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KERALA KARSHAKAN English journal

The First English farm journal from the house of Kerala Karshakan

Lotus vs Waterlily

Distinguishing the Fascinating Aquatic Blossoms

INSIDE KERALA KARSHAKAN

English journal

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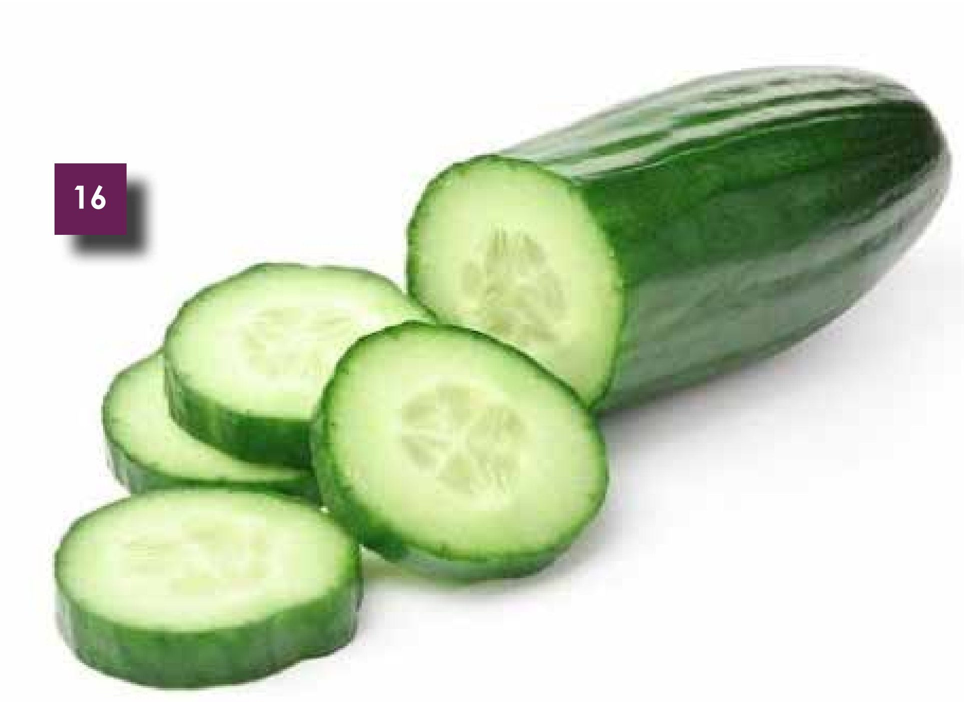

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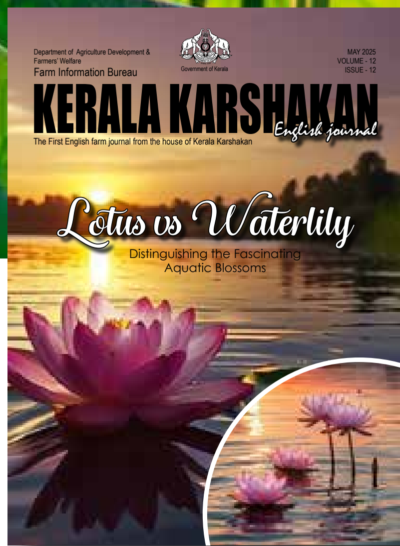

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Yellow Broccoli

Breeding for Colours in Vegetables A Pathway to Diversity and Nutrition

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Introduction

Vegetables play a pivotal role in human nutrition, offering essential vitamins, minerals, and antioxidants. Among the emerging trends in agriculture, breeding vegetables for diverse colours has gained remarkable attention due to their nutritional

Purple Cauliflower

Orange Cauliflower

and market value. Colours in vegetables result from bioactive compounds like anthocyanins, carotenoids, chlorophyll, and betalains, which are associated with specific health benefits. This write-up delves into the methods, implications, and prospects of breeding vegetables for colours, focusing on the needs of farmers

Green Cauliflower

Red Bhendi

and students.

The Importance of Colour in Vegetables

The significance of colour in vegetables extends beyond aesthetics. Nutritionally, different pigments are linked to health benefits. For instance, anthocyanins, which give vegetables their purple and red hues, are known for reducing oxidative stress and lowering the risk of cardiovascular diseases. Carotenoids, responsible for orange and yellow colours, improve eye health and boost immunity. Chlorophyll, which provides the green colour,

Purple Carrot

Purple Potatoes

supports detoxification and gut health, while betalains, found in red and yellow vegetables, offer anti-inflammatory properties. Economically, colourful vegetable varieties such as purple cauliflower and black tomatoes command premium prices in markets, making them lucrative for farmers. Additionally, colour preferences vary by region, with traditional and cultural dishes often incorporating vegetables of specific colours.

Role of Wild Species in Vegetable Colour Breeding

Wild species of vegetables are vital for developing colourful

Purple Radish

Purple Beans

and nutrient-rich varieties, offering unique pigments, genetic diversity, and resilience to environmental stresses. These species often possess rare pigments like anthocyanins, carotenoids, and betalains, which are absent in cultivated vegetables. For instance, wild carrots (Daucus carota subsp. carota) contribute deep purple and red hues, while wild tomatoes (Solanum pimpinellifolium) offer diverse colours, including yellow and orange.

Wild relatives enhance the nutritional value of vegetables with higher levels of bioactive compounds, such as antioxidants in wild beets (Beta vulgaris subsp. maritima), which improve both colour and health benefits. They also broaden the genetic base of crops, introducing traits for pest and disease resistance, drought tolerance, and pigment stability under stress.

Pre-breeding programs use wild species to transfer desirable traits into cultivated lines. For example, crosses between wild and cultivated carrots have resulted in vibrant purple and red varieties, while wild spinach contributes disease resistance alongside improved leaf colours.

Although challenges like genetic incompatibility exist, modern tools like marker-assisted selection and genome editing are making the integration of wild traits more efficient. With continued research and conservation of wild germplasm, breeders can develop visually appealing, nutritious, and resilient vegetable varieties.

Target Vegetables for Colour Breeding

Certain vegetables have become primary targets for colour breeding due to their natural pigment diversity and consumer demand. Carrots exhibit a wide range of colours, including orange, purple, white, yellow, and red, with each variation offering distinct nutritional benefits such as high beta-carotene or anthocyanin content. Similarly, tomatoes are available in red, yellow, orange, green, black, and bi-coloured forms, with lycopene being the primary antioxidant. Capsicum, or bell peppers, offer vibrant shades of green, red, yellow, orange, and purple, providing a rich source of Vitamin C. Beetroots, which are naturally red, yellow, or white, are valued for their betalains and dietary fiber. Cauliflower, traditionally white, has been bred into orange, purple, and green varieties, which are rich in glucosinolates and Vitamin C. These vegetables showcase the potential for colour breeding in enhancing both nutritional and aesthetic appeal.

Factors Influencing Colour Development

The development of colour in vegetables depends on genetic, environmental, and agronomic factors. Genetically, pigment traits are governed by genes involved in biosynthesis pathways. For example, the genes CHS and DFR play a vital role in anthocyanin production. Environmental conditions such as light intensity, temperature, and soil fertility also impact pigment development, with high sunlight enhancing anthocyanin content and cool nights promoting carotenoid accumulation. Agronomic practices, including balanced fertilization and irrigation, further influence colour expression. Improper handling during post-harvest stages can lead to pigment degradation, affecting both appearance and nutritional quality.

Breeding Techniques for Colour Development

Several breeding methods are employed to enhance the colour of vegetables. Conventional breeding involves selecting colourful variants from local or wild germplasm and crossing them with other varieties to combine desirable traits. Mutation breeding introduces novel colours through induced genetic changes, as seen in golden cauliflower developed via radiation. Modern techniques

Yellow Beets

like marker-assisted selection (MAS) enable breeders to identify and propagate pigment-related traits more efficiently. Biotechnological approaches such as CRISPR-Cas9 allow precise editing of pigment biosynthesis genes, while transgenic methods introduce colour-enhancing genes from other species. Additionally, polyploidy breeding, which involves chromosome doubling, can intensify pigment production, as demonstrated in tetraploid watermelon with deeper red pulp.

Case Studies

Several successful examples illustrate the potential of colour breeding. In India, breeding programs have adapted purple carrots rich in anthocyanins to suit local climates, offering both nutritional benefits and marketability. In Europe, black tomatoes with high anthocyanin content have gained popularity in niche markets, showcasing the appeal of novel colours. Mutation breeding has also led to the development of orange cauliflower, which is rich in beta-carotene and widely appreciated for its vibrant appearance and health benefits.

Challenges in Colour Breeding

Despite its potential, colour breeding faces several challenges. Consumer acceptance can be a barrier, as novel colours may encounter resistance in traditional markets. Limited genetic diversity in some crops restricts the scope of breeding programs. Environmental sensitivity of colour expression adds another layer of complexity, as climatic variations can affect pigment production. Additionally, regulatory hurdles for biotech-derived colourful varieties often delay their commercial release, further complicating the process.

Recommendations for Farmers

Farmers can maximize the benefits of colourful vegetable varieties by selecting those adapted to their local climates and following optimal cultivation practices. Balanced nutrient application and adequate irrigation are crucial for consistent colour development. Post-harvest handling and proper storage conditions are also essential to retain the visual and nutritional quality of colourful vegetables, ensuring better marketability and consumer satisfaction.

Conclusion and Future Prospects

Breeding colourful vegetables presents a promising opportunity to enhance both nutritional security and agricultural profitability. By adopting colourful varieties, farmers can cater to niche markets and achieve higher returns. For students and researchers, this field offers exciting avenues for innovation in genetics and breeding.

Future efforts should integrate advanced technologies like MAS and CRISPR-Cas9 with traditional breeding methods to sustainably produce diverse and vibrant vegetable varieties. Popularizing colourful vegetables at the national level will not only improve human nutrition but also create opportunities for economic growth and environmental conservation.

Introduction:

Kerala's unique coastal farming practices, like Pokkali and Kaipad rice cultivation, showcase how traditional methods can thrive even in challenging, salty environments. Pokkali rice is grown in the central coastal regions, while Kaipad rice is cultivated in the northern coastlines of Kerala. Both are saline tolerant rice varieties that have adapted to survive in fields that flood with seawater during certain seasons. Farmers alternate between rice and prawn or fish farming in the same fields, which enriches the soil naturally. These methods not only support sustainable agriculture but also preserve Kerala's agricultural heritage, offering valuable insights into how traditional practices can address

SUSTAINABLE COASTAL FARMING: THE LEGACY OF POKKALI AND KAIPAD RICE IN KERALA

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modern day environmental challenges.

POKKALI

The oldest indigenous rice variety that has 3000 years of organic cultivation and climate resilience history. It is a unique saline tolerant rice variety that is cultivated using extensive aquaculture in an organic way in the water-logged coastal regions of Alappuzha, Kottayam, Thrissur and Ernakulam districts of Kerala. Pokkali rice got its Geographical Identification tag (GI Tag) in 2008-2009, also making it the first product in Kerala to receive the tag.However, the Pokali system has stood the test of time, offering a glimmer of hope for sustainable rice cultivation in this fragile ecosystem.

The rice got its name Pokkali, because of its notable height, which can grow up to 6 feet. Pokkali rice cultivation alternated with extensive aquaculture is known as Pokkali farming. In Kerala, when the southwest monsoons wash the salinity of the tiny soil mounds made in the fields, is the ideal time to start Pokkali paddy cultivation.
Cultivation Practices:

The Pokkali system of rice cultivation in the acid saline soils of Kerala is a unique method of rice production. In this method, a single-crop of rice is taken in the low saline phase of the production cycle (June to mid- October) on mounds, to be followed by prawn farming during the high saline phase (November to April). Only

Kuthiru

the panicles are cut about 30 cm from top and the rest of the stalks are left to decay in the water, which in time become feed for the prawns that start arriving in November–December. Then, the second phase of the Pokkali farming, the prawn filtration, begins.

