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Magazine



KOKEDAMA:

UNLEASHING CREATIVITY THROUGH

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FROM THE FOUNDER & CEO'S DESK

Dear Readers,

Welcome to the latest issue of Just Agriculture a publication dedicated to empowering, informing and inspiring the agricultural community. The landscape of agriculture continues to evolve, we are witnessing significant advancements in technology, sustainability practices, and global trends that are reshaping the way we produce, consume, and think about food, from precision farming to the integration of AI in crop management, innovation is at the heart of the agricultural revolution. However, alongside these opportunities, challenges like climate change, supply chain disruptions and labor shortages remain pressing concerns that require our collective action and resilience.

At Just Agriculture, we are committed to being a bridge between these emerging technologies and the farmers, agribusinesses and stakeholders who will shape the future of agriculture. In this issue, we delve into topics that matter most: sustainable farming practices, the rise of agri-tech and the crucial role of policy in ensuring a thriving agricultural ecosystem. We also highlight success stories from across the globe,



demonstrating how adaptability and innovation are driving positive change.

I believe that the future of agriculture is bright, but it requires all of us farmers, scientists, policymakers and consumers to work together toward a common goal: ensuring food security, environmental sustainability and the well-being of future generations.

Thank you for your continued support and for being a part of this incredible journey. I hope this issue inspires you as much as it has inspired us to bring it to you.

Dr. D.P.S. BADWAL
Founder & CEO,
Just Agriculture-the Magazine

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FROM THE CHIEF EDITOR'S DESK

Dear Readers,

The journey of agriculture is a story of resilience, innovation, creativity, and enduring hope. As we present this issue of Just Agriculture, we reaffirm our commitment to empowering farmers, researchers, agricultural entrepreneurs, students, and institutions through meaningful knowledge exchange.

This edition begins with “Bluetongue Disease: A Veterinary Perspective,” offering valuable insights into an important livestock health concern. It also explores new possibilities in ornamental horticulture through “Gaillardia: A New Horizon in Floriculture” and celebrates creative plant artistry in “Kokedama: Unleashing Creativity Through Moss Ball.”

Sustainable resource utilisation is highlighted in “Microwave-Assisted Recovery of Cellulose from Banana Peel Waste: A Sustainable Valorization Approach,” which examines the conversion of agricultural waste into valuable resources. The issue also presents “Millet Production in Assam: Importance, Challenges, Policy and Way Forward,” discussing the potential of millet cultivation and the support required for its wider adoption.

The growing role of digital tools is examined in “Mobile Applications in Agriculture: A Way Forward,” while “India's Shrimp Domestic Market: Current Status, Emerging Opportunities, Value



Addition and the Way Forward” explores developments and opportunities within the country's aquaculture sector. Finally, “Vermicompost: Nature's Black Gold for Sustainable Agriculture” highlights the importance of organic waste management in improving soil health and supporting sustainable farming.

At Just Agriculture, we remain committed to connecting research, innovation, and practical action. I extend my sincere gratitude to our authors, reviewers, editorial team, and the farming community, whose dedication continues to inspire us.

Let us continue sowing innovation and cultivating a sustainable agricultural future.

Dr. Sushila Hooda
Chief Editor,
Just Agriculture-The Magazine

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A close-up photograph of two sheep in a grassy field. The sheep in the foreground has its mouth open, revealing a bright blue tongue. Both sheep have yellow ear tags. The background is a soft-focus green field.

BLUETONGUE DISEASE: A VETERINARY PERSPECTIVE DIVERSIFICATION

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INTRODUCTION

Bluetongue, also called catarrhal fever of sheep or sore muzzle, is a viral disease of domestic and wild ruminants such as sheep, goats, cattle, camels, llamas, antelopes, and deer. It is not spread directly between animals but is transmitted by the bites of tiny *Culicoides* midges. First identified in South Africa in the late eighteenth century, it has since spread across tropical, subtropical, and temperate regions. Sheep are the most severely affected, whereas cattle often

show mild signs or remain apparently healthy; severity varies with the virus strain and the sheep breed. Midge populations peak in late summer and autumn, and their ability to travel long distances has aided the spread of the disease into new areas. The name refers to the bluish discoloration of the tongue, caused by vascular thrombosis, edema, and haemorrhage following viral damage to endothelial cells.



ETIOLOGY

Bluetongue is caused by the bluetongue virus (BTV), genus *Orbivirus*, family *Reoviridae*, and is spread mainly by infected *Culicoides* midges. BTV is a small, non-enveloped virus about 90 nm in diameter, surrounded by a sturdy three-layered protein coat. Its genome consists of 10 segments of double-

stranded RNA that encode the structural and non-structural proteins essential for replication and survival. The outer capsid proteins VP2 and VP5 are important in infection and determine the virus type. Twenty-eight classical serotypes have been identified worldwide, all capable of causing disease in susceptible ruminants.

EPIDEMIOLOGY

Bluetongue is a major transboundary disease, and because of its economic and animal health impact the World Organization for Animal Health (WOAH) classifies it as a notifiable disease of global concern. Changing climatic conditions have been linked to the wider distribution of *Culicoides* midges, particularly in Europe, increasing the risk of spread into new regions. The disease is endemic in India and is not zoonotic. Whole-genome sequencing has shown that segment reassortment and point mutations give rise to new strains that may differ in virulence, host preference, and vector transmissibility. Strengthening global genomic surveillance is therefore essential for early detection of emerging strains, preparedness, and coordinated control.

PATHOGENESIS

After the bite of an infected midge, BTV first multiplies in the local lymph nodes, is carried by dendritic cells to the skin, and then enters the bloodstream, producing a primary viremia. It spreads to organs such as the lungs, spleen, and lymph nodes, replicating in lymphocytes, macrophages, and vascular endothelial cells. Early in infection a small amount of free virus is present in the plasma; later the virus becomes predominantly attached to erythrocytes, which accounts for its prolonged circulation in infected animals.

The pathogenesis of bluetongue is largely centered on damage to small blood vessels. Infection causes cell injury through necrosis and apoptosis and increases vascular permeability; endothelial



damage results in vascular occlusion, impaired blood flow, and tissue infarction. Vasoactive mediators released by infected platelets, macrophages, dendritic cells, and endothelial cells aggravate this damage, leading to oedema and effusion. Although viremia may be prolonged, the infection is not truly persistent; continued detection of the virus mainly reflects the lifespan of infected red blood cells.



CLINICAL SIGNS

Bluetongue is mainly characterized by fever and inflammation of the mucous membranes of the oral and nasal cavity and of the coronary band of the feet. Affected animals show excessive salivation, nasal discharge, swelling of the lips, tongue, and lower jaw, and coronary band inflammation that often causes lameness. The nasal discharge, initially watery, becomes thick and mucous and may dry into crusts. Oedematous swelling is common in the lips, tongue, ears, face, and intermandibular region, and erosive lip lesions may progress to ulceration. Pregnant ewes may abort, and severe cases may show emaciation, recumbency, muscular weakness, and profound debility.

PATHOLOGY

The characteristic changes result from viral replication in endothelial cells, causing oedema, hyperaemia, haemorrhage, and tissue infarction. Gross lesions include cyanosis of the tongue and oral mucosa, necrosis and loss of tone in the oesophageal musculature, and abundant frothy fluid in the trachea and bronchi. Histopathologically, muscles show necrotic fibers surrounded by macrophages, with fibroblast proliferation and increased collagen deposition, particularly in areas of multifocal mineralization, while the hoof corium shows marked hyperaemia with oedema and neutrophilic infiltration. When infection occurs during pregnancy, BTV may cross the placenta and cause severe congenital cerebral abnormalities in sheep and cattle.



DIAGNOSIS

Clinical diagnosis is based on characteristic signs, gross lesions, and the presence of competent insect vectors. Definitive diagnosis combines molecular, serological, and virological methods; BTV antigens and nucleic acids can be detected in lymph nodes, bone marrow, blood, liver, lungs, and spleen. Virus isolation is most successful early in infection, when viraemia is highest. Reverse transcription polymerase chain reaction (RT-PCR) is commonly used to detect viral RNA and identify serotypes, and real-time RT-PCR provides rapid, sensitive, and specific results that aid outbreak investigation and control. Confirmation is achieved by isolation and identification of the virus, usually from blood or spleen samples. There is no specific antiviral treatment; therapy is supportive, with antibiotics to control secondary bacterial infections.



