting without prior tillage, ensuring the wheat crop matures before the onset of the pre-monsoon period. The process involves using a specially designed zero-till seed-cum-fertilizer drill, which creates narrow slits in the soil for seed and fertilizer placement. Wheat sown using zero tillage technology benefits farmers by advancing sowing time and reducing cultivation costs. It eliminates the need for land preparation, resulting in a cost saving of approximately Rs. 6500-7000 per hectare. Additionally, it reduces labour time 7–8 hours per hectare, and fuel consumption 45-50 lit per hectare, also preserving water upto 35-40% per hectare.

Keywords: *Zero tillage, Adaptation, Wheat, Conservation Agriculture, and Greenhouse Gas.*

NS-T4-38

IMPACT OF DIFFERENT DRIP FERTIGATION LEVELS ON THE QUALITY OF ASIATIC LILIES (*Lilium* spp.) CULTIVATED UNDER OPEN FIELD CONDITIONS OF HIMALAYAN TARAI REGION IN INDIA

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This study investigated the impact of different drip fertigation levels on the quality of Asiatic lilies (*Lilium* spp.) cultivated under open field conditions of Himalayan tarai region in India. Our research evaluated three fertigation treatments: 120% recommended dose of fertilizer (RDF), 100% RDF, and 80% RDF, alongside a conventional method. The results demonstrated that the 120% RDF treatment significantly increased plant height, leaf area, and biomass, whereas the 100% RDF treatment improved bud initiation, floret diameter, and shelf life of spike. Specifically, the 120% RDF through drip fertigation had taller plant height (104.00 cm) and maximum leaf area (1291.54 cm^2), whereas the 100% RDF found superior in bud number per spike (5.50 per plant) and the maximum shelf life (27.70 days). The conventional method consistently underperformed across

all the metrics. These findings underscore the importance of optimized fertigation in improving both growth and floral quality, providing practical guidelines for growers aiming to increase economic viability and sustainability in lily cultivation.

Keywords: Drip fertigation, conventional method, spike quality, vegetative growth

NS-T2-39

ROBOTICS IN HORTICULTURE: INNOVATIONS AND FUTURE PROSPECTS – A REVIEW

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The integration of robotics into horticulture marks a revolutionary step in plant cultivation, offering innovative solutions to critical challenges such as labor shortages, productivity demands, and sustainability concerns. Globally, horticulture contributes approximately 33% to agricultural GDP and employs over 1 billion people; however, labor shortages threaten this sector's efficiency. Robotics emerges as a transformative force, addressing these challenges through automation and advanced technology. This paper delves into the profound impact of robotics on horticultural practices, highlighting the opportunities and obstacles inherent in modern horticulture. Key automated processes-such as harvesting, irrigation, greenhouse management, sorting and grading, pest control, and precision farming are analyzed to showcase the potential of robotics in enhancing efficiency and reducing resource wastage. For instance, automated harvesting robots can reduce manual labor by up to 70% and improve operational speed by 40%, while precision irrigation systems cut water use by up to 50%. Cutting-edge technologies, including artificial intelligence, machine learning, sensor systems, and remote sensing, enable real-time monitoring, intelligent decision-making, and operational control, paving the way for smarter, more sustainable agricultural systems. By examining the current status of robotic solutions and their applications in horticulture, this study outlines the scope for future advancements. It emphasizes the importance of ongoing research and development to address the technical, economic, and practical challenges of integrating robotics into horticultural operations. Ultimately, this paper envisions a future where robotics seamlessly blends into horticulture, ensuring efficient, scalable, and sustainable practices capable of meeting the nutritional and economic demands of a global population projected to exceed 9.7 billion by 2050.

Keywords: Artificial intelligence (AI), Automated, Horticulture, Precision farming, Robotics

* * *

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ट्रायकोडर्मा वीरीडी
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जड गलन व सुखात से रक्षण
नुक्सानकारक फफूंद को नष्ट करे
कचरे को विघटीत करे
पानी मे घुलनशील

मात्रा: 250 ग्राम प्रति एकड
5 से 10 ग्राम प्रति किलो बीज

बेसीवेक

ब्युवेरिया बेसीआना
जैविक कीटनाशक
सफेद मक्खी, थ्रिप्स, एफीड्स
मीलीबग व ईल्लियो का नियंत्रण
कीटक के शरीर पर विकसित
होकर उनका नाश करे

मात्रा: 1 से 2 ग्राम प्रति लिटर पानी

स्युडोवेक

स्युडोमोनास फ्लुरोसंस
जैविक कृमि, फफूंद व बेक्टेरिया नाशक
सुखात, जड व तना गलन से सुरक्षा
कृमि व बेक्टेरियल ब्लाइट से सुरक्षा
पौधे की वृद्धी व विकास के लिये उत्तम
पानी मे घुलनशील