A noteworthy feature of this traditional rice cultivation method is that neither chemical fertilizers nor plant protection chemicals are applied in the field. The Pokkali fields are also subjected to periodic submergence. The daily tidal inflows and outflows, besides the tremendous microbial activity owing to the presence of large quantities of organic matter (decomposed aquatic weed mass and paddy stubbles), make the pokkali fields particularly fertile. This integrated farming system makes efficient use of land and resources but also helps to control pests and diseases, enrich the soil and maintain the ecosystem's health.

Despite the benefits, Pokkali system faces several challenges like unpredictable rise in sea levels, shortage of labour, market competition etc.

Characterization studies revealed that Pokkali rice is medium bold in shape, with very good cooking quality, special taste, average protein (7.5 – 8.5%) and intermediary amylase (> 20%) content. Pokkali rice has intermediate gelatinization temperature with a hulling percentage of more than 80, milling percentage of more than 75.

The rapid climatic changes and the rising sea levels across the world have encouraged the search for saline-resistant varieties, hence Pokkali which can also grow in saline water will have a great future.. Most importantly, this farming is ecofriendly without exploiting natural resources and biodiversity.

Orkayama

Ezhome-1

Nutritional Profile:

Pokkali rice varieties are rich in protein, fiber, and antioxidants, making them highly nutritious. The grain contains essential antioxidants like tocopherol, oryzanol, and tocotrienol, which play a vital role in boosting immunity. With its low carbohydrate content, Pokkali rice is ideal for diabetic patients. Moreover, it is enriched with vital micronutrients like iron, boron, sulfur, and vitaminE.

KAIPAD SYSTEM

Kaipad is an indigenous rice farming system practiced in the coastal wetlands of North Kerala, which are saline-prone and naturally organic. This farming system is found in the districts of Kozhikode, Kannur, and Kasaragod. In Kaipad, rice farming is carried out in a unique manner, relying entirely on natural factors such as the monsoons and sea tides. The first crop season takes place in saline wetlands subjected to regular tidal action, utilizing the heavy South West monsoon to flush out salt from the fields. Following rice cultivation, traditional fish farming is practiced. Local farmers, using their indigenous knowledge, grow a single rice crop on mounds during the low to medium saline phase from June to October. No chemical fertilizers or pesticides are used, and no cultural operations are required until harvest. After the paddy is harvested, the Kaipad fields are left for aquaculture, primarily shrimp farming. The rice produced through this method is entirely organic.

Kuthiru', and 'Orkayama' are the traditional land races widely grown in Kaipad rice tracts. 'Mundon', 'Kandorkutty', 'Orpandy', 'Odiyan', 'Orissa', 'Punchakayama' and 'Kuttadan' are the other land races cultivated in some pockets of Kaipad. These land races are tolerant to low

Ezhome-2

and medium salinity. The average rice yield of these local cultivars is about 1.0 – 1.5 t/ha. The traditional cultivars are susceptible to lodging, and with poor grain qualities like awn on grains, long bold, and heavy shattering of grains which make harvest a tedious and laborious process. The nutritive quality analysis of Kaipad cultivars has shown that they are rich in iron, calcium, and potassium. Additionally, they are a good source of protein, fiber, and B-complex vitamins such as folate and pyridoxine.

Kerala Agricultural University had recently developed an array of high yielding rice cultures through a challenging breeding project utilizing local land races in breeding programme. Out of these cultures, two were released for commercial cultivation in 2010 in the name, 'Ezhome -1' and 'Ezhome -2'.

Ezhome-1

A hybrid derivative of the Jaya x Kuthiru cross, this rice variety is known for its tolerance to salinity, high yield potential, and resistance to lodging. Each plant produces an average of 18-20 tillers, with approximately 21 panicles per plant. The variety features compact panicles with closely arranged, awnless grains and brown-colored kernels. In the saline Kaipad tracts, depending on the salinity levels, the average yield during the first crop season ranges from 1.4 to 1.6 tons per acre, while in non-saline wetlands, the yield is around 2 to 2.4 tons per acre.

Ezhome-2

A hybrid derivative of Jaya x Orkayama, this is a medium-duration crop that matures in 120-125 days and is suitable for all seasons. The plants typically reach a height of 110-120 cm and produce an average of 20 panicles per plant. The grains are awnless and straw-colored, with light brown kernels. In the saline Kaipad tracts, depending on the salinity levels, the average yield in the first crop season ranges from 1.2 to 1.4 tons per acre, while in non-saline wetlands, the yield is around 2 to 2.5 tons per acre.

Conclusion

Pokkali and Kaipad rice farming are vital parts of Kerala's agricultural heritage, showcasing sustainable ways to grow crops in challenging coastal environments.

These traditional practices not only support local communities but also offer valuable insights into resilient and eco-friendly farming methods that can serve as models for adapting to environmental changes. Preserving these unique systems ensures a future where tradition and sustainability go hand in hand.

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Importance of Cassava Production and the Impact of Stem and Root Rot Disease on Yields

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Climate change significantly affects crop production and productivity, intensifying food insecurity and increasing poverty across the globe. Tropical tuber crops like cassava, sweet potato, yams and aroids play a crucial role in addressing the challenges posed by climate change in agriculture due to their resilience and adaptability, especially in regions facing extreme weather conditions.The role of tuber crops in mitigating climate change impacts on food security and poverty makes them vital for sustaining livelihoods.

Among the different tropical tuber crops, cassava (*Manihot esculentaCrantz*), belonging to the Euphorbiaceae family and native to South America, is the most important crop for ensuring food security.

Collar rot

Tuber rot

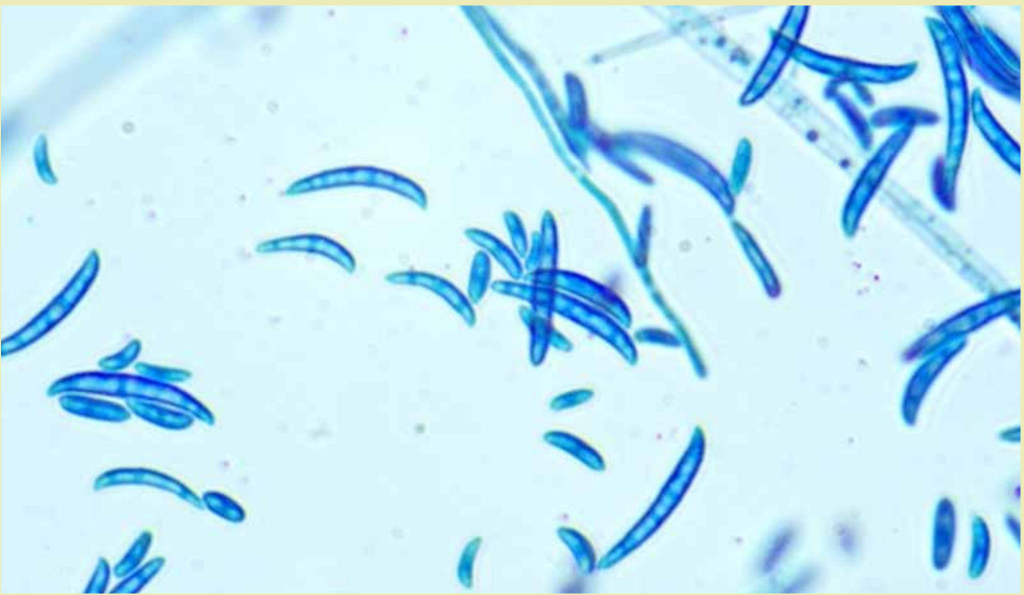
Wilting

Globally, cassava stands as the fifth most significant food crop after maize, rice, wheat and potato (FAOSTAT, 2023), serving as a staple for over 500 million people world wide (Otekunrin, 2024). Its starch-rich tuberous roots not only serve as a vital food source but also play a key role in industries such as textiles, paper, cosmetics and pharmaceuticals.

Cassava is primarily cultivated in Africa, Asia, and South America and thrives in tropical and subtropical climates across these regions. As per the latest statistics, Nigeria, the Democratic Republic of Congo,Thailand,Ghana, Brazil, Indonesia andCambodiaare the leading cassava-growing countries in the world,with India ranking 16th in production. In India, cassava is cultivated in 1.66 lakh hectares, with a total production of 59.38 lakh tonnes and an average productivity of 35.77 tons/ha (FAOSTAT, 2023). Tamil Nadu,Kerala, Meghalaya, Andhra Pradesh and Nagalandare the main cassava-growing states in India. Tamil Nadu leads in cassava production in India, followed by Kerala, which cultivates the crop in 0.57 lakh hectares, producing 23.34 lakh tonnes and contributing 40.26% to the country's total production (GOI, 2023).

Cassava farming provides crucial support to smallholder farmers, especially in developing countries, offering a reliable source of income. Being recognized as a "famine crop" world wide, cassava thrives in degraded soils with relatively low fertility and is resistant to drought, making it an ideal crop for smallholder farmers in harsh upland conditions. Additionally, cassava contributes to carbon sequestration by improving soil health and organic matter content. Its adaptability to agro ecological farming practices reduces dependency on synthetic fertilizers and pesticides, promoting sustainable land use.The crop's ability to remain underground for extended periods allows farmers to harvest it when needed, serving as a natural food reserve during droughts, wars, economic crises, or periods of food scarcity. Furthermore,its versatility in food processing,such as the production of starch and sago, cassava flour, animal feed and fermented products, enhances value addition, generating employment opportunities and strengthening rural economies.

Microscopic view of the pathogen



Fusariumsp in Potato Dextrose Agar (PDA) medium

The average yield of cassava is well below its potential of 80 t/ha under ideal conditions, mainly due to various biotic and abiotic factors. Key diseases affecting cassava include fungal diseases like cassava tuber rot (CTR), root rot (CRRD), cassava stem and root rot (CSRR), cassava anthracnose disease (CAD), cassava brown leaf spot, and cassava leaf blight; viral diseases such as cassava mosaic disease (CMD) and cassava brown streak disease (CBSD); and bacterial diseases like cassava bacterial blight (CBB)(Legget al., 2015; Hareeshet al.,2023). Among these, cassava root rot disease (CRRD) is especially devastating, as it directly affects the tuberous roots, the crop's primary economic product. A complex of soil-borne pathogens causes CRRD and can survive in fields even without a host in the soil, making subsequent cultivation difficult. This has been reported as a serious production threat from countries like Nigeria,Congo,Cameroon,Togo,Uganda,Benin,Ghana, Argentina, Brazil,Thailand and Vietnam. Fungi belonging to the Genus *Fusarium, Lasiodiplodia, Neoscytalidium,* and *Diaporthe/Phomopsis complex, Phytophthora*were reported to be the causal organisms, with *Fusarium*being the most prevalent causal organism. In India, tuber rot caused by *Phytophthora palmivora* has been reported from Kolli hills in Tamil Nadu, Thiruvananthapuram, Kollam, and Kottayam districts of Kerala, which causes major economic loss of up to 70% in cassava production (Sankar et al.,2013). The disease symptoms include brown, watery lesions in the tuber with a foul smell, making it unfit for further use. Apart from this, a new threat, cassavastem and root rotdisease,has become a menace to the farmers in Kerala, particularly in wetland regions and the disease was first observed in 2019 and reported(Jeeva et al., 2020). The infection led to the rotting of roots, stem in the collar region,and tubers, ultimately causing plant wilting and complete yield loss. Fusarium solani species complex (FSSC) was reported as the main causal organism. The disease was initially reported in Kollam district and later from other districts of Kerala as well, especially Thiruvananthapuram, Idukki,Kottayam,Eranakulam and Thrissur, where cassava is grown in wetlands.Yield loss of up to 100% was reported from wetlandsof Kerala((Jeeva et al., 2023)

ICAR-Central Tuber Crops Research Institute (ICAR-CTCRI) conducted extensive surveys, lab studies, and field trials, which revealed that these symptoms are likely caused by pathogens. The problem worsens in acidic soils with nutrient imbalances, especially in waterlogged conditions, which damages the plant roots and causes wilting of the plant.

The symptomatology, factors responsible for the severity and management strategies are below (ICAR-CTCRI, Technical Leaflet: TL-6/2024).

