विकसित कृषि से विकसित नागालैंड

Viksit Krishi Se Viksit Nagaland

Farmers' Problems and Their Solutions

An Information Bulletin on Agricultural Development in Phek District, Nagaland

Published by

भा.कृ.अनु.प.-कृषि विज्ञान केंद्र - फ़ेक
भा.कृ.अनु.प.-राष्ट्रीय मिथुन अनुसंधान केंद्र,
मेड्ज़िफेमा, नागालैंड

ICAR - Krishi Vigyan Kendra - Phek
ICAR - National Research Centre on Mithun,
Medziphema, Nagaland

2025

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Medziphema, Nagaland

2025

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We sincerely acknowledge the valuable contributions of all stakeholders in the successful implementation of the Viksit Krishi Sankalp Abhiyan and the preparation of this bulletin. We extend our heartfelt thanks to ICAR-ATARI, Zone VII, Umiam, Meghalaya, and the farmers of Phek District for their enthusiastic participation and valuable insights.

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PREFACE

This information bulletin, **"Viksit Krishi Se Viksit Nagaland",** encapsulates the outcomes and actionable recommendations derived from the **Viksit Krishi Sankalp Abhiyan** held in Phek District, Nagaland, from May 29th to June 12th, 2025. Organized by the ICAR-Krishi Vigyan Kendra (KVK), Phek, in collaboration with the ICAR-National Research Centre on Mithun, Medziphema, Line departments of Govt of Nagaland, and School of Agricultural Sciences, Medziphema, this initiative aimed to interact with the farmers and share the latest technologies and address critical challenges faced by farmers in the region.

The bulletin highlights key issues such as soil health deterioration, water scarcity, soil erosion, organic plant protection measures, limited access to farm machinery, and marketing constraints, offering practical and sustainable solutions to enhance agricultural productivity and farmer livelihoods. It is our hope that this document serves as a valuable resource for farmers, policymakers, and agricultural stakeholders in Phek District and beyond, fostering a path toward a prosperous and sustainable agricultural future.

We extend our gratitude to all contributors, including scientists, agricultural officers and farmers, whose insights and dedication made this initiative a success.

Girish Patil, S.
Director

SHRI MHATHUNG YANTHAN
MLA & Advisor
Department of Agriculture
Government of Nagaland

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D.O No. ADV/AGRI/2024-25/299

MESSAGES

The publication of the Information Bulletin "*Viksit Krishi Se Viksit Nagaland*" marks a significant milestone in our collective efforts to build a vibrant, resilient, and self-reliant agricultural ecosystem in the state.

I had the privilege of attending the state-level launch of the *Viksit Krishi Sankalp Abhiyan (VKSA)* in Nagaland, and I am heartened to witness how this national campaign is being translated into meaningful action at the grassroots level, particularly through the concerted efforts in Phek and Meluri districts. This initiative, spearheaded by ICAR-KVK Phek in collaboration with ICAR-NRC on Mithun, the Line Departments of the Government of Nagaland, and the School of Agriculture Sciences, Medziphema, exemplifies the spirit of convergence and innovation.

The bulletin provides a comprehensive overview of field-level realities, challenges, and practical solutions ranging from natural resource management and organic interventions to mechanization and market linkages. This valuable documentation not only amplifies the voices of our farmers but also serves as a guide for informed policymaking and strategic field-level implementation.

As we move forward towards the vision of *Viksit Bharat @2047*, agriculture remains a cornerstone of progress for Nagaland. I commend all the dedicated scientists, extension personnel, and farmers whose unwavering commitment has brought this initiative to life.

May this publication inspire continued collaboration and sustained progress in our agricultural sector.

With warm regards and best wishes,

(MHATHUNG YANTHAN)
MLA & Advisor
Department of Agriculture
Government of Nagaland

केन्द्रीय कृषि विश्वविद्यालय
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CENTRAL AGRICULTURAL UNIVERSITY
LAMPHELPAT, IMPHAL-795004, MANIPUR (INDIA)

MESSAGES

It gives me immense pleasure to note the publication of the information bulletin "Viksit Krishi Se Viksit Nagaland", which documents the outcomes of the Viksit Krishi Sankalp Abhiyan (VKSA) organized in Phek District, Nagaland, from 29th May to 12th June 2025.

Dr. ANUPAM MISHRA
Vice-Chancellor,
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As the Zonal Nodal Officer for the Northeast region under VKSA, I had the opportunity to closely observe and support the planning and execution of this important national initiative in the Northeastern states, including Nagaland. The VKSA campaign in Phek District stands out as a remarkable example of ground-level convergence between academic institutions, ICAR research centres, state departments, and grassroots farming communities.

This campaign, led by ICAR-Krishi Vigyan Kendra Phek in collaboration with ICAR-NRC on Mithun, Line Departments, Government of Nagaland, and the School of Agricultural Sciences, Medziphema, has successfully addressed region-specific challenges such as soil health deterioration, water scarcity, erosion, low mechanization, and market access. What is most encouraging is the participatory approach, bringing farmers, scientists, students, and administrators on a common platform to identify saps and co-develop practical. scalable solutions.

The bulletin serves not merely as a report, but as a roadmap for sustainable agricultural development in the hill and tribal regions of Nagaland. It showcases the immense potential of knowledge transfer and grassroots extension when supported by coordinated institutional efforts.

I take this opportunity to commend all the faculty members, students, extension personnel. and scientific staff from CAU and partner organizations whose commitment made this initiative impactful. My heartfelt appreciation also goes to the resilient farmers of Phek and Melun District whose insights and engagement enriched the campaign.

Let us continue our collective efforts to transform agriculture in the Northeast through science-led, farmer-focused, and climate-resilient interventions-truly embodying the spirit of Viksit Krishi Se Viksit Nagaland, and ultimately, Viksit Bharat (2047).

(ANUPAM MISHRA)
Vice-Chancellor,
Central Agricultural University, Imphal
Zonal Nodal Officer, VKSA (Northeast Region)

SHRI WEZOPE KENYE
Agriculture Production Commissioner
Government of Nagaland

MESSAGES

It gives me immense pleasure to note the publication of the information bulletin "Viksit Krishi Se Viksit Nagaland", encapsulating the essence and outcomes of the Viksit Krishi Sankalp Abhiyan (VKSA) conducted from 19th May to 12th June 2025 in Phek and Meluri District, Nagaland.

This initiative, led by ICAR-KVK Phek in collaboration with ICAR-NRC on Mithun, the Line Department of Agriculture, Government of Nagaland, and the School of Agricultural Sciences, Medziphema, is a commendable step towards bridging the gap between scientific knowledge and grassroots agricultural practice. The insights gained and shared during this programme, especially on key issues such as soil degradation, water management, erosion control, organic farming practices, mechanization, and market access, are of strategic importance for sustainable agricultural development in the state.

The recommendations outlined in this bulletin serve not only as a roadmap for improving farm productivity but also as a call to action for all stakeholders—government agencies, scientists, extension personnel, and farmers—to work in synergy for the prosperity of our farming communities.

With best wishes,

Let us take collective strides towards "Viksit Krishi Se Viksit Nagaland", fostering an agricultural transformation that is inclusive, resilient, and future-ready.

(WEZOPE KENYE), IAS
Agriculture Production Commissioner
Government of Nagaland

SHRI SANUZO NIENU
Director of Agriculture
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MESSAGES

It is heartening to see the publication of the information bulletin "Viksit Krishi Se Viksit Nagaland", capturing the ground-level impact and outcomes of the Viksit Krishi Sankalp Abhiyan (VKSA) held in Phek and Meluri District from 29th May to 12th June 2025.

Agriculture remains the backbone of Nagaland's economy, and this multi-stakeholder initiative-led by ICAR-KVK Phek in collaboration with ICAR-NRC on Mithun, the Line Departments of Govt. of Nagaland and other partners-has highlighted the true spirit of convergence for rural transformation. The challenges identified- ranging from declining soil health to mechanization gaps and marketing constraints— have been addressed with context-specific recommendations.

I commend all field officers, scientists, and farmers for their active participation. Let us continue working together toward a sustainable, technology-driven, and farmer-centric agriculture sector that realizes the vision of "Viksit Krishi Se Viksit Nagaland."

(SANUZO NIENU)
Director, Agriculture
Government of Nagaland

Dr. B.M. SUNEP
DIRECTOR ANIMAL HUSBANDRY
& VETERINARY SERVICES
NAGALAND: KOHIMA

MESSAGES

The initiative and documentation under "Viksit Krishi Se Viksit Nagaland" are both timely and visionary. The VKSA programme led by ICAR-KVK Phek in collaboration with ICAR-NRC on Mithun, Medziphema the Line Departments of Govt. of Nagaland and School of Agricultural Sciences, Medziphema in Phek and Meluri District from 29th May to 12th June 2025 showcased the power of participatory development and institutional collaboration.

As livestock and animal husbandry are integral to the livelihood of farmers in Nagaland, the inclusion of ICAR-NRC on Mithun, Medziphema— our key research institute in the region-brought unique strength to this campaign. The emphasis on integrated farming systems, animal health, and indigenous livestock promotion complements our department's goals.

I congratulate all stakeholders and especially acknowledge the farmers for their valuable inputs. This bulletin is not just a report—it is a blueprint for rural prosperity and integrated Agri-livestock development.

(B.M. Sunep)
Director, Animal Husbandry and Veterinary Services
Government of Nagaland

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MESSAGES

It gives me immense pleasure to know that KVK, Phek, Nagaland has taken an apt initiative to bring a compilation as the outcome of the Viksit Krishi Sankalp Abhiyan (VKSA) at Phek District, which was hosted by ICAR, New Delhi under the patronage of Ministry of Agriculture and Farmers' Welfare, Govt. of India, which is now captured in the form of a bulletin "Viksit Krishi Se Viksit Nagaland."

As the coordinating unit under Zone VII comprising of five states namely Manipur, Meghalaya, Mizoram, Nagaland and Tripura in the Northeast region; ICAR-ATARI, Zone VII, Umiam is committed and leading the strong frontline extension workforce of 43 KVKs across five states to promote region-specific, demand-driven, and technology-enabled agricultural transformation in the region realizing the dream of Viksit Bharat @2047. The execution of VKSA (Kharif Campaign) programmes during 29 May-12 June, 2025 by ICAR-KVK, Phek under the guidance of ICAR-NRC on Mithun, Medziphema with close supervision ICAR-ATARI, Zone VII, Umiam in with State Departments of Nagaland - embodies this mission in a successful note.

This bulletin not only highlights field-level issues like soil degradation, water management, and input constraints, but also unlocked the opportunities for the scientists of VKSA Teams to explore the unexplored farm innovations and indigenous germ plasms prevailing in the district which have significant effect for sustaining the hill agriculture and could establish an ideal model of convergence and participatory planning. I congratulate all the VKSA Teams in engaged in the district Phek and encourage all other KVKs to replicate such focused campaigns for inclusive agricultural development.

(A.K. Mohanty)
Director, ICAR-ATARI, Zone VII
Umiam, Meghalaya

CONTENT

AGRICULTURE AND ALLIED SECTORS IN PHEK DISTRICT, NAGALAND: CHALLENGES AND OPPORTUNITIES

Editors

Phek District, located in the hilly terrain of Nagaland, is an agrarian region where approximately 60% of the population depends on agriculture and allied activities for their livelihood. The district's diverse agro-climatic conditions support a variety of farming systems, including agriculture, horticulture, fisheries, and livestock, with traditional practices like the Zabo system and Jhum (shifting) cultivation coexisting alongside modern techniques. Despite its rich natural resources and cultural heritage, Phek faces significant challenges in these sectors, including soil degradation, water scarcity, market access issues, and limited infrastructure. This section outlines the key problems, proposed solutions, and available data to provide a comprehensive overview of the agricultural landscape in Phek District.

1. Agriculture

Overview: Agriculture in Phek District is predominantly subsistence-based, with rice as the staple crop, occupying about 70% of the cultivated area and contributing 75% of total food production. The district practices both jhum cultivation and wet terrace cultivation (WTC), with the latter being prominent among the Chakhesang and Angami tribes where water is available for irrigation. The Zabo system, an indigenous method in Kikruma village, of Phek district, integrates agriculture with forestry, horticulture, fishery, and animal husbandry, achieving an average paddy yield of 1.95 tonnes/ha compared to 1.0 tonne/ha in Jhum fields.

Challenges

- **Soil Degradation**: Continuous jhum cultivation has led to significant soil erosion and nutrient depletion, with soil loss rates previously as high as 50 t/ha per year. Unsustainable practices and lack of soil testing exacerbate fertility issues.
- **Water Scarcity**: Farmers face severe water shortages during the winter/lean season, limiting irrigation for crops.
- **Land Fragmentation**: Small and fragmented land holdings reduce efficiency and make mechanization challenging.

- **Climate Change**: Changing rainfall patterns and increasing temperatures affect crop yields and traditional farming cycles.
- **Market Access**: Lack of infrastructure for preservation and transportation leads to a glut of produce, such as ginger and cardamom, reducing farmer income.

Solutions

- Implement soil conservation measures like terracing and contour farming to reduce erosion.
- Promote the Zabo system for integrated farming and water conservation.
- Conduct regular soil tests to guide nutrient management and apply agricultural lime (250–300 kg/ha) to correct soil pH.
- Establish low-cost water harvesting systems to address winter water scarcity.
- Enhance market linkages through schemes like eNAM to connect farmers to larger markets.

Data

- Cultivated Area: Approximately 70% cultivated land is under rice cultivation of Phek district.
- Soil Erosion Reduction: UNDP's SLEP program reduced soil erosion from 50 t/ha to 26 t/ha in project areas.
- Jhum Coverage: Jhum constitutes 76% of the cropped area in Nagaland, with significant presence in Phek.

2. Horticulture

Overview: Horticulture thrives in Phek's temperate climate, supporting crops like Naga Mircha (GI-tagged chili), large cardamom, kiwi, and passion fruit. The area under horticulture crops in Nagaland was 91.633 thousand hectares in 2024, a slight decrease from 93.389 thousand hectares in 2023. Phek contributes significantly to this, with initiatives like the Mission for Integrated Development of Horticulture (MIDH) promoting orchard expansion and protected cultivation.

Challenges

- **Market Linkages**: Farmers struggle to market high value crops due to poor infrastructure and lack of exposure.
- **Chemical Inputs**: Government promotion of chemical fertilizers threatens Nagaland's organic farming tradition, reducing soil fertility.
- **Biodiversity Loss**: Cash crop monocultures, such as cardamom, have reduced crop diversity, impacting food security.

Solutions

- Adopt climate-smart horticulture practices to enhance productivity and mitigate climate change impacts.
- Register farmers under Farmer Producer Organizations (FPOs), such as Kiwi Chansu, to improve market access.
- Promote organic farming through schemes like Paramparagat Krishi Vikas Yojana (PKVY) to preserve soil health and biodiversity.
- Establish post-harvest management facilities to reduce spoilage and enable value addition (e.g., juices, pickles).

Data

- Horticulture Area (Nagaland): 91.633 thousand hectares (2024).
- Key Crops: Naga Mircha, cardamom, kiwi, passion fruit.
- Millet Diversity: Phek's Millet Resource Centre documents and preserves multiple millet varieties.

3. Fisheries

Overview: Fisheries in Phek are integrated into systems like Zabo, where paddy-cum-fish culture yields 50–60 kg of fish per hectare. The district has potential for ornamental fisheries and freshwater prawn farming, but practices remain primitive compared to modern aquaculture techniques.

Challenges

- Lack **of Scientific Knowledge**: Fish farmers lack access to modern farming techniques, limiting productivity.
- Seed **and Feed Availability**: Non-availability of quality fish seed and feed hinders growth.
- Market **Constraints**: Lack of organized markets restricts fish marketing and profitability.
- Training **Infrastructure**: Limited training facilities impede skill development.

Solutions

- Conduct training programs through ICAR-KVK Phek and the Department of Fisheries to disseminate modern aquaculture techniques.
- Develop fish seed production enterprises to ensure quality seed availability.
- Promote diversification into ornamental and cold-water fisheries to increase income.
- Establish market tie-ups to improve fish marketing.

Data

- Fish Yield (Zabo System): 50–60 kg/ha in paddy-cum-fish culture.
- Potential Areas: Ornamental fisheries, freshwater prawn farming.

4. Livestock

Overview: Livestock farming, including cattle, pigs, goats, sheep, rabbits, poultry, and ducks, is integral to Phek's economy, supplementing family income and providing draft power. The district has significant land holdings for livestock farms, with 5 cattle farms, 10 piggery farms, 2 goat farms, 1 sheep farm, 1 rabbit farm, 7 poultry farms, and 1 duck farm.

Challenges

- **Infrastructure Gaps**: Only one veterinary laboratory (ELISA Lab, Kohima) is functional, limiting disease diagnosis and management.
- **Limited Veterinary Services**: With only 11 veterinary hospitals and 55 dispensaries state-wide, access to veterinary care in Phek is constrained.
- **Market Access**: Lack of processing and marketing infrastructure limits livestock product sales.
- **Feed and Fodder Shortages**: Inadequate supply of quality feed affects livestock productivity.

Solutions

- Establish additional veterinary laboratories and strengthen existing facilities to improve animal health services.
- Promote livestock diversification through schemes like the National Livestock Mission.
- Develop Farm Machinery Banks to provide subsidized access to equipment for feed processing.
- Facilitate market linkages through private sector partnerships under ATMA.

Data

- Livestock Farms in Phek: 5 cattle, 10 piggeries, 1 buffalo, 2 goat, 1 sheep, 1 rabbit, 7 poultry, 1 duck.
- Veterinary Facilities (Nagaland): 11 hospitals, 55 dispensaries.
- Training Centers: Only VFATI and NLDP (Lerie Kohima) available state-wide.

Conclusion

Phek District's agriculture, horticulture, fisheries, and livestock sectors hold immense potential due to its diverse agro-climatic conditions and indigenous practices like the Zabo system. However, challenges such as soil degradation, water scarcity, limited infrastructure, and market access constraints hinder productivity and farmer livelihoods. Government schemes like MIDH, PKVY, ATMA, and the National Livestock Mission, combined with community-driven initiatives like the Millet Resource Centre and Chizami Weaves, offer pathways to sustainable development. By addressing these challenges through targeted interventions, Phek can transform into a model of integrated and sustainable farming, aligning with the vision of Viksit Krishi Se Viksit Phek.

FARMER'S ISSUES AND SOLUTIONS: PHEK DISTRICT, NAGALAND

AREA OF FOCUS: SOIL SCIENCE

Esther T. Longkumer
Chief Technical Officer, Soil Science
Krishi Vigyan Kendra – Phek, Nagaland

Problems Identified under Soil Science during the **Viksit Krishi Sankalp Abhiyan**

1. Water Shortage during Winter

Issue: Farmers experience severe water scarcity during the winter/lean season which affects crop irrigation.
Solutions: Construction of low-cost water harvesting systems to irrigate crops during winter/lean season.

2. Soil Health Deterioration

Issue: Decline in soil fertility due to nutrient imbalance and lack of organic matter.
Solutions:

- Conduct soil tests to determine nutrient levels, pH, and other soil properties.
- Apply agricultural lime @ 250–300 kg/ha to improve soil pH.
- Use vermicompost, bio-fertilizers, and azolla compost to enhance soil fertility.
- Green manuring with crops like dhaincha, sunhemp, Eupatorium odoratum, and Alder nepalensis leaves.
- Adopt conservation agriculture practices such as reduced tillage, mulching, and cover cropping.
- Promote crop rotation and intercropping to improve soil biodiversity and pest management.

3. Soil Conservation

Issue: Soil erosion and degradation due to topography and unsustainable farming practices.
Solutions: Implement terracing or contour farming to reduce soil erosion and maintain soil structure.

4. Farm Machineries

Issue: Limited access to farm machinery hinders productivity and timely agricultural operations.

Solutions:

- Establish Farm Machinery Bank in each block under the Sub-Mission on Agricultural Mechanization (SMAM).
- Provide farmers with subsidized access to modern agricultural tools and equipment through Department of Agriculture, Govt. of Nagaland.

5. Marketing

Issue: Farmers face difficulty in marketing produce due to lack of market linkage and exposure.

Solutions:

- Register kiwi farmers under the Farmer Producer Organization (FPO) Kiwi Chansu.
- Organize marketing programs by Government agencies like ICAR-KVK Phek, line departments, NGOs to train farmers and connect them with potential buyers

SOIL HEALTH MANAGEMENT

Context & Background

Soil Degradation

Soil testing is essential in agriculture for determined nutrient level and management of crop production

Soil Management Practices

(a) Vermicomposting

(b) Biofertilizers

(c) Agriculture Lime

(d) Green Manuring

(e) Live & Straw Mulch

AREA OF FOCUS: ANIMAL SCIENCE

Harini K. R.
Subject Matter Specialist (Animal Science)
Krishi Vigyan Kendra – Phek, Nagaland

Context & Background

- Scientific feeding of livestock and poultry.
- Feeding Mithuns and cattle during scarcity- Importance of fodder trees.
- Biosecurity measures in Livestock and Poultry farms
- Vaccination schedule of livestock and poultry.
- Management of foot and mouth diseases in mithuns.
- Government schemes related to livestock and poultry.

Problems Identified under Animal Science during the **Viksit Krishi Sankalp Abhiyan**

1. Mithun and cattle rearing

Issue 1: Scarcity of fodder during winter.

Solutions:

- Feeding of concentrate feed around 2 kg/animal daily to increase the body weight gain. Concentrate mixture can be prepared from locally available feed ingredients.
- Paddy by products like rice bran and straw can be fed.
- Cultivation of fodder like Napier, Congo signal, Para grass and Maize.
- Preservation of fodder by silage and hay making helps feeding animal during scarcity.
- Agroforestry system with fodder trees (Ficus hookeri (Khabbu), Prunus avium (Kuvie, Wild cherry), Malus sylvestris (Wildapple, chiipho), Morus nigra (Mulbery, Liikushe) to avoid fodder scarcity during the lean season.
- Rotational grazing in the forest areas to optimize the production and effective usage of fodder and land.

Issue 2: Occurrence of foot and mouth disease in Mithun.

Solutions:

- Proper vaccination of mithuns every 6 months against Foot and Mouth disease prevents the disease occurrence in animals.

Issue 3: Problem of ecto parasite and endo parasite in animals.

Solutions:

- Proper vaccination of mithuns every 6 months against Foot and Mouth disease prevents the disease occurrence in animals.
- Proper deworming of animals to improve the production. Administration of Ivermectin injection to treat the ectoparasite infestation in mithuns.

Age	1st dose	Subsequent dose	Remark
Young	1 or 2 months	Every 3-4 months until 1 year	Against all worm
Adult	-	-	Twice a year particularly in the month of march or October or 2 weeks before breeding

Issue 4: Farmers are not milking the animals.

Solutions:

- Farmers should start milking of the animals and value addition of milk like panner, curd, lassi etc for better income.

2. Pig rearing

Issue 1: Poor growth rate of piglets.

