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From the Editor-in-Chief's Desk

I am happy and proud to announce the release of the Special issue on Horticulture for the month of October, 2023.

Horticulture is the art and science of cultivating plants, and it plays a crucial role in our lives. From growing fruits and vegetables for our tables to creating beautiful gardens that soothe the soul, horticulture enhances our well-being. It's not just about gardening; it's a sustainable practice that contributes to environmental conservation, biodiversity, and even urban greening. Whether you have a small window box or manage vast agricultural fields, horticulture connects us with nature and underscores the importance of responsible land management and plant care. It's a fundamental part of our lives, enriching our world with beauty and sustenance.

It gives me great pleasure to inform you that we have curated and finalized 25 articles for publication in this issue.

I extend my heartfelt gratitude to the Guest Editor Dr. K. Sundharaiya for his contribution as Guest Editor for this Issue and also for the dedicated editorial team and the talented authors for their invaluable contributions in bringing this issue. Your efforts have played a pivotal role in making AgriTech Today Magazine a source of enlightenment and knowledge in the agricultural domain.

Editor-in-chief

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Nutritional Importance of Dragon Fruit

Ph. Chandramani Singh[1*], L. Basil[1], L. Somendro Singh[1], N. Johnson Singh[1], N. Soranganba[1], S. Roma Devi[1], P. Bijaya Devi[2], Umakanta N.[3], T. Basanta Singh[3], Ch. Premabati Devi[3] and Ramgopal Laha[3]

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Abstract

Dragon fruit is a highly juicy nutritious exotic fruit with an attractive shape and colour. It is a low-calorie fruit that is high in fibre and provides a good number of vitamins, calcium, and phosphorous. Dragon fruit, owing to its nutritional and functional properties, can help in reducing the risk of chronic diseases. The fruit is processed into many value-added products; however, that has been limited to small-scale processing industries. Whereas, at present the availability of fresh fruit is very seasonal and localized but the potential for domestic and international marketing is very high.

Keywords: Dragon fruit, Nutritious, Cultivars, Chronic diseases, Value-added products

Introduction

Dragon fruit (Pitaya/ Pitahaya) is a tropical fruit native to southern Mexico, Central America, and South America, which belongs to the family Cactaceae. It is mostly grown in tropical and sub-tropical parts of the world, including Thailand, Indonesia, Vietnam, Sri Lanka, Taiwan, Japan, Malaysia, Philippines, Mexico, Australia, Ecuador, and China. In Central America, the Dragon fruit is called "Pitaya". In Asian countries, it's called "Strawberry pear". It's also known as the Honolulu queen, whose flowers bloom only open at night. Dragon fruit is juicy and contains black tiny edible seeds, soft in texture that are similar in appearance to Kiwi seeds. The fruits are fleshy, oval-shaped with spikes, and roughly baseball size. The fruit weighs between 400g to 750g having a sweet, mildly sweet, and slightly sour taste. The colour of fruit pulp may vary from white, to red, pink, and purple. The cultivars with deep pink flesh are more flavourful. Dragon fruit contains prebiotic fibre that promotes the growth of beneficial bacteria in your gut potentially improving metabolic health.

Composition of Red Pitaya

Pitaya is a juicy nutritious colorful fruit with black tiny edible seeds. The water content of pitaya fruit is very high (84.40 %). Pitaya is a low-calorie fruit with natural sugar, rich in pectin fibre (0.5 g/100g of edible part), niacin (0.30g/100g of edible part), Vitamin C (8mg/100g of edible part), and minerals like (Calcium-10 mg/100g of edible part), (Iron-1.30mg/100g of edible part) and (Phosphorus-26mg/100g of edible part). The dragon fruit has a low protein content of about (1.40g/100g of edible part) and the fat content is very low (0.40g/100g of edible part).

Health Benefits

1. Dragon fruit has healthy properties for gastritis, heartburn, stomach ulcers, and acidity.
2. The fruit contains captin, a natural substance that acts as a Cardiac tonic and nervous system stimulant effects, which makes it a suitable fruit for the treatment of hypertension, arrhythmias, and nervousness.
3. The fruit with white pulp may help improve blood sugar levels because it contains an anti-diabetic component.
4. Dragon fruit contains high in vitamin C and other antioxidants, which are good for the immune system.
5. The fruit contains betacyanin (purple pigment) that has anti-cancer properties and anti-premature aging of the organism.
6. The sap of the pitaya plant has skin-healing properties to treat wounds, sores, and boils.
7. Consumption of dragon fruit with Kidney stones problem should be avoided because the fruit contains oxalates.

Cultivars

Dragon fruit is predominant in two separate genera namely, '*Hylocereus*' and '*Selenicereus*'. The most commercially cultivated varieties are from the *Hylocereus* genus. The Dragon fruits are grown on climbing cacti and need wooden or cemented pillars of trellising to support the plant. Pitaya plants can produce fruits after one year of establishment. Pitaya species are mostly found in tropical and sub-tropical America, in evergreen and deciduous forests in diverse landscapes up to 1700 m above mean sea level and 500 to 2000 mm rainfall. Three cultivars are grown commercially includes, *Hylocereus undatus* (white dragon fruit), which has fruit with bright pink skin and white flesh, *Hylocereus polyrhizus* (red dragon fruit) has fruit with bright pink skin and varying hues of pink flesh, and *Selenicereus megalanthus* (yellow dragon fruit) has yellow skin and white flesh with

black seeds. Fruits from the genus *Stenocereus* look similar to dragon fruit; however, they are rounder and have a sour flavor. For fresh dragon fruit produce July to September is the peak season for most varieties; however, varieties of *Selenecereus megalanthus* produce fruit during the winter season (November to February).

Value added products

Being a non-climacteric type and to get the best quality for consumption of the dragon fruit, it should be harvested in ripe. The Dragon fruit has a good potential to be processed into many products. Different value-added items of dragon fruit are jam, jelly, juice, marmalade and preserves, sorbet, powder, energy and fruit salads, ice cream, pastries, pulp, and wine. The juice of the red cultivars are commonly used as a natural food colorant and dye. Fruit peel has the potential as an antibacterial agent and antioxidant.

Conclusion

Dragon fruit is an excellent and reasonable source of nutrition, supplementing vital nutrients to the human body such as low sugar, proteins, and carbohydrates, and rich in pectin fibre, vitamins and minerals. Pitaya should provide all essential nutrients and play a critical role in preventing chronic disease and promoting good health.

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Case Study on Popularization of CTCRI and TNAU Tapioca Varieties in Namakkal District of Tamil Nadu

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Tapioca is the major tuber crop cultivated in Namakkal District in an area of 15000 ha with a productivity of 32 tonnes / ha during 2006. It is almost grown in 15 blocks of this District. Namakkal District occupies second position in tapioca cultivation, which covers 40 per cent of tapioca area of the Tamil Nadu as an industrial crop for sago industry. Even though area is more in Namakkal District, its production is low due to low productivity which is lower than the state average productivity (48 t/ha). 99 % of tapioca area is under the variety of Mulluvadi. The yield potential of this variety is 30 /ha and it is also susceptible to Cassava Mosaic Disease and highly infected by red spider mite, mealy bug and spiralling whitefly. KVK,Namakkal has formulated five On Farm Testing (OFTs) and eight Front Line Demonstrations (FLDs) with an objective of maximizing yield through introduction of high yielding tapioca varieties (H226, Sree Vijaya, Sree Padmanaba, Sree Athulya, Sree Apporva, Sree Harsha, Sree Rekha and Sree Pavitha) released from Central Tuber Crops Research Institute, Trivandrum and (Co4 & Yethapur 1) TNAU, Coimbatore with integrated crop management practices since 2007 at Sendamangalam, Namagiripettai, Mohanur, Tiruchengode and Rasipuram blocks of Namakkal District of Tamil Nadu.

Plan and Implementation

In addition several multi location trails also conducted in farmer's field through supply of planting materials of new varieties released from CTCRI, Trivandrum at Tiruchengode and Sendamangalam blocks by KVK, Namakkal. These varieties also showing resistance as well as tolerance to the major pest and diseases of Tapioca (Table.1.). Then training cum demonstration on precision farming techniques in Tapioca was conducted at all blocks of Namakkal District in coordination with Department of Horticulture under the financial and technical guidance of Precision Farming Centre, TNAU, Coimbatore from 2006 to 2020. Rainfed Tapioca cultivation practices also demonstrated and totally 82 trainings were conducted at all blocks of Namakkal district from 2006 to 2022 in coordination with Department of Horticulture, Namakkal District. Recent production technology in Tapioca also popularized by means of regular advisory services, field visit, diagnostic visits and also made farmers exposure visit to CTCRI, Trivandrum since 2006. By seeing the yield potential of CTCRI tapioca varieties, 57 farmers from Rasipuram block got the planting materials from CTCRI, Trivandrum through prior booking.

Output

The area under CTCRI high yielding varieties has increased from 261 ha to 2770 ha especially in Sendamangalam and Namagiripettai block of Namakkal District through interchange of planting materials among the farmers for the past 15 years. Now 20 % of the farmers of these blocks are cultivating H226, Sree Vijaya, Sree Athulya, Co4, Yethapur 1 and Yethapur 2 varieties of Tapioca under irrigated condition mainly through drip fertigation and also obtained the yield of 38 – 42 tonnes / ha (Fig.1.). Among the four varieties H226, Sree Vijaya and Sree Athulya occupies major area of cultivation. In addition farmers also experienced complete control of red spider mite incidence, 90 % control of mealy bug through cultivation of resistant variety Sree Athulya and 100 % control of Cassava Mosaic Disease through cultivation of Sree Padmanabha variety.

Outcome

A total of 2700 ha of tapioca area in Namakkal district occupies CTCRI and TNAU varieties. Since tapioca price fixation is done based on starch content of the tubers. The new varieties also having high starch content (28 to 32 %) when compared to Mulluvadi (22 %) and provides good net income (Rs. 80,000/0.4 ha)

to the farmers. The undersized tubers used for making dried chips as a concentrate feed for cattle.

Impact

Apart from Namakkal district, the planting materials of improved varieties of tapioca also supplied by KVK farmers to other District farmers mainly through KVKs (Trichy & Salem) to cover 122 ha. The gradual reduction of area under Tapioca cultivation was noticed from 15260 ha to 7400 ha in 2010 – 2011 & 6000 ha in 2015 -16 due to occurrence of severe drought. But again, the area under tapioca also regained to 16150 ha producing 646000 MT with a productivity of 40 t/ ha since 2017 with new improved varieties (Source: State Department of Horticulture, Namakkal District, 2018). The productivity is increased from 32 tonnes / ha (2006) to 43 tonnes/ ha in 2020 -22. So, the farmers got better economic returns thus helped to educate their children in the good colleges.

Table 1. Varietal wealth – Introduced to Namakkal District by KVK, Namakkal from 2007 to 2022

Variety	Duration (Months)	Irrigated / rainfed	Yield (t/ha)	Starch content (%)	Special features
CTCRI Varieties					
H-226	10	Rainfed	30-35	28-30	Drought tolerant
Sree Prakash	7	Irrigated	30-35	29-31	Early maturing and tolerant to leaf spot
Sree Harsha	10	Rainfed	35-40	38-41	Drought tolerant
Sree Vijaya	6-7	Irrigated	25-28	27-30	Early maturing and tolerant to leaf spot
Sree Rekha	8-10	Irrigated	45-48	28-30	Excellent cooking quality
Sree Athulya	10	Both irrigated & rainfed	38.7	30.2	High extractable starch (30.2%)
Sree Apoorva	10	Both irrigated & rainfed	38.0	29.9	High extractable starch (30%)
Sree Padmanabha	9-10	Irrigated	38	25.8	CMD resistant
Sree Pavithra	10	Irrigated	38	35	High yielding (40 t/ha) & tolerant to CMD
Sree Reksha	10	Rainfed and Irrigated	45-50	27-31	The tubers with brown skin, cream rind and white flesh colour. It is completely resistant to cassava mosaic disease caused by both Indian cassava mosaic virus and Sri Lankan cassava mosaic virus. It is also tolerant to post harvest physiological deterioration.
TNAU varieties					
CO (TP) 4	8.5	Both irrigated and rainfed	50.6	40	Moderately susceptible to Indian Cassava Mosaic Virus
CO (TP) 5	9 to 10	Irrigated	38	28	Resistance to Cassava Mosaic Disease
Tapioca YTP 1 (Yethapur 1)	9 to 10	Both irrigated and rainfed	49.5	25 to 27	Very low incidence of mosaic virus
Yethapur 2	10	Both irrigated and rainfed	46.2	29	Tolerance to Casava Mosaic Disease

Fig. 1: Performance of Tapioca varieties in Namakkal District





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The Battle Against Citrus Greening Disease

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Citrus greening disease, often known as Huanglongbing (HLB), is one of the most serious threats to the global citrus sector today. Because of its relentless expansion and fatal repercussions, the fight against this pernicious plant disease has escalated in recent years. Citrus greening, a bacteria-related disease caused by *Candidatus Liberobacter asiaticus*, is known for its capacity to weaken citrus trees, diminish fruit production and devastate once-thriving orchards. The Asian citrus psyllid (*Diaphorina citri*), a small insect vector responsible for disease transmission as it feeds on citrus plants, complicates matters further. The effects of citrus greening extend well beyond agricultural lands. This disease not only offers significant economic risks to citrus growers and the citrus-based economy, but it also affects the livelihoods of millions of people who rely on citrus farming for income and nutrition. Furthermore, it jeopardises the availability of this popular fruit in worldwide markets, raising worries about food security (Hung *et al.*, 2004).