Symptomatology

This disease affects all growth stages of the crop. The main symptom is the blackening of the stem and the presence of fungal mycelia/pustules near the collar region. Usually, the infection starts at the base of the stem just below the soil and progresses upwards and downwards. Later on, it spreads to the tubers,which subsequently get decayed. The feeder roots and stems are more infected than the tubers. In severelyaffected plants, the lower leaves show abnormal yellowing, drooping and wilting.

Factors responsible and causal organism

Since 2020, the disease has been widespread and noticed in the cassava-growing wetlands of all districts of Kerala. Thesymptoms usually appear very quickly in a short span of time, approximately within 7-10 days, following the onset of rainafter a period of elevated temperature. In Kerala, the incidence was high during May-June and September-October.

Different species of Fusarium in the soil cause stem and root rot. Infection is favoured by high soil acidity (pH: 3.5-5.0) andimbalanced soil nutrient status, especially excess N and low levels of Ca, Mg, B and Zn, which aggravate therotting followed by pathogen infection. To address this issue, the following management strategies were developed:

Management

- Follow strict sanitation of the field by removing and burning the infected plants
- Maintain proper soil drainage, especially in clayey soils
- In clayey soils, adopt deep ploughing or digging to a depth of up to 50 cm, followed by application of recommended dose of organic manures either as farm yard manure (FYM) or compost @12.5 tonnes per hectare to improve the soil physical properties, which will facilitate proper drainage and percolation of excess water in wetland conditions.
- Enrich the above farmyard manure (FYM) with *Trichoderma asperellum* before application: Mix 2.5 kg of *T. asperellum* with 100 kg of FYM and keep in the shade for two weeks, covered with a plastic sheet, blend this enriched mixture with 12.5 tonnes of FYM for application on one hectare of land.

Sl. No	Fertilizer	Content	Quantity required (g per kg or kg per ton)
1	Urea	N- 46%	50
2	Di ammonium phosphate	N-18%, P_2O_5 - 46%	260
3	Muriate of potash	K_2O - 60%	400
4	Magnesium sulphate	Mg -16%	155
5	Zinc sulphate	Zn - 33%	40
6	Borax	B-10.5%	40
7	Filler/lime/dolomite/any other inert material		55

- Alternatively, prepare *T.asperellum*-enriched manure by mixing 1 kg of T. asperellum with 100 kg of FYM or vermicompost. Apply 50 g of this enriched manure per plant or as recommended.
- Apply soil ameliorant, either phosphogypsum or lime @ 1.5 tonnes per hectare 10-15 days before planting after ensuring enough soil moisture at the time of application
- Follow balanced application of primary, secondary and micronutrients either through customized fertilizer (CF) with the grade as N: P2O5: K2O: Mg: Zn: B @ 7: 12: 24: 3.5: 1.25: 0.4 (Preparation of CF is given in Table 1) @ 41 g per plant at 30-45 days after planting and top dressing with urea and muriate of potash @ 27 and 15 g per plant respectively with in 30-45 days after first application or by following soil test based application of recommended nutrients @ N: P2O5: K2O: $MgSO_4$: ZnSO4: Borax @ 100: 50: 100: 20: 12.5: 10 kg per hectare.
- Apply neem cake @ 20 g per plant
- Use only healthy, uninfected setts as planting materials and avoid planting setts from infected fields
- Dip the setts in Carbendazim 50% WP solution (prepared by dissolving one gram in one litre) for 10 minutes. This willprovide protection from fungal infections in and around the planting material
- After rainfall, if the initial symptoms are observed, drench the soil around the stem with Carbendazim 50% WPsolution (prepared as above) and the drenching volume can be adjusted according to the age of the plant.

Further research is required to identify the diversity of the pathogens involved and to understand their interactions, correlating them withsoil factors and enabling the development of targeted disease management strategies to mitigate its impact on cassava cultivation.

With its resilience to changing climate conditions, cassava is expected to become increasingly important in sustaining livelihoods in the coming decades and can play a crucial role in ensuring socio-economic security, particularly in tropical regions.

There fore, managing the most important disease affecting the primary economic part of the plant is essential, as it directly impacts both food security and the income of millions of farmers. Prioritizing disease management is key to maintain consistent yields and ensuring the long-term viability of cassava as a staple crop.

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Orange fleshed cucumber with added nutritional and health benefits

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Carotenoids are pigments produced by plantsgiving bright red, yellow and orange shades in many fruits and vegetables. These pigments play an important role in human nutrition and people who eat carotenoid rich foods get protective health benefits as well. Carotenoids also act as antioxidants in the human body thus possess strong cancer-fighting properties. Some carotenoids are converted by the body to vitamin A, which is essential fornormal vision and balanced growth and development. Further, because lutein and zeaxanthin absorb harmful blue light that enters the eye, they may be preventive against eye illness (Johnson, 2002). Common vegetables rich in carotenoids include carrot, pumpkin, green leafy vegetables, tomato, sweet potato *etc*.

Owing to the health concern and changing food habits of people, salad preparations have becomecommon in human diet, and tender cucumbers are indispensable part ofmany salad recipes. It is reported to be native to Indian Subcontinent (Sebastian et al.2010) and evidence suggests that its cultivation appears to have spread to Western Asia and then to Southern Europe (Brothwell andBrothwell, 1969). North eastern India characterized by the transition zone between the Indian, Indo-Malayan and Indo-Chinese biogeographic regions has diverse cucumber germplasm influenced by the immigration of germplasm from Southern China (Staub *et al*. 1997, 1999).

During the recent exploration and collection missions conducted by ICAR-NBPGR, Regional Station, Thrissur in the North- Eastern states of India(Mizoram, Tripura, Arunachal Pradesh, Nagaland and Manipur), collected nearly 40 cucumber (*Cucumis sativusL.*) samples. Rich diversity among different genotypes were observed for exterior skin colour and shape of the tender fruit as well as skin and flesh colour of the ripe fruits. Generally, the tender fruits mainly

Fig.2. Cucumber skin and flesh colour at salad stage

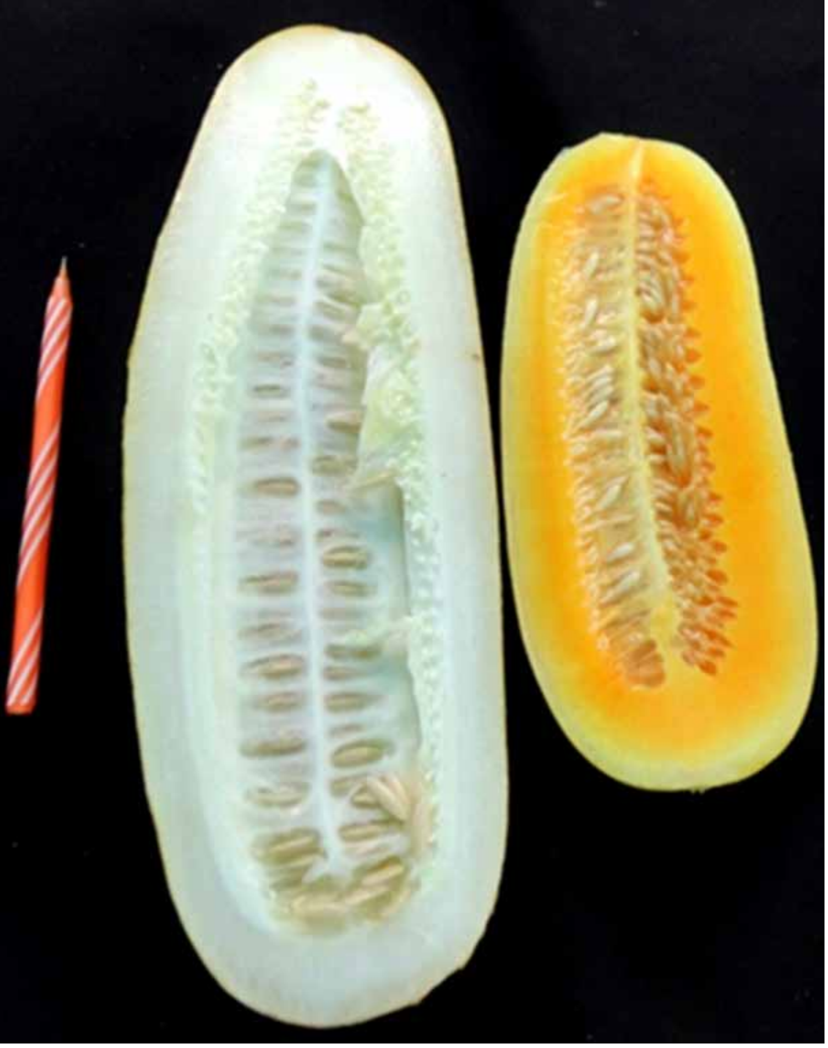

Fig3. Orange fleshedand non-orange fleshed cucumber germplasm - at ripe stage

consumed as salad vegetable, are green to dark green skinned and cream/white fleshed (Fig. 1) and attain yellow to brown skinned with cream/ white flesh at maturity. However, among them ten genotypes Tripura (3), Mizoram (4) and Arunachal Pradesh (3)developed orange fleshed (mesocarp/endocarp) fruits at ripe stage, unlike the usual cream/ white fleshed ones (Fig. 2). Fig. 3 shows the orange fleshed cucumber germplasm at ripe stage. Orange fleshed cucumbers can also be consumed as salad vegetable at the tender stage similar to other genotypes (Fig. 4). The content of total carotenoids was observed high in orange fleshedcucumbersand IC613271, IC613461, IC613467 and JB/11-155 recorded 1371.16, 1823.59, 1870.65 and 1393.0 µg/100grespectively. Also, the average carotenoid content of physiologically mature fruits were more than 10 times the average carotenoid content at the tender marketable stage(Fig. 5).Quality evaluation of orange fleshed cucumber germplasm showed that fruits at ripe stage possess 9.33 % dry weight

Fig4. Orange fleshed cucumber germplasm - at ripe stage

Fig.5. Orange fleshed cucumber (JB/11-155) at tender and ripe stages

of ash, 2.31 % sugar, 91.2 (µg/g) Ascorbic acid and 93.6 % moisture (Ranjan et al., 2019). This distinct group of cultivars known as Xishuangbanna gourd is scientifically named as *Cucumissativus var. xishuangbannensis*, reported to be derived from the Yuannan Province in South West China, in close proximity to North Eastern states of India. Cucumber being a highly cross-pollinated crop, the Indian germplasm might have acquired the genes for carotene synthesis through seed exchange and inter-crossing between populations.

