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The First English farm journal from the house of Kerala Karshakan

Golden Pods Unlocking the Potential of Vanilla

INSIDE KERALA KARSHAKAN

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BEYOND THE VINE UNRAVELLING THE DIVERSITY OF EDIBLE *Passion fruit species*

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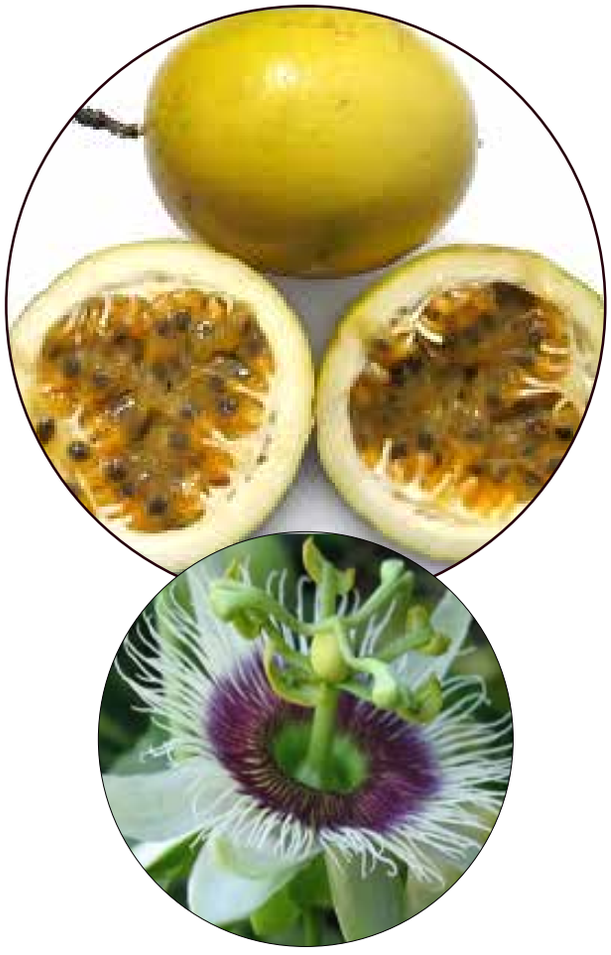
Introduction

The Passifloraceae family comprises about 700 species and 16 genera, with only two cultivated genera: Passiflora L. and Tetrapathaea (DC.) Rchb. It belongs to the order Violales, Class Magnoliopsida, and Phylum Magnoliophyta. Around 520 species of the Genus Passiflora are distributed in Neotropics and Africa. A majority of Passiflora species (approximately 96%) are found in the Americas, with significant diversity in Brazil and Colombia. Brazil hosts roughly 30% of Passiflora species, including 89 endemic species. These plants flourish best in tropical to subtropical humid climates up to 2000m altitude, requiring temperatures between 20-30°C. They thrive in light, sandy loam soils with a pH of 6.0 - 7.0, offering good drainage and abundant organic matter. They are predominantly propagated by seeds, cuttings, or grafting onto resistant rootstocks. Seedlings are transplanted

Passifloraedulis



Passifloraedulis var. flavicarpa

after 3 months into polybags, while semi-hardwood cuttings are rooted before planting. Spacing, land preparation, and trellising are crucial, with recommended systems like the Kniffin and bower. Fruit-bearing begins after 10 months, yielding 7 to 9 kg or 200 to 250 fruits per vine.

Uses

Passion fruit leaves are utilized as a vegetable and are recommended for various medicinal purposes. The boiled extract of fresh tender leaves is often used to address conditions such as diabetes, diarrhea, gastritis, abdominal flatulence, and as a liver tonic. Passion fruit rinds hold promise for extracting secondary metabolites, notably therapeutic total phenols, with attributed immunomodulation, anticarcinogenic, and antioxidant properties. Passifloraedulis leaves are specifically consumed to combat dysentery and hypertension. The rinds, comprising around 5-6% protein, are repurposed as fillers in poultry and stock feed. Passion fruit seeds yield about 23% oil, comparable to oils from sunflower and soybeans. This oil is both edible and employed in industrial applications. From air-dried leaves, the glycoside “Passiflorine” is extracted, serving as a sedative or tranquilizer and sparking renewed interest in the pharmaceutical industry, particularly in Europe. Furthermore, passion fruit is rich in essential nutrients such as Vitamin A, B2, and C, while also containing non-nutritive phytochemicals like carotenoids and polyphenols. Passion fruit juice is recommended as a digestive stimulant and used in gastric cancer treatment.

Different specious of edible passion fruit

The economic value of the Passiflora genus comes from the production and commercialization of its fruits. 70 species of edible Passiflora fruits are recognized, the commercial production of passion fruit is primarily reliant on the cultivation of only a few species, such as Passifloraedulis Sims, P. alata Curtis, P. setacea DC, P. ligularis A. Juss, P. nitidaKunth, P. cincinnata Mast, P.

tripartita (Juss.) Poir, P. maliformis L., and P. quadrangularis L (figure 1). Among these species, only P. edulis is widely cultivated in commercial scale.

Giant granadilla *(PassifloraquadrangularisL.)*

- It thrives in warm, wet tropical lowland environments.
- It is found in Mizoram, Nagaland, Manipur, and Arunachal Pradesh in India.
- It is considered invasive in various regions, including the Bahamas, Australia, Galapagos, Hawaii, French Polynesia, and other Pacific islands.
- The vine is a slightly woody or herbaceous vine with glabrous branches, reaching 3-5 meters in length and climbing using axillary tendrils. It has trigonal or quadrangular stems that mature into a cylindrical shape, often with winged angles.
- The leaves are alternate and glabrous, measuring 10-20 × 8-15 cm, broadly elliptical or ovate, with prominent pinnate venation and sessile glands on petioles.
- The flowers are solitary and pendulous, with white, violet, or pink sepals and oblong-lanceolate white petals. The corona is multiseriate.
- The fruit is green, oblong-ovoid, with three longitudinal furrows, 20-23 cm in length, resembling melons, with very thick flesh and approximately 164 seeds per fruit. The fruits also contain cyanogenicglucosides in various parts of the plant (up to 138 ppm).

Purple passion fruit *(PassifloraedulisSims)*

- It has higher levels of protein, fat, and ascorbic acid compared to the giant granadilla and yellow passion fruit varieties.
- It thrives at higher elevations, requiring about 2000 meters for optimal flowering and fruiting.
- Vegetative growth and flowering are restricted if temperatures fall below 15°C.

Passifloraquadrangularis

Passifloranitida

- The ripe fruits are typically 4-5 cm in diameter, deep purple in color, weighing around 35-45 grams.
- Juice content ranges from 31-35%.
- Protein content is approximately 9.4%, and the vitamin C content ranges from 24-30 mg per 100 grams.
- The main carotenoids present in purple passion fruit include carotene, β-carotene, and phytofluene.
- Additional reported carotenoids include β-apo-12'-carotenal, β-apo-8'-carotenal, cryptoxanthin, auroxanthin, and mutatoxanthin.

Yellow or golden passion fruit (Passifloraflavicarpa Deg.)

- It is found at lower elevations, primarily in the foothills of Manipur, Mizoram, Arunachal Pradesh, and Nagaland in India.
- It thrives in lower elevation regions compared to the purple passion fruit.
- It is relatively rich in phosphorus, iron, sodium, potassium, and vitamin A compared to other passion fruit types.
- It is rich in citric acid, which is the predominant acid in yellow passion fruit, measured at 6.6 mg/g.
- The fruits are usually larger in size than the purple variety.

Sweet passion fruit or ouvaca (Passifloraalata Curtis)

- It is an evergreen vine thriving up to heights of over 6 meters, is indigenous to the Amazon region, spanning from Peru to eastern Brazil.
- It is known as "ouvaca" for its striking red star-like flowers, it also goes by names such as fragrant grenadilla and maracuja de refresco.
- Its large, fragrant flowers, blooming in late summer or early fall, exhibit unique characteristics with eight concentric coronas, setting them apart in the plant kingdom.
- The fruits are egg-shaped, yellow to bright orange fruits, weighing between 90–300 g and measuring 8–15 cm in length.
- It is acknowledged for its medicinal use in Brazil's Pharmacopoeia since 1929 and extensively utilized in South American folk

Passifloraligularis

Passifloramaliformis

medicine.

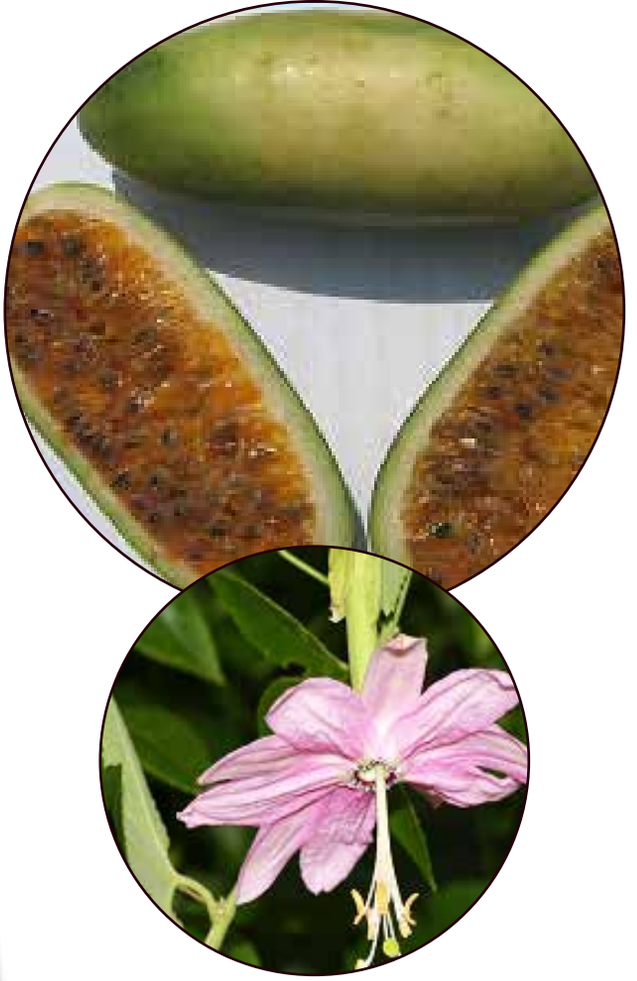
- The vine is moderately frost-hardy vine thrives in full sun, either indoors or in regions with temperatures above 5°C, making it an attractive addition to gardens for its ornamental and potential medicinal value.

