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JUST AGRICULTURE®

Magazine

DECODING SEEDS

HOW OMICS TECHNOLOGIES ARE TRANSFORMING SEED SCIENCE AND CROP IMPROVEMENT

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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

Publisher & Editor:
Dr. D.P.S. Badwal on behalf of Just Agriculture Communications Group & printed at Just Agriculture Publications, Jalandhar.

FROM THE
CHIEF EDITOR'S DESK

Dear Readers,

The journey of agriculture is a story of resilience, innovation, and enduring hope. As we present this issue of Just Agriculture, we reaffirm our commitment to strengthening the backbone of our nation, our farmers, researchers, and agricultural entrepreneurs. This edition brings forward timely insights on key themes shaping Indian agriculture, where science and policy meet.

We begin by exploring the efficiency of Ultrasonic Food Cutting, a revolution in precision slicing that enhances food processing standards. Complementing this focus on modernization, we examine Biomass Densification as a critical tool for the clean energy transition in thermal power plants. These advancements demonstrate how industrial engineering is now being tailored to serve the unique needs of the agricultural sector.

The issue also highlights the entrepreneurial spirit through the Millionaire from Moringa, showcasing a journey of sustainable success. On the scientific front, we delve into Brassinosteroids, a phytohormone essential for climate-resilient agriculture. These narratives prove that whether through business innovation or laboratory research, the goal remains the same: a more robust and profitable farming future.

Furthering our commitment to sustainability, we present a Life Cycle Assessment of the "Farm to Fork" journey to improve food processing. We also explore Decoding Seeds, where Omics technologies

are fundamentally transforming seed science and crop improvement. Together, these contributions reflect an integrated ecosystem where science, sustainability, and digital transformation converge to empower our community.

At Just Agriculture, we remain committed to providing a credible platform for knowledge exchange that translates into meaningful action. I extend my gratitude to our authors, reviewers, editorial team, and above all, the farming community whose dedication inspires our work. Included in this issue is a Press Release regarding our latest initiatives.

Let us continue sowing innovation and cultivating sustainable growth.

Dr. Sushila Hooda
C hief Editor,
Just Agriculture-The Magazine

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ULTRASONIC FOOD CUTTING:
A REVOLUTION IN PRECISION SLICING

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INTRODUCTION

Ultrasonic food cutting is an advanced unit operation in food processing that employs high-frequency mechanical vibrations to improve slicing precision, portion control, and product integrity along industrial production lines. In contrast to conventional mechanical cutting systems, which depend primarily on blade sharpness and applied mechanical force, ultrasonic cutting blades oscillate at frequencies typically in the range of 20–40 kHz (20,000–40,000 cycles per second). These vibrations generate a localized reduction in interfacial friction between the blade and the food matrix, resulting in cleaner cuts, reduced deformation, minimized product adhesion, and improved hygienic performance. Consequently, ultrasonic cutting enhances process efficiency, maintains structural and sensory quality of food products, and reduces material losses during high-throughput operations.

HOW ULTRASONIC CUTTING WORKS?

The core components of an ultrasonic cutting system include:

Ultrasonic power generator: Converts mains electrical power (e.g., AC 220 V) into high-frequency electrical energy suitable for ultrasonic use.

Transducer (Converter): An electromechanical device that converts electrical energy into mechanical vibrations at ultrasonic frequencies.

Amplitude booster: Modifies the vibration amplitude before it reaches the cutting tool.

Sonotrode / Blade (Tool head): The actual cutting implement that vibrates longitudinally and interacts with the food product.

ENGINEERING BENEFITS ULTRASONIC CUTTING

Reduced cutting force and friction

Ultrasonic vibration lowers the force needed to cut even dense or frozen foods. This means lower stress on product structure and reduced deformation — essential when handling delicate items like cakes or cheese.

Clean and precise cuts

The frictionless surface created by ultrasonic vibrations prevents smearing and tearing. Multi-layered or textured foods (e.g., sandwiches, filled pastries, nut breads) are separated cleanly without displacing contents, a significant advantage over conventional blades.

Minimal product sticking and easier cleaning

Food does not adhere to the blade, dramatically reducing cleaning time and machine downtime in some setups by 70–90 % compared to conventional blades.

Higher productivity and consistency

Ultrasonic cutters can function at higher speeds while maintaining uniform slice thickness and quality, making them ideal for mass production environments. Machine parameters like vibration amplitude and feed speed can be adjusted for precision control.

Integration and automation

These systems can be retrofitted into existing production lines or designed as part of fully automated solutions, interacting with conveyors, portioning devices, and robotic handling.

REAL-WORLD APPLICATIONS IN THE FOOD INDUSTRY

Ultrasonic cutting has become increasingly common across multiple sectors:

Bakery and confectionery

Cakes, breads, pastries, and confectionery items that are sticky or fragile benefit from uniform, aesthetically pleasing slices without displacement of fillings or toppings.

Dairy and cheese

Both soft and hard cheeses can be cut cleanly without crumbling especially important for products with inclusions like nuts or fruit.

Meat and frozen Foods

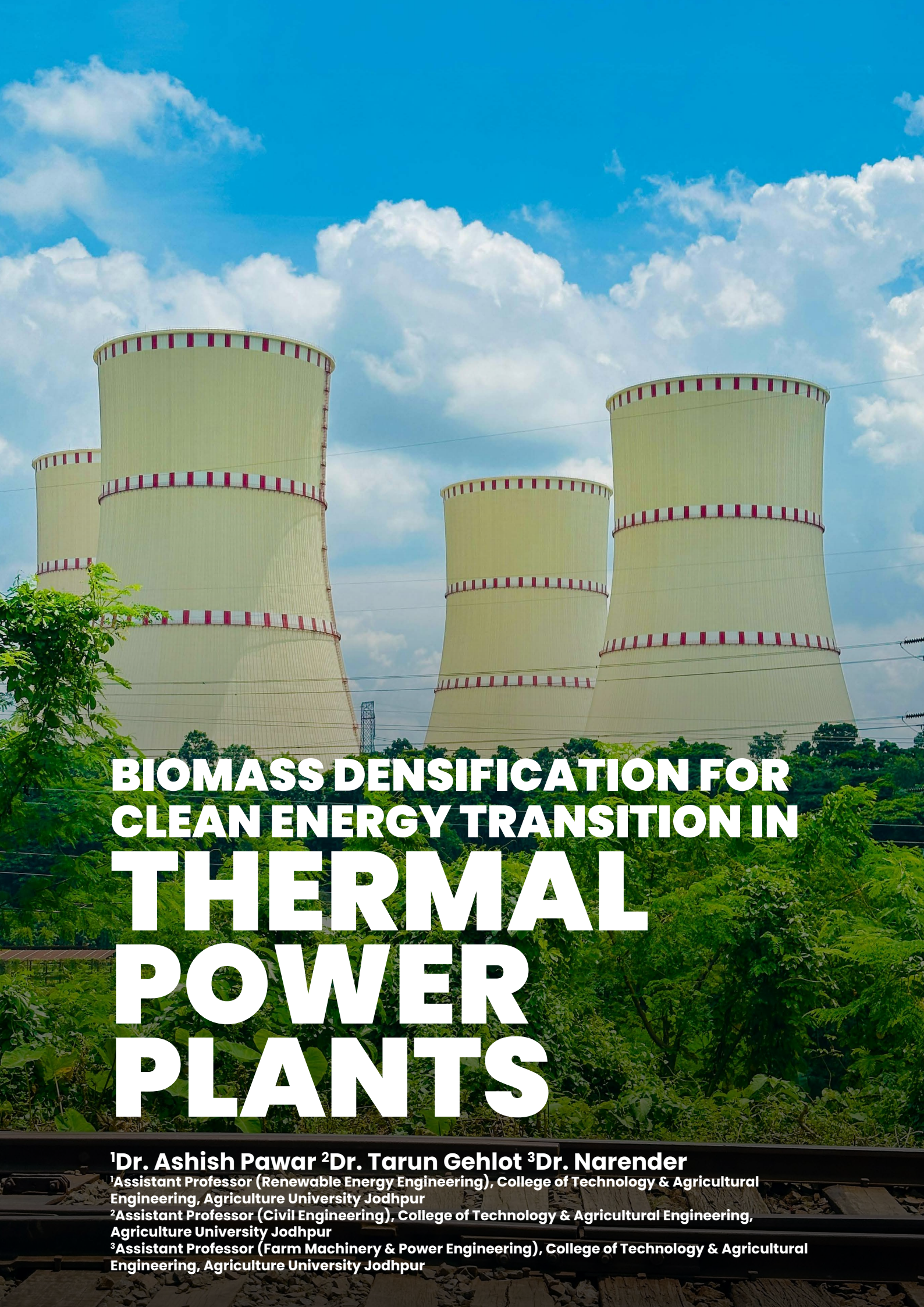
Modules can slice meats and fish, including frozen blocks, without thawing, preserving freshness and reducing contamination risk.

Prepared foods and sandwiches

Delicate, layered products with various fillings are sliced without compressing or smearing internal ingredients.

CONCLUSION

Ultrasonic food cutting represents a major technological leap in food engineering. By leveraging high-frequency mechanical vibrations to reduce friction and enhance precision, it addresses many limitations of traditional cutting methods from product deformation and waste to hygiene and productivity challenges. Today, this technology is not only transforming industrial food manufacturing but also setting new standards for quality and consistency in processing lines worldwide.



BIOMASS DENSIFICATION FOR CLEAN ENERGY TRANSITION IN THERMAL POWER PLANTS

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INTRODUCTION

The global energy sector is undergoing a major transformation toward cleaner and sustainable energy sources in order to reduce greenhouse gas emissions and combat climate change. Although renewable energy technologies such as solar and wind are rapidly expanding, coal-based thermal power plants still account for a significant portion of electricity generation in many countries, particularly in developing economies like India. These power plants provide reliable base-load electricity but also contribute substantially to carbon emissions and environmental pollution. One promising strategy to reduce the environmental impact of coal-based power generation is the integration of biomass as a renewable fuel. However, raw biomass such as crop residues, wood chips, and agricultural waste have limitations including low bulk density, high moisture content, irregular shape, and difficulty in transportation and storage. To overcome these challenges, biomass densification technologies have been developed. Biomass densification converts loose agricultural residues into compact fuels such as briquettes and pellets with higher energy density and improved combustion characteristics.

Biomass densification plays a crucial role in enabling the use of biomass in thermal power plants through co-firing with coal. This approach not only reduces dependence on fossil fuels but also supports rural economies and helps manage agricultural residues. The adoption of biomass densification for power generation is therefore emerging as an important pathway for achieving a clean energy transition in thermal power plants.