DIFFERENTIAL DIAGNOSIS

Bluetongue should be differentiated from photosensitization, contagious ecthyma (Orf or contagious pustular dermatitis), foot-and-mouth disease, *Oestrus ovis* infestation, ulcerative dermatitis, acute haemonchosis, sheep pox, peste des petits ruminants (PPR), pneumonia, and malignant catarrhal fever. Careful evaluation of clinical signs, pathological lesions, epidemiological history, and laboratory findings is essential for accurate diagnosis.



CONTROL AND PREVENTION

Control is challenging because the disease affects a wide range of host species and is caused by multiple virus serotypes. Reducing exposure of susceptible animals to insect vectors is the main strategy, although it is difficult under field conditions. Prevention therefore relies on prophylactic vaccination together with vector control, such as reducing midge breeding sites and limiting animal exposure during periods of high vector activity.



VACCINATION

Vaccination remains the primary method for preventing and controlling BTV infection. It is the most effective and practical strategy for reducing losses and may help interrupt transmission between infected animals and insect vectors. Continuous surveillance combined with timely vaccination before periods of increased vector activity is the most practical and reliable approach for preventing bluetongue outbreaks.



The background of the entire page is a close-up photograph of several Gaillardia flowers. The flowers have multiple layers of petals, with colors ranging from light pink to deep magenta. The centers of the flowers are a bright yellow, densely packed with stamens. The flowers are set against a backdrop of dark green, finely divided foliage. The lighting is soft, highlighting the texture of the petals and the vibrant colors of the blooms.

GAILLARDIA: A NEW HORIZON IN FLORICULTURE

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INTRODUCTION

Floriculture is one of the fastest-growing sectors of horticulture, driven by rising demand for flowers in landscaping, religious ceremonies, social events, urban beautification and the cut flower industry. Among ornamental annuals, Gaillardia (*Gaillardia pulchella* L.), commonly known as “Blanket Flower”, “Fire Wheel” and “Sundance”, has gained popularity for its vibrant blooms, prolonged flowering period, ease of cultivation and adaptability to diverse agro-climatic conditions. Belonging to the family Asteraceae, it is widely cultivated as a loose flower crop and valued in landscape gardening. Gaillardia is highly tolerant to drought, high temperatures and poor soils, making it suitable for low-input cultivation. In India, it is an important substitute for marigold, chrysanthemum and China aster during periods of flower scarcity and is extensively used for garlands, decorations and religious and social functions.

Genetics

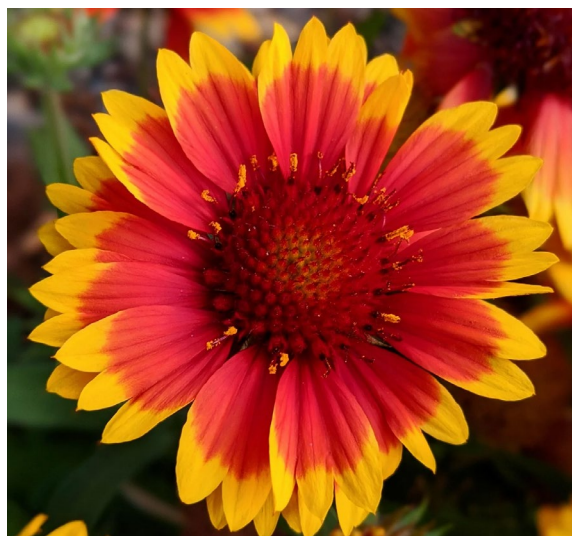
The genus Gaillardia comprises approximately 25-30 species, of which Gaillardia pulchella and Gaillardia aristata are the most commercially important ornamentals. *G. pulchella* has a chromosome number of $2n = 36$, while *G. aristata* occurs in both diploid and tetraploid forms, contributing to its wide genetic diversity and ornamental variability.

Botanical Description

Gaillardia is an erect, bushy annual herb, 30-90 cm tall, with profuse branching. It bears alternate, lanceolate leaves and solitary flower heads (4-6 cm diameter) in shades of yellow, orange, red, scarlet and attractive bi-colour combinations. Each capitulum consists of colourful ray florets and fertile central disc florets. A strong taproot system makes the crop highly tolerant to drought and well adapted to diverse environments.

Origin and Distribution

Gaillardia, commonly known as Blanket Flower, belongs to the family Asteraceae. The genus was named in honour of the eighteenth-century French botanist and patron M. Gaillard de Marentonneau. The crop is native to North America, particularly the central and southern United States and Mexico, and has been successfully introduced into many tropical and subtropical regions because of its adaptability and drought tolerance.



Species	Key Characteristics	Major Uses
<i>Gaillardia pulchella</i> L.	Annual: profuse branching with abundant, colourful blooms.	It reduces erosion in coastal area.
<i>Gaillardia aristata</i> Pursh.	Perennial: larger flowers with prolonged blooming.	Requires low maintenance, suitable for dry land.
<i>Gaillardia grandiflora</i>	<i>Gaillardia aristata</i> × <i>Gaillardia pulchella</i>	

Varieties

- **Mesa Yellow:** 1st F1 yellow-blooming cv. Evolved from seed.
- **Introductions:** Burgundy, Dazzler, Double Tetra, Fiesta, Gaity Double, Golden Goblina, Lollypop Orange, Lollypop Yellow, Monarch Strain, Red Plume, Sundance.

Climate Requirements

Gaillardia is a warm-season annual crop well suited to tropical and subtropical climates. It grows best in full sunlight at an optimum temperature of 18-30°C. Moderate rainfall and low humidity favour healthy growth and prolonged flowering. The crop tolerates drought, high temperatures and moderate salinity, making it suitable for semi-arid regions.

Soil Requirements

Gaillardia grows well in a wide range of soils, but well-drained sandy loam to loamy soil rich in organic matter is ideal, with an optimum pH of 6.5-7.5. Waterlogging should be avoided as it restricts root growth and encourages fungal diseases. Well-decomposed FYM or compost applied before planting

improves soil fertility, moisture retention and flower yield.

Propagation

Gaillardia is primarily propagated through seeds. Healthy, bold and disease-free seeds from true-to-type plants should be used for uniform establishment. Seed treatment with bio-fertilizers, biocontrol agents or Beejamrut under natural farming improves germination, enhances seedling vigour and protects seedlings from seed-borne diseases.

Nursery Management

A well-prepared nursery with fertile, well-drained soil and FYM/compost is essential for healthy seedlings. Seeds germinate within 5-8 days and seedlings become ready for transplanting after 25-30 days when they develop 4-6 true leaves.

Land Preparation

Land preparation involves 2-3 ploughings to achieve fine tilth and removal of weeds and residues. During final preparation, 20-25 t ha⁻¹ FYM or compost should be incorporated to improve soil fertility and structure. Raised beds are recommended for better drainage and disease prevention.

Transplanting and Spacing

Healthy 25-30 days old seedlings with 4-6 true leaves should be transplanted in the evening or on cloudy days to minimize transplanting shock, with light irrigation immediately afterwards. Gaillardia can be transplanted at 30 × 20 cm, 30 × 30 cm or 45 × 30 cm depending on the purpose; 45 × 30 cm is recommended for commercial cultivation as it provides better aeration, sunlight interception, branching and flower quality and facilitates intercultural operations.

Nutrient Management

Balanced nutrient application plays an important role in improving plant growth, flowering and flower quality of Gaillardia. The recommended fertilizer dose for commercial cultivation is 150 kg N, 100 kg P₂O₅ and 100 kg K₂O per hectare. Proper nutrient management ensures vigorous plant growth, increased flower yield and better-quality blooms.

Irrigation Management

Although Gaillardia is drought tolerant, timely irrigation is essential for better growth, continuous flowering and higher yield. Light irrigation should be given immediately after transplanting and thereafter scheduled according to soil type, weather and crop stage; intervals of 7-10 days are generally suitable during the vegetative stage. Adequate moisture during flowering improves flower size, number and yield, while over-irrigation and waterlogging should be avoided to prevent root diseases. Drip irrigation and organic mulching are recommended for efficient water use, moisture conservation and improved soil health.

Weed Management

Weeds compete with gaillardia for moisture, nutrients, sunlight and space, especially during early growth. The first hand weeding should be done 20-25 days after transplanting, followed by further



weedings as required. Earthing-up improves root growth, while organic mulching suppresses weeds, conserves soil moisture and enhances soil microbial activity, making it an effective eco-friendly practice under natural farming.