Wild passion fruit (Passiflorasetacea DC)

- It is native to eastern Brazil, thrives in a variety of habitats, from dense forests to secondary regrowth areas, using its tendrils for support.
- The fruit is almost 6cm, with sweet-acid flavored pulp, is highly edible and commonly consumed raw or used in juice production.
- It prefers sheltered, sunny spots or dappled shade in moist, well-drained soils of tropical low to moderate elevations, displaying a penchant for neutral to slightly alkaline soils with a phrange of 6.5 to 7.5.
- The vine shows resistance to CABMV and shows a high heritability of 99.94%.
- Medicinally, its leaves and roots are believed to contain 'passiflorina,' an effective tranquilizer, while the leaves are attributed with anthelmintic, antihysteric, and diaphoretic properties, often used in addressing various conditions like fevers, skin inflammations, and erysipelas.
- The seed germinates in warm temperatures but air layiering is the best propagation method.

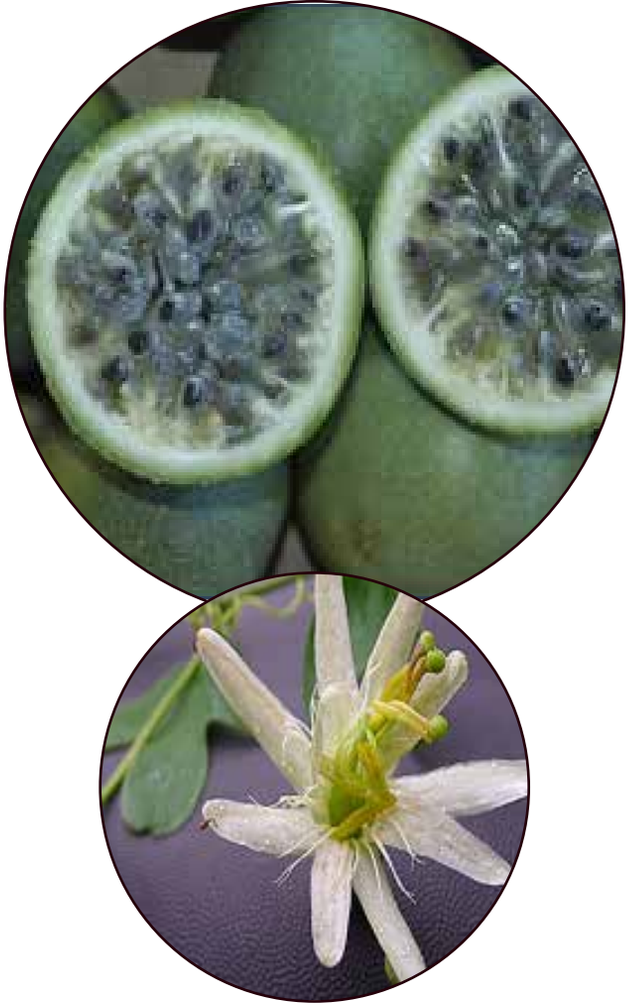
Sweet granadilla (PassifloraligularisA. Juss)

- It is native to western and northern South America.
- They are commonly known as sweet granadilla and are fast-growing woody vine predominantly found in the Amazon region.
- Its natural habitat spans altitudes up to 3000 meters, making it intolerant to excessive summer heat, necessitating cool, shady conditions for cultivation.
- It flourishes in subtropical climates within temperatures of 16-18°C, requiring wet humid conditions.
- The plant showcases heart-shaped leaves and large, pale green flowers, yielding sweet, ovoid, orange-yellow fruits extensively utilized in both fresh consumption and beverages.



Passifloratripartita

Passifloracincinnata



Passiflorasetacea

Passifloraalata

- It holds nutritional and commercial significance due the presence of Glucosyl-hydrolase inhibitors in their leaves, enzymes catalyzing the breakdown of complex sugars.
- The sweet granadilla is a promising source of vitamin C, not only in its fruits but also in its leaves, contributing to its status as a nutrient-rich plant.
- A recent discovery in north eastern India highlighted its potential for commercial cultivation in India (Shankar et al., 2021).
- The fruit, measuring 6.5-8 cm in length and 5-7 cm in width, boasts a hard skin of various colors and contains numerous black elliptical seeds surrounded by sweet, aromatic, jelly-like pulp, rich in vitamins and minerals.
- Cultivation practices involve fertilization based on soil analysis, drip irrigation in low rainfall conditions, and yields peaking in the second and third years, reaching 16 and 15 tons per hectare, respectively.

Bell apple (PassifloranitidaKunth)

- This represents tasty orange-yellow fruits similar to Passifloralaurifolia.
- This fast-growing tropical vine displays blue and red flowers, resembling Passifloralaurifolia and Passifloraquadrangularis, with fruits measuring 4cm or 1.6 inches.
- It is native to Amazon jungle region, encompassing various tropical lowlands across regions like Costa Rica, French Guiana, and extensive parts of Brazil.
- It is not frost hardy and need protection from extended temperatures below 50–55 °F (10–13 °C).
- The fruits are enjoyed for its fresh and good flavour and are used in beverages such as the popular drink Purple Passion.
- The fruits are decorative orange-colored with brown streaks and attractive, bright white retroflexed petals in its flowers, measuring approximately 10-11 cm in diameter.
- Its foliage, characterized by leathery, shiny, and bright leaves, contributes to its overall

allure.
- The plants are well-suited for pot cultivation, this plant requires rich, well-drained soil.
- The plant demands a temperature above 12°C and is not frost hardy hence need winter care by growing in green house or indoors with ample light.

Passifloracincinnata Mast

- It is widely distributed across South America, particularly in eastern Brazil, southern Paraguay, southern Argentina, and eastern and southern Bolivia
- The vine is robust with glabrous, rigid stems, palmate leaves typically displaying five lobes, gland-bearing petioles, and colorful sepals and petals.
- The flowers are large fragrant flowers, approximately 10-13 cm in corolla size, feature a showy corona of violet and pink filaments and slightly face backward.
- The fruits are green ovoid, ranging from 3-4 cm in diameter and 5-6 cm in length and contain 34% pulp, 26% seed, and 40% peel.
- The plant demands a temperature above 12°C and is not frost hardy hence need winter care by growing in green house or indoors with ample light.
- It is recognized for its medicinal and analgesic properties, this species demonstrates higher tolerance to water stress and pests compared to other Passiflora species, making it a preferred rootstock for them.

Banana passionfruit (Passifloratripartita (Juss.)Poir)

- It is native to the high elevation Andean regions in southern Colombia, Ecuador, Peru, Bolivia, and Venezuela.
- This has been cultivated since pre-Columbian times by various cultures in western South America.
- It is mainly grown for its fruit, particularly in Colombia, notably in Boyaca, this species yields oblong or oblong-ovoid berries, 5–12 cm long and 3–4 cm wide, with a leathery peel ranging in color from pale yellow to yellow-orange or green at maturity.
- The fruit's orange flesh, with a sweet-sour taste, houses small black elliptic seeds and is commonly utilized in juices, desserts, jams, and preserves due to its appealing taste and texture.
- It thrives in cool climates with average temperatures of 14-16°C and evenly distributed rainfall ranging from 1500-2000 mm.
- It is generally propagated by seed and starts yielding from 10-12 months after transplanting.
- The fruits are produced throughout the year with average yield of 10 t/ha.

Stone granadilla or cholupa (Passifloramaliformis L)

- It is native to regions in northern Ecuador, Colombia, Venezuela, and the Antilles.
- It is fast-growing evergreen shrub and vine utilizes slender, woody stems, extending up to 3–10 meters, employing tendrils for climbing support.
- The green or orange-green fruits, about 4 cm (1.6 inches) in diameter, are notable for their high total phenol content and antioxidant activity, with a tough skin sometimes requiring tools for opening.
- The arils, comprising 85.44% water and offering 42 kilocalories per 100-gram serving, contain carbohydrates, fiber, protein, and fat, while being an excellent source of magnesium and phosphorus, alongside various minerals and organic compounds responsible for its grape-like flavor and aroma.
- It is commonly consumed raw or used in beverages, this fruit is celebrated for its grape-reminiscent taste and nutritional richness.
- It can thrive in warm, wet tropics and necessitates a minimum temperature of around 16°C (61°F) during flowering for successful fruit set
- The vine exhibits resistance to honey fungus and flourishes in moderately fertile soils.

Golden Pods Unlocking the Potential of Vanilla

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Introduction

The term "vanilla" originates from the Spanish word 'vainilla,' derived from 'vaina,' meaning pod, and 'illa,' indicating small, describing the vine that produces small pods. Botanically known as Vanilla planifolia Andrews, it belongs to the Orchidaceae family, with a diploid chromosome number of

2n=32. It is native to southeast Mexico and thrives in humid tropical rainforests. Vanilla, a member of the orchid family, is a climbing monocot with sturdy stems, short oblong leaves, and inflorescences producing over 20 flowers. Its fruit, often called 'beans' or 'pods,' is a nearly cylindrical capsule, approximately 20 cm in length. The first vanilla plantations were established by the Totonac Indians in the Veracruz region

around 1767. The dissemination of V. planifolia from its origin area was facilitated after Columbus' encounter with the New World in 1492. Plantations grew after the discovery of a practical hand pollination method in Reunion Island in 1941. This led to the rapid spread of vanilla cuttings worldwide, particularly in the Indian Ocean area, marking the rise of this region as the major vanilla exporter till now.