CONCEPT OF BIOMASS DENSIFICATION

Biomass densification is the process of compressing loose biomass materials into solid fuels with higher density and uniform shape. Agricultural residues such as rice straw, wheat straw, mustard stalks, sawdust, and sugarcane bagasse can be converted into briquettes or pellets using mechanical pressure and sometimes heat. The two most common forms of densified biomass fuel are:

1. Biomass briquettes: cylindrical or rectangular compressed blocks of biomass.
2. Biomass pellets: small cylindrical particles produced through pelletization.

These densified fuels possess several advantages over raw biomass, including:

- Higher bulk density
- Improved handling and transportation
- Lower moisture content
- Uniform size and shape
- Higher calorific value
- Better combustion efficiency

Fig: Biomass Densification Process Power Generation

Research has shown that densification improves the fuel properties of biomass, making it comparable to medium-grade coal in certain cases. Pelletization also reduces energy consumption during processing and improves the overall quality of the fuel.

Due to these benefits, densified biomass fuels are increasingly being used in industrial boilers and thermal power plants.

BIOMASS CO-FIRING IN THERMAL POWER PLANTS

Biomass co-firing is the process of substituting a portion of coal with biomass in existing coal-fired power plants. In this process, biomass pellets or briquettes are blended with coal and burned together in the boiler to produce steam for electricity generation.

This approach offers several advantages:

- Reduction in coal consumption
- Lower greenhouse gas emissions
- Utilization of agricultural waste
- Minimal modification required in existing power plants

Studies and industry experiences indicate that biomass co-firing can be implemented at relatively low biomass-to-coal ratios without major modifications to existing infrastructure. Even small percentages of biomass blending can significantly reduce emissions and energy consumption. In India, thermal power plants are encouraged to adopt biomass co-firing using pellets made from agricultural residues. The Central Electricity Authority has advised power utilities to utilize 5–10% biomass pellets along with coal in power plants to reduce pollution and improve sustainability. The adoption of biomass co-firing can therefore play an important role in transitioning the power sector toward cleaner energy systems.

ROLE OF BIOMASS DENSIFICATION IN CLEAN ENERGY TRANSITION

Biomass densification supports the clean energy transition in several ways.

4.1 Reduction of Carbon Emissions

Coal-based thermal power plants are major sources of carbon dioxide emissions. By partially replacing coal with biomass, the overall carbon footprint of electricity generation can be reduced. Biomass is considered carbon-neutral because the carbon dioxide released during combustion is roughly equal to the carbon absorbed by plants during their growth cycle. Therefore, using biomass pellets in power plants contributes to lowering net greenhouse gas emissions. Each percentage increase in biomass co-firing can reduce carbon emissions by a similar proportion in coal-fired power plants.

4.2 Utilization of Agricultural Residues

Large quantities of agricultural residues are generated every year in farming regions. In many cases, these residues are burned in open fields, leading to severe air pollution. Biomass densification provides a sustainable solution for managing crop residues by converting them into

valuable energy resources. The use of agricultural waste for pellet production not only reduces environmental pollution but also contributes to renewable energy generation.

4.3 Improvement in Fuel Handling and Storage

Raw biomass has low density and irregular shape, which makes transportation and storage difficult. Densification significantly improves the bulk density of biomass fuels, allowing them to be transported and stored efficiently.

Pellets and briquettes also provide uniform combustion characteristics, which makes them suitable for industrial-scale energy production in thermal power plants.

4.4 Enhancing Energy Security

Biomass resources are locally available and renewable. Utilizing densified biomass fuels reduces dependence on imported coal and fossil fuels. This contributes to energy security and promotes the use of indigenous energy resources.

5. Biomass Densification Technologies

Several technologies are used for biomass densification, depending on the type of feedstock and desired product.

5.1 Briquetting Technology

Briquetting machines compress biomass under high pressure to produce solid briquettes. The process may involve screw presses, piston presses, or hydraulic presses. Briquettes typically have diameters ranging from 50 mm to 90 mm and are widely used in industrial boilers and small-scale power plants.

5.2 Pelletization Technology

Pelletization involves compressing finely ground biomass through a die to produce small cylindrical pellets, usually 6–12 mm in diameter. Pellet mills are commonly used for this purpose. Pellets are more uniform and have higher energy density than briquettes, making them suitable for co-firing in large thermal power plants.

5.3 Torrefaction Technology

Torrefaction is an advanced thermal treatment process in which biomass is heated in the absence of oxygen at moderate temperatures (200–300°C). This process improves the fuel properties of biomass and makes it more similar to coal. Torrefied biomass pellets have higher calorific value, lower moisture content, and improved grindability, allowing them to be used in power plants with minimal modifications.

POLICY SUPPORT AND INITIATIVES

Governments around the world are promoting biomass utilization to support renewable energy goals. In India, several initiatives have been introduced to promote biomass densification and co-firing in thermal power plants. The Ministry of Power has mandated biomass co-firing in coal-based thermal power plants as part of efforts to reduce air pollution and carbon emissions. The policy recommends blending around 5–7% biomass pellets with coal. This initiative is expected to reduce carbon dioxide emissions by approximately 38 million tonnes annually while also providing additional income opportunities for farmers. Additionally, the government provides financial incentives and subsidies for setting up biomass pellet manufacturing plants. These policies encourage entrepreneurs and industries to invest in biomass densification technologies.

FUTURE PROSPECTS

The future of biomass densification in the power sector appears promising. Continuous research and technological advancements are improving the efficiency and cost-effectiveness of densification technologies. Advanced processes such as torrefaction, pyrolysis, and hybrid biomass fuels are expected to enhance the performance of biomass fuels in thermal power plants. In addition, increasing environmental regulations and global climate commitments are encouraging power utilities to adopt cleaner energy solutions. Countries with large agricultural sectors have significant potential to utilize biomass residues for energy production. By integrating biomass densification with existing power infrastructure, nations can achieve a gradual and economically viable transition toward cleaner energy systems.

CONCLUSION

Biomass densification has emerged as a vital technology for enabling the use of renewable biomass fuels in thermal power plants. By converting loose agricultural residues into high-density briquettes and pellets, densification improves fuel handling, storage, and combustion efficiency. The integration of densified biomass fuels through co-firing with coal offers a practical pathway for reducing greenhouse gas emissions while maintaining reliable electricity generation. It also provides solutions for agricultural residue management, rural employment generation, and sustainable energy production. With strong policy support, technological advancements, and effective supply chain development, biomass densification can play a transformative role in the clean energy transition of thermal power plants. The authors claim no originality of the work except for the arrangement and presentation of the subject matter through screening of various reviews from books, journals, websites etc.

MILLIONAIRE FROM MORINGA: A JOURNEY OF INNOVATION & SUSTAINABLE SUCCESS

Parashuram M Patil

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BIRDS Campus, Tukkanatti (Village), Mudalagi (Taluk), Belagavi (Dist.) Karnataka

Name: Shri. Prakash Ramu Udagatti
Age: 40 Years
Education: Diploma in Agriculture
Address: S/O Ramu Udagatti, Udagatti totta, Shirgaon village,Chikkodi taluka, Belagavi District, Karnataka-591214.

BACKGROUND/ SITUATION ANALYSIS:

Shri Prakash Ramu Udagatti, despite having a Diploma in Agriculture, was unable to utilize his technical knowledge effectively for nearly 15 years due to family constraints. His 7-acre farm faced challenges such as undulating terrain, water scarcity, and dependence on rainfed conditions. Traditional cropping systems resulted in low productivity and unstable income, limiting economic growth and farm sustainability.

CATALYSTS OF CHANGE:

Post-2019, with improved water availability, he transformed his farming approach under the technical guidance of ICAR BIRDS Krishi Vigyan Kendra (KVK), Belagavi-1.

He adopted a diversified farming system:

- Drumstick (ODC variety): 5 acres
- Betel vine: 1 acre
- Sugarcane (wide spacing): 1 acre

This transition marked a shift from subsistence farming to a market-oriented, high-value horticulture system.

PATHWAY(S) TO PROGRESS:

Shri Prakash Ramu Udagatti adopted innovative and climate-smart practices by planting the improved ODC variety of drumstick for pod purpose in January 2024, which started yielding from June 2024, ensuring early returns.

He followed scientific spacing of 13 feet (row to row) and 7 feet (plant to plant) for better growth and productivity. To enhance soil health and sustainability, he applied vermicompost along with bio-agents such as VAM, Trichoderma, and Pseudomonas, supported by mulching for moisture conservation and weed control.

Additionally, he developed an efficient drainage system to manage excess water during heavy rainfall, preventing crop damage. These integrated practices significantly improved yield, reduced input costs, and became key drivers of his success, leading to higher income and a sustainable farming model.

HIGHLIGHTS

- Shifted from traditional farming to a diversified, high-value horticulture system
- Adopted ODC drumstick cultivation (5 acres) with spacing (13 ft × 7 ft)
- Achieved early and consistent yield within 5–6 months
- Implemented climate-smart practices: mulching, bio-inputs, and drainage management
- Transitioned to a sustainable and market-oriented farming model.

TECHNOLOGICAL INTERVENTIONS

- Adoption of ODC drumstick variety for pod production.
- Scientific spacing: 13 ft × 7 ft
- Application of vermicompost and bio-agents (VAM, Trichoderma, Pseudomonas)
- Use of mulching for moisture conservation.
- Installation of efficient drainage system.
- Use of manual harvesting tools to reduce drudgery.

PRODUCTIVITY & INCOME ENHANCEMENT:

- **Increase in Productivity (%):** Achieved high productivity with 57 tons of drumstick yield from 5 acres, indicating a substantial improvement over traditional cropping systems
- **Increase in Income (₹/year):** Net profit increased from₹70,000 per acre (traditional crops) to ₹4,40,000 per acre, generating about ₹22,00,000 from 5 acres during 2025
- **Reduction in Cost of Production / Drudgery:** Use of bio-agents (VAM, Trichoderma, Pseudomonas) and vermicompost reduced input costs; adoption of drumstick harvester minimized labour effort and eliminated the need for climbing trees
- **Improvement in Livelihoods & Food Security:** Transition to a high-income, sustainable farming system ensured better financial stability and resilience for the family
- **Employment Generation:** Created self-employment and additional labour opportunities during harvesting and marketing; owning a vehicle and developing direct market linkages significantly enhanced profitability.

Production Performance

- Total plants: 2200 plants in 5 acres
- Yield (2025): 57 tonnes
- Average daily harvest: 1 tonne/day
- Fruit characteristics:
  - 11 pods = 1 kg
  - Average weight per pod: 90 grams

This reflects high productivity under scientific cultivation practices.

Economics of Cultivation

- Harvesting & packaging cost: ₹2.5/kg
- Market selling price: ₹60 to ₹180/kg (through direct network marketing)

Income Enhancement

- Previous income: ₹70,000/acre (traditional crops)
- Current income: ₹4,40,000/acre
- Total income (5 acres): ₹22,00,000 (2025)

Key Economic Advantages

- Reduced input costs through bio-inputs.
- Higher price realization via direct market linkages.
- Daily cash flow due to continuous harvesting.