Solutions:

- Ensure colostrum and milk is fed to piglets. Cross fostering with other females or feeding artificial colostrum in case of death of mother or less milk from its mother.
- Prevent cold stress of newborn piglets by providing heat with the help of incandescent bulb and proper bedding in creep area in farrowing pen.
- Provide creep feed 150-200g along with sow milk before weaning.
- Irondextran injections (100 – 200 mg) should be given to piglets on 4th and 14th day of age to prevent piglet anemia.
- Regular deworming of piglets: First dose at the age of 2 month and subsequently every 2 months once until one year. Breeding pigs should be dewormed twice a year before breeding and before giving birth.

Issue 2: Problem of diarrhea after weaning in piglets

Solutions:

- Post weaning diarrhea can be prevented by providing creep feed and milk replacer before weaning.
- Maintain hygiene in pig shed.

- Affected animals should be treated at the earliest.

Issue 3: Death of the pigs due to swine fever.

Solutions:

Vaccinate the pigs against Classical Swine Fever as per the following schedule:

Vaccine	Primary vaccination	Booster	Revaccination
CSF vaccine	2 months & above	6 months after 1st dose	Annually

Issue 4: Some farmers are unaware of breeding management of pigs.

Solutions:

- Three female and one male can be kept for breeding in small scale pig farming.
- Females can be bred at the age of 7 or 8 months and males at the age of 8 months.
- Breeding of female should be done after 2nd or 3rd heat. Heat cycle is 23 days interval and heat period are 2-3 days. The sow comes to heat by 7-10 days after weaning.
- Detect the female in heat by oestrus signs such as vulvar swelling and discharge, standing to be mounted and mount on other animals, erect ears. Teaser boar or backpressure test/ riding test can be used to detect heat.
- Females should be taken to male for breeding after detecting heat. Two mating is advised 12 hours interval after during heat period.
- The breeding male should be used 3-4 times a week and two times in a day 12-18 hours apart (morning or late evening).

Issue 5: Farmers are not providing concentrate feed to pigs and practicing excess feeding of unconventional feeds.

Solutions:

- Provide adequate concentrates in the ration fortified with vitamins and minerals as per the body weight (0.75 kg in young and upto 2 kg in adults). During pregnancy and lactation, the sow should be fed extra (2.5 - 3 kg) to meet its nutrient requirement.
- Unconventional feeding: kitchen waste can be fed to animals after boiling and locally available wild leaves, roots and tubers- sweet potato tapioca can be fed to the pigs upto 20-30% of their diet.

3. Backyard poultry rearing

Issue 1: Mortality of chicks due to improper brooding management.

Solutions:

- Immediately after arrival of chicks feed 8 gm of glucose per liter of water or Jaggary (10% gur

solution) within 30 minutes of arrival at farm.

- Provide electrolyte, glucose and vitamins in the drinking water for first 2 to 3 days to overcome stress.
- Brooding is essential for 4-6 weeks of age. (First week 350C and reduce 50C every week)
- Brooding management: Fix chick guard made of cardboard sheet/ wooden / metal / locally available material in circular pattern with 1.5 feet height.
- Spread litter 2-3 inch (litter material viz., rice husk, ground nut hulls, wood shavings etc)
- Put newspaper over the litter and spread ground maize or rava or fine mash / crumble feed 2-3 days. Place feeder and water.
- Remove the old newspaper after 3 days and destroy it by burning.
- Artificial heat can be provided by incandescent bulbs (one 40-watt bulb for 20 to 30 chicks), infrared bulbs, heat coil or Charcoal Choolah (*Bukhari*)
- The bulbs must be hanged above the reach of the chicks. Switch on the bulb for 24 hours in a day, however, switch it off for only 30 minutes in a day.
- Remove brooder guard after 7 to 10 days.
- The birds can be let out for scavenging after 4-6 weeks of age.

Issue 2: Farmers are unaware of vaccination of poultry.

Solutions:

- Proper vaccination of birds as per the following schedule:

Age	Vaccine	Dose	Route
0 day	Marek's Disease	0.2 ml	Subcutaneous
1st week	Ranikhet Disease (Lasota)	One drop	Eye drop
4th week	Ranikhet Disease (Lasota)	One drop	Eye drop
10th week	Ranikhet Disease (R2B)	0.5 ml	IM inj
6 to 10 weeks	Fowl Pox	0.5 ml	IM inj

Bio-Security Measures in Livestock and Poultry Farm

Biosecurity consists of the procedures and measures envisioned to prevent pathogens entering and spreading within a farm.

Farm Hygiene and Personal Hygiene: Regular cleaning and disinfection of farm facilities, and personal hygiene includes washing hand, feet and clothing with soap.

Animal Quarantine and Isolation: Separate the newly arrived animals, sick animals, or those showing signs of infection prevents the spread of diseases.

Restricted Access to Farm: Limit access to unauthorized individuals and vehicles from contaminating the premises.

Pest Control: Controlling rodents and insects, is crucial in preventing diseases and contamination.

Vaccination: Regular vaccination of animals against common diseases to increase immunity and prevent infections.

Proper disposal of carcass and waste: Do not throw animals in river/water bodies. Follow deep burial method and 6 ft deep, spread lime/ bleaching powder.

Record Keeping: Maintaining accurate records of animal movements, health, and treatments helps in disease surveillance and traceability.

Feeding Management of Pigs

- Pigs are monogastric and omnivorous animals
- Feed costs are nearly 70% of the total cost in pig farming
- Semi intensive farming: household kitchen or hotel waste are fed.
- Intensive farming: balanced diet in the form of concentrate to full the nutrient

Creep feed

- Feed for young piglets from 7 days onwards.
- Substituting the decreasing milk production of sow and is beneficial for early weaning.
- 20 – 22% protein result in body weight gain of up to 12 - 20 kg by the time of weaning.
- Feed 150-200 grams

Ingredients	I Parts (%)	II Parts (%)	III Parts (%)
Maize Powder	47	35	30
Rice Powder	0	15	20
Skim Milk Powder	10	10	10
Soyabean Meal	6	6	6
Sesame oil cake	12	12	12
G N Cake	15	15	15
Molasses	5	5	5
Mineral Mixture	1.5	1.5	1.5
Lysine	1.5	1.5	1.5
Methionine	0.01	0.01	0.01

Daily feed requirement of pigs

Stages	Days	Body weight (Kg)	Feed requirement (Kg/animal/day)
Weaner	56-120	12-15	0.25-0.75
Grower	121-180	15-35	0.75-1.50
Finisher	181-300	35-80	1.50-2.50
Pregnant gilt	2-2.5 kg/day		
Lactating sow	3.0-4.0 kg/day+200 g /piglet		
Boar	2.5 kg feed+4-5 kg succulent green fodder		

Concentrate feed composition of pigs

Ingredients	Starter (%)	Grower (%)	Finisher (%)
Maize	60	64	60
Wheat Bran	6.5	6.5	14.5
Soyabean Meal	13	12	10
Ground Nut Cake	12	10	10
Fish meal	6	5	5
Mineral Mixture	2	2	2
Salt	0.5	0.5	0.5
Lysine	1.25	0.8	0.7
Total	100	100	100

Unconventional Feeds for Pigs


Molasses


Tapioca starch waste


Potato


Sugar beet pulp

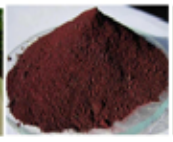

Turnip


Bakery waste


Sweet potato


Cabbage


Radish


Blood meal


Water hyacinth


Fruit waste

AREA OF FOCUS: ORGANIC PESTS MANAGEMENT PRACTICES

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Context & Background

Organic farming is a sustainable agricultural system that minimizes or completely avoids the use of synthetic fertilizers, pesticides, growth hormones, and additives in animal feed. Instead, it emphasizes the use of natural resources such as organic biomass, compost, manure, crop rotation, biological pest management, on-farm inputs, and traditional knowledge. This approach aims to achieve environmental, social, and economic sustainability.

Problems Identified under Plant Protection during the **Viksit Krishi Sankalp Abhiyan**

1. Paddy: Stem borer and leaf folder are major pests

Issue: Farmers experience severe attack of stem borer and leaf folder that results in severe yield loss.

Solutions:

- Growing of flowering plants along the field bunds of paddy (Marigold, mustard, cosmos, sunflower etc) to conserve natural enemies viz., lady bird beetle (coccinellid beetles), praying mantis, dragon fly, damsel fly, green lacewing and spiders to exploit maximum potential of bio-control fauna
- A coir rope is dragged across rice fields to knock down case worms, leaf folder larvae, swarming caterpillars, and cutworms, causing them to fall into water treated with kerosene (prepared by mixing 1 liter of kerosene with 25 kg of soil and spreading it over 1 hectare)

2. Maize: Fall armyworm is a major pest

Issue: Farmers facing severe incidence of fall armyworm that results in huge yield loss and sometimes complete crop failure

Solutions:

- Collection and destruction of egg masses and larvae of fall armyworm at early stage of crop growth

- Intercrop maize with legumes viz., pigeonpea, field pea, black gram, french bean etc. in 2:1 to 4:1 ratio to conserve natural enemies
- Application of sand mixed with lime in 9:1 ratio into whorl of maize plants to control fall armyworm

3. Chilli and king chilli: Thrips is a major pest

Issue: Famers noticed severe attack of thrips on chilli and king chilli which results in severe yield loss

Solutions:

- Border cropping with 3-4 rows of tall growing crops like sorghum/maize/bajra/ fodder grasses etc. sown thickly as a barrier for thrips movement
- Intercropping of chilli with maize or sorghum and cowpea at 10:3:1 as barrier and reservoir crops for multiplication of natural enemy which will lead to biological control of thrips
- Installation of yellow and blue sticky trap @ 15/acre for monitoring of sucking pests

4. Citrus: Trunk borer is a major pest

Issue: Farmers experienced severe incidence of trunk borer on citrus tree which results in yield loss and crop failure

Solutions:

- Locate the trunk borer and seal the holes with mud after inserting cotton soaked in petrol/ kerosene or apply kerosene and lime in the ratio of 3:1 into the holes and seal the hole with mud
- Painting the trunk with lime solution or Bordeaux mixture

5. Fruit crops: Fruit flies are major pests

Issue: Farmers are facing the problem of fruit flies on various fruit crops like mango, peach, plum, nectarine, citrus and cucurbitaceous crops

Solutions:

- Ploughing of soil under the tree to expose pupae of fruit flies
- Collection and destruction of affected and fallen fruits
- Use of low-cost fruit fly trap to catch adult flies (Install 10-12 traps/ha.): Make a trap using a 1-liter disposable water bottle by creating 2 holes on the bottle, 5 cm above its bottom. Prepare attractant mixture for fruit flies by combining vinegar (1 cup), water (2 cups) and honey (1 tbsp). Shake the mixture and then fill the bottle up to the level of the holes. Hang the trap on tree branches approximately 5 feet high

Natural pesticides/organic pesticides recommended to spray on any affected crops

1. Chilli, ginger and garlic paste

Preparation

500 gram chilli + 500 gram ginger + 500 gram garlic

⇩

Grind it and make a paste

⇩

Soak it in 6 liters of water for overnight

⇩

Next day morning filter it with muslin cloth

⇩

Take one liter of filtered solution, mix with 10 liters of water and add one tea spoon of surf powder

⇩

Spray on the affected crops

2. Tobacco Decoction Preparation

Take one kg of fresh tobacco leaves and chop into small pieces

⇩

Boil it in 10 liters of water for 1-2 hours

⇩

Then filter the solution through muslin cloth

⇩

Take one liter of filtered solution and mix in 10 liters of water and add 5 gm of soap powder or liquid soap

⇩

Spray on the affected crops

Major Insect Pest of Rice and their Management

Introduction

- Rice is the primary food crop in the Phek district including Northeast Region (NER). It is widely cultivated in jhum fields, hills, valleys, terraces and uplands
- Various biotic and abiotic stress factors, such as pests, diseases, excessive rainfall, water logging, soil fertility issues and adverse weather conditions, contribute to the decline in rice yields
- The presence of insect pests is considered a major factor limiting production and productivity of crop.

Management practices

- Growing of flowering plants along the field bunds of paddy (Marigold, mustard, cosmos, sunflower etc) to conserve natural enemies *viz*., lady bird beetle (coccinellid beetles), praying mantis, dragon fly, damsel fly, green lacewing and spiders to exploit maximum potential of bio-control fauna

- Clipping of tips of rice seedlings before transplanting eliminate the egg masses of stem borer
- A coir rope is dragged across rice fields to knock down case worms, leaf folder larvae, swarming caterpillars, and cutworms, causing them to fall into water treated with kerosene (prepared by mixing 1 liter of kerosene with 25 kg of soil and spreading it over 1 hectare)

- Trimming of field bund to eliminate eggs of rice grasshopper
- Harvesting of crop close to soil surface, ploughing or flooding the field after harvest to kill hibernating larvae in the stubbles
- For biological control of stem borers and leaf folders, release of egg parasitoids, Trichogramma japonicum and T. chilonis six to eight times at a rate of 50,000 per hectare per week, beginning from 30 days after transplanting

Insect pests of rice in Phek district of Nagaland

The insect pests attacking on rice crops in this region are rice yellow stem borer, leaf folder, case worm, rice blue beetle, rice hispa, gundhi bug, rice root weevil, rice horned caterpillar, lymantrid caterpillar, swarming caterpillar and rice grasshopper. Among these, rice yellow stem borer, leaf folder, rice blue beetle, rice root weevil and rice grasshopper are the major pests causing major damage to the crops leads to reduction in yield of the crop.

Yellow stem borer | Larva | Dead heart | White ear

Rice leaf folder | Larva | Folding of leaves and white patches on leaves

Rice blue beetle | adult beetles scrapping on leaves leading to white streaks

Rice root weevil | Grubs feeds on roots leads to drying and death of the plant

Rice grasshopper | Nymphs and adult feeds on leaves irregularly

Natural/organic pesticides

Chilli, ginger and garlic paste

- 500-gram chilli + 500-gram ginger + 500 gram garlic
- Grind it and make a paste
- Soak it in 6 liters of water overnight
- Next day morning filter it with muslin cloth
- Take one liter of filtered solution and mix with 10 liters of water

Tobacco leaf extract

- Take one kg of fresh tobacco leaves and chop into small pieces
- Boil it in 10 liters of water for 1-2 hours
- Then filter the solution through muslin cloth
- Take one liter of filtered solution and add in 10 liters of water and add 5 gm of soap powder or liquid soap
- Go for application on affected crop

BOTANICAL REMEDIES

Remedies from organic material	Target Diseases & Insect-Pests	Method of Application
Citronella grass 	Insects: storage pests, cockroaches, mosquitoes, fruit flies Fungi: *Aspergillus,Macrophomina* Bacteria: *Erwinia carotovora*	Oil as repellent
Finger millet 	Insect: army worms, caterpillars, cutworms, fruit flies	•Residues as mulch . •Grown as trap crop for cutworms. •Soak residue in water for spraying fruit flies.
French marigold 	Insect: rice green leafhoppers, brown plant hoppers, diamond back moth, black bean aphids, ants, beetles, cotton strainers, flies, maize borers, storage pests. Fungi: Cocliobolus, Pyricularia, Uramyces, Phytophthora Nematode and bacteria in general	•Plant together with crop to attack nematodes. •Leaves prevent storage pests . •Crush 100-200g leaves, roots, flowers, pour on 1 litre boiling water, soak for 24 hrs, add 1 litre cold water, soap, mix and spray
Garlic 	Insects in general Fungi: *Alternaria, Cercospora, Colletotrichum, Curvularia, Fusarium, Helmintosporium, Pestalotia, Cochliobolus,* *Bacteria: Xanthomonas*	•Garlic repel aphids, beetles, peach borer, mice, moles, termites . •Dried bulb as powder spray for scab, mildew, bean rust and tomato blight. •Chop cloves, soak in 2 tsp oil for 1 day, mix with ½ litre soapy water and filter, mix 1 part of solution in 10-parts water, use as spray.
Ginger 	Fungi: *Cercopspora*	Extract juice from rhizome .and use it as spray
Goat weeds 	Insect: diamond back moth, cotton strainers, flies, snout& stored beetles, maize weevils, Nematodes and bacteria in general	Dried and powdered plant material or water extract as spray. Planting goat weed as neighbouring plant against pest attack . Used as mulch.

Insect Pests Management in Natural Farming

INTRODUCTION

- Natural Farming refers to a method of agriculture that is free from chemical inputs and relies on livestock-based practices. Rooted in the principles of agro-ecology, it is a holistic and diverse farming approach that combines crops, trees, and animals to make the best use of functional biodiversity
- This farming method offers the potential to boost farmers' incomes while also providing several additional advantages, such as improving soil fertility, promoting environmental sustainability, and helping to lower or prevent greenhouse gas emissions
- Natural Farming is based on utilizing the natural ecological processes found within and around agricultural systems.

Key principles of natural farming

- Increased recycling of biomass
- Boosted plant resilience through improved functional biodiversity
- Enhanced soil quality by managing organic matter and promoting soil biological activity
- Reduced wastage of energy, water, and nutrients
- Greater diversity of genetic resources
- Strengthened positive biological interactions

Aims and objectives of natural farming

- Conserve native plant and animal species
- Rejuvenate soil fertility and support its biological activity
- Ensure crop diversity in agricultural practices
- Optimize the use of land and natural resources such as sunlight, air, and water
- Encourage the presence of beneficial insects, animals, and soil microbes to aid in nutrient cycling and natural pest and disease control
- Rely on inputs derived from natural or locally available resources
- Lower the cost of agricultural inputs
- Enhance farmers' earnings

3. Physical method

Sun drying of seeds

Different methods of crop protection in natural farming

1. Cultural Method

Pest population can be reduced by partial modification of farming system. This system includes following various methods.

Deep summer ploughing

Crop rotation

Transplantin/sowing of crops at the right time

Timely irrigation

Selection of resistant varities

Mixed cropping/intercropping

Sowing of trap crop

Collection and destruction of infected fruits

2. Mechanical method

- This method involves reducing pest populations or damage by hand or hand-operated devices.
- Bagging of ripening fruits of citrus reduces the damage of citrus fruit sucking moth.
- The upward movement of the nymphs of mealy bugs on the mango trees can be checked by banding the tree trunks with 400 gauze polythene sheet or band (30 cm wide) round the trunk during the months of November and December.

Yellow sticky trap (Aphid and whitefly) and Blue sticky trap (Thrips)

Sieving and winnowing to control stored grain pest's attack

Collection and destruction of egg masses and early instar larvae

Low-cost fruit fly trap

4. Biological Method

This method of crop protection uses natural enemies of pests such as parasites, predators, beneficial microorganisms (bacteria, viruses, fungi, worms) and birds.

Chrysoperla carnea

Lady Bird Beetle

Cryptolaemus montrouzieri

Trichogramma Spp.

Cotesia Spp.

Mantid

Mynah

Spiders

Virus infested caterpillars

Green fungus

Bt infested caterpillars

White fungus

AREA OF FOCUS: INCREASING PRODUCTION AND PRODUCTIVITY OF HORTICULTURAL CROPS

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Context & Background

Phek district in Nagaland, with its diverse agro-climatic conditions, holds significant potential for horticultural growth, boasting a wide range of fruits and vegetables, including high-value kiwi. The district already has a substantial area under horticulture and many farmers practice traditional organic methods. Government initiatives are actively promoting sustainable farming and value addition. However, poor road connectivity, lack of cold storage and processing units, technical knowledge gaps, acidic soils, fragmented landholdings, and limited credit access hinder full realization of this potential. Overcoming these challenges to boost horticultural production and productivity is crucial for enhancing rural livelihoods, ensuring food security, generating employment, tapping export markets, and fostering sustainable development in the district.

Problems Identified under Horticulture during the **Viksit Krishi Sankalp Abhiyan**

1. Use of Pollinizers in Kiwi Cultivation

Issue: Farmers struggle with inconsistent bee visits to nectar-less kiwi flowers, impacting fruit size and yield. This often necessitates expensive and labor-intensive artificial pollination, which also carries risks of pollen wastage and disease transmission.

Solutions:

- Many farmers are unaware that kiwi plants require both male and female plants for successful fruit production.
- Only female plants bear fruit, but male plants (pollinizers) are essential for pollination.
- To ensure good fruit set, farmers should maintain a ratio of 1 male plant for every 9 female plants and plant them in a zig-zag or inter-row pattern for effective pollen transfer.
- Choosing compatible varieties such as 'Tomuri' (male) with 'Hayward' (female) is

important.

- Farmers should avoid spraying chemicals during flowering and promote bee activity to aid natural pollination.

2. Challenges in the Marketing of Kiwi and Persimmon Fruits

Issue: Challenges in marketing kiwi and persimmon fruits primarily revolve around their high perishability, limited cold chain infrastructure, and often low consumer awareness outside of traditional markets.

Solutions:

- Farmers should form Farmer Producer Organizations (FPOs) or Self Help Group (SHG) for collective harvesting, packaging, and selling to improve bargaining power and reduce reliance on middlemen.
- Strengthening market linkages with external buyers through the support of Government agencies like KVKs, Horticulture Department and other line departments are essential.
- Setting up local collection points and cold storage facilities can minimize post-harvest losses.
- Promoting digital marketing through platforms like eNAM or WhatsApp and participating in agri-expo can increase market reach.

3. Value Addition in Kiwi and Persimmon

Issue: Value addition for kiwi and persimmon in Phek district faces challenges from limited processing infrastructure and technical know-how, inadequate cold chain facilities, and weak market linkages, hindering product diversification and broader market access.

Solutions:

- Promoting small-scale community processing units can add local value and create jobs.
- Strengthening market linkages through direct buyer connections via platforms like e-NAM and supporting cooperatives will help farmers access better prices, while developing regional branding can boost product recognition.
- Infrastructure development, including improved road connectivity, cold storage facilities, and water management, will reduce losses and ensure steady production.

4. Problems Faced by Farmers Regarding Schemes for Protected Cultivation

Issue: Farmers encounter significant hurdles in accessing and implementing protected culti-

vation schemes due to high initial investment costs, complex subsidy procedures, and lack of technical knowledge and skilled labor for managing these advanced technologies.

Solutions:

- The MIDH scheme provides financial assistance and support to farmers for adopting protected cultivation techniques, which help improve crop productivity and quality.
- Farmers receive subsidies to construct polyhouses, shade net houses, and greenhouses that protect crops from extreme weather, pests, and diseases.
- Farmers can grow off season vegetable crops and high valued crops which will enhance the economic status.

5. Flower and Fruit Drop in Kiwi During Rainy Season

Issue: Heavy and prolonged rainfall during the flowering period of kiwi fruit can lead to significant flower and fruit drop due to poor pollination (bees are less active), washing away of pollen, and increased susceptibility to fungal diseases like Botrytis fruit rot.