Citrus greening disease has its origins in Asia, where it has been present for generations. The disease's first mention dates back to the late 1800s in China, where it was known as "huanglongbing" or "yellow dragon disease," a name derived from the characteristic yellowing of leaves in affected citrus trees. During the disease's first discovery, most research was conducted in its native Asian habitat, albeit full investigations on its causal agents were initially limited. Citrus greening arrived in the United States in the early 2000s, initially appearing in Florida in 2005 (Nguyen *et al.*, 2023) and then spreading to other citrus-producing regions. The disease is thought to have entered the United States via the transportation of infected plant material or the movement of infected Asian citrus psyllids, small insects that serve as primary vectors for the bacterium CLas, which is responsible for disease transmission when feeding on citrus trees. Citrus greening has spread fast since then, crossing continents and becoming a global agricultural threat. The worldwide mobility of diseased plant material and psyllids has aided its global spread, emphasising the necessity for a full study of its origins to inform the ongoing battle against this devastating citrus disease.

To protect the future of citrus agriculture worldwide, efforts to prevent citrus greening have increased, with an emphasis on producing resistant citrus cultivars, implementing effective vector control measures and developing early detection tools.

Economic and Agricultural Impact: Citrus greening has a significant economic and agricultural impact. Fruit yield and quality are reduced in infected plants, resulting in considerable economic losses for citrus growers. In severe cases, sick trees become unproductive and must be destroyed, compounding financial difficulties. The disease has put citrus growers and the citrus-based industry's livelihoods in risk.

Global Spread and Efforts to Combat: Citrus greening has expanded fast from its Asian roots to citrus-growing countries around the world, necessitating coordinated efforts to reduce its impact. These efforts include the development of disease-resistant citrus varieties, the implementation of strict quarantine procedures to prevent the spread of contaminated material and the use of integrated disease management tactics to control the Asian citrus psyllid population.

Detection

Visual Symptoms Inspection: Visual inspection is one of the most accessible approaches for diagnosing citrus greening. Pathologists and producers inspect citrus trees for symptoms such as asymmetrical browning of the leaves, known as chlorosis and the occurrence of mottled, deformed and bitter fruit. Visual examination provides an early sign of infection and directs subsequent diagnostic steps.

Polymerase Chain Reaction (PCR) Testing: PCR is a molecular technique used to detect the presence of the citrus greening-causing bacterium CLas. DNA is retrieved from leaf samples gathered from potentially affected trees. CLas DNA is amplified using PCR, allowing it to be detected even at low amounts. This approach has a high specificity and sensitivity, making it a reliable diagnostic tool.

Immunological Assays: Immunological tests, such as enzyme-linked immunosorbent assays (ELISA), are used to detect specific proteins connected to CLas. These tests focus on the interaction of antibodies with CLas antigens to provide a quick and cost-effective diagnosis.

Nucleic Acid-Based Detection: Other nucleic acid-based detection technologies, such as loop-mediated isothermal amplification (LAMP) and quantitative real-time PCR (qPCR), have gained favour because to their speed and sensitivity in identifying CLas DNA. They are especially useful for large scale testing in commercial orchards (Tsai *et al.*, 2008).

Spectroscopy and Remote Sensing: New tools for detecting citrus greening include spectroscopy and remote sensing. These methods examine the spectral properties of citrus tree canopies in order to detect small changes associated with disease. Large-scale monitoring of orchards is possible because to hyperspectral and multispectral imagery, as well as unmanned aerial vehicles (UAVs) (Li *et al.*, 2014).

Electronic Nose Technology: Gas sensors in electronic nose devices can identify volatile organic chemicals released by sick citrus plants. These gadgets offer quick, non-invasive and potentially early disease detection.

Citrus Health Management Programmes: Several citrus-producing regions have comprehensive citrus health management programmes in place. These programmes include regular monitoring of orchards, prompt removal of sick plants and strict quarantine procedures to prevent disease spread.

Early diagnosis of citrus greening is critical for minimising economic losses and limiting its spread. The combination of different detection methods and ongoing research efforts continue to improve disease diagnosis accuracy and efficiency, providing hope in the ongoing battle against this powerful citrus crop pest.

Devastating effect on citrus crops

Citrus greening disease has wreaked havoc on citrus crops all over the world, leaving an indelible impact on citrus growers and the citrus sector as a whole. The consequences of this pernicious disease are multifaceted. It causes a significant decrease in fruit productivity and quality, with infected plants producing smaller, deformed and frequently bitter fruit. These yield losses, which range from 30% to 100%, place severe financial hardship on farms. Pest management initiatives, which include increasing pesticide applications to control the Asian citrus psyllid vector, raise production expenses, further reducing profitability. As citrus greening advances, infected trees health deteriorates, resulting in yellowing leaves, branch dieback and decreased yield. Many damaged trees become unviable and must be removed and replaced, adding to financial constraints. The economic toll affects entire regions that rely on citrus production, affecting revenue, employment and related industries, threatening livelihoods and community stability. Beyond regional borders, worldwide citrus supply chains are affected, resulting in higher prices and reduced fruit availability for consumers. Citrus farming's sustainability is under jeopardy, necessitating ongoing research, investments in disease-resistant cultivars and the use of integrated pest and disease management practises to ensure the industry's future. The continued fight against citrus greening is critical to preserving this important agricultural sector and its contribution to the global economy.

The Culprit: Asian Citrus Psyllid

The Asian citrus psyllid (*Diaphorina citri*) is at the heart of the citrus greening disease (Huanglongbing or HLB) catastrophe (Setamou *et al.*, 2023). This insect is about 3-4 millimetres long and has remarkable mottled brownish wings and a downward-sloping pointed head, adopting a

distinctive roof-like wing posture at rest for simple identification. Its tiny stature, however, betrays its significant significance as the major vector for HLB. While feeding on the phloem sap of infected citrus trees, infected psyllids pick up the bacterium *Candidatus Liberobacter asiaticus* (CLas). They carry CLas within their bodies once infected and further feeding on healthy citrus trees exposes the bacterium into the tree's vascular system, enabling HLB spread. The psyllid life cycle is divided into four stages: egg, nymph, pupa and adult. These stages are distinguished by the consumption of citrus sap, the release of protective waxy compounds and as adults, the potential transmission of HLB if infected. Because of its rapid reproduction and mobility, the psyllid is an effective HLB vector, demanding stringent management measures such as pesticides and integrated pest control to battle the disease's rapid spread and preserve citrus crops.

Management Strategies

A multimodal approach is required to effectively manage and control citrus greening disease (Huanglongbing). Regular orchard monitoring is critical for early detection, using optical surveys, pheromone traps and remote sensing technologies to identify sick plants and pest populations. Strict quarantine measures prevent the spread of infectious materials and pests across borders. The disease vector, the Asian citrus psyllid, must be managed using integrated pest control measures that include insecticides and natural predators. Infected trees should be removed and replaced as soon as possible to prevent further transmission. Disease-resistant citrus varieties are being developed through genetic alteration and traditional breeding (Alquezar *et al.*, 2021). Some growers use antibiotics and nutritional therapy to extend the yield of afflicted trees. Tree health is improved through improved nutrition and soil management practises. Compliance with control measures requires public knowledge and education. Continuous research and global collaboration promote innovation, providing optimism for the protection of citrus orchards and the industry's resilience in the face of this serious danger.

Innovative biological management tactics have taken front stage in the ongoing war against citrus greening disease, harnessing the prowess of beneficial insects and natural predators to tackle the Asian citrus psyllid, the major vector responsible for spreading HLB. These tactics include a variety of natural friends, such as ladybirds, whose ravenous hunger for psyllids and their nymphs aids in population control. *Tamarixia radiata*, a parasitoid wasp, lays its eggs within psyllid nymphs, eventually killing them and demonstrating substantial potential in psyllid management (Chen and Stansly, 2014). Lacewing larvae, which have a voracious appetite for small insects such as psyllids, are placed into orchards to help with population control. Predatory mites, such as *Amblyseius swirskii*, are effective against psyllid eggs and nymphs and certain bird species, such as the green lacewing bird, help in psyllid predation (Juan-Blasco *et al.*, 2012). Furthermore, conservation initiatives to encourage the presence of natural enemies, such as parasitoid wasps, include promoting habitat-friendly circumstances in orchards through diversified flora and reduced pesticide use. To maximise pest management, monitoring and targeted release programmes ensure that beneficial insects are deployed during important periods of the psyllid's life cycle. These biological control initiatives provide an environmentally beneficial and sustainable alternative to chemical pesticides, establishing balanced ecosystems inside citrus orchards and allowing growers to protect their citrus trees from the hazardous impacts of this citrus-devastating disease.

Conclusion

The citrus sector is contending with Huanglongbing (HLB) disease, which is transmitted by the Asian citrus psyllid. Despite the hurdles, the industry has deployed a variety of HLB-fighting techniques, including early diagnosis, monitoring and the development of disease-resistant cultivars. To reduce the disease's impact, quarantine procedures, integrated pest management and biological control activities are applied. Public awareness and education campaigns are very important in disease prevention and compliance. HLB has serious consequences for the

sector, including lower fruit yields, higher production costs and economic losses. These problems, however, have inspired the industry to explore new solutions, create worldwide collaboration and engage in research and development in order to safeguard the future of citrus cultivation. Despite the substantial hazards, the citrus industry is committed to safeguarding this key agricultural sector and ensuring that citrus fruits be enjoyed for future generations.

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Horticultural Crops Suitable for Coconut Planting Systems

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By growing crops in between coconut palms, there would considerably yield an increase in coconut and the root system is not competitive. Thus, the combination of crops has a mutually beneficial effect and there is the profitability of the whole cropping program. Coconut plantation (up to 8 years of planting and after 20 years of age) offers excellent scope for intercropping and hence in utilizing the available land resources in an optimum manner. Coconut seedlings are planted 7.5 meters to 9.0 meters wider apart. The wider spacing between the crops gives grower an opportunity for raising other crops, either annuals as intercrop or perennials as mixed crop as a source of additional income. Studies reveal that only 28 % of the land is occupied by the coconut trees and more than 80 % of the root activity was confined to a lateral distance of 2 m from the trunk. Thus, the remaining area could be profitably exploited for cultivating other crops. The venetian leaf structure and leaf orientation of the palms permit light penetration to the interspaces. The solar energy received by the crops under coconut canopy in older palms spaced 7-10 m apart is 43%of the normal sunlight. This light penetration facilitates growth of many shade tolerant crops in the interspaces. Coconut based cropping systems involving cultivation of compatible crops like tubers, flowers, medicinal and aromatic crops, fruits, vegetables, spice crops, in the interspaces of coconut is economically superior to coconut monocropping. Coconut-based high-density multispecies cropping systems (HDMSCS) involving many crops like banana, pineapple, clove, and pepper was established.

Vegetable crops

Vegetable crops are short durational and shade loving crops with high efficiency of photosynthesis and biological fixation. This ensures their suitability for growing as intercrops under fruit plantation. Intercropping of the vegetables ensures efficient resource and space utilization including improvement of soil and orchard nutrient status, reduction in fruit drop and enhancing fruit yield and quality. It also provides additional income to farmers and helps in maximization of land use.