SOCIAL/PERSONAL EMPOWERMENT/AWARDS & RECOGNITION:

Shri Prakash Ramu Udagatti has emerged as a role model farmer in his region, gaining recognition and respect from fellow farmers and the local community for his successful drumstick cultivation. His transformation has strengthened his decision-making role within the family and farm, showcasing effective leadership in adopting innovative practices.

He has been widely recognized by local farmers, YouTubers, and media platforms, and his success story has been featured through interviews by Farm TV, the Taluka Agriculture Department, and ICAR BIRDS KVK, Belagavi-1 (Tukkanatti). His achievements have inspired other farmers to adopt sustainable and high-value farming practices, establishing him as a source of motivation and knowledge sharing in the community.

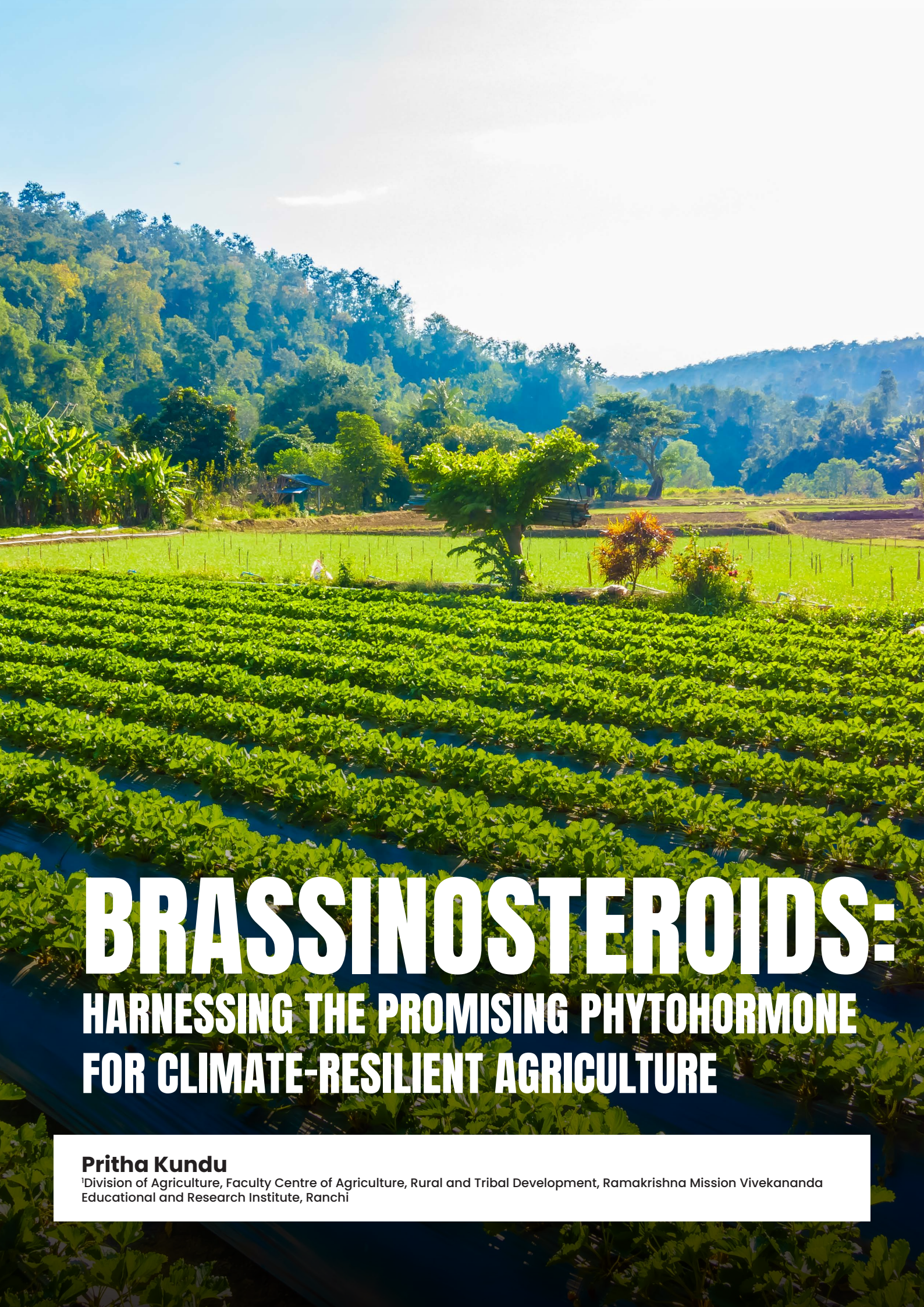
Influence to Other Farmers

- Motivated farmers to shift towards drumstick and high-value crop cultivation
- Promoted adoption of scientific practices (spacing, bio-inputs, mulching)
- Encouraged farmers to develop direct market linkages for better income
- Actively shares knowledge through farm visits and interactions
- Recognized as a local role model for progressive and sustainable farming

VISUAL SNAPSHOT OF SUCCESS/ ACTION PHOTOGRAPHS.

Happy farmer with his produce in his hand along with him P M Patil, Scientist (Horticulture), KVK, Belagavi-1 and Archana Patil, Krishi Sakhi, Shirgoan.

Harvesting with manual hand harvester.



BRASSINOSTEROIDS:
HARNESSING THE PROMISING PHYTOHORMONE FOR CLIMATE-RESILIENT AGRICULTURE

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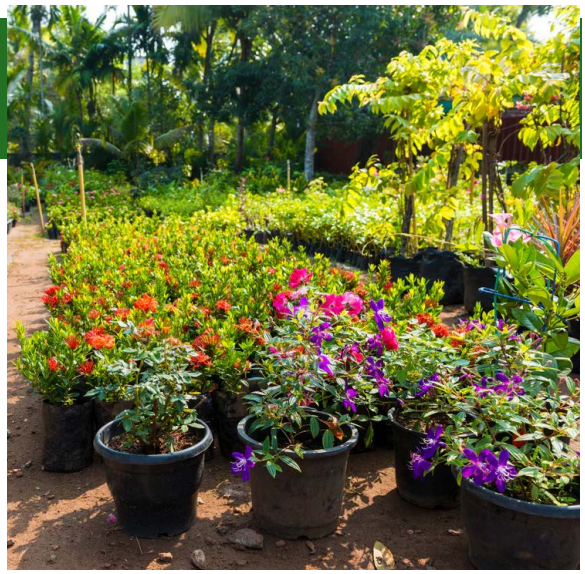
ABSTRACT

Climate-resilient agriculture integrates advanced technologies and biological strategies to sustain crop productivity under changing environmental conditions. Among these approaches, phytohormones play a crucial role in regulating plant growth, development, and stress adaptation. Brassinosteroids (BRs) are a class of naturally occurring polyhydroxylated sterol compounds present in almost all plant tissues, including roots, shoots, leaves, flowers, pollen, seeds, and vascular tissues. They are key regulators of physiological and biochemical processes such as photosynthesis, cell elongation, and biomass accumulation. In addition to promoting normal plant growth, BRs enhance plant tolerance to various abiotic and biotic stresses by modulating stress-responsive pathways. Owing to these multifunctional roles, BRs have emerged as promising tools for improving crop resilience, productivity, and quality in sustainable agricultural systems. Understanding the biosynthesis, signalling pathways, and physiological functions of BRs will be essential for developing innovative strategies for crop improvement and stress management under climate change.

INTRODUCTION

The Sustainable Development Goals (SDGs), endorsed by United Nations Member States, underscore the importance of sustainable agricultural practices in strengthening human well-being while safeguarding the environment. In addressing the underlying challenges of crop production utilization of modern tools and technologies is of utmost importance, which includes GPS-guided machinery, drones, real-time sensors, genetic engineering and simulation-based crop modelling for developing high-yielding, stress-resilient, and nutritionally enhanced crop varieties.



Of all the mentioned advancements, utilising phytohormones as key plant growth regulators (PGRs) play profound roles throughout the plant life cycle, modulating an array of plant developmental, biochemical and

physiological processes and imparting adaptive response under both optimal and adverse conditions. Numerous studies have reported that the exogenous application of specific phytohormones - like jasmonates, brassinosteroids, naphthaleneacetic acid (NAA), N-(2-chloro-4-pyridyl)-N'-phenylurea (CPPU), and ethephon – has the potential to improve plant growth while also significantly affecting sex differentiation, seed yield, and imparting resistance to biotic and abiotic stresses. Therefore, phytohormones are integral tools offering promising solutions for sustaining plant growth and improving yield under adverse environmental circumstances with extensive use in agriculture and horticulture.

At present, nine major classes of phytohormones have been identified, with auxins being the first discovered phytohormone, following idenfication of cytokinins (CKs), gibberellins (GAs), ethylene (ET), salicylic acid (SA), brassinosteroids (BRs), jasmonates (JAs), abscisic acid (ABA), and strigolactones (SLs) being the most recently characterized phytohormone. This article discusses the identification and functions of less-discussed phytohormone brassinosteroids (BRs) for use in sustainable agriculture.

BRASSINOSTEROIDS

Brassinosteroids (BRs) are a class of polyhydroxysteroids that act as essential plant hormones and are involved in a broad spectrum of biochemical, physiological and developmental processes. BRs are naturally occurring polyhydroxylated sterol derivatives present in every plant part, such as root, shoot, leaves, pollen, flower, seed and vascular cambium in all species of plants which share structural similarity with animal and insect steroid hormones.

2.1. Isolation and Discovery of BRs

The growth promoting brassinosteroids extract was isolated from Brassica napus by Mitchell and his co-workers from the USDA, who called it "brassins" while examining pollen extracts of 30 plant species and later brassinolide was recognised as the most bioactive form of BRs. BRs are present in both free and conjugated forms, with approximately 69 conjugated and 5 free forms reported. BRs were discovered toward the end of the twentieth century, but their dynamic applications and physiological roles have been widely explored since the beginning of the twenty-first century; consequently, are often regarded as the "hormone of the twenty-first century."

2.2. Biosynthesis of BRs in Plants

The biosynthesis of BRs is assumed to predominantly occur in the endoplasmic reticulum. In plant systems, the formation of dynamic protein complexes composed of sequential enzymes called metabolons has been proposed as a mechanism to enhance the efficiency of substrate channelling within a single biosynthetic pathway, and BR biosynthesis follows

a triterpenoid pathway, which is largely mediated by cytochrome P450 (CYP) enzymes. The pathway begins with the hydroxylation of cellular membrane-associated campestrol (Sakurai, 1999). As the biosynthesis advances, intermediates undergo successive hydroxylation and gradually become more polar with the addition of a hydroxyl group at specific C positions, including C-22 and C-23 on the side chain and C-2, C-3 and C-6 on the steroidal rings.