Intercultural Operations

Regular intercultural operations help maintain healthy crop growth and continuous flowering in Gaillardia. Removal of dried leaves, damaged branches and faded flowers (deadheading) encourages new flower bud formation by redirecting plant energy. Light hoeing improves soil aeration and nutrient uptake, while proper field sanitation helps reduce pest and disease incidence.

INSECT PESTS AND DISEASES MANAGEMENT

Pest/Disease	Symptoms	Management
Aphids (<i>Aphis gossypii</i> , <i>Myzus persicae</i>)	Sap sucking on shoots, leaves and buds; leaf curling, stunted growth, honeydew formation	Remove affected parts, conserve natural enemies, spray neem oil (2-3%), maintain field sanitation
Thrips (<i>Thrips tabaci</i>)	Flower distortion, discoloration and reduced flower quality	Use blue/yellow sticky traps, remove weeds, apply neem-based formulations
Red Spider Mites (<i>Tetranychus urticae</i>)	Leaf yellowing, bronzing and drying under hot conditions	Maintain moisture, remove affected leaves, apply botanical/biological acaricides
Damping-off (<i>Pythium</i> sp.)	Collar rot, seedling collapse and death	well-drained nursery beds, treat seeds with Trichoderma/Beejamrut
Powdery Mildew (<i>Erysiphe cichoracearum</i>)	White powdery growth on leaves, stems and buds	Maintain spacing, avoid excess nitrogen, remove infected parts, use sulphur/biological fungicides
Leaf Spot (<i>Alternaria</i> , <i>Cercospora</i>)	Brown-black spots on leaves and premature leaf fall	Maintain sanitation, avoid overhead irrigation, remove infected leaves, follow crop rotation

Harvesting

Gaillardia starts flowering 55-70 days after transplanting depending on cultivar and growing conditions. Flowers should be harvested in the early morning or evening for better freshness. Fully opened, bright-coloured flowers should be picked at 2-3 day intervals to maintain continuous flowering and increase total yield.

Yield

Flower yield depends on the variety, season and crop management. Under proper cultivation, an average yield of 15-20 tonnes of fresh flowers per hectare can be obtained. After harvest, flowers are packed in bamboo baskets, gunny bags or suitable containers and transported to the market.



CONCLUSION

Gaillardia is a promising ornamental flower crop with excellent adaptability, prolonged flowering and commercial value. Its tolerance to drought, heat and low-input conditions makes it suitable for sustainable floriculture. Adoption of improved production practices, balanced nutrition, efficient irrigation and natural farming inputs can enhance flower yield and quality, making Gaillardia a profitable alternative flower crop for farmers and a contributor to the growth of the floriculture sector.



KOKEDAMA: UNLEASHING CREATIVITY THROUGH MOSS BALL

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INTRODUCTION

Gardening offers endless ways to bring nature indoors, and Kokedama, a Japanese art that has gained worldwide popularity, is one of the most distinctive. Valued for their minimalistic appearance, Kokedama can be displayed on a tray, in a shallow bowl or suspended as string gardens. This article covers their origins, step-by-step instructions for making a moss ball, care tips and display ideas.

ORIGIN AND SIGNIFICANCE

Kokedama (“ko-keh-dah-mah”) is a centuries-old Japanese gardening technique whose name means “moss ball”. It evolved from bonsai and kusamono, combining the elegance of miniature trees with the simplicity of moss-covered plants, and embodies harmony, balance and respect for nature.

The Essence of Kokedama

Kokedama departs from traditional potted plants: the plant is wrapped in a ball of soil, covered with moss and often suspended or displayed on a platform, letting its natural beauty shine as an organic, sculptural element.

Choosing the Right Plant

Choose plants that thrive in medium to low light and prefer moist soil. Tropical jungle plants, ferns and ivy are popular because they adapt well to the humid environment of the moss ball.

Soil Mix and Moss Selection

Traditionally, a clay-based soil called “akadama” is combined with peat moss to retain moisture, but you can mix clay and peat moss in an 85:15 ratio, which balances water retention and aeration for plant growth.

For moss, you can use dry floral moss, which is readily available and soaked in water before use, or gather moss from your surroundings and prepare it for the Kokedama.

Step-by-Step Guide to Making Kokedama

Follow these step-by-step instructions to make your own moss ball:

- Line your work area with newspaper or a tarp to catch any mess.
- Soak dried moss in water for an hour, then squeeze out excess water, keeping it damp.
- Combine clay and peat moss in an 85:15 ratio, adding water until the soil can be gathered into a ball without crumbling.
- Remove the plant from its container, dust off excess soil and loosen the root ball.
- Make a hole in the soil ball large enough for the roots and spray the soil to keep it workable.
- Place the roots in the hole, ensuring they are well covered by the soil mixture.
- Press moss firmly around the ball and wrap it with twine, making at least two passes; trim excess string.
- Mist the finished Kokedama with a spray bottle to maintain moisture.



CARE TIPS FOR KOKEDAMA

Kokedama is low-maintenance and regular watering is key. Soak the moss ball in water for 15-30 minutes once a week or when the moss feels dry. Plants prefer bright, indirect light and occasional fertilizing during the growing season.

► **Enhancing Your Kokedama Display**

Kokedama also offers endless possibilities for enhancing your living space. Here are some ideas to elevate your Kokedama display:

► ***Creative Hanging Techniques***

Suspend moss balls from the ceiling or a wall-mounted hook with decorative hangers or clear fishing line, experimenting with heights and arrangements for a visually attractive display.

► ***Stylish Containers and Display Ideas***

Containers such as ceramic bowls, shallow dishes or wooden trays complement the natural aesthetic, and elements like driftwood or stones create a harmonious display.

► **Kokedama Variations: Exploring Possibilities**

Besides traditional ferns and tropical plants, there are many exciting variations to explore:

► **String Gardens:** Creating a Cluster of Kokedama, Grouping several Kokedama, hung at different heights and in various sizes, creates a dynamic and eye-catching installation that can be indoors or outdoors.

► **Air Plants and Tillandsia Kokedama,** Tillandsia need no soil and absorb nutrients and moisture from the air; suspend the air plant within a base of sphagnum moss or floral foam.

► **Succulent Kokedama:** A Modern Twist, Succulents thrive in arid conditions with minimal care. Use a well-draining soil mix with perlite or pumice to create a contemporary, desert-inspired succulent Kokedama.

► **Benefits of Kokedama in Home Gardening**

Apart from being visually appealing,

Kokedama offers several benefits for home gardening enthusiasts:

► **Stress Relief and Well-being**

Gardening reduces stress and promotes well-being; the mindful, meditative process of creating and caring for Kokedama brings calm and a deeper connection with nature.

► **Unique Decorative Element**

Kokedama serves as a striking decorative element that adds a touch of natural beauty to any space.

► **Educational and Engaging for Children**

Making a moss ball and caring for its plant engages children in gardening, fostering a love of plants, responsibility and lessons about the natural world.

► **Popular Plants for Kokedama**

Choosing the right plant ensures successful growth and longevity. Popular options include: Sansevieria, Pothos, Ferns, Syngonium, Blushing zebra plant, Peace lily, Succulents etc.

► **Common problems in Kokedama**
You may encounter some challenges; here are solutions to common issues:

► **Overwatering and Root Rot**

Overwatering is the most common problem. To avoid root rot, do not let the moss ball sit constantly in water; let it dry out slightly between waterings and adjust frequency to the moss moisture and the plant's needs.

► **Pests and Diseases**

Kokedama is generally resistant to pests and diseases, but inspect regularly for aphids or mealybugs and treat with organic insecticidal soap or neem oil spray. Good air circulation prevents fungal diseases.

► **Reviving a Dying Kokedama**

Assess moisture levels and adjust watering, trim dead or yellowing leaves and check for pests or diseases. If necessary, repot into a fresh Kokedama with a well-draining soil mixture suited to the plant.

► **Where to Find Kokedama and DIY Resources**

If you lack the time or confidence to make one yourself, several options are available:

► **Nurseries and Garden Centers**

Many nurseries and garden centers offer pre-made Kokedama in a variety of plants.