Cultivation practices

The collections were initiated during 2011 and the plants of these genotypes are observed to be highly adapted as a *Kharif, Rabi*as well as summer season (polyhouses) crop for the tropics. Sandy loam with good drainage and pH range

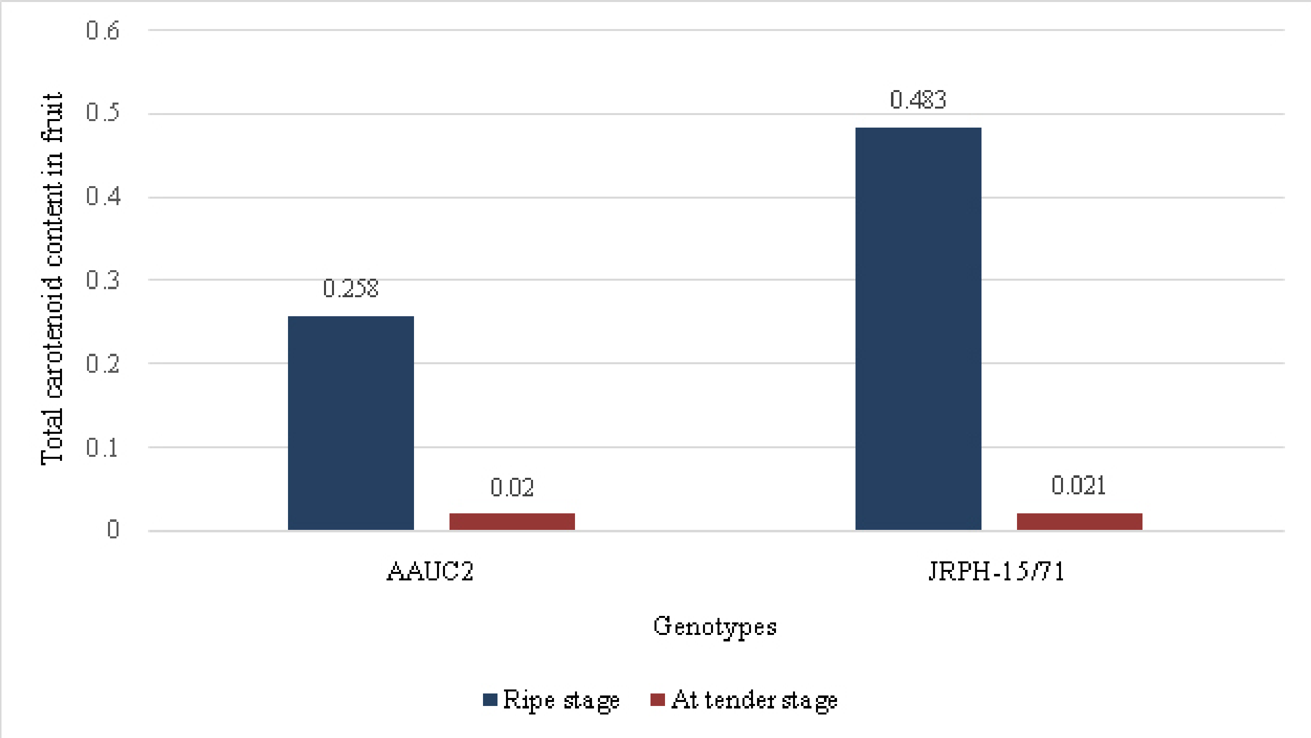

Fig. 6. Carotenoid content in ripe and tender stage cucumbers- A comparison

of 6.5 – 7.5 are optimum for the cultivation of orange fleshed cucumbers. Following the ploughing, either ridges or channels are prepared respectively for Kharif and Rabi/ summer season at a spacing of 60 cm between plants. Thin the seedlings to two per hill at 15 days after sowing. Apply FYM @ 20-25 t ha-1 as a basal dose along with half dose of N (35 kg) and full dose of P2O5 (25 kg) and K2O (25 kg ha-1). The remaining dose of N (35 kg) can be applied in two equal split doses at the time of vining and at the time of full blooming. Need based irrigation should be donein alternate days during flowering and fruiting. Spread dried twigs on the ground or erect vertical support for trailing (Fig. 6). Weeding and raking of the soil can be undertaken at the time of fertilizer application andearthing up may be done during rainy season.The important pests are Epilachna beetle and red pumpkin beetle, which can be controlled by applying Ekalux @3 ml per lit. Downy mildew, powdery mildew and

Fig. 7. Growing cucumber on vertical support

mosaic are the major diseases. Downy mildew can be managed by applying Curzate @0.2 % and powdery mildew by applying Trichoderma @20 g/ lit as a prophylactic measure. Mosaic disease can be controlled by applying any systemic insecticides like Confidor @4 ml per 10 lit.

The fruits can be harvested at 8-10 days after anthesis for harvesting at tender stage for consuming as salad and at 30-45 days for harvesting the ripe fruits. As the ripe fruits possess good shelf life during storage, they may be promoted for preparation of fresh juice and 'smoothy', as a promising substitute of *Pottuvellari* (Snap melon) or along with it. The fruit slices may be incorporated as a component in fruit salads and fresh juice as well as in Indian *curry* preparations like *raitha*. Sweet candies can also be prepared by adopting scientific dehydration protocols. The seeds of carotenoid rich cucumber germplasm have been conserved at the Meditm Term Storage facility of ICAR-NBPGR Regional Station, Thrissur.

Recent publication on orange fleshed cucumber reported that the average carotenoids content in the flesh of ripe cucumber fruit ranged from 2.54 µg g-1 (Pusa Uday) to 54.00 µg g-1 (AZMC-1) (Ranjan *et al.*, 2019). In India, no variety of cucumber with carotenoid content has been released for cultivation. However, EOM 402-10 is an orange fleshed cucumber line developed and released from USA, with carotene content of 7.54 mg g-1± 0.68in endocarp and 2.72mgg-1± 1.15 in mesocarp(Staub *et al.* 2011). Hence, efforts should be focussed to transfer this trait to otherwise high yielding varieties, which in turn will enhance the nutritional value of cucumber.

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Tropical Tuber Crops Landraces in Kerala: Diversity and Traditional Uses

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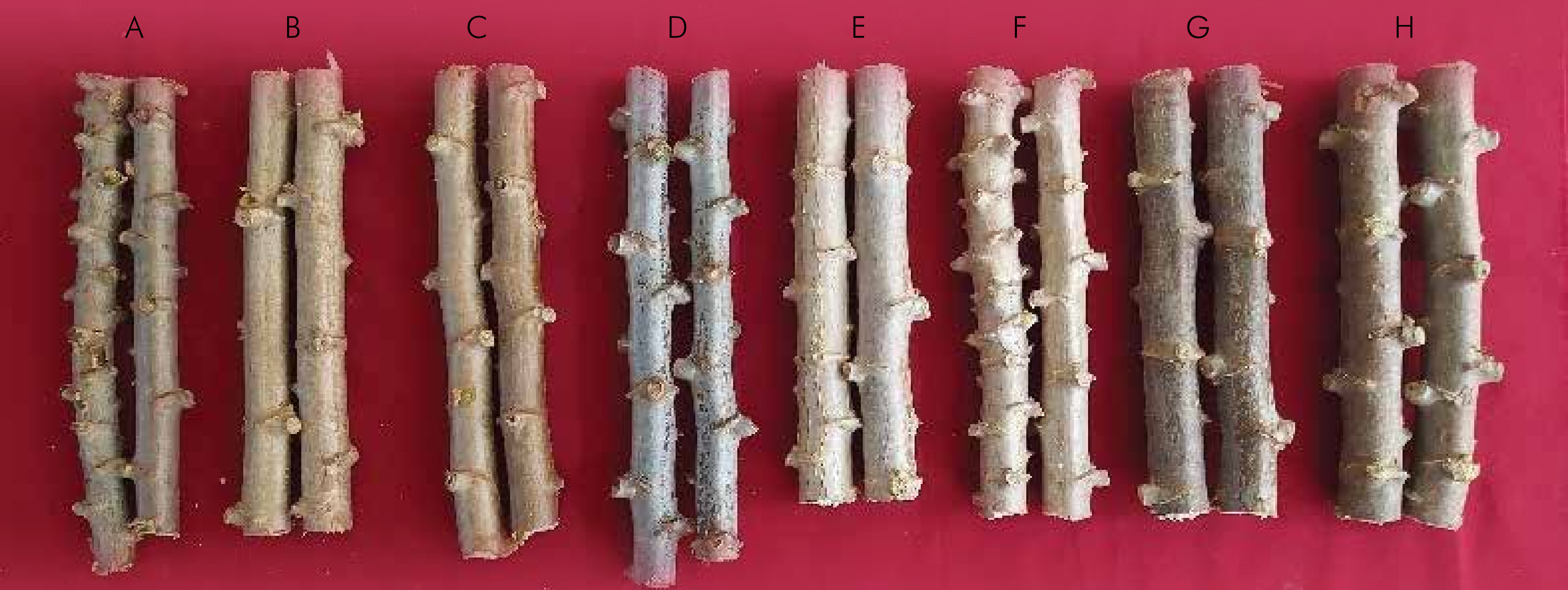


A-H: Karinjarukku, Thanduchuvappan, Njarukku Vella, Singapore Vella, Konni Kambu, Umman Vella, Njarukku, Karuppan

Human civilizations historically emerged and thrived in river basin regions, where agriculture served as the foundational activity. During this period, grains and various legumes became integral to human diets. However, since prehistoric times, tuber crops have played a vital role in human sustenance. Even today, tuber crops exhibit superior productivity compared to many other plant-based foods and demonstrate remarkable resilience to adverse conditions, including climate change. Consequently, tubers are often referred to as the "crops of the future."

Nadan Chuvappu Kachil, Peruvallikachil, Anakalan, Neelakkachil, Karnataka Kachil, Nadan Vella

Local varieties/landraces are the varieties that are evolved and adapted within specific geographical regions through natural and farmer-driven selection processes. These varieties evolve under the influence of local soil and climatic conditions, without formal scientific breeding interventions, thereby maintaining significant biodiversity. These exhibit a high degree of genetic diversity, which enables them to adapt to unique environmental

Kaduvakkayyan

Puligodan

Aranchena

conditions such as local soil types, climate, pests and diseases. These are invaluable as they represent a source of genetic material that can be used for breeding new, more resilient or diverse crops, especially in developing countries.

Variants of indigenous breeds

According to a study by the Food and Agriculture Organization (FAO), indigenous species can be classified into primary and secondary. Primary landraces are cultivars that farmers have developed and refined over generations through selection, based on desirable field traits. While secondary landraces or creoles are derived through breeding processes, different cultivation methods, re-breeding etc., which altered their original genetic makeup.

In this, the primary species can be divided into two categories according to their origin.

1) Autochthonous or indigenous landraces: These are crops native to a particular region, cultivated by local farmers for over a century and are refined through repeated selection and adaptation to the region's specific conditions e.g.: varieties of rice and sorghum.

2) **Allochthonous or non-native varieties:** A crop originating in one region and introduced into another region through selection by farmers can be included in this group e.g.: varieties of cassava in India which originated in Latin America.

Native varieties of cassava

In Kerala, cassava cultivation primarily addresses food security, unlike in other regions of India where it is often industrially oriented. The introduction of cassava to Kerala dates back to the late 19th century when Visakham Thirunal Balaramavarma, the Maharaja of Travancore, brought the crop from Brazil for experimental purposes. This marked the beginning of cassava's widespread cultivation in the region. Later, during the dry season, farmers used to eat the tubers of *Ottakollakambu* and *Nedumangadankambu*, which mature in one year, along with its rind. At the same time, bitter species like *Moonnu Vellamootti, Anchu Vellamooti, Kattankampu* etc., were used as food and also as a fence for protecting the crops. In addition, Padachi,

Vennachena

Dishes of Palanamaskaram in Thiruvalla Sree Vallabha Temple

Arumasakambu, Kavikambu etc., which have a relatively short maturation period are still found in Southern Kerala, even though in small quantities.

Cassava landraces are vibrant in terms of their stem and leaf pattern. *Kantharipatappan, Kochangamutten, Njarukku, Pachanjarukku, Karinjarukku, Noorumuttan, Vella Noorumuttan, Padappu Noorumuttan, Karutha Singapore, Kavikambu, Ottakambu, Vella Ottakambu, Ullichuvala, Nullichuvala, Karuppan kambu, Vella Kaliyan, Karutha Kaliyan, Kozhivalan, Eucalyptus cheeni, Plavella, Karian, Karilaporion, Tanduchuappan, Chuvalathandan, Thottavella, Elamurian, Chullikampu, Pathinettu, Karineelachoppan, Vellilamurian* and others. *Kottayam Kappa, Kanjirapalli Kappa, Pullad Kappa, Nedumangadan Kappa, Konni Kambu, Mananthavadi Cheeni* and Ayur Vella are some cassava landraces that are famous for their place of origin.

Cassava landraces are also named as

per the presence of yellow colour of flesh due to β-carotene eg. *Manjavarian, Muttavarian, Manjamutta, Manja anakkomban, Karian and Kariyilaporian. Depending on the colour of the skin or rind, cassava has landraces such as Panni Vella, Ullichuvala, Sundari Vella, Vella Malayan, Vella Diwan, Vella Thala, Vella Chulli, Chuvanna Chulli, etc. Vella Ethan, Ethekkathodan, Ethenchuvala, Ethakkappuzhukkan* which resembles Kerala banana when the tuber is cooked; Manguzhanthan that cooks softly like pudding/cooked starch; *Kasalachadi, Ambakadan, Matiluchadi, Kalikalan, Quintal and Patachi which are high yielding; Ummen Cheeni, Vakhtinkara Vella, Arian, Anamanthari, Vellarosa, Pachamullan, Ceylon, Malayan, Malavella, Block Vella, Block Kattan, Thodan, Rottivarika, Mulamudan, Nururathal, Vakeel Ambalamkulukki, Raman* are few other examples of cassava landraces.