Natural vanilla accounts for only 2% of the total vanilla flavor market, being replaced by synthetic alternatives like vanillin and ethyl vanillin. Madagascar is the leading global producer, supplying over 80% of the world's vanilla. According to FAO 2019 data, Madagascar produces the most vanilla (2926 tons), followed by Indonesia (2304 tons) and China (885 tons). Papua New Guinea, the fifth-largest producer with 502 tons, faced declining production due to severe fungal diseases affecting the vines. In India, major vanilla-growing states include Kerala, Karnataka, Tamil Nadu, Assam, and Andaman Nicobar Island, with expansions in Orissa and the Northeast. Introduced 200 years ago by the East India Company, vanilla cultivation struggled until the 1990s when prices surged. Recent growth, especially in Kerala, Karnataka, and Tamil Nadu, is attributed to its short yield period, low cultivation costs, and compatibility with other crops. However, the spread of viral diseases like vanilla

Bourbon vanilla Or Bourbon-Madagascar vanilla	• Bourbon vanilla is esteemed for its rich flavor, named after the Bourbon dynasty from the era when Reunion Island was a hub for its cultivation. • Primarily grown in Madagascar, Reunion Island, Seychelles, Mauritius, and Comoros in the Indian Ocean, Bourbon vanilla owes its distinct taste to the Vanilla planifolia. • Manual pollination, pioneered by Edmond Albius, a young slave, revolutionized Bourbon vanilla cultivation, allowing the orchid to yield vanilla beans. • The meticulous process includes stages like scalding, steaming, drying, and refining, nurturing the beans' flavor over months to years, culminating in their full aromatic potential. • The "Bourbon" curing method produces premium-quality vanilla beans with higher moisture content, graded as Grade A and averaging around 33% moisture. • The beans typically measure 5 to 6 inches (13cm - 15cm) in length, feature a deep black color, and boast a delightful flavor profile characterized by creamy, strong, full, and rich notes. • Notably, these vanilla beans possess an intact structure without any breaks or splits, showcasing their exceptionally high quality.
Mexican vanilla	• Marketed as Grade B and referred to as extract beans, these noticeably differ from Grade A beans due to their lower moisture content and visual imperfections like splits and cracks, making them less visually appealing than Grade A beans. • Despite their appearance, these beans are characterized by a rich and smooth flavor profile with subtle hints of smoke and spice. • They typically measure between 3 to 5 inches (7cm - 9cm) in length, displaying a dark brown color, and contain a moisture content ranging between 15-25%.
Tahitian Vanilla	• Tahitian Vanilla beans originate from French Polynesia and are derived from Vanilla tahitiensis, possibly a hybrid of Vanilla plantifolia and Vanilla odorata. • Hand-selected from Papua New Guinea's East Sepik province, these Grade B beans are ideal for crafting vanilla extract with their shorter length and 20-25% moisture content. • These beans offer a rich, sweet, and creamy flavor profile, complemented by subtle notes of caramel and a delightful floral aroma.
West Indian Vanilla	• West Indian Vanilla originates from Vanilla pompona and is cultivated in the Caribbean, Central, and South America. • This variety showcases a distinct flavor profile and unique characteristics, offering a different taste experience compared to widely cultivated vanilla species. • Grading for West Indian Vanilla is likely determined based on factors such as appearance, aroma, moisture content, and overall sensory qualities, evaluated subjectively by local producers or farmers.

Figure 1. Interesting insights of

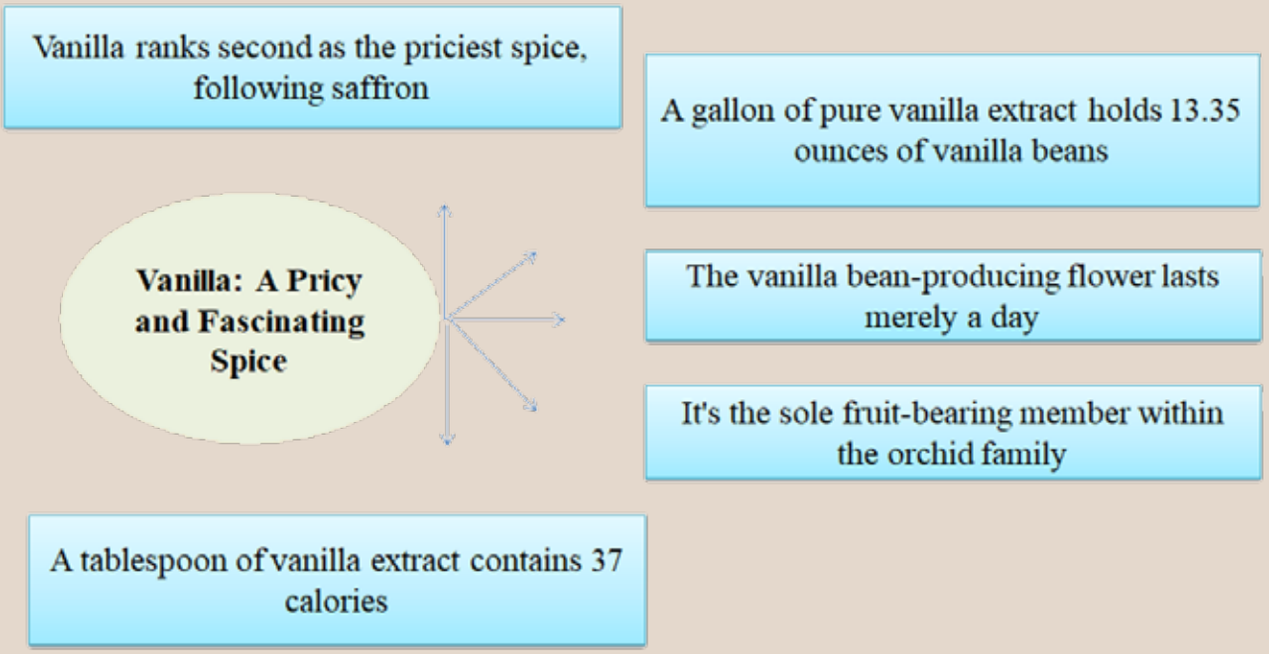

Table 2: Vanilla species diversity in India

Species	Origin/Distribution	Characters
V. andamanica Rolf.	Andaman & Nicobar Islands	Leaf type resembles V. platanifolia. Pods are thicker but number of fruits per bunch is less. Tolerant to Phytophthorameadii and Fusariumoxysporum.
V. aphylla	Kerala	Leafless type; field tolerance to F. oxysporum.
V. pilifera Holt.	North East India	Leafless in juvenile phase, but produce narrow leaf later.
V. walkaeriae	Tamil Nadu	Leafless type.
V. wightianaLindl.	Andhra Pradesh	Leafless form and natural seed setting observed.

mosaic remains a concern, perpetuated by unscrupulous farmers selling cuttings from diseased plants in Wayanad. The USA is the largest global importer of vanilla beans (50 to 60%), followed by France and Germany. Consegic Business Intelligence forecasts a 4.2% Compound Annual Growth Rate (CAGR) for the vanilla market from 2023 to 2030, driven by increased demand in the food and beverage sector. The grading of vanilla worldwide considers appearance, aroma, moisture content, and overall sensory qualities, differentiating varieties like Bourbon-Madagascar, Mexican, Tahitian, and West Indian into Grade A and Grade B beans based on their characteristics Table 1.

Uses of vanilla

Vanilla is a versatile spice with a rich history and potential health benefits. It is commonly used in food flavoringand perfumery due to its delightful aroma. Beyond its sensory appeal, vanilla is believed to have potential health benefits, serving as an immune booster, a

Figure 2: A few Indian species of vanilla

Vanilla pilifera

Vanilla andamania

Vanilla aphylla

Vanilla walkaeriea

Table 3. Vanilla flowering and pollination parameters

Flowering month	Mid-January (Dec to Jan)
I raceme contain	20-30 flowers
I plant contain	10-12 flower clusters
No of flower open in one cluster per day	1-2
Anthesis	4-6am
Best time for pollination	6am-1pm
Flower start closing	1pm to 4pm
Pollen viability	57hrs
Stigma receptivity	40hrs before opening and 16hrs after
Mode of pollination	Often cross pollination with 20% outcrossing
Flowering starts from 3rd year	Maximum flowering by 7- 8th year
Pollination by	Humming birds Meliponabees Orchid bees Snakes
An expert can pollinate	1000-2000 flowers a day
Mechanism to prevent pollination	Herkogamy because of rostellum
In one bunch we can pollinate	10-12 flowers
Success rate of hand pollination	858-100%

Figure 3.Vanilaplanifolia(a) flowers, (b) dried pods, (c) fresh pods and (d) vine

natural anti-cancer agent, and a remedy for toothaches. It's also considered an aphrodisiac and can be used as a mild sedative in the form of vanilla tea. In traditional medicine, vanilla has been employed to alleviate conditions like fever, sore throat, anemia, arthritis, and palsy. Additionally, its aromatic properties make it a popular choice for aromatherapy. The interesting insights of vanilla is given in the figure 1.

Species diversity of vanilla beans

The Vanilla genus includes 90 to 188 species, with three main cultivated types: Vanilla planifolia, Vanilla pompona (West Indian Vanilla), and Vanilla tahitensis (Tahitian Vanilla). Only Vanilla planifolia is

grown in India. Vanilla tahitensis differs with slender stems, narrow leaves, longer segments, and reddish-brown, broad beans. Vanilla pompona resembles planifolia but has longer leaves; however, both tahitensis and pompona produce beans of inferior quality compared to planifolia.

Indian institutes like the Indian Institute of Spices Research (IISR) in Calicut maintain around 300 vanilla germplasm accessions, and the Indian Cardamom Research Institute (ICRI) in Idukki conserves approximately 21 accessions, primarily focusing on commercially cultivated Vanilla planifolia and preserving endemic Indian species such as Vanilla andamanica, V. pilifera, V. walkeriae, and V. wightiana

Botany and Floral Biology

As depicted in the figure 3, Vanilla plants are characterized by their long climbing stems, equipped with aerial rootlets for attachment and roots that penetrate the soil. The blooming season spans approximately two months, featuring single-day flowers that are naturally pollinated by specific small bees. However, in regions lacking these natural pollinators, artificial pollination is required, often accomplished using a wooden needle. Vanilla flowering and pollination parameters are explained in the table 3. The flowers are robust, branching racemes bearing substantial, waxy, pale greenish-yellow flowers. These flowers exhibit bisexual characteristics, presenting a zygomorphic structure with sepals and petals forming a perianth and a distinctive trumpet-shaped labellum. Enclosed within the labellum is a central structure referred to as the column. Blooms usually occur between 4 am and 6 am and endure only for a single day. The process of flower opening spans around 11 hours, with the pollen's viability lasting for approximately 57 hours. Stigma receptivity commences 40 hours before full flower opening and remains functional for 16 hours after. For successful reproduction, these flowers necessitate hand-pollination within a tight window of 12 hours from opening to prevent withering. While the natural pollinator for vanilla is the Melipona bee native to Mexico, the cultivation process often requires manual pollination due to the absence of these specific bees in other regions.These flowers showcase a spectrum of colors ranging from pale green to yellow to creamy white. They eventually yield lengthy capsule-like fruits, a process that takes four to nine months to reach maturity. Harvesting is typically carried out when unripe pods transition to a golden green hue at their base.