The experiment conducted at the CPCRI, Kasaragod have indicated that vegetables like snake gourd (*Trichosanthes anguina* L.), bottle gourd (*Lagenaria siceraria* (Molina) Stardl.), ridge gourd (*Luffa acutangula* Roxb.) and coccinia (*Coccinia indica* L. Voigt) and cucurbits are compatible with coconut. Intercropping with vegetables was found to generate additional employment of 215 to 365 man-days/ha/year. Cucumber is one of the best vegetable intercrops for coconut plantations in the Andamans. Ridge gourd and sponge gourd can also be recommended as suitable intercrops in coconut plantations of these islands. In South India, additional revenue could be obtained from coconut plantation (where there is sufficient infiltration of sunlight to the base) by planting. In vegetable crops colocasia, amorphophallus, yams etc could be grown successfully and if there is still space and sunlight vegetables like Dolichos cow pea, sweet potato, amaranthus, coriander, chilli, cassava,Moringa, bhendi, brinjal, radish etc could be grown. In case of vegetable cowpea Arka Garima, Arka Suman and Arka Samrddhi, Amarnathus - Arka Suguna and Arka Arunima, Coriander – Arka Isha, Palak – Arka Anupama, Chilli -Arka Haritha and Arka Meghana, Brinjal – Arka Anand and Arka Harshitha, Bhendi – Arka Anamika and Arka Nikita and Radish – Arka Nishant may be recommended to grown under Coconut plantation depending upon the availability of sunlight and shade.

Fruit crops

The practice of growing biennial and perennial crops like banana, papaya, pineapple, mango, jack fruit, lime and lemon etc., along with coconut is prevalent in the holdings of small farmers. Fruit based cropping system with coconut, comprising of coconut,

Table 1: Annuals and perennials grown as intercrops in Sri Lankan Coconut plantations

Crop	Common name	Botanical name
Fruit crops	Pineapple	*Ananas comosus*
	Banana	*Musa* spp.
	Papaya	*Carica papaya*
	Pomegranate	*Punica granatum*
	Guava	*Psidium guajava*
	Mango	*Mangifera indica*
	Rambutan	*Nephelium lappaceum*
	Durian	*Durio zibethinus*
	Dragon fruit	*Hylocereus undatus*
	Lemon	*Citrus limon*
Vegetable crops	Chilies	*Capsicum frutescens*
	Snake gourd	*Trichosanthes cucumerina*
	Drumstick	*Moringa oleifera*
	Brinjal	*Solanum melongena*
	Bottle gourd	*Lagenaria siceraria*
	Okra	*Abelmoschus esculentus*
Spice and beverage crops	Pepper	*Piper nigrum*
	Clove	*Syzygium aromaticum*
	Cardamom	*Elettaria cardamomum*
	Nutmeg	*Myristica fragrans*
	Cinnamon	*Cinnamomum verum*
	Cocoa	*Theobroma cacao*
Tubers and root crops	Cassava	*Manihot esculenta*
	Sweet potato	*Ipomoea batatas*
	Yam	*Dioscorea alata*
	Taro	*Xanthosoma sagittifolium*
	Ginger	*Zingiber officinale*
	Turmeric	*Curcuma longa*
Cereals and millets	Maize	*Zea mays*
	Finger millet	*Eleusine coracana*
	Foxtail millet	*Setaria italica*
	Sorghum	*Sorghum bicolor*
Legume crops	Groundnut	*Arachis hypogaea*
	Soybean	*Glycine max*
	Pigeon pea	*Cajanus cajan*
	Cowpea	*Vigna unguiculata*
	Green Gram	*Vigna radiata*
	Gliricidia	*Gliricidia sepium*

black pepper, pineapple was found best under West Bengal condition. Among the mixed crops tested, banana is found to be the most important intercrop for coconut garden. It responds to similar irrigation and manuring systems as coconut and also comparatively free from serious pests and diseases except the burrowing nematode in certain pockets. Banana as intercrop is mostly grown under rain fed conditions. About 1000 banana plants could be raised/ha of coconut garden (125 palm/ha). Pineapple could be successfully raised as an intercrop both under rainfed and irrigated conditions. Under irrigated conditions, the size of each fruit would be about 1.5 kg; while as a rainfed crop, the size is reduced to half (0.71 kg). About 4000 kg pineapple/ha can be harvested in the multi-storeyed cropping system and much more when only pineapple ingrown as inter-corp. Two new conventional fruit crops that attract the farmers as money spinning intercrops in coconut garden are Mangosteen and Rambutan. Farmers in costal Karnataka and some parts of Kerala have already successfully tried these crops in coconut garden as companion crops. Nutritious fruit Avocado is mostly grown successfully as an inter crop in coffee plantation in parts of Tamil Nadu, Kerla and Karnataka and this fruit may be grown in widely space coconut plantation.

Spice crops

In recent years, tree species like clove, nutmeg and cinnamon have been introduced and planted in the center of four coconut palms spaced 7.5 m apart. However, the suitability/compatibility of mixed cropping systems has mostly been overlooked and as a result, the competition with coconut for soil moisture during the stress period, the incidence of sunlight, the infestation of pests, and occurrence of diseases have been observed. The crops selected for mixed-cropping should preferably be shade tolerant since the incidence of sunlight would be insufficient below the coconut canopy.

Plantation crops

In South India, additional revenue could be obtained from coconut plantation (where there is

sufficient infiltration of sunlight to the base) by planting:

- Pepper vines on palm basins and letting them grow and yield.
- Cocoa could be grown as a perennial secondary crop
- Areca palms could be intercropped
- Banana and/or tapioca could be planted as an annual crop.

Attempts are being made to grow coffee, rubber and forest species (un-branched and quick growing type) in between coconut rows.

Flower crops

As per the recommendations of CPCRI, Kasargod, *Heliconia stricta* 'Iris', *H.bihai* x *H.caribaea* 'Kawauchi', Heliconia stricta Sunrise and H. orthotropica 'She', are found to be suitable as intercrop in coconut plantations. A combination of varieties viz., 'She' and 'Sunrise' can be planted in 1:1 ratio for year-round production of inflorescences. The coconut palms (Disease Early and Middle) 11-17 % increase in yield in three years' time, was mainly due to complimentary use of resources by both crops and improved microclimate. *Heliconia stricta* 'Iris' can be recommended as an intercrop during early stage in coconut plantations where the light intensity is low (30 to 35%) for improving the livelihood of farmers. Alpinia 'Jungle King' is suitable for intercropping in coconut gardens. It produces flower throughout the year except during April-May. The inflorescences produced in these plants were of marketable standards with more than 1 meter in length and spike circumference of 20cm.In some plantations they intercrop orchids too. *Tagetus-Gomphrena* sequential cropping (30% area) under coconut-based farming system in coastal humid tropics fetches year-round income from the system with a BCR 2.6.

Medicinal Crops

Different medicinal crops like Aloe vera, Asparagus, Swertia, Aswagandha, Mentha were planted as intercrop in coconut plantation to find out the total system productivity. It was found that cultivation of medicinal crops under these systems helped to increase the system productivity. Maximum system productivity (8.62 t copra/ha) was recorded in coconut and Asparagus system followed by coconut + Aloe vera and Coconut Rawalfia over coconut as monocrop 2.8 t copra/ha).

Green manure crops

Growing of leguminous green manure crops in the basin of adult coconut plantations and incorporation on of biomass generated resulted in substituting nitrogen fertilizer for coconut up to 30 per cent. Besides incorporation of green manures improve soil physical, chemical, biological properties. It reduces the weed growth and runoff. Suitable leguminous species for green manuring in the coconut garden are Pueraria phaseoloides, Mimosa invisa, Calopogonium mucunoides, cowpea (Vigna unguiculata), sunhemp (Crotolaria juncea), horse gram (Macrotyloma uniflorum), daincha (Sesbania aculata) and Sesbania spinosa etc. It contributes about 15-25 kg of biomass and 100-200 g of nitrogen in coconut basins during a growth period.

Cover crop in Coconut plantation

Mucuna or Velvet bean or Magical bean has been adopted by many farmers in Tamil Nadu, Kerala and Karnataka as cover crop in coconut plantation particularly monsoon season. The major reason for adoption is weed suppression also to improve the yield of standing/succeeding crops under various situations Use of cover crops like *Mucuna* is an eco-friendly technology for efficient and sustained control of all weed species including the most noxious *Cyperus*. Being a legume, *Mucuna,* also improved the soil physical, chemical and biological properties in a significant way which helped the subsequent crops to enhance growth and productivity. Therefore, it is highly recommended to use *Mucuna* in rotation with any vegetable crop or as a cover crop in tree orchards and plantation crops. Being a short duration leguminous crop Mucuna was found to leave behind > 25tons/ha of biomass at the end of the cropping season which helped to improve the soil health in a significant way. The carbon sequestration potential of *Mucuna* was worked out to be 28.52 Kg CO_2/ha/day.

The biodegradation of the *Mucuna* residues were found to increase the soil phenolic acids significantly which helped to control germination of weed seeds. Utilization of leguminous cover crops such as *Pueraria phaseoloides*, *Mimosa invisa* and *Calopogonium* species as green manures to supply biologically fixed nitrogen and easily decomposable biomass to coconut, to substitute 50 % nitrogen fertilizer, was standardized. Then, growing *Glyricidia* as green manure crop and using the biomass as green manure was found to be ideal soil management practices in coconut plantation of littoral sandy soils.

IIHR mucuna varieties available: Arka Dhanvantri, Arka Subhra, Arka Aswini and Arka Charka.

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Heirloom Tomatoes: A Culinary Journey through Time

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Tomatoes, originating from the highlands of South America, have evolved over centuries into one of the most beloved and versatile fruits of the world. Among the diverse range of tomato varieties, heirloom tomatoes stand out as time-honoured treasures, offering a tantalizing glimpse into the history, genetics and culinary traditions of agriculture unlike the modern hybrid varieties, which are bred for uniformity and commercial production. This article aims to provide a comprehensive understanding of heirloom tomatoes.

Origin and history

Variety: Sungold

Variety: Brandywine

Variety: Black Beauty

Heirloom tomatoes, often revered as "heritage" or "vintage" tomatoes, are unique in the way that they have not been subjected to the *extensive hybridization* and *genetic modification* that characterizes many modern tomato varieties. Instead, they represent a direct link to the past, with individual cultivars often bearing names that harken back to their regional or familial origins. These tomatoes have been cultivated for generations, preserving their distinct characteristics and flavours. Heirloom tomatoes trace their origins to diverse regions, including South America, Mexico and Europe. Some heirloom varieties have histories dating back hundreds of years.

Variety: Black Krim

Variety: Pineapple

Variety: Ananas Noire

Distinctive characteristics

Diverse appearance: What sets heirloom tomatoes apart is their captivating diversity. They defy the uniformity of their commercial counterparts by exhibiting a remarkable array of sizes, shapes and colours. They can be round, pear-shaped, ribbed, or even resemble miniature pumpkins. And, the skin of these heritage cultivars often has beautiful, intriguing patterns – stripes, marbling, streaks, blotches, or blushes of blue or pink. From the humble cherry-sized "Sungold" with its vibrant orange hue to the hefty, ribbed "Brandywine" with its rich pinkish-red flesh, each heirloom variety tells a unique story through its appearance and flavour.

Flavour profiles: Perhaps the most celebrated aspect of heirloom tomatoes is their extraordinary flavour. While commercially produced hybrids can be fairly insipid, heirlooms that have been allowed to ripen on the vine have strong flavours – sweet, rich, tart, or a combination of all of these at once. They offer a sensory adventure that ranges from the robust, earthy undertones of the "Black Krim" to the sweet, tropical notes of the "Pineapple" tomato. It is this wide spectrum of flavours that elevates heirlooms to a gourmet status, making them the preferred choice of chefs and home cooks seeking to create dishes bursting with taste.

Open-pollinated: Heirloom tomatoes are typically open-pollinated, which means they can be pollinated naturally by insects, wind, or other mechanisms. Open-pollination plants breed true, or grow "true-to-type". This means that the seeds collected from an heirloom tomato will grow plants similar to their parent plants. This characteristic allows for the

preservation of their genetic traits through seed-saving. Thus, heirloom tomatoes have been passed down through generations, carefully cultivated and cherished by dedicated gardeners and seed savers who recognize the importance of maintaining this genetic diversity.

Note: A tomato variety needs to have existed for more than half a century to be an authentic heirloom tomato!

Cultural significance

Each heirloom variety often comes with its own story, passed down through generations, adding depth to the cultural and historical narratives associated with these tomatoes.

For instance, "Reisentraube", a cherry tomato variety was brought to the US by German immigrants, and handed down through generations of Pennsylvania Dutch people as far back as the mid-1800s. And then, there is "Nebraska Wedding", an orange cultivar, which was brought to Nebraska in the late 1800s, where it was passed down at weddings to new brides in farming communities.

