

MAR 2025



Agro India

The Ultimate Agri Business Magazine

Betel Leaves

Microgreens

Geranium

Sugarcane

Soil Less Cultivation

Drones

APNI FASAL KA ASAL FAAYDA UTHAAYE!

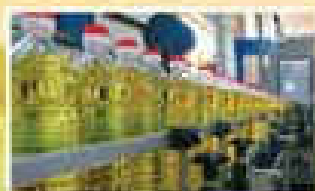
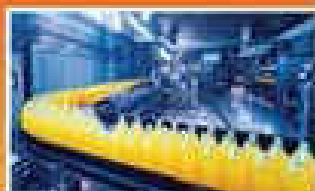
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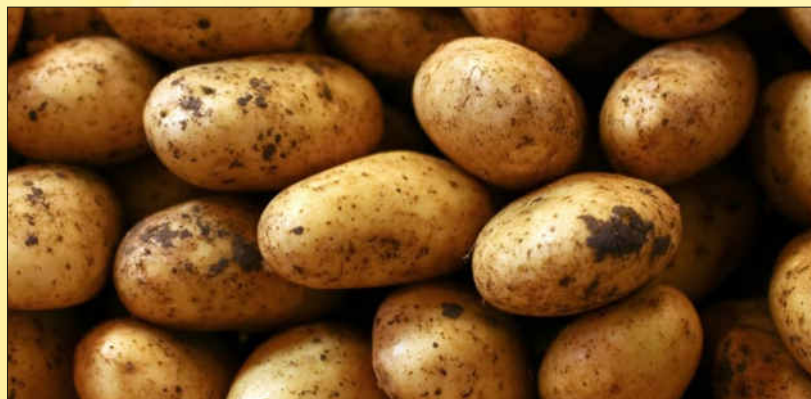
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EDITORIAL

It is projected that , in the year 2025, the Agriculture Sector and allied activities are expected to contribute around 16% to India's GDP at current prices and supporting 46 % of the population. Further, the growth of agricultural sector may increase at the rate of 4% in the coming year.

It is an encouraging sign that agricultural production will reach to a higher level of 165 million tonnes in the current year mainly driven by favourable monsoon. Even, the horticulture sector has also shown remarkable improvement with a record production of fruits and vegetables.

In this circumstances, the Union Budget -2025 has announced significant schemes and programmes. Few of the proactive schemes are PM Dhan Dhanya krishi Yojana, Rural Prosperity program and Mission for Atma nirbhar in production of crops like pulses and edible oils to boost agricultural productivity, empowering rural communities and promote sustainability, etc.,

Few of other schemes which are considered as effective are national mission on high yielding seeds, a new generation bank with ten lakh germplasm lines, mission for cotton productivity, facilitating short term loans through Kisan Cards, setting up Urea plants, harnessing of fisheries and aquaculture to boost sea food exports many more. Due importance has also been given to Horticulture sector to improve the export of fruits and vegetables which is promoting food processing industry by adding value.

It is, however, many of such schemes have shown varied levels of success, but some of the schemes would require revision and address challenges so that farmers get suitable benefits from these schemes and supporting measures to the expected levels.

V.R. RAVI KUMAR

AGRI WORD POWER



Aquaponics: A system of aquaculture in which the waste produced by farmed fish or other aquatic animals supplies nutrients for plants grown hydroponically, which, in turn, purifies the water.

Bolting: When a plant produces flowers or seeds prematurely instead of a crop. This is usually the result of excessive heat and sun exposure.

Companion planting: The belief that two plants growing near each other produce mutual benefits.

Double Cropping: Raising two different crops on the same area within one growing season.

Endophyte (fungus): Any type of fungus living in a plant (endo, within; phyte, plant) without causing harm to the plant's appearance.

Feeder: Refers to a meat-type animal of sufficient age and weight to be put into a feedlot for finishing prior to slaughter.

Genus: A group of closely related species of plants.

Hay: Forage harvested during the

growing season and preserved for later feeding.

Illuviation : the movement of particles and chemicals from the topsoil into the subsoil.

Kidney Bean : a climbing French bean, with red seeds, used as a vegetable.

Legumes: A family of plants with the ability to fix nitrogen in the soil, thus reducing the amount of nitrogen fertilizer needed for a crop.

Moldboard Plow: A farm tool having one or more heavy blades to break the soil and cut a furrow prior to sowing. Soils inverted or turned over in the process.

No-Till Farming: Designed to control soil erosion, a farming practice leaving the soil undisturbed except for fertilization and seeding operations

Oddlot: Refers to livestock with a physical trait that does not match other livestock in a group.

Pistil: The female sexual reproductive, seed-bearing organ

of a flower, consisting of an ovary, style and stigma.

Quality Grade: An evaluation of the degree of marbling (intramuscular fat) and degree of maturity affecting the tenderness, juiciness and flavor of beef, pork or lamb.

Ruminants: Livestock such as cattle, sheep and goats. Their digestive system is unique, allowing them to better use high roughage feedstuffs, including forages.

Sludge: Solid sediment left over from industrial wastewater treatment plants that is commonly used as a fertilizer or livestock food additive because it contains high levels of nutrients; however, it may contain high levels of heavy metals and pollutants.

Trellis: A support system for plants allowing the positioning of shoots, foliage and fruits for maximum interception of sunlight, air and spray circulation and ease of management.

Under Grazing: The poor pasture management practice allowing vegetation to become over mature before animals have an opportunity to graze.

Vermiculite: A lightweight, flaky mineral called "mica" that has been heated to the point of expansion. The sponge-like granules are then capable of holding both water and air.

Wean: To separate calves from their mothers (cows), allowing the cows to recover their body condition and allow for specialized feeding of the calves. ●

AI in Indian Agriculture

India's agriculture sector is changing fast, and AI plays a big role in this transformation. With AI-assisted farming, farmers can boost productivity, cut costs, and make farming more efficient and profitable.

AI in Crop Monitoring: AI helps farmers monitor crops in real time, providing important data about diseases before they spread. As farmers can take action early, this results in crop savings. A study found that AI-based monitoring can reduce crop losses by up to 25%.

Smart Irrigation for Better Water Management: Water scarcity is a major challenge in Indian farming. AI-powered irrigation systems are helping to optimize water usage in farming. These systems analyze soil moisture and weather conditions. Farmers using smart irrigation have saved up to 30% of water.

AI in Soil Analysis: Healthy soil leads to good crop yields. AI-powered tools analyze soil quality and suggest fertilizers. This helps farmers improve soil health. Studies show that AI-based soil analysis can increase crop yields by 20%.

Precision Farming with AI: AI has made it easy to sow seeds at the right depth and space, increasing precision. Also, AI predicts the best harvesting time to maximize production and reduce crop wastage. Farms in India that use precision agriculture have seen visible yield improvement by 15-20%.

AI and Weather Predictions: Erratic weather patterns affect farming, but with AI-powered weather forecasting, farmers can plan better. The accurate weather forecast by AI helps in saving several crops. Research shows that these losses are 10-15% less.



Automated Farming Equipment: With the use of automated farming equipment like tractors and harvesters, there is a huge saving in labor costs. Farmers can operate with minimal human effort. Experts say these farm automation equipment practices can cut farmers' labor costs by 20%.

AI in Supply Chain Management: With AI, farmers now get better prices for their crops. AI-powered platforms connect farmers with buyers directly. This reduces dependency on intermediaries. Farmers can track demand and price trends in real time. Studies suggest that AI-driven supply chains can increase farmers' income by 10-15%.

The Future of AI in Indian Farming: AI is set to revolutionize Indian agriculture as more farmers adopt AI to improve their farming. With the rise of agri-tech startups, farmers are adopting smart farming practices. Government initiatives are also supporting smart farming. As technology continues to evolve, farmers who embrace AI will be better equipped to tackle challenges and improve their yields.

National Horticulture Fair 2025

ICAR-Indian Institute of Horticultural Research will host the National Horticulture Fair-2025 in Bengaluru from February 27 to March 1. The event is being organized in collaboration with the Society for Promotion of Horticulture (SPH), BESST-HORT, a Technology Business Incubator ICAR-IIHR, ICAR-ATARI Bengaluru, and all of the leading development departments, institutions, and firms that promote horticulture and related sectors. The theme of the National Horticulture Fair 2025 is "Horticulture for Viksit Bharat Nutrition, Empowerment, and Livelihood." The goal is to showcase and promote nutritionally rich crops and varieties and empower needy farmers with need-based information, technologies, and programs on various aspects of horticultural crops.

The event will focus on technologies that are ideal for socioeconomically deprived communities and can boost production, income, and livelihood in horticulture crops while remaining socially compatible, economically acceptable, and environmentally safe, according to IIHR. The institute will display more than 250 varieties and technologies developed by ICAR-IIHR in areas such as crop production, crop protection, post-harvest management, value addition, and horticultural machinery and tools. The event will host skill-oriented workshops on mushroom production, protected cultivation (including vertical farming and terrace gardening), and advisory sessions on field-based challenges in different horticultural crops. There will also be sales of seeds, planting materials, new varieties and hybrids, processed products, equipment, and machinery.

Google building digital agri stack

Global tech giant Google is building a digital agri-stack using satellite imagery and has started with a base layer that will help identify farm boundaries. Data and analysis of this base layer of the stack can be used in a slew of applications like bettering the subsidy payments, farm insurance or farm loans, Manish Gupta, a senior director at Google DeepMind said. We have built the first such model that using satellite imagery analysis can now start to identify field boundaries based on usage pattern start to identify what crops are being grown and so on," Gupta said, speaking at the Mumbai Tech Week here.

The model has taken inspiration from UIDAI's Aadhar, ascribing a unique ID to each farm and is intended to act as a base layer of the "digital agri stack. Gupta said it is upon the startups and other agri-tech players to build solutions which will provide loan crop insurance and also subsidies using the data churned out by the platform. Pointing out the relevance of such a platform, he said 40 per cent of the Indian population are agriculturists and the annual farm lending alone is a \$550 billion opportunity with a lot of it cornered by the informal sector lenders.

The comments come at a time when the Indian banking system is trying to improve its agri-lending system. Largest lender SBI's chairman C S Setty spoke this week about the bank mulling to use satellite imagery-based inputs for making its agri lending



processes more efficient.

Meanwhile, Gupta also rued that the amount of content available in Indian languages is very limited and Google is trying address the same with its initiatives. He said about 10 per cent of the overall 8 billion people speak Hindi, but the language accounts for only 0.1 per cent of the online content. It has launched the "Vaani" project aimed at bridging this gap under which aspires to collect speech data in form of voice recordings from across all the over 700 districts.

The company has launched the first phase of the project under which it has collected 14,000 hours of audio data from 80 districts with people speaking in 59 languages. He also said that Indians under appreciate the relevance of artificial intelligence to expand the boundaries of science, and pointed to the work by DeepMind which led to a Nobel Prize in Chemistry.

Namdhari Seeds acquires Dutch seed firm



Namdhari Seeds, a Karnataka-based vegetable and flower seeds breeding company, has acquired 100% stake in the open field vegetable seed business of Axia, a Dutch vegetable seeds breeding company. Axia produces tomatoes, hot and sweet peppers, melons, watermelons, cucumbers, squash, and eggplant in its open fields and these seeds are marketed under the US Agriseeds brand across

North America, South America, West Asia, Africa, and Europe.

Even after the acquisition, Namdhari's Group will continue to use the US Agriseeds brand in these markets with the existing customers and distributors, the company said. As part of the acquisition, Catalyst Seeds, New World Seeds, and California Hybrids will now be part of Namdhari Seeds. Gurmukh Roopra, CEO, Namdhari's, "The acquisition of US Agriseeds marks a pivotal step in the Namdhari Seeds journey to expand its footprint and become a significant player in the global vegetable seeds market." Namdhari's, however, refused to divulge the size of the acquisition citing a non-disclosure clause.

Karnataka Budget 2025

The Karnataka Budget 2025-26 has laid a solid foundation for the state's agriculture, horticulture, and livestock sectors. With well-targeted interventions, the government aims to enhance farm productivity, ensure sustainability, and improve farmers' incomes. As an agricultural economist, I view this budget as a balanced mix of welfare and growth-oriented policies, catering to the evolving needs of the rural economy.

Agriculture in Karnataka is at a crossroads, facing challenges from climate variability, market fluctuations, and input costs. The Raitha Samruddhi Yojana continues to be a beacon of support for small and marginal farmers, with Rs.428 crore allocated to help 50,000 farmers adopt improved agricultural practices. A welcome move is the investment of Rs.440 crore in water conservation and irrigation infrastructure, benefiting 1.81 lakh farmers. Given Karnataka's dependency on monsoon rains, efficient water management will be a game-changer for improving yields and ensuring resilience against droughts.

Another highlight is the emphasis on digital agriculture and precision farming. Integrating AI, data analytics, and soil health monitoring into decision-making can optimize resource use and boost productivity. This shift aligns well with global agricultural trends and can position Karnataka at the forefront of modern farming.

Horticulture has been a strong pillar of Karnataka's agri-economy, and this budget rightly prioritizes it. The Comprehensive Horticulture Development Scheme



Phase 2, with an allocation of Rs.95 crore, focuses on market expansion, infrastructure, and value addition. One of the most commendable initiatives is the establishment of seed banks for indigenous and GI-tagged crops. This move will preserve Karnataka's rich biodiversity while ensuring farmers benefit from premium pricing for unique crop varieties. Furthermore, efforts to control pest outbreaks in plantation crops, with Rs.62 crore allocated for scientific interventions, demonstrate a proactive approach to crop protection.

Animal husbandry and dairy farming have gained prominence in recent years as resilient income sources for rural households. The Anugraha Scheme, which provides enhanced compensation for accidental livestock loss, is a much-needed intervention. Additionally, the expansion of veterinary services, including 50 new animal hospitals and 100 upgraded veterinary centers, will improve livestock health and productivity.

Dr. Himanshu Pathak Takes Charge as Director General of ICRISAT



Dr. Himanshu Pathak has been appointed Director General of ICRISAT, bringing extensive experience in agricultural research. His leadership aims to advance crop resilience, sustainability, and global food security for smallholder farmers in semi-arid regions across Asia and Africa. Dr. Himanshu Pathak has officially taken charge as the new Director General of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), based in Hyderabad, India. ICRISAT, recognized as the only

international agricultural research center in India, stands at the forefront of research dedicated to enhancing the livelihoods of smallholder farmers in semi-arid regions.

Dr. Pathak brings extensive experience to this role, having previously served as the Secretary of the Department of Agricultural Research and Education (DARE) and the Director General of the Indian Council of Agricultural Research (ICAR). He has made significant contributions to agricultural research and policy, especially in the areas of soil science and agricultural chemistry. ICRISAT has long been a leader in agricultural research for dryland regions, focusing on crops vital to smallholder farmers in the semi-arid tropics. With operations spanning East, Southern, and West Africa, ICRISAT is committed to advancing crop productivity, resilience, and sustainability in challenging agricultural environments. Over the past five decades, the institute has made landmark contributions, including the development of the world's first pigeonpea hybrid and Africa's first biofortified pearl millet.