Cultivation practices

Vanilla cultivation typically thrives in warm, humid tropical climates between 10°N and 20°S latitudes at elevations of 700 to 1500 meters. It requires well-distributed rainfall for nine months, followed by a three-month dry period, but excessive humidity can lead to disease, while direct sunlight in arid climates may cause sun scorching. Vanilla integrates well with coconut, arecanut, and coffee plantations, favoring loamy or laterite soils rich in organic matter with good drainage. Propagation involves stem cuttings, requiring about 8 to 10 internodes for optimal growth. Regular irrigation, mulching, and nutrient-rich organic matter are crucial for growth and flowering. Harvesting is done when pods turn fully yellow, with yields ranging between 300-800 kg/ha based on cultivation practices. The vine's total lifespan is approximately 15 years, with an average yield of 3 to 4kg from a 7 to 8-year-old vine.

Quality attributes of a high quality vanilla beans

- Length of bean ranges from 17 to 25 cm.
- Beans are highly aromatic with a distinct flavor profile.
- They are free from mildew and insect infestation.
- Appearance is dark brown and oily.
- Processed beans have a vanillin content ranging from 2.2% to 2.4%.
- Pure vanilla contains approximately 35% alcohol
- It also must have various other compounds such as P-hydroxybenzoic acid, P-hydroxybenzaldehyde, P-hydroxybenzyl alcohol, vanillic acid, and vanillin alcohol.

Introduction

Agriculture has evolved significantly since its inception. Change is an unavoidable law in agricultural practices, just like it is in nature. From antiquity to the present, numerous such developments in farming have occurred in order to improve the production and productivity of crops using existing resources with new dimensions. India also has a large repository of traditional knowledge related to biological resources. Farming has become an integral aspect of Indian culture and history. As a result, traditional wisdom continues to have a significant impact on agricultural practices even today.

Traditional agriculture

Traditional farming or conventional agriculture is the foundation pillar of Indian agriculture which is in practice since 10,000 years. Traditional agriculture is primarily a sustainable and stable farming practice that has been used for generations and is capable of producing the food grains to the consumers. Many conventional farmers in developing countries continue to use traditional agricultural methods that are in symmetry with neighboring ecosystems, stable, sustainable, and well-organized.

INDIGENOUS TRADITIONAL KNOWLEDGE (ITK) FOR SUSTAINABLE AGRICULTURE

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Green Revolution emphasized upon Introduction of synthetic fertilizer responsive high yielding genotypes, short-duration cultivars, use of chemical pesticides such as insecticides, fungicides, and herbicides for crop protection and farm mechanization to double or triple production over conventional/traditional practices.

Revolutionary approaches in Indian Agriculture

Many revolutionary approaches were made in Indian agriculture since 1960's for achieving and maintaining the self sufficiency in food grain production and those revolutions which changed the Indian agriculture scenario are presented in Figure 1.

Every agricultural system has its own set of advantages and limitations, similarly green revolution has also posed both positive and negative impacts on Indian agriculture. To counteract the negative consequences of the green revolution, integration of scientific and traditional knowledge in crop production is essential to ensure long-term sustainability in agricultural production.

Integration of scientific and traditional agricultural practices

Science and technology have made great contributions to human progress. It has made enormous advances in comprehending nature in agriculture, medicine, industry and other industries that would be inconceivable without science and technology. However, it is true that modern science frequently builds on traditional knowledge and expands and enhances observed information by meticulous testing and experimentation. Modern agriculture is the culmination of classical empirical approaches that spawned modern scientific technologies. However, traditional knowledge and scientific knowledge systems necessitate the active participation of the scientific community, which can provide distinctive value to the traditional knowledge system. In this article, illustrations of different Indigenous Traditional Knowledge (ITK) practices and its scientific importance during different stages of crop production are presented below.

1. ITKs during land preparation and sowing

Over the years, farmers have been practicing different practices during land preparation and sowing with an aim of healthy crop production. The type and timing of ploughing can influence the soil micro climate and affects the survival of insect pests and their natural enemies. Ploughing the field after completion of one crop period and turning the soil to expose to sun light will help in exposing the inactive stages like eggs, pupa and hibernating stages of insects to their natural enemies by which the

pest population comes to check (Dhaliwal et al. 2010). Fall ploughing or summer ploughing is often helpful in reducing the overwintering populations of lepidopteran and coleopteran pests which undergo diapauses in the soil during winter (Dhaliwal and Arora, 1998). Cow dung and poultry manure application to the soil bind the soil together and keep it compact. It is easy to cultivate the fields and it also provides Nitrogen, Phosphorus and Potash, which helps in achieving increased productivity (Kumar and Singh, 2013). Application of neem cake helps in protecting crops from pest attack because the Azadiractin, Melantriol, Nimbinin, Nimbidin, Salanin, Nimbin, Nimbolin A and Nimbolin B active principles present in the *Azadirachta indica* which shows anti-feedant, repellent, oviposition detterent and insect growth regulator activity upon insect pests (Boadu et al. 2011; Mishra, 2014; Lokanadhan et al., 2012; Vijayalakshmi et al. 1995). Burning residues immediately after harvesting and before sowing can kill the different stages of insect pests and pathogens which acts as a source of inoculum for the subsequent crops and the end product after burning i.e., ash which adds nutrients to the soil. Seed treatment before sowing is necessary to increase the seed germination percentage, seedling development and successful crop establishment. Traditionally farmers followed several seed treatment methods which are low cost, safe use, and eco-friendly viz., cow dung, cow urine, cow milk, butter milk, curd, sheep manure, cow dung powder and cow urine, panchagavya, beejamrita, salt solution, ash solution, lime water, asafoetida solution, turmeric, mint leaf extract, leaf extract of *Vitex negundo, Ocimum sanctum, Azadirachta indica, Pongamia pinnata* Datura leaf extract, garlic extract, citronella oil (Gowthami et al. 2016)

2. ITKs for soil and nutrient management

Collecting the fallen leaves around the field and placing at the base of the plant conserves moisture and improves soil fertility. Spraying of fermented solution of cow dung (5 kg of cow dung and 15L of cow urine mixed in a bucket. The bucket mouth covered with muslin cloth and the material stirred every alternate day for 15 days. Finally one litre of above fermented dung diluted in 10 L of water and mixed thoroughly. The solution is scived with a muslin cloth before spraying with sprayers helps in providing nutrients in small quantities for germinating seeds. Spraying of Panchagavya on crop plants provides nutrients to the crops and also acts as bio-pesticide. Panchagavya contains several nutrients i.e., macronutrients like N, P, K and micronutrients which are required for the growth and development of plants (Mathivanan, 2013). Panchagavya also contains various amino acids, vitamins, growth regulators like Auxins, Gibberellins and also beneficial micro-organisms like azatobacter, phospho- bacteria and pseudomonas etc. confers resistance against pest and diseases. Soil drenching with cattle urine acts as plant growth promoter as it contains 2.5% urea which is known to break dormancy and improve germination (Kundu et al. 1993).

3. ITKs for soil and water conservation

Intercropping deep rooted crops with shallow rooted crops helps in proper nutrient harvesting by the crops. Green manuring helps in conserving soil water because it increases the infiltration and water holding capacity of the soil and also improves soil health by increasing the organic carbon content in the soil. Growing Agave spp. as a barrier around the field helps in reducing run-off and increases infiltration rate.

4. ITKs for pest and disease management

Planting of castor as trap crop diverts the population of *Spodoptera litura* from vegetables like tomato, brinjal, chilli, potato, etc. Growing marigold as border crop helps in protecting tomato crop from fruit borer attack because the bright coloured flowers of marigold attracts adult female of fruit borer towards it for oviposition and hence the main crop will be protected from pest attack (Dhaliwal et al. 1998). Growing of onion/garlic as intercrop in brinjal field acts as

a repellent against the adult stages of shoot and fruit borer of brinjal because the diallyl sulfide present in onion/garlic which has very good repellent property (Prowse et al. 2006). Growing of coriander in chilli crop as intercrop help in repelling sucking pests.

Application of wood ash over the plants protects them from sucking pests. Wood ash contains silica which interferes with insect's feeding and also hinders fungal pathogens multiplication (Jandaik and Sugha, 2009). Spraying of ash and turmeric helps in protecting the crops from aphids and other sucking pest attack because the silica content in ash hinders the feeding in insects and sesquiterpene, ketone and arturmerone present in turmeric act as insect repellent. Placing neem cake at the root zone helps in protecting the crops from cut worm attack and stem rot disease and spraying of neem oil or neem seed kernel extract also protects the crops from pest attack because active principles like Azadiractin, Melantriol, Nimbinin, Nimbidin, Salanin, Nimbin, Nimbolin A and Nimbolin B present in the neem shows anti-feedant, repellent, oviposition detterent and Insect growth regulator activity upon insect pests (Boadu et al. 2011; Mishra, 2014; Lokanadhan et al., 2012 and Raghavendra et al. 2016).

Spraying of garlic also helps in keeping pests and diseases away. Garlic contains a sulphur compound an excellent natural antibiotic and a fungicide (managing rust, blackspot and other fungal diseases) Garlic has antifeedant, bactericidal, fungicidal, insecticidal, nematicidal and repellent properties. Garlic also contains the volatile compounds allicin, citral, geraniol and linalool, which are known to have insecticidal properties. Presence of Allicin (alkaloid) in garlic helps in preventing diseases. Spraying of asafoetida (100-150gm of asafoetida boiled in 1L of water for 10-15 minutes and then diluted by adding 200L of water. The solution is further sprayed onto the crop) helps in protecting the crops from fungal pathogens because of the presence of Sulphur in asafoetida makes it to act as fungicide. Spraying of curd upon plants helps in protecting the plants from pathogen attack. Acidic nature of curd affects growth and development of pathogens and reduces the incidence of wilt, dry root rot, powdery mildew and downy mildew diseases. The Lactobacillus in curd lowers the pH and favours the growth of beneficial endophytes and inhibits the growth of pathogenic microorganisms. Swabbing kerosene to the stem region or pouring it to the holes and plugging with cotton helps in protecting from stem borer in mango and cashew crops since the

petroleum products are generally insecticidal in nature (Chapman, 1967).