► **Kokedama Workshops and Classes**

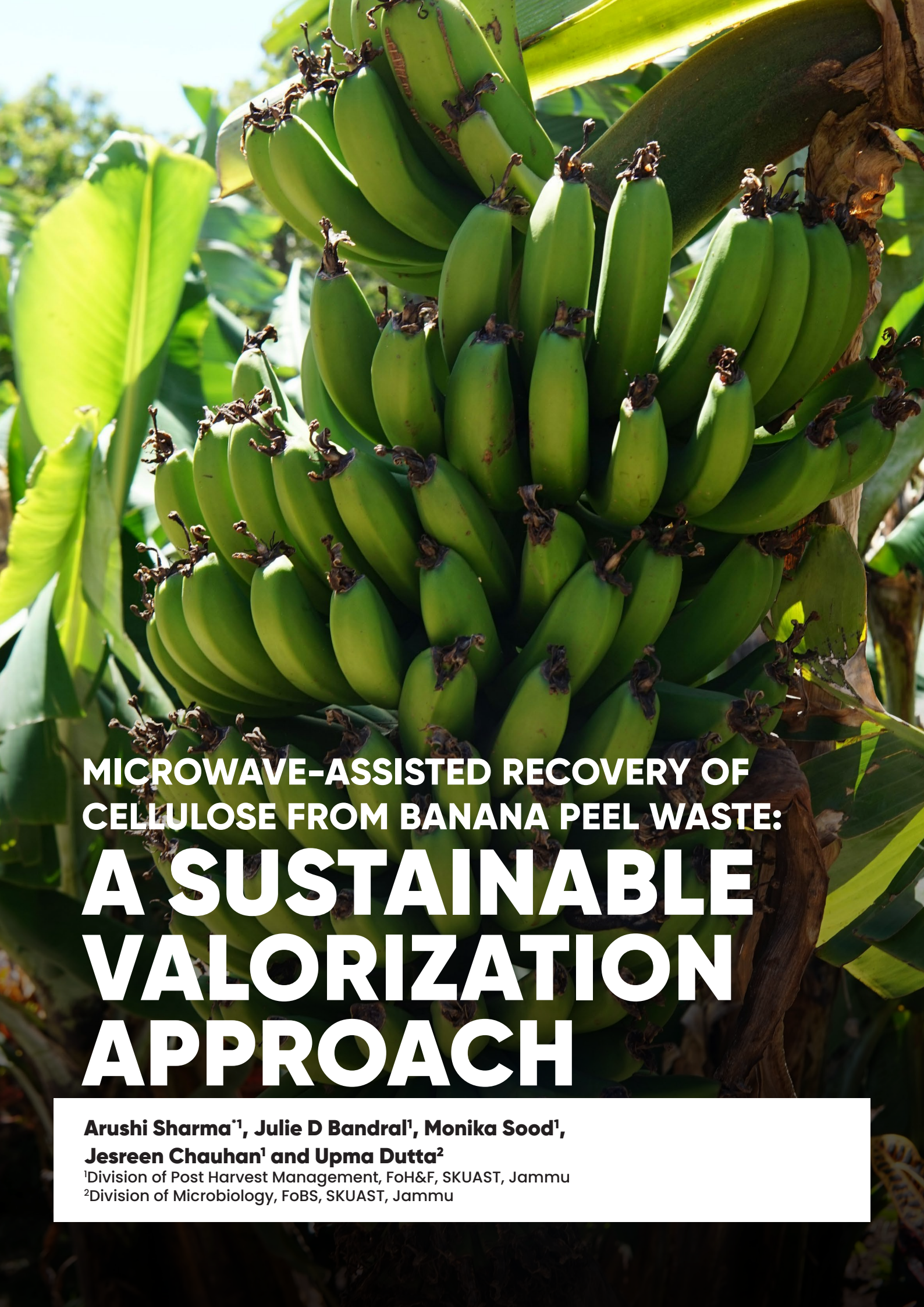
Workshops and classes offer hands-on guidance and expert knowledge; check local botanical gardens, community centers or horticultural societies.

► **Online Tutorials and Communities**

Online tutorials, guides and forums offer tips for making moss balls, and online communities allow sharing ideas, troubleshooting and connecting with fellow enthusiasts.

CONCLUSION

Kokedama offers a unique and artistic way to bring nature into your home and garden. With its rich history, versatility and creative possibilities, this Japanese technique has captivated plant enthusiasts worldwide. By following the steps, caring for your Kokedama and exploring different plants, you can create stunning moss balls that add natural beauty and tranquillity to your surroundings.



MICROWAVE-ASSISTED RECOVERY OF CELLULOSE FROM BANANA PEEL WASTE: A SUSTAINABLE VALORIZATION APPROACH

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Agricultural wastes are generated in substantial quantities during the cultivation, harvesting, and processing of crops. These residues are an abundant and renewable biomass resource whose effective use can support sustainable resource management and the development of value-added products. Their lignocellulosic composition makes them a promising source of valuable biopolymers such as cellulose. Increasing pressure on conventional wood resources, coupled with growing environmental concerns, has further stimulated interest in agricultural residues as sustainable feedstocks for cellulose production.

Banana processing generates substantial lignocellulosic wastes, including peels, pseudostems, and rachis, which contain appreciable amounts of cellulose but are frequently discarded or underutilized. Banana peel, in particular, is a promising agro-waste resource for sustainable cellulose recovery. Cellulose is the



most abundant natural polymer, with desirable properties such as renewability, biodegradability, biocompatibility, and good mechanical characteristics, making it suitable for bio composites, biodegradable films, packaging materials, and nanocellulose-based products. Several studies have demonstrated the potential of banana-derived residues as feedstocks for cellulose recovery and its use in paper, bio composites, and reinforcement materials.

However, cellulose is embedded within





a complex lignocellulosic matrix containing hemicellulose, lignin, pectin, extractives, and inorganic components, so its isolation requires effective removal of these non-cellulosic constituents. Conventional extraction involves sequential solvent treatment, alkaline delignification, and oxidative bleaching. Although these methods can produce cellulose of suitable quality, they often

require prolonged treatment, high energy input, and considerable quantities of chemicals, limiting their economic and environmental sustainability. Efficient approaches that reduce treatment time and chemical consumption are therefore essential for sustainable cellulose recovery from agro-waste.

With the increasing demand for eco-friendly and cost-effective extraction

technologies, microwave-assisted processing has emerged as an efficient alternative to conventional heating. Unlike conventional heating, which relies on conduction and convection and transfers heat relatively slowly, microwave energy interacts directly with polar molecules and ions in the treatment medium. This causes rapid molecular movement and volumetric heating, enabling faster and more uniform energy transfer throughout the biomass–reagent system. Such rapid heating can enhance reagent penetration and accelerate the disruption of lignin–carbohydrate linkages, facilitating delignification and hemicellulose removal.

Microwave radiation can shorten processing durations from hours to minutes while potentially reducing energy and chemical requirements. Appropriate treatment can remove non-cellulosic components efficiently while preserving the purity, crystallinity, and thermal stability of the recovered cellulose. Lower reagent concentrations and shorter treatment times may also reduce

water consumption and wastewater generation, lowering the environmental footprint of the process. However, these advantages depend on careful selection of processing conditions, as excessive microwave exposure or severe chemical treatment may adversely affect cellulose structure. Consequently, microwave-assisted extraction offers a promising route for the valorization of banana peel waste into high-value cellulose. Its rapid, volumetric heating improves process efficiency and supports more sustainable biomass fractionation than prolonged conventional heating. The recovered cellulose has potential for use in advanced bio-based materials, including bio composites, packaging films, and nanocellulose-based systems. Thus, integrating microwave-assisted processing with banana peel valorization provides a resource-efficient pathway for converting an abundant agricultural residue into a valuable functional material, supporting sustainable material recovery and circular economy principles.





MILLET PRODUCTION IN ASSAM: IMPORTANCE, CHALLENGES, POLICY AND WAY FORWARD

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INTRODUCTION

Assam's economy is primarily based on agriculture and allied activities, which support more than 70% of the population. Rice is the dominant food crop, but the state's diverse agro-climatic conditions give scope for a wider range of crops. Among these, millets are receiving renewed attention because of their nutritional value, short duration and adaptability to diversified farming systems. The primary millets cultivated in Assam are finger millet (*Maruadhan* / Ragi), foxtail millet (Koni dhan) and proso millet (Cheena bajra), depending on local soil, rainfall, temperature and farming practices. The Indian Council of Agricultural Research (ICAR) notes that

millets tolerate several environmental stresses and have shorter growing periods, making them relevant to climate-resilient farming. For Assam, millets can also support crop diversification, small farmers, local processing, and women-led enterprises and farmer producer organisations (FPOs). Presently, millets are cultivated on only 6,000 hectares in 15 districts under the Assam Millets Mission (listed in Table 2). The United Nations General Assembly declared 2023 the International Year of Millets to raise awareness of their benefits, promote their cultivation in arid lands with minimal inputs and create sustainable market opportunities for smallholders.