मात्रा : 500 ग्राम प्रति एकड

पेसीलोवेक

वर्टिसीलीयम क्लेमायडोस्पोरीयम
जैविक कृमि नाशक
मिट्टी मे पाये जाने वाले कृमि
के अंडो को नष्ट करता है।
पानी मे घुलनशील

मात्रा : 250 ग्राम प्रति एकड

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एबावेक

एबामेक्टीन 1.9 % इ.सी
कीटनाशक एवं मितेनाशक
बहुपयोगी कीटनाशक जो युरोपीयन
लाल घुन, चित्तीदार लाल मकडी,
दो धब्बोवाली स्पाईडर माइट्स, थ्रिप्स,
सफेद मक्खी से फसल को रक्षण दे
फल, सब्जिया, फुल एवं हरेक फसल मे
उपयोगी
सुबह एवं शाम के समय उपयोग करे

मात्रा : 15 मि.लि प्रति 15 लिटर पानी

ईमावेक-जी

ईमामेक्टीन बेंज़ोएट 5% एस. जी दानेदार संयोजन
ईल्ली के शरीर मे जाकर उसको
लकवाग्रस्त कर के उनका नाश करे
फल छेदक, तना छेदक, बोलवर्म जेसी हरेक ईल्लीयो
से रक्षण करे
धान, फल, सब्जिया, तीलहनी एवं
हरेक फसल मे उपयोगी
सुबह एवं शाम के समय उपयोग करे

मात्रा : 8 से 10 ग्राम प्रति 15 लिटर पानी

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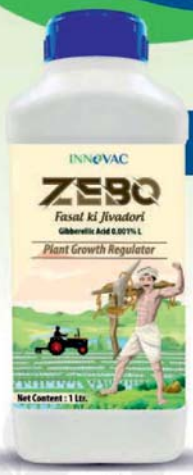
स्पाइडर सिलिकॉन +

नॉन आयोनिक सिलिकॉन एडजुवन्ट
हर एक छिडकाव जैसे कीटनाशक, फफूंद नाशक एवं
वृद्धि उत्तेजक की शक्ति बढ़ाएं
पत्ते के सतह तनाव को दूर करके छिडकाव की हुई दवाई को पत्ते एवं
पौधे के ऊपर चिपकाने तथा उनका अवशोषण करने की क्षमता बढ़ाए
बारिश के मौसम में दवाई को धुलने से बचाए
दवाई के लिए उत्प्रेरक का काम करें
कोई भी छिडकाव का परिणाम सुधारे
मात्रा : 5 मि. लि प्रति 15 लीटर पानी

झेबो



फसल की जीवादोरी
ऑर्गेनिक जिब्रेलिक एसिड,दरियाई वनस्पति अर्क,
अमीनो एसिड एवं सूक्ष्म पोषक तत्वों का संयोजन
बीच अंकुरण की मात्रा बढ़ाएं, प्रकाश संश्लेषण को बढ़ाएं
फूलों की संख्या एवं फल का आकार रंग और चमक बढ़ाएं
सूक्ष्म पोषक तत्व की कमी दूर करें
मात्रा : 2-3 मि .लि प्रति लीटर पानी

एक्सपान्डर N P K +

फसल का वृद्धि ईंधन
विशिष्ट रूप से विकसित जैविक खाद जिसमें नाइट्रोजन स्थिरीकरण,
फास्फेट घोलने वाले एवं पोटाश वहन करने वाले सूक्ष्मजीव पाए जाते है
रासायनिक खाद की निर्भरता कम करें, जमीन की फलद्रुपता बढ़ाएं
जमीन में सूक्ष्म जीवों की संख्या बढ़ाए. फसल की वृद्धि विकास के लिए उपयोगी
मात्रा : छिडकाव - 2 से 3 मि.लि प्रति लीटर पानी
सिंचाई - 1 लीटर प्रति एकड

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खरबूजा, लौकी, करेला, खीरा,
कद्दू, स्क्वैश ईत्यादी के लिये

फेरोमेट-एफ एक्स्ट्रा टाईम ब्लोक

आम, संतरा, चीकू, अंगूर, अनार,
अमरूद, पपीता जैसे फल के लिये

अनुठी स्लो रीलीज़ टेक्नोलोजी से निर्मित,
जो संपूर्ण पाक अवधि तक
फसल को फल मक्खी से बचाता है।
ईस्तेमाल मे सरल है।

प्रमाण: 5 से 10 सेट प्रति एकड

फेरोमेट एक्स्ट्राटाईम ट्रेप

फेरोमेट ग्लास ट्रेप

फेरोमेट वी एवं एफ
एक्स्ट्रा टाईम ब्लोक के साथ
उपयोग के लिये। उच्च गुणवत्ता
पी.पी प्लास्टीक से निर्मित

फेरोमेट डेल्टा ट्रेप

फेरोमेट ल्यूर के साथ
उपयोग के लिये।
आकार मे छोटे पतंगे
पकडने के लिये

Improving Agriculture Improving Lives...