PM keen to focus on Agriculture

Prime Minister Narendra Modi recently called for expeditious implementation of the budgetary proposals for agriculture and rural development, urging stakeholders to focus on "action" instead of deliberating on a new budget. Addressing a post-budget webinar on 'Agriculture and rural prosperity', the Prime Minister emphasised that the budget reflects the government's new expansion of the vision for a "Viksit Bharat" with a consistent policy approach in its third term. "It is important to implement this year's budget in a speedy manner. The budget has been formed and our entire focus should be on the action," Modi said, adding that the stakeholders should identify "obstacles and shortcomings" in budget implementation.

Modi said before the budget, inputs and suggestions from all stakeholders helped in framing it. "Now this budget needs to be implemented more effectively on the ground, and for a better outcome, the (stakeholders') role is even more crucial. Agriculture is considered as the first engine of growth and the government is moving ahead with the twin target of achieving agricultural growth and rural prosperity, he said. Modi said the government is committed towards the goal of "Viksit Bharat" and the effort is to ensure no farmer is left behind and to advance every farmer. "We need to fully explore the country's agricultural potential and achieve more targets."

The Prime Minister highlighted record achievements in the agriculture sector, noting that foodgrain production has increased from 265 million tonnes a decade ago to over 330 million tonnes currently. Similarly, horticulture production has grown to exceed 350 million tonnes. Modi specifically mentioned the PM Dhan Dhanya Krishi Yojana, describing it as "a very important scheme" for him. The initiative will focus on 100 districts with low crop yields, following the successful model of aspirational districts. "We have announced the setting up of a Makhana Board in Bihar. I urge all stakeholders to explore and promote diverse nutritional foods across the country and in the global market," he said.

The Prime Minister highlighted ICAR's contributions, stating that between 2014 and 2024, more than 2,900 new varieties of foodgrains, pulses, and sugarcane and other crops were developed using modern tools and cutting-edge technology in the breeding programme. "You have to ensure these new varieties are available at affordable rates to farmers. We also need to ensure farmers' produce is not affected by weather aberrations," Modi said. He mentioned that a central mission on high-yielding seeds has been announced in the budget. "I especially urge the private sector to become part of the seed chain to ensure high-yielding seeds reach small farmers."

On pulses production, the Prime Minister acknowledged improvements but pointed out that India still imports 20 per



cent of its domestic consumption needs. While the country has achieved self-sufficiency in chickpeas (chana) and moong dal, Modi stressed increasing production of tur, urad and masoor through high-yielding varieties and hybrid seeds. The Prime Minister noted that approximately Rs 3.75 lakh crore has been transferred directly to 11 crore farmers under the PM-KISAN scheme since its launch six years ago. The annual financial assistance of Rs 6,000 is strengthening the rural economy.

He mentioned that a farmer-centric digital infrastructure has been created to ensure the benefits of this scheme reach farmers across the country, eliminating any scope for intermediaries or leakages. Referring to the fisheries sector, Modi said, "In 2019, we had launched PM Matsya Sampada Yojana. It was an important step towards strengthening the value chain, creating infrastructure and modernisation. It helped improve production, productivity and post-harvest management in the fishery sector." "The sector has seen higher investment and results are before us: fish production and export have increased two-fold. We are going to design a framework for sustainable harnessing of fisheries from the Indian Exclusive Economic Zone and High Seas," he added.

Modi urged stakeholders to explore ideas on ease of doing business in the fisheries sector while protecting the interests of traditional fishermen. "Our government is committed to enriching the rural economy", the Prime Minister said, adding that under the PM Awas Yojana-Gramin, crores of poor people are being provided with homes, and the Swamitva Yojana has given property owners 'Record of Rights'. He noted that the Pradhan Mantri Gram Sadak Yojana has benefited small farmers and businesses and also highlighted the progress in empowering self-help group. "We kept the target of 3 crore lakhpathi didis. With our efforts, more than 1.25 crore women have become lakhpati didis." The announcements in this budget for rural prosperity and development programs have created numerous new employment opportunities. Investments in skilling and technology are generating new opportunities

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Betel Leaves

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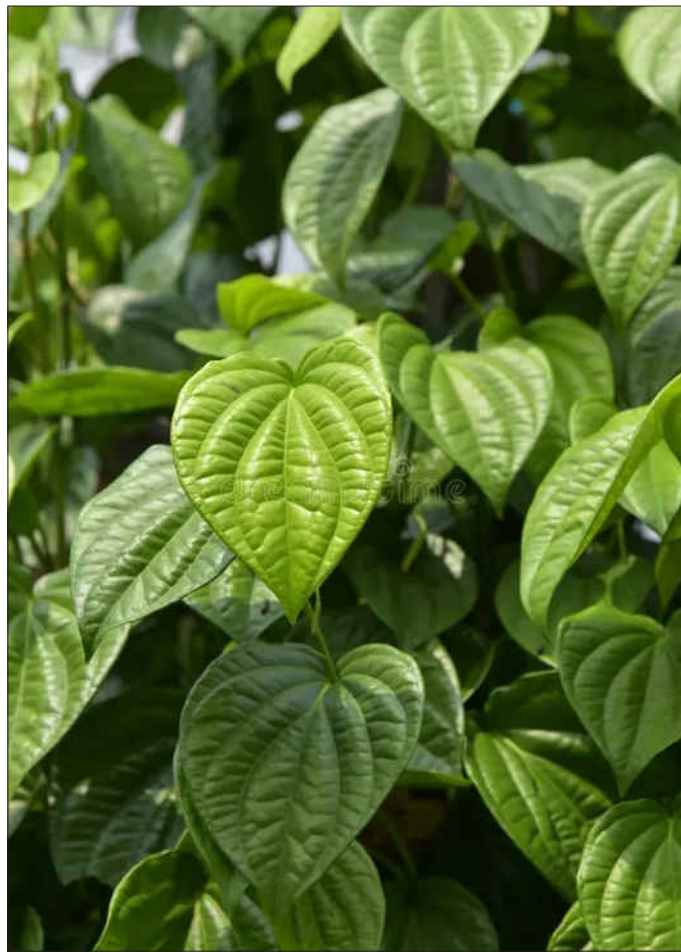
Central Institute of Agricultural Engineering, Regional Station, Coimbatore

P*iper betel L.* is the scientific name for the betel vine, which is a member of the Piperaceae family. In India, the young betel vine leaves are referred to as paan. The betel leaf is an evergreen and perennial, creeper, with glossy heart-shaped and white catkin. The word "betel" is a Portuguese word that was borrowed from the Malayalam word "vettilla." It is also used as a special item offered to the guests in order to show respect. Betel leaves are used as natural remedy for many ailments in South East Asia. Betel vines come in roughly 100 different types, 40 of which are indigenous to India.

The leaves are aromatic, warm, pungent and sharp in taste. The leaves are highly perishable in nature. It has been reported that the losses due to spoilage range between 35 and 75%. For its evergreen leaves, which are utilised in poojas and religious ceremonies as well as a chewing stimulant, betel leaves are grown in the tropics and subtropics. It is a cash crop grown in southern part of India in states of Andhra Pradesh, Telangana, Karnataka, Kerala, Tamil Nadu. It is also cultivated in Bihar, Assam, Madhya Pradesh, Orissa, Maharashtra, Tripura, Uttar Pradesh, West Bengal. There is a good export potential for betel leaves and India exports betel leaves to the neighboring countries.

BETEEL LEAF VARIETIES IN INDIA: Based on the shape, size, brittleness and taste, betel vine is classified into pungent and non-pungent varieties. The below table shows the popular varieties from betel vine growing states.

HEALTH BENEFITS OF BETEL LEAVES: Betel leaves are reported to have numerous health benefits. Betel leaves possess nutraceuticals for preventing diabetes mellitus in patients. Betel leaf extract containing polyphenols compounds like chatecol, allylpyrocatechol are responsible for antioxidant activity. The betel leaves have also been reported to own anti carcinogenic properties and it destroys tobacco carcinogens due to existence of the bioactive compounds. Betel chewing induces secretion from catecholamine from the adrenal cortex that may have effect on the stamina, blood glucose, heart rate, and neural activity in our body. Betel leaf juice is credited with diuretic properties. Its juice, mixed with diluted milk and sweetened slightly, helps in easing obstructed urination.

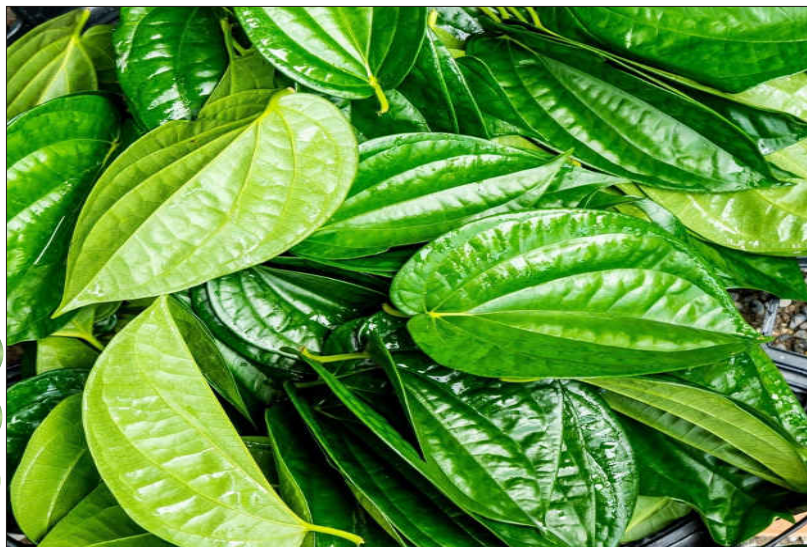


PROCESSING OF BETEL LEAVES: Fresh betel leaves after harvesting are washed, sorted and graded according to their size and quality. Then they are packed by arranging properly in bamboo baskets lined with wet and dried banana leaves and wet cloth to retain their freshness while marketing.

Since betel leaves have limited shelf life, various techniques are followed to preserve them. They are as follows:

De-petiolation is a process where the petioles are removed from the leaves. This process will help in delaying senescence. De petiolated betel leaves were found to be better than leaves with petiole in terms of storage life.

Dehydration is the process of removal of moisture from the leaves. The process of dehydration reduces the water activity thereby reducing the microbial attack and increase the shelf life. Betel leaves can be



**Vernacular Names
In India, betel leaf is
known by different names**

LANGUAGE	NAME
Assamese	Thmol
Bangla7	Paan
Gujarati	Naagveli, nagurvel, paan
Hindi	Paan
Kannada	Veeleya, vilya, vilyadelai
Malayalam	Vettilla, vetta, vetrila
Marathi	Paan, videchapana
Khasi	Tympew
Sanskrit	Nagavali, tambula
Tamil	Vettalai (verrilai)
Telugu	Tamalpaku
Urdu	Paan

dried and powdered.

Curing is the process in which green leaves are treated with smoke, high temperature and pressure in a bhatti or closed room with little or no ventilation so as to regulate the temperature inside the room for improving organoleptic qualities and ultimately the green leaves are to one month and results in superior quality bleached leaves, being very soft and sweet in taste converted to white or yellowish white colour leaves. In this process, the shelf life of betel leaves is extended up. After completion of the curing process,

NUTRITIONAL COMPONENT	COMPOSITION
Energy	44kcal/100g
Water	85-90%
Protein	3-3.5%
Fat	0.4-1%
Mineral	2.3-3.3%
Fibre	2.3%
Chlorophyll	0.01-0.25%
Carbohydrate	0.5-6.1%
Potassium	1.1-4.6%
Calcium	0.2-0.5%
Vitamin C	0.005-0.01%
Vitamin A	1.9-2.9mg/100g
Thiamine	10-70 µg/100g
Nitrogen	2.0-7.0%
Iron	0.005-0.007%

the leaves are graded, spoiled leaves are discarded, cured leaves are taken out and the uncured green leaves are cured again for 8-24 hours depending upon the colour of the leaves.

Chemical treatment: By adding a solution of sodium bicarbonate and tartaric acid to the container, the betel leaves' shelf life might be prolonged. The packing material could be cleaned with sodium hypochlorite prior to packaging because it lowers spore loads and prevents the yellowing. Studies revealed that shelf life of betel leaves was increased by 6 hours of post-harvest dipping in 25 ppm benzyladenine (BA) and 50 ppm kinetin solutions before being packed in vented polythene bags.

VALUE ADDED PRODUCTS FROM BETEL LEAVES: Betel leaves can be processed into powder or oil extracted, which find uses in health care and food products.

BETEL LEAVES - HEALTH CARE

TOOTHPASTE: The antibacterial effects of the essential oil in betel leaf is three times more effective than that of fluorides, because fluorides only serve to inhibit bacterial development and not to destroy them, whereas the essential oil in betel leaf has

bactericidal properties and can therefore, maintain the health of the teeth and gums and eliminate bad breath more effectively. Hence they are used in toothpastes.

BETEL LEAVES IN SKIN CARE :

Betel leaves have anti-inflammatory and anti-bacterial properties and hence it can be used as a solution for various skin issues. Betel leaves act as the best solution for acne prone skin.

ESSENTIAL OIL : The betel leaf essential oil is valued in Ayurveda for its stimulating, carminative, aromatic, antiseptic, warming and aphrodisiac properties. It has several medicinal applications among natives and is especially used to harden gums, preserve teeth and sweeten breath. It also improves voice and is reputed aphrodisiac.

BETEL LEAVES-FOOD PRODUCT :

Betel leaf powder finds its usage in the preparation of healthy food products like khakhra and homemade chocolates. Khakhra is referred to as crispy chapathi or roti. It is common Gujarati bread or snack. In Betel leaf Khakhra, the betel leaves powder are added in the concentration of 5% level. Also chocolates could be prepared incorporating betel leaf powder as a healthy snack. ●

Use of Drones in Agriculture

Prem kumar K. S, M. Sakthimurugan, M. Saranya, P. Vivek, A. Surendrakumar and R. Kavitha

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A drone, also known as an Unmanned Aerial Vehicle (UAV), is an aircraft that operates without a human pilot on board. Instead, it is controlled either autonomously by onboard computers or by a remote control from a ground station. Drones have become an integral part of modern technology, with applications ranging from military and defense to commercial and recreational uses.

The concept of unmanned flight has been around for over a century, with the first rudimentary drones being used in military training exercises in the early 20th century. However, it wasn't until the late 20th and early 21st centuries that advancements in electronics, computing, and materials science made drones more practical and accessible.

COMPONENTS OF DRONE: Drones consist of several key components that enable them to fly and perform various tasks:
The Components are,

Airframe: The physical structure of the drone, which includes the body and the wings or rotor arms. The airframe is designed to be lightweight yet strong enough to support the drone's weight and withstand the forces encountered during flight.