MILLETS AND ASSAM'S AGRICULTURAL DIVERSITY

Assam has a humid and per-humid agro-ecological condition, and millets can complement existing cropping systems, particularly where farmers depend excessively on a single crop or irrigation is limited. The Assam Millet Mission (AMM), launched on November 16, 2022, promotes millet cultivation and its value chain. It is supported through the World Bank-financed Assam Agribusiness and Rural Transformation Project (APART), coordinated by the Assam

Rural Infrastructure and Agricultural Services (ARIAS) Society, with technical support from the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT). Beyond production, it covers technology, seed production and distribution, farm machinery, post-harvest management, value addition, storage and market linkages, aiming to move from millet cultivation to a complete millet value chain.



FROM FARM TO HOUSEHOLD

According to ICAR, millets are nutrient-dense cereals containing carbohydrates, protein, dietary fibre, minerals and B-vitamins. Increasing millet consumption can diversify household

diets, so millets should be integrated into everyday diets and not treated only as commercial crops. A pilot project serving millet-based items under PM POSHAN Assam was launched on 10th January 2025,

in convergence with the Assam Millet Mission, for 78 days, benefiting 2,465 children in 11 schools in Udalguri district. Sweet Mix and Khichdi Mix are served on alternate days, each child receiving 50 grams of the finger millet-based recipe daily before class, at the full cost of the Mission under the Agriculture Department, Assam. Such interventions link agricultural policy with nutrition policy: when locally produced nutritious crops enter public food programmes, demand strengthens and dietary diversity improves.



MILLETS AND CLIMATE-RESILIENT AGRICULTURE

ICAR describes millets as crops with shorter growing duration, stress tolerance and efficient adaptation to difficult environments, and they may require up to 70–80% less water than rice or wheat. In Assam, however, given excessive rainfall, flooding, changes in rainfall distribution and soil-related constraints, millets should not be presented as a universal replacement for rice.

Challenges to Millet

Expansion in Assam

Millet expansion in Assam faces several challenges. First, rice is central to Assamese

food culture and long-established consumption habits are not easily shifted, so consumer awareness and dietary preferences matter most. Second, post-harvest infrastructure for threshing, drying, cleaning, milling and storage must be strengthened. Third, farmers need quality seed and technical knowledge. Fourth, market demand must grow alongside production, as farmers encouraged to cultivate millets without reliable buyers face marketing difficulties; procurement, aggregation, processing and institutional demand must develop together. Fifth, value addition and branding need attention, including food safety, packaging, quality standards and market research.

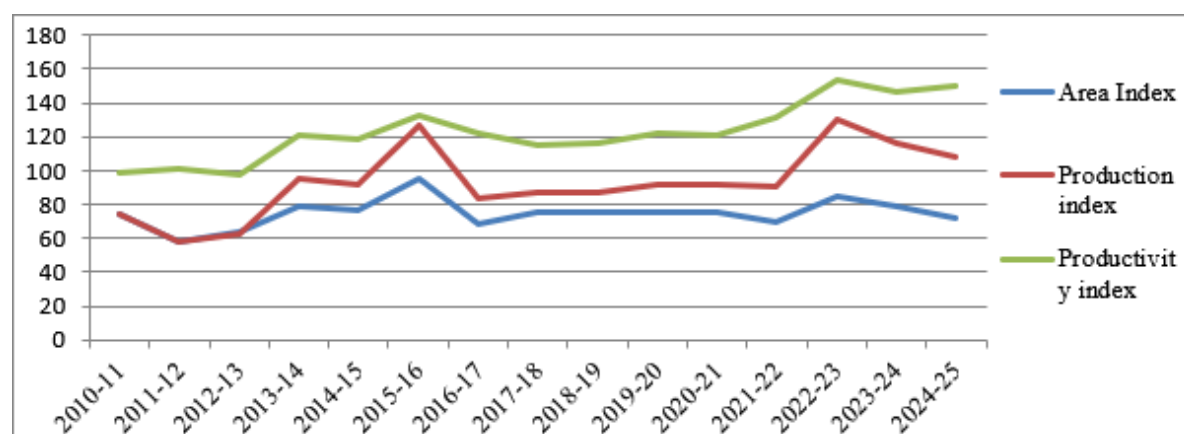
Area, Production and Productivity index of Millets in Assam

Table 1: Based on Area, Production and Productivity index measure CAGR (%).

YEAR	Area index	Production index	Productivity index
2010-11	74.74	73.84	98.8
2011-12	57.52	57.97	100.78
2012-13	63.83	62.48	97.89
2013-14	78.46	94.77	120.8
2014-15	77	91.48	118.81
2015-16	95.14	126.3	132.75
2016-17	68.4	83.13	121.54
2017-18	75.41	86.85	115.16
2018-19	75.08	86.85	115.67
2019-20	75.11	91.62	121.98
2020-21	75.11	91.62	121
2021-22	69.46	91	131
2022-23	84.81	130.33	153.67
2023-24	79.44	115.93	145.95
2024-25	72.22	108.58	150.35
CAGR (%)	-0.25%	+2.79%	+3.04%

Table shows that the area under millets in Assam declined slightly (CAGR –0.25%) during 2010–11 to 2024–25, while the production index grew at a CAGR of 2.79% and the productivity index at the highest CAGR of 3.04%. Thus, production growth over the last 15 years reflects improved productivity rather than expansion of cultivated area.

Area, Production and Productivity index of millet in Assam (2010 to 2025).



District-wise Area, Average Yield and Production CAGR (%).

District	Area (in ha) CAGR (%)	Avg. Yield (in Kg/ ha) CAGR (%)	Production in (Tonnes) CAGR (%)
Baksa	-12.00%	-4.36%	-15.46%
Barpeta	2.29%	11.12%	13.75%
Bongaigaon	-2.47%	0.92%	-1.60%
Dhubri	-17.07%	0.37%	-16.75%
Goalpara	1.69%	2.06%	3.81%
Golaghat	-0.77%	15.14%	14.42%
Jorhat	-	12.47%	-
Kamrup	0.86%	6.04%	7.06%
Karbi-Anglog	-5.89%	0	-5.84%
Kokrajhar	-2.29%	23.65%	20.68%
Morigaon	2.49%	7.18%	9.74%
Nagaon	1.63%	4.85%	6.55%
Sonitpor	4.04%	1.14%	5.53%
Tinsukia	-10.68%	0.75%	-10.02%
Udalguri	6.65%	13.75%	21.16%



The district-wise CAGR (%) results show variation in millet growth across districts. Udalguri, Kokrajhar, Golaghat and Barpeta recorded relatively high production growth, mainly from productivity improvements, while Dhubri, Baksa and Tinsukia declined in both area and production. Kokrajhar, Golaghat and Udalguri have relatively high average yields. Overall, productivity improvement rather than area expansion has driven production growth in several districts over the last 5 years.

Future of millets in Assam

To promote millets in Assam, region-specific research should identify varieties suited to its agro-ecological conditions, and seed systems should be strengthened

so farmers get timely access to quality seed and scientific practices. Millets should be integrated with suitable crop rotations and diversified farming systems rather than promoted as a replacement for rice. Drying, threshing, milling, storage and processing infrastructure should be accessible to farmer groups and rural enterprises, and FPOs and SHGs should be connected with institutional buyers, schools, nutrition programmes, local markets and private enterprises. Public awareness should cover health benefits as well as recipes that fit local food preferences, and government programmes should connect production, nutrition, processing, entrepreneurship and markets.

CONCLUSION

Millets can become an important component of Assam's strategy for agricultural diversification, nutritional security and sustainable rural livelihoods. The Assam Millet Mission has laid an institutional foundation by combining production support with post-harvest management, value addition and market development, and recent initiatives involving PM POSHAN and the continued focus of ICAR and Assam's agricultural institutions further integrate millets into agricultural and nutritional policy. The objective should be not to replace Assam's rice-based food system but to diversify it. By combining scientific research with traditional food knowledge, strengthening farmer organisations, creating women-led enterprises and developing reliable markets, millets can

move from an underutilised crop to a component of a more diverse, nutritious and resilient rural economy.