2.3. Physiological Role of BRs in Plants

BRs are integral phyto-hormones that regulate a diverse range of biochemical and physiological activities, including cell division, cell elongation, photomorphogenesis, xylem differentiation, tracheary element differentiation, as well as the transition from vegetative to reproductive stage, reproductive development and overall plant growth. Furthermore, BRs modulate the initiation of lateral root primordia, playing a crucial role in lateral root development, and play a vital role in hypocotyl elongation, root and shoot development, stomatal patterning, pollen tube growth, seed germination, pollen development, and fertilisation.

Among all the different functions regulated by BRs, photosynthesis is particularly important as it is fundamental to plant biomass accumulation and growth (Siddiqui et al., 2018). BRs enhance photosynthetic efficiency by increasing chlorophyll biosynthesis within plant cells. Consequently, BRs enhance net photosynthetic rate, stomatal conductance, internal CO2 fixation and carbonic anhydrase activity, leading to improved carbon assimilation and sugar accumulation. Exogenous application of 24-epibrassinolide (EBL) increases chlorophyll a, chlorophyll b, and carotenoid content, improving light utilisation capacity in many crops like rice, wheat, green gram, chick pea, faba bean and mustard.

In addition to developmental regulation, BRs play an integral role in generating stress responses, modulating plant tolerance to both abiotic and biotic stresses, and influencing stomatal development (Ackerman-Lavert and Savaldi-Goldstein, 2019). BRs are also critical in maintaining male and female fertility in crops, and regulate etiolation, stigma elongation, plant architecture, thermo-tolerance, proton transport, tiller number, leaf angle, and leaf size.

These hormones exhibit a strong interaction with auxins, specifically by modifying auxin transport pathways, thereby indirectly participating in long-distance signalling and coordinating tropic responses in various plant organs.

Additionally, exogenous application or genetic manipulation of BR biosynthesis and signalling pathways has been reported to enhance crop yield potential.

2.4. Role of BRs in Crop Production

The application of BRs offers significant potential for enhancing crop resilience and supporting sustainable agriculture under increasing abiotic stresses associated with climate change. By

elucidating the mechanisms of BR action, their potential as an innovative strategy to enhance the productivity and quality of crops. Application of BRs at different growth stages has been reported to enhance nutrient uptake, plant growth, yield, and quality attributes in many crops. Even at very low concentrations, BRs positively influence tropical, subtropical, and temperate crops by improving growth, quality, and stress tolerance, thereby contributing to higher productivity and greater economic benefits for farming communities. Some of the positive effects of BR(s) application on some agronomic crops are listed in Table 1.

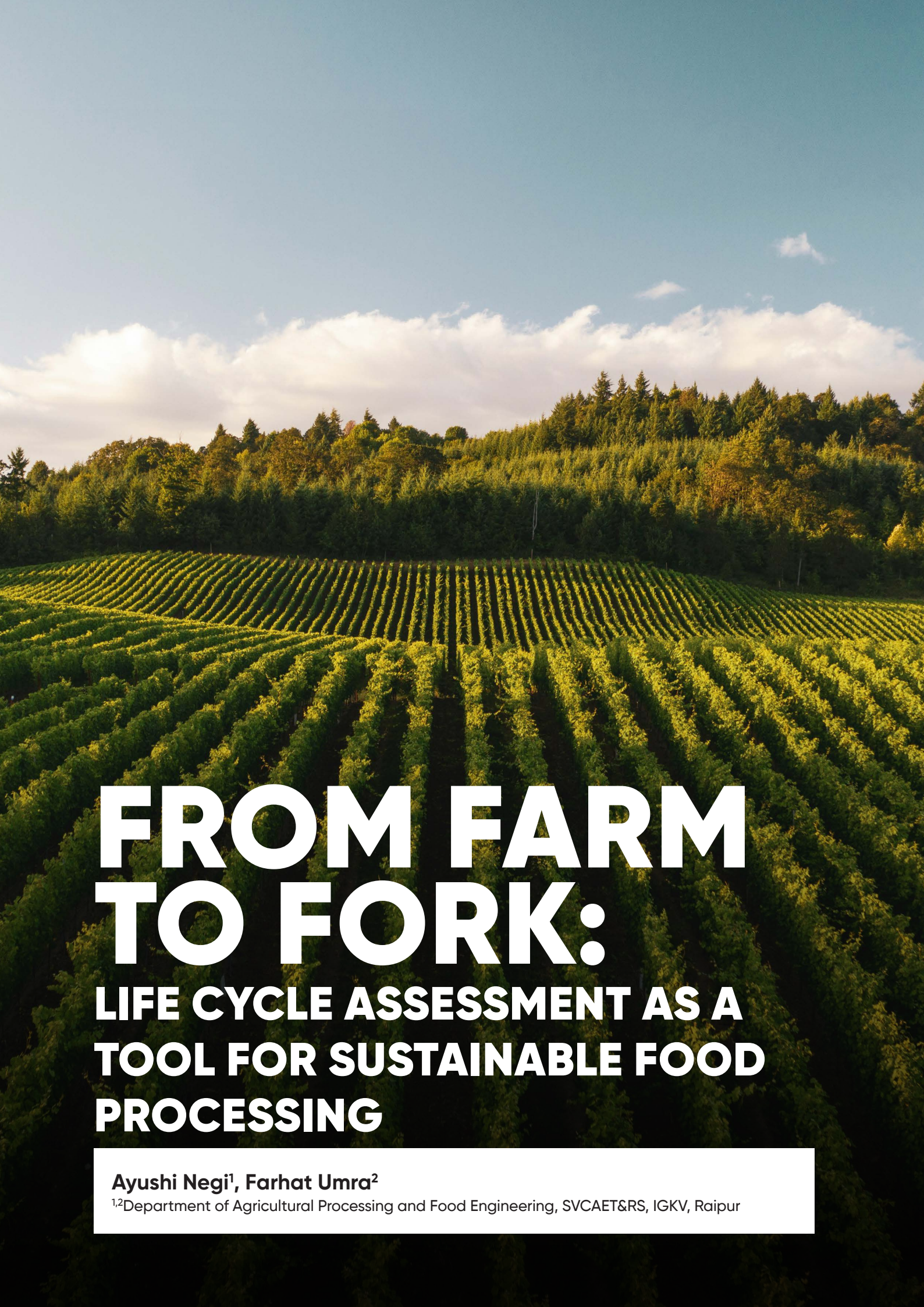
Table 1: Effect of exogenous application of BRs on agronomic crops

Crop	BR type, dosage and mode of application	Effects on Plant
Wheat	24-epibrassinolide (EBL) by foliar application	Enhancement of growth, biomass, yield, and decrease in oxidative damage in wheat under drought
Egyptian cotton (Gossypium barbadense)	Putrescine (Put) at 2 ppm and EBL at 10-7 M	Increase in morphological characters, e.g., plant height, number of leaves per plant, leaf area per plant and total plant dry weight, total free amino acids, total sugars, total soluble phenols, antioxidant enzymes CAT, POX and SOD activities, increasing in the number of open bolls, fibre length, fibre strength and micronaire value.
Fingermillet	Brassino steroids @ 0.1 ppm	Positive influence on the morphology, growth and development of the plant
Cowpea	100 nM EBR	Improved photosystem II efficiency, inducing increased effective quantum yield of PSII photochemistry (ΦPSII), photochemical quenching coefficient (qP) and electron transport rate (ETR).
Mustard	Brassinolide (BL) at 0.5µM	Promotion of shoot, root and foliar growth indicating that BL mitigated the negative effect of the semi-arid conditions.
Barley	10−6, 10−7 and 10−8 M BL; leaf spraying (3×, both leaf sides)	Decreased the production of malondialdehyde (MDA) and reactive oxygen species (ROS) in the leaves and roots by increasing enzymatic antioxidant activities, ameliorating photosynthetic parameters and maintaining the plant growth under drought stress

CONCLUSION

Phytohormones play an integral role in regulating and modulating plant growth, development, and stress responses, expanding across all phenological stages. Both endogenous hormone signalling and exogenous application are reported to be effective strategies to enhance plant resilience and boost crop productivity under changing environmental conditions. However, the understanding, particularly of the cross-regulation between different plant hormones governed by a complex network of hormonal interactions and environmental signals, is limited at present, which curtails the tailoring of phytohormone application for specific crops, developmental stages and agroecological zones.

In conclusion, phytohormones are a promising frontier in plant science and related research fields. A deeper understanding of their multifaceted role and intricate regulatory networks will be foundational in formulating sustainable strategies for crop improvement, stress mitigation and novel biotechnological applications.



FROM FARM TO FORK:

LIFE CYCLE ASSESSMENT AS A TOOL FOR SUSTAINABLE FOOD PROCESSING

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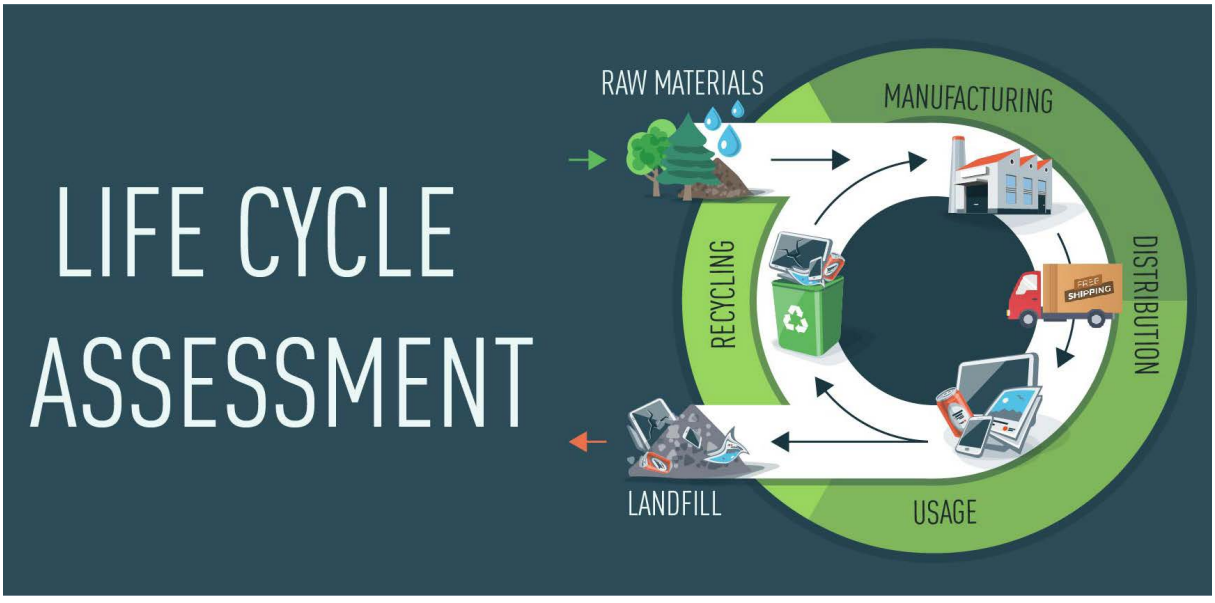
INTRODUCTION

Global food production is showing substantial growth due to increasing population demand, accompanied by a rising demand to promote better nutrition and overall well-being of an individual. Thus, growing demand calls for quick manufacturing and faster processing. It is crucial to evaluate the environmental impact of these processing and manufacturing activities, particularly in terms of their energy consumption. As the food processing sector expands and consumption levels rise, the resultant environmental impact becomes more pronounced, underscoring the need for improvements in the sector. The need of an hour in improving food production and consumption systems should be discussed on sustainable development, mentioning both the environmental and socio-economic aspects of food systems as environmental consequences are significant. Food industry alone is responsible for the greenhouse gas (GHG) emissions accounting for (25%). Food processing industry generate measurable amounts of solid waste, air pollutants, and wastewater. The food manufacturing sector plays a crucial role in food security and has the potential to operate in an eco-friendlier manner by optimizing performance, improve efficiency, reducing energy usage, reducing waste, and maximize the shelf life of food products. Life Cycle Assessment (LCA) is a standardized approach especially made for the analysis of the environmental impacts associated with a product,process, or service throughout its entire lifespan, i.e., from cradle to grave.