Solutions:

- Enhance pollination by installing Apis mellifera beehives (2–3 hives/ha), maintaining a 1:9 male-to-female plant ratio in zig-zag or inter-row patterns, and practicing hand pollination during prolonged rainy spells.
- Improve drainage and field conditions by creating raised beds or ridges in poorly drained areas, ensuring proper drainage to prevent waterlogging, and using locally available mulch materials to reduce soil splashing and fungal spread.
- Protect plants from weather stress by using windbreaks or 50% shade nets to minimize mechanical damage from wind and rain, especially during the flowering and fruit development stages.

6. Inadequate Supporting Structures in Kiwi Crop

Issue: Key issues for kiwi support structures are vulnerability to strong winds due to inadequate design/windbreaks, and the high initial investment cost for robust trellis systems.

Solutions:

- Training ensures proper vine direction, supports heavy fruit loads, and enhances overall plant health and yield in the vigorous, climbing kiwi vine.
- The T-Bar Trellis System (most common) involves vertical posts with a horizontal crossbar; vines are trained along wires to allow better sunlight exposure, air circulation, and easy management.

- The Pergola System is a flat-roofed wire structure supported by poles; it is ideal for home gardens or larger areas where space is not limited, helping in better canopy development and higher fruiting.

7. Flower and Fruit Drop in King Chilli (Raj Mirch) During Rainy Season

Issue: Mainly caused by excessive moisture, leading to poor pollination, increased fungal diseases, and plant stress from water logging.

Solutions:

- Enhance pollination by using bee attractant solutions or hand pollination in small plots.
- Manage waterlogging by using raised beds or ridge planting and improving drainage with furrows or contour drains to prevent water stagnation in heavy rainfall areas.
- Spray NAA (20 ppm) or Planofix once at flowering to reduce flower drop.

8. Plant spacing in Vegetable crops

Issues: Due to a lack of awareness and adoption of recommended practices, leading to reduced yields and increased pest/disease incidence from overcrowding. Traditional farming methods and limited access to extension services further exacerbate these issues.

Solutions

- Proper plant spacing in the rows significantly benefits farmers by boosting yields and produce quality through optimized resource allocation, leading to healthier, more vigorous plants and increased income.
- It also mitigates pest and disease issues by improving air circulation and easing management, potentially cutting pesticide costs.
- Furthermore, efficient resource utilization of water and nutrients reduces input waste, resulting in cost savings and promoting sustainable farming practices.

NURSERY MANAGEMENT IN HORTICULTURAL CROPS

Vegetable nursery is a place or an **establishment for raising or handling of young vegetable seedlings** until they **are ready for permanent planting in main field.**

Nursery bed is defined as a **prepared area in a nursery where seed is sown to raise the seedlings.**

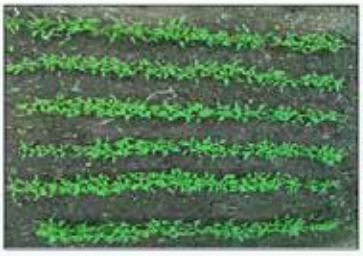
Ex: **Tomato, Brinjal, Chillies, Capsicum, Cauliflower, Cabbage, Knol-khol, Chinese cabbage, Brussels sprouts, Broccoli, Celery, Parsley,** etc.

Advantages

- Easy to grow and maintain many plants per unit area.
- Protect the seedlings against biotic and abiotic stresses.
- Uniform and 100% crop stand in the main field can be maintained.
- An early crop / standing crop in the field can be harvested, which can fetch higher price.
- Eliminates the problem of difficult soils and easy weed control.
- Employment generation especially for rural women.

Nursery Preparation

- **Raised beds** (15–20 cm height) are ideal during the **rainy season** for better drainage.
- **Flatbeds** can be used in **winter and summer** seasons.
- **Standard bed size:** 3 m (length) × 1 m (width) × 15–20 cm (height).
- **Spacing between beds:** 30–45 cm for drainage and intercultural operations.
- **Fertilization:** Mix **20–25 kg well-rotted FYM** per standard bed.
- **Orientation:** Length: **North to South** Width: **East to West**
- **Seed sowing rows:** Run parallel along the **width (East–West)**
- **3–5 cm apart** for optimum sunlight exposure throughout the day.
- Cover seeds with fine mix of sand:soil:FYM/leaf compost in **1:1:2** ratio
- After **25–30 days**, when seedlings have **5–6 leaves**, uproot and **transplant.**



OFF-Season Vegetable Cultivation in Low-Cost Polyhouse

A smart agricultural technology allows fresh vegetables to be grown before or after their normal season

Benefits

- ❑ Ensure fresh vegetables during lean periods
- ❑ Overcoming adverse climate
- ❑ High-quality and clean products
- ❑ Non-traditional areas: high altitudes desert
- ❑ Efficient management of crop pests and diseases
- ❑ Self-employment for unemployed educated youth
- ❑ Better prices for produce
- ❑ Promote year-round income generation

Low-cost polyhouse

- ➢ These are **simple construction greenhouses** with low initial costs.
- ➢ The frame may be of **bamboo,** G.I. pipes, wooden logs or steel pipes but no heating and cooling systems are provided for the structure.
- ➢ The top of the greenhouses is covered with **polythene sheet,** but the side walls have **shade nets** from the ground up to 5 to 6 feet in height with or without manually rollable plastic over it.
- ➢ The initial cost of these greenhouses is **less than half to** that of semi-climate-controlled greenhouses.

Crops suitable for offseason cultivation

1. **Tomato**
2. **Cherry tomato**
3. **Capsicum**
4. **Parthenocarpic cucumber,**
5. **Gherkins**
6. **Watermelon**
7. **Muskmelon**
8. **Bitter gourd**
9. **Pole Beans**

AREA OF FOCUS: AGRONOMIC MANAGEMENT

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Context & Background

Phek district of Nagaland is one of the most blessed districts consisting of diverse biodiversity in flora and fauna. The mainstay of the people is agriculture and jhum is practiced widely occupying an area of 12160 ha. The next prevailing farming system is terrace rice cultivation which is practiced since time immemorial on hill slopes with terrace benches using rainfed irrigated water from streams and rivers. The indigenous system of irrigation and agricultural practice in this region, called the Rüza system, more popularly known as Zabo, is a time-tested unique water management practice that has been yielding good harvests for nearly a century. The Zabo or Rüza system is a sustainable integrated form of farming comprising forestry, horticulture, agriculture, fishery and animal husbandry with well-founded soil and water conservation base. The major crop is paddy, cultivated mainly during the kharif season. Maize, beans, pea, cowpea, arhar and rice bean are the common agronomical crops. Agronomic management is a multidisciplinary field focused on optimizing the utilization of agricultural resources to achieve sustainable and profitable crop production.

Problems Identified under Agronomy during the **Viksit Krishi Sankalp Abhiyan**

1. Reduced jhum cycle

Issue: Due to increased human population and increased pressure on land which leads to decreased soil fertility and productivity

Solutions:

- Promotion of multi-tier agroforestry systems combining crops, trees, and livestock for sustainable agriculture.
- Wet Terrace Rice Cultivation (WTRC) and Alder tree-based farming are more sustainable alternatives.
- The Zabo system, an indigenous integrated farming system, is a good example of sustainable land and resource management farming system

2. Hilly and undulating topography

Issue: Farmers do not maintain line sowing and recommended spacing

Solutions:

- To construct bench terraces which effectively transforms a steep slope into a series of flat, cultivable steps, making line sowing and uniform spacing much easier, though it is labour intensive to construct initially they offer long term sustainability
- Ropes with marked intervals can be used to guide seed placement, ensuring consistent spacing
- Line sowing makes inter-row weeding (manual or with small tools) much easier and more efficient compared to broadcast sowing, where weeds are mixed throughout the crop.

3. Fallowing in wet terrace rice cultivation

Issue: Rainfed dependence

Solutions:

- Farmers can grow short duration drought tolerant pulses like black gram, lentil, field pea and garden pea which can utilize the residual soil moisture after paddy harvest and will also enhance the soil fertility status. However, this should be carried out with minimal tillage.
- Growing of leguminous cover crops such as Sesbania rostrata, Crotalaria juncea during the fallow period and incorporate them into the soil to improve organic matter and restore nitrogen

Introduction of Azolla or Blue green algae in flooded terraces to fix atmospheric nitrogen, enrich soil health and suppress weeds

4. Climate Change and Extreme Weather

Issue: Increased frequency of droughts and unseasonal rainfall disrupts crop cycles and reduces yields

Solutions:

- To adopt conservation agriculture practices such as minimum tillage or zero tillage during dry season, mulching, and year-round ground cover to conserve the soil moisture during dry season
- To construct farm ponds and rooftop water harvesting systems to capture and store

rainwater and to promote trenches and spring sheds to recharge ground water and reduce runoff on hill slopes

5. Low productivity and subsistence farming

Issue: Use of local seeds, low input use and traditional tools result in low productivity per hectare and farming mainly for household consumption

Solutions:

- Promotion of integrated farming system
- Promotion of high yielding varieties and climate resilient crop varieties
- Encourage low-cost organic inputs viz., vermicompost, biofertilizers and neem based biopesticides
- Introduce soil health cards to guide nutrient application in farmer's field
- Establish custom hiring centres at village or cluster level to enable small farmers to hire farm machineries at low cost
- Promotion of multi cropping to increase total productivity and to integrate high value crops for market-oriented farming
- Converge subsidies through MOVCDNER, RKVY, NFSM etc.

Recommended crop rotation and intercropping system.

Crop rotation	Intercropping system
Paddy – Mustard	Maize – French beans
Paddy – Field pea	Maize – Rajma
Maize – Blackgram	Foxtail millet – Rajma
Paddy – Cabbage	Foxtail millet –French beans
Maize – Cabbage	Soybean – Cabbage
Paddy – Garden pea	Soybean – Potato
Millet – Soybean	Maize – Cowpea
Maize – Potato	

FEEDING STRATEGIES FOR ENHANCING MITHUN PRODUCTION AND LOW-COST FEED DEVELOPMENT

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Mithun (*Bos frontalis*) is domesticated from wild gaur and found mainly in Assam, Arunachal Pradesh, Manipur, Mizoram and Nagaland of the Northeastern Hill Region of India. It is also found in Bhutan, China, Myanmar and Bangladesh (Simoons, 1984). This unique bovine species is believed to be domesticated more than 8000 years ago. It plays an important role in economic, social and cultural life of the tribal population of Northeastern Hill region. Mithun is reared under free-range condition at various altitudes between 300 to 3000 m asl without resorting any scientific feeding programmes. However, Mithun can also be reared in semi-intensive and intensive condition as well. The animal is used as a sacrificial animal by the tribal communities in the Northeastern Hill region and other adjoining countries. It yields leanest meat among all the bovine species.

Natural habitats

Mithuns prefer areas with mild environmental temperature, high rainfall and medium humidity. The highest density of Mithun is observed in East Siang, East Kameng and parts of lower Subansiri districts where average rainfall is in between 3310 – 4724 mm along with high humidity. However, there are some areas in Arunachal Pradesh where rainfall is even on higher side, but Mithun population is much less. It might be due to higher level of humidity along with high temperature in those zones (Gupta et al., 1999). On the other hand, areas with low environmental temperature coupled with low rainfall is also not suitable for Mithun as has been evidenced in Twang and Dirang Dzong areas of the West Kameng district where Mithun population density is only 0.7/km^2.

Mild temperature with high rainfall and medium humidity in evergreen forest areas are suitable for growth of trees with broad leaf constituted one of the major components of fodder sources for Mithun. However, in the areas where environmental temperature as well

as rainfall is comparatively lower along with the increase in elevation evergreen forests are replaced by alpine and sub-alpine meadows which are suitable for sheep, yak and goats. High rainfall along with high environmental temperature and humidity favours for development of evergreen tropical vegetation. However, such areas are also not preferred by Mithun though suitable fodders for them are abundant, might be due to high environmental temperature and humidity during monsoon not preferred by Mithuns.

Mithuns are available as lower elevation as 300 m in Bandarban district (Bawon Zo) in the Chittagang hills in Bangladesh and as higher elevation as 3000 m in Arunachal Pradesh. They are basically shed loving animals. Shed seeking during summer might be attributed to heat stress. It indicated by Larkin (1954) that heat stress in animals might be the effect of both temperature and humidity and their interaction with genotype. So, determination of thermo neutral zone and fasting heat production (basal metabolic rate) in different types of Mithuns might give some insight about their tolerance to heat stress in relation to them colour patterns and distribution.

Feeding behaviour

Free Range: Though mild temperate zone is preferred by Mithun, a small population is also observed in tropical and temperate zones. Mithun habitat areas, especially in the subtropical to mild temperate zones are covered with moist / rain forests. These forests are rich in wide variety of flora in terms of tall trees in the first tire and tall shrubs, evergreen herbs and vines in the second tier. A variety of grasses are observed on the ground while creepers with broad leaf are wrapped around big trees. Mithuns prefer to browse on leaves and twigs of trees and shrubs and graze on long grasses. Broad-leaf trees like Ficus hookerii are in their preference list. Mithun may travel long distance in search of preferred species of forages. They consume Ficus leaves with greater relish. Mithuns follow a routine system of browsing and grazing. They browse along the edges of forests in the morning, go to deeper part as the day progresses and prefer to stay under shade in a sunny day. However, in the afternoon when environment is cool can be seen grazing in the often forest cleanings or in the abandoned jhum (Gupta et al., 1999).

As grazer they are very much selective and prefer certain species of herbage, stages of growth and particular parts of the forage and found to be concentrated in a particular area of forest abundant species of plant.

Studies on the vegetations in the forest of Phek district of Nagaland conducted by National Research Centre on Mithun indicated that 91.58% of grasses, 83.30% of herbs, 70.77% of

shrubs and 80.47% of tree leaves out of 107, 18, 79 and 129 numbers of species, respectively were consumed by Mithun. Major grass species *included Arundinella sp., Borrena hirticulata, Curculigo secusvata, Cynodon dactylon, Dimeria sp., Imperta cylindrica, Phragrmites sp., Setaria palmifolia and Thysanolaena agrostis*. The herbs available were *Persiceria nepalensis, Galinsogo perviflora, Artemisia vulgaris, Ageratum conzoides, Crystella parasitica, Eupatorium sp., Polygonium chinensis, Jasminum sp.,* etc. These grasses and herbs are rarely available in pure stand in sizable area. In composite form, percentage of species available as well as their chemical composition varies with seasonal changes. The predominant species available during monsoon were *Setaria palmifolia, Cynodon dactylon, Thysanolaena agrostis, Artemisia vulgaris, Persicaria nepalensis, Galinsogo perviflora, Ageratum conzoides, Crytella parasitica and Heydyatis scandens*. The predominant species available during winter are *Thysanolaena agrostis, Setaria palmifolia, Eupatorium sp., Ageratum conzoides and Crystella parasitica*. Majority of the species mentioned above are available throughout the NEH region (Balaraman and Goley, 1991 and Heli, 1996).

Common fodder trees available throughout the Northeastern Hill region, majority of which are consumed by Mithun are as follows: *Acer laevigatum, Adenosacme longifolia, Albizzia sp., Alnus nepalensis, Amoera wallichii, Arotocarpus lakoocha, Bauhina purpurea, Bauhinia variegate, Brassiopsis mitis, Bridelia retusa, Dacynia indica, Debrogesia longifolia, Desmos longiflorus, Emblica officinealis, Exbucklandia populnea, Celtis tetrandra, Erytharia stricta, Eurya accumenata, Ficus bengalensis, Ficus benjaminia, Ficus cunia, Ficus dalhousiae, Ficus elevate, Ficus elmeri, Ficus hookerii, Ficus hirata, Ficus hispada, Ficus infectoria, Ficus nemoralis, Ficus religiosa, Goruga pinnata, Grevia elastica, Gmelina arborea, Lagerstroemia speciosa, Leea indica, Litsea citrada, Litsea polyantha, Macranga denticulata, Meliosma pinnata, Morinda angustifolia, Morus alba, Morus levigata, Mussanda roxburghii, Orecocnide integrifolia, Oroxylum indicum, Prunus ceresoides, Prunus persica, Polyanthus sp., Rhaphidosphora sp, Sabia sp, Saraina panduana, Saurauia nepalensis, Scheffelera sp., Spondius pinnata, Stereosper tetragonium, Syzyjium sp., Terminalia bellerica, Trevesia sp. and Turpinia nepalensis. Important shrubs which are of choice of Mithun are Amomum sp., Borrena hirticulata, Callicarpa vestita, Chlerondendron sp., Dendrocalamus sp., Hibiscus chinensis, Hibiscus subdereffa, Osbekia nepalensis, Polygonum chinensis, Pouzolzia sp., Quix sp., Sarcochlamys pulcherrima, Solanum nigrum, Stereospermum chelonoedes, Urtica sp., etc. Generally preferred grasses are Alloteropsis semialata, Arundinella sp., Axonopus compressus, Avena sativa, Borrena hirticulata, Carex cryciata, Commelina bengalensis, Curculigo secusvata, Cynodon dactylon, Dimeria sp., Imperta cylindrica, Oplismenus*

compositus, Phragrmites sp., Pogonetherum crinitum, Schitostachyum sp., Setaria palmifolia and *Thysanolaena agrostis* and creepers are *Alternanthera sesiles, Cissus assamina, Jasminum sp., Melothria sp., Phaseoulus sublabatus and Vites sp*. in the state of Arunachal Pradesh, Manipur, Mizoram and Nagaland. The preferred herbs are *Borrena hirticulata, Impatiens sp. and Plantago major and tuber was Ipomea batatus* (Heli, 1996; Haque et al., 2008; Prakash et al., 2008, Padmakumar et al., 2015).

The primitive agricultural practice in Northeastern Hill region is one of the most important factors for dwindling natural vegetation. This is also responsible for decreasing the carrying capacity in the locations of jhumland (Pal and Bujarbaruah, 2002). Due to hilly terrain and high rainfall, the Mithun habitat is prone to soil erosion that in turn affects the overall nutrient dynamics in the soil-plant-animal continuum. In deciduous trees, the nutrient composition of leaves significantly varies with maturity and in different seasons due to leaching and transport of nutrients (Guha and Mitchell, 1966; Kenworthy, 1973). Further, as the topography of the Mithun habitat is undulating, leaching of minerals is a common phenomenon (Kleinman et al., 1996) and soils are prone to mineral deficiencies, which could affect vegetation (Prasad et al., 1986)

The Na content varied widely, and, in all the foliages, it was deficient compared to the required range. It is well known in the NEHR that Mithun shows salt-hunger behavior extensively under free-grazing condition (Simoons, 1984), which might be due to the deficiency of Na in the foliages as it has been recorded in the present study. The higher Ca and Mg contents in the foliages might be due to relatively higher uptake of these elements from coarse textured soils with low cation exchange ability (Sillanpaa, 1982). These types of the soils generally found in the NEHR of India. The Ca:P ratio was much wider in all foliages, compared to those recommended for ruminants (McDowell, 1997), which may create problem with vitamin D metabolism (ARC, 1984). However, it can be overcome by supplementing with the foliages with higher P that are recorded in the present study and *Tithonia diversifolia* like foliages, which contain higher P (Olabode et al., 2007).

Intensive and Semi-intensive: Agricultural and forest by-products that are relished by Mithun are banana leaves and stems, pineapple leaves, potato haulms, rotten tubers, sweet potato vines, tapioca waste, brewery waste (processed millet / barley grains), dried distillery grains and solubles, tubers, etc., (Gupta et al.,1999, Das et al., 2011). Paddy is the major cultivated crop in Northeastern Hill region of India. Nevertheless, due to lack of awareness and practice of feeding paddy straw to ruminants especially to Mithun is not done. Farmers allow paddy

straw to be decomposed in fields (Prakash et al., 2008). However, it can be used as a source of roughage for Mithun also.

Feed intake

Incorporation of *Lagerstroemia speciosa* tree leaves in paddy straw and concentrate based total mixed ration up to 30%, the dry matter intake observed to be 2.52% of its body weight and 91.9 g per kg metabolic body weight per day (Prakash et al., 2008). However, in intensive system the intake of dry matter on jungle grass-based ration with supplementation of 2.0 kg rice bran fortified with 1% mineral mixture and 1% common salt, is 6.86 and 6.09 kg in male and female Mithun calves, respectively which correspond to 2.98 and 2.53% of the body weight (Pal et al., 2004). On feeding a ration comprised of 50% concentrate and 50% roughage (tree leaves of *Ficus hirta*, *Debrogesia longifolia*, *Lagerstroemia speciosa and Litsea sp* – 2 parts and paddy straw – 1 part) average dry matter intake was 4.93 ± 0.21 and 4.74 ± 0.21 kg in male and female Mithun weighing 230 and 221 kg, respectively. It corresponds to 101.1 ± 4.93 and 98.3 ± 3.33 g per kg metabolic body size per day (Das et al., 2011).

Energy requirement

No data is available regarding energy requirements (digestible energy / metabolizable energy / net energy) for maintenance, growth, lactation, etc. It is mentioned earlier that there is lot of variation among different types of Mithuns in terms of milk yield, adult body weight, growth rate, etc. It provides an opportunity for selection of these animals in terms of efficient meat producer. Lower energy requirement per kg metabolic body size for maintenance might be used as one of the basic tools for selection of Mithun for better growth rate. Higher milk yield in beef cattle is positively correlated with higher energy requirement for maintenance. It indicates that the higher the milk yield in Mithun, the lower is the efficiency of utilization of energy in terms of growth. Beef cattle with higher milk yielding capacity has 11% higher metabolizable energy requirement for maintenance compared to low yielder (Montano-Bermudez et al., 1990). Cattle having a greater propensity to deposit fat subcutaneously are better able to increase thermal insulative efficiency and are more tolerant of and adoptable to cold environment (Webster and Young, 1970). It explains about lower maintenance requirements for low milk yielder. Comparative study regarding efficiency of utilization of energy in different types of Mithuns, using roughage as well as concentrate-based diets is imperative to make Mithun rearing a viable proposition in commercial line.