MOBILE APPLICATIONS IN AGRICULTURE: A WAY FORWARD

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INTRODUCTION

Agriculture is closely linked with knowledge: timely information on weather, seeds, crop management, pests, markets and government support can raise farm productivity and income. The growth of ICT and smartphones, supported by Digital India, has opened new opportunities for agricultural extension. Institutions such as ICAR, State Agricultural Universities, KVKs and private companies are developing applications that give farmers real-time, need-based and often location-specific information, making mobile applications a portable knowledge hub for modern agriculture.

MOBILE APPLICATIONS: A NEW FACE OF AGRICULTURAL EXTENSION

Traditional extension relies on face-to-face contact, which is limited by inadequate manpower, distance, transport costs and the large farmer-to-extension-worker



ratio. Mobile applications complement it by providing information instantly and repeatedly, without waiting for a field visit or training programme.

Applications deliver text, photographs, videos, audio, maps, weather alerts and interactive advisories; a farmer can photograph an unfamiliar infestation to identify the pest, or use weather advisories to time irrigation, spraying and harvest. Extension is thus shifting from a "one-way information delivery system" towards a more interactive, farmer-oriented model.



MAJOR ROLES OF MOBILE APPLICATIONS IN AGRICULTURE

Access to Scientific Crop Production Technologies

Applications provide information on improved varieties, seed treatment, sowing, nutrient, irrigation and weed management, plant protection and harvesting, helping farmers adopt scientific practices and receive updates faster than printed literature.

Weather-Based Advisory Services

Unexpected rainfall, drought, heat waves, frost and storms can cause heavy crop losses; applications such as Meghdoot provide weather-based agro-advisories to help plan farm operations.

Pest and Disease Identification

Mobile applications help farmers recognize pest and disease symptoms through photographs; AI-based platforms

such as Plantix show the potential of image-based diagnosis and suggest management measures.

Market Information and Digital Trading
Lack of market price information weakens farmers' bargaining power. Applications such as AgriMarket give nearby market prices, while e-NAM supports digital market integration, enabling better decisions on where and when to sell.

Government Schemes and Agricultural Services

Lack of awareness can prevent eligible farmers from benefiting from schemes on income support, insurance, soil health and subsidies. PM-Kisan, PMFBY Crop Insurance, UMANG and other digital services bring such information closer to farmers.



IMPORTANT MOBILE APPLICATIONS FOR AGRICULTURE

India has developed a diverse ecosystem of mobile applications addressing different agricultural requirements.

Kisan Suvidha

A farmer-oriented platform bringing together weather, market prices, plant protection and advisories.

Pusa Krishi

Linked to ICAR; provides technologies, crop varieties and farm machinery information.

Meghdoot

Turns weather information into practical agro-advisories for scheduling farm operations.

PMFBY Crop Insurance App

Provides crop insurance, premium and claim information transparently.

e-NAM

Connects agricultural markets and facilitates transparent price discovery and trading.

m-Kisan

Delivers SMS-based advisories without needing smartphones or high-speed internet.

Bhuvan Hailstorm App

Uses geo-tagging and mapping to assess crop losses caused by hailstorms.

UMANG

An integrated platform for accessing farmer-related government services.

Pashu Poshan

Guides balanced feeding and livestock nutrition for better animal health.

AgriMarket App

Uses GPS to show nearby markets and prevailing prices.

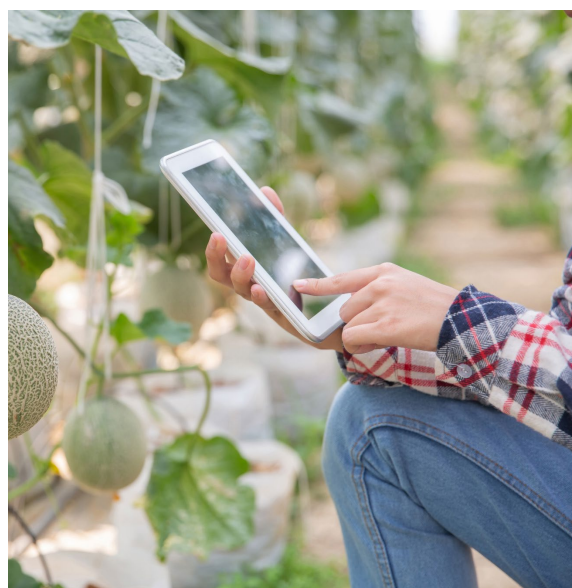
Soil Health Card App

Provides soil information and nutrient recommendations for balanced fertilizer use.

ADDITIONAL DIGITAL APPLICATIONS AND SERVICES

Farmer Portal offers schemes, advisories and services; Kisan Rath addresses transport and logistics for produce; the CHC Farm Machinery App eases access to machinery through Custom Hiring Centres, especially for small and marginal farmers. Other services include crop-monitoring platforms and PM-Kisan-related services.

Region-specific applications are important because Indian agriculture is highly diverse.



ADVANTAGES OF MOBILE APPLICATIONS IN AGRICULTURE

The growing adoption of agricultural applications offers several important advantages:

- **Anytime, anywhere access:** Information whenever it is needed.
- **Reduction in information-search costs:** Saves time, travel and expense.
- **Real-time information:** Rapidly updated weather, market and advisory data.
- **Improved farm decision-making:** Better timing of sowing, irrigation and marketing.
- **Enhanced productivity:** Scientific technologies improve crop and livestock output.
- **Sustainable resource use:** Efficient use of water, fertilizers and inputs.
- **Climate resilience:** Alerts help farmers prepare for climatic risks.
- **Improved extension outreach:** One platform can serve very many farmers.
- **Support for mechanization:** Machinery-hiring apps improve access to equipment.
- **Farmer empowerment:** Information strengthens independent, informed decisions.

CHALLENGES IN THE ADOPTION OF AGRICULTURAL MOBILE APPLICATIONS

Digital Literacy

Limited smartphone exposure makes digital literacy programmes essential.

Internet Connectivity

Low-bandwidth design with offline features is needed in poor connectivity areas.

Language Barriers

Applications must support regional languages to be useful to farmers.

Awareness

Farmers must know the application exists, understand its purpose and trust its information.

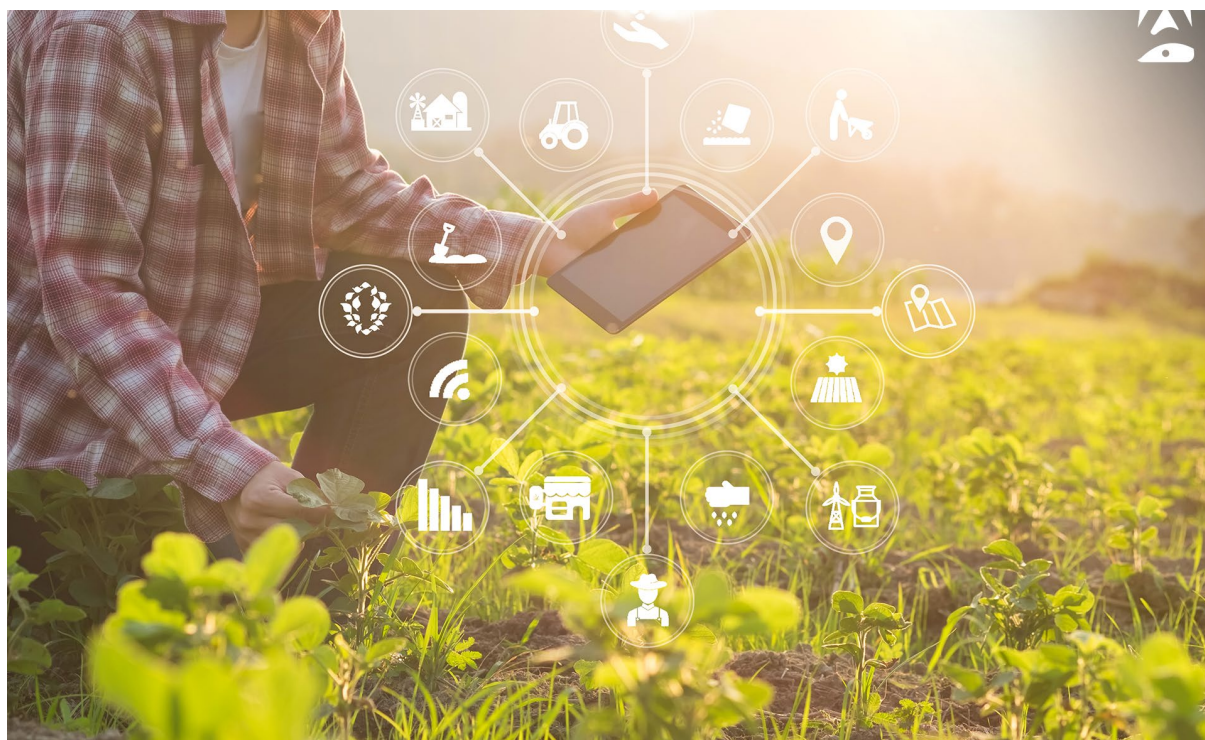
Data Reliability

Information must be scientifically validated, updated and localized.