Variety: Reisentraube

Variety: Nebraska Wedding

Variety: Costoluto Genovese

It is, however, important to note that heirloom tomatoes, just like heirloom quilts or jewellery, are passed down because they have great value to the person handing them down.

What exactly do heirloom tomatoes taste like?

In general, heirloom tomatoes taste sweeter than other tomato varieties. There is also an interesting association to be made between the colour of heirloom tomatoes and their flavour, however, it is not an exact science, and there are exceptions. Still, the following considerations can be kept in mind if one goes for shopping heirloom tomatoes:

i. **Yellow heirloom tomatoes:** they tend to have milder tastes with less acidity.

ii. **Pink heirloom tomatoes:** usually the sweetest tomato variety, with a good balance between acidity and sugar content.

iii. **Orange heirloom tomatoes:** another sweeter variety with low acid content.

iv. **Red heirloom tomatoes:** often mistaken for the average "grocery store hybrid tomato", these have strong flavours that lean more towards acidity than sweetness.

v. **Black heirloom tomatoes:** more of a maroon or purplish colour; these tomatoes usually have an earthier taste that some people even call smoky.

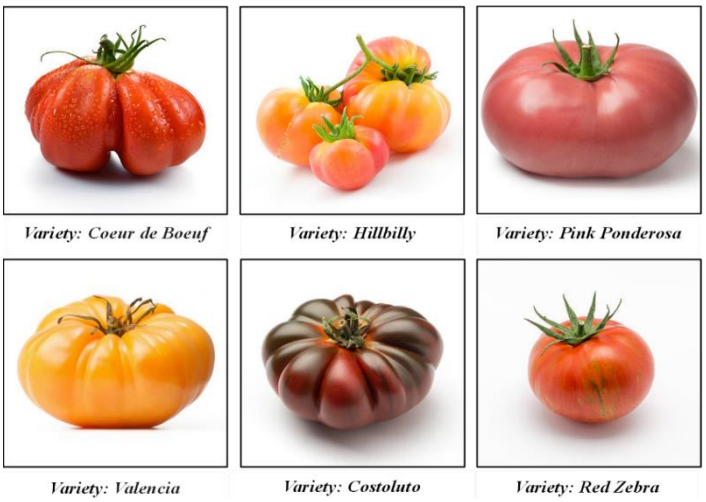
vi. **Striped heirloom tomatoes:** not just eye-catching, but also tongue-catching with their very sweet and juicy taste.

Heirloom tomatoes vs. Hybrid tomatoes vs. Genetically modified tomatoes

Unlike hybrid tomato seeds, which are produced through the cross-pollination of two tomato plants with complementary desirable properties, heirloom tomato seeds are developed through selective breeding within their own type by selecting the seeds from plants with the best characteristics. For instance, many people think that the well-known "Roma" tomato was created by crossing a "Pan American" tomato with a "San Marzano" tomato to create a tomato having traits from both.

Another important distinction between heirloom tomato types and hybrid tomato varieties is that heirloom tomato seeds can be planted and will produce plants that resemble the ones from which they were originally collected. In hybrid tomatoes, this does not always happen; if the seed is fertile to begin with, it might grow into a plant that resembles one of the grandparents or something entirely new.

To generate hybrid tomato plants that yield a lot of fruit, are disease and pest-resistant, retain for as long as possible (to make it easier to export them across the world) and have the best appearance,



Variety: Coeur de Boeuf *Variety: Hillbilly* *Variety: Pink Ponderosa*

Variety: Valencia *Variety: Costoluto* *Variety: Red Zebra*

tomato plants need to be regularly cross-bred.

While this facilitates commercialization and reduces waste from rotting tomatoes, at some point the breeders lost sight of the value of flavour and nutrition. This is why heirlooms typically taste better and offer more health advantages than other types.

What about genetically modified (GM) tomatoes? A GM tomato is a tomato variety whose DNA has been altered in a laboratory to increase the same properties mentioned above, i.e., disease resistance, aesthetics, storage capacity and even the absence of seeds. As a result, it is a quick route to hybrid tomatoes but unquestionably a departure from what nature intended.

Challenges and conservation

Genetic erosion: Heirloom tomatoes, celebrated for their rich history, diverse flavours and cultural significance, are facing a perilous threat – genetic erosion. While these unique tomato varieties have been cherished for generations, changing agricultural practices and the ascendancy of commercial hybrids have placed their genetic diversity at risk. Efforts to conserve and promote their cultivation are essential.

Seed saving: Seed saving in heirloom tomatoes serves as a bridge between the past and the future, enabling the conservation of unique genetic diversity and cultural heritage. By encouraging seed-saving practices, we not only ensure the survival of heirloom tomato varieties but also contribute to the preservation of agricultural traditions and the protection of biodiversity, securing a vibrant legacy for generations to come.

Conclusion

Heirloom tomatoes are not just agricultural crops; they are living symbols of our agricultural and culinary heritage. Their remarkable genetic diversity, rich history and unparalleled flavours make them not only a culinary delight but also a valuable genetic resource in the face of a changing climate and agricultural challenges. As consumers and growers alike rediscover the charm and flavours of heirloom tomatoes, their preservation and cultivation continue to be celebrated, ensuring these unique tomato varieties remain a vital part of our food culture.

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Three Sisters Planting Method: An Indigenous Agricultural Tradition

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The Three Sisters planting method is a time-honoured agricultural technique that has been practiced by the indigenous people of North America for centuries. It involves the interplanting of three main crops, viz. corn (maize), beans and squash. This traditional agricultural system is not only a practical method for enhancing crop yields but also embodies deep cultural and ecological significance. This article delves into the history, principles, procedure, benefits and modern applications of the Three Sisters planting method.

Historical background

The Three Sisters planting method has its roots in the agricultural practices of various indigenous tribes, particularly those in the Eastern Woodlands and Great Plains regions of North America. Some of the tribes that practiced this method include the Haudenosaunee (Iroquois), Lenape, Cherokee and others.

The name, "Three Sisters", reflects the interdependent relationship among corn, beans and squash in this agricultural system. These crops were considered sacred by many indigenous cultures, and the planting method itself was often accompanied by ceemonial rituals and storytelling.

Principles of the Three Sisters planting method

The Three Sisters planting method is characterized by several key principles, viz.

i. **Companion planting:** Corn, beans and squash are planted together in close proximity. Each plant serves a specific purpose within the system, and they support each other's growth.

ii. **Complementary roles:**

- **Corn (Maize):** Corn serves as the "big or elder sister" in the trio, providing a tall, strong support for the beans to climb. It also creates a natural trellis for the bean vines.

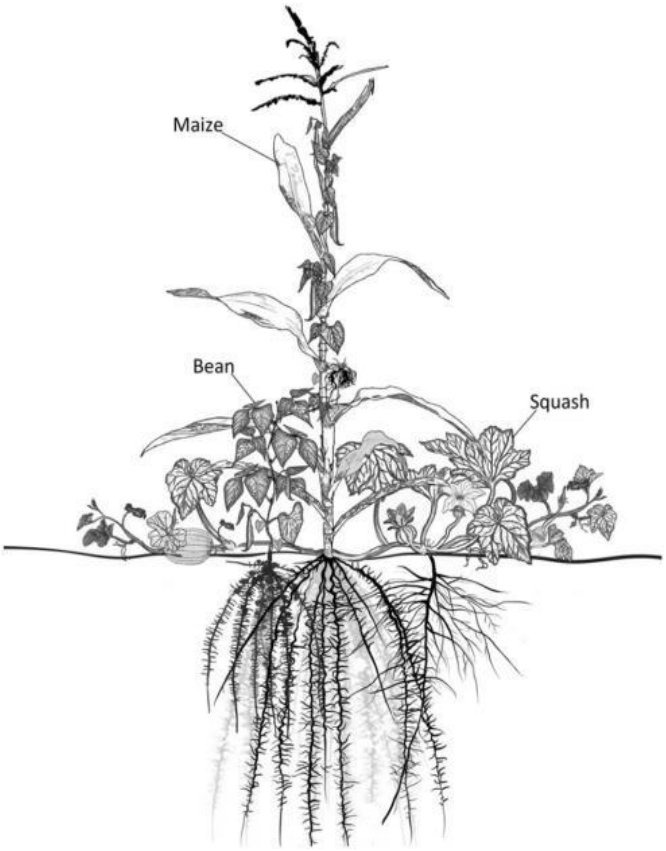


Fig. 1: An illustration of the three sisters – corn, beans and squash

- **Beans:** Beans are the "giving sisters" that fix atmospheric nitrogen in the soil through their root nodules. This nitrogen enrichment benefits both corn and squash, enhancing their growth.
- **Squash:** Squash plants, with their large leaves and sprawling growth habits, serve as the "little sisters". They create a living mulch (ground cover) that shades the soil, keeping it cool; reduces weed competition and conserves moisture.

iii. **Polyculture:** The Three Sisters method embraces polyculture or multiple cropping, where multiple crop species are grown together in a single plot. This diversity provides resilience against pests, diseases and environmental fluctuations.

iv. **Sustainable agriculture:** The interplanting of these three crops is sustainable and minimizes the need for synthetic fertilizers and pesticides. It also promotes soil health and fertility.

Which seeds or varieties to plant?

i. **Pole beans** (not bush beans): Common pole beans, such as Scarlet Runner or Italian Snap, should work. There are some very vigorous hybrid pole beans which may climb up the thin hybrid corn stalks and pull them down. So, it is better to go for less vigorous climbers to be one the safer side.

ii. **Corn** such as sweet corn, dent corn, popcorn, or a combination. The modern sweet corn varieties will do, although native American gardeners traditionally used a heartier corn with shorter stalks or many-stalked varieties so that the beans did not pull down the corn.

iii. **Small-leaved squash**, such as summer squash (zucchini) or winter squash (Hubbard).

(**Note:** Pumpkins are too vigorous and heavy, therefore, they need to be planted in a separate bed.)

Sometimes, a fourth sister is included, such as a sunflower or amaranth, which attracts pollinators and lures birds away from the seeds. Sunflowers can be planted at the cross-section of the spaces between the corn hills and harvested for seeds. Amaranth could come up among the squash and could be harvested both for greens and for seeds.

How to plant the Three Sisters?

The Three Sisters method has some modifications, but the basic idea is to plant the sisters in clusters on low, wide mounds as opposed to the conventional single row.

i. The three sisters require plenty of space to grow to their highest potential, and therefore, a sunny area that receives at least 6 to 8 hours of direct sunlight each day should be selected for planting the crops. It is better to visualise a small field as this method of planting does not require rows. With four to six maize plants per hill, each hill will be around 4 ft × 4 ft (120 cm × 120 cm), therefore, the required space should be calculated based on this consideration. The plot should not be near any tree, wall or other shaded areas.

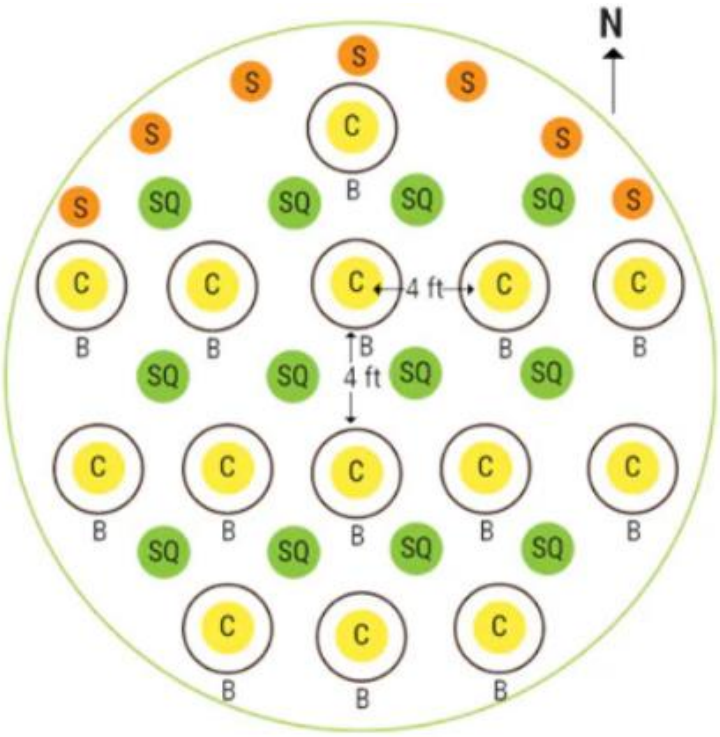


Fig. 2: Garden layout for the Three Sisters planting, (C = Corn, B = Bean, SQ = Squash and S = Sunflower)

ii. The soil should be prepared with a lot of organic materials, e.g., well-rotten manure or weed-free compost in the spring, since corn is a heavy feeder and the nitrogen from the beans will not be available to the corn during the first year. A near-neutral pH (5.5-7.0) is ideal for growing corn, beans and squash. If necessary, the soil may be amended with lime, gypsum/sulphur and wood ash to get the soil to the right pH.

iii. A soil mound that is 3 to 4 ft (90 to 120 cm) wide and about a foot (30 cm) high in the centre is created. The centre of the mound should be flat and approximately 10 inches (25 cm) in diameter. The mounds are placed 4 ft (120 cm) apart, if there are several of them. The corn will grow in the mound with beans around the corn, and squash around the beans.

iv. Once the risk of frost has passed and nightly temperatures reach 13°C (55°F), corn is planted first. About 5-7 seeds are sown in each mound and each seed is evenly spaced about 6 inches (15 cm) apart. The seeds are sown at a depth of about 1 to 1.5 inches (2.5 to 4 cm) and covered with soil afterwards.

v. Once the corn seedlings are 15-30 cm tall, 3 or 4 larger and stronger seedlings are kept and the others, discarded. The beans and squash should not be planted until the corn plants are 6 inches to 1 ft (15 to 30 cm) tall. This ensures that the corn stalks will be strong and sturdy enough to support the beans.

vi. The patch should be weeded before planting the beans. Four bean seeds are sown in a circle around the corn at a spacing of 6 inches (15 cm) from the stalk. The depth of sowing may vary depending on the variety chosen.