5. ITKs during food grain storage

Proper storage of grain is utmost important to prevent the losses due to insects, pathogens and rodents during storage. Though several chemical control methods are available during commercial storage, at household level, many traditional practices are being followed from several years to protect grains during storage viz., sun drying of grains, use of ash, red soil coating method, plastering of storage bins with clay and cow dung, storage of pulses with common salt, turmeric application method, use of garlic cloves, mixing of leaves, stepping method or stamping method, use of salt and chilli powder, use of neem (margosa) leaves, use of neem leaves and dry chillies, use of neem oil, use of camphor, use of castor powder, sand mixture method, use of dried red chillies, use of lime powder, use of matchbox, fumigation of the godown /store rooms, use of neem seed powder, use of ginger rhizome, use of custard apple seed powder and use of tulsi seeds (Prakash et al., 2016). Storing the grains and seeds mixing with salt is very ancient traditional method of storage practiced in rural areas to protect from storage pests and the reason behind it is salt has a hygroscopic and insecticidal property and hence keeps the seeds and grains away from storage insect pests attack. Storing the seeds and grains after mixing with ash protects the grains and seeds from storage pests because ash contains silica which interferes with biting and chewing insects and also hinders some fungal pathogens multiplication during storage. Using neem, pungum, Vitex, etc. helps in protecting the seeds and grains from storage pest attack because number of limonoids present in neem shows anti-feedant, repellent, oviposition detterent and insect growth regulator activity upon insect pests (Boadu et al. 2011) Vitexin and negundoside are the active principles present in Vitex, which shows repellent activity upon insect pests (Prasad, 2014). Karanjin is the active principle present in pungum, which shows antifeedent, JHA and insecticidal activity upon insect pests (Kumar et al. 2006). Placing datura fruits at the entrance of rat burrows helps in management of rodents since alkaloids (hyoscyamine, hyoscine, atropine, scopolamine, saponins), flavonoids, phenols, essential oils and glycosides present in datura fruits has toxic effect on rodents and other insects also.

Conclusion

The modern agriculture stressed upon introduction of high-yielding seed types and increased use of chemical inputs, resulting in enhanced output and self-sufficiency in food grains for the country. However, the negative effects of modern agriculture includes environmental pollution, genetic erosion, loss of natural habitat balance, loss of traditional knowledge and practises, decrease in soil fertility, increased farmers' reliance on inputs, decreased ground water level, decreased food quality, and increased cultivation costs. As a result, an Organic Movement has emerged. The most essential organic farming technique is the adaptation of indigenous practises in crop production programmes. It is a significant task to preserve this ancient knowledge. As a result, this rich knowledge heritage should be extracted, conserved, documented, and developed.

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Lizard

Bacteria

Fungi

SOIL BIODIVERSITY AND ITS IMPORTANCE

Soil is one of the most diverse habitats on Earth. Besides providing a medium for the growth of plants, it is also the habitat of various organisms. About one million organisms can be found in one gram of soil. The species, number and composition of organisms found in soil depends on many factors such as soil temperature, moisture, acidity, organic matter and nutrient content of the soil. Many substancesexcreted by plant roots are found to be attractive to soil organisms. Larvae of beetles and butterflies use soil as a temporary habitat.

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Protosova

Nematodes

Srpingtails

Soil biodiversity plays an important role in ecosystem functioning including the decomposition of organic matter. Organic compounds that reach the soil through animal and plant remains are made up of simple sugars, starch, cellulose, pectin, fats, waxes, lignin, phenols, tannins, alkaloids, pigments, and other products. Large masses of organic matter added to soil are immediately acted upon by soil organisms. The firstto act on the plants and animal residues that fall into the soil are organisms like earthworms, millipedes etc.They puncture the leaf epidermis, macerate the leaf litter, pulverise it and mix it with soil. Later they are attacked by many micro-organisms and are broken down into smaller compounds.

The movement of organisms through the soil helps to increase the porosity of the soil and the infiltration of water into the soil, thereby improving the soil structure. Soil organic matter (SOM) is a direct product of the combined biological activity of plants, microorganisms and animals plus various abiotic factors. It is responsible for crucial aspects of soil function such as aeration and fertility. Production of SOM, including extracellular polysaccharides and other cellular debris, increases the capacity of the soil to maintain structure once it is formed. Direct processing of organic matter (e.g. snails, earthworms, enchytraeids, millipedes, ants, and termites) can improve the incorporation of organic matter below the soil surface, increase the numbers of water stable soil aggregates, improve water infiltration, aeration and root penetration and increase microbial activity.

Many freeliving soil organisms are capable of fixing atmospheric nitrogen. Bacteria of the genera Azotobacter,

Mites

Engitrieds

pseudoscorpion

bacteria or PGPB) can successfully mitigate the negative impacts of drought in plants, thereby enhancing plant resilience to climate change. PGPB also enhance the resistance of the plants to biotic stress like pathogens and abiotic stress like salinity, as well as increase nutrient availability. Hence they are suitable to be utilised as eco-friendly biofertilizers. There are some microorganisms in soil which are capable of degrading the contaminants in soil such as pesticides into harmless substances.

Soil biodiversity is influenced by factors such as climate change, ecosystem degradation, soil erosion, the use of large machineries through soil, chemical pollution, depletion of organic matter, human exploitation, and species invasion. Land use is an important factor among these. There are many types of land use patterns such as grasslands, forests, farmlands, wastelands, etc. Among these, grasslands have the highest soil biodiversity. Due to higher root density in grasslands, the rhizosphere area increases and this provides nutrients to soil bacteria and increases their density compared to bulk soil. Forests have more soil biodiversity than farmlands. But these are comparatively lesser in barren lands. Changing land use patterns affect soil biodiversity in many ways.Among the land-use changes, the conversion of agricultural land into urban areas (soil sealing), and the conversion of natural or seminatural habitats into agricultural land use are the most prominent threats to soil biodiversity. Urbanization reduces the diversity of soil organisms by destroying their habitats. Studies have shown that as the intensity of harvesting practices in forests increases, the abundance of soil organisms decreases; also,the removal

Beetle

Woodlice

Centipede

Beijerinikia, Derxia and Cyanobacteria are important among them. Besides the ability to fix atmospheric nitrogen, Azotobacter also has the ability to produce biologically active substances such as vitamin B, IAA, and gibberellins. Many fungi and bacteria (Aspergillus, Penicillium, Bacillus, etc.) have the ability to solubilize bound phosphate. Thereby, they increase the nutrient availability of the soil. These organisms produce organic acids like citric, succinic, lactic, and oxalic acids responsible for the solubilization of insoluble forms of phosphorus. A commercial preparation called "Phosphobacterin" containing B.megaterium has become popular. Another area of attraction is mycorrhiza, in which the host and the fungus live in intimate symbiotic relationship. The fungi help in the phosphorus nutrition of plants through increased surface area of absorption, offer protection against moisture stress and some of the soil-borne plant pathogens, and enhance rooting and survival of cuttings through production of growth hormones.

Soil organic carbon is derived from the breakdown of lignin, cellulose, and other organic compounds by soil microorganisms. Decomposition of organic compounds increases soil carbon sequestration. Some pesticides can be used by microorganisms as carbon and energy substrate, thus causing degradation of the pesticide.

Many actinomycetes and some fungi and bacteria are used in industry for the production of antibiotics. Torulopsis sp., Ashbya gossipii produces thiamine and Streptomyces olivaceous and Streptomyces griseus produce vitamin B12. It has been proven by research that some soil microorganisms (plant growth promoting

Millipede

Frog

Ants

of forest floor material (through intensive harvesting or burning) has a strong impact on the community of soil organisms.

The loss of a great amount of soil through soil erosion leads to the dispersal and mixing of a huge richness and abundance of soil organisms. Consequently, erosion has a direct impact on soil population dynamics. Furthermore, loss of nutrients associated with soil runoff may also lead to population fluctuations, as it modifies the energy sources accessible to the system. The use of heavy machinery in agriculture and the reduction in soil organic carbon content can lead to soil compaction. Soil compaction changes the soil physical structure, reducing available habitat for soil organisms. Intensive human exploitation of soil often leads to subsequent deterioration in soil health such as decline in organic matter, soil compaction, soil contamination and soil salinization, resulting in a decline in soil biodiversity.

The soil organisms are more common in surface soil. Therefore, activities that destroy the surface soil will also adversely affect the soil organisms. For example, tillage, use of pesticides, fungicides and herbicides, all of these can reduce soil biodiversity. Intensive tillage can affect soil organisms directly by mechanically harming or killing them, or indirectly by degrading soil structure through disruption of soil aggregates and depletion of SOM in surface soil. It destroys the habitat of soil organisms. This disruption of soil structure exposes soil organisms to increased risk of desiccation and limits access to food resources. Chemicals used to kill insects, fungi, and weeds can also kill beneficial organisms in the soil.Organic pesticides show less dramatic effects on soil microbiology than do other classes of toxic organics, probably because the former is

Erthworm

Millipede

Mole

screened to avoid such effects.

Fertile lands for agriculture have become centres of civilization. As the growing population requires more food, synthetic chemicals became more necessary. These practices and intensive conventional agriculture have many impacts on the soil. Different farming practices can support or reduce biodiversity and soil habitat through earthworms. Several studies have shown that concentrations of bacteria, fungi, actinomycetes, earthworms, and arthropods are lower in conventional agriculture than in organic agriculture.Earthworm abundance is higher in intercropping than monocropping.Nitrogen fertilization can affect soil bacterial diversity directly by changing soil chemistry. When applied at high rates, ammonium and urea fertilizers can inhibit soil microorganisms due to ammonia toxicity and increases in ionic strength.

When soil biodiversity decreases, the natural quality of soil also decreases. The sustenance of every form of nourishment we consume is contingent upon the soil. If the soil is not good, every living thing on the earth will have to suffer its fate. Therefore, it is the duty of each and every one of us to protect them. Organic farming methods will help us a lot in this case. Application of green manures, mulches and cover crops can help increase soil biodiversity. While applying fertilizers and other toxic chemicals, use it only in the right amount as and when required. Tillage and use of heavy machinery in fields should be done only if it is absolutely necessary. Small precautions are enough to protect the soil and its biological diversity. If we do not ignore them, soil will definitely benefit from it and thereby we can build up a healthier soil ecosystem.

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Ephemeroptera (Mayfly)

AQUATIC INSECTS

BIOINDICATORS OF WATER POLLUTION

Introduction

Aquatic insects are abundant and diverse groups that inhabit a variety of aquatic environments. Aquatic insects have been used as bioindicators and the most frequently used groups in biological assessment of water quality (Afzanet al., 2018). The physico-chemical qualities of water is an important factor for determining the abundance and distribution of benthos including aquatic insects (Dance and Hynes, 1980). Aquatic insects from orders Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies) are indicators for good water quality, while Diptera (midges) are excellent in detecting bad water quality conditions (Metcalfe,1989).