THE WAY FORWARD

The next generation of applications should become interactive decision-support systems that understand farmers' specific situations.

Future applications can integrate artificial intelligence and machine learning, image-based pest and disease diagnosis, satellite and remote-sensing data, hyperlocal weather, soil and crop data, voice-based advisory, regional languages and dialects, digital marketplaces, online input and service delivery, farm machinery hiring, digital crop records, livestock advisory, and crop insurance and financial services.



CONCLUSION

Mobile applications are becoming a powerful component of modern agricultural extension, connecting farmers with scientific knowledge, weather information, markets, government schemes, machinery and expert advice at unprecedented speed and scale. Their real strength lies in making relevant information available at the right time, in the right language and in a usable form. However, technology alone cannot

transform agriculture: digital literacy, reliable connectivity, multilingual content, scientific validation and strong human extension networks are equally important. Applications provide speed and scale, while scientists and extension workers provide context, trust and personalized support. With farmer-centric design, they can help build smart, climate-resilient and sustainable agriculture and enhance farmers' incomes.



INDIA'S SHRIMP DOMESTIC MARKET:

CURRENT STATUS, EMERGING OPPORTUNITIES, VALUE ADDITION AND THE WAY FORWARD

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INTRODUCTION

India's shrimp industry has transformed over three decades through intensive culture of *Litopenaeus vannamei* and advances in hatcheries, feeds, disease and farm management, making the country a major international supplier. MPEDA data show *Litopenaeus vannamei* production rising from 976,213 tonnes in 2021–22 to 1,304,779 tonnes in 2025–26 (about 33.7%), while frozen shrimp exports reached 792,647 tonnes worth US\$5.624 billion in 2025–26, up from 741,529 tonnes worth US\$5.177 billion in 2024–25.

Export orientation gives access to established markets but exposes the sector to swings in international demand, exchange rates, tariffs, food-safety rules and trade disruptions. Domestic consumption should therefore be a complementary channel, not an alternative. The central question is no longer whether India can produce enough shrimp, but whether it can build a domestic value chain that turns this production base into affordable, safe, convenient and attractive food for Indian consumers.



EXPANSION OF INDIA'S SHRIMP PRODUCTION AND EXPORT SECTOR

L. vannamei production reached 1.30 million tonnes in 2025–26, with black tiger shrimp (*Penaeus monodon*) at about 69,072 tonnes and scampi at about 18,960 tonnes. Total seafood exports hit a record 1,972,018 tonnes worth US\$8.46 billion, with frozen shrimp contributing about 40% of volume and 66.5% of earnings. The United States and China remain major destinations, alongside the European Union, Southeast Asia and Japan; this concentration means shifts in single markets can affect farm-gate prices. The next stage should complement export capacity with stronger domestic distribution, retailing and product development.



WHY HAS THE DOMESTIC SHRIMP MARKET REMAINED RELATIVELY UNDERDEVELOPED?

An export-oriented production system

Processing plants, quality control, cold stores and logistics were built around international specifications, with exports providing clear price signals while domestic consumption received little strategic attention. Such a system does not automatically create an efficient domestic food market.

Fragmented domestic distribution

There is no uniformly organized national distribution system; coastal consumers have better access to fresh shrimp than inland cities, and quality, size, freshness, price and origin remain uncertain. A modern market needs integration of farms, collection centres, hygienic handling, refrigerated transport, wholesale markets, supermarkets, restaurants and online retailers.

Cold-chain limitations

Shrimp is highly perishable, so the domestic market needs more than diverted export-grade shrimp. Investment is required in pre-chilling, insulated transport, refrigerated retail cabinets, decentralized cold stores and last-mile delivery to build consumer confidence.

Price perception

Processing, packaging, storage, transport and retail margins make shrimp a premium product, restricting price-sensitive households. Multiple price segments—smaller grades, frozen, minced and value-added products—can broaden the consumer base.

Consumer familiarity and culinary diversity

Shrimp is embedded in coastal food cultures but less established inland, where consumers may be unfamiliar with cleaning, deveining, thawing and cooking. Its short cooking time and versatility

make this an opportunity; education should focus on practical preparation rather than premium positioning.

Misconceptions regarding nutritional value

Cholesterol concerns have historically influenced seafood choices. Communication should be evidence-based, presenting shrimp as neither universally beneficial nor harmful, highlighting its protein and micronutrients alongside appropriate preparation, and developed with nutrition professionals.

Inconsistent retail quality

Poor handling, inadequate icing, odour and incomplete cleaning discourage repeat purchase and reflect weaknesses in the retail chain rather than consumer preference. Standardized hygienic handling, grading, cleaning and packaging could substantially improve the experience.



THE OPPORTUNITY FOR DOMESTIC MARKET DEVELOPMENT

India's large population and diverse food cultures, familiarity with shrimp in coastal states, the growth of organized retail and online seafood delivery, and a domestic food-processing sector are structural advantages. The objective is to move from a simple commodity model towards a diversified domestic shrimp economy by strengthening each link of a value chain that is currently optimized for export.

Value addition as a pathway for domestic market expansion

Peeled and deveined, tail-on and tail-off, marinated, ready-to-cook and breaded shrimp, cutlets, patties, burgers, kebabs, biryani kits, curries and frozen meal components can reduce preparation time. Products should address specific needs: convenience for working households, snack formats for younger

consumers, portion-controlled products for institutional food service, and mild, boneless formulations for families. Value addition converts shrimp from a raw commodity into a portfolio of differentiated foods.

From “shrimp commodity” to “shrimp brand”

The farmer and production origin are generally invisible to domestic consumers. A branded sector could provide information on species, production region, size grade, harvest and processing dates, storage conditions, cooking instructions, traceability, food-safety certification and nutrition, building an identity around quality, safety, convenience and traceability rather than price alone.

Cold-chain modernization

Domestic consumption cannot expand sustainably without a reliable cold chain



from pond to consumer: rapid icing and hygienic handling at farms, sorting and chilling at aggregation points, refrigerated or insulated transport, functional refrigerated retail displays and temperature-controlled last-mile delivery. Regional seafood distribution hubs in major cities could integrate wholesale distribution, cold storage, processing, packaging and online fulfilment.

Digital marketing and direct-to-consumer models

Online platforms can connect consumers directly with processors and retailers while sharing information on origin, quality and preparation. Short cooking videos and recipe content can show how easily shrimp fits into everyday meals. Social media can introduce new products, demonstrate recipes, communicate food-safety practices, promote regional cuisines, explain storage and thawing, connect consumers with local producers and build recognizable domestic brands.

Learning from the fish and poultry sectors

Fish has a deeply established distribution network, and poultry has benefited from consumer-oriented marketing and standardization. The lesson is how repeated communication, standardized products, convenient formats and strong distribution normalize a food in everyday diets; shrimp should be positioned as an accessible, protein-rich food rather than only a premium seafood item.

Seafood festivals and experiential marketing

Festivals bridge producers and consumers, letting people experience shrimp in varied culinary forms. Regional events could combine direct farmer–consumer interaction, live cooking demonstrations,

product exhibitions, nutritional education, entrepreneur networking, chef competitions, live processing demonstrations on hygiene and direct retail sales, and are particularly valuable in inland cities.

“Pond-to-plate” models

This framework connects production, traceability, processing and consumption, communicating the journey from farm to consumer through menus and outlets built around traceable shrimp. The Zhingalala model is an example of a shrimp-focused food-service concept; such models should be evaluated and adapted rather than replicated, with attention to food safety, traceability, scalability and farmer participation.

Increasing farmer participation in domestic value addition

Added value should not remain concentrated downstream. Farmer producer organizations, cooperatives and cluster-based marketing can enable collective grading, branding, direct sales and value-added processing, giving small and medium producers bargaining power so that rising domestic consumption benefits producers rather than only intermediaries.