(**Tip:** Coating the bean seeds with Rhizobium culture before sowing aids in nitrogen fixation in the soil and benefits all the plants.)

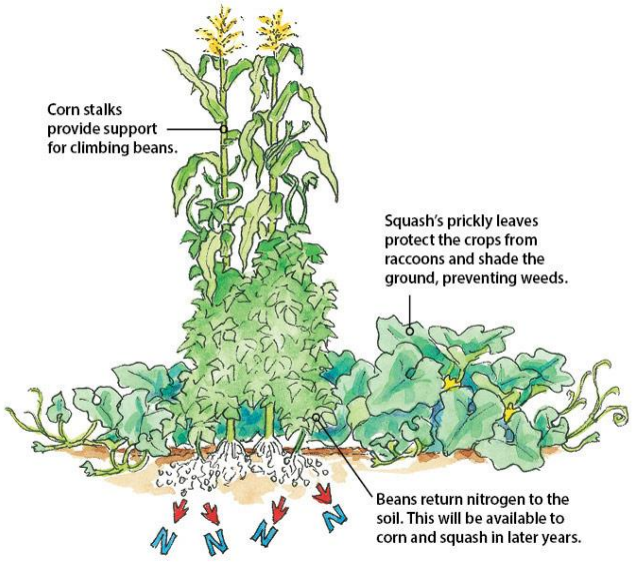
vii. When little sprouts appear from the bean seeds, about 1 week later, 6 squash (or pumpkin) seeds are sown. The squash needs the maximum sunlight among the three sisters; therefore, care has to be taken that they are not in the shade. The squash seeds are sown about 1 ft (30 cm) away from the beans. If pumpkin is planted in place of squash and there are more than one mound, the pumpkin should be planted in every alternate mound. This will prevent overcrowding of the garden by pumpkin vines.

viii. The plot is watered about 1 inch (2.5 cm) a week, which is roughly 0.6 gallons (2.3 L) for every 1 ft (30 cm) of the garden.

Benefits of the Three Sisters planting method

The Three Sisters planting method offers a range of benefits, making it an effective and sustainable approach to vegetable farming:

i. **Enhanced yields:** By planting these three crops together, each plant benefits from the strengths



of the others. Corn provides support for beans, beans enrich the soil with nitrogen and squash

Fig. 3: An illustration of the complementary roles of the three sister plants

shades the soil, reducing weed competition. This symbiotic relationship often results in higher crop yields.

ii. **Nutritional balance:** Corn, beans and squash complement each other nutritionally. Corn provides carbohydrates, beans supply protein and squash offers vitamins and minerals. This combination creates a balanced and nutritious diet.

iii. **Soil health:** The rotation of these crops and the nitrogen-fixing ability of beans improve soil fertility over time. This reduces the need for chemical fertilizers, promotes microbial diversity in the soil and enhances soil structure.

iv. **Pest and weed management:** The Three Sisters system naturally deters some pests because of the interplanting of different crops. Additionally, the mulching effect of squash helps suppress weeds by blocking sunlight from reaching weed seeds.

v. **Water use efficiency:** The broad leaves of squash act as a natural (living) mulch, reducing water evaporation from the soil as well as its loss through surface runoff. This promotes

water conservation and helps maintain soil moisture.

vi. **Resilience to environmental factors:** The combination of these three crops can help buffer against environmental stressors. For example, corn provides some wind protection, while the beans can stabilize the soil.

vii. **Cultural significance:** The Three Sisters method is deeply rooted in indigenous cultures and traditions. Its practice serves as a connection to ancestral knowledge and a way to preserve cultural heritage.

Modern applications and adaptations

The Three Sisters planting method is not limited to historical or indigenous contexts. It has gained recognition and adoption in modern agriculture for its sustainable and ecological benefits. Here are some ways in which this traditional method is applied today:

i. **Sustainable farming:** Many small-scale farmers and community-supported agriculture (CSA) initiatives embrace the Three Sisters method as part of their commitment to sustainable and regenerative farming practices.

ii. **School and community gardens:** Educational programmes and community gardens often use the Three Sisters planting method to teach children and community members about sustainable agriculture, indigenous culture and the importance of local food production.

iii. **Restoration agriculture:** Some ecological restoration projects use the Three Sisters method to reintroduce native plant species and promote biodiversity in disturbed ecosystems.

iv. **Crop rotation:** Crop rotation schemes that incorporate corn, beans and squash can help conventional farmers improve soil fertility, reduce the need for synthetic inputs and gain additional income from a limited space.

v. **Home gardening:** Home gardeners and enthusiasts have also adopted the Three Sisters method as a way to maximize space and promote sustainable gardening practices.

Fig. 4: Three Sisters planting adopted in a home garden for maximizing small spaces

Challenges and considerations

While the Three Sisters planting method offers numerous advantages, it also presents some challenges and considerations, some of which are listed below:

i. **Crop compatibility:** Not all varieties of corn, beans and squash are compatible for the Three Sisters method. Some experimentation may be needed to find the most suitable combinations for specific climates and soil types.

ii. **Spacing and layout:** Proper spacing and arrangement of the three crops are essential for success of this method of panting. Overcrowding can lead to competition for resources (nutrients, sunlight and water) and reduced yields.

iii. **Pest and disease management:** While the Three Sisters method can deter certain pests, it may not be entirely pest-proof. Integrated pest management practices may still be necessary.

iv. **Cultural sensitivity:** When adopting this method outside of indigenous contexts, it is crucial to do so with cultural sensitivity and respect for its origins. It is important to

acknowledge and honour the cultural significance of this tradition.

Conclusion

The Three Sisters planting method is a remarkable example of sustainable and companion planting that has deep cultural roots and enduring ecological benefits. Its principles of interdependence, diversity and soil health offer valuable lessons for modern agriculture and ecological restoration efforts. Whether practiced in small-scale gardens, community farms, or as part of a broader commitment to sustainability, the Three Sisters method reminds us of the wisdom embedded in indigenous agricultural traditions and their relevance in addressing contemporary challenges in agriculture and food security.

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Health Benefits of Flower Gardening: Cultivating Wellness and Well-being

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Gardening has long been recognized as a hobby that not only beautifies our surroundings but also offers numerous health benefits. In particular, flower gardening has gained attention for its positive impact on our mental, emotional, and physical well-being. Research has shown that spending time cultivating and nurturing flowers can have a profound effect on our overall wellness. From improving concentration and memory to reducing stress and enhancing relationships, the benefits of flower gardening are wide-ranging and significant. In this article, we will delve into the health benefits of flower gardening, exploring the various ways in which this therapeutic hobby can contribute to a healthier and happier life.

1. **Concentration and Memory:** One of the key advantages of flower gardening is its ability to enhance concentration and memory. Studies have demonstrated that being around plants, particularly in natural environments, can improve cognitive function and boost mental performance. Tasks performed in the presence of nature are often executed with greater accuracy and yield higher quality results. Moreover, spending time outdoors or in the company of ornamental plants can significantly improve memory retention and attention span. According to a study conducted at the University of Michigan, exposure to nature can increase memory retention by up to twenty percent. The calming influence of natural environments fosters a positive work environment by enhancing concentration and focus. Consequently, work performed under the influence of ornamental plants tends to be of higher quality and completed with greater accuracy compared to work done in nature-deprived environments.
2. **Educational Programs and Special Events:** In addition to the personal benefits of flower gardening, the presence of parks and botanical gardens in a community contributes to cultural awareness and education. These natural landmarks often serve as venues for educational programs and special events, particularly for children. By exposing them to the value of environmental conservation and raising their consciousness about nature, these programs play a vital role in shaping the future generation's appreciation for the environment. The educational initiatives led by botanical gardens and zoos not only teach children about environmental responsibility but also have a positive impact on adults in the community. By fostering an appreciation for nature, parks and gardens instill a sense of responsibility for the care and protection of the environment. This collective consciousness and appreciation for nature contribute to the overall well-being of the community.
3. **Flowers Generate Happiness**: The presence of flowers in our homes and workplaces has been shown to improve our moods and reduce the likelihood of stress-related depression. Flowers and ornamental plants have the ability to increase the levels of positive energy and create a sense of security and relaxation. The natural aesthetic beauty of flowers has a soothing effect on individuals, significantly reducing stress levels and anxiety. Research has revealed that people who keep flowers in their homes experience higher levels of happiness and relaxation. The positive energy derived from the environment in which flowers are present contributes to a decrease in stress-related depression. Ultimately, adding flowers to our surroundings can lower perceived stress levels, creating an atmosphere of relaxation, security, and happiness. Flowers not only provide pleasing visual stimulation but also help to foster a more optimistic outlook on life.

4. **Health and Recreation**: Access to parks and recreational activities has a positive correlation with physical activity rates, which in turn improves mood and overall health. By providing affordable or free recreational services, parks and urban green spaces positively impact people's health. Research has shown that the presence of a park in a neighborhood increases the level of physical activity among residents. The availability of aesthetically pleasing areas or facilities encourages individuals to engage in exercise, leading to improved physical health. As a result, residents of neighborhoods with beautiful parks are generally healthier and more resilient against minor illnesses. The increase in exercise among these residents translates into reduced healthcare costs, as they require fewer medical services. Moreover, regular physical activity contributes to a more positive mental outlook, making healthy individuals happier. The presence of parks in neighborhoods promotes exercise, leading to improved physical well-being and enabling residents to fully enjoy their lives.
5. **Accelerates Healing Process**: Incorporating plants into hospital recovery rooms or providing views of aesthetically pleasing gardens has been found to expedite the healing process for patients. The soothing effects of ornamental horticulture have a significant impact on patient recovery. Studies have shown that simply having daily views of flowers and other ornamental plants in landscaped areas outside patient recovery rooms can significantly speed up recovery time. Additionally, horticulture therapy, which involves patients caring for and nurturing plants themselves, has been found to reduce recovery time after medical procedures. Patients who actively interact with plants experience a shorter recovery period. The presence of plants in hospital environments not only improves the physical state of patients but also contributes to their overall well-being and mental state. By incorporating plants into healthcare settings, we can create an environment that expedites the healing process and helps patients overcome mental barriers that may impede recovery.
6. **Improves Relationships and Compassion**: Spending more time around plants has been shown to enhance relationships and increase feelings of compassion. The presence of ornamental plants affects the levels of compassion individuals feel toward others. Research has indicated that people who spend more time around plants are more likely to help others and have more advanced social relationships. Caring for nature translates into caring for others, fostering shared bonds and a sense of responsibility within communities. Extended exposure to nature and wildlife not only increases compassion for the environment but also positively affects how individuals interact with each other. Being around plants can help improve relationships and increase concern and empathy toward others.
7. **Improved Human Performance and Energy**: Spending time in natural environments has been found to enhance human performance, increase energy levels, and improves feelings of vitality. Being in nature boosts feelings of vitality and energy, making individuals feel more alive and active. This increased vigor leads to improved performance levels in various aspects of life. Natural environments foster a positive outlook on life, making individuals more engaged and proactive in their endeavors. By increasing perceived vitality, plants contribute to improved performance at work and home. The added energy and vitality derived from spending time in nature have a positive impact on individuals' overall productivity and satisfaction.
8. **Learning:** Children who spend time in natural environments, particularly those with access to plants, have been found to learn better. The presence of plants in learning environments enhances children's focus and concentration,

ultimately improving their learning capabilities. Ornamental plants create a positive learning environment, reducing distractions and enabling children to better engage with their schoolwork. This is particularly beneficial for children with attention deficit disorders, as exposure to natural environments helps them focus and concentrate better in the classroom. The soothing effects of natural aesthetic beauty minimize distractions, allowing children to absorb and retain information more effectively. By altering the learning environment, plants contribute to better learning outcomes for children.