Aquatic insects

Aquatic insects are macroinvertebrates that inhabit river and stream beds, lakes, and

reservoirs and are associated with various types of substrates such as mineral sediments, detritus, macrophytes and filamentous algae (Rosenberg and Resh, 1993).

Bioindication concept

Bioindication is an integrated investigation of various biological responses to varied external factors (Parmar et al., 2016). The biological responses tend to reflect the state of environmental pollution, disturbance or degradation. The concept of biological indicators using aquatic insects is based on their diversity, abundance and distribution in relation to the physical and chemical conditions of the habitats.

Stonefly (Plecoptera)

Bloodworm midge (Diptera)

Caddisfly (Trichoptera)

Characteristics of bioindicators

According to Peck et al. (1998), the aquatic bioindicators respond quickly to environmental changes, have few generations per year, easily sampled and identified, show high sensitivity for detecting early changes in their geographical area and provide information without interruption of the extent of damage caused by environment alteration or pollution. The use of bioindicators is essential for environmental monitoring.

Bioindicator insects of aquatic environment

Several aquatic insect groups can be used as aquatic environment bioindicators. In pollution studies, aquatic insects particularly members of the orders Ephemeroptera, Plecoptera, Tricoptera and Diptera (Dudgeon,1999) are among the most commonly chosen groups of bioindicators used in environmental assessment because they provide more accurate information about the changing conditions. Freshwater invertebrates can be divided into three groups or classes (i) pollution-sensitive organisms: These are organisms that require good water quality to survive. They may require clear or non-turbid waters and or high dissolved oxygen levels. For instance, stonefly, mayfly and caddisfly (ii) moderately pollution-sensitive organisms: These are organisms that can survive in fair water quality. Their habitat requirements are not as strict as pollution-sensitive organisms. These include but limited to crane fly, crayfish, dragonfly, damselfly and (iii) pollution-tolerant organisms:

Cranefly (Diptera)

Damselfly (Odonata)

These are organisms that can survive in poor water quality. Their adaptations allow them to survive in turbid waters, nutrient-enriched waters or in water with low dissolved oxygen. For example, leeches, aquatic worms, midges, water striders, backswimmers, water bugs and true bugs (Ojija and Laizer, 2016).

Ephemeroptera

Ephemeropterans are widely distributed throughout the fresh water environment and they live in various types of standing and running waters (Elliott and Humpesch, 2010). Out of all the ephemeropterans, genus Baetis is classified as the most sensitive group (Arimoro and Muller, 2010). Baetis species is the only tolerant and is able to survive within a specified range of water parameters. Hanna and Shekha (2015) reported a total of 25 species. The study site was dominated by Ephemeroptera which indicates the abundance of mayfly and indicates clean, unpolluted water.

Plecoptera

Plecoptera are very sensitive to pollution and habitat disturbance (Eaton and Lenat, 1991). The absence of Plecoptera indicates the water quality degradation and physical alteration.

Trichoptera

Amongst the aquatic insects, the order

Whirlgig beetle (Coleoptera)

Trichoptera (caddisflies) is probably the most widely distributed and the larvae are common in running water (Malicky, 2010). Their response to perturbation and reliance on plant matter for food are reasons why caddisflies are widely used in several aspects of water quality monitoring (Resh, 1992). Hydropsychidae is usually considered as very tolerant to organic pollution in rapid bioassessment protocols used in Europe and Thailand and based on a family level of identification (Mustow, 2002).

Diptera

Diptera community pattern and diversity are affected by organic effluent. Many dipteran families are indicators of polluted water because they are found in high abundance in pollued environments (Arimoro et al., 2007). Some of dipteran families (Simuliidae and Tipulidae) live in moderate clean to clean water (Allan and Flecker, 1993). 'Bloodworm' midge larvae are usually the most abundant and often nearly exclusive inhabitants of organically enriched streams where low levels of dissolved oxygen have eliminated intolerant predators and competing species (Olive, 1976). Latha and Thanga (2010) reported the dominance of Diptera indicating the presence of pollution gradient in Kadinamkulam lake, Kerala.

Odonata

Odonata (dragonflies) species are very sensitive to changes caused to their habitat, especially lakes and flooded drainage areas (Corbet, 1980). Odonates are characterized as an excellent habitat indicator of present and past (long term) environmental conditions in aquatic habitats (Steward and Samways, 1988). Odonata can live in polluted as well as clean water, but the algal abundance and luxuriant growth of macrophytes are prior requirements.

Hemiptera

Aquatic hemipterans stand out as an important group of aquatic insects, which are considered important in environmental reclamation of aquatic habitats and are often used to gauge toxins in an environment (Wollman, 2001). The relatively more abundance or dominance of Gerridae and Veliidae of order Hemiptera in the stream could be due to their modified body structure. The increase of water temperature and DO are highly correlated with development rate of Gerrids.

Gerrid (Hemiptera)

Water scorpion (Hemiptera)

Coleoptera

The members of family Gyrinidae (whirling beetles) are found in fresh water ponds, lakes, open flowing streams etc. The members of Haliplidae (crawling water beetles) live among aquatic vegetation along the edges of ponds, lakes, streams and creeks.

Dragonfly (Odonata)

Environmental factorsinfluencing the abundance and distribution of aquatic insects
Physical parameters

Substrate

Different types of substrates in the rivers influence the abundance and diversity of aquatic insects because habitat preference differs among different species (Collier, 2004). Hydropsychidae (Trichoptera) prefers large and stable substrate whereas Baetis sp. and Caenis sp. (Ephemeroptera) prefer sandy substrate as their habitat (Georgian and Thorp, 1992). Different types of substrates that exist together in a river create high richness and diversity of aquatic insects that live in the rivers.

Canopy cover

Partly shaded canopy cover is optimal for the growth of aquatic insects as the sunlight still can reach under water for photosynthesis processes. Contrary, shaded canopy cover might negatively affect the abundances of aquatic insects as the canopy cover blocks the sunlight from directly passing through the water. This phenomenon decreases the rate of photosynthesis and thus reduces the amount of dissolved oxygen in the water.

Water velocity and light

Water velocity is directly important for regulating aquatic ecosystem. For example, high water velocity during heavy rain might carry away the aquatic insects especially those that burrow in the sediments (ephemeropterans) and thus reduce their abundances. However, high water velocity is important in maintaining high level of dissolved oxygen which is crucially required by macroinvertebrates especially aquatic insects for respiration. Light penetration is important for the photosynthesis process to occur. Photosynthesis process provides sufficient amount of oxygen in the water. Therefore, rivers with relatively low velocity are often dominated with tolerant group of aquatic insects towards oxygen depletion such as Chironomus sp. (Diptera: Chironomidae) and Culex sp. (Diptera: Culicidae) (Popoola and Otalekor, 2011).

Water temperature

Water temperature significantly affects abundance, diversity and distribution of aquatic insects (Burgmeret al., 2007) as it influences their embryonic development, growth, emergence, metabolism and survivability. Different species prefer different ranges of water temperature. For

Backswimmer (Hemiptera)

example, stoneflies (Plecoptera) prefer lower water temperatures than mayflies (Ephemeroptera) (Brittain, 1990) possibly because some order of aquatic insects are temperature dependent and high temperature favors their feeding and metabolism rates. Besides, water temperature has an inverse relationship with dissolved oxygen in the river (Popoola and Otalekor, 2011). When water temperature increases, respiration process occurs rapidly and thus decreases the level of dissolved oxygen in the water. The higher water temperatures probably favored the densities and diversity of Hydropsychidae in the Mae Tao and Mae Ku watersheds northern Thailand (Prommi and Payakka, 2015).

Chemical parameters

Dissolved Oxygen (DO)

One of the chemical parameters that might affect the abundance and distribution of aquatic insects is dissolved oxygen (DO), which is the amount of free, non-compound oxygen that present in the water. Intolerant order of aquatic insects such as Ephemeroptera, Plecoptera and Trichoptera prefer high level of DO while moderately tolerant orders such as Diptera could inhabit the river with low levels of DO. Too high or too low levels of DO could harm the aquatic insects and affect water quality in the rivers.

Biochemical Oxygen Demand (BOD)

BOD is the total amount of oxygen needed by aerobic microorganism in the water to breakdown or stabilize the organic matter in the rivers (Parmar, 2010). BOD is inversely related with the abundance of aquatic insects because aquatic insects require enough oxygen for their respiration process (Fleeger et al., 2003).

Total Suspended Solids (TSS)

According to APHA (1998), total suspended solid (TSS) includes a variety of small particles such as silt, decaying plant and animal matter and sewage that can be trapped by a filter. When the level of suspended solid is too high in the river, light cannot easily penetrate into the rivers, thus reducing the amount of dissolved oxygen produced by photosynthesis under the water (Cushing and Allan, 2001). Therefore, increased level of TSS would negatively affect the abundances of aquatic insects and thus reducing the primary productivity of the rivers (Ismail, 2017).

pH

pH is a measure of hydrogen ion concentration in water. Majority of the aquatic insects prefer pH ranging from 6 to 9 (Chapman, 1992). When the pH water falls outside the range, the mortality rate for most of the aquatic insects will increase. However, extremely high or low pH values would increase solubility of toxic materials, thus making them mobile and chances of toxic materials being absorbed by the aquatic insects increases (Tordoff et al., 2000).

Organic matter

Intolerant groups of aquatic insects such as Ephemeroptera, Plecoptera and Trichoptera could not tolerate with high organic content causing their limited abundances (Popoola and Otalekor, 2011). However, pollution tolerant groups such as Chironomus (Diptera: Chironomidae) are abundant in the river with high level of organic contents, possibly from leaf litter, recreational activity or untreated sewage (Popoola and Otalekor, 2011).