Propulsion System: This includes motors and propellers (for multi-rotor and single-rotor drones) or engines (for fixed-wing drones). The propulsion system generates the necessary thrust to lift the drone and maneuver it through the air.

Flight Control System: The "brain" of the drone, the flight control system includes sensors (such as accelerometers, gyroscopes, and GPS) and a microprocessor that stabilizes the drone and executes the pilot's commands.

Power Supply: Most drones are powered by rechargeable lithium-polymer (LiPo) batteries, which provide the energy needed for flight. The battery life is a critical factor in determining the drone's flight time.



Inspecting farm infrastructure (fences, roads, buildings) using drones. Reduced maintenance costs, improved safety.

Weather Monitoring: Tracking weather patterns, temperature, and precipitation using drone-collected data. Improved planting, harvesting, and irrigation decisions.

Drone Sensors Used: Different types of sensors and software are generally used in drone for precious applications. Sensors such as RGB cameras, Multispectral cameras, hyperspectral cameras, thermal cameras and LiDAR Sensors. software solutions are Pix4D, Agisoft Metashape, DroneDeploy, FarmWise and Granular used in drone.

Benefits:

- Increased efficiency
- Improved crop yields
- Reduced chemical usage
- Enhanced decision-making
- Cost savings

CONCLUSION: The integration of drones into agriculture is transforming the industry, offering innovative solutions to age-old challenges. From monitoring crop health and optimizing irrigation to increasing efficiency and reducing costs, drones provide farmers with actionable insights and precision tools to enhance productivity.

As technology continues to advance, the potential applications of drones in agriculture are bound to expand further, paving the way for smarter, more sustainable farming practices. Embracing this technology is not just an investment in efficiency but also a step toward ensuring food security for a growing global population. ●

Communication System: This allows the drone to receive commands from the ground control station and transmit data back to the operator. Communication is typically done via radio signals, though advanced drones may also use satellite links. Payload: The payload refers to the equipment the drone carries, which can include cameras, sensors, weapons, or other tools depending on the drone's intended use. In commercial drones, the payload is often a high-resolution camera or sensor used for data collection.

APPLICATION OF DRONES IN AGRICULTURE:

Crop Monitoring: Using drones to visually inspect and monitor crop health, growth, and development. Early detection of pests, diseases, and nutrient deficiencies.

Precision Farming: Utilizing drones to gather data for informed farming decisions, optimizing inputs and yields. Increased efficiency, reduced waste, and improved profitability.

Soil Mapping: Creating detailed

soil maps using drone-collected data on moisture, temperature, and nutrient levels. Informed irrigation, fertilization, and planting decisions.

Irrigation Management: Using drones to monitor soil moisture, detect water stress, and optimize irrigation systems. Reduced water waste, improved crop health.

Pest and Disease Detection: Identifying pests and diseases using drone-collected images and sensors. Early intervention, reduced chemical usage.

Yield Prediction: Estimating crop yields using drone-collected data on growth, development, and health. Improved harvesting, pricing, and marketing decisions.

Crop Spraying: Using drones to apply pesticides, fertilizers, or seeds precisely and efficiently. Reduced chemical usage, improved coverage.

Livestock Monitoring: Tracking livestock health, behavior, and location using drone-collected data. Improved animal welfare, reduced disease transmission.

Farm Infrastructure Inspection:

The Essence of Scented Geranium

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Rose-scented geranium (*Pelargonium* species; family: Geraniaceae; $2n = 77$) is a multi harvest, evergreen, perennial aromatic crop cultivated for its essential oil. The plant is commonly called as Geranium, Rose geranium and Rose scented geranium. It was introduced into India from France and was initially grown as an ornamental plant on south Indian hills. Geranium is one of the important aromatic plants, yielding an essential oil having high economic value in national and international market for its very profound and strong rose-like odour. Cultivation of rose-scented geranium for its essential oil was initiated in 1954 on Nilgiri hills of Tamil Nadu, from where the cultivation spread to other parts of India. Presently, the crop is cultivated on a limited scale in south Indian States of Andhra Pradesh, Karnataka and North Indian States of Uttar Pradesh, Uttarakhand and Himachal Pradesh.

It has several medicinal and aromatic values of commercial importance. India has always been an importer of essential oil. The shoot biomass on steam distillation yields the essential oil of commerce that is highly valued in the industry. More than 220 compounds have been identified and reported in the essential oil.

Rose scented Geranium (Geraniaceae) is an important high value perennial, aromatic shrub originated from South Africa as well as reunion



Madagascar, Egypt and Morocco. There are 700 different species and only 10 are utilized for production of geranium oil. It is generally believed that present day cultivars cultivated for distillation of oil rich in citronella or geraniol content are referred as *Pelargonium* species. Presently two types of geraniums called Algerian or Tunisian and Bourbon or Re-union are identified in India. It is propagated vegetatively through rooted terminal stem cuttings.

Generally rose-scented geranium cultivated from October to April-May in the northern Indian plains. Soft stem cutting of 8-10cm length containing 4-5 leaf, with 3-4 nodes, and 8-10cm in length was prepared in the month of April.

Biosynthesis of essential oil : In aromatic crops, essential oil is synthesized as secondary plant metabolite from the products of photosynthesis. It gets accumulated in specialized structures such as glandular trichomes, idioblasts, excretory cavities, canals, heartwood etc. In rose-scented geranium, the volatile oil is stored in oil glands (modified

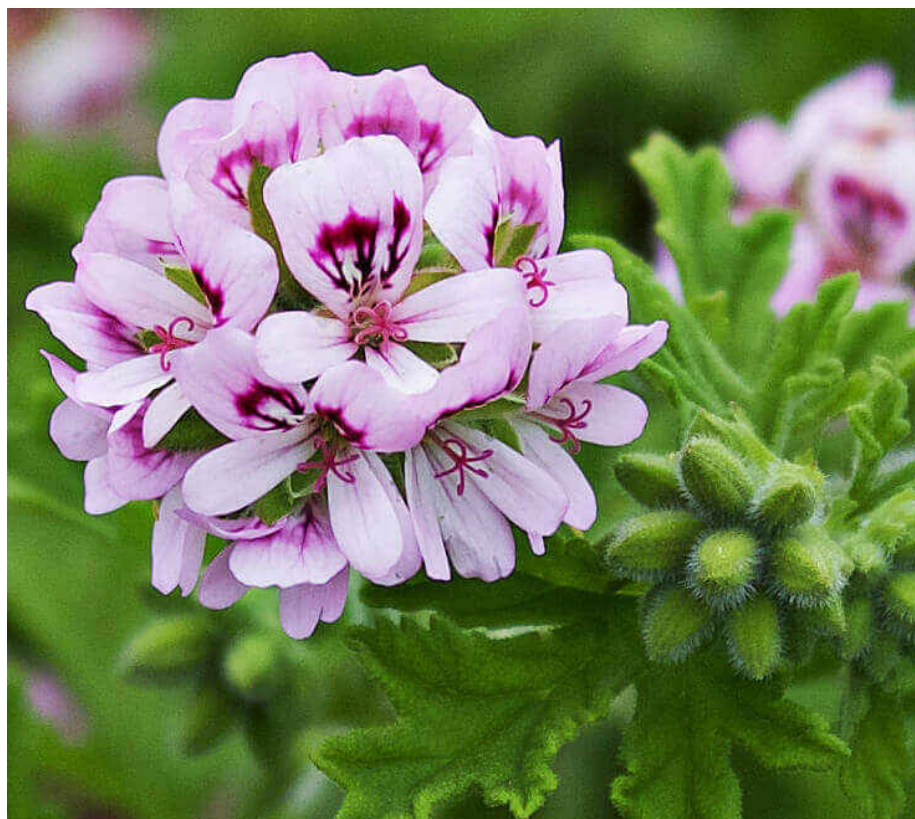


epidermal hairs) distributed over the surfaces of both sides of leaves, petioles, tender stem and flowers. The synthesis and accumulation of aromatic oils is a function of the activities of numerous enzymes. The exact role of essential oil in the plant system is a subject matter of speculation. The volatile oil undergoes catabolism and serves as a source of stored energy which the plant can utilize in times of need. Essential oil therefore undergoes dynamic changes throughout the life cycle of the aromatic plant. In rose scented geranium oil yield and composition vary based on crop age and time of the day.

Storage of the essential oil:

Proper storage of essential oil is important to retain the colour, odour and chemical composition of the oil and to avoid undesirable chemical transformations during storage. The distilled rose-scented geranium oil is filtered through cotton, muslin cloth or filter paper to exclude extraneous matter.

It is treated with anhydrous sodium chloride or sulphate, allowed to stand for few hours to absorb free and dissolved water, registered, filled up to the brim in air-tight aluminum containers, capped tightly and stored in cool, dark place. Properly stored oil retains its chemical composition for a long period. Occasionally, the oil is colored red due to reaction with the metal (mild steel) of the distillation



still during distillation. Tartaric acid treatment restores the characteristic color of the oil. If the red color persists, the oil is redistilled or rectify.

Exploring the Versatile Benefits of Rose-Scented Geranium

- Rose-scented geranium oil is widely used in various types of rose fragrances where petal and foliage effects are desired.
- Traditionally, geranium was used to staunch bleeding, heal wounds, ulcers and skin disorders as well as treat diarrhoea, dysentery and colic.
- Geranium is now indispensable aroma therapy oil and is

the mind and It is also used for isolation of rhodionol which forms a part of the most high grade perfume. The extracts of *P.graveolens* are reported to be used as antibacterial and insecticidal agents.

- Rose-scented geranium is widely used for scenting soaps and high-grade perfumes due to the presence of low molecular weight aroma compounds.
- The hypothesized uses include attracting pollinators, repelling predators, providing biotic or abiotic stress resistance and competitive advantage in a plant community. ●

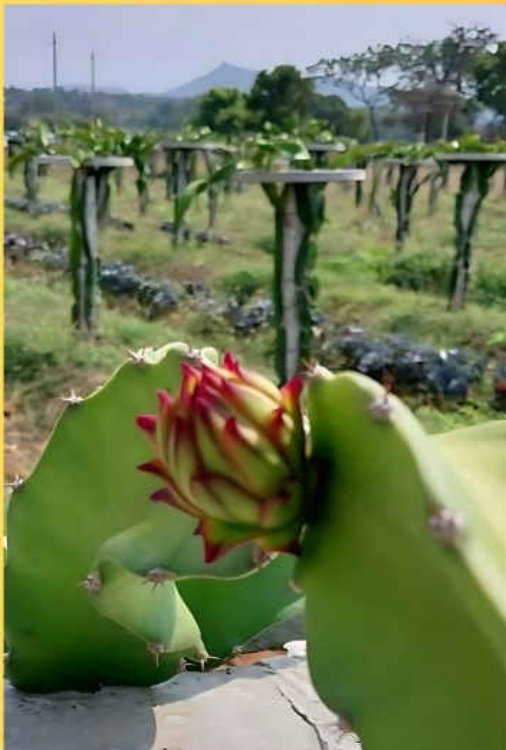
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Indian Flower Exhibitions

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Department of Floriculture and Landscaping

Dr. Y.S.R Horticultural University, College of Horticulture, Anantharajupeta, Annamayya dist



Flower shows are spectacular events that celebrate the beauty and diversity of flowers. They typically feature elaborate displays and arrangements of flowers from local gardens, professional florists, and even international participants. These shows often include competitions, educational workshops, and demonstrations on gardening and floral design. Visitors can stroll through themed gardens, purchase plants and gardening supplies, and enjoy the artistic and horticultural excellence on display. They are a great way to learn about different flower varieties, gain inspiration for your own garden, and appreciate the artistry that goes into floral arrangements. Flower shows hold immense significance for both enthusiasts and the general public.

Promoting Horticulture and Floriculture: Flower shows provide a platform to showcase a wide variety of flowers, plants, and horticultural techniques. They encourage people to appreciate the beauty and diversity of flora. By displaying rare and exotic species, flower shows promote conservation efforts and highlight the importance of preserving biodiversity.

Educational Value: Visitors, especially students and budding gardeners, can learn about different plant species, their growth patterns, and care requirements. Workshops, seminars, and demonstrations during flower shows impart knowledge on gardening techniques, landscaping, and sustainable practices. India hosts several flower festivals and events that are a treat for the eyes and soul.

Inspiration and Creativity: Flower shows inspire creativity by presenting innovative designs, arrangements, and landscaping ideas. Visitors can replicate these concepts in their own gardens. Floral artistry, themed displays, and unique combinations of colors and textures stimulate the imagination.

Community Building: Flower shows bring together people from diverse backgrounds who share a common interest in plants and flowers. They foster a sense of community, allowing enthusiasts to exchange ideas, tips, and experiences.

Boosting Tourism and Economy: Well-organized flower shows attract tourists and contribute to local

economies. Visitors spend on tickets, food, and accommodation. Cities hosting flower festivals gain visibility and become attractive destinations for travellers.

Aesthetic Pleasure and Stress Relief: The sheer beauty of meticulously arranged flowers provides a visual treat. It uplifts moods and reduces stress. Strolling through well-maintained gardens during a flower show offers a serene escape from daily life.

Networking Opportunities: Professionals in the horticulture industry, including nursery owners, landscapers, and garden designers, can network and collaborate during these events.

India hosts several flower festivals and events that are a treat for the eyes and soul.

Tulip Festival:

Location: Srinagar, Jammu & Kashmir.

Time: March and April.

Details: The Indira Gandhi Memorial Tulip Garden in Srinagar boasts over 70 varieties of tulip flowers, making it the largest tulip garden in Asia. The colorful blooms against the backdrop of the Zabarwan range and the Dal Lake create a paradisiacal sight. Cultural events, boat rides, and local cuisines add to the



experience. The Tulip Festival in Kashmir is a mesmerizing celebration of spring's beauty, held annually at the enchanting Indira Gandhi Memorial Tulip Garden in the heart of Srinagar, the capital city of Jammu and Kashmir. Beyond love, the Tulip Festivals in Kashmir are a cultural feast. Unlike other festivals that may center on religious or traditional features, this one is widely appealing. It acts as a melting pot, attracting domestic and international tourists. As your eyes feast on bright tulips, your ears are serenaded by traditional folk music from the area. It's more than just a picturesque location or a popular tourist destination. It stands for rebirth and hope, an ode to the resilient spirit of the people and the unquestionable beauty of the land in a region that frequently makes the news for conflict and upheaval.

Rose Festival:

Location: Zakir Hussain Rose Garden in Chandigarh.

Time: February (three days).

Highlights: Millions of varieties of roses in vibrant colors and fragrances. Visitors can participate in events, and children can even become the Rose Prince and Rose Princess. The festival showcases an array of roses, with over 50,000 rose bushes of 1,600 different species.

Ooty Flower Show:

Location: Ooty, Tamil Nadu.

Time: Annual event.