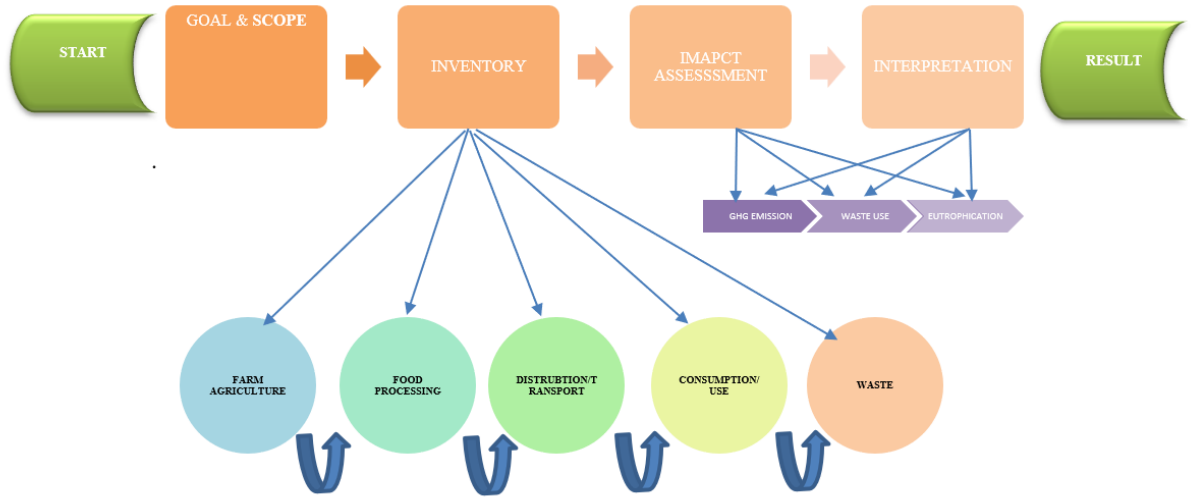


CONCEPT

A Life Cycle Assessment (LCA) offers comprehensive insights into the environmental impacts of across various indicators such as- raw material utilization, energy consumption, carbon emissions, and water use. Life cycle assessment (LCA) along

with energy management are useful tools in the food industry, by promoting efficient management practices across entire food supply chain. LCA forms a framework includes defining the goal and scope, inventory analysis, impact assessment, and result interpretation. Clearly articulating the goal is essential for simplifying the scoping process and establishing study boundaries, which, in turn, enhances the precision and efficiency of data collection. Additionally, the selection of a 'functional unit' is a unique aspect of LCA that sets it apart from other environmental assessment methodologies. This functional unit serves as a quantitative measure of the performance of a product system. Careful selection of the functional unit is crucial for improving the accuracy of LCA studies and the relevance of their findings. The life cycle inventory process entails mapping and quantifying the inputs and outputs associated with a process or a system. During the impact assessment phase, the potential effects of these input and output streams on human health, ecosystems, and the future availability of natural resources are identified and evaluated.

Life Cycle Assessment (LCA) process for Food by ISO 14040



LCA IN FOOD INDUSTRY

The Role of Life Cycle Assessment (LCA) in the Food Industry

Life Cycle Assessment (LCA) in the food industry serves several critical functions.

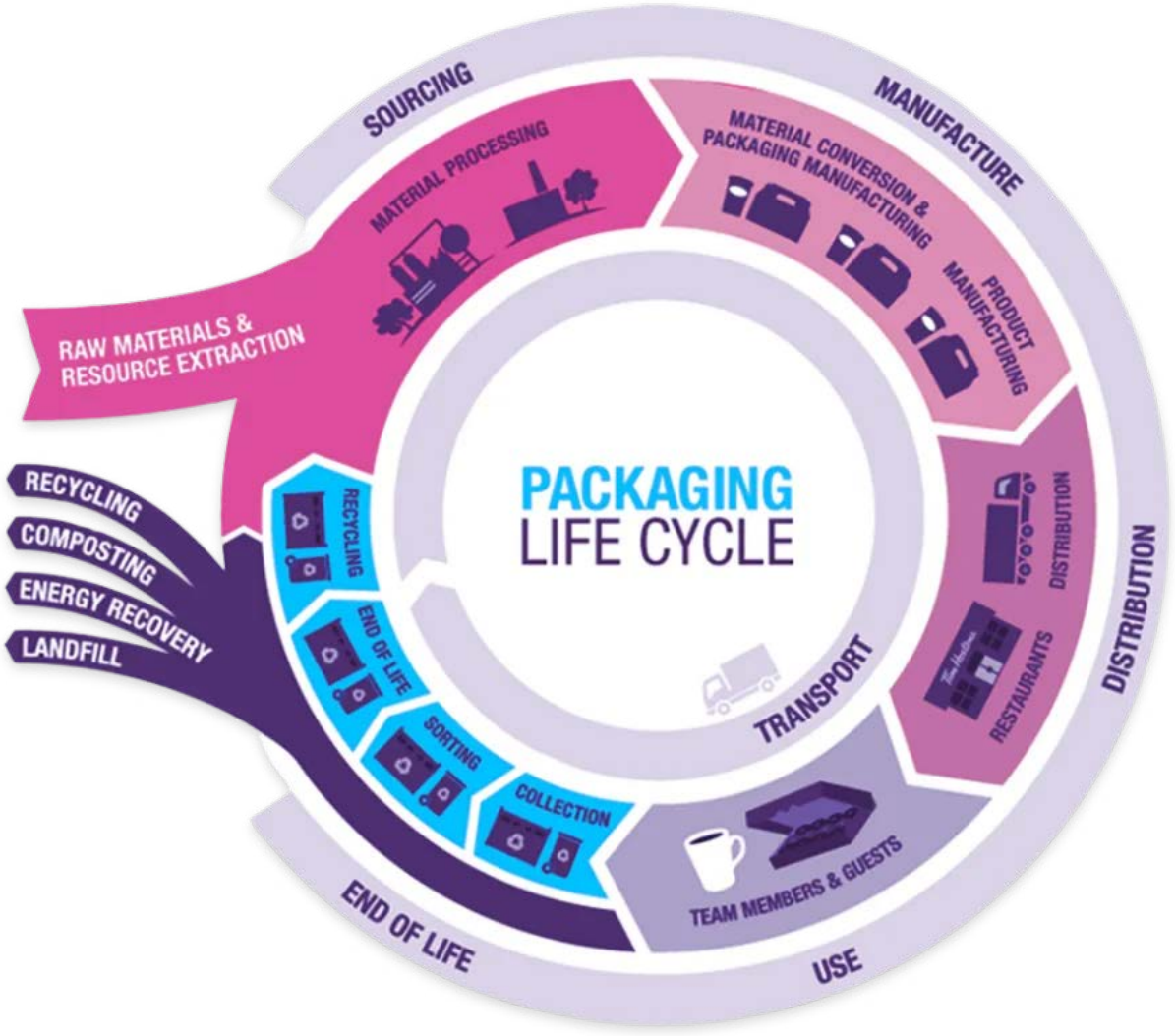
1. It is used to quantify the environmental impacts associated with food products.
2. This facilitates the comparison of various processing technologies, enabling the identification of energy and emission hotspots. This assessment supports the development of sustainable production practices and informs policy.
3. This contributes to enhancing the environmental performance of food supply chains.

Table 1 Review of life cycle assessment studies in food processing industry

S. No.	Product / Sector	Goal & Scope	System Boundary	Functional Unit	Key Impact Categories	Major Findings
1	Dairy Processing	Evaluate environmental impact of milk processing	Cradle-to-gate	1 L processed milk	GWP, Energy use, Water footprint	Energy consumption during pasteurization major contributor
2	Rice Milling	Assess energy and emission profile	Gate-to-gate	1 ton milled rice	GHG emissions, Electricity use	Parboiling stage highest energy demand
3	Fruit Juice Processing	Compare conventional vs improved processing	Cradle-to-grave	1 L juice	Carbon footprint, Waste generation	Packaging contributes significantly to total GWP
4	Meat Processing	Evaluate environmental hotspots	Cradle-to-gate	1 kg processed meat	GWP, Eutrophication, Land use	Raw material production dominates total impact
5	Wheat Flour Milling	Analyze resource efficiency	Gate-to-gate	1 ton flour	Energy intensity, Emissions	Electricity use in milling is key hotspot
6	Edible Oil Processing	Assess sustainability of oil extraction methods	Cradle-to-gate	1 kg refined oil	GHG emissions, Water use	Solvent extraction increases environmental load
7	Sugar Industry	Evaluate life cycle emissions	Cradle-to-grave	1 kg sugar	Carbon footprint, Wastewater	Bagasse utilization reduces net emissions

LCA IN PACKAGING INDUSTRY

The primary purpose of food packaging, particularly for beverages, is to protect them from external contamination, damage, and other influences. Effective packaging ensures that the ingredients and nutritional components remain unalterable from the producer to the consumer. Furthermore, traceability, convenience, and tamper indication are increasingly significant functions of packaging in the food industry. Food packaging must comply with industry standards and consumer expectations by containing food in a cost-effective manner that ensures food safety and minimizes environmental impacts. Food packaging represents a critical sector within the food industry, significantly contributing to the environmental impact from production through to the material's end-of-life. Numerous studies have been conducted within the packaging industry to enhance material sustainability, thereby reducing environmental damage and waste. In product-package systems, the production of packaging materials constitutes the primary source of environmental impacts, accounting for 59% to 77% of the total impact. Conversely, the production of carton-based containers exhibits lower



energy consumption compared to the manufacturing of glass and steel materials, resulting in reduced CO2 emissions within the packaging subsystem. A 10% reduction in bottle weight could decrease the Global Warming Potential (GWP) by up to 4%, while packaging wine in cartons instead of glass bottles could achieve a GWP reduction of approximately 5%. Furthermore, refillable bottles can diminish packaging impacts by up to 87% compared to conventional disposable bottles. Numerous studies have identified the end-of-life stage as one of the most critical phases in the life cycle of packaging. Specifically, a study examining the end-of-life of various packaging materials, including newspapers, cardboard, mixed paper, glass bottles and jars, aluminum cans, tin-plated steel cans, plastic bottles, and other conventionally recoverable materials, underscored that recycling significantly reduces greenhouse gas emissions. Notably, recycled glass from packaging, when used in the production of new materials, requires 35% less energy than the production of virgin glass.