Policy priorities

A national domestic shrimp strategy should complement existing export infrastructure. Priorities include integrating domestic distribution into fisheries and seafood infrastructure programmes; expanding cold-chain facilities beyond export clusters into major consumption centres; supporting small-scale processing and ready-to-cook development; implementing food-safety and labelling standards consistently; and encouraging young entrepreneurs to develop shrimp products and digital seafood businesses. MPEDA, ICAR fisheries institutes, state fisheries departments and industry organizations can contribute technology, market intelligence, training, quality assurance and consumer education.

Towards a resilient dual-market strategy

The future is not export versus domestic consumption. A resilient model keeps exports as the principal high-value outlet while a stronger domestic market diversifies demand, buffers farmers during international downturns, and supports price stability and employment.

Research priorities

Knowledge gaps include regional consumption patterns, willingness to pay, preferred product formats,

price elasticity, freshness perceptions, acceptance of frozen products and the role of nutritional information. Value-chain and margin studies across farm-gate, wholesale, retail and value-added stages would show where domestic value is lost, and research is needed on packaging, shelf-life extension, modified-atmosphere packaging, freezing, ready-to-cook formulations and decentralized cold chains suited to Indian conditions.

Way forward

The next phase should move beyond producing more shrimp towards producing, distributing and marketing it more intelligently. Six priorities are particularly important:

- strengthen domestic cold chains to protect quality from harvest to consumption;
- develop affordable value-added products across different price categories;
- build consumer-facing brands that make quality, traceability and food safety visible;
- use digital platforms strategically through online retail, recipe-based marketing and direct-to-consumer models;
- strengthen farmer participation through producer groups and cluster-based enterprises; and
- maintain export competitiveness while diversifying domestic demand, with the domestic market as a complementary pillar, not a substitute.



CONCLUSION

India has built one of the world's most significant shrimp production and export industries: *L. vannamei* production reached about 1.30 million tonnes in 2025–26, frozen shrimp exports 792,647 tonnes valued at US\$5.62 billion, and total seafood exports a record US\$8.46 billion. Yet export success should not obscure the importance of domestic market development, which can diversify demand, improve resilience to international fluctuations and create opportunities in processing, retailing, food service and entrepreneurship, especially through value-added, ready-

to-cook, breaded, meal-kit, regional and branded chilled or frozen products.

India therefore needs to progress from an export-dominated shrimp economy towards a dual-market system based on exports, domestic consumption and value addition. The objective is a safer, more organized, more convenient and more economically inclusive value chain that creates stable markets, improves farmer returns and delivers high-quality seafood to Indian consumers; domestic market development is an important component of the next phase of India's shrimp aquaculture.





VERMICOMPOST: NATURE'S BLACK GOLD FOR SUSTAINABLE AGRICULTURE

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INTRODUCTION

Rising demand for safe food and sustainable farming has pushed farmers towards eco-friendly practices. Years of heavy dependence on chemical fertilizers raised yields but also reduced soil fertility and organic matter, caused nutrient imbalance and environmental pollution, and increased production costs, creating a need for organic nutrient sources that improve both productivity and soil health.

Among organic manures, vermicompost has emerged as one of the most efficient and environment-friendly biofertilizers. Produced by earthworms and beneficial microorganisms from organic wastes, it is often called “Black Gold” because it improves soil fertility, enhances microbial activity and promotes healthy plant growth.



WHAT IS VERMICOMPOST

Vermicompost is a finely decomposed organic manure formed when earthworms break down biodegradable materials such as farm residues, crop and vegetable wastes, fruit peels, cattle dung, poultry litter, sugarcane trash and leaf litter. The castings contain essential plant nutrients, beneficial microorganisms, enzymes, vitamins, humic substances and growth-promoting compounds. Unlike ordinary compost, it is produced under controlled biological conditions and is generally richer in nutrients and microbial populations.

IMPORTANT EARTHWORM SPECIES USED

The most commonly used species are:

- *Eisenia foetida* (Red Wiggler)
- *Eudrilus eugeniae* (African Night Crawler)
- *Perionyx excavatus* (Indian Blue Worm)

They are surface-dwelling, have high feeding capacity, reproduce rapidly and efficiently convert organic waste into high-quality compost.



NUTRIENT COMPOSITION

Nutrient	Average Content
Organic Carbon	12–20%
Nitrogen (N)	1.5–2.0%
Phosphorus (P ₂ O ₅)	0.8–1.5%
Potassium (K ₂ O)	1.0–1.8%
Calcium	2–5%
Magnesium	0.5–1.0%
Micronutrients	Adequate quantities
Beneficial Microorganisms	Very high

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They are surface-dwelling, have high feeding capacity, reproduce rapidly and efficiently convert organic waste into high-quality compost.

PREPARATION OF VERMICOMPOST

Selection of Site

A cool, shaded, well-drained location protected from direct sunlight and heavy rainfall.

Materials Required

Cow dung, vermicompost bags, crop residues, dry leaves, vegetable waste, kitchen waste, earthworms and water.

Procedure

1. Prepare a compost bed (12/8 × 4 × 2).
2. Place coarse materials at the bottom for drainage.
3. Add partially decomposed organic waste mixed with cow dung.
4. Introduce healthy earthworms after partial decomposition.
5. Maintain moisture around 60–70% and cover the bed with gunny bags or straw.
6. Turn the material occasionally if necessary.
7. Harvest after 45–60 days, when the material is dark, granular and earthy in smell.

Proper moisture, aeration and temperature are essential for high-quality compost.



ROLE OF EARTHWORMS

Earthworms, often called Nature's Ploughmen, continuously improve soil structure while feeding on organic matter. They fragment organic residues, accelerate decomposition, enhance microbial activity and nutrient mineralization, produce nutrient-rich castings, and increase soil aeration and water infiltration.

BENEFITS OF VERMICOMPOST

Improves Soil Structure

Regular application enhances aggregation, porosity, aeration and water-holding capacity.

Enhances Nutrient Availability

Nutrients are released slowly, improving nutrient-use efficiency and reducing losses.

Stimulates Plant Growth

Natural growth-promoting hormones stimulate root development, flowering and fruit formation.

Increases Beneficial Microbial Population

Beneficial bacteria and fungi suppress harmful pathogens and improve nutrient cycling.

Improves Seed Germination

Seeds in vermicompost-amended soils show higher germination and more vigorous seedlings.

Increases Crop Yield

Yield increases of 10–30% have been reported, depending on crop, soil type and management.

Improves Produce Quality

Fruits and vegetables often show better colour, taste, shelf life and nutritional quality.

Eco-friendly Waste Management

Large quantities of agricultural, household and market wastes are recycled into valuable manure instead of becoming pollutants.



APPLICATION IN DIFFERENT CROPS

Field Crops – Apply 2–5 ton per hectare before sowing.

Vegetables – Apply 2–3 ton per hectare or 200–500 g per planting pit.

Fruit Crops – Young plants 2–5 kg per plant; bearing trees 10–20 kg per tree annually.

Flower Crops – Apply 1–2 kg per square metre before planting.

Nursery – Mix vermicompost with soil and sand in equal proportions for healthy seedlings.

ECONOMIC IMPORTANCE

Vermicomposting is an attractive rural enterprise: initial investment is low, raw materials are locally available, demand for organic manure is rising, it suits self-help groups and farmer producer organizations, and it generates additional income from organic waste while recycling farm wastes sustainably.

LIMITATIONS

Certain precautions are necessary: avoid fresh animal dung with high heat; protect beds from ants, rodents and poultry; prevent waterlogging; maintain optimum moisture (excessive drying reduces earthworm activity); and avoid pesticide-contaminated materials. Proper management ensures consistent production of high-quality vermicompost.

FUTURE PROSPECTS

The growth of organic and natural farming and integrated nutrient management has increased demand for vermicompost. Government support through organic farming schemes, consumer awareness

of pesticide-free food and concern for soil health should expand production further. Integrating vermicompost with biofertilizers, microbial inoculants and precision nutrient management can play a vital role in climate-resilient agriculture and long-term sustainability.

CONCLUSION

Vermicompost is one of the most valuable organic inputs for modern agriculture. By converting biodegradable wastes into nutrient-rich manure, it addresses waste management, restores soil fertility, enhances crop productivity and reduces dependence on chemical fertilizers. Adoption at farm and community levels can raise farmers' income while supporting environmental conservation and sustainable food production. With growing emphasis on healthy soils and eco-friendly farming, vermicompost truly deserves its reputation as Nature's Black Gold.



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