Description: The Annual Flower Show in Ooty is a showstopper in South India. The beautiful hill station comes alive with a riot of colours as various flowers are showcased. The Ooty Flower Show is an annual event held at the Government Botanical Garden in Ooty, Tamil Nadu. The event showcases a stunning variety of flowers, with around 300,000 flower saplings of over 150 types on display. Visitors can also enjoy cultural activities, music performances, and beautifully crafted flower sculptures. It's a great opportunity to experience the floral diversity and vibrant culture of the region.

International Flower Festival:

Location: Gangtok, Sikkim.

Details: This festival celebrates the diverse flora of Sikkim. The vibrant





displays include orchids, rhododendrons, and other exotic flowers. The scenic beauty of Gangtok adds to the charm of this event. The International Flower Festival in Gangtok, Sikkim, is a month-long celebration held every May at the Flower Exhibition Centre near the White Hall Complex. This festival showcases a stunning variety of flowers, including 600 species of orchids, 30 types of rhododendrons, and many other plant species. The flower displays, the festival features seminars, lectures, cultural performances, adventure sports, and a food festival with local Sikkimese delicacies. It's a fantastic event for nature lovers, botanists, and anyone interested in experiencing the rich floral heritage of Sikkim.

Lalbagh Flower Show:

Location: Bangalore, Karnataka.

Time: Held during the Republic Day and Independence Day.

Highlights: The historic Lalbagh Botanical Garden transforms into a floral wonderland. Elaborate displays, themed arrangements, and rare species of flowers are showcased. The Lalbagh Flower Show is a much-anticipated event held at the Lalbagh Botanical Garden in Bengaluru, Karnataka. This year, the show will take place from January 16th to January 26th,

2025, coinciding with Republic Day celebrations. The theme for this year's show is honouring Maharishi Valmiki and his legacy, with intricate floral displays depicting scenes from the Ramayana. The show features around 25 lakh flowers, including 10 lakh dedicated to the central theme. Visitors can expect a stunning display of 85 varieties of annual flowers and 27 varieties of temperate flowers in Lalbagh's iconic glasshouse.

Some other flower shows are

Chrysanthemums Show

Chandigarh is known for its Chrysanthemums, and this show held in December showcases various varieties of these beautiful flowers.

Rose Flower Show

The Empress Botanical Garden in Pune hosts this show, where roses take centre stage. It is organized by the Agri Horticultural Society of Western India during the monsoon season.

Horticultural Show

Kolkata's Horticultural Society holds a flower show every winter, displaying a variety of flowers, fruits, and vegetables.

Kaas Plateau Flower Show

Located in Maharashtra, this show

is famous for its carpet of wildflowers that bloom during the monsoon season.

Dasara Flower Show

Held in Mysore during the Dasara festival, this show features a stunning display of flowers and is a major cultural event in the region.

Cherry Blossom Festival

Although not as common as other flower shows, this festival celebrates the blooming of cherry blossoms in certain parts of India.

Conclusions:

Flower shows around the globe serve as a testament to the beauty and diversity of nature. They provide a platform for horticultural enthusiasts, experts, and the general public to come together and celebrate the intricate art of gardening.

These events not only showcase an array of stunning floral displays but also promote environmental awareness and conservation efforts. Through flower shows, we gain a deeper appreciation for the natural world and the importance of preserving it for future generations. In essence, flower shows are a vibrant reminder of the harmony between humans and nature, inspiring us to cultivate and cherish the beauty that surrounds us. ●

Under Utilised Fruit Crops

A Potential Source of Natural Food Colourant

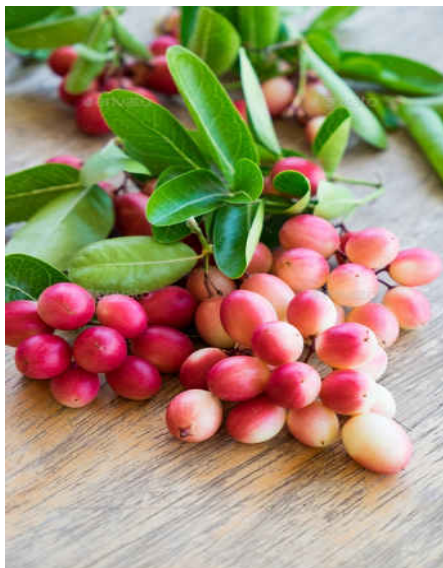
S.Bhuvaneswari, Anuradha Sane and G.C.Sathisha

ICAR-Indian Institute of Horticultural Research, Hesaraghatta lake (PO) Bengaluru

Food colourants are widely used in food industry. These colourants are classified as synthetic food colourant and natural food colourant. Synthetic food colourants are water soluble and are available as paste and powder. In recent past, usage of some of the synthetic food colourants are banned by government owing to its carcinogenic effect and a cause of health disorder in mankind. Harmless and healthy alternative to synthetic colourant is the usage of natural food colourant. Most natural colorants are extracts derived from plant tissues. Under utilized fruit crops - store house of antioxidants, vitamins and minerals are potential source of natural food colourant. This underutilized fruit powder colourant not only adds natural colour to the food products but also improves its nutritional value especially antioxidants vitamins and mineral content. This article gives insight into a few under utilized fruits which are can be used as natural food colourant.

West Indian Cherry / Barbados Cherry (*Malpighia emarginata*): Commonly known as West Indian Cherry, Barbados Cherry, Acerola. It is an evergreen shrub or small tree and grows up to 3.6 m tall. Fruits are red in colour, small (4.8 g), about the size of a cherry. The ripe fruit is bright red and sweet. The fruit is very rich in vitamin C and has a tart flavor. Cherry fruit has a high content of flavonoids and also rich in antioxidants. Cherry Powder is used as a thickening agent in sauces and soups.

Karonda (*Carissa carandas*): It is a small to medium-sized evergreen shrub, grows up to 3-5 m in height with dense, thorny branches and dark green glossy leaves. Fruits are small (1.6 to 4.7 g), round, about 2-3 cms in diameter. The skin ranges from green to deep purple when ripe. The flesh is



juicy and tart. It is widely cultivated in Uttar Pradesh and West Bengal.

Karonda fruits are generally high in nutrients like iron, calcium, magnesium and phosphorus. Pink varieties are considered to be excellent in iron concentration. Rich in antioxidants (138mg/100g), anthocyanins, vitamin C, Iron (62%), Zn (20.59%), Calcium(1.89%) Magnesium(0.67%). The dark purple karonda powder can be used as natural food colourant, because of its tartness, it can be used as substitute to tamarind in various culinary recipes.

Egg Fruit/ Canistel (*Pouteria campechiana*): It is evergreen tree, grows up to 10 m tall. It has glossy leaves and produces orange-yellow fruits. Fruits are round to oval-shaped, about 7-12 cms long weighing 150 to 200 g, very sweet pulp and creamy, resembling the texture of a hard-boiled egg yolk. Egg fruit can be pulped and powdered. Egg fruit is a good source of vitamins A and C, potassium, and dietary fiber. It contains many minerals, including calcium, copper, iron, magnesium, phosphorus, potassium, sodium, and zinc. The yellow egg fruit powder can

be used as natural colourant in smoothies, cakes, milk shakes and as colouring agent in ready to eat extruded snack.

Jamun (*Syzygiumcumini*). It is a medium to large-sized evergreen tree, can grow up to 30 m tall. Fruits are small purple-black berries (10 to 25g), about 1-2 cms in diameter. The flesh is juicy and sweet with a slightly tart flavor. Jamun is rich in bioactive compounds like anthocyanins, flavonoids, and polyphenols. iron (52.7mg/kg), (7.85mg/kg) and contains calcium(0.76%) and magnesium (0.60%). The pink jamun powder can be used as natural colourant in ice creams, smoothies, desserts, milk shakes, breakfast cereals as an replacement to synthetic colourant and flavorant.

Kokum(*Garcinia indica*): It is a small to medium-sized evergreen tree, grows up to 18 m tall. Fruit are small, about 3-4cms in diameter with deep purple red skin. The flesh is white and has a tangy/sour taste, often used in culinary applications. It is widely grown in Western ghats of India mainly in the states of Maharashtra, Karnataka, Goa and others in the western coastal region. Kokum fruit is rich in vitamin C, fibre and essential nutrients like magnesium, iron, zinc, calcium, vitamin B6, and potassium. The dark red kokum powder is used in various culinary preparations, to add sour to chutney, pickles, jams, syrups and beverages.

At ICAR-IIHR, Bengaluru, process protocol for the development of finger millet based ready to eat extruded snacks with coated with natural fruit colourant from jamun powder, cherry powder egg fruit powder, as an alternative to synthetic colorant was optimized. Incorporation of these powders increased the antioxidants, iron and zinc content in the millet based extrudates. ●

Potato Crop Suitability

Evaluation for Farm Sustainability

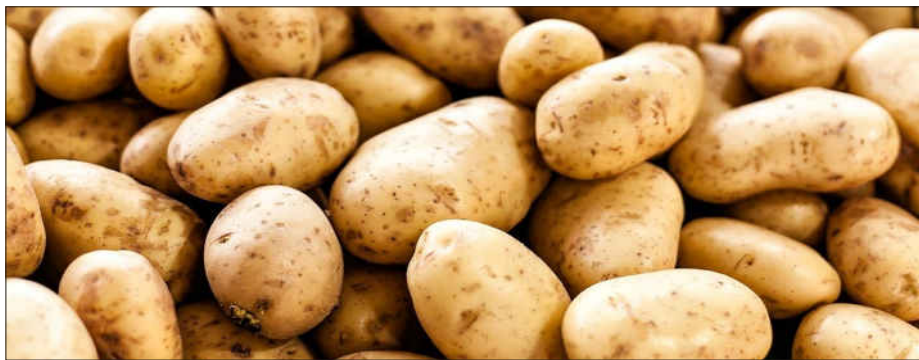
R. Srinivasan, N. Maddileti and V. Ramamurthy

ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore

Potatoes (*Solanum tuberosum* L.) are a vital source of carbohydrates, proteins, vitamins and minerals, thus holding a fundamental role in the food chain. Global and Indian scenario Potato is the third most important food crop in the world after rice and wheat in terms of human consumption. India is the second largest producer of potatoes in the world, after China. The potato production in India during 2013 was 45.34 million tons from 1.99 million ha area with a productivity of 22.76 t/ha. There has been a phenomenal increase in potato area (8.5 times), production (29.4 times) and productivity (3.5 times) over six decades. Potato is a predominant vegetable in India, at present most of the domestic supply of potatoes is consumed as fresh (68%) followed by processing (7.5%) and as seed (8.5%).

Karnataka used to be among the top ten potato producing states in India. Potato Production in Karnataka takes place during the summer / monsoon season (Kharif), unlike most of the potato production in India (90%), which takes place during the winter season (Rabi). The most significant food crop in the world is the potato. In India, the potato is a temperate crop that is produced in a subtropical climate.

A crop that has traditionally been "the poor man's friend" is the potato. Loamy soil, sandy loam, silt loam, clay soil, and other types of soil can all be used to grow potatoes. To reduce resistance to tuber enlargement, the soil should be loose. Fertile and well-drained soil are prerequisites. Acidic soil with a pH range of 4.8 to 5.4 is needed for potato growing. The potato is within the category of the cool-weather crop. The successful potato farming and productivity in Hassan district of



Karnataka.

Land and crop suitability evaluation : Land evaluation is concerned with the assessment of land performance when used for specified purposes (FAO, 1976) and can be defined as "all methods to explain or predict the potential use of land". Land evaluation analysis is considered as an interface between land resources surveys and land use planning and management. In addition to information about climate, hydrology, vegetation, agricultural practices and their socio-economic aspects, land suitability evaluation for implementing rainwater harvesting requires detailed field data, such as slope, soil depth, soil texture, and percentage surface stoniness.

Soil surveys are important sources of data that can be used to improve physical land suitability classifications, planning, and environmental protection based soil quality and crop adoptability. Farm scale soil surveys highly useful for providing quantitative information about the spatial distribution of soil properties and their potential. Detailed soil maps that contain more information about soil properties and its spatial distribution are necessary for modern land evaluation, land suitability analysis, land resources management, land use planning, and other environmental modelling. Detailed farm soil details and other

climatic condition evaluated in part of Hassan District in Karnataka and prepared suitability map (S1-Highly, S2- Moderately, S3- marginally and N- Not suitable).

An area of about 919 ha (35%) is highly suitable (S1), moderately suitable (Class S2) for growing potato is 1143 ha (43%) with minor limitations of gravelliness, drainage, slope and rooting depth. An area of about 285 ha (11%) is marginally suitable (Class S3) for growing potato with moderate limitations of texture, rooting depth, slope and gravelliness. An area of about 95 ha (4%) is not suitable (Class N) in the study area.

Conclusions: The suitability of any crop is based on the soil quality and prevailing climatic conditions deciding the quality of crops and productivity. Regionally specific crops always have special qualities and tastes. South Karnataka, famous for good-quality potato production, has recently seen farmers shifting to coconut plantations due to water scarcity and labor problems. Therefore, assessment of farm suitability evaluation of potatoes is a better option for crop choice and avoiding crop loss. Developing soil-based crop suitability maps with good spatial distribution and helping to adopt site-specific crop use and nutrient management. ●

Entrepreneurship

Opportunities in tuber crops for enhancing income

Sheela Immanuel, D. Jaganathan, P. Prakash and G. Byju

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Tuber crops are an important livelihood and food security crops which are cultivated in tropical and subtropical countries. Major tuber crops grown in India are cassava, sweet potato, yams and aroids which include elephant foot yam, taro and tannia. These groups of crops can be referred as future food security crops due to its climate resilience and tolerance to erratic climatic conditions. Realizing the potential and their socio economic relevance of tuber crops, ICAR-CTCRI, Thiruvananthapuram was established in July 1963 with its Regional Station at Bhubaneswar, Odisha in September 1976 with a mandate to conduct research on different aspects of tuber crops. In India, cassava is cultivated in nine states with three southern states viz. Kerala, Tamil Nadu, and Andhra Pradesh contributing to about 96% of the total production. Cassava is a secondary staple food in Kerala, while it is an industrial crop in Tamil Nadu and Andhra Pradesh. Cassava is mainly used for edible consumption, industrial applications and animal feed sector in India. About 60% of the total cassava produced in India are used as raw materials to produce starch, sago and dry chips and it has scope for wider applications in food, paper and textile industries. In recent years, cassava has been globally recognized as a potential candidate for bioethanol production due to its high carbohydrate content and ability to grow under low management conditions.

Farmers in Tamil Nadu, Kerala, Andhra Pradesh, Odisha and North Eastern states depend on these crops for their livelihood, nutrition, food and economic security. It offers business opportunities to multitude of people. Importance of cassava in the socioeconomic development of rural areas has gained recognition during the last few years. It is also a source of income and is used as a raw material



in manufacturing of processed food, animal feed and industrial products. Entrepreneurship development is an effective strategy for the growth and development of an economy. It provides employment opportunities for a larger population and equips them with their own strategies to develop their knowledge and skill in the business world. A holistic entrepreneurial ecosystem existing in the country is providing entrepreneurial avenues for the farmers, women and youth especially in the agriculture sector. In addition to setting up their own income generating enterprises, they can generate jobs for others as well. It provides opportunities for the job seekers to transform themselves into job providers.