CONCLUSION

Given that food production systems and consumption patterns are among the primary contributors to environmental impacts, the application of life cycle thinking and assessment to food-related supply chains has significantly expanded over time. Life cycle assessment has been extensively utilized to evaluate agricultural systems, processing, and manufacturing activities, as well as to compare alternatives "from field to fork" and up to food waste management. Nevertheless, despite the growing number of LCA food studies and the burgeoning literature on both methodological aspects and case studies, several challenges remain to be addressed to ensure that LCA provides robust results.

DECODING SEEDS:

HOW OMICS TECHNOLOGIES ARE TRANSFORMING SEED SCIENCE AND CROP IMPROVEMENT

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INTRODUCTION

Seeds are the foundation of agriculture and play a crucial role in ensuring global food security. The quality of seeds directly influences crop productivity, plant establishment, and tolerance to environmental stresses. For many years, seed science relied mainly on traditional breeding, seed testing, and physiological studies to improve seed quality. Although these approaches significantly improved crop performance, understanding the molecular mechanisms regulating seed development, dormancy, germination, and longevity remained limited. In recent years, the emergence of omics technologies has transformed biological research, including seed science. Omics approaches allow researchers to study the complete set of genes, RNA molecules, proteins, and metabolites present in biological systems. These technologies provide a comprehensive understanding of the molecular processes occurring within seeds (Weckwerth, 2011; *Rajjou et al.*, 2008). The integration of different omics approaches has enabled scientists to decode the complex regulatory networks controlling seed traits. As a result, modern seed research is becoming more precise and efficient, contributing significantly to crop improvement and sustainable agriculture (*Angelovici et al.*, 2017).

OMICS TECHNOLOGIES

Omics refers to large scale approaches used to analyze different biological molecules in an organism. In seed biology, omics technologies help researchers study molecular components involved in seed development and function. Major omics fields used in seed research include:

- Genomics
- Transcriptomics
- Proteomics
- Metabolomics
- Epigenomics
- Phenomics

Each of these approaches provides information at a different biological level, and together they help scientists understand the complete molecular landscape of seeds (Weckwerth, 2011).

GENOMICS IN SEED RESEARCH

Genomics involves the study of the entire genetic material or genome of an organism. Advances in genome sequencing technologies have enabled researchers to identify genes responsible for important seed traits such as seed size, germination capacity, dormancy, and stress tolerance (*Varshney et al.*, 2009). Through genomic studies, scientists can locate quantitative trait loci (QTLs) controlling seed characteristics and develop molecular markers for plant breeding. These markers are useful for selecting desirable traits during crop improvement programs.

For example, research in Arabidopsis has identified genes such as DOG1 (Delay of Germination 1) that regulate seed dormancy, providing valuable insights into the genetic control of germination (*Bentsink et al.,* 2006).

TRANSCRIPTOMICS: STUDYING GENE EXPRESSION

While genomics identifies genes, transcriptomics focuses on studying gene expression by analyzing RNA molecules. Transcriptomic analysis helps researchers determine which genes are active during different stages of seed development and germination (*Wang et al.,* 2009). Using advanced technologies such as RNA

sequencing (RNA-Seq), scientists can study gene activity during seed maturation, dormancy, and germination. This helps identify genes involved in hormone regulation, particularly those associated with abscisic acid (ABA) and gibberellic acid (GA) pathways that control seed dormancy and germination.

Transcriptomics also helps researchers understand how seeds respond to environmental stresses such as drought, salinity, and temperature changes (*Nonogaki et al.,* 2010).

PROTEOMICS IN SEED BIOLOGY

Proteomics is the large-scale study of proteins present in biological systems. Proteins are essential molecules that carry out most cellular functions, including metabolic reactions, structural support, and stress responses. Proteomic studies have identified several important proteins involved in seed development and protection. These include seed storage proteins, heat shock proteins (HSPs), and late embryogenesis abundant (LEA) proteins, which play important roles in protecting seeds from environmental stress during maturation and storage (*Rajjou et al.,* 2012). Understanding the role of these proteins helps researchers improve seed vigor, stress tolerance, and longevity.

METABOLOMICS AND SEED METABOLISM

Metabolomics focuses on the analysis of small molecules or metabolites present in biological systems. In seeds, these metabolites include sugars, amino acids, lipids, and secondary compounds involved in metabolic processes. Metabolomic studies help researchers understand how seeds accumulate and utilize energy reserves that support germination and early seedling growth. These studies also provide insights into biochemical changes that occur during seed ageing and deterioration. Identification of metabolic markers related to seed vigor and viability can help improve seed quality assessment and storage strategies.

INTEGRATION OF MULTI-OMICS APPROACHES

One of the most important developments in modern seed science is the integration of multiple omics technologies, known as multi-omics approaches. By combining data from genomics, transcriptomics, proteomics, and metabolomics, researchers can obtain a comprehensive understanding of the molecular networks regulating seed development and performance.

Multi-omics approaches allow scientists to:

- Identify genes controlling important seed traits
- Understand regulatory pathways involved in seed germination
- Discover molecular markers for seed quality assessment
- Develop improved crop varieties with better seed performance

This integrated approach is becoming a powerful tool for solving complex problems in seed biology and crop improvement.

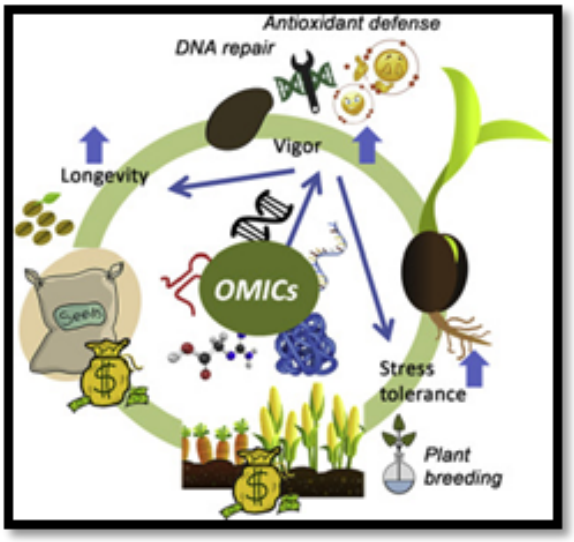


Fig. 1. Applications of Omics Technologies in Seed Biology for Improving Seed Longevity, Vigor, Stress Tolerance, and Crop Productivity

APPLICATIONS IN SEED SCIENCE AND AGRICULTURE

Advances in seed omics have several practical applications in agriculture:

1. **Improving seed vigor and germination:** Omics technologies help identify molecular markers associated with high seed vigor and germination capacity.
2. **Developing stress-tolerant crop varieties:** Understanding molecular responses to environmental stress helps breeders develop resilient crop varieties.
3. **Enhancing seed nutritional quality:** Omics approaches enable researchers to improve seed protein and nutrient composition.
4. **Improving seed storage and longevity:** Identification of genes and proteins associated with seed ageing helps develop better storage techniques.
5. **Supporting modern plant breeding:** Omics-based tools allow faster and more precise selection of desirable traits.

FUTURE PROSPECTS OF SEED OMICS

The future of seed science lies in integrating omics technologies with artificial intelligence, high-throughput phenotyping, and big data analysis. Emerging approaches such as single-cell omics and spatial transcriptomics will allow scientists to study gene activity at the cellular level within seeds. These advanced technologies will provide deeper insights into seed biology and contribute to the development of high-quality seeds capable of meeting the challenges of climate change and increasing global food demand.

CONCLUSION

Seeds are vital for sustainable agriculture and global food security. Advances in omics technologies have revolutionized seed biology by providing a deeper understanding of the molecular mechanisms controlling seed development, dormancy, germination, and longevity. The integration of genomics, transcriptomics, proteomics, and metabolomics is helping scientists decode complex biological processes within seeds. These insights are contributing to the development of improved crop varieties with better seed quality, enhanced stress tolerance, and higher productivity. As omics technologies continue to evolve, they will play an increasingly important role in shaping the future of seed science and crop improvement.

ASMS Strengthens Agri-Commerce Network with AYOU's Hyderabad Rollout

Avio Smart Market Stack Limited ("ASMS") has announced the expansion of its agri-supply and aggregation platform under the AYOU brand into Hyderabad, marking a significant milestone in scaling its post-harvest infrastructure and market linkage capabilities under Project AVIO Agritech. Following its strategic investment in Shree NagaNarasimha Pvt. Ltd. (SNN), which operates under the AYOU brand, ASMS has been working closely with the team to operationalise and expand the platform beyond its established base in Bengaluru. As part of this next phase of growth, AYOU has initiated operations in Hyderabad, with meaningful progress already made in onboarding supply partners, securing warehouse infrastructure, and establishing strong linkages with key offtakers across quick commerce, modern trade, and institutional segments. The official commercial launch of operations in Hyderabad is expected in early May 2026.

AYOU has built a robust operating presence in Bengaluru, supported by well-integrated supply chains and strong demand partnerships. The platform currently caters to leading quick commerce and retail players such as Swiggy Instamart, Blinkit, Zepto, KPN Fresh, along with other large-format buyers across modern trade and institutional channels. This deep demand-side integration has been instrumental in driving scale, consistency, and operational discipline.

The Hyderabad rollout represents the first major geographic expansion following ASMS' investment and underscores the platform's readiness for multi-city execution. The new operations are designed to replicate AYOU's proven model focused on structured aggregation, quality-driven supply, and technology-enabled warehouse management. With foundational work already completed across infrastructure and partnerships, the Hyderabad expansion is well-positioned to enable efficient sourcing, aggregation, and distribution of fresh produce in one of India's key consumption hubs.

This expansion aligns with ASMS' broader vision of building a distributed, technology-enabled agri-commerce ecosystem under Project AVIO Agritech. By integrating physical infrastructure with digital intelligence, the company aims to enhance supply chain efficiency, minimize post-harvest losses, and strengthen farmer-to-market connectivity.