Protein requirement

No data is available regarding requirements of protein for different purposes in Mithun except for those animals having growth rate about 450 g per day and maintenance. However, Mithun might have developed some capacity to detoxify or nullify the effects of some anti-nutritional factors like tannin as it is mainly dependent on fodders rich in these factors, in natural condition. Tannin affects digestion and utilization of protein. So, during determination of requirements of protein in Mithun for different purposes these factors also must be considered. However, it is reported that Mithun calves attained 464 g average daily gain, fed on paddy straw-based diet containing 8% crude protein on dry matter basis (Annual Report, 2009 – 10). However, the requirements of protein and energy can be fulfilled using the recommendations of ICAR as mentioned below when growth rate is 450 g per day as tabulated below (Table 1):

Table 1: ICAR Requirement Table

Body weight (kg)	Dry Matter (kg)	Digestible Crude Protein (g)	Total Digestible Nutrient (kg)
Growth rate (450 g/d)			
50	1.7	240	1.2
60	1.9	240	1.3
70	2.1	250	1.4
80	2.4	250	1.6
90	2.6	260	1.8
100	2.8	260	2.0
120	3.4	280	2.3
140	3.8	300	2.6
160	4.3	320	2.9
180	4.8	340	3.2
200	5.3	370	3.6
220	5.8	400	4.0
240	6.3	430	4.4
260	6.8	460	4.8
280	7.3	470	5.1
300	7.8	480	5.4
Maintenance			
350	6.2	300	3.3
400	7.0	330	3.8
450	7.8	360	4.3

Body weight (kg)	Dry Matter (kg)	Digestible Crude Protein (g)	Total Digestible Nutrient (kg)
500	8.5	380	4.8
550	9.1	410	5.0
600	9.5	430	5.2
650	9.9	440	5.3

(ICAR, 2015)

Mineral requirements

Meager information is available on seasonal micronutrient dynamics of the evergreen tree fodders in the Northeastern Hill region. The topography of this region is undulating. In such area leaching is very common phenomenon due to heavy rainfall (Kleinman et al., 1996) and soils are prone to mineral deficiency which could also affect the vegetation (Prasad et al., 1986). Craving for salt is more pronounced in Bibos species viz. Mithun, gaur, bentang and koupray than other large hoofed wild animals (Wharton, 1957). Information regarding requirements of various macro and micro-minerals and their availability during free-grazing condition in Mithun is inadequate. Various hypotheses have been presented regarding this including a) hunger for mineral and sodium chloride, b) want of some trace minerals, etc. However, it is reported that nutrient content is adequate in of most of the foliages (out of 16) consumed by Mithun under free-grazing system, except sodium (Prakash et al., 2009). This could be the reason, why the Mithuns reared under free-grazing condition often exhibit the salt licking behaviour in contrast to those kept under confined condition. The content of Fe, Cu, Mn and Zn in some fodders available in Northeastern Hill region is presented in Table 1. The level Fe, Mn and Zn is found to be higher in all the fodders, but level of Cu is within the normal range when prescribed normal range is 30 – 50, 20 – 40, 20 – 40 and 07 – 11 mg per kg for Fe, Mn, Zn and Cu, respectively (McDowell, 1997). The importance of mineral elements to the health and well-being of animals has been recognized for centuries (Underwood, 1956).

Water requirement

Data on water requirement is very meager. Growing Mithun calves consume about 15.18 litres of water per 100 kg body weight (Pal et al., 2008). However, environmental temperature has a significant effect on it. Drinking water consumption per unit of body weight is higher in summer than in winter. Supplementation of concentrate feed on free grazing animals increases water consumption. It is estimated that Mithun calves consume 4.30 litres of water per kg dry matter intake.

Growth rate

In paddy straw and concentrate based total mixed ration, supplementation of *Lagerstroemia speciosa* tree leaves up to 30%, the growth rate and feed conversion efficiency is observed to be 441 g and 10.0, respectively. It is also reported that Mithun can be reared successfully in the intensive system (Prakash et al., 2008a). However, in intensive system the average daily gain on jungle grass-based ration with supplementation of 2.0 kg rice bran fortified with 1% mineral mixture and 1% common salt, is 371 and 306 g, in male and female Mithun calves, respectively (Pal et al., 2004). Male Mithun calves show 548 g average daily gain fed on a ration containing *Borrena hirticulata* 300 g, rice straw 300 g and concentrate 400 g per kg in intensive system (Prakash et al., 2008). Average daily gain is observed to be 602 ± 44 and 554 ± 9.03 g in male and female Mithun calves respectively, fed on a ration comprised of 50% concentrate and 50% roughage (tree leaves of *Ficus hirta, Debrogesia longifolia, Lagerstroemia speciosa* and *Litsea sp* – 2 parts and paddy straw – 1 part) (Annual Report, 2007 – 08).

In case of beef cattle, economic pressure to improve production efficiency has prompted the researchers, to evaluate the performance of different types of cattle and methods used, to produce high quality meat with higher yield. Feeding grain diets to cattle is generally considered to yield meat that is more tender, flavourful and juicy than that of forage-fed cattle. However, feeding of grain-based diet results with excess fat deposition (Dikeman et al., 1985). In this way feeding grain-based diet is inefficient as fat deposition is energetically more expensive than protein synthesis on a tissue weight basis (Thorbeck, 1977). Feeing cattle for maximum rate of gain, results in improved feed efficiency because of dilution of maintenance requirements (Dikeman, 1973). Therefore, feeding for maximum rate of gain and terminating the feeding period when cattle have deposited a minimum amount of trimmable fat, result in optimal feed efficiency.

Tenderness of meat is an important parameter for evaluation of meat quality. After slaughter of animals, reduced proteolysis of myofibrilar proteins due to reduced activity of μ-calpain and m-calpain, or in the other way over-activity of their inhibitor, calpastatin, produce less tender meat. So suitable feeding strategy and selection of Mithun strain having less capastatin content in their meat should be considered besides consideration growth rate, milk production and other economic traits for viable Mithun production system.

Strategies for feeding Mithun

Availability of fodders is not uniform throughout the year as depicted below (Fig. 1). Therefore, arrangement for supplementary feeding is mandatory in Mithun rearing in free range system during summer and winter season.

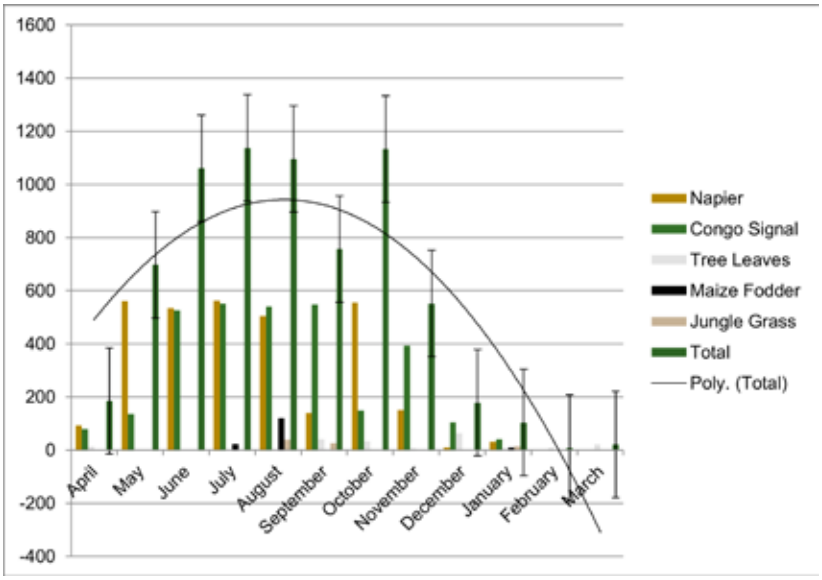

Fig. 1. Fodder production trend in organized farm in Nagaland (kg/d) (10-acre area)

It is to mention here that in free range system Mithun's equivalent to more than 2.5 Adult Cattle Unit (ACU) i.e two adult and one calf, cannot be kept. Otherwise, the arrangements supplementary feeding in the form cut and carry tree fodders should be made (Table 2).

Table 2. Some of the important fodder tree species, period of fodder availability and approximate yield

Sl No	Botanical name	Common name (Nepali / Sikkimese)	Age of first lopping (years)	Approximate yield / tree (kg at age in year)
		2000 masl altitude and above		
1.	Salix sp	Salix	8	8 – 10 (10)
2.	Populus cilliata	Shinnka	4	5 – 7 (8)
		1400 – 2000 masl altitude		
3.	Castanopsis sp.	Katuse	7	-
4.	Saurauia napaulensis	Gogun	4 – 5	30 – 40 (20 – 25)

Sl No	Botanical name	Common name (Nepali / Sikkimese)	Age of first lopping (years)	Approximate yield / tree (kg at age in year)
5.	Celtis australis	Khari / Phutta	-	150 (5)
6.	Machilus edulis	Kawala	-	60 – 90 (15)
7.	Prunus ceresoides	Wild cheri	3 – 5	100 (8 – 10)
8.	Helixanthera ligustrina	Lisso	15 – 16	400 (15 – 20)
9.	Machilus sp	phumchi	-	-
10	Schima wallichii	Chillowne	-	-
		1000 – 2000 masl altitude		
11.	Ficus hookerii	Nevaro	5 – 7	20 – 80 (10 – 15)
12.	Ficus nerifolia	Dudhilo	7 – 10	90 (9)
13.	Ficus semicordata	Khanyun	4 – 5	270 – 300 (12 – 14)
14.	Brassaiopsis hainla	Chuletro	4 – 5	50 – 150 (4 – 10)
		600 – 2000 masl altitude		
15.	Ficus subincisa	Lute Khanyun	4 – 5	160 – 200 (7 – 8)
		Below 1600 masl altitude		
16.	Ficus bengalensis	Bar	5 – 6	500 – 700 (30)
17.	Ficus infectoria	Kabra	5 – 10	60 – 80 (15 – 30)
18.	Ficus hirta	Khasre	5 – 8	-
19.	Ficus glaberrima	Pakhure	5 – 6	60 – 100 (1 – 12)
20.	Litsea polyantha	Kutmero	5 – 6	150 (12 – 14)
21.	Erythrina arborescens	Faledo	-	-
22.	Malotus philippensis	Sindure	7 – 8	160 (50)
23.	Celtis orientalis	Khari	7 – 8	160 (50)
24.	Bauhinia variegata	Koiralo	-	50 – 75 (10 – 12)
25.	Artocarpus lakoocha	Barhar	-	-
26.	Grewia elastica	Sialphusre	-	-
27.	Lisea citrata	Sil timur	-	7 – 8 (9 – 12)
28.	Bauhinia purpurea	Tanki	-	-
29.	Betula cylindrostachys	saure	-	-
30.	Ficus elastica	Rubber tree	7 – 8	-

Deciduous tree species: Sl No 1,2,6,9,17,18,21,23,24,26,27,27,29 Singh et al., (1996)
Evergreen tree species: Sl No 3,4,5,8,10,11,13,14,15,16,19,22,30
Deciduous & Evergreen: Sl No 7,12,20,25

It is not an economically viable proposition of rearing Mithun in semi-intensive or in intensive system feeding traditional concentrate mixture. However, it is observed that feeding Mithun using agro-industrial by-products like dried distillery grains and soluble (DDGS) or brewers

grains up to 40% and paddy straw might be a viable proposition. Complete feed blocks might be prepared using DDGS, brewers' grains paddy straw, hay and tree fodders. Arrangements might be made for supplementing mineral mixture in free range animals craving for salts are very much prevalent. Further the mineral blocks might be prepared and dispensed in free range Mithuns in the forest for improving their growth and reproductive performance.

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GENETIC AND GENOMIC RESOURCES OF MITHUN – AN UPDATE

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INTRODUCTION

Mithun, scientifically referred to as *Bos frontalis* (Lambert, 1807), is a species of bovine that lives in open areas within tropical rainforest habitats of India, Bangladesh, Bhutan, China, and Myanmar (Mondal et al., 2004). Mithun is believed to have evolved from the Gaur (*Bos gaurus*), a wild bovine species found in South and Southeast Asia. It possesses a sturdy and well-balanced physique and exhibit aggression when subjected to confinement. The body has a strong and balanced structure, with noticeable muscles. The skull is shaped in a 'V' formation, with a wide and easily identifiable frontal bone. The coat that covers the head is typically black, with a forehead that is either grayish or white, extending to the face. The horn exhibits a substantial size at its base, protruding outward, and gracefully curving upward with a gradually narrowing tip. The horn tips are rounded, and the eyes are vivid and alert, adorned with thick black eyebrows. Male individuals have greater muscular development and possess more prominent horns compared to their female counterparts. Mithun has a prominent dorsal ridge, which is more pronounced in males compared to females, in contrast to indigenous cattle that have a hump. The neck is robust and highly developed, exhibiting a substantial dewlap and prominent creases. The chest was robust and wide. These animals possessed a dense and sleek dermis that was tightly connected to their bodies, resembling that of typical bovine livestock. The udder exhibited strong attachment, small size, and correct positioning, including teats that were either black or white. Mithun bulls possess sizable scrotums that are blackish brown in color. Mithun possesses a lengthy tail that extends to the hock joint, featuring a tail switch that can be either black or white (Mukherjee et al, 2014).

This paper presents an overview of the genetic and genomic resources related to Mithun, the pride of Northeast India.

MITHUN GENETIC RESOURCES

Mithun, characterized by its distinctive morphology and behaviour, has adapted to the diverse and challenging environments of the region. Through centuries of domestication and selective breeding, the Mithun has developed into several distinct strains, each with its own morphological and genotypic characteristics.

ARUNACHALI MITHUN

The Arunachali Mithun is one of the prominent strains distinguished by its unique morphological features.

Morphological Characteristics: Arunachali Mithuns are noted for their convex forehead and short, stump-like horns. The horns are relatively smooth and not very massive compared to other strains. The body weight of Arunachali Mithuns is moderate, and their overall physique is robust yet less imposing in size (Figure 1).

Appearance: The Arunachali Mithun's body is generally covered with short, dense hair. The color of the coat is typically a shade of brown/black with varying white patches. One of the unique features of Arunachali Mithun is the dorsal side of the forehead in between the horns is convex.

Figure 1: Female Arunachalee Mithun

Figure 2: Male Nagami Mithun

NAGAMI MITHUN

The Nagami Mithun is another significant strain with distinct characteristics.

Morphological Characteristics: Nagami Mithuns are distinguished by their straight forehead and large, curved, upward-reaching horns, which are often corrugated. These massive horns contribute to the breed's impressive appearance. The body of the Nagami Mithun is large and robust, reflecting its well-adapted nature to its environment (Figure 2). The typical characteristic features of Nagami Mithun are black coat colour with white stockings in the legs. The dorsal side of the forehead in between is a straight lune in Nagami Mithun.

Appearance: The Nagami Mithun exhibits a more muscular and massive physique compared to other strains.

MANIPURI MITHUN

Manipuri Mithuns are renowned for their distinctive coloration and physical attributes.

Morphological Characteristics: One of the most noticeable features of Manipuri Mithuns is the prevalence of black stockings on their legs. Over 60% of Manipuri Mithuns have a jet-black coat, with the rest of the body often displaying a rich, dark brown color. This black coloration is one of the key differentiators from other strains (Figure 3).

Appearance: Manipuri Mithuns have a sleek and elegant appearance with a well-defined body structure. Their coat is uniformly dark, adding to their unique and striking appearance.

Figure 3. Male Manipuri Mithun

MIZO MITHUN

The Mizo Mithun, also known for its unique traits, adds to the diversity of the Mithun population.

Morphological Characteristics: Mizo Mithuns typically have a robust and muscular build

with a distinctive head shape and horn structure. The horns are not as pronounced as those of the Nagami Mithun but are still significant in size and curvature. The coat color of Mizo Mithuns varies from brown to dark brown, with some individuals exhibiting lighter shades.

Appearance: The Mizo Mithun's body is well-adapted to the hilly terrain of Mizoram, showing a strong and agile physique. Their coat color and horn structure contribute to their adaptability and resilience.

The morphological and genotypic characteristics of the four strains of Mithun—Arunachalee, Nagami, Manipuri, and Mizoram—highlight the rich diversity within this species. Each strain exhibits unique features that are a result of adaptation to specific environments and selective breeding practices. Understanding these variations is crucial for the effective management and conservation of Mithun populations, as well as for optimizing their roles in the agricultural and cultural landscapes of the Norteastern region of India.

MITHUN GENOMIC RESOURCES

Mithun Genome Sequence and Draft Assembly: Recent genomic research on *Bos frontalis* (Mithun) and closely related species have yielded significant insights into their genetic composition and evolutionary connections. In their study, Mukherjee et al. (2019) successfully obtained a genome assembly of the Indian Mithun that is of excellent quality. The assembly consists of 5,015 scaffolds and reveals a total of 28,044 distinct protein-coding genes. Additionally, they found that approximately 43.66% of the genome is composed of repeat sequences. Ren et al. (2017) conducted an analysis of the mitochondrial genome of the Gayal (*Bos frontalis*). They emphasized that the genome consists of 16,340 base pairs and contains 37 genes, including 13 protein-coding genes. The researchers also observed that the Gayal shares genetic similarities with other Bos species, which is of great importance for conservation initiatives. Prabhu et al. (2019) conducted a study on the mitochondrial genome of the Indian Mithun. They found a strong evolutionary connection between the Indian Mithun and the gaur (*Bos gaurus*). Additionally, they observed notable differences in the mitochondrial genomes of Indian and Chinese Mithuns. Deb et al. (2020) conducted a study on the Bangladeshi *Bos frontalis*, where they analyzed its mitochondrial genome. They found that the genome consists of 16,347 base pairs and has a high proportion of AT pairs. Additionally, they discovered that 68.93% of the genome is made up of protein-coding genes. This research contributes to a better knowledge of the species and helps in its conservation efforts.

Genomic diversity of Mithun: Qu et al. (2012) conducted a study on the Yunnan Mithun in China and discovered that despite the tiny population size, there was no significant genetic bottleneck. This was due to the introduction of genes from local zebu and yellow cattle. In their study, Mukherjee et al. (2022) employed microsatellite markers to evaluate genetic diversity among different bovine populations. They observed substantial variance and distinct genetic traits between Mithun and Gaur, while also discovering a minor reduction in the Gaur population. In their study, Mukherjee et al. (2019) performed a thorough analysis of the genetic makeup of Mithun populations in the North-Eastern Hilly States of India using a high-density SNP approach. The results showed that there is significant genetic diversity within each population, but limited genetic differences between populations. The researchers also observed some inbreeding, particularly in the Manipur population, but no distinct subgroups were identified. Genetic markers can be utilized with a specific emphasis on their functions in confirming parentage, identifying individuals, and detecting genetic diseases. DNA markers are crucial for the identification of quantitative trait loci (QTLs) in order to improve genotypic selection in breeding programs and livestock genome mapping, despite its complexity, shows potential for identifying functional genes, QTLs, and genes associated with disease resistance (Marle-Köster et al, 2003).

CONSERVATION OF MITHUN

The study conducted by Mukherjee et al. in 2018 presents a detailed analysis of the genetic makeup of two distinct populations of Indian Mithun (farm and field) using advanced genotyping techniques. The findings indicate that these populations have a relatively homogeneous genetic background with very limited interbreeding with indicine (Bos indicus) cattle. The farm Mithun population shows more frequent short runs of homozygosity (ROHs), indicating recent inbreeding, while the field population exhibits longer ROHs, suggesting older founder effects and genetic drift. Both populations exhibit genetic similarity and homogeneity, with only minimal introgression from indicine and taurine (*Bos taurus*) breeds.

Apum et al, 2020 examined the population situation and conservation initiatives for the Mithun (*Bos frontalis*), a partially domesticated animal highly esteemed by the Adi tribe in Arunachal Pradesh, India. Although the Mithun population in the area is currently high, it is facing a loss as a result of its widespread utilization in the social, economic, cultural, and political activities of the Adi people. The Adi community has undertaken conservation efforts to save the cultural significance of the Mithun. These initiatives are being carried out by groups such as the Adi Baane Kebang, Adi Cultural and Literary Society, and Adi Students Union.

The research on Mithun semen cryopreservation underscores its efficacy in preserving genetic material and facilitating artificial insemination (AI). The utilization of cryopreserved Mithun sperm has yielded a 75% success rate in achieving conception, leading to the birth of live calves. Although there is a decline in sperm quality after freezing, it nevertheless remains sufficient for achieving effective artificial insemination and genetic enhancement. Cryopreservation aids in reducing the dangers of inbreeding, hence promoting the preservation of genetic variety in Mithuns by artificial insemination (Mondal et al, 2010).

BREEDING AND IMPROVEMENT PROGRAMS

The Mithun population is decreasing as a result of ongoing inbreeding practices worsened by the fragmentation of their habitat, the restricted presence of certified sires, and the preference of farmers for dominating bulls. The process of inbreeding has resulted in a decrease in size, productivity, and reproductive efficiency. This has been further exacerbated by deforestation, poaching, and habitat devastation caused by the spread of agriculture and climate change. Mithuns, a species that flourishes in elevated, wooded regions, are facing difficulties as a result of diminishing habitats and a decrease in the supply of food. In addition, the dissemination of contagious diseases and interbreeding with indigenous zebu cattle are exacerbating the decline of distinctive Mithun attributes. The frequent killing of high-grade Mithuns for their meat poses an additional danger to their population. In order to effectively address these concerns and ensure the preservation of Mithuns, it is imperative that there needs to be a collaborative approach including many stakeholders such as the government, researchers, and local populations. This approach should focus on the development and implementation of comprehensive conservation policies (Ponraj, 2018).

Mithuns, originally employed as a means of trade, have experienced a growing trend of commercialization owing to their high desirability and ease of conversion into cash. This is mostly driven by their worth as a source of meat, milk, hides, and skin. The increasing economic worth of these products has led to a greater utilization and commercialization in the area can create more room for new breeding programs. (Moyong, 2012).

FUTURE DIRECTIONS

Research Priorities: Thorough investigations are necessary to comprehend the genetic diversity present in Mithun populations, particularly in geographically isolated and under-researched regions. This understanding is crucial for implementing effective conservation and

breeding initiatives.

Ecological Roles: There is a lack of research on the ecological influence of Mithuns in their natural environments. Additional research is required to reveal the functions of these organisms in forest ecosystems and their relationships with other species and environmental conditions.

Disease Resistance: Although there is some existing study on the disease resistance of Mithun, further investigations are necessary to examine their genetic ability to withstand developing diseases and environmental stressors, especially in the context of changing climates.

Commercialization's Impact: The impact of commercialization on Mithun populations, particularly alterations in breeding techniques, is still not well comprehended. Additional research is required to investigate the long-term effects on genetic health and population dynamics.

Ongoing research is necessary to comprehend the ways in which Mithuns adapt to climate change, particularly by studying genetic markers associated with heat stress and drought resilience. Performing high-resolution genetic mapping to uncover genes associated with qualities such as disease resistance and climate tolerance. Commencing long-term ecological study to evaluate their role in habitats and the impact of environmental changes on their survival. The objectives include creating comprehensive health monitoring programs to monitor disease patterns and guide breeding and conservation strategies; assessing the effects of commercialization on breeding methods and genetic diversity; and studying genetic and phenotypic adaptations to climate fluctuations to improve resilience.

In order to efficiently oversee Mithun genetic resources, policies should encompass the implementation of conservation programs aimed at safeguarding genetic diversity through the establishment of gene banks and protected areas. Additionally, there should be regulations in place to control commercialization activities and mitigate any potential adverse effects on populations. Furthermore, it is crucial to integrate climate adaptation strategies into conservation endeavors. Genomic data should serve as the basis for disease management in order to create vaccines and treatments. It is recommended that governments allocate funds for research, enforce measures to safeguard habitats, and promote collaboration among stakeholders. On the other hand, NGOs should prioritize lobbying, field-based conservation programs, and research partnerships. Collectively, these actions will augment the preservation of Mithun and guarantee their continued existence and ecological importance.