Entrepreneurship

Entrepreneurship means an individual or a small group of people who creates new business with a motive to earn profit. They involve themselves in business venture and are ready to undergo greater risks in the business market. If the business returns back profits, they can earn more and become a successful entrepreneur. Agriculture sector provides ample opportunities for business development as it is designated as a sun rise sector. Entrepreneurial

pursuits often involve innovation, persistent interest, financial support and risk bearing ability. Agri-entrepreneurship includes agri-business which encompasses cultivating crops, processing and value addition, input production which includes bio-fertilizers, bio-control agents, organic products, farm implements, custom hiring center, planting material production and so on.

Business opportunities in tuber crops

Minisett technique in tuber crops:

The ICAR-CTCRI has developed a rapid multiplication technique using cassava minisettts in which two- node cuttings are raised in the nursery in shade house (35 per cent shade). The minisettts are planted end to end horizontally, at 5 cm deep leaving 5 cm between the rows. The minisettts are transplanted to the main field 3 to 4 weeks after planting at a spacing of 45 x 45 cm. The stem yield (no.ha⁻¹) in cassava was 24,000 in normal sett planting, while in minisett technique it was 60,000. This method gives an increased yield of 80 t ha⁻¹ for minisett cassava wherein the normal sett planting produced an yield of only 30 t ha⁻¹. Minisettts can be done for

Organic production of tuber crops



elephant foot yam, yams and taro. Entrepreneurs can develop setts by minisetts technique and supply to the end users and this can provide them a good business opportunity. The Institute offers training to the persons who are interested to produce minisetts.

Development of seed villages for supply of quality planting materials

: Good quality seeds or planting materials are very much important in any crop as they decide the yield. Cassava is a vegetatively propagated crop and the stem cuttings are used as planting materials. The stems are stored in a dry and cool place and used for the next planting season. One of the major constraints reported by the farmers in adopting improved varieties of cassava are lack of access to good quality planting materials of the improved varieties. Since the planting material demand is on the higher side from farmers and industries, it is not possible by the research institutes to cater to the needs of the farmers. If the supply of planting materials demand is met, the cassava cultivation may be extended to non traditional areas of our country. Farm youth, farmers and farm women can make use of this opportunity and can produce their own planting materials in their farms and they can sell it to other farmers who are in need of planting materials. They can get training on quality planting material production from research organizations so as to produce healthy and disease free planting materials. This forms a good avenue of employment and income generation for the rural community.

Production of organic tubers :

Organic produce have high demand in the market as they are safe to consume. Cassava plant is very acquiescent to organic farming and it produces higher yield. Organically grown food products receive premium price and have greater acceptability in the market with more consumer preference and it fetches better price for the entrepreneur. In India, organic certification is done by different agencies which regulate organic food in the domestic market and imports. Participatory Guarantee System (PGS) is a process of certifying organic products, which ensures that their production takes place in accordance with the prescribed quality standards. PGS Green is given to chemical free produce under transition to 'organic' which takes three years. It is mainly for domestic purpose. The National Programme for Organic Production (NPOP) grants organic farming certification through a process of third party certification for export purposes. This provides better business opportunities for farmers, women and other agro based entrepreneurs to earn a living by selling quality organic tubers. Even though area under organic farming is increasing, it is not able to meet the demand of organic produce requisite. So, organic farming has vast scope of business opportunities as the consumer prefers mostly organically grown tubers.

Production of micro nutrient mixture 'Micronol': Micronol is a microfood which is used as foliar micro nutrient spray in tuber crops.

The ICAR-CTCRI has developed micronol for cassava, sweet potato, yams, elephant foot yam and Chinese potato. This is widely used by farmers from different parts of the country. With the technical knowhow from the Institute, stakeholders can produce the micronol and sell it in the market. It is a good opportunity for the stakeholders to produce this foliar fertiliser and can earn a good income and they can start a village based production unit as there is vast demand in the market for new generation fertilizers.

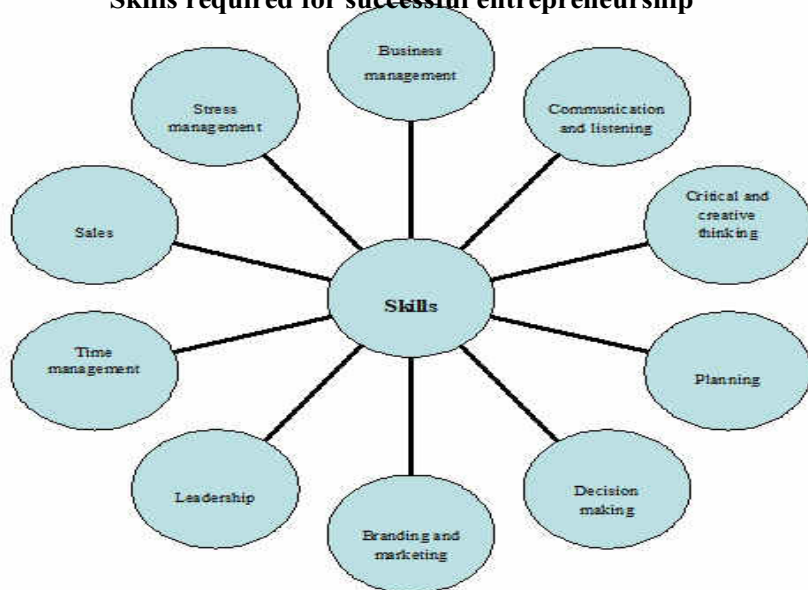
Production of Customised fertiliser :

It is a mixture of major nutrients, secondary and micro nutrients specific to crops and soil requirements. Fertilisers namely urea, di ammonium phosphate, muriate of potash, magnesium sulphate etc are mixed and different grades of customised fertilisers and are prepared based on plant requirement. This is easy to produce and no drudgery is involved in preparing this product. It can be made in packets and sold in the market. This will save labour cost for the end users and it is more profitable. With the technical help from the Institute entrepreneurs can start small units and they can produce the customized fertilizers as per the recommendations of the Institute.

Production of thippi from cassava waste:

During the manufacture of sago, the tapioca tubers are de-skinned and soaked in water. The tubers are then fed into the crusher adding water for extraction of milk which is passed through a sieve to

Skills required for successful entrepreneurship



remove the fibrous materials. This fibrous material in pulp form, when dried is known as tapioca thippi. It is low in protein and fat, but fibre content is 8-9%. In Tamil Nadu, cassava is grown as an industrial crop for the large scale production of sago and starch. There are large-scale starch factories and small sago and starch production units in Tamil Nadu, generating more than 40 tonnes of solid waste per annum. Thippi, the solid waste is one among them. The work conducted at ICAR-CTCRI revealed that thippi compost can be used as an alternative to FYM, green manuring *in situ* with cowpea, crop residue incorporation, vermicompost and coir pith compost and even fertilizers up to N @ 50 kg ha⁻¹, MgSO₄@ 2.5 kg ha⁻¹ and ZnSO₄@2.5 kg ha⁻¹. Thippi compost application can reduce the bitterness and increase the starch content of cassava tubers. This quality parameter is very advantageous to cassava cultivators as there is market demand for less bitter cassava tubers. Thippi compost production unit may be set up by the entrepreneurs and focusing on a customer centric approach it can find market throughout the country.

Soilless production of tuber crops by hydroponic formulation : Soilless production methods, such as hydroponics, aeroponics, and aquaponics, offer a sustainable solution for urban farming of

vegetables and tuber crops. These systems eliminate the need for soil, allowing precise control over nutrients and conditions, which accelerates growth and increases yield. They also minimize soil-borne diseases and pests, making urban farming more resilient and efficient. ICAR-CTCRI has standardized hydroponic nutrient formulation, which is tested for tuber crops: taro, Chinese potato, sweet potato, greater yam under climate control facility and rain out shelter. The yield is higher with no incidence of soil borne diseases, recorded higher palatability score in most of the crops and varieties grown in hydroponics. We will get safe to eat food and the labour involved is less and it helps in resource conservation. Entrepreneurs can adopt this method of cultivation to increase their profit and to sell safe to eat foods in the market.

Biocapsules for growth promotion and disease management : The Institute in collaboration with ICAR-Indian Institute of Spices Research, Kozhikode (ICAR-IISR) jointly developed biocapsules of three growth promoting and disease suppressing microorganisms by utilizing the commercialized encapsulation technology for the smart delivery of agriculturally important microorganisms. The technology involves encapsulation of the microorganisms of interest in a gelatin capsule for delivery to

agricultural crops for the enhanced soil nutrient solubilization, enhanced growth, yield and suppression of disease. It can be produced and sold in the market which fetches good revenue to the producer.

Starch and sago production units :

The starch content of the fresh cassava root is about 30% and gives the highest yield of starch per unit area of any crop grown. Starch is the most important value added product from cassava. Starch extraction can be done by using different methods. Cassava starch is used in food processing, beverage industry, production of candies, paper industry, textile industry etc. Cassava starch is mainly marketed in Gujarat, Maharashtra, West Bengal and Tamil Nadu. The entrepreneurs can establish starch producing factories which will help them to earn more from production of starch and starch has immense export potential to various countries internationally. Sago, derived from raw tapioca, is in the form of small hard globules with pearl white colour. Sago is manufactured from the wet starch powder crushed from tapioca. Sago and its finished products are used as food, animal feed and as raw material for several industrial products. Sago is almost pure starch, a type of carbohydrate and hence has many health benefits. More than half of the sago produced in the country are marketed in Pune and Nagpur in Maharashtra and Kolkata and Siliguri in West Bengal, Patna in Bihar, Kanpur and Varanasi in Uttar Pradesh, Guwahati in Assam. Demand for sago is generally more during festival seasons and in Sravana month (August) due to more auspicious festivals being held then. Entrepreneurs can establish family owned sago producing units, and thereby do business and earn better income.

Establishment of bioformulation unit extracted from cassava leaves

: Three bioformulations were developed by ICAR-CTCRI namely *Nanma*, *Menma* and *Shreya* from cassava leaf extracts. The apparatus and the process of extraction were also developed by the Institute. The bioformulation is effective against

Micronol for tuber crops



borer pest like pseudostem weevil in banana and red palm weevil in coconut. These technologies were perfected more than a decade ago and proved very effective for the eco-friendly management of a variety of insect pests. The entrepreneurs can create bioformulation production units and they can manufacture bioformulations which have immense market scope and good demand among the farmers.

Small scale unit for waxy coating of cassava :

Cassava can be kept fresh only for a period of two to three days and after that it becomes blackened due to post harvest deterioration. To make them remain fresh and to maintain their weight, wax is coated on the outer surface of the cassava tubers. This wax coating helps cassava to maintain its freshness and helps it to retain moisture and thereby the weight of the tubers may be retained. Entrepreneurs can attempt this technology and they can establish cassava wax coating units so that they can do this as a business and earn income. As the wax coated cassava remains fresh it can be shipped to international markets for export promotion.

Fabrication of machineries for tuber crops

Cassava chipping machine :

Cassava chipping machine produces chips of uniform size and shape. There is a great demand for the product in the market. To avoid heavy post-harvest losses, the roots are customarily processed into sundried chips. Cassava chips are used for preparation of flour which is used like rice flour. It also forms a major component in many animal feeds. In industries it is used as raw material for manufacturing starch, dextrin, glucose and ethyl alcohol. Machine

chipping becomes more economical, when compared to manual chipping as it reduces labour and minimize the time. The cost of the machine is less and it accommodates tubers irrespective of the size. It is easy to operate and it can produce uniform chips and adjust the chip thickness too. Manufacturing cassava chipping machines offers a good potential for creating business for different stakeholders who are involved in machinery development.

Mobile starch extraction unit:

Mobile starch extraction unit is electrically operated with low cost and is used for starch extraction and it can be transported from one place to other. This unit has the provision to disintegrate the root tissues, wash out the starch from the tissue and separate the starch. It has provisions for easy transportation, to store peeled and sliced tubers, convenient to operate and easy to fabricate and maintain. These machines are suitable for use in villages, adding value to produce and generate additional employment. This can be used to extract starch from cassava, sweet potato and elephant foot yam. This machine can be manufactured and sold in the market for starch extraction as it is a mobile unit which is useful for the clients employed in starch extraction.

Small scale enterprises for value added products from tuber crops:

Value-addition is transformation of raw agricultural product into a new and economically more beneficial product through the means of packaging, processing etc. Large proportion of agricultural produce is wasted due to improper storage and warehousing, lack of transportation and food processing facilities. Now-a-days there is a significant shift in

consumer food preference towards processed food products. Number of value added products can be prepared from tuber crops.

Cassava based food products:

Cassava chips, sago wafers, cassava flour, snack foods, protein enriched pasta, hydrocolloid fortified pasta and rice analogue from cassava based composite flour.

Sweet potato based products: Fried chips (deep fat, vacuum), french fries, crisps, preserves (puree, jam, jelly), starch noodles, gluten-free spaghetti and food bars.

Cassava and sweet potato based functional products:

Antioxidant rich functional sago, dietary fibre enriched functional sago, dietary fibre enriched pasta, low glycemic spaghetti. Entrepreneurs can add more value to the developed products with proper management and marketing initiatives. The processed food market opens up a great potential for entrepreneurs be it fast food, packaged food or organic food.