9. **Medicinal Properties**: Cultivating plants has long been recognized for its medicinal properties, offering numerous holistic remedies for common ailments. One of the most evident benefits of plants and trees is their potential medicinal value. By cultivating plants, we can continue to explore the natural world's medicinal properties and arm ourselves with additional defenses against disease and infection. Natural herbal remedies provide simple and holistic methods for treating minor complaints. Cultivating plants not only benefits humanity but also expands our knowledge of the natural world, empowering us with more tools to combat illness and promote well-being.
10. **Mental Health**: Research has consistently shown that spending more time outside in nature has a positive impact on mental health and overall outlook on life. Individuals who spend more time in natural environments have a significantly more positive outlook than those who spend a great deal of time indoors. Communing with the natural world increases feelings of vitality and energy, leading to improved mental health. People who spend time outside every day are less likely to experience depression or stress, resulting in fewer burdens on their mental well-being. The presence of flowers and ornamental plants in our surroundings contributes to improved mental health and a more positive outlook on life. Spending time in nature can positively impact our mental well-being, fostering relaxation, happiness, and a greater appreciation for life.
11. **Perceived Quality of Life**: Beautifully landscaped areas are associated with a higher perceived quality of life. The aesthetics of a community greatly influence residents' perception of their overall well-being. Living in areas with natural beauty is often associated with a higher quality of life. A high quality of life has numerous benefits, including increased spending within the community, which positively affects the economy and social fabric of the town. Thriving communities appreciate the importance of landscaping in creating an overall high quality of life. By installing landscaping, communities invest in their success and the happiness of their residents.
12. **Reduce Community Crime**: The presence of beautiful parks has been found to reduce community crime rates. Parks play a crucial role in creating a sense of community and encouraging residents to become politically active when businesses threaten to downsize them. Beautifying parks and crime-ridden neighborhoods has been shown to decrease criminal acts and bring residents together. When people take pride in the beauty of their neighborhood, they are less likely to engage in activities that detract from its appeal. The presence of parks fosters community cohesion, making the community a safer place to live. It also encourages political activism and unifies people around a common cause.
13. **Reduce Stress**: Gardening has been proven to reduce stress levels in individuals. The act of nurturing plants and spending time in natural environments provides a positive outlet for stress and frustration. Gardening serves as an excellent coping mechanism, allowing individuals to transform their negative feelings into positive emotions. The satisfaction derived from nurturing plants has a calming effect,

ultimately reducing stress levels and promoting relaxation. By providing a means to cope with daily frustrations, gardening helps individuals manage their stress and improve their overall well-being.

14. **Therapeutic Effects of Gardening**: Gardening has therapeutic effects, particularly for individuals who have experienced trauma. Through the act of nurturing plants, individuals can work through their issues and facilitate their healing process. Gardening serves as a therapeutic tool, promoting a better psychological state during recovery and helping individuals overcome mental barriers that may hinder their healing. By cultivating plants, individuals can find solace and strength, ultimately aiding in their overall well-being.
15. **Traffic Safety and Driver Satisfaction**: Beautifying roadways and creating natural medians positively affects driver satisfaction and safety. Drivers are more at ease on roadways with natural landscaping; resulting in more positive perceptions of the community they are driving through. Additionally, trees along roadways serve as natural obstructions, reducing the likelihood of accidents caused by cars crossing medians into oncoming traffic lanes. Beautification of roadways not only enhances aesthetics but also contributes to driver safety and a more positive driving experience.
16. **The Upgrade Effect**: As parts of a community improve their urban green spaces, other areas are encouraged to follow suit. The upgrade effect benefits the entire community, as neighborhoods and businesses inspire each other to beautify their surroundings. Enhancing the aesthetics of a community creates a cycle of self-improvement, encouraging all sectors of the community to contribute to its overall beauty. By cultivating a love for neighborhood parks and green spaces, communities stimulate competition and promote a continuous cycle of improvement.

Conclusion

In summary, the multifaceted benefits of flower gardening are significantly transformative. From bolstering social relationships to aiding mental health, it enhances personal well-being and encourages community improvement. By integrating flower gardening into our daily lives, we foster wellness while contributing to a happier, healthier existence. Why wait? Start your flower garden today and unlock a more vibrant life amidst nature's serenity.

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Harvesting the Future: AI-Powered Revolution in Horticultural Sciences

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India's horticulture sector is a vital source of income and employment, requiring investment in technology, adoption of organic farming methods, standardization, private firm involvement, incentives, and certifications for Good Agriculture Practices. These initiatives aim to improve productivity, skill development, environmental benefits, and export opportunities. Artificial Intelligence (AI) is transforming the industry, ensuring sustainable practices and transforming cultivation, nurturing, and harvesting.

AI in Crop Management

One of the most significant impacts of AI in horticulture is its ability to enhance crop management. AI-powered systems analyze a multitude of factors, such as weather patterns, soil conditions, and crop health, to provide farmers with real-time insights and recommendations. These insights enable precision agriculture, allowing farmers to optimize irrigation, fertilizer use, and pest control, ultimately increasing crop yields while reducing resource wastage.

Predictive Analytics for Disease Management

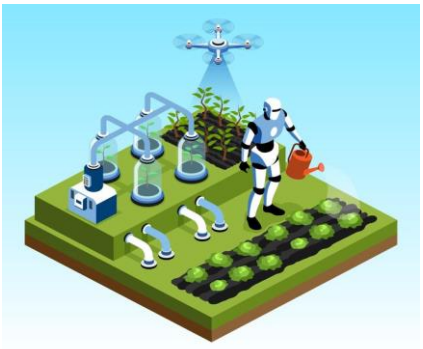
Disease outbreaks can be devastating to crops and, consequently, food supplies. AI excels at predictive analytics, using historical and real-time data to forecast disease outbreaks. Machine learning models can recognize early signs of disease through image recognition and sensor data, enabling farmers to take timely action to prevent or mitigate crop losses.

Optimizing Resource Efficiency

In a world grappling with resource scarcity, AI is playing a pivotal role in ensuring the efficient use of resources in horticulture. Smart irrigation systems equipped with AI algorithms can precisely control water distribution, responding to the specific needs of different crops and soil types. This not only conserves water but also reduces energy consumption in the irrigation process.

Robotic Assistance

Robotic technology, guided by AI, is increasingly being employed in horticulture. Robots can perform tasks such as planting, weeding, and harvesting with remarkable precision. AI algorithms enable these machines to navigate complex environments, recognize ripe fruits, and make delicate decisions to minimize damage to crops during harvesting.



Enhancing Crop Genetics

AI is accelerating the breeding of crops for desirable traits. Machine learning models analyze genetic data to predict which plants are likely to exhibit specific characteristics, such as disease resistance or increased yield. This significantly speeds

up the traditionally laborious process of selective breeding.

Challenges and Ethical Considerations

While the integration of AI in horticultural sciences holds great promise, it also presents challenges. Data privacy, access to technology for small-scale farmers, and the potential for over-reliance on AI are some concerns that must be addressed. Ethical considerations, such as responsible use of AI in agriculture and its impact on rural communities, are equally important aspects to ponder.

Current approaches & achievements of AI in horticulture

Harvest CROO Robotics – Crop Harvesting

SkySquirrel Technologies Inc. is a company that uses drones and computer vision technology for crop analysis and monitoring in agriculture. The company uses drones to collect aerial imagery and data, which are then processed using computer vision algorithms to identify crop health and growth. The data is then analyzed to generate meaningful insights and reports, providing farmers with detailed crop health reports. The technology supports precision agriculture practices by offering data-driven recommendations for irrigation, fertilization, and pest control. It also allows for timely interventions, reducing crop losses and minimizing the need for excessive pesticide or fertilizer use. The company's user-friendly interface and scalability make it suitable for both small-scale and large-scale agricultural operations.

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An operator operating a combine can direct a driverless tractor using a system that uses off-the-shelf equipment (sensors, radar, and GPS), which has been developed using increasingly complex software. At the 2016 Farm Progress Show, Case IH and New Holland both debuted their brand-new autonomous tractors.

Blue River Technology – Weed Control

Blue River Technology is a leading provider of advanced technology solutions in agriculture, particularly in weed control. Their innovative machinery and software systems use computer vision and machine learning to enable precision and sustainable agriculture. The technology uses high-resolution cameras and sensors mounted on agricultural equipment to capture detailed images of the field. It uses machine learning algorithms to identify and differentiate between crops and weeds in real-time, allowing for targeted herbicide application. The system also makes real-time decisions on herbicide application, ensuring only targeted weeds are treated.

Crop and Soil Health Monitoring AI

PEAT – A machine Vision for Diagnosing Pests / Soil Defects

PEAT is a technology that uses machine vision and AI to diagnose pests and soil defects in agricultural fields. It uses high-resolution images captured by cameras mounted on drones, tractors, or stationary posts. Machine vision algorithms analyze the images to identify pests and soil defects, while AI-based diagnosis uses deep learning models to classify pest infestations and assess soil quality. Real-time feedback and recommendations are provided to farmers through a user-friendly interface. PEAT can integrate with other data sources for more context and accuracy.

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Trace Genomics- Machine Learning for Diagnosing Soil Defects

Trace Genomics analyses soil health using DNA sequencing and machine learning, giving farmers in-depth insights on nutrient levels, soil

composition, disease risk, and microbial diversity. By eliminating excessive fertiliser and pesticide use, the platform's data-driven recommendations help farmers embrace precision agriculture techniques and advance sustainability.

FarmShots-Satellites for Monitoring Crop Health and Sustainability

FarmShots is a technology platform that uses satellite imagery and data analytics to monitor crop health and sustainability in agriculture. It uses high-resolution satellite imagery from various sources, extracts valuable information, and monitors crop health. The platform can identify factors affecting crop health, such as vegetative health, growth stage, irrigation management, pest and disease detection, and customized recommendations. It also provides sustainability insights, helping farmers minimize resource usage and reduce environmental impact. The platform stores historical data and trends, allowing users to track changes in crop health over time.

SkySquirrel Technologies Inc. - Drones and Computer Vision for Crop Analysis

SkySquirrel Technologies Inc. is a company that uses drones and computer vision technology for crop analysis and monitoring in agriculture. The company uses drones to collect aerial imagery and data, which are then processed using computer vision algorithms to identify crop health and growth. The data is then analyzed to generate meaningful insights and reports, providing farmers with detailed crop health reports. The technology supports precision agriculture practices by offering data-driven recommendations for irrigation, fertilization, and pest control. It also allows for timely interventions, reducing crop losses and minimizing the need for excessive pesticide or fertilizer use. The company's user-friendly interface and scalability make it suitable for both small-scale and large-scale agricultural operations.

aWhere - Satellites for Weather Prediction and Crop Sustainability

aWhere is a company that provides weather data and agronomic insights to support agriculture and improve crop sustainability. They use satellite technology to collect and analyze weather data from various sources, providing real-time and historical information for farmers. They use advanced agronomic models to predict crop responses to weather conditions, helping farmers optimize their practices. aWhere also promotes sustainable agriculture by providing insights into soil health, water usage, and crop protection. They combine weather and agronomic data with geospatial intelligence to provide localized recommendations.

Automated Irrigation system

An automated irrigation system is a technology-driven solution that efficiently manages the watering of plants, crops, or landscapes. It uses sensors like soil moisture and weather sensors to determine when and how much water is needed, and a controller to control the system. Solenoid valves control the flow of water to different irrigation zones, allowing for customized watering. Pipes and tubing distribute water from the water source to the irrigation zones, and emitters deliver water to plants. Automated irrigation systems can be controlled remotely using smartphones, tablets, or computers, and may incorporate smart algorithms to optimize

watering based on historical data, plant type, and weather forecasts.

Fruit recognition, end-effector, and detachment

Fruit recognition is a computer vision task used in agriculture, food processing, and robotics for fruit picking. Machine learning techniques like convolutional neural networks are used. An end-effector is a specialized tool used in robotic arm or manipulator tasks, such as grasping, cutting, or detaching fruits from their branches. Detachment is the process of physically separating a fruit from its parent plant or tree, improving efficiency and reducing labor costs in agriculture.