CONCLUSION

Overall, the Mithun (*Bos frontalis*) is a distinctive example of a partially domesticated bovine animal that holds considerable cultural, economic, and ecological significance in Northeast India and its surrounding areas. Although Mithun possesses a strong and adaptable physical structure suitable for temperate rainforest environments, it is currently confronted with significant challenges such as inbreeding, habitat fragmentation, and heightened commercialization. The complexities arising from climate change exacerbate the problem by influencing the availability of feed, the prevalence of diseases, and the occurrence of heat stress. Consequently, these factors have a direct impact on production and welfare.

A comprehensive strategy is necessary to preserve and enhance Mithun populations. Genomic research provides valuable opportunities for deepening our knowledge of genetic variation, reducing the dangers of inbreeding, and strengthening the ability to withstand environmental pressures and diseases. The efficacy of cryopreservation and artificial insemination in maintaining genetic material highlights the capacity of these methods to aid in the preservation and improvement of Mithun populations. By combining conservation measures with genetic developments, we may provide a solid basis for sustainable management and breeding operations. Effective initiatives require collaboration among stakeholders, including government entities, researchers, and local people. To ensure the preservation and sustainable growth of Mithun populations, it is necessary to address the issues of habitat loss, climate change, and commercialization by educated and coordinated activities.

REFERENCES: Available on request

PARASITES OF MITHUN (*BOS FRONTALIS*)

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Abstract

Mithun (*Bos frontalis*) holds a cherished place in the cultural and agricultural heritage of the tribal communities residing in the rugged landscapes of north-eastern India. However, the striking diversity in topography and climatic conditions in this region exposes these revered animals to a range of parasitic infestations, resulting in compromised meat and milk production. Building upon earlier reviews, this paper offers an updated reports of findings on gastrointestinal helminth parasites, tissue protozoa, and ectoparasites, with an emphasis on studies conducted over the past decade. The review contextualizes these parasitic challenges within semi-intensive and free-ranging Mithun husbandry systems in the north-eastern hilly region of India, aiming to foster a deeper understanding of their implications for Mithun well-being and productivity.

Keywords: Mithun, Gastrointestinal, Parasites, Helminth, Protozoa, Ectoparasites

INTRODUCTION

Mithun (*Bos frontalis*), a member of the class Mammalia, order Artiodactyla, and family bovidae, is a symbol of status and prosperity, peace, and harmony among the tribal people in northeast Indian states of Arunachal Pradesh, Nagaland, Manipur, and Mizoram state of India. The Mithun population in India stands at approximately 390,000, marking a 30.6% increase since the previous census. Arunachal Pradesh accounts for the majority of the population at 89.7%, followed by Nagaland with 5.98%, Manipur with 2.36%, and Mizoram with 1.02%. These bovines are also found in neighboring countries such as Myanmar, Bhutan, Bangladesh, China, and Malaysia, however India hosts the largest Mithun population globally, comprising about 97.57%, while Myanmar, Bangladesh, China, and Bhutan account for approximately 0.96%, 0.32%, 0.96%, and 0.18%, respectively. (Mukherjee et al., 2022). The Mithun is central to the cultural identity and economic well-being of tribal communities, especially in Nagaland

and Arunachal Pradesh where it holds a revered status as state animal. The animal is typically raised with great respect and often serves as a ceremonial animal. While it is ultimately sacrificed for meat during festive seasons, the act of slaughtering holds deep cultural significance, symbolizing wealth, status, and prosperity. Mithun meat is regarded as being more tender and superior to the meat of any other species.

Since the animals are semi-domesticated and managed in fenced tracts of the forest rather than being kept inside or near villages, they are exposed to increased risks of contracting and transmitting diseases of both domestic and wild animals. Their free-roaming lifestyle exposes them to various infections from the forest ecosystem, often going unnoticed and beyond the reach of veterinary intervention. While tribal communities have reported sporadic deaths of Mithun across different regions, there is no adequate information on their health status. The specific etiological agents responsible for these infections have not been thoroughly identified or documented.

Like other animals, mithun is susceptible to various diseases, including parasitic infections. While parasitic diseases typically do not cause high mortality, they can lead to a decline in productivity over time, resulting in significant economic losses for farmers. The climate in the north-eastern hilly region of India, with relative humidity around 80%, temperatures ranging from 15–35°C, and soil pH between 6.5 and 8.5, provides favorable conditions for the growth of parasite larvae, making it an ideal environment for the propagation of various parasite species.

Despite the socio-economic and cultural importance of Mithun, research on their health, particularly parasitic infestations, remains sparse, with much of the knowledge stemming from a limited number of studies. Building upon earlier reviews, this paper aims to consolidate recent findings on parasitic challenges affecting Mithun, focusing on gastrointestinal helminths, tissue protozoa, and ectoparasites.

While parasitology in mithun is an underexplored field, the available studies provide important outlook on the epidemiology and impact of parasitic diseases on this species. This review highlights these contributions, contextualizes the findings within semi-intensive and free-ranging husbandry systems in north-eastern India, and identifies critical knowledge gaps that warrant further investigation.

1. OVERVIEW OF HELMINTH PARASITES IN MITHUN

Helminth parasites are a major concern for the health and productivity of mithun, affecting

various aspects of their physiology and performance. This section provides an overview of the helminthic infections documented in mithun, covering a diverse range of parasites, including trematodes, gastrointestinal nematodes, and cestodes. Key trematodes such as *Fasciola gigantica*, and *Paramphistomum epiclitum*, as well as nematodes like *Mecistocirrus digitatus*, *S. digitata*, and cestodes including *Moniezia* species and *Cysticercus tenuicollis*, are discussed in terms of their epidemiology, pathology, and molecular characteristics. Understanding these infections in detail is crucial for creating accurate diagnostic tools and practical control measures to reduce their impact on the health and productivity of mithun.

1.1 Trematodes

The different gastro-intestinal trematodes recorded in mithun based on faecal and postmortem examination include *Fasciola gigantica*, *Gastrothylax crumenifar*, *Paramphistomum epiclitum*, *Calicophoron calicophoron*, and some unidentified amphistomes (Rajkhowa et al. 2005, Tandon et al. 2005; Biswas et al., 2014; Chamuah et al., 2013a, 2016, 2017a). The occurrence of these trematodes is dependent on a suitable climate along with the presence of a snail intermediate host in mithun-inhabited area which is necessary for completion of their life cycle. As per our investigation, the prevalence of these parasites was higher in Arunachal Pradesh, with clinical cases recorded in these areas. Mithun is more closely associated with Assam's low-lying areas, particularly the districts of Lakhimpur, Sonitpur, and Dhemaji. ICAR-NRC on Mithun, Medziphema has already extended help to this region in the form of an Animal Health Camp, Mithun Mela, and technology transfer programs, as well as extensive regular deworming.

Epidemiology and pathology of trematode infection in Mithun

Fascioliasis and amphistomosis are major fluke infections that are responsible for significant morbidity and mortality in ruminants. However, the occurrence of fluke infections in mithun is reported to be minimal. In mithun, subclinical infections with adult amphistomes such as *Paramphistomum*, *Epiclitum*, *Gastrothylax crumenifer*, *Cotylophoron cotylophorum*, and *Fischoderius elongatus* have been documented. Additionally, *Gastrodiscoides*, *Gastrothylax crumenifer*, and *Paramphistomes epiclitum* have been reported from Arunachal Pradesh and Bhutan. Despite this, there are cases of mortality in mithun calves due to heavy infections with immature amphistomes (unpublished data). Liver fluke infections in mithun are rare, and the causative agent of fasciolosis is identified as Fasciola *gigantica* (Chamuah et al., 2014).

The geographical distribution of Fasciola spp. is influenced by the availability of suitable aquatic Lymnaeid snails and favourable climatic and ecological conditions (Tandon et al., 2005).

Fluke infections are a primary cause of clinical manifestations in ruminants, with fascioliasis being particularly impactful, often resulting in mortality. The occurrence of fasciolosis is influenced by a multifactorial system, which comprises hosts, parasites, and environmental effects The life cycle of Fasciola is involved with snails of the genus Lymnaea, which act as the intermediate hosts. In the natural foci of fasciolosis, the parasite and their intermediate as well as final hosts form an association, posing a potential epidemiological threat. It is, therefore, important that the existence and localization of such an association should be identified beforehand so that the situation can be brought under control through various measures.

In most of the tropical developing countries, the temperature is generally favourable for the development of both the fluke and their intermediate host, however due to variations in the precipitation and humidity, there are fluctuations in the development of snails and free-living stages of parasites. There is a marked increase in the reproduction of snails in the rainy season that leads to a peak in their population towards the end of the season. This trend slows down or completely ceases during the dry or cold periods, resulting in a lower snail population. This is accompanied by a considerable fluctuation in herbage infestation and the survivability of metacercariae. The infective stage may survive for 10 months in the humid tropics, and the longevity of metacercariae has been reported to vary from a few weeks to 3-4 months in a relatively hot and dry climate. The ultimate determinant of the epidemiology of the parasitic disease is the rate of egg production by the adult flukes, which subsequently influences the degree of pasture contamination. In addition, the grazing habits and management of the animals may significantly influence the epidemiology of liver fluke infection.

During post-mortem examination of mithun at Itanagar, Arunachal Pradesh, the incidence of Fasciola gigantica infection was recorded at 4.4%. Grossly, the liver appeared greyish white and hard in consistency, with a markedly distended bile duct containing *F. gigantica* and tissue debris.

Microscopically, the bile ducts exhibited cholangitis, characterized by a marked thickening of the duct walls. There was significant fibrosis of hepatic lobules, leading to pseudolobulation, along with infiltration of mononuclear cells into the liver parenchyma. In some areas, migratory

tracts indicated haemorrhages in the parenchyma, while the hepatic cords showed coagulative necrosis and mild fatty changes.

Although clinical cases of fasciolosis in mithun have not yet been documented, the chronic form of the disease appears to be more prevalent.

Sero-prevalence of fasciolosis in Mithun

Diagnosis of fasciolosis in mithun by faecal examination has been reported by different authors (Tandon et al., 2005, Chamuah et al., 2014). Although the procedure of faecal sample examination is simple and confirmatory, it is not a useful diagnostic tool at low levels of adult fluke burden. Importantly, it cannot detect infection at the prepatent period, because eggs are found in faeces when the flukes are already matured (usually between 10 and 14 weeks of infection). Hence, the need for methods other than faecal egg examination for the diagnosis of infection with fasciolosis has been obvious for decades.

Early prepatent diagnosis of fasciolosis in mithun is essential for arresting its negative impact on productivity, and efforts are therefore being directed towards trying to identify putative antigens for the serodiagnosis of this infection. *Fasciola* releases substantial amounts of excretory-secretory products (ESPs) during the migratory phase through the liver, and cysteine proteinases are the predominant antigens present in these excretory-secretory products. The excretory-secretory products produced by *Fasciola* are key players in understanding the host-parasite interaction and offer targets for the diagnosis of fasciolosis. The Cathepsin L-cysteine protease-based ELISA has been validated as a highly sensitive and specific diagnostic assay for the early prepatent detection of fasciolosis in other ruminants in field conditions.

The native cysteine protease of *F. gigantica* was purified to near-complete homogeneity, and SDS-PAGE analysis identified it as a 28 kDa protein (Chamuah et al., 2014). This purified protein was subsequently used to standardize an ELISA.

The seroprevalence of fasciolosis in mithun was recorded in free-range conditions as well as in semi-intensive conditions by using the indirect ELISA. Out of 156 animals tested, the sera of 30 animals were found to be reactive in ELISA, which yielded a percentage of 19.23%. Out of this, 25.84% was recorded in free-range conditions and 10.44% was recorded in semi-intensive conditions.

According to our study, the incidence of fasciolosis is low in the semi-intensive system of rearing

compared to the free-range system. This may be due to the practice of regular deworming and the better system of management on farms. In free-range conditions, there is easy access to the metacercarial infestation in the natural grazing area of the forest.

Molecular characterization of Fasciola gigantica in Mithun

Even though *F. gigantica* is the prevalent species in India, *F. hepatica* is also reported from high altitude regions of India. In addition to these two species, there are reports of intermediate forms of *Fasciola* from India (Raina *et al*., 2013). Morphological differentiation between *F. hepatica* and *F. gigantica* is becoming a challenge because of the emergence of intermediate forms of *Fasciola* spp. To overcome the limitations of phenotypic methods, genotypic approaches have been used for the identification and differentiation of *Fasciola* spp. Over the last two decades, several PCR-based approaches, including PCR- linked restriction fragment length polymorphism (PCR-RFLP), PCR-linked single-strand conformation polymorphism (PCR-SSCP), and specific PCR assays, have been developed for the accurate identification of *Fasciola* spp.

In mithun, genetic characterization and molecular identification of *Fasciola gigantica* was performed using the ribosomal ITS-2 and 28S rDNA regions, which served as markers to distinguish species and analyze polymorphisms (Raina et al., 2013). Analysis of 22 adult flukes revealed that the ITS-2 sequence typical of *F. gigantica* exhibited micro-heterogeneity, with nucleotide variations not corresponding to either *F. gigantica* or *F. hepatica*. These findings suggested the presence of both pure *F. gigantica* and flukes with mixed ITS-2 genotypes in mithun. Importantly, no flukes with the ITS-2 sequence of *F. hepatica* were identified, consistent with earlier studies in cattle and buffalo from India (Sharma et al., 1989).

Sequence analysis of the 28S rDNA region (N-terminal 618 bp) revealed a single nucleotide polymorphism (SNP) at position 284, characterized by a G-to-A transition. Phylogenetic analysis based on this SNP clustered *F. gigantica* into two distinct lineages, 284A and 284G. Comparative analysis of *Fasciola* isolates from Africa and Asia (Iran, Thailand, and India) confirmed this polymorphism, grouping isolates into the same two clades. These findings suggest two major lineages of *F. gigantica* for 28S rDNA across these regions, highlighting regional genetic variability.

Morphometric identification of *Fasciola* species can be challenging due to the existence of intermediate morphological forms. Molecular approaches targeting ribosomal and mitochondrial genomes have provided a reliable means to resolve ambiguities. While studies

using ITS-2 markers have confirmed the presence of *F. gigantica* in cattle and buffalo in northeastern India, reports of ITS-2 polymorphic forms in these regions remain scarce (Prasad et al., 2009). *F. gigantica* has been reported in the plains of India (Pandya et al., 2015), while *F. hepatica* is restricted to the temperate Himalayan regions. These studies highlights the genetic complexity within *F. gigantica* populations and underscores the importance of molecular tools in understanding the epidemiology and genetic diversity of *Fasciola* in mithun and other ruminants.

Amphistomiasis

Immature amphistomosis is an acute and potentially fatal condition in young ruminants, characterized by profuse diarrhoea, dehydration, pale mucous membranes, and a rough body coat, often culminating in the death of the animal. Amphistomes have been detected in mithun through fecal examination, but cases of immature amphistomosis in mithun calves are rarely documented. Clinically, affected animals exhibit anorexia, fluid fetid diarrhoea, and submandibular edema. A post-mortem observation of a young mithun calf revealed signs consistent with immature amphistomosis.

In paramphistomosis, the pathological changes are primarily due to the mechanical damage caused by immature flukes to the mucosa of the gastrointestinal tract after they excyst in the small intestine. These immature paramphistomes penetrate the mucosa and anchor themselves by drawing a plug of mucosa into their acetabulum. The strangulated portion of mucosa becomes necrotic and eventually sloughs off, leading to erosive lesions and mucosal petechiae, which cause significant intestinal discomfort. This discomfort manifests as inappetence or anorexia in the host. Anorexia, combined with impaired food assimilation, results in weight loss. The small intestine becomes hyperemic and edematous, which can partially occlude the bile duct, leading to necrosis of the bile duct and its epithelial lining. The animal loses plasma albumin due to seepage through the erosions in the digestive tract, and develops polydipsia. This condition, along with anorexia and the breakdown of plasma proteins in the intestine, results in loose and fetid feces. The reduction in plasma protein concentration leads to complications such as hydropericardium, hydrothorax, pulmonary edema, ascites, and bottle jaw. Pulmonary edema, coupled with starvation and exhaustion, often becomes the immediate cause of death in affected animals.

1.2 Gastrointestinal Nematodiasis

Gastrointestinal nematodiasis is a major problem encountered in mithun calves. The different gastro-intestinal helminths recorded are as follows: *Trichostronglylus* sp, *Haemonchus* sp. *Mecistocirrus digitata*, *Toxocara vitulorum*, *Strongyloides papillosus*, *Bunostomum phlebotomu*n, Capillaria species, Oesophagostomum sp and *Nematodirrus* species (Tandon *et. al*. 2005; Chamuah *et al*. 2013a, Biswas et al., 2014;Chamuah *et al.* 2017b, 2020). *T. vitulorum, S. papillosus, B.* phlebotomum and *H. contortus* are the major causes of anaemia and mortality in mithun calves (Rajkhowa *et al.* 2005). Parasitic gastroenteritis is a major cause of concern. There has been evidence that parasitic gastroenteritis is directly or indirectly associated with mortality and morbidity in Mithun.

These parasites were directly or indirectly associated with parasitic gastro-enteritis. T. *vitulorum, S. papillosus*, *Haemonchus* and *Mecistocirrus* were mainly responsible for calf mortality (Rajkhowa *et al.* 2003). Reported clinical symptoms were progressive loss of body coat, emaciation, faces may contain blood and mucous. Mud coloured diarrhoea is the common symptom of *T. vitulorum* infection. Frequent death of calves has been reported in Haemonchus and Mecistocirrus infection. The pale mucous membrane is a common symptom of blood-sucking worms. The infiltration of polymorphonuclear infiltration in the sub-mucosa with the hyperactivity of goblet cells leading to occlusion of the gland is the major histopathological lesion in Toxocara infected cases in the tissue section of the small intestine. There was evidence of diffuse hyperaemia, thickening, and ulceration of the intestinal mucosa in the Amphistomiasis cases. There was a record of petechial haemorrhage in the anterior part of the duodenum and jejunum. The presence of parasites in the abomasal mucosa revealed the presence of petechial haemorrhages (Chamuah *et al*. 2017b).

Under farm conditions at the National Research Centre on Mithun, Medziphema, lesions consistent with pimply gut are commonly observed in deceased mithun calves. These lesions are attributed to repeated infections and chronic exposure to Oesophagostomum spp., characterized by extensive greyish-white nodules distributed throughout the rectum and large intestine. The nodules range in size from a pinhead to a pea, and the entire intestinal wall was thickened, congested, and edematous with mild haemorrhages. Chronic enteritis is a common sequela of this condition and it is commonly evidenced by mononuclear cell infiltration comprising mostly macrophages, lymphocytes, and eosinophils. It occurs due to immunopathological phenomenon with, eosinophil, mast cell, leucocyte & neutrophil. The resulting nodules were often associated with diarrhoea of the infected animal and an

inability to digest food, accompanied by extreme weight loss, and weakness resulting in death. The animal had a hunched back and a stiff gait, whereas a less severe infection, will cause intermittent diarrhoea, weight loss, and a reduction in meat production. In farm conditions, management of the animals along with the browsing habit of grazing significantly influences the epidemiology of *Oesophagostomum* and other strongyle infections in mithun.

High humidity, at least in the microclimate of the faeces and the herbage is essential for larval development and their survival. The high biotic potential of parasites such as *H. contortus* results in its rapidly assuming dominance at times when environmental conditions on pasture are favourable for the development and survival of the free-living stages of larvae. A high prevalence and seasonal abundance of eggs and adult stages of Haemonchus parasites were observed during the hot and humid season. The hatching of eggs and the survival of the infective stage of larvae depend on the two most important components of the external environment, which are temperature and relative humidity. The development, survival, and transmission of eggs and infective larvae are influenced by climatic and environmental factors like temperature, humidity, and precipitation.

The optimum temperature for the development of maximum number of larvae is in the range of 18°–26°C and humidity as high as 100%, although some development can occur at 80%. However, even in dry weather where the ambient humidity is low, the microclimate in faeces or at the soil surface may be sufficiently humid to permit continual larval development. These factors often lead to seasonal fluctuations in the availability of infective larvae, which subsequently affect the prevalence of infections and worm burdens in the host. These epidemiological factors could be the same for mithun under farm conditions when compared to mithun under free-range conditions, where these factors are not severe for the precipitation of disease in the latter. Grazing animals habitually harbor a variable yet significant worm burden, with active parasite development occurring predominantly during the rainy season. In regions characterized by distinct rainy and dry seasons, a majority of third-stage larvae (L3) enter a state of arrested development toward the end of the rainy season. Consequently, faecal egg counts decline and remain consistently low throughout the dry season. However, with the onset of the rainy season, the pasture becomes heavily contaminated with infective larvae, leading to a high intake of these larvae by the animals. This results in a sharp rise in faecal egg output. However, the plots surrounding drinking places and permanent ponds may be sufficiently humid to maintain optimum larval development and transmission throughout the year, thus maintaining the epidemiology of parasites.

The larvae of some genera of nematodes can delay maturation to adult stages, and this phenomenon is known as hypobiosis. Subsequent resumption of parasitic development usually coincides with the onset of the rainy season, which is the most favourable period for larval development and transmission. This may occur as a manifestation of the acquired immunity of parasites or as a result of prior exposure to adverse climatic conditions during the stages as free-living larvae. However, as mithun prefers to browse the shrubs and tree leaves, the degree of parasitic infection in the alimentary tract is comparatively less. The phenomenon of a periparturient rise in faecal egg count of female animals also plays a major role in the epidemiology of gastrointestinal nematodes in mithun. This could be due to the release of prolactin hormone level, which causes temporary relaxation of immunity in pregnant animals.

Molecular identification of Mecistocirrus digitatus in Mithun

PCR-RFLP of the β-tubulin isotype-1 gene was carried for identifying *Mecistocirrus digitatus* in Mithun (Chamuah et al., 2017b). The β-tubulin isotype-1 gene fragment was PCR amplified from the genomic DNA of *M. digitatus*. The primary PCR produced a specific product of 840 bp. A nested-PCR on this product amplified a 787 bp fragment, which was then digested with Rsa1 to differentiate species. Rsa1 digestion of the nested-PCR product resulted in two bands of 456 bp and 331 bp. This pattern was compared with that of *Haemonchus contortus* β-tubulin isotype-1 gene from goat, which showed a distinct banding pattern consisting of three bands (440 bp, 190 bp, and 140 bp). Additionally, the ITS-2 region was used as a molecular marker to confirm the species. Sequence analysis of the ITS-2 region from Mecistocirrus showed 100% homology with the *M. digitatus* ITS-2 sequence and 83% identity with the ITS-2 sequences of *H. contortus* and *H. placei*. To further confirm the species, 20 randomly selected worms were sequenced for ITS-2, and all specimens were identified as *M. digitatus*.

Based on the sequence data of ITS-2 and β tubulin genes, the worms collected from the mithun in Nagaland and Arunachal Pradesh were identified as *M. digitatus*. However, a broader survey of mithun-endemic regions is necessary to assess the prevalence of both *Haemonchus contortus* and *Mecistocirrus digitatus* using molecular probes. Such studies would provide a more comprehensive understanding of the epidemiology of these parasites in mithun populations.