Heavy metals

Cadmium (Cd), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni) and Zinc (Zn) are several types of heavy metals that are usually traced in aquatic ecosystems (Zhou et al., 2008). Direct effects of heavy metals results in the declining in abundance and diversity of macroinvertebrates especially aquatic insects. Meanwhile, indirect effects of heavy metals contamination cause

alterations of species interactions (Courtney and Clements, 2002). Toxic effects of metals can occur at the individual level, for example, increasing mortality of sensitive species and also changing other vital processes such as growth and reproduction (Chanu et al., 2017). Oligochaetes, chironomids, and Hydropsychid caddisflies are relatively tolerant to metal whereas some genera of Ephemeroptera, mainly within the family Heptageniidae are considered highly sensitive to metals (Clements et al., 2000). The bioaccumulation factor (BAF) is the ratio of the substance concentration in the body and the substance in the environment. It is considered bioaccumulation when metal concentrations in organisms are larger than the concentrations of the aquatic sediment. Thus, for values ≥ 1, bioaccumulation is accepted (Klavins et al., 1998). The BAF is described by the following formula:

Organism metal concentration
Sediment metal concentration

Ecological index

Shannon-Wiener Index (H')Shannon-Wiener Index (H') is widely used to assess the diversity of species in the sampling stations and it reflects the degree of species composition per unit area. The higher value of (H'), the greater the diversity and the cleaner the environments are (Metcalfe, 1989).

$H' = -\sum [(ni/ N) \ln (ni/ N)]$

H' = Shannon-Wiener Index
ni = Total individuals belonging to the i species
N = Total individuals of population sampled

Biological Indices

There are several biological indices that are commonly used to classify the river water quality such as Biological Monitoring Working Party (BMWP), Family Biotic Index (FBI), etc (Ismail, 2017).

Biological Monitoring Working Party (BMWP)

It is used to measure water quality using macroinvertebrates as biological indicators. This index is based on the principle that different family of macroinvertebrates have different tolerances to pollutant.

$BMWP = \sum [(ni \times ai) + (ni2 \times ai2) + \ldots\ldots + (nin \times ain)]$

Where
ni = Number of family sampled
ai = Tolerance value for each family

Average Score Per Taxon (ASPT)

The Average Score Per Taxon (ASPT) represents the average tolerance score of all taxa within the community, and was calculated by dividing the BMWP by the number of families represented in the sample. From this value, the water quality of each lake was assessed.

Family Biotic Index

It was developed by Hilsenhoff (Hilsenhoff, 1988) to summarize the various tolerances of the benthic arthropod community with a single value. The Biotic Index was subsequently modified to the family-level with tolerance values ranging from 0 (very intolerant) to 10 (highly tolerant) based on their tolerance to organic pollution, creating the Family Biotic Index (FBI). Tolerance values for each family were developed by weighting species according to their relative abundance in the State of Wisconsin. The FBI was then used to evaluate the water quality of each lake.

$FBI = \sum x\,it\ i/N$

Where
xi= number of individuals within a taxon
ti= tolerance value of a taxon
n = total number of organisms in the sample (100)

Conclusion

It is obvious that aquatic insects serve as eminent bioindicators of water quality and ecosystem health. They complement physical and chemical methods in assessing water conditions, provide temporal history of perturbation and have potential to predict environmental changes in a timely manner.

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Blood Fruit

Haematocarpus validus

An Underutilized species with potential health benefits in Thyroid and Anemia conditions

The Indian subcontinent with its rich biodiversity heritage home to many wild edible plants with enormous potential for use in medicine, agriculture, and the food industry. One such species is Haematocarpus validus (Miers) Bakh.f. ex Forman, also named as Blood Fruit (English), Khoon Phal

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(Hindi) due to its dark red to crimson colored fruit as well as pulp. It is a dicotyledonous woody climber in the family Menispermaceae. This species is found primarily in Tripura, Assam, Arunachal Pradesh, Sikkim, and Meghalaya (North-east India); West Bengal (WB) and the Andaman and Nicobar Islands (ANI). In ANI, this plant is mainly found in the forest areas of the North and Middle Andaman Islands and North Nicobar Islands. In addition to being tasty and packed with antioxidants, the fruits are used by the locals for consuming fresh and also for preparation of many processed products. The ethno-medicinal value of this fruit is well recognized, and it is used as an iron-rich fruit by village people. Apart from the edible and medicinal properties of the fruit, the blood red-colored juice extracted from the fruits is widely used by the locals as a natural colorant for the local handicraft sector. This species is less researched for its large scale multiplication and conservation, but due to its immense potential, it can be one of the potential future fruits with multiple usages.

Botany

In general, plants belonging to Haematocarpus species are large, woody and climbing in nature on nearby growing tall trees. Botanically, leaves are simple, alternate, non-peltate, elliptic, three-

veined, and petiolate. The bark is light grayish brown and rough with stout branches. It has varied inflorescences viz., cauliflorous, axillary, extra-axillary, terminal panicle or raceme. The male and female flowers are produced individually on the plants of the Haematocarpus species. Sepals 12–15, in 3 series, usually larger in the inner series, imbricate, 6 petals, 3 of the inner series auriculate at the base, and 6 free, expanded connectives extending inwards are characteristics of male flowers. The sepals and petals of female flowers are identical to those of male flowers, and they have six-minute staminodes and six reflexed carpels. Drupes are the fruits, which are stalked, narrow near the base, and have a smooth endocarp. The bent, non-endospermic, short-radicle seeds have thick, lengthy cotyledons. Seeds can be dispersed by barochory, gravitational dispersal, zoochory, or anthropochory, or by birds, animals, or people.

Morphological characteristics

Sangma (2016) conducted a study on the morphological traits of this plant in the Garo Hills of Meghalaya. Study revealed that the plants have a climbing habitat, are tall, and produce ovoid-shaped fruits. RHS color chart study revealed the great variation in fruit colors including N34A,

Table 1: Scientific classification of blood fruit

Kingdom	Plantae
Order	Ranunculales
Family	Menispermaceae
Genus	*Haematocarpus*
Common Name	Blood fruit, Khoon Phal

N30A, 53D, 33A, 45A, N34B, 53A, 45B, 46-A, 42A, and 46B. The inflorescence was discovered to be in pseudo-raceme axillaries and ranged in size from small to intermediate.

Flowering

The flowering period varies depending on the climate where the plant is growing. The plant has been noted to flower more than once per year in the climatic conditions of Andaman. April to August are the busiest months for harvesting (Bohra et al., 2016). According to Khatun et al. (2014), vines in Bangladesh produce flowers between mid-November and mid-January, and they bear fruit from May to August. The vine begins to flower under the Garo highlands conditions in Meghalaya from October to December, and fruits start to appear in the local markets from the last week of March till June (Sangma, 2016).

Distribution and habitat

Blood fruit is mainly found growing in India, Bangladesh, Indonesia, Singapore, Thailand, and Sri Lanka. It is a native of South East Asia. In India, the plant is mainly found growing in wild in Andaman & Nicobar Islands, Arunachal Pradesh, Mizoram, Tripura, Assam, and Meghalaya; and usually, its commercial cultivation is not observed. The evergreen perennial creeping woody climber H. validus can thrive in extremely dry environments and in highly acidic soils. It can reach heights of up to 1000 m or more (Rahim et al., 2015), and the stems are densely branched and dark green with glabrous leaves. This plant creeps and grows on other large trees, such as banyan, jackfruit, Baccaurea species, or other long supporting trees. According to a recent study by Singh and Bedi (2016) in Meghalaya, the presence of subtropical moist evergreen trees and an enormous amount of herbaceous undergrowth on a steep landscape are characteristics of the forest type of species occurrence.

Nutrient Potential

Many edible fruits are abundantly available in the forest and wild areas, however, enormous amounts of wild fruits are typically not collected and therefore got wasted. As the potential of such fruits as subsidiary food sources are essentially unknown to the village and tribal communities only, they remain hidden from the rest of the world. These edible fruits have been identified as having rich nutritional value and they play an important role in the nutrient supplementation of rural and tribal communities (Nazarudeen et. al, 2010). According to Islam et al. (2012), the vitamin C content in the fruits of H. validus (13.15 mg) is higher than that of the commercially available mango (10.88 mg), jackfruit (11.08 mg), litchi (7 mg), and papaya (7.48 mg). Fruits are rich in carotene, carotenoids, and minerals, and are also a great source of micronutrients including Ca, K, Mg, and P and natural antioxidants. The fruits of H. validus have a iron content of 0.57 mg/100 g, which is higher than that of commercial fruit crops such as pomegranate, guava and cherry (0.3 mg/100 g), mango (0.2 mg/100 g), and apple (0.1 mg/100 g) (Singh, 2013). Another important feature of H. validus fruit and leaf is the good content of Selenium (Se), which is generally absent or found in extremely low levels in other fruits. Maintaining an optimal physiological concentration of selenium is essential for preventing not only thyroid disease but also for sustaining overall health. This can be achieved through a well-balanced diet or, if needed, through supplementation. Therefore, the fruits of H. validus can be projected as a

Table 2: Nutrition value per 100 gm of fruit of Haematocarpus validus

Source:	Khatun et al., (2014)	Sasikumar et al., (2021)	Alex et al., (2022)
Moisture (%)	90.12	79.59	-
Protein (g)	0.6	4.83	0.12
Carbohydrate (g)	6.99	11.20	0.25
Fat (g)	1.44	0.70	-
Energy (Kcal)	50	-	-
Ash (g)	1.23	2.12	-
Iron (mg)	0.57	-	57.29
Vitamin C (mg)	13.15	-	-
Carotenoids (µg)	1170	-	-
β- carotene (µg)	9.0	-	-
Crude fiber (g)	1.22	1.56	-
Copper (µg)	129.57	-	0.96
Zinc (µg)	0.14	-	0.92
Manganese (µg)	152.04	-	0.73
Calcium (mg)	9.16	-	218
Magnesium (mg)	6.86	-	76
Sodium (mg)	0.42	-	6.2
Strontium (mg)	-	-	4.22
Phosphorus (mg)	39.5	-	240
Potassium (mg)	255.70	-	1740
Selenium (mg)	-	-	0.12

novel dietary source of iron and selenium (Alex et al., 2022). The fruits are rich in antioxidants, can also decrease the chance of developing several illnesses, including diabetes, cancer, neurodegenerative disease, and coronary heart disease. However, clinical researches on validating these aspects are scanty due to the availability of meagre information in the public domain about the importance of this species. Various researchers estimated the nutritional value of the mature fruits as presented in Table 2.

Uses of Fruit

The abundance of anthocyanin in the fruit gives rise to its vibrant blood-red flesh. The fruit juice serves a dual purpose, being employed both as an organic fertilizer and a natural food color. Ripe fruits find application in various food products, with the edible part being the mesocarp. Premature fruits, on the other hand, are utilized to create value-added items like chutney, pickles, and squash.

Medicinal uses

The plant has various medicinal applications, such as using tender shoots to address jaundice, employing roots for itching relief, utilizing fruits and seeds to treat anemia, and employing leaf decoction for alleviating body pains. Additionally, the fruit juice is employed in treating dysentery. Notably, the fruit is rich in choline, offering benefits for liver health, cognitive function, and preventing fatty liver buildup.