Robotic technologies for the management of orchards in horticulture

Robots are increasingly used in various tasks, including harvesting, field surveillance, drone spraying, grading, sorting, and packaging of horticultural products, greenhouses, and nurseries. Robotics Plus is used in Orchard AI-Robotics projects, automating fruit harvesting and pollination for apples and kiwi fruits. Research is also focused on greenhouse-grown horticulture, with robots developed for tomato harvesting, pollination, leaf cutting, and predicting harvest and yield. Mobile robots use artificial intelligence to assess crop conditions and estimate flower and fruit concentrations.

Robotic fruit transportation

Robotic conveyors are recommended for automated harvesting and transporting fruit containers in the workplace. These systems require autonomous navigation, intelligent management within the orchard, and container handling. In the Pacific Northwest region, these containers hold nearly 400 kg of fruit, requiring a self-propelled automated conveyor system for efficient movement.

Conclusion

Horticultural sciences and AI must coexist; their union is more than merely convenient. The pressures on our agricultural and horticulture systems increase along with the growth of the world's population. AI provides methods to deal with these problems effectively and sustainably. We are laying the groundwork for a more resilient and successful agricultural future by utilising AI to optimise crop management, forecast and prevent illnesses, preserve resources, and improve crop genetics. It's crucial to strike a balance between technology advancement and morally righteous behaviour as we move forward. AI has the potential to lead us to a day where we can reap the earth's bounty while also protecting and preserving it for future generations.

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Roof Gardening: The Blooming Trend for Elevating Urban Greenery

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A green roof is a building's roof that is partially or totally covered with plants and a growing media that is planted at the top of a waterproofing membrane (Yu *et al*., 2017). Additional layers, such as a root barrier, drainage, and irrigation systems, may be included. The world's ever-increasing population is putting a lot of social, economic, and ecological stresses on the environment. It will also increase food demand in the future. Cities industries and automobiles are lowering the quality of water and air, causing health issues. The temperature of the atmosphere has been rising day by day as a result of climate change. One of the most vital reasons for creating a roof top garden is the aesthetic vision of a green area in the city, which not only contributes to the people' quality of life but also provides fresh veggies. Roof gardens can provide nutritious food, temperature management, hydrological benefits, architectural embellishment, habitats or pathways for pollinators, and more. (Rao, 2016).

History and Evaluation

Roof gardening is not a new concept; it has ancient origins dating back to the Hanging Gardens of Babylon. However, it has gained renewed interest in recent years, particularly with the rise of urbanization. In the early 20th century, the concept of rooftop gardens was popularized by the likes of Frederick Law Olmsted, a landscape architect distinguished for his work on Central Park in New York City. Today, innovative technologies and a developing interest in sustainable living have propelled roof gardening into the mainstream. Rooftop gardening in India has a rich history rooted in ancient indus valley civilization and has evolved over time to address modern environmental and urban challenges. It continues to be a valuable practice that contributes to sustainable living and environmental conservation in the country.

Benefits of Roof Gardening

Environmental Benefits

- **Mitigating Urban Heat Islands:** Roof gardens help reduce the urban heat island effect by absorbing sunlight and releasing it slowly, thereby lowering temperatures in cities (Akbari *et al*., 2009).
- **Improved Air Quality:** Plants on rooftops filter pollutants and carbon dioxide, contributing to cleaner air and reducing the carbon footprint of buildings. (Nowak *et al*., 2000).

Energy Efficiency

- **Insulation:** Green roofs provide natural insulation, reducing heating and cooling costs in buildings.
- **Stormwater Management:** They absorb rainwater, reducing runoff and the strain on urban drainage systems (Wong *et al*., 2003).

Biodiversity and Habitat Creation

- Roof gardens create habitats for birds, insects, and even small mammals, contributing to urban biodiversity (Lohr *et al*., 2004).

Aesthetic and Social Benefits

- **Aesthetic Appeal:** Roof gardens enhance the visual appeal of urban landscapes, making cities more attractive and liveable.
- **Recreation and Relaxation:** They provide spaces for residents to relax, unwind, and connect with nature, improving overall well-being (Blanchard *et al*., 2019).

Types of roof top gardens

Green roofs/ Living roofs

In such type of roof top garden, crops are directly grown into shallow beds in a soil based growing medium that planted over a waterproofing

membrane. It may also include additional layers such as a root barrier and drainage and irrigation systems.

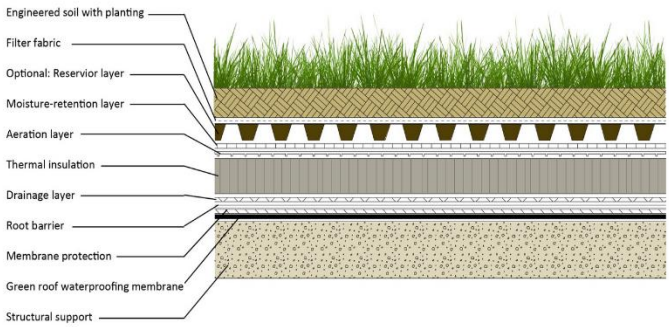
Roof top container garden

It involves the cultivation of vegetables in the containers which is made up by the plastic, wood, cement or soil etc. Plastic grow bags or empty plastic bags with high thickness, empty tin container can also be utilized to grow plants. Different size plastic beds are also available in market which can also be used to grow vegetables.

Hydroponic system

It involves the cultivation of vegetables in the soil less medium, water based nutrient solution provided for the growth of the plants instead of soil. Hydroponic system can be installed in the open-air system or in the closed system. This system required on going fertilizer inputs for higher yield.

Image representing basic structure of green roof garden



Source: https://architizer.com/blog/product-guides/green-roofs

Crop selection for roof gardening

The specific crops you choose will also depend on your personal preferences and the unique conditions of rooftop garden. Regular monitoring, proper care, and experimentation with different plants will help to discover what thrives best in our rooftop environment. Some of the easy and hardy crop that can be selected for growing on the roof top garden are mint, fennel, ginger, lemongrass, dill, basil, bay leaf, parsley, rosemary, gladiolus, marigold, rose, gerbera, hibiscus, periwinkle, strawberry etc.

Challenges and Solutions

While the assistances of roof gardening are substantial, there are challenges to overcome:

1. **Structural Considerations:** Roofs must be able to support the added weight of gardens. Engineering solutions, such as lightweight soil and modular systems, have been developed to address this issue (Oberndorfer *et al*., 2007).
2. **Maintenance:** Roof gardens require regular maintenance. Automated irrigation systems and drought-resistant plants can help reduce maintenance efforts (Snodgrass and Snodgrass, 2010).
3. **Initial Costs:** Setting up a roof garden can be expensive. However, long-term savings on energy bills and increased property values often justify the investment (Cameron and Olexsak, 2011).
4. **Accessibility:** Safeguarding that tenants have access to these green spaces can be a challenge in some buildings. Creative design solutions, like rooftop lounges and common areas, can address this (Rowe, 2011).

Inspiring initiative: Bengaluru's "Green Roof Policy"

In September 2021, Bengaluru in the Indian state of Karnataka, had been actively exploring the implementation of a "Green Roof Policy" to encourage sustainable urban development and environmental conservation.

Key Features: The policy may have included the following features:

1. **Mandatory Green Roofs:** In some cases, the policy may have made it mandatory for certain types of buildings, especially large commercial or government structures, to include green roofs as a part of their construction plans.
2. **Incentives and Subsidies:** To promote the adoption of green roofs, the policy may have offered financial incentives, tax benefits, or subsidies to building owners who incorporated green roofs into their projects.

3. **Guidelines and Standards:** The policy likely provided guidelines and standards for the construction and maintenance of green roofs, ensuring that they are ecologically sound and provide the intended benefits.
4. **Biodiversity Promotion:** Encouragement of native and drought-resistant plant species on green roofs to support local biodiversity.
5. **Monitoring and Compliance:** Mechanisms for monitoring compliance with the policy and penalties for non-compliance may have been included.

Future Directions and Research Opportunities

Rooftop gardening is a feasible option for sustainable urban agriculture, and there are various future possibilities and research opportunities to expand its use and impact. These prospective research directions can aid in addressing current challenges, enhancing techniques, and expanding the benefits of rooftop gardening. The important issues for future research are plant selection and adaptation, water Management and irrigation strategies, ecological impact and biodiversity and economic feasibility and social equity. The knowledge and practice of rooftop gardening can be innovative by concentrating on these research directions, making it more effective, sustainable, and available for urban settings.

Conclusion

Roof gardening shows a symbiotic relationship between nature and urban existence. As cities expand, embracing this trend can help minimize environmental concerns, improve citizens' quality of life, and reinvent the aesthetics of urban design. Roof gardening is poised to become a vital aspect of sustainable urban development, paving the way for greener, healthier, and more lively cities in the future, thanks to ongoing technological and architectural improvements. So, if you've ever gazed up at the skyline and fantasized about a green refuge above, it may be time to take gardening to new heights and explore the world of roof gardens.

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Improving Crop Resilience Through Vegetable Grafting

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Global climate change represents the biggest abiotic threat to plant and human health and has been given immense consideration worldwide due to its potential impact on agricultural practices. Globally, environmental stressors are the primary cause of crop failures and, on average, result in a 50% yield decrease. Importantly, vegetable production is prone to a broad spectrum of these abiotic environmental stresses. More commonly soil borne pathogens are most destructive and causes a serious crop loss in vegetables like tomato, brinjal, pepper, watermelon, cucumber.

The commercial use of vegetable grafting is a relatively recent innovation. Commercial vegetable grafting originated in Japan and Korea and was practiced for about 30 years. It was introduced to Western countries in the early 1990s and is currently being globally practiced using local scion cultivars and introduced rootstocks.

The first attempt in vegetable grafting was done by grafting watermelon (*Citrullus lanatus*) onto pumpkin (*Cucurbita moschata*) rootstock in Japan and Korea in the late 1920s. Among the Solanaceous crops, aubergine (*Solanum melongena L.*) was first grafted on to scarlet onto scarlet aubergine (*Solanum integrifolium* Lam.) was started in the 1950s.

Scenario in India

In India, grafting work has been started in IIHR, Bangalore by Dr. R M Bhatt and his associates. TNAU, Coimbatore has done work on brinjal grafting using Solanum nigrum as rootstock. NBPGR regional station, Thrissur, Kerala have done work on cucurbit grafting by taking *Momordica cochinchinensis* as rootstock with success rate of 98%. CSKHPKV, Palampur initiated work on grafting in cucurbits solanaceous vegetables and have identified more than 22 rootstocks of these vegetables.

More than 400 vegetable producers in India's Andhra Pradesh state have taken to cultivating grafted

vegetables in an attempt to double their incomes through increased yields. Farmers are reporting around 30-50% increase in yields from use of grafted varieties over traditional varieties. The farmers, from villages around Kuppam town of Chitoor district, are being provided grafted seedlings as part of an ICRISAT-led project, 'Doubling farmers' income through grafted vegetable seedlings in Andhra Pradesh. Department of Vegetable Crops, Horticultural College and Research Institute, TNAU, Coimbatore, Tamil Nadu initiated research on vegetable grafting in brinjal to mitigate root-knot nematode (*Meloidogyne spp.*) and dry root rot (*Macrophomina phaseolina*) incidence during 2008. The technology was standardised and released during the year 2016. Currently, the department is producing grafted brinjal plants and supplying to the farmers on request basis @ 7 Rs per graft. Some private players are also involved in grafting. One amongst them is 'VNR Seed Private Limited' in Chhattisgarh which is supplying grafted brinjal, tomato, cucumber, muskmelon and watermelon seedlings resistant to bacterial wilt to farmers

An unorthodox approach

Now-a-days, grafting promises to be an effective unorthodox tool over slow conventional breeding methods against various biotic and abiotic stresses. The plants developed through conventional methods reflect the genotype (G) × environment (E)

interaction only, whereas a grafted plant brings two different genotypes together and shows effective interaction of rootstock (R)× scion (S)× environment (E) thereby determining the positive and negative influence of rootstocks on plant performance and fruit quality of scion.

Grafting not only provides vigour to the plant but also provides resilience against adverse environmental conditions and soil-borne pathogens. It also improves resource uptake capacity of plant and increases its resource use efficiency. Grafting enhances the soil biological properties by increasing the population of bacteria and actinomycetes with a great potential to protect plants against many pathogens.