Landraces of greater yam

Greater yam (Dioscorea alata) is a versatile crop valued for its adaptability in both wild and cultivated environments. In Kerala, greater yam plays a significant role in traditional diets and cultural practices. Based on tuber morphology, various landraces of greater yam have been identified *Patalakachil, Bharnikachil, Neendikachil, Narankachil, Amakachil, Anakkalan, Tunikachil, Mullan Kachil, Kaduvakkaiyyan, Undakachil, Kalakomban etc. Landraces with distinct coloration include Vellakachil, Neelakachil, Urulaneela, Chandanakachil, Chorakachil, Manjakachil, Pullikachil and Elamneelakachil. Certain varieties, such as Kinaruvella and Mangachil, thrive* in kitchen gardens, while Inchikachil and Gandakashala are recognized for their aromatic tubers. Other notable varieties include *Palvalli, Cheruvallikkachil, Pulingodan, Parakkachil, Kannur Kachil, Palakakachil, Narankachil, Kallangkachil, Engakadan, Niravukachil, Marottikachil, Nooran, Roskkamban, Wayanadan Kachil, Ambalavayal, Quintal Kachil and Orissa Vella.*

Native varieties of other tubers

Elephant foot yam has been a part of Kerala's agricultural practices since ancient times. Its uses, under the name 'Suranam,' were detailed in the 15th-century text Yogasarasamgraha by Vasudevacharya. The indigenous varieties of elephant foot yam are mainly classified according to the texture of cooked tuber. Eg. *Neyychena, Vennachena* etc. They are mostly used to give consistency to curries. *Aranchena* are *Naranchena* are varieties that are high in fibre and are used for frying.

Taro landraces are used for their leaves, stems, and corms. *Kudachembu* with broad leaves; *Karinthal, Karimchembu* and *Neelachembu* with bluish-black stems; *Palchembu* oozes white exudate when cut and almost all parts of the plant (except for the root) can be used; *Cheruchembu* with light green stalks; *Makkalepottichembu* producing ample number of cormels; *Chuttichembu, Pandikuchembu* and *Karkidakachembu* etc are landraces of taro. *Anchilapacha, Bhadrakalichuvala*, and *Nadan cheeni* are landraces in sweet potato.

Some important uses of tuber landraces

Local varieties have a great influence on the unique culture of each country. *Trikkarthika,* the festival of lights in the month of *Vrischika*

(November-December) is observed as the tuber crops day. *Bharnikachil* was cooked in the dusk of this festival. In between the Malayalam months *Vrischikam* to *Medam*, native tubers like *Kannan chembu, Karkidakachembu, Vanchembu, Onattukarachembu, Aramchena, Vennachena, Neyychena, Kinaruvellakachil, Vellakachil are used to make dishes like Asthram, Erisseri, Puzhukku*, etc. Alocasia called Maaran is taken for medicine and death rituals.

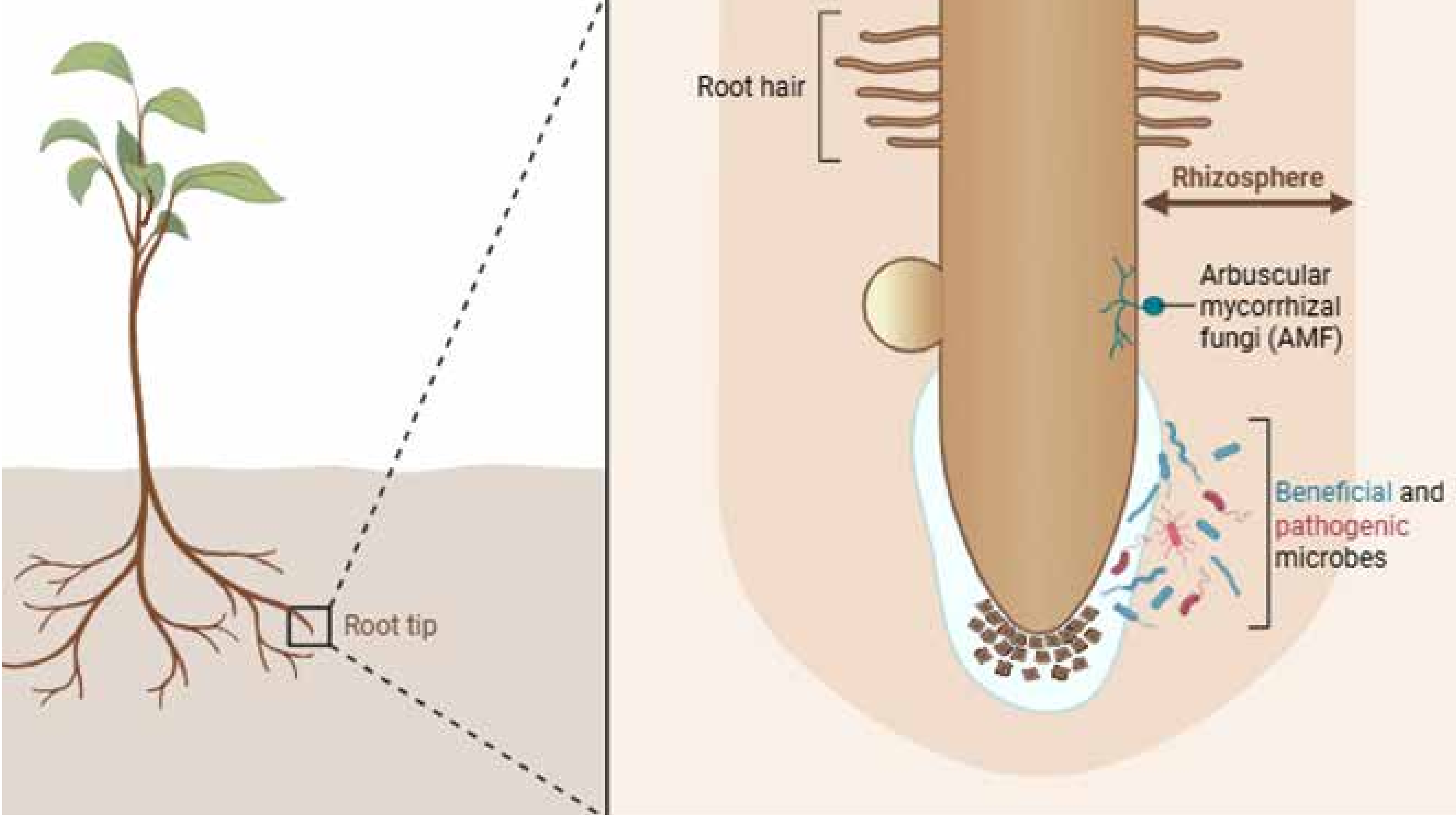
Tuber crops, especially taro, are integral to rituals such as *oottu* and *padapu* in rural temples dedicated to local deities like *Thamburan* and *Maadan*. These are also used as a substitute for meat in some rituals and the traditional rituals of the hill tribes. The influence of native tubers like *Thamarakannan chembu, Vanchembu, Nadan kachil, Neyychena* etc. is seen in many of the traditional recipes of Travancore such as dishes in rituals like *Palanamaskaram* in Thiruvalla Sree Vallabha temple, *Peruntamrutu Pooja* in Sree Padmanabhaswamy temple and Thiruvattar temple etc.

Demand for indigenous breeds

Native tuber crops are well-adapted to soils with low-fertility and harsh environmental conditions, making them resilient to temperature extremes and nutrient deficiencies. These varieties are rich in micronutrients and metabolites offering health benefits. Indigenous varieties serve as donors of resistance genes for most major diseases and pests of crops in a region. In this way, it is possible to develop new resistant crop varieties suitable for the current highly unstable adverse climate. It is also an integral part of many traditional ceremonies.

Conservation of landraces was first discussed at the Vienna Agricultural Congress in 1890 to preserve biodiversity in agriculture. After World War II, as part of the Green Revolution, high-yielding varieties and improved seeds were supplied to farmers which led to the abandoning of cultivation of indigenous varieties and thereby gradual loss of the indigenous biodiversity. Uniform farming practices and lack of intensive cultivation led to the destruction of many indigenous varieties. Through this, genetic erosion occurred and valuable traits in the crops were destroyed. Today, due to the arrival of highly productive varieties and urbanization, many of the indigenous species that were used in Kerala have gone extinct. At the same time, the overall identity of the ever-famous agriculture in Kerala was questioned through this.

ICAR-Central Tuber Crops Research Institute located at Sreekariyam, Thiruvananthapuram is the only research centre in the world established for the collection, conservation, and comprehensive research of tropical tuber crops and a rich tradition dating back about six decades. The collection and conservation of tuber landraces is now more actively carried out through the Project for wild and underutilized edible varieties funded by the Kerala State Biodiversity Board. Preserving these landraces is essential to address emerging food security challenges and maintaining Kerala's rich agricultural heritage. These crops not only form a critical part of the traditional diet but also serve as a testament to Kerala's ability to withstand food crises in the past.



The Hidden Symphony Beneath Our Feet

Unlocking the Power of the Rhizosphere Microbiome for Sustainable Agriculture

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Plants are not solitary organisms; they cultivate an intricate and highly specialized microbial community within the rhizosphere, the dynamic zone surrounding their roots. Within this interactive environment, plant roots engage in complex relationships with a vast array of microorganisms, forming a symbiotic system that extends their functional capabilities.Often described as the plant's "second genome," this microbial community significantly enhances plant resilience, influencing nutrient uptake, growth, and defense mechanisms. The rhizosphere is home to an astonishing diversity of microbial species, each contributing to plant health in unique ways. These microbes not only support plant survival but also provide resistance against environmental stress, making the rhizosphere a critical player in plant adaptation. This microbiome is essential for plant health and productivity, fostering beneficial interactions that enhance nutrient cycling, strengthen stress tolerance, and suppress plant diseases (Sarsaiyaet al., 2025).

Diversity and Composition of Rhizosphere Microbiomes

Beneath the soil, an intricate network of life thrives, where countless microorganisms,both prokaryotic (bacteria and archaea) and micro eukaryotic (fungi and protists)form a complex and dynamic community. Over the years, extensive research has explored the composition of rhizosphere microbiomes in agricultural plants, uncovering their functional roles and the variations they exhibit across different plant hosts and geographic regions. Notably, rhizosphere microbial communities can vary significantly from one location to another, influenced by soil conditions, climate, and plant species (Zhang et al., 2024).The diverse microbial community in the rhizosphere consists of several key functional groups, each contributing uniquely to plant health and soil fertility. As shown in the Figure 1, the rhizosphere is a dynamic zone where plant roots interact with a diverse community of beneficial and pathogenic microbes, including arbuscular mycorrhizal fungi (AMF).Among these, mycorrhizal fungi play a particularly vital role in enhancing nutrient uptake and improving plant resilience, while simultaneously fortifying plants against environmental stresses and pathogenic threats. However, fungi are not the sole contributors to a thriving rhizosphere; beneficial bacteria also play crucial roles. For instance, Pseudomonas fluorescens, a well-known Gram-negative bacterium, is commonly found in agricultural soils, where it acts as both a plant growth promoter and a natural defense against pathogens (Li et al., 2024). Similarly, Bacillus subtilis, another key player, enhances plant growth while suppressing harmful microbes, making it an invaluable component of the soil ecosystem.Trichoderma species, known for their biocontrol capabilities, actively suppress plant pathogens while promoting plant health, making them essential members of the rhizosphere community. Across the rhizosphere, bacterial communities belonging to the phyla Proteobacteria, Actinobacteria, and Bacteroidetes engage in complex interactions with plant roots, shaping nutrient dynamics and contributing to overall ecosystem stability (Zhu et al., 2024).Alongside these microbial groups, certain bacteria exhibit plant growth-promoting traits that directly benefit crops by improving nutrient uptake and enhancing stress tolerance RhizosphericActinomycetes have been shown to produce bioactive secondary metabolites with antibacterial, antifungal, and antiviral properties, as well as promote plant growth under controlled conditions.