Commenting on the development, **Vidyasagar Reddy, Managing Director, Avio Smart Market Stack Limited**, said: *"Our investment in AYOU is centered on building a scalable, execution-focused agri platform with strong integration across supply and demand. The expansion into Hyderabad marks a significant milestone, demonstrating both operational readiness and the ability to replicate our model across markets. As we continue to build under Project AVIO Agritech, such expansions will play a critical role in shaping a distributed, technology-driven agri ecosystem."*

About AYOU

AYOU is an agri-supply and aggregation platform focused on sourcing fresh produce directly from farmers and Farmer Producer Organizations (FPOs) and supplying to quick commerce, modern trade, retail, and institutional clients across India.

About Avio Smart Market Stack Limited (ASMS)

Avio Smart Market Stack Limited (ASMS) is a rural financial inclusion and technology company focused on building integrated rural commerce and agri-tech platforms under Project AVIO.

Cargill Showcases Brand Gemini at Kurkumbh Plant, Outlines Manufacturing Excellence, Product Safety and Quality procedures for consumers

Marking three decades of brand Gemini, Cargill today opened the doors to its Kurkumbh plant in Maharashtra, offering a closer look at its world class manufacturing standards, stringent food safety and quality practices, while outlining plans to strengthen its edible oils business in India through its flagship consumer brand, Gemini.

The visit was hosted by **Dheeraj Talreja, Vice President & Managing Director, Cargill Food South Asia,** who shared Cargill's growth priorities and strategic importance of Maharashtra market, where Gemini is a market leader. Well-known Marathi actor **Priya Bapat** also joined the visit along with select consumers, influencers and media, adding her perspective as a long-standing consumer of the brand.

Maharashtra is a key market for Gemini, where the brand has strong presence and consumer base. With highest per capita GDP in the country, high consumption of multiple oils including sunflower, soybean, groundnut and cottonseed, Maharashtra is a strategically important geography and logistics backbone for Gemini's diversified portfolio of cooking oils. Cargill has had manufacturing presence in Kurkumbh, Maharashtra since 2005. Today this plant employs over 500 people (full time and contractual), engaged in refining and packaging the full range of Gemini oils.

With a strong legacy of 30+ years behind us, Gemini is known for its unshakable consumer trust and superior product quality. As we look at the next 30 years, Gemini is transforming into a future ready edible oils brand, deeply rooted in India's traditions, while evolving with modern consumers through premiumization, digital engagement, and presence on next generation distribution channels", said Dheeraj Talreja during the plant tour.

Advancing Portfolio to Meet Health & Wellness Preferences

Gemini offers a comprehensive portfolio, including sunflower oil, soybean oil, groundnut oil, rice bran oil, kachi ghani mustard oil, vanaspati, and blended oils. The brand today reaches over 5 million households catering to diverse consumer needs and is available across 1 lakh+ retail outlets in the state.

With evolving consumer preferences towards premium, health led and lifestyle-oriented oils, Gemini is considering expanding into a range of premium cold-pressed oils. This reflects a premiumization push for the edible oil brand aimed at driving future growth, while focus on maintaining leadership across its core product categories of sunflower and soyabean oil continues.

Channel Expansion Across E-commerce and New-age Retail

Gemini's presence across e-commerce and quick commerce platforms is also being strengthened, indicating the growing online consumer purchasing pattern. While a large percentage of business is still driven by physical retail stores, Gemini recorded strong growth in its e-commerce business over the past year, increasing its contribution to overall sales. As online platforms gain momentum amongst urban audiences seeking convenience and easy product discovery, Cargill is also expanding across these channels to remain close to consumers.

Recognized for Food Safety and Quality

Cargill's Kurkumbh facility has been recognized at the Confederation of Indian Industry (CII) Food Safety Awards 2024, for 'Outstanding Performance in Food Safety' in the 'Large Manufacturing Food Businesses – Fats & Oils' category.

Gemini was also ranked as No. 1 sunflower oil brand in India in 2023 (extended for two years), as per a brand study by Consumer Voice, a Govt recognized testing organisation. These recognitions reflect the company's adherence to stringent food safety protocols, consistent quality practices, and alignment with regulatory standards.

Community Development

As an active member of society, Cargill has been collaborating with local stakeholders and government programs on community programs in the state, focused on improving education, nutrition, and public health. Infact, Cargill leadership today inaugurated a school development initiative, Project Vidya Vikas, at the local State Reserve Police School, Daund which includes new playground flooring, provision of additional benches and building toilets for the school, benefitting over 1500 students from local communities.

Past initiatives include, 'Badhte Kadam', a program to address health and nutrition deficiencies among school children, reaching over 5,000 children in Kurkumbh over three years. 'Project Sahyog', a comprehensive village development program was implemented in Kurkumbh Village of Daund Block of Pune District. In addition, Cargill has been supporting maternal and child health programs by providing monthly micronutrient-fortified food and conducting awareness sessions on nutrition and healthcare in partnership with Anganwadi workers, benefitting over 4,200 beneficiaries across 168 Anganwadi centers. Cargill also supported local communities during the COVID-19 pandemic through relief initiatives, as part of its ongoing community engagement efforts.

About Cargill

Cargill is committed to providing food, ingredients, agricultural solutions, and industrial products to nourish the world in a safe, responsible, and sustainable way. Sitting at the heart of the supply chain, we partner with farmers and customers to source, make and deliver products that are vital for living.

Our 155K+ employees innovate with purpose, providing customers with life's essentials so businesses can grow, communities prosper, and consumers live well. With 160 years of experience as a family company, we look ahead while remaining true to our values. We put people first. We reach higher. We do the right thing – today and for generations to come. For more information, visit Cargill.com and our News Center.

Yara India Builds on 15 Years of Progress with a Future-Focused Strategy for Sustainable and Digital Farming

Yara India today reinforced its long-term commitment to advancing sustainable, innovative crop nutrition solutions and digitally enabled agricultural growth in the country, guided by its core ethos of purpose, partnership and prosperity. As part of this vision, Yara is enhancing last-mile product traceability by onboarding a majority of its key channel partners onto the Retailer Ordering System (ROS), a key feature of Yara Connect, the retailer-facing mobile application designed to strengthen the smallholder farming ecosystem by connecting Yara with its extensive network of retailers and dealers. . With the growing demand for biological solutions in agriculture, the company is also scaling its R&D efforts to expand its biologicals portfolio and introduce more advanced, sustainable products for farmers across India.

As the company completes 15 years of operations in India, this milestone reflects the depth of its partnerships, the scale of its impact, and the strong foundation it has built to drive the future of Indian agriculture.

Over the years, Yara India has advanced sustainability through responsible manufacturing and digital advisory tools. It has also strengthened soil health initiatives and collaborations with FPOs, research institutes, and government partners.

Yara has significantly strengthened India's crop nutrition landscape. A major milestone in this journey was its 2018 acquisition of the Babrala urea facility, the largest standalone FDI in India's regulated fertiliser sector , which today enables high-quality production and supports efficient logistics across key agricultural regions.

Yara has also led supply-chain innovation through India's first premium fertiliser rake movement and a first-of-its-kind premium vessel movement, setting new benchmarks for efficiency and quality delivery in the sector.

Reflecting on the 15-year milestone, **Sanjiv Kanwar, Managing Director, Yara South Asia,** said, "Our journey in India has been guided by a clear purpose, to responsibly feed the world and protect the planet. Over the past 15 years, we have partnered closely with farmers, governments, and industry stakeholders to drive sustainable, innovation led agricultural growth. India remains a strategic market for Yara, and as we look ahead, our focus is on deepening our commitment to innovation, sustainability, and farmer prosperity."

Yara India's progress has been strengthened by its partnerships with global and national institutions. Speaking on the occasion, **Chargé d'Affaires Arvinn Gagdil, Deputy Ambassador Royal Norwegian Embassy in Delhi,** remarked, "Yara's 15-

year journey in India reflects the strong and growing cooperation between India and Norway in advancing sustainable agriculture. Through innovation, technology, and farmer engagement, Yara has made significant contributions to the sector, and we look forward to continued collaboration in the years ahead."

As part of the commemoration, Yara India hosted a special gathering at the Royal Norwegian Embassy in New Delhi, bringing together government representatives, agricultural experts, policy leaders, industry stakeholders, and progressive farmers. The programme featured leadership addresses, the unveiling of a special Yara@15 Compendium and brand film, and a panel discussion on **"India's Agri GDP 2X Journey: Reimagining the Future of Farming."** Farmer representatives shared first-hand accounts of how Yara's innovative solutions and digital platforms have improved productivity, quality, and resilience in their fields. The event concluded with discussions on emerging opportunities in sustainable agriculture, innovation-driven growth, and partnership-led development.

About Yara India

Yara is the world's leading fertilizer company and provider of environmental solutions. Yara India, a wholly owned subsidiary of Yara International ASA, is a leading provider of crop nutrition solutions, committed to advancing sustainable agriculture. Established in 2011, the company marks 15 years in India, guided by its philosophy of Purpose, Partnership, and Prosperity.

With a strong farmer-centric approach, Yara India promotes balanced crop nutrition through over pan India Yara Crop Nutrition Centres (YCNCs), benefiting 1.2 million farmers across 15 states. Through partnerships with 218 Farmer-Producer Organisations (FPOs), the company reaches over 150,000 farmers, while its digital platforms connect with more than 12 million farmers nationwide. The company has strengthened its ecosystem through Yara Knowledge Growth Centres (YKGCs), advanced soil testing, and the Yara India Technology Centre (Yara ITC), one of Yara's three global digital hubs driving innovation. Its portfolio includes speciality fertilisers such as YaraVita, water-soluble nutrients, and emerging biostimulant solutions, supported by a robust manufacturing base, including the 1.2 million MT urea facility in Babrala, Uttar Pradesh.

Yara India also advances inclusive growth and long-term prosperity through the Yara Grow Enterprise, empowering MSMEs, youth, and women to build resilient rural communities.

Amid Rabi Losses and Weak Monsoon Outlook, CropLife India Issues Zaid Crop Advisory

Urges timely sowing, science-based crop protection and vigilance against counterfeit inputs

At a time when farmers across several states are dealing with significant losses to Rabi crops from unseasonal hailstorms, CropLife India, the apex association of leading R&D-driven crop science companies, has issued a Zaid Crop Advisory urging farmers to prioritise timely sowing, science-based crop protection and responsible input sourcing during a cropping window that has become critical for farm incomes this year.

The advisory comes at a time when Indian farmers are confronting multiple challenges ahead of the Zaid season. Successive western disturbances have damaged harvest-ready Rabi crops across Rajasthan, Haryana, Uttar Pradesh, Madhya Pradesh and other states; prompting the Union Agriculture Minister to direct officials to expedite coordinated crop loss assessments. In several regions, these disruptions has delayed field preparation for the upcoming Zaid crops. Meanwhile, disruptions to global supply chains and key shipping routes due to the conflict in West Asia have raised input costs across agricultural sectors, including crop protection. While the Government's recent decision to temporarily waive customs duty on key petrochemical inputs is a welcome step, the full benefit is expected to materialise only in subsequent production cycles. Private forecaster Skymet has projected a below-normal monsoon for 2026 at around 94 per cent of the long-period average, with a 30 per cent probability of drought, while NOAA has indicated a 62 per cent chance of El Niño emerging by June–August. A weaker monsoon outlook makes Zaid season returns even more important as a financial buffer ahead of an uncertain Kharif.