Other uses

Fruits can be used as a natural colorant in the food industry and as they are a rich source of the purple to bright scarlet pigment used to dye local handicrafts (Rahim et. al, 2015) and as natural colourant in the preparation of desserts and beverages (Khatun et al. 2014).

Table 3: Ethnobotanical use of Haematocarpus validus plant parts

Tribes/ Area	Plant part	Uses
Tripura	Immature fruits, ripe Fruits	Immature fruits used for processed products such as squash and ripe fruit juice for dyeing local handicrafts
Tribes in Assam and Meghalaya	Ripe fruit juice	Juice from ripe fruits is used for beverages and natural colourant
Nicobarese Tribes	Leaf	Leaf decoction is used for getting relief from body ache

This species is gaining popularity due to its multifarious uses, however, due to its indiscriminate harvesting from natural forests over the years, the natural regeneration is hampered, and the species is now listed as critically endangered by the IUCN red list.

Ethno-botanical uses by various communities

As blood fruit is particularly found in forest areas, its use is mainly done by local communities/tribes (Table 3). Understanding the usage of various plant parts may help in understanding the probable industrial or pharmaceutical use of this species for specific purposes.

Conclusion

An adequate physiological level of Selenium (Se) in blood fruits ensure in preventing thyroid disorders and promoting overall well-being. Furthermore, higher iron (Fe) content in these fruits can be advantageous in treating anemia. Generally, supplementation with the organic form has demonstrated greater effectiveness. The blood fruit, with its potential as a natural source of selenium and boasting high iron content, can serve as a novel dietary source of both iron and selenium. The fruits and other parts of the plants of H. validus have industrial, food, and medical applications, the fruits in particular have lots of nutritional benefits comparable to those of commercial fruit crops. However, this economically significant species is categorized as highly threatened (Khatun et al., 2014) as per the IUCN red list. It became Critically Endangered in Meghalaya, (Singh and Bedi, 2016) and attained vulnerable status in Bangladesh (Sarwar, 2013) due to increasing anthropological activities and climatic changes. Similarly, in ANI, loss of biodiversity is a rising concern. A wide range of underutilized and neglected species including H. validus contribute to preserving cultural diversity related to eating patterns, social interactions, and health practices. Therefore, they are important for ecosystem and local communities. This urges the need to take proactive steps towards the conservation of this species. Research and funding should be directed towards identifying new avenues on the application side to promote marketability of fruits, processed products and other industrially important compounds from different parts of the plant. This underutilized fruit needs to be brought into the mainstream to cater the needs of the increasing population facing hidden hunger.

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Dragon Fruit

CULTIVATION IN KERALA

PLANT PROTECTION CHALLENGES

Mealybugs(Ferrisia virgataCockerell, Pseudococcidae, Hemiptera)

Kerala, known for its lush green landscapes and diverse agricultural practices, has witnessed a remarkable surge in dragon fruit cultivation in recent years. This exotic fruit also referred to as pitaya, has captured the hearts of Keralites, and it is now a common sight in many homesteads and farms across the state. However, as the cultivation of dragon fruit continues to expand, it is not without its fair share of challenges, particularly concerning pest and disease management. In this article, we will explore the dragon fruit trend in Kerala and shed light on the pest and disease issues farmers face, offering potential solutions to sustain this growing trend.

Dragon fruit is a tropical fruit that belongs to the Selenicereus genus of the climbing cacti (Cactaceae) family. It is indigenous to Central America but is extensively grown in tropical and subtropical regions around the world. English Name Dragon fruit is attributed to its leather-like skin and prominent scaly spikes on the fruit exterior. The fruit is top demanded for its striking appearance, with vibrant pink or yellow skin and white or red flesh speckled with small black seeds which makes it a perfect ingredient in

Spiralling Whiteflies (Aleurodicus dispersesRussell, Aleyrodidae:

food delicacies. French traders introduced this crop to Vietnam as a gift for the King and then it became popular among the wealthy families of the country.

Dragon fruit is a rich source of functional components like polyphenols, vitamin C, and antioxidant pigments.The red and purple colors of dragon fruits are due to betacyanins and betaxanthins. Many of the antioxidants present in the fruit help to cut back the incidence of degenerative diseases like arthritis, arteriosclerosis, cancer, heart diseases, inflammation, and brain dysfunction. Hence, it is sometimes referred to as the "wonder fruit of the 21st century."

The plant is a climbing cactus vine that grows well in dry areas. It can be propagated by seed or by stem cuttings. The fruiting stage is reached more rapidly with cuttings, less than one year after planting, as opposed to three years for seedlings. The economic life of the crop is 25 years. A distance of 2–3 m is required between

Hairy caterpillar

Fruit Borer

planting lines at a rate of three cuttings per vertical support. Dragon flowers bloom only at night and span for only one night.However, plants have four to six fruiting cycles in one year. Moths, hawks, ants, honey bees, and bats in the species range pollinate the flowers. Some of the dragon fruit varieties are self-sterile which form fruit after cross pollination. However, in newly introduced places, lack of natural pollinators stands in the way of pollination which culminates in poor fruit sets and small-sized fruits. Assisted pollination during the flower bloom is popular among dragon fruit growers to ensure good quality fruits. Mostly grown self-pollinating varieties are Vietnamese white, American beauty, Dark Star, Delight, Florida Red, Giant Vietnamese, Hailey's Conet, Makisupa, Rixford, Seoul Kitchen, Surinam Red, Thai Dragon, Thomson, Vietnamese White, Voodoo Child, Wiangel, Condor, Natural Mystic, Purple Haze etc.

This exotic fruit comes in three different forms. The most commonly seen

- White flushed pitaya pink-skinned fruit with white flesh. Varieties: Mariya Rosa
- Red-fleshed pitaya is a red-skinned fruit with

Stem Canker

red flesh. Varieties: Malaysian Red, Manila Red

- Yellow pitaya has yellow-skinned fruit with white flesh. Varieties: Israel yellow, Bruni

The shift towards dragon fruit cultivation has been largely attributed to its adaptability to Kerala's climate and its relatively low maintenance requirements. The cacti-like dragon fruit plants thrive in warm and humid conditions, making Kerala's tropical climate an ideal match. As a result, dragon fruit is grown in homesteads, gardens, and small farms, contributing to increased self-sufficiency and income generation for many.

Pest and Disease Challenges

Despite the growing popularity of dragon fruit cultivation in Kerala, it is not immune to pest and disease issues.The novelty of dragon fruit cultivation in Kerala began approximately 8 to 9 years ago, and hence there is limited literature available on the pests and diseases affecting this crop. Nonetheless, being a succulent and exotic crop, the risk of serious pest attacks is a concern that requires attention. To address this knowledge gap, periodic observations have been carried out in the dragon fruit growing areas of Thrissur and Malappuram districts during 2021-2022. Based on these observations, a list of pests has been documented and is enlisted in this paper.

Sucking pests

Mealybugs(Ferrisia virgataCockerell, Pseudococcidae, Hemiptera)

These tiny pests can infest dragon fruit plants, leading to reduced fruit quality and yield. They are often found on the stems and fruit. A countable attack by the mealybugs was first noticed in November 2021. The nymphs and adults were colonized on the growing tips and were feeding on the green stem. The margins of the shoot had turned yellow due to the feeding by this pest. A single spray of Econeem 0.03% EC could effectively manage the pest.These insects secrete honeydew that promotes the growth of sooty mold which in turn reduces the photosynthetic ability of the crop.

Spiralling Whiteflies (Aleurodicus dispersesRussell, Aleyrodidae: Hemiptera)

In January 2022, a few colonies of spiralling whiteflies were found damaging the stem of dragon fruit. Though a few colonies of whiteflies were spread throughout the field, significant damage or symptoms could not be observed.

Lepidopteran pests

Fruit Borer: The next pest observed was a fruit

borer in which the caterpillar was found boring into the flesh of the fruit, leaving a borehole at the anterior end of the fruit. When cut open, a stout caterpillar was feeding vigorously on the flesh. The caterpillar was reared inside a plastic trough for about 21 days after which it died. Hence, its exact identity could not be confirmed.

Beet Armyworm: Caterpillars of the beet armyworm, Spodoptera exigua(Hubner) (Lepidoptera: Noctuidae), was found feeding on the stem and flowers of the dragon fruit. The caterpillar voraciously fed on the flowers, and it was efficiently managed by a single application of Flubendiamide 480 SC.

Hairy caterpillar: A few hairy caterpillars,Somena scintillansWalker (Lepidoptera: Erebidae) were found boring into the green stem, resulting in scraping of the green matter as well as holes on the stem.

Major diseases observed

Anthracnose: Anthracnose is a fungal disease that affects dragon fruit plants, causing dark lesions on the fruit's skin, which can lead to fruit rot and reduced market value.

Stem Canker: Stem canker, a disease affecting dragon fruit plants, has been reported as another challenge in dragon fruit cultivation in Kerala. This disease leads to the development of cankerous lesions on the stems, potentially weakening the plants. Spraying any systemic fungicide followed by contact fungicide can control the incidence. Excess moisture and insect injury must be avoided to prevent the disease.

Challenges in Pest Management

Given the relatively recent adoption of dragon fruit cultivation in Kerala and the limited availability of literature on pests and diseases, practical observations and research in the field are essential. A number of pests like aphids, thrips, mealybugs, scales, etc., have been reported from leading dragon fruit-growing countries. The first report of Spodoptera litura(PRODLI) (Prathapanand Santhoshkumar, 2022) as a serious pest of dragon fruit from Kerala was published in November 2022. Though not many reports on the pests of dragon fruit from India are available, extensive monoculture, heavy fertilizer application, and lack of research data in India point to the chances of the mentioned pests emerging as major ones in the near future.

Conclusion

The rising trend of dragon fruit cultivation in Kerala is a testament to the resilience and adaptability of this exotic fruit in the state's tropical climate. However, the success of dragon fruit farming is contingent upon effective pest and disease management. Given the relative novelty of dragon fruit cultivation in Kerala, it is crucial for farmers and researchers to collaborate and gather information on the pests and diseases that affect the crop. With periodic observations and documentation, farmers can better understand the challenges they face and develop targeted strategies to protect their dragon fruit crops, ensuring the continued growth of this agricultural phenomenon in the state. Practical observations and continuous research are the keys to successful pest management in this thriving agricultural venture.

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