Microbial Functions in Plant Growth and Defense

Plant growth-promoting rhizobacteria (PGPR) enhance plant vitality by colonizing roots, facilitating nutrient absorption, and stimulating essential plant hormones, which improve stress tolerance and boost crop yields for sustainable agriculture and play a crucial role in nutrient cycling, enriching the soil through nitrogen fixation and phosphorus solubilization, two essential processes for soil fertility and plant development. These microbes also contribute to plant protection through microbial antagonism, a natural defense mechanism where beneficial microorganisms actively suppress plant pathogens, reducing the risk of infections. Moreover, by strengthening plant resistance to both biotic and abiotic stresses, the rhizosphere microbiome plays a key role in enhancing overall plant resilience.

These beneficial microbes also influence plant immune responses at the molecular level, interacting with key defense pathways to enhance resistance against pathogens and environmental stresses.At the molecular level, the root microbiome is deeply intertwined with plant defense pathways, such as those regulated by jasmonic acid (JA) and salicylic acid (SA) (Pandey et al., 2023). These pathways govern how plants respond to pathogens and herbivores, with microbial interactions further enhancing these defense mechanisms. The interplay between JA and SA signaling is particularly significant, as their cross-communication can either amplify or fine-tune plant immunity, ensuring an optimal response against threats. This dynamic regulatory system not only shapes microbial recruitment but also influences plant resilience, ultimately leading to stronger, more adaptable crops.

Factors Influencing the Rhizosphere Microbiome

While plant signalling pathways play a crucial role in shaping microbial recruitment, a variety of external factors also influence the composition and functionality of the rhizosphere microbiome, ultimately determining plant-microbe interactions. This hidden world is influenced by root exudatescompounds such as oligosaccharides and glycoproteins, that serve as both nourishment and a recruitment signal for beneficial microbes (Vives-Peris et al., 2020). These exudates serve as signals, drawing in beneficial microbes and shaping the surrounding soil community. The composition and diversity of rhizosphere microbial communities are significantly influenced by soil conditions, climate, and plant species, shaping plant-microbe interactions and overall plant health.Recent research has revealed that the factors influencing microbial diversity in the rhizosphere are not uniform across different microbial groups.

According to Xu et al. (2025), soil characteristics exert a stronger influence on the alpha diversity of prokaryotic communities, while plant traits play a more significant role in shaping micro eukaryotic diversity. Among these soil factors, rhizosphere soil pH emerged as the most crucial determinant of prokaryotic diversity, whereas fresh root weight stood out as the primary factor influencing microeukaryotic diversity (Xu et al., 2025). This intricate balance between soil properties and plant physiology highlights the complexity of microbial interactions in the rhizosphere, ultimately influencing plant health and growth.

Molecular Approaches for Microbiome Identification and Analysis

To effectively manipulate and harness the rhizosphere microbiome for agricultural benefits, it is essential to first understand its composition, diversity, and functional potential. Advances in molecular and analytical techniques have enabled researchers to decode these intricate microbial interactions, shedding light on their roles in plant growth and soil health. Cutting-edge tools like metagenomics and transcriptome sequencing, are now unravelling the complexities of this underground network, revealing its profound impact on plant growth and ecosystem balance. Some of these beneficial microbes, identified through metagenomics, remain elusive in traditional laboratory settings, yet they play critical roles in nutrient cycling and plant defense. To decode the structure and function of this community, researchers employ various analytical methods. Direct soil phospholipid fatty acid (PLFA) analysis captures the microbial fingerprint of the soil, while colony-forming unit (CFU)-PLFA provides a glimpse into culturable microbial populations. Meanwhile, community-level physiological profiling (CLPP) using the BIOLOG system sheds light on the metabolic activities of these microbial communities. PLFA-based methods reveal shifts in microbial populations under different environmental conditions, while CLPP allows scientists to predict functional roles by analyzing microbial metabolic potential (Sarsaiyaet al., 2025). As molecular biology and genomics continue to advance, researchers are gaining deeper insights into these microbial interactions, bringing us closer to harnessing their potential for sustainable agriculture and environmental stability.

Understanding the complex microbial interactions provides a foundation for developing strategies to optimize plant-microbe relationships for agricultural benefits. Given the crucial role of these beneficial microbes in plant growth and defense, scientists are exploring ways to enhance and harness these microbial interactions for improved crop productivity. To optimize these natural interactions, researchers have explored microbiome manipulation, an approach that involves selectively recruiting beneficial microbes to enhance plant growth and stress tolerance. This fine-tuned microbial selection not only diversifies the rhizosphere community but also strengthens plant immune responses, allowing crops to better withstand environmental challenges.

Conclusion and Future perspectives

Emerging research is increasingly integrating microbiome studies with precision agriculture techniques, aiming to harness technological innovations to monitor and manage the intricate interactions between plants and their associated microbial communities. As research continues to unveil the complexities of this underground ecosystem, the importance of microbial diversity in agriculture and ecological stability becomes increasingly evident. A deeper understanding of microbiome functionality can also contribute to the development of biological control agents that enhance crop resilience against pests and diseases, ultimately improving the efficiency of precision agriculture practices. However, translating these findings into practical applications remains a challenge due to the complexity of microbial interactions and the variability of environmental conditions that influence crop growth. To bridge this gap, future research should focus on addressing key knowledge gaps in microbiome studies (Xu et al., 2025). This includes investigating the precise mechanisms through which rhizosphere microorganisms contribute to plant health and productivity, as well as their potential roles in mitigating environmental stresses (Zhu et al., 2024).

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Lotus vs Waterlily

Distinguishing the Fascinating Aquatic Blossoms

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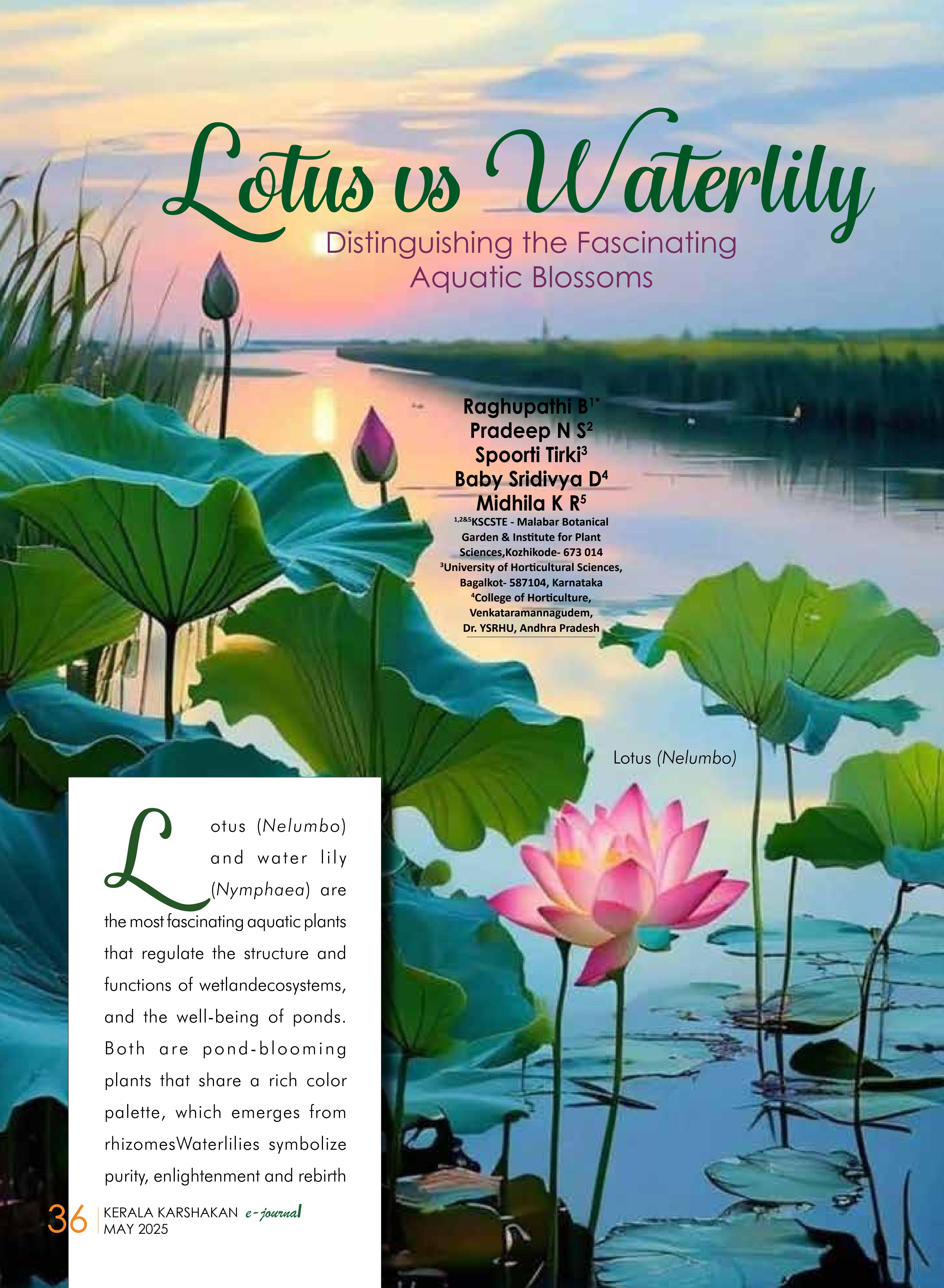

Lotus (*Nelumbo*)

Lotus (*Nelumbo*) and water lily (*Nymphaea*) are the most fascinating aquatic plants that regulate the structure and functions of wetlandecosystems, and the well-being of ponds. Both are pond-blooming plants that share a rich color palette, which emerges from rhizomesWaterlilies symbolize purity, enlightenment and rebirth in various cultures. Monet's famous paintings immortalized these blooms in art history. Lotus flower is not a bloom with the spectacle of beauty, but a beacon of enlightenment, purity, and renewal. In ancient Egyptian mythology the lotus linked to creation and rebirth. They add both beauty and variety to the areas where they grow, such as ponds and lakes. They are not only eye-catching but also protect aquatic organisms from direct exposure to sunlight and predators sneaking nearby. These plants adapt well in diverse climates, provide habitat, improve water quality, and with their lush foliage and striking blooms make a vibrant beauty to water gardens. The flowers during summer maintain the temperature of the water bodies. Theycontrol the growth of algae by absorbing water minerals and blocking the excess sunlight thereby keeping the water clean and translucent. The lotus seeds have a record of germinating after many years of production.These plants are good sources of nutrition, food, and medicine. The health

Water lily *(Nymphaea)*

Lotus leaves

Lotus seeds

benefits highlighted are anti-inflammatory, hepato-protective, anti-hyperglycaemic, anti-hyperlipidaemic, and anticancer properties. The rhizome and seed of these plants are rich sources of carbohydrates, proteins, vitamins, minerals, amino acids, phytochemicals,and dietary fiber.Although there may be a confusion betweentwo of them at first glance,it might not be easy to differentiate the twoand Neophytes, usually call them waterlilies but the differences in these beautiful flowers are obvious and they may not even be closely related and there is a vast difference between these two plants. Thisarticlehighlights the difference between lotus and water lily, which helps in creating awareness, accurate identification,scientific study&conservationby understanding the ecosystem

Water lily seeds

health and stability.

Primarily they belong to separate families of flowering plants i.e. waterlily belongs to family Nymphaeaceae, whereas lotus belongs to Nelumbonaceae family. The similarity between the both families is because of the convergent evolution, that is both adopted similar ruses to survive in an ecosystem.The lotus family is a monogeneric, consisting of just two species, Nelumbo nucifera (sacred lotus) and N. lutea (American lotus). The genus Nymphaea consists of 50 species with two hybrid varieties hardy and tropical according to the environmental conditions it survives. In which some are day bloomers and others are night bloomers. So, the species diversity of nymphaea is much broader than the lotus.