The morphology of Mecistocirrus was in concert with the findings of Soulsby (1986). The parasites exhibited a reddish hue and turgidity, attributed to their voracious blood-feeding behavior. Additionally, the distinctive anterior cervical region, prominent vulvar flaps, and characteristic bursa confirmed their identification. During our investigation, huge numbers

of parasites were recovered from abomasums. We observed clinical signs including complete pallor of the mucous membranes, dehydration, severe anaemia, and dark bloody faeces, which are typical of Mecistocirrus infection. Rajkhowa et al. (2003) similarly described symptoms such as iron-deficiency anaemia, intermittent constipation, loss of appetite, weight loss, and progressive wasting associated with this condition.

Trichuris spp. infection

The pathological alterations associated with Trichuris infection, include excessive mucus secretion, catarrhal typhlocolitis, hemorrhage, and sloughing of the mucosa. Trichuris infections are commonly characterized by inflammation and structural changes in the intestinal mucosa. In our observations, the rectum exhibited hypertrophy and hyperplasia of goblet cells, along with increased goblet cell activity. Additionally, focal aggregation of mononuclear cells was noted in some areas.

Microfilaremia

Microfilaria is also a commonly observed condition in mithun and is mostly transmitted by the Culicoids mosquito. However, it does not produce any clinical symptoms. It has been recorded from both Arunachal and Nagaland based on post-mortem examinations. Based on gross morphology and PCR amplification of marker genes, it is identified as Setaria digitata (Chamuah et al. 2015).

S. digitata is a long, milky white worm with tapering and spirally coiled hind ends, most commonly found in the peritoneal cavity of mithun in Arunachal Pradesh and Nagaland. The larvae of this filarial nematode are known as microfilaria, which is found in the blood of the host. Its life cycle is indirect, and the culicine mosquito acts as the intermediate host of the parasite (Soulsby, 1986). Even though the adult worms are generally considered to be non-pathogenic, which may be responsible for mild fibrinous peritonitis, the larval forms are considered to be pathogenic. Even though, the prevalence of S. digitate infection in cattle in India is reported to range from 77 to 95 %, the reports of S. digitata infections are very scanty in mithun (Rajkhowa et al. 2005).

Molecular identification of Setaria species in Mithun

To study the prevalence of S. digitata microfilaria in mithun, a pilot work was conducted

(Chamuah et al., 2015). Briefly, blood samples collected from 41 adult mithun irrespective of age and sex were screened by the modified Knott technique. Of these, 10 (12.19%) animals were found to be positive for microfilaria infection in the blood. For the recovery of adult parasites, a total of 110 mithun were examined during slaughtering and in various ritual festivals and marriage ceremonies of the local tribal population of Arunachal Pradesh and Nagaland. Among 110 animals, Setaria adult parasite was recovered from the peritoneal cavity of 9 (8.2%) animals.

The recovered parasites were identified as S. digitata based on the morphological key (Soulsby 1986). For a detailed study, genetic characterization of the parasite was done based on ribosomal (12S rDNA, 28S rDNA and ITS-2) and mitochondrial (Cytochrome C Oxidase subunit 1-COX1) regions. On sequence analysis, the ribosomal DNA 12S, 28S and ITS-2 regions showed 98% identity with that of S. digitata, while the mitochondrial COX1 gene showed 99% identity with S. digitata of Sri Lankan isolate (Accession ID EF179382,) and 87% similarity with *S. labiatopapillosa*. The ITS-2 region showed 98% similarity with the Sri Lankan isolate (Accession ID EF196088) whereas it was 96% similarity with *Brugia pahangi* (Accession ID EU373652), 95% similarity with *B. malayi* (Accession ID EU37361) and 96% identity with Onchocerca volvulus (Accession ID AF228572).

Epidemiology of S. digitata infection

The epidemiology of *S. digitata* infection is influenced by the climate and the availability of vectors. This nematode is transmitted via mosquito vectors belonging to the genera *Aedes, Culex,* Anopheles and *Armigeres*. Within 8–10 days following ingestion by mosquitoes, these microfilariae moult twice to develop into infective third-stage larvae (L3 larvae) in the thoracic muscles of the vector. Infected mosquitoes are then capable of transmitting L3 larvae to other susceptible hosts during their blood meals. In the host, the L3 larvae will reach sexual maturity within 8-10 months, thus completing the life cycle.

In our study the intensity of infection with microfilaria of *S. digitata* was higher in older animals than in younger animals, and the prevalence of infection was higher in warmer seasons due to the pronounced activity of mosquitoes. Also, the gender of the host did not show any influence on the occurrence of *S. digitata* infection in Mithun.

1.3 Cestode *infection in Mithun*

Cestode infections are a significant concern in the health and productivity of mithun, affecting

their growth, reproduction, and overall well-being. These parasitic flatworms, belonging to the class Cestoda, include various species that can cause notable clinical and economic impacts. Notably, monieziasis (*Moniezia spp.*), hydatid disease (*Echinococcus granulosus*), and cysticercosis (*Cysticercus tenuicollis*) are among the key cestode infections observed in mithun. Each of these infections presents distinct pathological and clinical features, influencing the health and productivity of the animals in different ways. Understanding these infections is crucial for developing effective control and management strategies.

Monieziasis

In mithun, Moniezia benedeni and M. expansa are frequently observed in both adult animals and calves (Chamuah et al., 2016). The development of cysticercoids occurs within oribatid mites, which is essential for completing the parasite's life cycle. Clinically, infected animals display a range of symptoms, including lethargy, depression, a rough body coat, stunted growth, loss of vitality, the passage of cestode segments in faeces, a pot-bellied appearance, pallor of mucous membranes, reduced weight gain, and constipation. During post-mortem examinations, the small intestine is often filled with Moniezia spp., which severely disrupts nutrient absorption. In calves, pot-bellied appearance and dry skin are common manifestations of infection.

The presence of appropriate intermediate hosts and favourable environmental conditions, such as temperature, humidity, soil pH, and vegetation availability, significantly influence the epidemiology and prevalence of cestode infections in mithun. The highest mean seasonal egg counts are typically seen in animals under one year of age, followed by those aged 1-3 years during winter. In animals older than three years, the level of infection is insignificant.

Although fenbendazole remains the recommended anthelmintic treatment, a well-balanced diet and regular deworming management offer a better and more sustainable control, particularly in calves (Chamuah et al., 2016). Morphological examination identified the cestode as Moniezia benedeni, while PCR amplification of the mitochondrial enzyme Cox1 confirmed the species identification with 100% certainty. To fully understand the epidemiology of cestodes, it is important to consider the completion of the cysticercoid stage in oribatid mites and the environmental factors present in these regions, such as temperature, humidity, soil composition, and available vegetation, which play crucial roles in facilitating the life cycle of the parasite.

Hydatid cyst and its genotyping in Mithun

The genotypic variation of Echinococcus granulosus in livestock across the northeastern states of India is not well documented, despite the high prevalence of this disease in the region's livestock. Additionally, reliable seroepidemiological data for Echinococcus infections in this area remain scarce. To address this gap, we conducted a study focused on genotyping this parasite.

Hydatid cysts caused by E. granulosus are commonly observed during post-mortem examinations in mithun. Furthermore, we identified *E. ortleppi* in two mithuns from Arunachal Pradesh, which holds significant zoonotic potential. Out of 110 animals examined post-mortem, 16 were found to be infected with hydatid cysts. Molecular markers, such as NAD1 and COX1, were employed to genotype *E. granulosus*, confirming its presence in the region (Chamuah et al., 2016).

Between 2010 and 2016, a pathological study was conducted on multiple infected organs in 110 animals. Histopathological examination of hydatid cysts in the liver revealed extensive fibrous connective tissue proliferation along with eosinophilic and lymphocytic infiltration. In contrast, the lung parenchyma exhibited severe emphysema with macrophage and lymphocytic infiltration. These parasites result in significant organ damage, including pressure atrophy in the liver, lungs, spleen, and kidneys. The presence of Echinococcus in mithun populations is likely due to the sharing of a wild sylvatic life cycle involving dogs, foxes, and other wild canids.

Hydatid cysts collected from mithun were genetically characterized using the NADH1 gene and sequence analysis showed 100% homology with *E. granulosus*, while two isolates displayed 99% homology with *E. ortleppi*. A phylogenetic tree was constructed to explore the relationship of these isolates with global Echinococcus species, revealing that four (80%) of the isolates clustered with *E. granulosus* genotypes G1-3, with robust bootstrap support (1000 replicates). In contrast, two isolates (20%) clustered with *E. ortleppi*, representing genotype 5. The NADH1 gene sequences of *E. granulosus* and *E. ortleppi* from mithun isolates were submitted to GenBank under accession numbers KM884826 and KM884827, respectively.

Our study highlights that E. granulosus is a widespread parasite in mithun populations, but E. ortleppi also poses a significant infectious threat in the northeastern region of India. The findings provide the first evidence of E. ortleppi circulation in mithun and suggest the existence of specific mechanisms facilitating the persistence of different Echinococcus species in the

region. Therefore, E. ortleppi should be taken into account during epidemiological surveys of this parasitic infection in domestic ruminants and mithun. As more genetic sequencing data become available, it will contribute to a deeper understanding of the transmission dynamics and epidemiology of Echinococcus species among mithun, domestic livestock, wild canids, and humans in northeastern India.

Cysticercus tenuicollis

We reported for the first time the occurrence of C. *tenuicollis* from the peritoneal cavity of mithun from Itanagar, Arunachal Pradesh. Although C. *tenuicollis* is prevalent in sheep and goats in the north-eastern states of the country, it has not yet been recorded from mithun. Since these animals have been brought from wild habitats, like hydatidosis, *C. tenuicollis* could also be maintained in the sylvatic cycle with wild carnivores as the reservoir hosts.

2. PROTOZOAL INFECTIONS

2.1 Tissue Protozoa:

Coccidiosis is one of the most frequently reported parasitic diseases in mithun, characterized by high morbidity under intensive management conditions (Rajkhowa et al. 2003; Chamuah et al. 2014). The common *Eimeria* species identified in mithun include *E. bovis*, *E. zuernii*, *E. ovoidalis*, *E. bukidonensis*, *E. auburnensis*, *E. ellipsoidalis*, *E. subspherica*, and *E. albamensis*. These infections are facilitated by favorable climatic conditions for oocyst sporulation. Seasonal variation in prevalence is evident, with the highest rates typically observed during the pre-monsoon period.

Coccidial infections are reported across all age groups, but young mithun are particularly susceptible due to their higher pathogenicity. Poor management practices significantly contribute to disease severity. Herds reared under semi-intensive systems, especially in unhygienic environments, show higher incidence rates of eimeriasis compared to animals raised in free-range systems, where the incidence is notably lower.

Toxoplasmosis is another protozoan infection of concern, though clinical cases have not yet been reported in mithun. Serological studies have indicated the presence of *Toxoplasma gondii* antibodies in mithun from Nagaland (Rajkhowa et al. 2008). The prevalence of infection appears to increase with the age of the animals, likely due to prolonged exposure. The close proximity of mithun habitats to human settlements, where domestic cats serve as the definitive

host of *T. gondii*, is thought to facilitate transmission.

Wild canids such as dogs and foxes may also contribute to maintaining a sylvatic infection cycle. Mithun at lower altitudes are more vulnerable to *T. gondii* infections than those at higher altitudes, possibly due to differences in environmental and wildlife interactions. A serological survey of 195 mithun revealed a 4.10% suspicion rate, with 0.51% testing positive for *T. gondii* antibodies (Chamuah et al. 2013b).

Proper management practices, combined with regular health monitoring and serological surveys, are essential to mitigate the impact of protozoan infections such as coccidiosis and toxoplasmosis in mithun populations.

2.2 Blood Protozoa:

A comprehensive study was conducted in Nagaland and Arunachal Pradesh to assess the prevalence of Theileria orientalis, a tick-borne pathogen previously considered benign but now posing significant threats to the livestock industry. PCR screening of 340 Rhipicephalus microplus ticks and 25 Amblyomma sp. ticks revealed that 25 R. microplus ticks were positive for T. orientalis, while none of the Amblyomma ticks tested positive. Among 275 Mithun blood samples from these regions, 31 animals were found to be infected. Phylogenetic analysis confirmed the presence of the highly pathogenic Type 2 (Ikeda) genotype in Mithun, marking the first documentation of oriental theileriosis in the species (Chamuah et al., 2023).

Another blood protozoa, Trypanosoma evansi, a flagellated haemoprotozoan parasite that significantly impacts livestock health and productivity, poses a serious threat to mithun (*Bos frontalis*), a semi-domesticated bovine species indigenous to the hilly regions of India. In a seroprevalence study conducted on 266 mithun, 46 animals (17.29%) tested positive for T. evansi in the hilly regions of Arunachal Pradesh and Nagaland. Regional variations were observed, with one positive case out of 16 samples (6.25%) in Khonoma, 5 out of 29 (17.24%) in Thevopisu, 27 out of 110 (24.55%) in Medziphema, and 13 out of 65 (20%) in Thevopfisu, while no seropositive cases were found in Middle Khomi, Porba, or Tening. Comparison of rearing systems revealed that 19 out of 110 (17.27%) mithun in the free-range system and 27 out of 110 (24.54%) in the semi-intensive system were positive, indicating a lower infection risk in the free-range system. Furthermore, PCR testing of 60 blood samples from Medziphema identified 17 positives (28.33%), although all samples were negative upon blood smear examination. The VetPCRTM T. evansi detection kit identified 9 positive cases out of 50 samples examined in the present investigation.

3. Rickettsial infection:

Anaplasmosis is a vector-borne rickettsial disease affecting ruminants, dogs, and horses, and is caused by Anaplasma spp. Till date, there have been no reports of anaplasmosis in mithun (*Bos frontalis*), a bovine species distributed in Northeast states of India, Bangladesh, Myanmar, and China. In order to elucidate the Anaplasma parasites prevalent in ticks and in the host, mithun, by PCR in the states of Nagaland and Arunachal Pradesh, a total of 340 Rhipicephalus microplus ticks and 25 Ambylomma spp. ticks were screened during the period of 2020-2023. Among the Rhipicephalus microplus ticks, only one tick tested positive for Anapalsma spp. while none of the Ambylomma ticks were found to be infected. Further, blood samples collected from 358 mithun from both Arunachal Pradesh and Nagaland were examined for Anaplasma species. During the investigations, eight animals (2.23%) tested positive for Anaplasma species by PCR. Phylogenetic analysis demonstrated the species present in Mithun as Anaplasma marginale and showed genetic diversity among A. marginale strains. Serological analysis using ELISA showed five out of 42 mithun serum samples were positive for A. marginale antibodies. These findings confirm presence of A. marginale in mithun and highlight the need for effective control measures, including tick management and regular screening. Further, this study provides the first evidence of anaplasmosis in mithun, highlighting the need for further research on surveillance and monitoring to understand the transmission dynamics in Mithun.

4. ECTOPARASITES IN MITHUN

Ticks and leeches are significant ectoparasites affecting mithun, causing direct and indirect economic losses. Ticks inflict injuries, induce tick pyrexia and paralysis, and transmit various pathogens, including bacteria, viruses, and protozoan parasites. The environmental conditions in the northeast region are highly favorable for the survival and reproduction of ectoparasites, leading to poor body condition, reduced growth, and decreased productivity in affected animals.

4.1 Tick infestations

In a seasonal study, the prevalence of *Rhipicephalus microplus* was highest during the summer. Rainfall was identified as a limiting factor influencing tick distribution, highlighting its importance in shaping seasonal variations. Other ectoparasites, such as *Amblyomma testudinarium* and the cattle-sucking louse *Linognathus vituli*, have also been reported in Mithun. Morphological identification confirmed the presence of *Ixodes ovatus* and *I.*

acutitarsus in mithun (Ronghang and Roy 2014, 2016). Additionally, studies have documented the comparative efficacy of plant extracts in controlling *Rhipicephalus (Boophilus) microplus* infestations in mithun (Dutta et al. 2018).

4.2 Leech infestations

Leech infestations are another prevalent challenge for mithun, particularly in free-range systems. Leeches attach to the animal's body surface, nasal cavity, and reproductive organs, secreting anticoagulant substances that prolong bleeding even after detachment. This continuous blood loss, coupled with the quantity of blood consumed by leeches, poses a severe burden on the health and productivity of affected animals. Farmers in the region regard leech infestations as a significant nuisance for both mithun and cattle.

The management of ectoparasites, including ticks and leeches, is critical for improving the health and productivity of mithun. Integrated control strategies, incorporating chemical, biological, and natural plant-based interventions, are essential to mitigate the impact of these parasites effectively.

5. DIAGNOSTICS AND CONTROL MEASURES

5.1 Availability of Diagnostics for Parasitic Diseases

Gastrointestinal parasites in mithun are typically diagnosed through fecal examination and post-mortem analysis, with microscopy serving as the gold standard for identification. These conventional methods provide critical insights into the presence and intensity of parasitic infections. However, advancements in serological techniques, particularly enzyme-linked immunosorbent assay (ELISA), have proven highly effective for sero-surveillance and prevalence studies of gastrointestinal parasites in mithun. ELISA enables the detection of parasite-specific antibodies, aiding in the early diagnosis and monitoring of infections, even when parasite eggs or larvae are not detectable in fecal samples.

In addition to traditional diagnostic methods, molecular markers have become indispensable tools for the accurate identification and differentiation of trematode and cestode species infecting mithun. Markers such as the internal transcribed spacer regions (*ITS-1* and *ITS-2*), 28S ribosomal DNA (*28S rDNA*), mitochondrial NADH dehydrogenase subunit 1 (*nad1*), and cytochrome oxidase subunit 1 (*cox1*) have been extensively employed. These markers not

only confirm species identification but also provide insights into the genetic diversity and phylogenetic relationships of the parasites.

For instance, *ITS-2* has been widely used in the identification of trematode species, including *Fasciola gigantica* and *Schistosoma sp.*, while mitochondrial genes such as *nad1* and *cox1* have been instrumental in genotyping cestodes like *Moniezia sp.* and *Echinococcus sp.* in mithun (Chamuah et al., 2016). These molecular tools allow for high-resolution differentiation of closely related species, which is critical in understanding the epidemiology and transmission dynamics of parasitic infections in mithun.

Furthermore, integrating molecular techniques with traditional diagnostic approaches has facilitated the identification of mixed infections and the tracking of zoonotic parasites like *Echinococcus granulosus* and *E. ortleppi*, highlighting their public health significance in mithun-endemic regions. This combined approach also aids in understanding the role of mithun in the transmission cycles of these parasites, emphasizing the importance of targeted control strategies.

Continued application of molecular and serological diagnostics in mithun parasitology will enhance our understanding of parasite diversity, prevalence, and host-parasite interactions, thereby improving the management and control of parasitic infections in this valuable livestock species.

5.3 Control Programmes for Parasitic Diseases in Mithun

Parasitism poses a significant challenge to improving the production performance of mithun, making effective control measures essential. The primary goal in parasite management is to combine targeted treatment with preventive strategies, considering the animal's health, type of parasitic infestation, and proper drug selection, dosage, and administration route.

Fenbendazole administered at 10 mg/kg body weight has been shown to effectively treat monieziasis in mithun. Similarly, piperazine is the preferred anthelmintic for treating Toxocara vitulorum infections. Piperazine has demonstrated advantages over levamisole and ivermectin due to faster recovery in cases of ascariasis. Albendazole, at a dose of 15 mg/kg body weight, has been well-documented as an effective broad-spectrum anthelmintic for mithun. Ivermectin, given subcutaneously at a dose of 1 ml/50 kg body weight, is highly effective against both endoparasites and ectoparasites, providing a versatile treatment option.

For ectoparasite control, Cypermethrin is routinely applied as a spray to manage Rhipicephalus microplus infestations at mithun farms. Additionally, the comparative efficacy of various plant extracts in controlling Rhipicephalus (Boophilus) microplus infestations has been studied and documented in the northeastern region. This highlights the potential of alternative, plant-based treatments alongside conventional chemical approaches.

Leech infestation is a common and troublesome issue faced by mithun in the north eastern region, causing various health problems and even death. To tackle this problem, a research investigation was conducted to evaluate the efficacy of herbal plant extracts against aquatic leeches. Six plant extracts were tested, and only ethanolic extracts of soapnut and tobacco showed effectiveness against aquatic leeches, with killing times of 6.0±0.40 and 31.5±1.32 minutes, respectively, at a 5% concentration. For land leeches, tobacco extract had an average killing time of 1.5±0.28 minutes, while soapnut extract took 14.25±1.10 minutes at a 5% concentration. Additionally, Litsea grass oil exhibited promising effectiveness against both land and aquatic leeches. These findings have implications for the control and management of leech infestation, providing potential solutions for the future.

A strategic approach to parasite control with regular monitoring, timely treatment, and preventive measures, is crucial for the successful management of parasitic infections in mithun. With proper planning and execution, these measures can significantly reduce parasitic burdens and improve the overall health and productivity of mithun herds.

SUMMARY AND CONCLUSION

Parasitic infections significantly impact the health, productivity, and economic potential of mithun (*Bos frontalis*). This review has provided a comprehensive overview of helminths, protozoa, and ectoparasites affecting mithun, emphasizing their epidemiology, pathology, and control measures.

Helminth infections, including trematodes, gastrointestinal nematodes, and cestodes, are prevalent in mithun across various regions. Trematode infections such as fasciolosis and amphistomiasis are notable for their economic impact, with molecular tools enhancing diagnosis and epidemiological studies. Gastrointestinal nematodiasis caused by species like Mecistocirrus digitatus and Trichuris spp., along with microfilaremia and Setaria infections, remain persistent challenges. Cestode infections, including monieziasis and hydatid disease caused by *Echinococcus granulosus* and *E. ortleppi*, highlight the zoonotic implications of

parasitic infestations in mithun.

Protozoal infections, notably coccidiosis and Toxoplasma gondii seroprevalence, underline the role of environmental and management factors in disease spread. Seasonal and age-related variation in these infections suggests the need for targeted interventions to mitigate their impact.

Ectoparasites, including ticks such as Rhipicephalus microplus and Ixodes ovatus, and blood-sucking leeches, are influenced by environmental factors, with infestations peaking during favorable climatic conditions. Their direct effects, combined with their role in transmitting pathogens, further exacerbate health and productivity losses.

Future research should prioritize the development and application of advanced diagnostic tools, particularly molecular techniques, for precise identification and epidemiological tracking of parasitic species in mithun. Integrated parasite management strategies need to be emphasized, combining chemical treatments with natural remedies and improved husbandry practices to ensure sustainable control measures. Seasonal studies are essential to understand the temporal dynamics of parasitic infestations, enabling the optimization of intervention timing for maximum effectiveness. Given the zoonotic implications of certain helminths and protozoa, focused research on their transmission pathways and public health risks is crucial to safeguard both animal and human health. Additionally, exploring the influence of climate change and regional husbandry practices on parasite prevalence will aid in developing targeted and region-specific management plans. Addressing these areas will enhance the overall health, productivity, and sustainability of mithun farming systems.