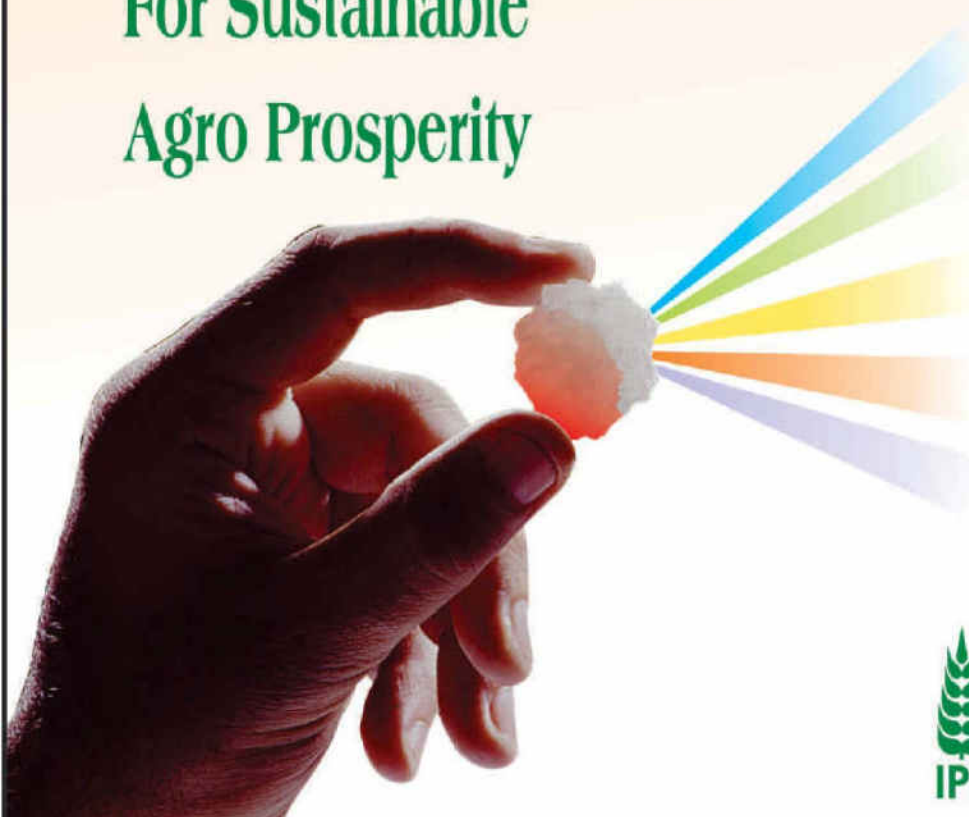
Factors favourable to start a business in tuber crops

- Availability of improved varieties of planting materials for multiplication in the fields
- Technological support from research organizations
- Handholding and capacity building
- Technology licensing for commercialization
- Guidance in preparation of business plan
- Incubation facilities in research organization

Conclusion : Tuber crops are the future crops as they are resilient to climate change and they can be grown in less fertile soil without much cost. Tuber crops offer livelihood options for farmers, farm women and other stakeholders. We need entrepreneurs to start small scale industries to tap these opportunities with the support of funding from Government and other funding agencies. Besides, these business opportunities lead to higher monetary return and better market. Higher export potential for such products augments the income potential of the entrepreneurs. ●



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Soil Less Cultivation

A New Approach for Quality Crop Production

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Soil is usually the most available growing medium for plants. It provides anchorage, nutrients, air, water, etc. for plant growth. However, soils do pose serious limitations for plant growth too, at times. Some of them are presence of disease-causing organisms and nematodes, unsuitable soil reaction, unfavorable soil compaction, poor drainage, degradation due to erosion etc. In addition, soil-based agriculture/open field vegetable production is somehow difficult as it involves more area, more water and a greater number of workers.

Moreover, such areas as like; metropolitan areas where soil is not favorable to grown vegetables, in some areas, there is water scarcity for proper irrigation and due to unfavorable geographical or topographical conditions there is lack of cultivable lands. Out of these difficulties another major difficulty is to hire labour. Under such a situation, soilless vegetable cultivation can be introduced successfully.

Soilless culture is the technique of growing plants in soil-less condition with their roots immersed in nutrient solution (Maharana & Koul, 2004). In soilless culture some cultural practices like soil cultivation and weed control are avoided, and land not suitable for soil cultivation can be used (Polycarpou et al., 2005). Plants grown in soilless media had consistently superior quality, high yield, rapid harvest, and high nutrient content. This system will also help to face the challenges of climate change and also helps in production system management for efficient utilization of natural resources and mitigating malnutrition.

Media for Soilless Culture : Soilless culture, also known as hydroponics, employs various types of growing media or substrates to support plant growth. The choice of growing media depends on plant species, system design, water availability and personal preferences. Here are some commonly used growing media in soilless culture:

Rockwool:

- Made from molten rock spun into fibers and compressed into cubes or slabs.
- Advantages: Excellent water retention, good drainage, and aeration.



Perlite:

- A lightweight volcanic glass that is expanded by heating.
- Advantages: Good drainage properties, retains some moisture, improves aeration, and prevents compaction.

Vermiculite:

- A mineral that expands when heated.
- Advantages: Excellent water-holding capacity, improves moisture retention, often used in combination with other media, contains minerals like potassium and magnesium

Coconut Coir:

- Derived from the fibrous husk of coconut shells.
- Advantages: Sustainable, excellent water-holding capacity, good aeration and drainage, pathogen-free, promotes rapid germination and rooting.

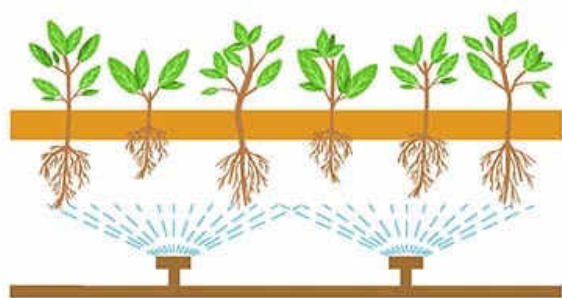
Peat Moss:

- Partially decomposed organic material from peat bogs.
- Advantages: Good water-holding capacity, stable environment for root development.
- Considerations: Not renewable, environmental concerns related to extraction

Sphagnum Moss:

- Known for its high water-holding capacity and aeration benefits.
- Advantages: Releases nutrients slowly, maintains acidic conditions ideal for acid-loving plants and promotes beneficial microbial activity.

Aeroponics



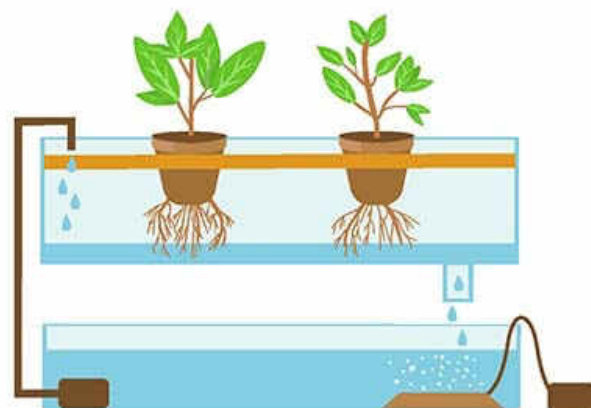
Deep Water Culture



Drip System



Nutrient Film Technique



Sawdust:

- Produced from wood during sawing processes.
- Advantages: Natural, eco-friendly, readily available. Provides good aeration and drainage.

Sand:

- Used for crops preferring well-drained conditions.
- Advantages: Excellent drainage, reduces waterlogging and root rot risk.
- Considerations: Poor water and nutrient retention, requires frequent irrigation and fertilization.

Types of Soilless Culture : Soilless culture encompasses various methods, generally categorized into solution culture and solid media culture. Here's a breakdown of these methods:

Solution Culture:

Circulating Methods:

Nutrient Film Technique (NFT):

Description: Plants are grown in a shallow stream of nutrient solution that constantly circulates over the roots.

Advantages: Efficient use of nutrients and water, good aeration for roots

Deep Flow Technique (DFT):

Description: Plants are grown with their roots submerged in a deep, circulating nutrient solution.

Advantages: Consistent nutrient and water supply, good for large plants.

Non-Circulating Methods:

Root Dipping Technique:

Description: Plant roots are periodically dipped into a nutrient solution.

Advantages: Simple setup, reduced risk of root diseases.

Floating Technique:

Description: Plants are supported on floating rafts with their roots submerged in a nutrient solution.

Advantages: Good aeration and nutrient supply, easy to manage.

Capillary Action Technique:

Description: Nutrient solution is drawn up to the roots through capillary action from a reservoir.

Advantages: Consistent moisture and nutrient supply, reduced need for pumps.

Solid Media Culture

Hanging Bag Technique:

Description: Plants are grown in bags filled with a growing medium, suspended vertically.

Advantages: Space-efficient, good aeration and drainage.

Grow Bag Technique:

Description: Plants are grown in bags filled with a growing medium, placed horizontally.

Advantages: Easy to set up, good for small-scale cultivation.

Trench Technique:

Description: Plants are grown in trenches filled with a growing medium.

Advantages: Suitable for large-scale cultivation, good moisture retention.

Pot Technique:

Description: Plants are grown in individual pots filled with a growing medium.

Advantages: Flexible, easy to manage and move plants, good for small-scale or experimental setups.

Aeroponics:

Description: Plants are grown with their roots suspended in the air and periodically misted with a nutrient solution.

Advantages: Excellent aeration, efficient use of water and nutrients, rapid growth.

Advantages of Soilless Cultivation

Increased Control Over Nutrient Delivery:

Nutrients can be precisely controlled and adjusted, ensuring plants receive optimal nutrition for growth.

Efficient Water Usage: Soilless systems typically use less water compared to traditional soil-based



cultivation, as water can be recirculated and reused in closed-loop systems.

Reduced Risk of Pests and Diseases:

Eliminating soil minimizes the risk of soil-borne pests and diseases, reducing the need for chemical pesticides or herbicides.

Higher Yields and Faster Growth:

Soilless cultivation allows plants to access nutrients directly, resulting in faster growth rates and potentially higher yields compared to traditional soil-based methods.

Challenges

Initial Setup Cost: The initial setup of soilless cultivation systems can be expensive due to the cost of equipment and infrastructure.

Maintaining Nutrient Balance:

Ensuring the appropriate nutrient balance is crucial and requires careful monitoring and adjustment.

Proper Oxygenation for Roots:

It is essential to maintain proper oxygenation for the roots to prevent root diseases and ensure healthy plant growth.

Replication of Soil

Characteristics: Some crops may benefit from certain soil

characteristics that can be challenging to replicate in a soilless environment.

Applications and Popularity

Sustainability and Efficiency:

Soilless cultivation offers a sustainable and efficient method of growing horticultural crops, particularly in areas with limited access to arable land or unfavorable soil conditions.

Commercial Horticulture:

It has gained popularity in commercial horticulture due to its potential for year-round production and controlled growing conditions.

Urban Farming and Indoor Gardening:

Soilless cultivation is also popular in urban farming and indoor gardening, enabling food production in metropolitan areas and regions with limited arable land.

Overall, soilless cultivation provides significant advantages in terms of resource efficiency, pest and disease management, and yield potential, making it a valuable method for modern agriculture. However, it also requires careful management and investment in appropriate technology and infrastructure to overcome its challenges. ●



Profitable Sugarcane

Cultivation through Mechanizing farm operations

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Sugarcane is an important agro-industrial crop of India which plays a crucial role in social and economical up-liftment of rural population. It is grown in an area of 5.03 million ha with production of 361.03 million tonnes. Uttar Pradesh State is largest producer of sugarcane as it contributes 43.65 % of the total area and 35.21 % of the total production of sugarcane in the country. In India, the majority of the farm holdings fall under small and marginal category (85 %) and the average size of land holding is about 1.16 ha. The average farm power availability is about 1.35kW/ha in Indian agriculture. The sugarcane cultivation involves different operations such as seed bed preparation, planting (seed setts cutting, furrow making, placement of seed setts, fertilizer and chemicals, soil covering over setts), weeding/interculture, spraying, harvesting including de-trashing and transportation. Most of these operations are being done with traditional tools and equipment which are very time, labour consuming (375 man-days/ha) and involve lot of drudgery that ultimately increases the cost of operation and reduces the net profit to the growers. In sugarcane agriculture, the mechanization is limited up to the land preparation and to some extent to planting and intercultural operations.

Sugarcane production has increased drastically from 1930-31 to till now in India with significant increase in sugar production from during that period. This was possible due to



development of high yielding varieties and efficient crop production and protection technologies. The demand of sugar in the world by 2050 will be 341 mt. This has to be achieved with the same or reduced land area and with reduced manpower and water resources. Combination of efficient mechanization equipment/technique along with high yielding varieties are going to play a pivotal role for this.

The farm labour input in sugarcane agriculture is becoming increasingly costlier on the one side; and on the other, the labour efficiency, the turnover of work and duration of working hours are deplorably deteriorating resulting in poor crop management, increasing the cost of cultivation and reduced income to the farmers. Hence, farm mechanisation is the need of the hour. The principal advantage of mechanized sugarcane agriculture is that it reduces the demand for labour and allows operations to be carried out faster. Mechanization is needed to get over some of the

major constraints to enhance productivity and to make farming less arduous and attractive enough to enable educated youth taking willingly agriculture as vocation. Mechanization also aims at increasing land labour efficiency by improving the safety and comfort of agricultural labour and to protect the environment by allowing precision operations and increasing the overall income. Efficient machinery helps in timely farm operation, input use efficiency, increasing productivity by about 30%. The equipment presently available, requirement and the gap/ availability for sugarcane with respect to farming operations like land preparation, Sowing and planting, weeding and interculture, plant protection, harvesting are discussed in this paper.

Sugarcane mechanization

Sugarcane planting : Sugarcane is planted in the form of cut setts of 2-3 buds. Thus cutting of setts is an important operation prior to planting. The different operations



Deep furrow sugarcane sett cutter planter

about 550 bud chips/hour. Savings in cost of operation and savings in time is about 26 and 80 %, respectively.

Motorized model: The equipment consists of outer frame, double headed bud chipper to chip the buds, cane holder to hold the cane, motor(1/2 hp) for operating the sugarcane bud chipping cutting blades attached to stainless steel cylindrical shaft and a collecting basket to collect the chipped out buds. In this equipment, the double headed chipping blades moves up and down by a 0.5 hp motor through smooth gear transmission system at about 75 strokes per min. A pedal is provided, which can be operated by leg to activate the power drive to the cutting mechanism. This is done by the dog clutch mechanism through the pedal lever to operate the sugarcane bud chipping blade. A safety guard has been provided that helps in directing the sugarcane bud chips into the collection tray. The capacity of the equipment is about 2500 bud chips/hour. Savings in cost of operation and savings in time is to the tune of 60 and 90 %, respectively.

Tractor operated Settling Transplanter: The equipment consists of Mainframe to be attached to standard three point hitch arrangement of a 40 hp tractor with adjustable arrangement for altering row to row spacing 90, 120 and 150 cm. Bud chip settlings to be dropped through the metering mechanism by two operators who are seated behind the equipment with adjustable arrangements for altering plant to plant spacing of 30, 45 and 60 cm. Furrow openers open the furrow, in which the settlings with soil are to be planted with adjustable arrangement for altering depth of planting 2 to 6 cm. The same furrow is used for irrigation after the settlings have

carried out during sugarcane planting are (i) Making of furrow or trench (ii) Sett cutting (iii) Placement of setts in furrows (iv) Fertilizer application in bands on either sides of setts (v) Application of fungicidal, anti termites and anti insecticide solution (vi) Covering and pressing of setts.

Deep furrow sugarcane sett cutter planter: The planter consists of furrow opening, sett cutting, fertilizer metering, power transmission, insecticide solution application and soil covering units. In furrow opening unit, provisions were made for adjustment of row spacing between two furrow openers either at 750 or 900 mm. Whole canes are fed into the depth of furrow bottom manually and sett cutting mechanism, cut the setts and the setts are dropped into the furrow opened by the deep furrow opener. Simultaneously, fertilizer is dropped into the furrow and also insecticide is sprayed into the above sett and then soil is covered by press roller.