Appearance: The lotus flowers are large, showy with layered petals with pink or any other color. The flowers usually found

Water lily leaves

Lotus flower

raised above the water on tall stems, whereas the waterlily has flat, round leaves that float on the surface of water in the ponds and lakes. The flowers also often rest on the water's surface creating an amazing sight.

Lotus (Nelumbo)

Water lily (Nymphaea)

Leaves: Lotus leaves areemergent above water level, while water lily leavesfloat on water level. The leaves of lotus are typically large, round, flat, thin, non-shiny and peltate that is the stalk of the leaf is attached underneath the leaf, in the center, rather than the edge. There is no slit to drain the water away but a depression can be seen towards the center of the leaf. The leaves are hydrophobic in nature, causing waterdrops tobead up and roll off, on its surface and, by the wind being pushed off from the leaf and thus it does not get wet and this phenomenon referred as "Lotus effect". Mostly the leaves are emergent, above the water surface, while the first leaves of the season are submerged or floating. As the summer advances, upright stems sometimes rising more than 5 feet (150 cm) in height above the water.Whereas waterlily leavesare round, flat,waxy, andhave a slit on one side that allows the rainwater to drain off. The leaf stalk is attached at the base of the drainage slit.Floating leaves of waterlilies spread like a plate and can reach up to 6 feet height called lily pads.

Lotus leaves

Water lily leaves

Flowers: Lotus flowers are largeup to 12 inches or 30 cm in diameter

Water lily flower

with thin, round to oval petals, with a papery appearance. They are borne above the water on strong stems nearly 4-6 feet above the water surface in ponds, but in small structures, they reach 2-4 feet above the water. They superficially look similar to the waterlily but can distinguished by the presence of an androecial ring in the center around the large cone–shaped carpellary receptaclecomposed of a variable but usually fairly large number of sepals and

Lotus rhizome

petals (tepals). When thisdrops off, they typically last for a day only, the receptacle remains upright, at first as green, then changes to brown. It finally opens to release large hard round seeds. Cone-shaped seed capsules with numerous holes, can be seen only with the lotus. Whereas in water lily single flower arises from each stalk and it looks like a star. The flowers usually float on the surface of the water generally in the hardy waterlily, exception in tropical waterlilies,in which the leaves are floating but the flowers are emergent, and can grow 6-8 inches above the water. The plant prefers to grow in 2 to 5 feet above the water.

Water lilyrhizome

Lotus flower

Water lily flower

Seeds: The flowers of lotus bloom for an average of 3-4 days after pollination. The tepals (sepals &petals) wither after

Comparison chart of Lotus and waterlily

Features	Lotus	Water lily
General Characteristics		
Family	Nelumbonaceae	Nymphaeaceae
Genus	Nelumbo	Nymphaea
Habitat	Deeper water (about 12 feet deep)	Shallow water (appr. 2-5 feet deep)
Types	Nelumbo nucifera and Nelumbo lutea	Tropical & Hardy water lilies
Height	Taller(6 feet above water level)	Comparatively smaller (8 inches)
Growth	Grow above the water surface	Few floats on the surface (Hardy waterlily)& above the surface (Tropical water lily)
Leaf Characteristics		
Appearance	Papery and thin, size exceeds 30 inches	Waxy and thick, 12-20 inches in diameter
Shape	Round with depression, no drainage slit	Round with a notch on one side
Secondary structures	Trichomes	Waxy cuticle
Nature	Hydrophobic, water repellent, exhibit "lotus effect"	Hold water, due to waxy coating on the leaves
Variegation	Consistent green color	Variegated leaf foliage
Flower Characteristics		
Size	Larger flowers than waterlily	Both large and small flowers
Petals	Round or sometimes ruffly	Pointed or star-shaped
Color	Limited compared to water lilies	Exhibit wide range of colors
Fragrance	Less defined, more subtle	Strong during blooming
Carpels	A cone-shaped carpellary receptacle	Connate, 3 or more distinct carpels
Stamens	Numerous, thin, filamentous Filamentous to laminar, many in	surrounding the carpellary receptacle number
Lifespan after pollination	Flowers wither within 2-3 days	Handful of days

Comparison chart of Lotus and waterlily

Features	Lotus	Water lily
Seeds Characteristics		
Ripening	It happens above the water	It happens under the water
Seed pod	Release of seeds on the water surface	Seed release take place under water
Rhizome Characteristics		
Propagation	Through seeds or rhizome	Through seeds, rhizome or leaves
Appearance	Creeps deep inside the mud	Grows under the water within the mud
Shape	Oblong or tubular	Tubular or bulb-like
Nature	Thick, large, fleshy stalks hold leaves & flowers	Many root stalks are produced and are smaller than lotus
Cultural Significance	High spiritual and cultural significance	Admired for the beauty, less spiritual & cultural significance.
Fertilizer	Require more fertilization &needbigger pots to grow	Require limited fertilization & comparatively smaller pots to grow

pollination and thereceptacle remains upright. Eventually, it ripens, bends down, and pops out and releases seeds over the water's surface. Seed dispersal usually occurs by animals or by the flow of water, While waterlily blooms only for a handful of days after pollination. petals fall into the water after pollination. The development and maturation seeds occur there and after, the mature seed pods swell and bend slightly from the stalk. The seed ripens and it opens to release many seeds under the water.

Rhizome: The rhizome of the lotusis a root stalk creeping deep inside the mud, which appears usually oblong or tubular shape. It forms thick, large, and fleshy stalks that hold the leaves and flowers.It is edible and can be eaten in a raw or pickled form, whereas rhizome of the water lily grows horizontally within the mud under the water, it is a modified stem that appears tubular, and bulb-like. It holds the flower and leaves by producing many root stalks.

In the world of water plants, nothing can replace lotus and waterlily. They are known to be jewels of the aquatic world. Both are popular aquatic ornamental plants, which can thrive well in fresh water conditions like ponds, lakes and slow-moving rivers and stunning aquatic flowering plants with wide range of flower colors suitable for water gardens andare invasive in nature, which grows and spreads very fast. Both require directsunlight for six hours or more in a day.

Ornamental Sunflower

Growing and Showcasing

Nature's Golden Gems

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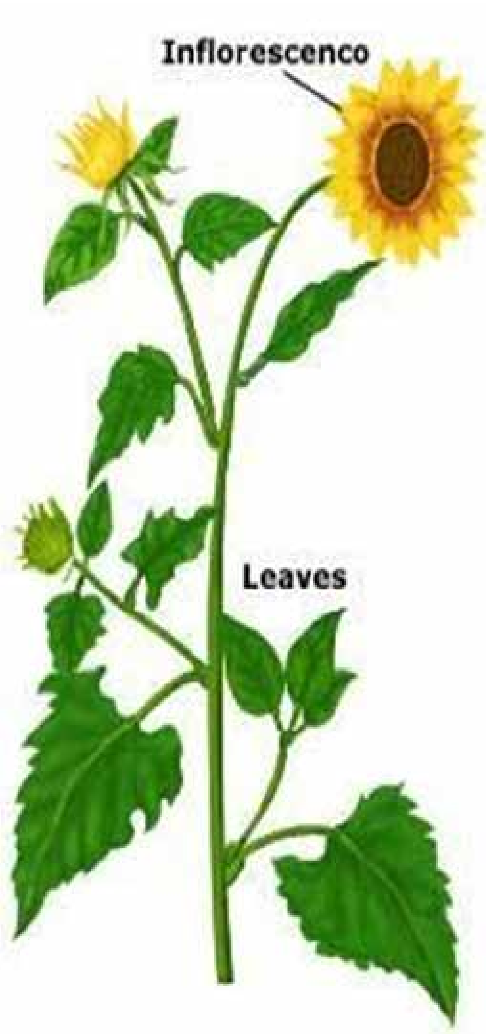
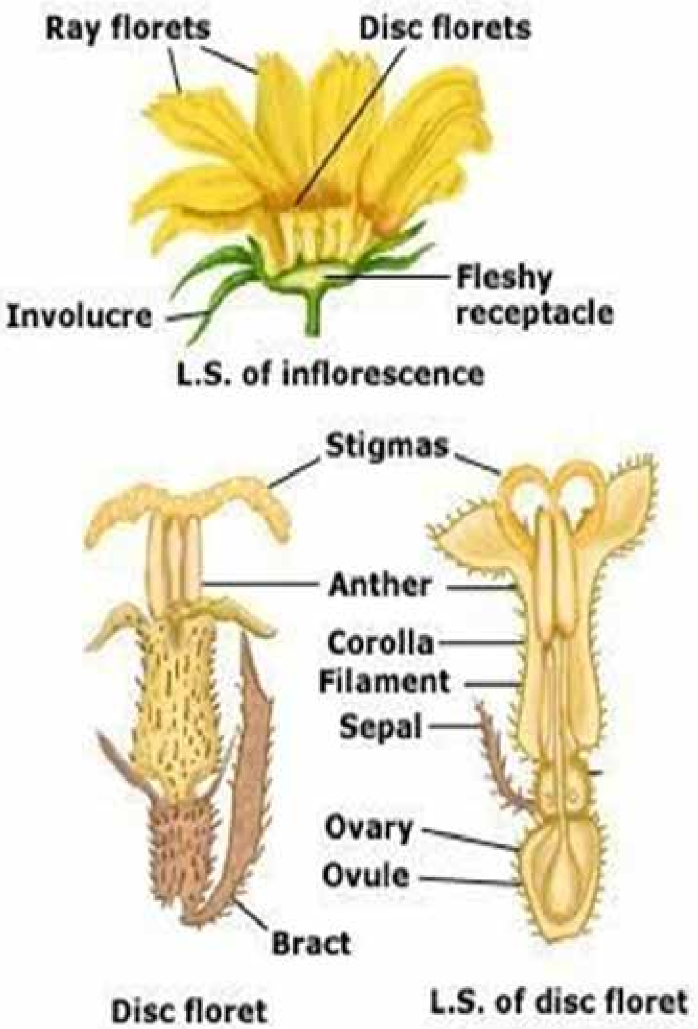
Introduction

Sunflower *(Helianthus annuus L.)* is basically an important oilseed crop. The term Helianthus, is derived from the Greek word 'helios' meaning sun and 'anthos' meaning flower. Sunflower belongs to the family Compositae or Asteraceae, the biggest family of flowering plants. The wild progenitor of the commercial cultivars are H. annuus L. and H.decapetalus. Sunflower is native to North America from where it was introduced into Europe and later into former USSR. In India, sunflower as an oilseed crop is introduced in 1969, it was first domesticated for food and medicine.In foreign countries sunflower was already in usage as a garden plant and as cut flower in bouquet preparation. The sunflower genome is diploid with a chromosome number of n=17. Cultivated sunflower has a chromosome number of 2n=2x=34. The wild progenitor of commercial cultivar is Helianthus decapetalus. Helianthus genus comprises 51 species, 14 annuals and 37 perennials. Helianthus annuus L. is a species with significant character variation particularly in qualitative traits. The sunflower is an annual erect plant with a long stem and one or more





flower heads.

Ornamental sunflower has been increasingly popular in floriculture due to aesthetic appeal and versatility. It is used for ornamental and landscape purpose. Mainly, ornamental sunflowers are used as cut flower for bouquet preparation, flower arrangement and for flower vasepurposes, because of its broad head and long stalk length, making them stay for longer periods in vase condition. It is also used as pot plant, table decoration, flower bowl, corsages, boutonniere and for decoration purposes. In landscapingused as a stunning addition to any garden, offering a range of orange and yellow colours, sizes, forms and petal type. These are used as borders and hedges, pollinator gardens, focal points, etc. Their hardy, adaptability character and easy-growing nature makes them perfect for beginners, while their beauty ensures they remain favourite among garden enthusiasts. Whether used for decoration floral arrangements or to attract pollinators. These sunflowers bring joy and charm

In this family, plants typically have a composite inflorescence known as a capitulum or head made up of receptacle and involucre bracts, which are modified leaves. The head is comprised of two flower types viz., ray and disc florets. The ray florets are arranged around the periphery of the capitulum, their petals having been combined into a single, large petal that points away from heads centre, while disc florets occupy the centre of the flower and have hermaphrodite types and do not have petals.

wherever they bloom.