References: Available on request

FOOT AND MOUTH DISEASE IN MITHUN: STATUS, CONTROL AND CHALLENGES

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INTRODUCTION

Foot-and-mouth disease is one of the viral diseases of livestock affecting all the cloven-hoofed animals. It is caused by the Aphthovirus of the Picornaviridae family. The disease is usually not fatal in adult animals, but there is often high mortality in young animals due to myocarditis. The virus is quasispecies in nature and undergoes rapid mutation. There are seven antigenically and genetically distinct serotypes viz. A, O, C, SAT1, SAT2, SAT3, and Asia1; and they do not show cross-protection in vaccinated animals. In India, FMDV O, A, and Asia1 serotypes are reported and antigenically matched strains of all the three serotypes are mandatorily included in the commercial vaccine formulation. The genome is a linear positive-sense single-stranded RNA measuring about 8.5 kb in size encoding four structural proteins (VP1-4) and varying numbers of non-structural proteins (NSPs).

MODE OF TRANSMISSION

The FMD virus (FMDV) is shed in all secretions and excretion from infected animals. Transmission can be either direct or indirect contacts between susceptible and infected animals. The FMDV can be introduced to healthy animals through any of the following points-

- Through contact with clinically affected animals.
- Through contaminated inanimate vectors such as vehicles, fodders, utensils, equipments etc.,
- Through air. Infected animals can secrete large amount of aerosol virus through exhaled air, which can infect other animals via the respiratory or oral routes. The virus can travel up to 60 km overland and 300 km by sea.
- All secretions and excretions from the infected animal such as saliva, faeces and urine.
- The virus may be present in milk and semen for up to 4 days before clinical signs appear.

- The disease has been transmitted to calves via infected milk.
- Through animal handlers, visitors and physicians.
- Recovered animals can remain as a carrier following infection. Carrier may transfer the virus from one animal to another. Carrier cattle may harbor the virus in the esophageal-pharyngeal fluid for 6-24 months.

CLINICAL SIGNS

In Mithun, the clinical signs and symptoms are more or less the same as in cattle and other livestock, however, there are reports that shows higher morbidity and mortality in case of Mithun reared in free range system. The severity of clinical signs will depend on the strain of virus, the exposure dose, the age and species of animal and the host immunity. Morbidity can reach 100% in susceptible populations. Mortality is generally low in adult animals (1–5%), but higher in young calves, lambs and piglets (20% or higher). The incubation period is 2–14 days. Clinical signs can range from mild or in-apparent to severe: they are more severe in cattle and intensively reared pigs than in sheep and goats. Common signs observed in acute infection are:

- High fever up to 104-106˚F (41˚C) and anorexia.
- Profuse salivation (saliva hanging in long ropy strings up to the ground).
- Vesicles in feet and wounds in the interdigital space of legs followed by lameness.
- Oral ulcers and lesions.
- Smacking of lips.
- Vesicles in the mammary gland

As the disease advances, rupturing of blisters can result in extreme lameness and reluctance to move or eat. Usually, blisters heal within 7 days (sometimes longer), but complications, such as secondary bacterial infection of open blisters can occur if proper care is not taken. In young animals, death can occur before development of blisters due to a multifocal myocarditis. Recovered animals may have complications like weight loss, growth retardation and a drop in milk production.

FMD CONTROL PROGRAMME IN INDIA

India is enzootic for foot-and-mouth disease (FMD) and economic losses due to the disease are more than ₹200 billion/annum. Currently, India is in stage three of the progressive control

pathway for control of FMD and aims to achieve FMD-free status with vaccination by 2030. The success of the FMD control program not only depends on the biannual vaccination of 500 million susceptible livestock such as cattle, sheep, goat, pig, buffalo, yak, mithun, and other wildlife, but also depends on effective sero-surveillance.

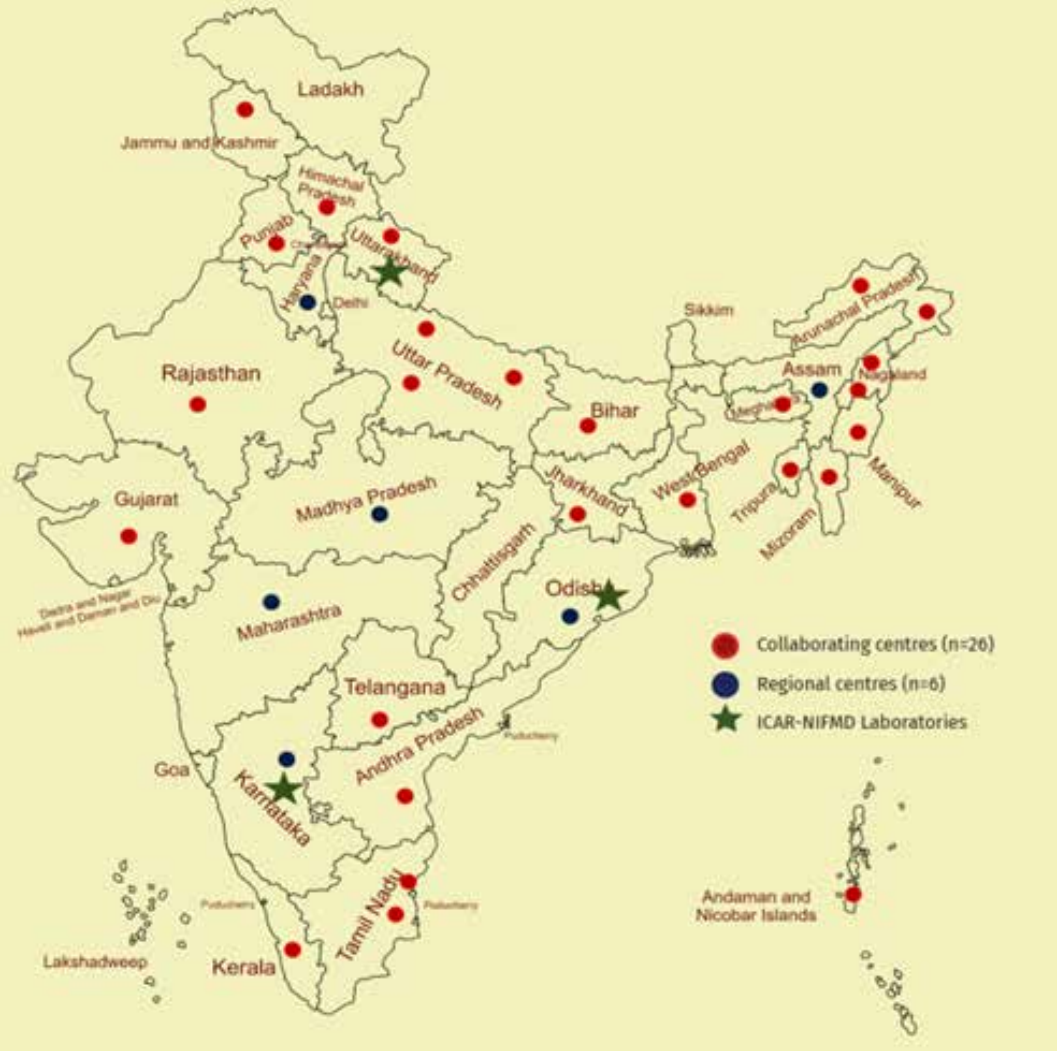


Figure 1. Map showing FMD control network (DFMD annual report 2022)

The flagship FMD control programme in India started in the year 2003 covering 54 districts. The programme then gradually expanded and further, NADCP was launch in the year 2019. Currently, there are 26 collaborating centers, 6 Regional Centers and ICAR-NIFMD laboratories under the FMD control programme engaging in seromonitoring and surveillance of FMD in the country. The programme covers many other important activities for effective control of the disease including disease diagnosis, development of diagnostic kits, vaccine matching, cataloguing of virus strains, vaccine quality control, disease epidemiology etc. Due to the non-stop and active vaccination campaign coupled with serosurveillance/seromonitoring under the programme, the disease occurrence and severity in India has been gradually reduced.

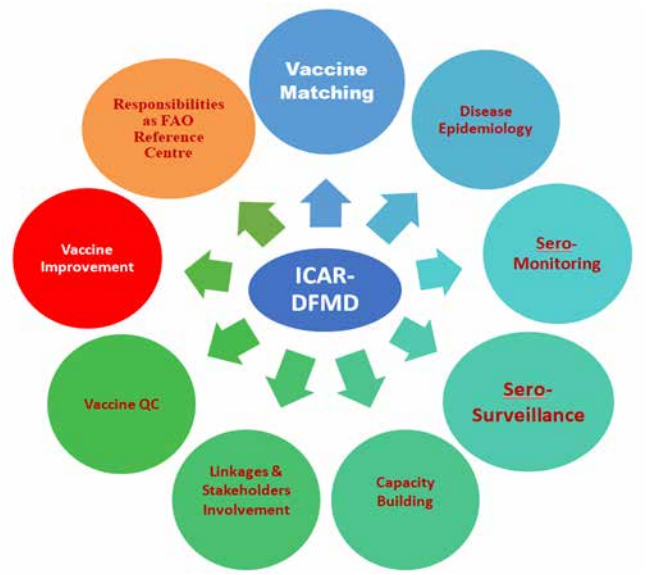


Figure 2. Activities under FMD Control program

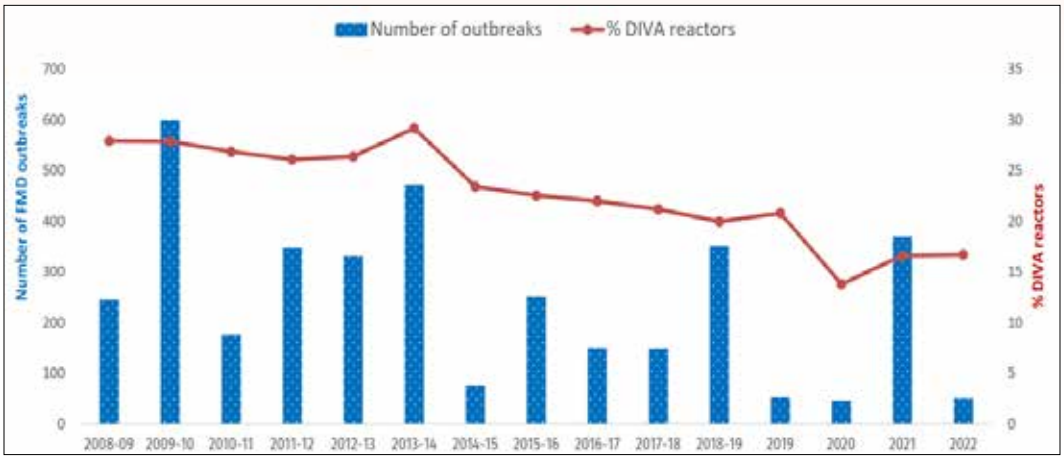


Figure 3. Trend of FMD outbreak and DIVA reactivity (DFMD Annual report 2022)

PREVENTIVE MEASURES

In FMD endemic countries like India, vaccination is the foremost action to prevent the occurrence of FMD. Bi-annual vaccination with inactivated trivalent vaccine is being followed. Routine vaccination of animals with proper dose is important to maintain herd immunity. Young animals should be vaccinated at 3 months followed by booster dose at 30 days after first vaccination. Then it should be repeated every 6 months interval. Following points must be followed for effective control of FMD:

- Vaccination of the entire animal in farm/village.
- Routine monitoring of health and veterinary care.
- In case of FMD outbreak, ring vaccination may be followed to prevent further spread of the disease in and around the area.
- Healthy and preferably routinely vaccinated animals should be brought into the village from outside sources that too only 15-21 days following vaccination.
- Avoid purchase of animals from disease prevailing areas.
- New animals should not be purchased until six months following outbreak.

- Strict quarantine measures for newly purchased animals.
- A foot bath or truck bath may be made at the entrance of the village/farm.
- Avoid community grazing during outbreak.

Figure 4. FMD Vaccine and vaccination of Mithun

CONTROL MEASURES

In case of outbreak of FMD, care must be taken to control and prevent the virus circulation to the healthy herds. Implementation of good sanitary measures and hygienic practices are important to check the dissemination of the virus to the surroundings and nearby places. Following measures are to be considered to prevent the spread of disease-

- Proper biosecurity measures should be in place at farm level-
- Control of people's movement in and around livestock and equipment

Controlled introduction of new animals into existing herds

- Proper cleaning and disinfection of livestock pens, buildings, vehicles and equipment
- Appropriate disposal of manure and dead carcasses
- Foot bath should be made at the entrance of the farm.
- Isolation and confinement of affected animals immediately after detection of clinical symptoms and restriction of animal movements.
- Infected animals should not be allowed to graze in common grazing pasture.

- Affected animals should not be allowed to drink water from ponds/streams/ rivers etc.
- Diseased animals should not be allowed to roam about with other animals of the village.
- Movement of animal handlers and attendants who attended diseased animals should be restricted to the other animal population / farms. If it is not practicable, people should scrub themselves and their belongings with soap and caustic soda.
- Calves should not be allowed to suckle affected mothers and they should not be fed with milk from affected animals.
- Mouth of the affected animals may be washed with antiseptic mouth wash. Potassium permanganate ($KMnO_4$) solution may be applied 3-4 times a day.
- Feet of the affected animals may be washed with 2% copper sulphate solution. Antiseptic lotion and fly repellents are to be used to avoid infection and maggot formation on the wound.
- Proper disinfection of the farm premises.
- Surveillance and monitoring in compliance with the State/National norms.
- Reporting of any suspected disease to the local authority/veterinary department.

CHALLENGES

Although the reduction of FMD outbreaks and virus circulation due to the stringent FMD control in India is evident in the last two decades, the goal of being a FMD free status is still at the horizon. Many factors are involved for this matter which may include the vast geographical area of India, in which many parts of the area are under developed and lack proper communication as well. The huge number of livestock in the country and stray animals could also be a contributing factor in recurrent virus circulation. The occurrence of multiple serotypes and variants of the virus and a wide host range make controlling a huge task in order to stop the virus circulation. Lack of awareness by the general public on the importance of vaccination and control of disease is also an important factor. Besides, the following points may directly or indirectly contributed to the problems-

- Emergence and re-emergence of genetic/antigenic variants of the FMD virus continuously occurring in the nature
- Porous international borders
- Lack of zoo-sanitary and bio-security measures at outbreak sites
- Climate change and animal movement

- Under reporting and poor emergency response to the disease
- Inadequate quantity and quality vaccine for FMD control in the country
- Unrestricted animal movement and presence of stray livestock in several parts of the country

CONCLUSION

FMD is one of the most important livestock diseases that cause a huge economic lost to the country. Although a strong network of control programme is in place, further strengthening of the surveillance system and more vaccine coverage is required to effectively control the virus circulation and the outbreaks. Better and more efficient vaccine, robust monitoring and reporting system will enhance the control strategy. Awareness and active participation of all the stakeholders is required to achieve the goal of FMD free country.

References: Available on request

GALLERY

ICAR-KVK Phek, Porba officially launched the Viksit Krishi Sankalp Abhiyan (VKSA) on 29th May 2025 at the Phek Town Council Hall. The national initiative, led by Hon'ble Union Minister Shri Shivraj Singh Chauhan, aims to empower farmers through awareness on improved technologies, new crop varieties, government schemes, and farmer-led innovations.

Dr. Sanjeev Kumar Singh, Head, KVK Phek, welcomed participants and highlighted the objectives of VKSA.

Chief Guest, Dr. Neisatuo Mero, Hon'ble MLA, 16-Pfutsero AC, Phek, formally launched the programme and stressed the need for sustainable agriculture, technology transfer, and collaboration among stakeholders.

Guest of Honour, Mr. Rhosietho Nguori, Deputy Commissioner, Phek, praised ICAR-KVK Phek for promoting science-led farming and emphasized grassroots-level farmer participation in agricultural development.

Highlights of the event:

- Launch of 11 farmer-friendly publications in local language
- Insights from scientists, officials, and farmer representatives
- Flagging off of VKSA Yatra to cover 106 villages in Phek and Meluri till 12th June 2025
- Strong support from district administration and farming community

The programme was moderated by Dr. T. Esther Longkumer, CTO, KVK Phek, and concluded with a vote of thanks by Dr. Narendra, Scientist (Agricultural Extension), ICAR-NRC on Mithun, Medziphema.

On first day 29th May, 2025 Team KVK Phek for Viksit Krishi Sankalp Abhiyan Campaign visited 9 villages by 3 teams. The villages covered are as below:

1. Phek Basa 2. Phek town 3. Phek Village 4. Porba 5. Wibo Porba

6. Pholami 7. Upper khomi 8. Middle khomi 9. Lower khomi

Team KVK Phek on second day i.e 30th May, 2025 for Viksit Krishi Sankalp Abhiyan Campaign visited 9 villages by 3 teams. The villages covered are as below:

1. Sakraba town
2. Sakraba village
3. Gidemi village
4. Losami
5. Losatephe
6. Lanyezo
7. Lozaphuhu
8. Tezatsu
9. Kizari







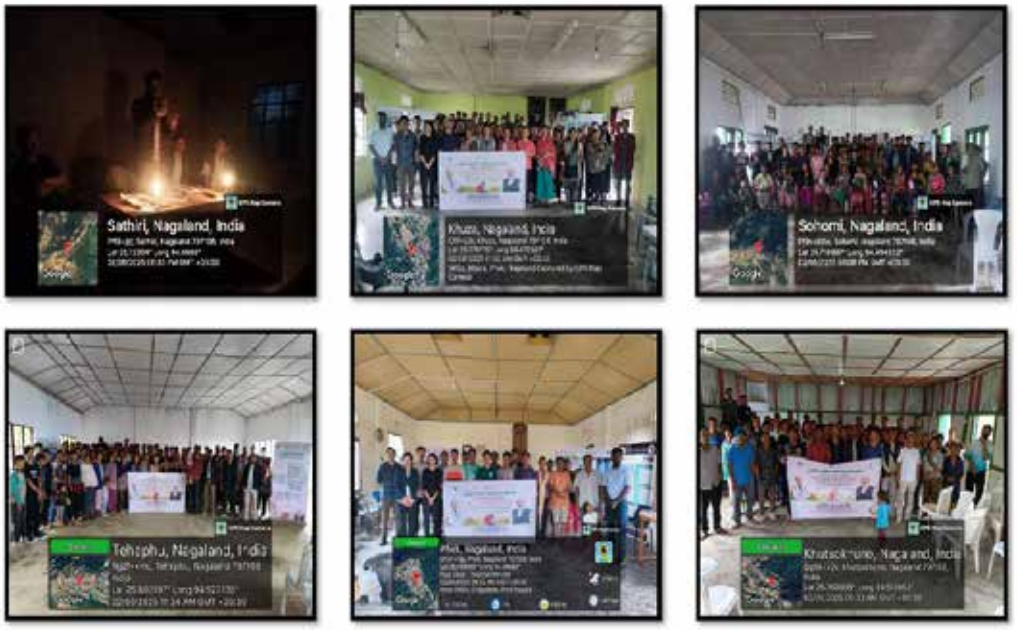

Team KVK Phek on third day i.e 31st May, 2025 for Viksit Krishi Sankalp Abhiyan Campaign visited 9 villages by 3 teams. The villages covered are as below:

1. Pfutseromi 2. Lekromi 3. Kami 4. Lasumi 5. Zapami 6. Kade

7. Khezhakeno 8. Leshemi 9. Lewoza

Team KVK Phek on forth day i.e. on 2nd June, 2025 for Viksit Krishi Sankalp Abhiyan Campaign visited 9 villages by 3 teams. The villages covered are as below:

1. Chepoketa	2. Khuza	3. Metsale	4. Khutsokhono	5. Tehephu
6. Suthotsu	7. Satheri	8. Sohomi	9. Kotisu	



Team KVK Phek on fifth day i.e. on 3rd June, 2025 for Viksit Krishi Sankalp Abhiyan Campaign visited 9 villages by 3 teams. The villages covered are as below:

1. Enhulumi 2. Mesulumi 3. Thetsumi 4. Razeba 5. Zhavame

6. Zelome 7. Chizami village 8. Chizami town 9. Sumi

Team KVK Phek on sixth day i.e. on 4th June, 2025 for Viksit Krishi Sankalp Abhiyan Campaign visited 9 villages by 3 teams. The villages covered are as below:

1. North Kikruma	2. Kikruma village	3. Pfutsero	4. Thipuzu
5. Rihuba	6. Phuyoba	7. Khulazu bawe	8. Khulazu basa
9. Chesezu			

Team KVK Phek on sixth day i.e. on 5th June, 2025 for Viksit Krishi Sankalp Abhiyan Campaign visited 9 villages by 3 teams. The villages covered are as below:

1. Chatheba
2. Chozuba village
3. Chozu Basa
4. Runguzu Nasa
5. Runguzu Nawe
6. Thuvopisu
7. Chozuba town
8. Yoruba
9. Suthozu Nasa

Team KVK Phek on eight day i.e. on 6th June, 2025 for Viksit Krishi Sankalp Abhiyan Campaign visited 9 villages by 3 teams. The villages covered are as below:

1. Dzulha	2. Khutsa	3. Thurutsuswu	4. Ruzazhu	5. Ruzazhu
6. Sekruzu	7. Khusomi	8. Suthozu	9. Phugi	

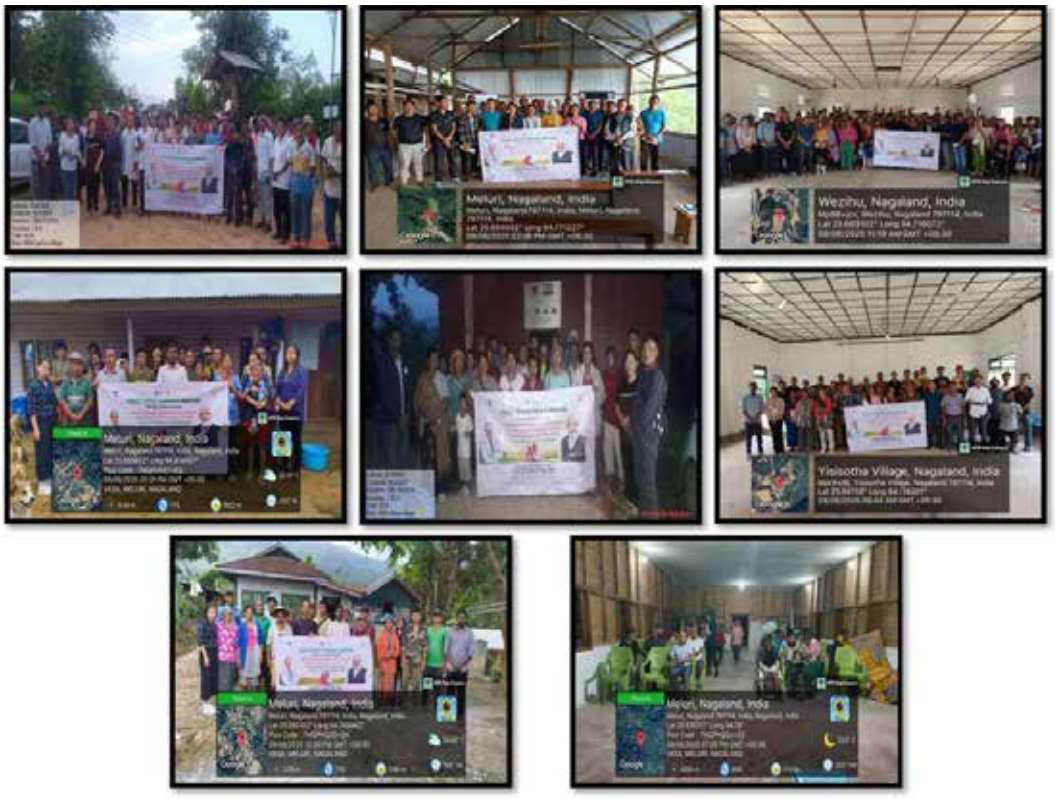
On **7th May 2025**, ICAR-KVK Phek, in collaboration with ICAR-NRC on Mithun, Medziphema, conducted a **VKSA outreach programme** at Middle Khel Porba village.