Mechanization package for sugarcane bud chip planting technology : The conventional method of planting of sugarcane, using stalk cuttings (setts), is gradually becoming uneconomical as the cost of "Seed Cane" used for replanting accounts for over 20 percent of the total cost of production. In the conventional system prevailing in India, about

10 tonnes seed cane / ha (nearly 10% of total produce) is used as planting material. Production of bud chips, raising of bud chip nurseries, transplanting of bud chip plants etc manually needs considerable time and resources and are serious deterrents in the popularization of the bud chip technology. The mechanization package for sugarcane bud chip planting been developed by ICAR - Central Institute of Agricultural Engineering-Regional centre.

Pedal operated sugarcane bud chipping equipment: The equipment consists of outer frame, bud chipper to chip the buds, cane holder to hold the cane, pedal and linkage mechanism for operating the bud chipper and collecting basket to collect the chipped buds. Sugarcane after harvesting at the 7-8 months and fed into the pedal operated sugarcane bud chipping machine. After placing the sugarcane in the appropriate position guided by a sugarcane guide mechanism, the chipping blade moves up and down by rocker arm motion activated by an eccentric mechanism. The up and down motion is obtained when the pedal is operated and the motion is transmitted from the pedal to the chipping blade through the transmission mechanism. A safety guard has been provided that helps in directing the sugarcane bud chips into the collection tray. The capacity of the equipment is



sugarcane bud chip planting technology

been planted for better establishment. The furrow closer which follows the soil opener closes the soil thereby giving stability to the settling plants. The field capacity of the equipment is 0.30 ha/h and the missing of 3 to 4 per cent at a working speed of 1.4 km/h. The plant establishment was more than 95%. The yield and quality parameters are on par when compared with manual planting.

Weeding and interculture

Rotary power weeder: The equipment consists of 8.3 hp light weight diesel engine mounted on a frame. Engine power is transmitted to the gear box and then to the ground wheels. There is provision to adjust wheel settings according to row to row spacing of the crop. Rotary weeder has 3 rows of discs mounted with 6 nos of curved blades fitted in opposite directions alternatively in each disc. These rotating blades enable cutting of the weeds, which is chopped up into the soil. Width of coverage is 350 mm and depth can be adjusted. Rotary weeder unit can be detached from frame and its plate and sweep type blades, junior hoe cultivator or a ridger can be fitted. The field capacity of the unit is 3 ha/day.

Tractor drawn three row rotary weeder: A three row tractor mounted rotary weeder was developed at Tamil Nadu Agricultural University with an operating width of 600 mm; the

spacing between consequent rotary weeding units is 300 mm. Hence the theoretical width of operation is 2400 mm. The depth of operation is 75 to 100 mm. The speed of operation is 1.00 to 2.00 kmh⁻¹. The field capacity of the unit is 2 ha/day.

Plant protection

ICAR CIAE-SBI Manually operated EPN applicator for sugarcane white grub management: The unit consists of chemical tank, pump, lance, injection mechanism, punching mechanism. Siphon mechanism has been used for the application of EPN solution in to the root zone. The manually operated EPN applicator was working satisfactorily for injecting the required quantity of 50 ml per plant. And also, the operation of the manually operated EPN applicator is classified as the light equipment and can be operated at an average depth of 14.08 cm. The actual field capacity is recorded as 0.0215 ha/hr with the field efficiency of 69.35%.

ICAR CIAE-SBI small tractor operated EPN applicator for sugarcane white grub management: Majority of the farmers follow the spot application of EPN to control white grub by manually. The manual application

was done by using crowbar to make 125 mm depth hole and drop the EPN solution to control white grub. Manual application method of EPN application involve more drudgery and non-uniform quantity of EPN solution in sugarcane root zone. Keeping the above view, a mini tractor operated EPN applicator has been developed by ICAR, Central Institute of Agricultural Engineering Regional Centre, Coimbatore in collaboration with ICAR Sugarcane Breeding Institute, Coimbatore. The developed small tractor operated EPN applicator consists of main frame, tank holding assembly, agitator, water pump, furrow opener and standard three-point hitch. A 150-liter tank was placed to carry the EPN solution. The tank consists of agitator and two EPN solution outlet flexible tubes. The agitator consists of two numbers of baffles at the end of vertical shaft. The agitator shaft was operated by 12 V high torque DC motor. The speed of the agitator shaft and discharge rate can be adjusted by using control units. The agitator provides continuous agitation of EPN solution and avoid suspension of particles so that it results in uniform delivery of the EPN. Pumping of EPN solution was done by two numbers of 4.0 LPM / 12v DC Water Sprayer Motor Diaphragm pump and it was



Tractor operated Settling Transplanter

powered by 12 V Battery. The average actual field capacity is 0.18 ha/h. The cost of operation was worked out as Rs. 2550 per ha

Harvesting

Sugarcane chopper harvester:

This is a chopper type sugarcane harvester. This machine performs the functions of base cutting, detopping, detrashing, chopping of cane, removal of trash, green leaves, tops and blowing billets into tractor trailer and transport trucks. The machine is suitable for sugarcane grown at 150 cm row to row spacing.

Tractor Operated Whole-Sugarcane Harvester :

Manual sugarcane harvesting is a very labour-intensive activity. A tractor operated whole cane harvester can be a boon for the people engaged with this job, the same has been developed with a base cutter unit, crop gathering unit, cane walker, de-topper and cane collection trolley.

All these mechanisms are hydraulically operated and can be mounted on a tractor three-point links. The de-topper unit is attached to left of the harvester main frame on a vertical supporting post, ahead to the base cutter to cut the top of the sugarcane leaf before base cutter cut the stalk.

The de-topping unit consists of a cane leaf gathering, rotary cutting

unit, height adjustment unit and hydraulic motor. The vertical supporting post is equipped with a telescope arrangement to adjust the height of the de-topping unit as per the head height of the sugarcane crop. The height adjustment is carried out with the help of a hydraulic cylinder. Base cutter and its hydraulic system are operated by the tractor PTO. A crop gathering unit is provided to separate and bend the sugarcane for gathering in a row; it is placed in front of the de-topper and base cutter unit. Cane walker unit is mounted on the harvester main frame above the base cutter, which is supported by the pneumatic tyre. It is provided for the conveying the cut cane and guiding into the collection trolley. Two chain conveyers rotate the clockwise and anti-clockwise to gather the cut cane from the base cutter to collection trolley. Cane collection trolley is attached to the main frame rear end with help of hitch pin and collection trolley is guided by two pneumatic wheels. The average field capacity of the unit is 0.11 ha/h and field efficiency of the unit is 0.70%. The equipment saves 71 % in cost when compared to manual harvesting.

Ratoon and trash management

Tractor mounted two row sugarcane stubble shaver :

It is a tractor mounted implement suitable for shaving sugarcane stubbles after harvest. The stubble shaver consists of rotary blades run by tractor P.T.O. The unit can also be used for off baring and fertilizer application.

Tractor operated sugarcane trash shredder (single row):

A tractor operated sugarcane trash shredder was developed at MPKV, Rahuri. The unit consists of trash compressing unit, shredding unit and power transmission unit. It can be operated with a 35 hp tractor. The width of operation is 60 cm. The field capacity of the unit is 1.5 ha/day.



sugarcane chopper harvester

Tractor operated sugarcane trash shredder (two row):

The main component of the unit is the rotating member with two rotary units. The spacing between them can be varied according to the row spacing of the crop. Swinging type curved blades are fitted on the rotary member in staggered manner. The rotating speed of the rotary unit is 1990 rpm. The field capacity of the unit is 2 ha/day.

Ratoon Management Device:

Ratoon management device (RMD) executes all the operations involved in management of ratoon crop such as stubble shaving, deep tilling, off-barring, placing manure, fertilizer/bio-agents, chemicals in liquid form and earthing up operations in a single pass of operation. It has capacity of 0.35-0.40 ha/h and saves 60% of the cost of operation.

Conclusion :

The mechanization of sugar cane could go a long way, not only in increasing production, but also in improving the quality of rural work. Clubbed mechanisation technology with effective mechanisation strategy will help to achieve the target of sugarcane productivity. Considering the facts that the mechanisation of sugar cane crops will address ever-increasing scarcity issues like scarcity of labour, cost of cultivation, drudgery and timely completion of cultural operations. So, mechanization in sugarcane is very important for sugarcane growers, sugar mills traders, etc. ●



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Nature's Hidden Gems

Medicinal Benefits of Aquatic Vegetables

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Aquatic vegetables often overlooked in daily diets are nature's treasure trove of health benefits. Thriving in water-rich environments like lakes, ponds, and wetlands these plants not only sustain the ecosystem but also offer remarkable medicinal properties. For centuries, various cultures have harnessed the healing potential of aquatic vegetables in traditional medicine, using them to treat a range of ailments. Rich in essential nutrients, antioxidants and bioactive compounds, these vegetables play a vital role in promoting overall well-being. As global interest in natural remedies and sustainable foods grows, the medicinal value of aquatic vegetables is gaining renewed recognition. From boosting immunity to managing chronic diseases these humble plants are emerging as powerful allies in enhancing human health.

AQUATIC VEGETABLES AND THEIR MEDICAL ATTRIBUTES

Water spinach (*Ipomoea aquatica*):

Family : Convolvulaceae

Medicinal Properties: Emetic, purgative in Assam. The plant given for nervous and general disability. It is also used for piles.

Cattail: (*Typha angustifolia* and *T. Latipholia*)

Family : Typhaceae

Medicinal Properties: The leaves are diuretic. The pollen is used in the treatment of nose bleeds, haematemesis (Vomiting blood), haematuria (Blood in urine). The seeds are haemostatic(stops blood flow).

Eelgrass (*Vallisneria spiralis*)



Family: Hydrocharitaceae

Medicinal Properties: The plant is aperitif (alcoholic drink consumed before food), demulcent (substance relieving inflammation), refrigerant.

Duck lettuce (*Ottelia alismoides*)

Family : Hydrocharitaceae

Medicinal Properties: It has been claimed that this plant has rubeficient (a medicine for external application that produces redness of skin) properties.

Water shield (*Brasenia schreberi* J.F. Gmel)

Family: Cabombaceae

Medicinal Properties: Leaves contain Gallic acid and traces of vitamin B12

Common water plantain (*Alisma plantago-aquatica* L.)

Family: Alismataceae

Medicinal Properties : The powdered seed is an astringent, used in cases of bleeding.

The seed is said to promote sterility. The root is used in the treatment of oliguria (low urine output), oedema (condition characterized by an excess of watery fluid collecting in the cavities or tissues of the body), nephritis (inflammation of the kidneys).

Dwarf waterclover (*Marsilea minuta*)

Family : Marsileaceae

Medicinal Properties : Leaf juice is used to stop nose bleeding.

Papyrus (*Cyperus papyrus* L.)

Family : Cyperaceae

Medicinal Properties : Its ash is useful in certain eye diseases.



Water shield (*Brasenia schreberi* J.F. Gmel)

Wasabi (*Wasabia japonica*)

Family : Brassicaceae

Medicinal Properties It suppresses the growth of stomach cancer cells. It is a powerful digestive stimulant and exhibits strong antioxidant and anti-diarrhoeal properties. All parts of plant possess bactericidal activities.

Fragrant Water Lily (*Nymphaea odorata* Ait.)

Family ; Nymphaeaceae

Medicinal Properties : The rhizomes are cooling and useful in diarrhoea, dysentery, dipsia (excessive thirst) and general debility. The flowers are astringent and cardio tonic. The seeds are aphrodisiac.

Chinese arrowhead (*Sagittaria sagatiifolia*)

Family ; Alismataceae

Medicinal Properties : Four new biologically active diterpenes, trifoliones A, B, C, and D, have been isolated from the tuber.

Paracress (*Spilanthes acmella* L.)

Paracress (*Spilanthes acmella* L.)

Family ; Asteraceae

Medicinal Properties : The flower heads are chewed to relieve the toothache.

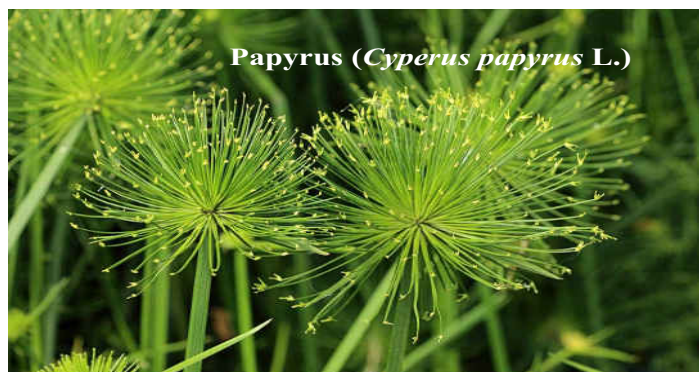
Whole plant has been well documented for its uses as spices, antiseptic, anti-bacterial, anti-fungal, anti-malarial and as remedy for flu, cough, rabies diseases and tuberculosis

Indian blue water Lily (*Nymphaea stellata* Willd.)

Family ; Nymphaeaceae

Medicinal Properties : The powdered rhizome is given in dyspepsia(indigestion), diarrhoea and piles.

Plant possesses hypoglycemic activity.



Papyrus (*Cyperus papyrus* L.)

Keysoor (*Scipus grossus*)

Family ; Cyperaceae

Medicinal Properties : Keysoor root has astringent properties, and is given to check diarrhoea and vomiting.

The root possesses cooling and laxative properties and acts as a tonic to the liver.

It is useful in burning sensations, fevers, and gonorrhoea.

Hydrolea (*Hydrolea zeylanica* (L.) Vahl)

Family ; Hydroleaceae

Medicinal Properties : Leaves are used for ulcers and prescribed for intestinal disorders



Eelgrass (*Vallisneria spiralis*)

Water pepper (*Polygonum hydropiper*)

Family ; Polygonaceae

Medicinal Properties : The leaves are anti-inflammatory, astringent, carminative, diuretic. They contain rutin, which helps strengthen fragile capillaries and thus helps prevent bleeding

Aquatic vegetables are not only a reliable and eco-friendly food source but also a rich reservoir of medicinal properties that contribute significantly to human health. Their abundance of essential nutrients, antioxidants, and bioactive compounds makes them valuable in preventing and managing various health conditions, including malnutrition, digestive disorders, diabetes, and inflammation.

As the demand for natural and functional foods rises, incorporating aquatic vegetables into daily diets can offer both nutritional benefits and therapeutic advantages. Embracing these nature-gifted plants can promote healthier lifestyles while supporting the preservation of wetland ecosystems, making them a vital part of future dietary and environmental balance. ●

The Mighty Microgreens

Small Plants, Big Benefits

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In an era where sustainability and health intersect more than ever, microgreens emerge as a beacon of nutritional innovation and environmental responsibility. These tiny greens, though small in size, pack a substantial punch in terms of nutrients and have begun to transform urban food landscapes across the globe. With their rapid growth cycle and minimal space requirements, microgreens represent a vital breakthrough in our quest to produce food that is as good for the earth as it is for our bodies. This article explores the myriad benefits of microgreens from their rich nutrient profiles to their versatile culinary uses, and their role in reshaping urban agriculture making a compelling case for why they are far more than just a passing trend.