"Farmers who have suffered Rabi losses cannot afford to miss the Zaid window. Every week of delay in sowing compresses the growing period and directly reduces yields. Our advisory focuses on what farmers can act on right now, selecting heat-tolerant varieties, ensuring irrigation every five to seven days, using mulch to conserve moisture and regular scouting for pests such as red spider mites, aphids and fruit flies, whose cycles accelerate in summer heat. With residual moisture from unseasonal rain still present in some

areas, vigilance against fungal diseases is equally important. Timely, need-based use of crop protection products, in line with label directions and Good Agricultural Practices, can make a significant difference in protecting yields during this short but vital season," said **Mr. Durgesh Chandra, Secretary General, CropLife India.**

"While the evolving geopolitical situation offers some near-term relief to supply chains, uncertainty remains and cost pressures have not fully eased. In such an environment, supply gaps and price volatility increase the risk of counterfeit or substandard crop protection products entering the market. This is a particular concern during the Zaid season, where even one failed spray application on a short-duration crop can result in total yield loss. Farmers must purchase only from licensed dealers, verify product authenticity and strictly follow label and leaflet directions," Mr. Chandra added.

The Zaid Crop Advisory covers management practices for short-duration summer crops such as watermelon, muskmelon, cucumber, bitter gourd, moong dal and fodder maize, grown between March and June. It recommends early sowing to ensure harvest before monsoon arrival, drip irrigation for water efficiency during peak summer heat, organic or plastic mulch to conserve soil moisture and regular field monitoring with need-based application of crop protection products. The advisory also emphasises use of mechanisation to complete land preparation quickly within the short Zaid window and intercropping with legumes such as moong to maintain soil nitrogen levels.

CropLife India reiterates its commitment to supporting farmers through timely advisories, stewardship and Good Agricultural Practices.

About CropLife India

CropLife India is committed to advancing sustainable agriculture and it is an association of 17 R&D driven member companies in crop protection. We jointly represent ~ 70% of the market and are responsible for 95% of the molecules introduced in the country. Our member companies have annual global R & D spend of 6 billion USD and are firmly committed to engaging with the farming community to enable Safe, Secure Food Supply.

Elitecon International Strengthens CSR, with 'Empowering Farmers through Smart & Sustainable Agriculture Initiative with ICAR-NIRCA Collaboration

Elitecon International Ltd (BSE: 539533), a diversified FMCG enterprise, has strengthened its Corporate Social Responsibility (CSR) framework with a focused push towards sustainable agriculture and rural development. As part of this, the company has launched a farmer-centric initiative, "Empowering Farmers through Smart & Sustainable Agriculture," aimed at introducing precision agriculture technologies and resource-efficient farming practices in tobacco-growing regions of Andhra Pradesh.

The initiative is designed to address key challenges in tobacco farming, particularly excessive water usage, high energy consumption, and inefficient input utilisation. Through the adoption of precision agriculture practices, the programme aims to enable measurable improvements, including up to 60-65% reduction in irrigation water usage, up to 45% lower energy consumption, and nearly 15% improvement in crop productivity. These efficiencies have the potential to increase farmer income by approximately ₹1.4 lakh per hectare per season.

As part of its broader CSR roadmap, the company is driving farmer engagement and rural empowerment by promoting climate-resilient and resource-efficient cultivation practices.

The initiative introduces modern technologies such as sensor-based irrigation systems, automated fertigation, IoT-enabled farm monitoring, and drone-assisted crop protection, helping farmers optimise water usage, nutrient delivery, and crop protection, and is being implemented with technical support from ICAR - National Institute for Research on Commercial Agriculture (ICAR-NIRCA), integrating scientific expertise with on-ground demonstrations and farmer training.

Commenting on the development, **Mr. Vipin Sharma, Executive Director, Elitecon International Ltd,** said, *"At Elitecon International, sustainability is embedded in our growth strategy. Through this initiative, we aim to create long-term value by empowering farming communities with practical, technology-driven solutions that improve efficiency, productivity, and income outcomes."*

As part of on-ground execution, farmers are being provided hands-on exposure through field demonstrations and training sessions focused on precision irrigation, fertigation practices, and advanced crop

protection methods, supporting the wider adoption of modern agricultural techniques.

In parallel, Elitecon International continues to integrate environmental responsibility across its operations through resource optimisation, responsible sourcing, and energy-efficient processes, while its governance-led CSR framework ensures transparency, accountability, and a continued focus on creating meaningful, scalable impact across communities.

About Elitecon International Limited

Founded in 1987 (erstwhile Kashiram Jain & Company Ltd), Elitecon International Limited (BSE: 539533) is a diversified FMCG and global trade enterprise. Headquartered in India, the company has built a growing international footprint with operations spanning the UAE, the UK, Singapore, and more than 50 countries worldwide.

With over three decades of manufacturing and a strong global supply network, 300+ strategic partnerships, and operations supporting the employment of over 2,000 individuals (directly and indirectly), Elitecon continues to strengthen its position as a fast-growing player in the global FMCG and trading ecosystem.

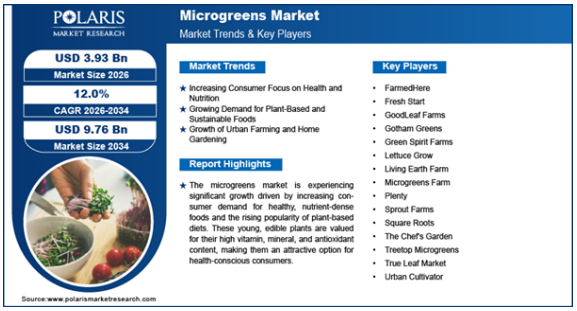
Microgreens Market Size Worth USD 9.76 Billion by 2034 | CAGR: 12.0%

The global Microgreens Market is experiencing unprecedented growth as demand for nutrient rich, sustainable food options accelerates across the food & beverages and agricultural sectors. According to the latest Microgreens Market Size, Share & Growth Analysis Report by Polaris Market Research, the market was valued at USD 3.52 billion in 2025 and is projected to expand at a robust compound annual growth rate (CAGR) of 12.0% from 2026 to 2034, reaching an estimated USD 9.76 billion by 2034.

This transformative expansion reflects powerful shifts in consumer preferences, technological innovation in agriculture, and evolving distribution dynamics that are reshaping the microgreens landscape globally.

1. Health & Sustainability Driving Consumer Demand

Microgreens — young, edible shoots harvested between 7 and 21 days after germination — are increasingly sought after for their concentrated nutrient profiles, vibrant colors, and versatile culinary use.



These greens have gained significant traction among health conscious consumers as nutrient dense alternatives to traditional produce, often delivering higher levels of vitamins, minerals, and antioxidants per unit weight.

The food & beverages industry is capitalizing on this trend by integrating microgreens

into menus ranging from fresh salads and smoothies to gourmet dishes at high end restaurants. Their appeal lies not only in enhanced nutrition but also in the sustainability attributes associated with their cultivation — especially when produced via innovative farming technologies.

2. Technological Innovation: Indoor Vertical Farming Takes the Lead

A pivotal driver of the Microgreens Market growth is the rapid advancement in controlled environment agriculture (CEA), including indoor vertical farming and hydroponics. These agricultural innovations enable year round production regardless of climate, optimize space utilization, and reduce resource consumption — all critical advantages in urban and space constrained environments.

Within the farming type segment, indoor vertical farming holds the largest share and is expanding fast due to its ability to deliver consistent quality and stable supply. Vertical farms leverage cutting edge lighting, climate control, and water efficient systems that minimize environmental impact while maximizing yields. This makes them a strategic choice for producers looking to meet rising microgreens demand from supermarkets, online grocers, and foodservice sectors.

3. Evolving Distribution Channels Expand Market Reach

Distribution channels play a critical role

in bringing microgreens to consumers. Retail stores currently dominate market share, driven by consumer preference for in store selection and the proliferation of supermarkets and health food outlets offering fresh produce. However, online platforms are rapidly gaining ground, propelled by the growth of e commerce and direct to consumer delivery models, particularly in urban markets.

Farmers markets and direct farm sales continue to contribute to market diversity, appealing to consumers who prioritize locally sourced produce and farm to table experiences. Restaurants and foodservice businesses also represent an important segment, especially for premium microgreens varieties such as basil, arugula, and radish, which enhance both flavor and presentation.

For more information, visit @ https://www.polarismarketresearch.com/industry-analysis/microgreens-market/request-for-sample

4. Regional Landscape: North America Leads, Asia Pacific Rising

The North America microgreens market stands as the largest regional contributor to global revenue, driven by a strong culture of health orientated food consumption, advanced agricultural technology adoption, and well established retail and e commerce networks. Consumers and producers alike are embracing microgreens as part of broader wellness and sustainability movements.

Europe also commands significant market share, supported by robust organic food sectors and progressive agricultural policies. Regions such as the Netherlands, Germany, and the UK are notable for integrating microgreens into both conventional and specialty food markets.

Meanwhile, the Asia Pacific microgreens market is at an inflection point, with growing urbanization, rising disposable incomes, and increased awareness of health centric diets fueling demand in countries such as Japan, China, and India. Although still in early stages compared to Western markets, Asia Pacific is poised for rapid expansion in the coming decade.

5. Competitive Landscape and Industry Innovation

The global Microgreens Market is characterized by diverse industry participation, ranging from commercial growers to technology innovators and home growing solution providers. Prominent players such as Gotham Greens, GoodLeaf Farms, The Chef's Garden, and True Leaf Market are actively expanding production capacity, adopting sustainable methods, and enhancing product portfolios to engage health driven consumers and foodservice clients.

Innovation is not limited to cultivation alone. Market participants are also exploring eco friendly packaging, optimized cold chain logistics, and value added offerings such as premium seed mixes and indoor growing systems to broaden consumer reach and improve profitability.

6. Outlook & Opportunities

With a projected market value of USD 9.76 billion by 2034 and a 12.0% CAGR, the Microgreens Market is emerging as a dynamic segment within the food & beverages and agriculture industries.

Key growth opportunities include expanding retail and online distribution, enhancing consumer education about nutritional benefits, and leveraging sustainable farming practices. Continued investment in controlled environment technologies will further strengthen supply chains and support year round production.

Conclusion

As consumer preferences shift toward healthier, plant based, and sustainable food choices, microgreens are set to become an integral component of future diets and agricultural strategies. The Microgreens Market is not just growing — it's flourishing, driven by innovation, demand for nutrient dense food, and scalable agricultural solutions that meet the needs of both producers and consumers worldwide.

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