Dr. Girish Patel S., Director, ICAR-NRCM, interacted with farmers, addressed field-level challenges, and discussed solutions. Dr. Sanjeev Kumar Singh, Head, KVK Phek, outlined VKSA objectives and ongoing activities. Scientists shared technologies on crops, livestock, and Mithun farming, while farmers actively engaged in discussions on jhum cultivation and animal management.

Information materials in local language were distributed, with emphasis on organic practices, government schemes, and sustainable Mithun farming. The programme reinforced the integration of traditional knowledge with modern science for rural livelihood improvement in Nagaland.

On the eleventh day of the Viksit Krishi Sankalp Abhiyan campaign, i.e. 9th June 2025, Team ICAR-KVK Phek visited nine villages under Meluri district through three dedicated teams. The villages covered are as follows:

1. Akhen	2. Reguri	3. Lephori	4. Old Thewati	5. New Thewati
6. Lutsam	7. Yesisota	8. Weziho	9. Mokie	



Team KVK Phek on twelveth day i.e. on 10th June, 2025 for Viksit Krishi Sankalp Abhiyan Campaign visited 9 villages by 3 teams. The villages covered are as below:

1. Kanjang 2. Matikhru 3. Khumiasu 4. Pokhungri 5. Avankhung

6. Washelo 7. Zhipu 8. Wuzu 9. Hutsu

Team KVK Phek on thirteenth day i.e. on 11th June, 2025 for Viksit Krishi Sankalp Abhiyan Campaign visited 11 villages by 3 teams. The villages covered are as below:

1. Khukegwo	2. Akhegwo	3. New Akhegwo	4. Laruri	5. Shutsu
6. Shatuza	7. Meluri	8. Phor	9. New Phor	10. Kuzatu
11. Yisi				

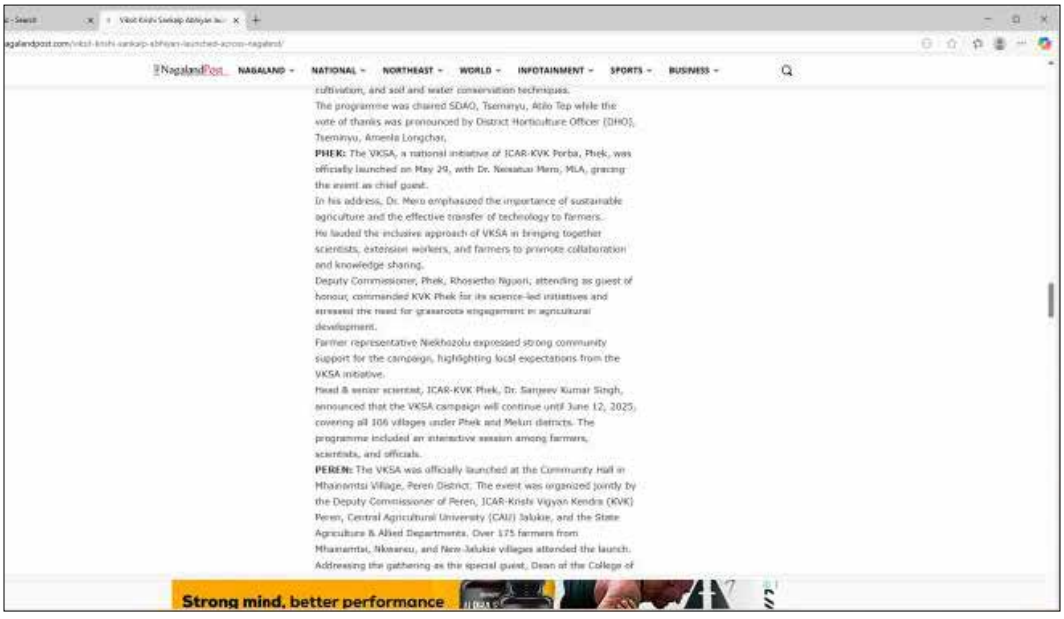
Team KVK Phek on forteenth day i.e. on 12th June, 2025 for Viksit Krishi Sankalp Abhiyan Campaign visited 7 villages by 3 teams. The villages covered are as below:

1. Phusachodu 2. Thenyizu 3. Chesezu Nasa 4. Chosaba 5. Surhoba

6. Kutsapo 7. Chobama

Published in Nagaland post on 30th May, 2025

News Clippings



NagalandPost NAGALAND ▾ NATIONAL ▾ NORTHEAST ▾ WORLD ▾ INFOTAINMENT ▾ SPORTS ▾ BUSINESS ▾

cultivation, and soil and water conservation techniques.

The programme was chaired SDAO, Tsemenyu, Atiko Tep while the vote of thanks was pronounced by District Horticulture Officer (DHO), Tsemenyu, Ameela Longchar.

PHEK: The VKSA, a national initiative of ICAR-KVK Porba, Phek, was officially launched on May 29, with Dr. Neiwatsu Mero, MLA, gracing the event as chief guest.

In his address, Dr. Mero emphasized the importance of sustainable agriculture and the effective transfer of technology to farmers.

He lauded the inclusive approach of VKSA in bringing together scientists, extension workers, and farmers to promote collaboration and knowledge sharing.

Deputy Commissioner, Phek, Rhosietho Nguoti, attending as guest of honour, commended KVK Phek for its science-led initiatives and stressed the need for grassroots engagement in agricultural development.

Farmer representative Niekhozolu expressed strong community support for the campaign, highlighting local expectations from the VKSA initiative.

Head & senior scientist, ICAR-KVK Phek, Dr. Sanjeev Kumar Singh, announced that the VKSA campaign will continue until June 12, 2025, covering all 106 villages under Phek and Meluri districts. The programme included an interactive session among farmers, scientists, and officials.

PEREN: The VKSA was officially launched at the Community Hall in Mhainamtsi Village, Peren District. The event was organized jointly by the Deputy Commissioner of Peren, ICAR-Krishi Vigyan Kendra (KVK) Peren, Central Agricultural University (CAU) Jalukie, and the State Agriculture & Allied Departments. Over 175 farmers from Mhainamtsi, Nkwareu, and New Jalukie villages attended the launch.

Addressing the gathering as the special guest, Dean of the College of

7 June 2025 MT

PDF reader

KVK Phek intensifies outreach program under VKSA across Phek, Meluri

■ MTNews
■ Kohima | 6 June

In alignment with the national effort to bolster Indian agriculture, Krishi Vigyan Kendra (KVK) Phek (ICAR-NRC on Mithun, Medziphema), under the aegis of ICAR-ATARI Zone VII, Umiam, has initiated an intensive awareness and outreach programme under the *Viksit Krishi Sankalp Abhiyan (VKSA)*. Conducted in collaboration with various line departments and scientists from SAS Medziphema, the campaign is being carried out from May 29 to June 12, reaching remote and ecologically sensitive villages in Phek and Meluri districts.

Launched nationally on May 29, 2025, by Union Agriculture and Farmers' Welfare Minister Shivraj Singh Chauhan, the campaign aims to mobilize rural farming communities toward sustainable, low-input agricultural practices.

With a core focus on Natural Farming (NF), VKSA promotes climate-resilient agriculture, nutritional security, and indigenous crop varieties. KVK Phek has been reaching some of the most inaccessible and underserved villages, overcoming monsoon challenges and poor road conditions. Field teams comprising agricultural scientists, extension workers, and technical staff have been engaging directly with farmers, local leaders, and community institutions across the districts.

As of June 6, the campaign had successfully covered 72 villages in Phek district. Each village visit featured awareness sessions and interactive farmer group discussions addressing topics such as Natural Farming practices, ecological benefits of traditional landraces, soil health management, use of bio-inputs, government schemes for farmers, and the role of indigenous knowledge in ensuring food and nutritional security.

The initiative emphasized the importance of region-specific, ecologically sound, and culturally relevant farming models. Farmers were encouraged to share personal experiences, innovative practices, and the challenges they face. This exchange fostered mutual learning and strengthened trust between the scientific community and local stakeholders.

Dr Sanjeev Kumar Singh, Head of KVK Phek, reported positive community feedback:

"Despite the difficult access, people are eager to learn and adopt methods that are both traditional and scientifically sound. This campaign is not just about awareness; it's about co-developing solutions for sustainable agriculture rooted in local realities," he said.

KVK Phek intends to expand the campaign in the coming weeks, with a continued emphasis on climate-resilient farming, youth involvement, and enhancing women's participation in local food systems.

2/8

Published in Eastern Mirror on 7th June 2025

News Clippings

Eastern Mirror J...
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4 | STATE

Viksit Krishi Sankalp Abhiyan gains momentum in Phek, Meluri

Participants and dignitaries during an outreach programme in Sakesil village, Phek district.

Kohima, June 6 (EMN): In alignment with the nationwide campaign to strengthen Indian agriculture, Krishi Vigyan Kendra (KVK) Phek (ICAR-NRC on Mithun, Medziphema), under ICAR-ATARI Zone VII, Umiam, launched an intensive awareness and outreach initiative under the Viksit Krishi Sankalp Abhiyan (VKSA), covering remote and ecologically sensitive villages across Phek and Meluri districts.

The campaign, from May 29 to June 12, is held in collaboration with the line departments and scientists from School of Agricultural Sciences (SAS), Medziphema.

The campaign was officially launched at the national level on May 29 by the Union Minister of Agriculture and Farmers' Welfare, Shivraj Singh Chauhan, with the aim of mobilising rural farming communities to adopt sustainable, low-input agricultural practices, an update from KVK Phek stated.

The campaign focuses on empowering farmers with knowledge of natural farming, enhancing climate resilience, improving nutritional security and promoting the use of indigenous crop varieties.

It stated that KVK Phek has taken the campaign to the grassroots, reaching some of the most remote and difficult-to-access villages in the district despite challenging terrain, poor road infrastructure and the early onset of the monsoon.

Field teams consisting of agricultural scientists, technical staff and extension workers have been travelling across the hilly terrain to directly interact with farming households, village leaders and local institutions.

As of June 6, the campaign has successfully covered 72 villages under Phek district.

During each village visit, the KVK team conducted awareness programmes and farmer group discussions on key topics such as principles and practices of natural farming, use of traditional landraces for ecological sustainability, soil health management and bio-inputs, government schemes for farmer welfare and agricultural development, importance of indigenous knowledge systems in enhancing food and nutritional security.

The campaign highlighted the need for region-specific farming models that are both ecologically sustainable and culturally appropriate. Farmers were also encouraged to share their own experiences, local innovations and challenges faced in agriculture. It mentioned that the initiative helped foster mutual learning between scientists and the community, while building trust and opening pathways for further collaboration.

Dr. Sanjeev Kumar Singh, head of KVK Phek, informed that the response from farmers has been highly encouraging. He stated that despite the difficult access, people were eager to learn and adopt methods that are both traditional and scientifically sound.

Input added that KVK Phek plans to continue the campaign in other villages in the coming weeks, deepening engagement and facilitating connections between farmers, research bodies and government programmes.

Special emphasis would be placed on promoting climate-resilient farming practices, encouraging youth participation in agriculture and strengthening women's roles in local food systems.

Phek, Meluri nu VKSA khro kekhruohi mhatho chü petokezhü

Kohima, Cadi 6: Seyie peteu nu Indiamia liecielierhie chükehieketuo rüsieu ruduo di Krishi Vigyan Kendra (KVK) Phek (ICAR–NRC on Mithun, Medziphema)-e ICAR-ATARI Zone VII, Umiam khronu line department-ko mu SAS Medziphema nu scientist ze kedzieduo di Viksit Krishi Sankalp Abhiyan (VKSA) khronu Cacü zha 29 nu vo Cadi zha 12 ketso Phek mu Meluri district peteu nu kepetse mu u khieümhou lhenu teiu la keviko gei kemichie kenyi rünako bo di zhapukechü mu kekhruohi mharhüko se mhachü petokezhü pushüte.

Seyie thu nu rüsieu Cacü zha 29 nhie Union Agriculture and Farmers' Welfare Kilonser Shivraj Singh Chauhan bu thezho nu seüde mhatho chishü.

Rüsieu nu lhenu mhalei Natural Farming (NF), teila perhiepfü thalieketuo, uva kepevi vieko biepekrakelie mu khenu mhalei kekreikecü pelhoukecüu biekemeyielie ketuo mhasi pie liecieniako thau chükeheieketuo penou di mhachükezhü pushü.

KVK Phek-e tsu puotha kerünuotho nunu rüsieu se mhachü di thechü puola kesuo, kemewikecü cha kesuo mu metsü teirüu sede di puokere seüjükecü donu rei district nu kepetsetho mu vo tsolie keretho rüna kropuo nu vokezhü pushü.

Agricultural scientist-mia, technical staff mu mhatho dze kesithomia sa keba Field team-ko thechü puolakesuoko pfüthe di rüvechü vo mezhü liecieniako kikruko, rüna krütamiako mu khenu krotho ze kerüchükecü chükezhü pushü.

Cadi zha 6 nhie ketso rüsieu se Phek district khrokeba rüna 72 bolie baketa pushü. Rüna puocü nu vokecü teiu nu KVK team-e zhapukechü mhathochieko mu liecieniza ze krotse rüchuko peba di cayie kemeyie, lhenu mhalei 'Natural Farming' gei puokeviko mu mhathoko, u tsiako pelhoukelie, rünyo thau mezakelie, liecieniza zhachü mu liecielierhie thau chükehieleketuo la sorkari kekhruohi mhathochie, kecüca mu uva kepevi ca biepekrakecü nu khenumia mhatho dorhü kemeyie kenbiekoselezakeshüchüba.

Rüsieu geinu nhamenyie mu nhachü nhara meza se bakelie mu mechü kelhou thau la puotoukecü kenuese la teibou nu liecie mhatho do rükrükecü semorokesuo cako se kezakeshü chü ba. Süsierei liecieniako bu u thuo chü mu ze kese kevorko geinu sikeleko, khenu mharhü kesako mu liecielierhie nu puokere seüjü kebako se kezakecü chü ba.

Mhatho hau geinu scientist-mia nu krotho donu mhasi keza, huoniehuo gei kepele penyilie mu kedzieduo di mhachü sa voketuo chako khrishulie bu mu liecieniako kenu kelakeshüko si di u hü selie bakecü Dr. Sanjeev Kumar Singh (Head of KVK Phek) kitsanu pushü.

Pfhülie kere donu rei themiako tsiepfamia mhathoko mu tsiedo dorhü kesa se mhachükecü kenuese nu mhatho dorhüko si mu se mhachü nyi se bakecü ngakelie pushü. Rüsieu zhapukechü puo rübes mo, derei keze di khenu sierkebako ze kepero di liecielierhie mezalieketuo la puochako pfhülie bakecü pushü.

KVK Phek-e vorketuo zhadoudoko rüsieu se rünako bo sa di liecieniako, mhasa-kepfhümiako mu sorkari mhathochieko donu kepero mu keze di mhachükecüu biekerüü salieketuo rhükeba pushü.

Rüsie keshako nu teila perhiepfü thalie kevi liecie mhathoko biekemeyie, khrieuakemia hüpie liecielierhie nu kepekrokelie mu khenu kecüca kechü thoko nu thenumapfü mhatho chükemetes salieketuo penou di mhachü voketuo KVK Phek kitsanu pushü.

MT MOKOKCHUNG TIMES 7

KVK Phek reaches over 9,000 farmers across Phek and Meluri districts

■ MT News
■ Mokokchung | 12 June

In a concerted effort to strengthen the agricultural foundation of Nagaland, Krishi Vigyan Kendra (KVK) Phek (ICAR-NRC on Mithun, Medziphema), under ICAR-ATARI Zone VII, Umiam, in collaboration with scientists from ICAR-NRC on Mithun, line departments, and SAS Medziphema, successfully concluded an intensive awareness campaign under the Viksit Krishi Sankalp Abhiyan. Conducted from 29th May to 12th June 2025, the campaign reached 110 villages across the remote and ecologically sensitive districts of Phek and Meluri, engaging a total of 9,180 farmers—5,546 men and 3,634 women.

Launched nationwide by the Union Minister of Agriculture and Farmers' Welfare, Shri Shivraj Singh Chauhan, on 29th May 2025, the campaign aimed to transform rural agriculture through the promotion of Natural Farming (NF), climate-resilient methods, nutritional security, and indigenous crop varieties.

KVK Phek field teams, composed of agricultural scientists, technical staff, and extension workers, overcame difficult terrain, poor road conditions, and early monsoon weather to connect directly with farming communities. They facilitated awareness programmes, farmer group discussions, and interactive sessions focused on the principles of Natural Farming, the importance of traditional crops for ecological sustainability, soil health and bio-input use, available government schemes, and the relevance of indigenous knowledge systems to food and nutrition security.

The campaign promoted region-specific, culturally relevant, and sustainable agricultural models, encouraging farmers to share their innovations, challenges, and success stories. This participatory approach fostered mutual learning and deepened trust between communities and scientists.

Reflecting on the campaign, Dr. Sanjeev Kumar Singh, Head of KVK Phek, said, "The overwhelming response from farmers, especially in such remote regions, speaks volumes about their readiness to adopt both traditional and scientifically validated practices. The campaign was more than just awareness—it became a platform for co-creating context-based, sustainable solutions for our agricultural challenges."

KVK Phek now plans to extend its outreach to more villages, with a continued focus on engaging farmers, involving youth, promoting women-led food systems, and building stronger links between research and community. The Viksit Krishi Sankalp Abhiyan has emerged as a vital step towards a resilient, self-reliant, and sustainable agricultural future for Nagaland.

VKSA concludes; farmers raise key issues

DIMAPUR: Viksit Krishi Sankalp Abhiyan (VKSA) campaign wrapped up in Mokokchung and Phek districts after a focused effort to improve farming practices and address concerns raised by local farmers.

In Mokokchung, the campaign, led by Krishi Vigyan Kendra (KVK) Mokokchung in collaboration with ICAR scientists and district agriculture officials, reached 96.59% of villages and engaged over 7,000 farmers, self-help groups, and rural youth. The sessions covered topics like sustainable agriculture, soil health, climate-resilient farming, resource conservation, livestock health, integrated farming, and natural farming. Experts conducted hands-on demonstrations and provided tailored guidance to meet local farming needs.

At the closing ceremony, Senior Scientist and Head of KVK Mokokchung, Dr. Keviletsu Khate, praised the farmers' active participation and noted that the campaign was not only about providing information but also about understanding their challenges.

Farmers highlighted several concerns, including difficulties in accessing quality seeds and planting materials on time, poor market linkages affecting the sale of perishable products, and the lack of irrigation infrastructure, with most relying on seasonal rainfall. Many requested the government to improve minor irrigation facilities and water conservation systems for year-round farming.

While awareness about government schemes has improved, procedural delays and unclear communication at the grassroots level still prevent many farmers from accessing benefits. Farmers expressed the need for more practical training sessions in organic farming, pest and disease control, composting, and scientific crop management.

The campaign fostered valuable knowledge-sharing between farmers and scientists, with experts recognizing local innovations and research gaps that could shape future agricultural policies. Organizers stressed the importance of better coordination between government departments and farmers to ensure effective implementation of agricultural schemes.

Meanwhile, in Phek and Meluri districts, KVK Phek, under ICAR-NRC on Mithun, Medziphema, carried out an intensive outreach campaign from May 29 to June 12, reaching 110 villages and more than 9,300 farmers.

Despite tough terrain, poor road conditions, and early monsoon disruptions, agricultural scientists and extension workers engaged directly with communities through awareness programs, farmer discussions, and interactive learning sessions.

The campaign focused on natural farming, traditional crops, soil health, bio-inputs, government schemes for farmer welfare, and indigenous knowledge systems to enhance food security. Farmers shared local innovations, success stories, and challenges, strengthening trust between scientists and the community. Dr. Sanjeev Kumar Singh, Head of KVK Phek, stated that the overwhelming response from farmers reflects their readiness to adopt both traditional and scientific farming methods. He emphasized that the campaign was not just about awareness but also about co-creating sustainable solutions for agricultural challenges.

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Kohima, [illegible]: Nagaland [illegible] Krishi Vigyan Kendra (KVK) Phek (ICAR–NRC on Mithun, Medziphema) [illegible] ICAR-ATARI Zone VII, Umiam [illegible] ICAR-NRC on Mithun, Medziphema [illegible] scientist [illegible] department [illegible] SAS, Medziphema [illegible] scientist [illegible] Viksit Krishi Sankalp Abhiyan [illegible]

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5.	Dr. Hannah K Asangla	Chief Technical Officer (Agronomy)	Krishi Vigyan Kendra, Phek
6.	Dr. Ragulraj S	Sr. Technical Officer	ICAR-NRC on Mithun, Porba
7.	Dr. Venkatesh	SMS (Agri Engineering)	Krishi Vigyan Kendra, Phek
8.	Dr. Sharanappa	SMS (Plant Protection)	Krishi Vigyan Kendra, Phek
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10.	Dr. Harini KR	SMS (Animal Science)	Krishi Vigyan Kendra, Phek

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6.	Mr. Zalekhu Lohe	Agriculture Inspector	Department of Agriculture
7.	Ms. Dzuzutolu Puro	Horticulture Inspector	Department Horticulture Office
8.	Dr Rosou Pohena	Veterinary Assistant Surgeon	Department of Animal Husbandry and Veterinary Sciences
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13.	Mr. Lupfusie Pojar	Soil Assistant	Soil & Water Conservation, Meluri
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विकसित कृषि से विकसित नागालेंड

Viksit Krishi Se Viksit Nagaland

Farmers' Problems and Their Solutions

An Information Bulletin on Agricultural Development in Phek District, Nagaland

Zabo farming, an indigenous and sustainable farming system, is traditionally practiced in the Phek district of Nagaland, particularly in Kikruma village by the Chakhesang tribe. The term "Zabo" means "impounding water" in the local dialect, and the system ingeniously integrates forest, water harvesting, agriculture, livestock, and fisheries on terraced hill slopes.

Photo credits: Dr. S. K. Singh, Head, KVK Phek

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