What Are Microgreens?

Microgreens are young vegetable greens, approximately 1-3 inches (2.5-7.5 cm) tall, that fall somewhere between sprouts and baby leaf vegetables. They have an intense aromatic flavour and concentrated nutrient content, and come in a variety of colours and textures. Despite their small size, they are bursting with colour, flavour, and nutrients, and are typically harvested 7-21 days after germination when the first true leaves of plant have emerged. Microgreens can be purchased whole and cut at home, keeping them alive until they are

consumed.

Why Are Microgreens Important?

They are not only a gourmet favourite but also packed with vitamins and minerals, offering health benefits in a small, compact and flavourful package. They are easy to grow and can thrive in limited spaces, making them perfect for urban agriculture.

Nutritional Benefits of Microgreens : Microgreens are known for being exceptionally rich in nutrients. Studies have shown that these tiny greens contain higher levels of vitamins and minerals compared to their fully-grown counterparts, with some varieties offering up to 40 times more nutritional value.

- **Popular Microgreens: Flavors and Nutritional Benefits**
- **Red Cabbage:** High in vitamin C and antioxidants. Mildly sweet with a crisp texture.
- **Sunflower:** Nutty flavour, packed with protein and healthy fats.
- **Pea Shoots:** Sweet and crunchy, rich in vitamins A, C, and folic acid.
- **Arugula:** Peppery flavour, rich in vitamin C and potassium.
- **Basil:** Sweet and fragrant, great for garnishing dishes.





- **Beet Greens:** Sweet and earthy taste, high in vitamins A, C, and iron.
- **Broccoli:** Mild flavour, contains high levels of sulforaphane, known for its cancer-preventing properties.
- **Cilantro:** Bold, citrusy flavour, packed with antioxidants.
- **Kale:** Slightly bitter, nutrient-dense, high in vitamins A, C, and K.
- **Mustard Greens:** Spicy flavour, contains high levels of antioxidants.
- **Radish Greens:** Peppery taste, rich in vitamins A, C, and B6.
- **Swiss Chard:** Colourful stems, a flavourful addition to any dish, rich in vitamins K, A, and C.
- **Wheatgrass:** Intense flavour, known for its detoxifying properties.
- **Carrot Greens:** Mild, slightly sweet flavour, good for blending in smoothies or salads.
- **Amaranth:** Vibrant colours, mild flavour, good for decorating dishes.

Microgreens vary not just in taste and nutritional profile, but also in the way they enhance the visual appeal and flavour of dishes. They are excellent for use in garnishes, salads, sandwiches, and even for blending into smoothies or juices. These tiny greens are packed with concentrated nutrients that can significantly contribute to daily nutritional goals, supporting

overall health and well-being. Consuming microgreens is an easy way to boost your intake of vitamins, minerals, and antioxidants. The health benefits associated with microgreens include improved digestion and a reduced risk of chronic diseases such as heart disease, diabetes, and certain types of cancer.

Culinary Versatility of Microgreens: Microgreens add fresh taste and a vibrant pop of colour to a variety of dishes. Chefs use them to enhance the flavour of salads, sandwiches, and wraps. They can also be blended into smoothies or juiced. Microgreens like arugula, with its peppery flavour, are perfect for adding a bit of zing to pizzas and pastas, while beet greens can sweeten up your salads.

Growing Your Own Microgreens: One of the biggest appeals of microgreens is their ease of cultivation. They can be grown indoors, making them accessible for urban dwellers without access to traditional garden spaces. All you need is a shallow tray, some soil or a soilless substrate like cocopeat, and seeds. Within just a couple of weeks, you can harvest your own microgreens, ensuring they are as fresh as possible. This quick turnaround not only provides freshness but also maximizes the

nutritional benefits, making it an ideal solution for anyone looking to incorporate more greens into their diet.

How to Grow Microgreens at Home

Setup and Supplies:

- **Containers:** Use shallow trays or repurposed food containers with drainage holes to ensure proper water management.
- **Growing Medium:** Opt for soil or a soilless mix such as cocopeat, which provides excellent moisture retention and aeration.
- **Seeds:** Select seeds specifically intended for microgreen cultivation (e.g., radish, kale, arugula, mustard) for the best results.
- **Lighting:** Ensure your microgreens receive sufficient light. If natural sunlight is inadequate, supplement with grow lights to mimic natural conditions.
- **Watering:** Use a watering can or spray bottle for gentle watering that doesn't disturb the seeds or young plants.

This process ensures that the microgreens develop in a controlled environment, promoting faster growth and resulting in fresher produce right from your windowsill or balcony.

Step-by-Step Cultivation Process for Microgreens

- **Prepare the Growing Medium:** Fill your container with the chosen medium, either soil or a soilless substrate like cocopeat. Moisten the medium thoroughly before evenly spreading the seeds.
- **Seed Preparation:** Enhance early germination by soaking seeds in plain water for 12 hours before sowing. Note that some seeds, like coriander, benefit from being broken into halves before sowing to improve



germination rates.

- **Cover and Germinate:** After soaking, distribute the seeds thinly over the medium. Cover the seeds with a thin layer of the same medium or a moist paper towel. Water gently, then cover with a lid or another tray to create a blackout period. This darkness should be maintained for 2-3 days or until the seeds have sprouted.
- **Light Exposure:** Once sprouted, place the microgreens in a location that receives indirect sunlight, such as a windowsill or kitchen countertop, or use a grow light. This exposure promotes essential photosynthesis.
- **Watering:** Mist the plants regularly to maintain moisture in the medium, ensuring it is moist but not waterlogged.
- **Harvesting:** Harvest the microgreens when they develop their first true leaves, typically 1-3 weeks after planting, or when they reach 1-3 inches in height. Use scissors for a clean cut just above the substrate line.

Tips for Successful Growth:

- **Moisture Management:** Ensure consistent moisture levels but be

careful to avoid overwatering which can lead to fungal issues.

- **Air Circulation:** Use a fan or ensure good air movement around the growing area to help prevent mold growth.
- **Light Management:** Maintain consistent light exposure and periodically rotate the trays to ensure even growth among all plants.

Environmental Impact of Microgreens:

Microgreens are not only beneficial for your health but also for the planet. They can be grown hydroponically/cocoonically, which reduces the need for soil and large amounts of water.

This method significantly lowers the risks associated with soil-borne diseases and pests. Due to their rapid growth cycle and minimal space requirements, microgreens are an ideal crop for vertical and urban farming initiatives. These practices help decrease food miles and carbon footprints, making microgreens a sustainable choice in modern agriculture.

The Future of Food: As we continue to grapple with the challenges of feeding a growing

global population, microgreens present a sustainable solution that is nutrient-rich and environmentally friendly. They illustrate the principle that even small changes in our diets can have a profound impact on our health and the planet. Whether you're a gourmet chef, a home cook, or simply looking to enrich your diet, microgreens provide an easy and efficient way to boost the nutrition and flavour of your meals. Try incorporating these tiny but mighty greens into your next dish and experience the difference for yourself!

Conclusion: Microgreens are more than just a culinary trend; they are a potent food source that can substantially impact our nutrition and urban agriculture practices. They offer a robust solution for enhancing the flavour and nutritional content of our daily meals.

There is strong encouragement to integrate microgreens into everyday diets, not only to benefit from their dense nutritional profile but also to support sustainable farming practices. Embrace these vibrant greens in your next meal and contribute to a healthier, more sustainable world. ●

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Heat Pump Drying

A perspective

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Drying is an ancient preservation method of food. It consumes more energy and time, limiting its application of drying use for high-moisture foods. Drying is the process of removing moisture from products to reduce the growth of bacteria, yeast, and mould to reduce the spoilage of the product. Drying improves shelf life, reduces packaging cost, reduces shipping weight, increases nutritive value, and enhances appearance (Chou and Chua 2001). The main three-fold goals of the drying process are economic growth, environmental consent, and the quality of the product (Okos et al. 1992; Patel KK and KarA. 2011).

India's export of dried and preserved vegetables has increased significantly, reaching \$208 million in 2023, making it the second-largest exporter globally. The major importers of Indian dried vegetables include Germany (\$23.3M), Brazil (\$21.9M), the United Kingdom (\$13.4M), Russia (\$12.5M), and the United States (\$11.6M). The fastest-growing markets between 2022 and 2023 were Russia, Brazil, and Belgium. Meanwhile, India imported \$6.16 million worth of dried vegetables, primarily from China, Turkey, Germany, Egypt, and Israel. Leading companies like Walmart, Loblaws Supermarkets, and Riviana Foods played a key role in shipping Indian dried vegetables to the U.S. (OEC. (2023).

Drying slows enzymes but doesn't inactivate them. This process will reduce the nutritional value of the product. For example, air-drying is



a common method in drying foods, but it affects the taste, colour, and nutritive value of that food. To prevent these issues, drying should be controlled. Heat pump drying is a technology that regulates temperature and humidity for control. Other common dryers in the food industry are spray dryers, freeze dryers, vacuum dryers, tray dryers, rotary dryers, fixed bed dryers, and fluidised bed dryers. Heat pump drying is energy-efficient with low operating costs, and its economic feasibility is debated due to electricity use.

Heat pump drying : Heat pump-assisted drying is a hybrid drying technology that combines different heat transfer modes for improved efficiency and involves using two or more stages of the same or different types of dryers to enhance the drying process. The addition of heat pumps to drying processes can be implemented in various methods. Among the most

promising techniques, heat pump drying and heat pump-assisted drying are widely used in the food industry.

It improves efficiency in terms of energy use and processing time. Only 510% of the supplied energy is absorbed by wet materials in drying, while 9095% of this energy can be recovered using heat pump technology, which is leading to significant energy savings. This method is an alternative for drying fruits and vegetables with lower energy consumption.

Heat pump-assisted drying is a highly efficient alternative to traditional drying systems. It tested a n R - 114 heat pump dehumidification system and has proved that the heat pump-assisted drying is more efficient, and a lot of theoretical analysis of heat pumps is found in the literature.

Principle and Mechanism: Heat

pump-assisted drying follows the same principle as pure heat pump drying, functioning like a reverse heat engine. It operates on refrigeration principles, cooling air to condense moisture while recovering latent heat, allowing efficient air recirculation. described heat pumps as thermodynamic systems that extract heat from lower-temperature sources to achieve the required drying temperature. These systems utilise low-temperature energy from ambient sources like air, water, and the earth. Such energy-efficient drying methods make heat pumps a sustainable alternative in food processing.

Heat pumps can utilise waste heat from industrial processes, upgrading it to the required temperature for thermal operations. As electric devices with heating and cooling capabilities, they transfer heat from a lower-temperature medium to a higher temperature.

A heat pump dryer consists of a conventional drying chamber with an air circulation system and refrigeration components. The drying air is dehumidified by the evaporator and reheated by the condenser, allowing precise temperature control from -20°C to 70°C. Studies comparing heat pump and hot air drying showed

superior colour and aroma retention in heat pump-dried products. Improved convection efficiency and controlled drying conditions make heat pump-assisted drying a reliable and effective method.

Advancements in heat pump drying now incorporate loop thermosyphons, a type of heat pipe that improves heat transfer efficiency. The working fluid condenses and returns to the evaporator via gravity, aiding in pre-cooling and reheating the drying air. Studies on bypass air ratios and recirculation fractions led to the development of a heat pump dryer with a loop thermosyphon for drying longan fruit. Although heat pump drying is costly, its break-even period can be reduced through lower operating costs and higher output.

Heat pump drying performance is evaluated through heat recovery, moisture extraction rate (MER), and energy efficiency measured by the coefficient of performance (COP). It ensures higher drying efficiency, better product quality, and environmental benefits. Specific moisture extraction rate (SMER) values range from 1.0 to 4.0 for HPD, compared to lower values in vacuum and hot air drying. HPD achieves 95% drying efficiency, outperforming vacuum

drying (below 70%) and hot air drying (3540%).

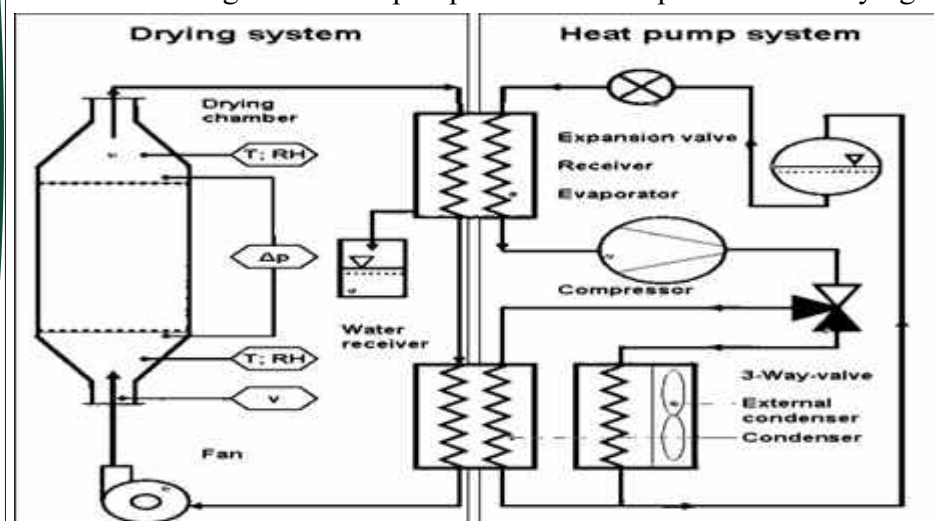
Heat pump-assisted drying significantly improves efficiency, reducing drying time by 40.7% and electrical energy use by 40% for onions. Its economic feasibility depends on design factors, especially in regions with high humidity and for materials with high initial moisture content. Adding a heat pump to other drying methods enhances performance in commercial operations. Various heat pump-assisted drying techniques, such as solar, microwave, infrared, fluidised bed, and atmospheric freeze drying, are already in use in the food industry.

Advantages and disadvantages heat pump drying :

The goal of drying is to achieve high-quality products at minimal cost and maximum efficiency, making energy-saving technologies essential. Heat pump drying enhances efficiency by recovering latent and sensible heat, reducing losses from vented moist air through air recirculation. Studies confirm its economic feasibility, with HPD using less energy than conventional systems and maintaining better product quality at lower temperatures. It minimises colour change and ascorbic acid loss while improving drying kinetics without compromising quality. Fluidised bed dryers with heat pump mechanisms allow precise temperature and humidity control, making them ideal for heat-sensitive food materials.

Conclusion : It is essential in the agri-food industry for energy-efficient drying techniques leading to high-quality, shelf-stable products. Heat pump-assisted drying offers a promising technique, with ongoing advancements aimed at making drying processes more economical and eco-friendly. ●

Schematic diagram of heat pump assisted atmospheric freeze drying



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