Botany:

The species known as the ornamental sunflower contains numerous genotypes with ray and disc florets and has multiple branches that are varied in height. It is an annual, erect and herbaceous plant with leaves simple, alternate with stout petiole and lanceolate in shape. Leaves are rough on both surfaces. A single head produces 350 to 2000 seeds. Seeds are pointed at the base and round at the end. The colour of the seeds varies from black to white but brown, striped or mottled seeds may also occur.

Floral Biology:

Sunflower has gained importance due to their short duration of maturity, photo-insensitivity, wide adaptability into different kinds of cropping pattern and drought tolerant. It blooms 55 to 75 days after the seeds are sown, depending on the type. In India, Karnataka, Andhra Pradesh, Maharashtra are major states for sunflower cultivation, with Karnataka leading in production, followed by Andhra Pradesh and Maharashtra.

Soil and climate:

Sunflower can be grown on a variety of soils; the optimum soils are those with adequate drainage. With a pH range of 6.5 to 8.0, it thrives in neutral to mildly alkaline soils, however acidic soils are not recommended. Sunflower is very adaptable, having given rise to several cultivars suitable for a wide range of ecological situations.

Nutrient management:

Plough the land and uniformly distribute 12.5t/ha of FYM. NPK fertilizers are applied at the rate of 60:75:60 kg/ha.

Time of sowing:

The plant is capable of year-round cultivation in the Indian condition due to its amazing resistance to temperature and photoperiod changes.

Seed rate and spacing:

Seeds are sown at the rate of 6kg/ha. Spacing followed is 60 x 45 cm in heavy soil and 45 x 30 cm in light soil. Follow ridge and furrow method. After sowing of seeds irrigating is done. Germination of seed occurs 5 to 7 days after sowing. Thinning is done 10 days after sowing.

Harvesting:

Flowering starts 55 to 75 days after sowing. Flowers are harvested when the heads are stiffened and become lemon yellow.

Industrial use:

While primarily grown for their aesthetic value, ornamental sunflowers also have industrial uses, including oil production, livestock feed and even soil remediation.

Oil production: Sunflower seeds even from ornamental varieties, contain oil that can be extracted and used for cooking, salad oil, etc.

Livestock feed: Sunflower seeds and meal (the byproduct of oil extraction) can be used as feed for livestock, particularly for birds and other animals.

Soil remediation: Sunflowers have shown the ability to remove toxins like lead, arsenic and uranium from contaminated soil, making them useful in phytoremediation efforts.

Fields of Fortune

Pioneering Entrepreneurship in Vegetable farming

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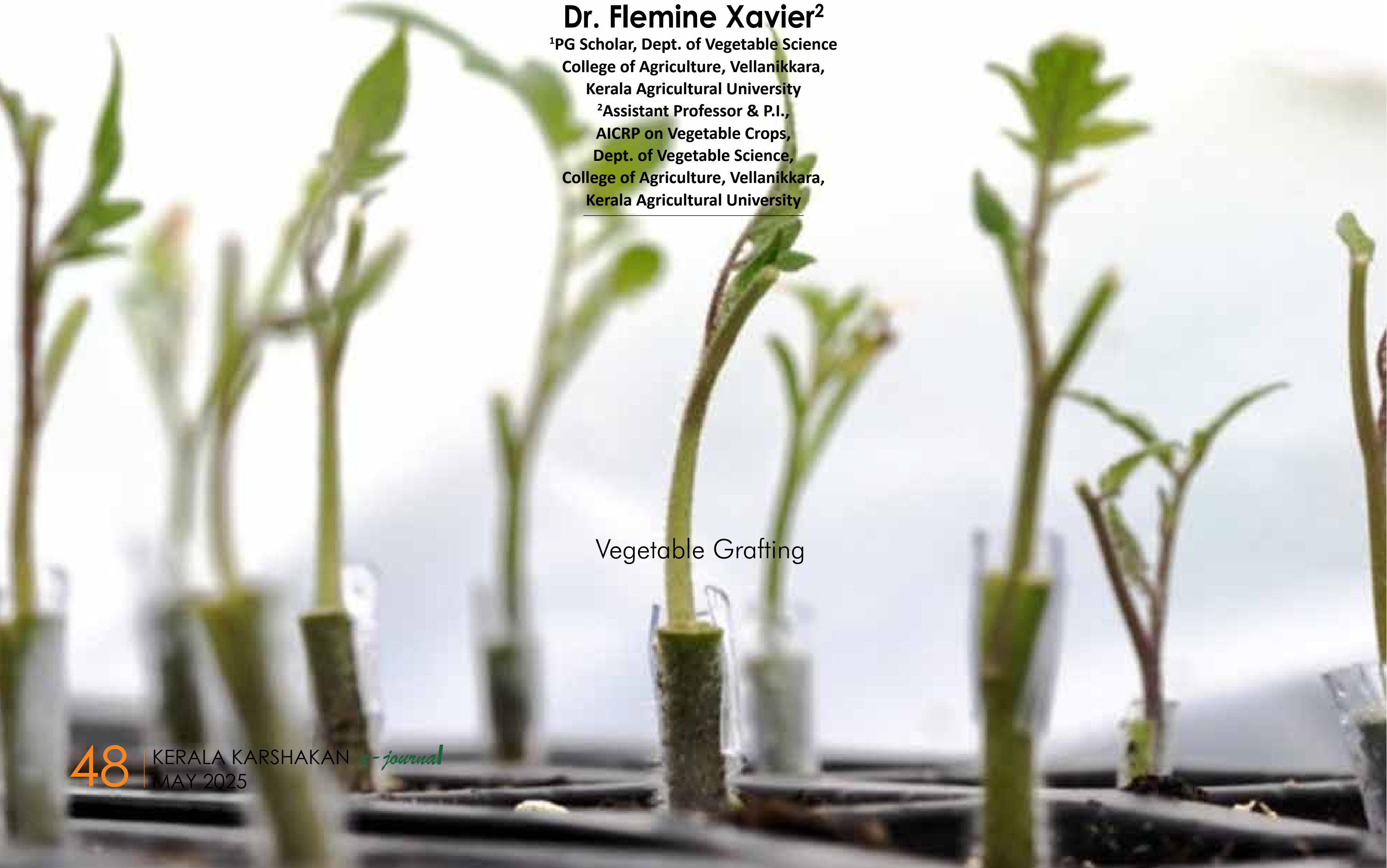
The vegetable farming sector of Kerala is a fertile ground for innovation and entrepreneurship, offering endless possibilities for new ventures.Vegetable farming, which plays a crucial role in ensuring food security opens up a world of economic prospects and entrepreneurial opportunities. Today, many people have transformed agriculture from a traditional way of life into a thriving and profitable business venture. New agricultural ventures that combine traditional farming methods with modern technologies are giving a new impetus to vegetable farming in Kerala.

As a rich source of proteins, vitamins, minerals, and antioxidants, vegetables boost the immune system and play a crucial role in our health care.The growing societal emphasis on health and wellness provides significant opportunities for vegetable farmers and entrepreneurs to leverage the increasing demand for nutritious products. Let's take a look at the entrepreneurial opportunities in the vegetable farming sector.

Vegetable Grafting

Vegetable grafting is an emerging field that is gaining significant attention of entrepreneurs.Vegetable seedlings produced through



Vegetable Grafting

grafting technology can resistsoil-borne diseases such as bacterial wilt. This disease, which is widely found in tomato,brinjal, chilli, cucurbits etc. causes substantial loss to farmers. Grafting technology is mainly used in solanaceous and cucurbitaceous vegetables. High-yielding, popular varieties are chosen as scions, while disease-resistant cultivars are selected as rootstocks. There is growing demand for grafted seedlings that offer resistance to pests and diseases and higher productivity, particularly among commercial farmers. Focusing on the production and distribution of grafted seedlingscan cater to this demand. Additionally, online platforms and agricultural markets provide excellent opportunities to expand the reach and market of these seedlings.

Microgreen farming

Microgreens are tender,immature plants which is slightly larger than sprouts that are harvested for consumption within 7 to 15 days of sowing. These tiny greens offer significant advantages over mature plants, including a short growth cycle, high nutritional value, vibrant colours and flavours.Recognized as a superfood, microgreens are rich in vitamins, minerals, protein, and fiber making them highly popular. As the demand for healthy, nutrient-dense foods continues to grow in Kerala, microgreens offer a promising market opportunity, particularly in urban areas. As they do not require soil or fertilizers, microgreens can be cultivated indoors in controlled environments, utilizing stands, trays, and proper lighting. Microgreens of various vegetables such asamaranthus, beetroot,mustard,radish, cabbage, fenugreek, broccoli and cowpea are popular today. When launching as an enterprise,focusing on the selection and cultivation of nutrient-rich vegetable varieties is essential.Different types of vegetables can be mixed together and sold in a pack. Microgreens can be harvested by cutting above the roots and packed attractively for market sale.

Hydroponics

Hydroponics is a high-tech farming methodwhere vegetables are grown in nutrient rich solution and eliminates the need for soil. Compared to conventional soil cultivation hydroponics is more water-efficientas the water is recirculated . Since it is a soilless method of cultivation, there is relatively less risk of disease and pest infestation.

Plants are grown in an environment where factors such as humidity, temperature, and light intensity are controlled. Even thoughhigh initial investment is required to set up a commercial hydroponics system

Microgreen farming

,its advantage is the ability to achieve high yields by utilizing vertical farming, maximizing limited space. The main methods followed in hydroponics farming are nutrient film technique(NFT) and deep water culture. Since it is an expensive venture, the best option will be to cultivate high value vegetables. Recently, many young entrepreneurs have achieved success by producing exotic leafy vegetables such as lettuce, kale, pak choi, celery, palak, and broccoli through hydroponics farming.Although these vegetables are rarely cultivated in Kerala, they are widely used in burgers and sandwiches and are in high demand among restaurants and supermarkets.

Value-added products

Preparing value-added products from vegetables is a great business opportunity. Freshly harvested vegetables have a limited shelf life, but when processed into a variety of value-added products, they can command a higher market price.Popular vegetable based products include pickles, kondattam, jam, jelly, squash, candy, sauce, chutney, chips, etc. Ash gourd, an important cucurbit crop n Kerala, can be used to make products like candy, Agra peda, halwa, jams, and sweet balls.Value-added products from moringa are an important business initiative that is growing rapidly in domestic as well as international market . A wide variety of products such as moringa leaf powder, capsules, soup powder, moringa tea bag, health mix, hair oil, face cream, and moringa seed oil are being prepared from moringa. The increasing global demand for moringa products is driven by their health and wellness benefits.Additionally, curry leaves, known for adding flavour and aroma to curries, can also be transformed into a range of products, including curry leaf powder, juice, tea, hair oil, and shampoo.

Vegetable Seedling Nursery

As vegetable farming gains increasing significance in Kerala, there is a growing demand for high-quality seeds and seedlings for home gardens and commercial cultivation. The main obstacle to achieving

Hydroponics

self-sufficiency in vegetable production is the lack of quality planting material. Considering thetime-saving benefits and reduced loss from poor seed germination , farmers prefer using seedlings over seeds. Therefore, the production and marketing of vegetable seedlings offers a good entrepreneurial opportunity. A modest investment is enough to start a small-scale ventureand once established ,continuous production of seedlings can ensure a steady income.Vegetable seedlings of both indigenous varieties and hybrids can be produced. Hybrid varieties are more popular among customers due to their higher yield potential and enhanced resistance to pests and diseases. The main

those who maintain kitchen gardens. Promotion using social media platforms and incorporating online delivery services can significantly expand the market reach making it a highly viable business venture.

Conclusion

Kerala's vegetable farming sector offersdiverse entrepreneurial opportunities

As the demand for healthy, nutritious and sustainable food continues to rise, entrepreneurs can seize these emerging trendsto create successful and profitable ventures.

The future of vegetable farmingsector in Kerala is not only promising but filled with endless possibilities for innovation and success.

Value-added products

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