Grafting: Bridge to Sustainable Resilience Building

For sustainable vegetable production on in the developing countries, eff orts are being focused on low cost, effective and simplified grafting technologies, i.e., low-cost healing chambers and grafting tubes as well as open-pollinated rootstock varieties or those developed from wild species.

Among all management tactics, vegetable grafting is considered as eco-friendly for sustainable vegetable production as a result of the resistant rootstock reduces the dependency upon agrochemicals needed for treating the soil-borne diseases and has opened a new vista in organic farming of vegetables. This tactic has rapidly expanded due to intensification of production practices, reliance on susceptible cultivars to satisfy specific market demands, a global movement and local invasion of novel pathogens, accrued use of organic practices, the fast adoption of high tunnel production systems.

Additionally, grafting provides advantages to manage abiotic stress, to reduce reliance on chemical and fertiliser inputs, and to boost fruit quality. Recently, with emphasis on multi tactic approaches to manage soil-borne pathogens vegetable grafting has emerged as a very important integrated pest management to manage soil-borne diseases of vegetable crops.

Prerequisites for vegetable grafting

Breeding host-resistant rootstocks

Host resistance can be generally classified into two categories: vertical resistance (resistance is governed by single genes) and horizontal resistance (resistance is controlled by multiple genes). Oftentimes, the horizontal resistance can be accidentally lost by continuous selection for horticultural characteristics. Several cucurbitaceous and solanaceous rootstocks are selected from wild germplasm, and therefore they are more likely to maintain non-differential/horizontal resistance to a wide range of pathogens.

Ways to achieve resilience through grafting

There are numerous studies describing the use of grafting techniques on different vegetable crops to improve tolerance against a broad spectrum of environmental stresses.

Flooding Resilience

It has been documented that grafting has been used by many research groups in various vegetable crops to improve flooding tolerance. Tomato is an example of a globally grown vegetable that is sensitive to flooding. The interspecific grafting of tomato to improve flooding

tolerance. In this experiment, a commercial tomato cultivar, Arka Rakshak, was grafted onto four egg- plant rootstocks, such as

BPLH-1, Neelkanth, Mattu Gulla, and Arka Keshav. In a recent study, tomato hybrids (Arka Rakshak and Arka Samrat) were grafted onto eggplant

rootstocks (IC-354557, IC-111056, IC-374873, and CHBR-2) and exposed to waterlogged conditions.

Observations revealed that there were no symptoms of leaf chlorosis or plant wilting and less of a reduction in chlorophyll at all plant growth stages. In contrast, the un-grafted plants experienced 41–100% reduction in chlorophyll content after 96 h of waterlogged stress, while the plants wilted and died 4–7 days after the stress was removed.

Drought Resilience

Although breeding and biotechnological interventions have resulted in some new drought-tolerant crop varieties, these advances have been mostly limited to cereal crops. water availability is highly affected by climate change which influences crop productivity, specifically that of vegetable crops, and total crop failures are common.

Therefore, grafting could be used to decrease production losses and increase the water use efficiency (WUE) during water scarcity.

Studies have showed that the antioxidant enzymes varied in fruits of non-grafted and grafted plants under drought stress. In cucumber, it has been documented that grafting improved the WUE by affecting the ABA biosynthesis pathway which enhanced plant growth and yield. Osmotic manipulations occurred in accordance with the water stress level when sensitive pepper plants were grafted with the relatively tolerant rootstocks. Another study which compared drought-tolerant rootstocks for watermelon concluded that wax gourd is a better rootstock than bottle gourd under drought-prone conditions.

thermal stress resilience

Temperature extremes can result in vegetable production losses by promoting wilt and necrosis, retarding the rate of truss appearance, and impacting the timing of fruit ripening. Vegetable crops are highly sensitive to both low and high temperatures.

In Morocco, *C. ficifolia* is the preferred root-stock for cucumbers and is an excellent rootstock for low soil temperature tolerance, particularly for spring production in winter.

Grafting tomato onto wild tomato rootstock exhibited the high relative growth rate of shoots and higher root mass ratios under low temperature as compared to selfed and non-grafted plants. Therefore, the results of study document the wild tomato (*Solanum habrochaites*) accession (LA) 1777 as another rootstock option when managing suboptimal root zone temperature in tomato and other solanaceous vegetable crops.

Salinity Resilience

About 7% of the world area and close to 20% of the arable irrigated land are affected by soil salinity. Many strategies have been employed in order to overcome this issue including breeding for salt-tolerant vegetable crops has also been considered, but the complex polygenic trait that evokes salt tolerance requires several cycles of plant breeding.

In the past decade, studies have investigated the salt tolerance of grafted vegetable crops and most of the studies have concluded that grafting is a highly efficient way to improve salt tolerance. When bottle gourd was used as a rootstock, the salt tolerance capacity of watermelon plants improved several-fold.

In the case of muskmelon, interspecific squash rootstock (*Cucurbita maxima* × *Cucurbita moschata Duch.*) increased salt tolerance, along with plant biomass and leaf area, in the grafted muskmelon compared to non-grafted control plants.

Conclusion

In conclusion, grafted vegetables have great potential in mitigating the environmental (biotic as well as abiotic) stressors in an eco-friendly and sustainable manner.

This grafting technique coupled with other resilient agricultural techniques such as less and less use of agrochemicals and more use of organic solutions such as Panchgavya can help build the resilience to the agro-ecosystem.

In India, where grafted vegetables are slowly coming into trend, more research and study need to be undertaken so as to create awareness among the local farmers to adopt this new technology and increase their income. Parts of India such as North-Eastern Region is full of potential of wild germplasms that must be rediscovered and exploited to create more such tolerant rootstocks that could be further used for crop improvement and grafting.

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Revolutionizing Horticultural Crop Production: Soilless and Hydroponic Systems in Greenhouses and Vertical Farms

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Soil isn't an absolute necessity for supporting plant growth; its primary role lies in supplying vital macronutrients and micronutrients required for plant development. Traditional agriculture relying on soil presents several disadvantages, including inefficiencies in irrigation water use, extensive land demands, heavy reliance on chemical fertilizers, and soil degradation. The pressing need for substantial quantities of nutrient-rich food to meet global population demands underscores the urgency of introducing modern, progressive agricultural technologies and methodologies. These innovations aim to align water and nutrient requirements efficiently to attain maximum crop yields. Conventional farming methods, which rely heavily on soil as the primary growth medium, are undergoing a revolution brought about by innovative techniques like soilless cultivation and hydroponics. These advanced methods have found fertile ground in controlled environments like greenhouses and vertical farms, completely reshaping the landscape of horticultural crop cultivation. Soil-less cultivation primarily thrives in greenhouse environments, demanding high-tech infrastructure, substantial capital investment, and the expertise of skilled operators. However, the benefits are substantial: exceptional productivity, efficient use of water and space, and the prevention of soil and groundwater pollution through closed-loop systems. Hydroponics, another method within Controlled Environment Agriculture, allows plants to flourish without soil by utilizing precisely controlled nutrient-rich water solutions. This approach enables higher crop yields compared to traditional farming, as it permits a denser planting arrangement in less space while conserving water. It's especially appealing in regions with scarce water resources. Nevertheless, the initial setup costs and energy consumption pose significant hurdles to its widespread adoption. Furthermore, limited crop diversity can be a challenge, as not all plants are well-suited to controlled environments.

The Rise of Controlled Environments: Greenhouses and Vertical Farms

In our pursuit of more effective, environmentally friendly, and consistently reliable crop cultivation, greenhouses and vertical farms have emerged as revolutionary solutions. These controlled settings provide the perfect environment for the flourishing of soilless and hydroponic systems. Greenhouses, which have long been recognized as sanctuaries for plant growth, have evolved into centers of precision agriculture. Within these controlled domains, the traditional dependence on soil has been replaced by innovative practices that prioritize soilless cultivation.

Plants thrive in inert growing mediums, where their growth is meticulously managed through the precise administration of nutrients, light, and environmental conditions. This transformative method facilitates year-round crop production, safeguards against adverse weather conditions, and optimizes the utilization of resources. In addition to this shift toward soilless cultivation, hydroponics, a

hydro-culture technique that eliminates the need for soil entirely, complements the controlled environments of greenhouses and vertical farms. In hydroponics, plants receive nourishment from nutrient-rich water solutions under meticulous control. The synergy between hydroponics and controlled environments, such as greenhouses and vertical farms, unlocks unparalleled potential. Hydroponics offers the advantage of increased crop yields, reduced water consumption, and efficient use of space, making it particularly attractive in densely populated urban settings. Collectively, the adoption of soilless cultivation and hydroponics within the confines of greenhouses and vertical farms signals a new era of sustainable agriculture. These practices provide solutions to challenges like seasonality, limited land availability, and resource conservation. By harnessing the capabilities of these controlled environments, we are reshaping the future of food production, ensuring a resilient and environmentally conscious approach to meet the ever-growing global demand for fresh, locally sourced agricultural products.

Soilless Cultivation: A Paradigm Shift

Conventional agriculture has traditionally depended on fertile soil as the fundamental medium for cultivating crops. However, soilless cultivation represents a departure from this conventional practice. In soilless systems, plants are cultivated in inert substances like coconut coir, perlite, or vermiculite, serving as a stable substrate. What makes this approach groundbreaking is the meticulous control it offers over the precise delivery of essential nutrients to plants. This method not only minimizes the risk of soil-borne diseases but also enables precise optimization of resource utilization. In the realm of horticultural crop production, the term "soil-less cultivation" encompasses all systems that facilitate plant management in conditions devoid of traditional soil. Here, the supply of water and essential minerals is achieved through a nutrient solution, often without the use of a conventional growing medium. This may include substrates like rock-wool, peat, perlite, pumice, coconut fiber, among others.

Soilless cultivation systems can be categorized into two primary groups:

i) Systems that rely on a liquid medium without any additional support for plant roots.

ii) Systems that utilize a solid medium, typically a substrate, to provide support for plant growth.

Moreover, soilless substrate-based cultures can be further classified into two subcategories:

i) Open systems, in which the nutrient solution draining from the roots is not recycled.

ii) Closed systems, where any excess nutrient solution is collected, adjusted, and reintroduced into the cultivation systems.

Soilless cultivation techniques have been introduced in protected crop settings and vertical farms to achieve several objectives:

i) To liberate plant cultivation from traditional soil, eliminating associated issues such as soil depletion, soil-borne diseases (particularly following the prohibition of methyl bromide as a soil fumigant), secondary soil salinization due to excessive fertilizer use and insufficient rainfall, and the need for crop rotation.

ii) To enhance control over the growth conditions of plants, including factors like root zone temperature, aeration, and the precise distribution of water and nutrients.

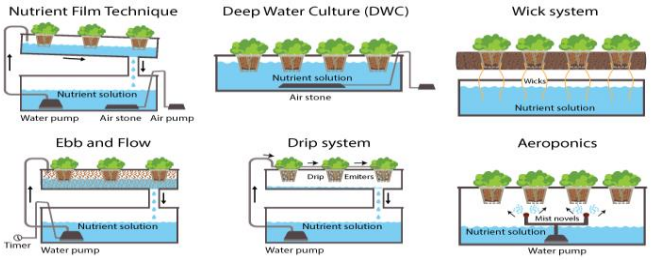
iii) To reduce the labor demands of crop management.

These innovations mark a significant departure from conventional soil-based practices, offering a pathway to sustainable and efficient crop production in controlled environments.

Hydroponics: Nourishing Plants with Precision

Hydroponics takes soilless cultivation to the next level. It entails the cultivation of plants in nutrient-enriched water solutions. This method directly supplies all the essential elements required for plant growth to their root systems. The precise regulation of nutrient delivery in hydroponics results in accelerated growth rates and enhanced yields when compared to conventional soil-based agriculture. The primary objective of all hydroponic systems is to improve control and efficiency in crop cultivation. In every scenario, the growth environment plays the pivotal role in determining crop productivity. In conventional outdoor farming, crops are subject to the unpredictability of weather and soil conditions. Transitioning from soil-based farming to hydroponic systems represents the initial step toward a trajectory of controlled environment production, ultimately culminating in fully indoor cultivation setups, as witnessed in the vertical indoor farming trend. Hydroponic innovations have demonstrated that direct exposure to nutrient-rich water can offer a more effective and adaptable approach to plant growth compared to traditional irrigation methods. Hydroponics represents a sustainable and effective agricultural technique that is gaining popularity, particularly in urban regions with limited space for traditional farming practices.

Different types of hydroponic systems



i. Deep Water Culture (DWC): In DWC systems, plants are cultivated within a nutrient solution that receives continuous aeration to ensure the roots receive an oxygen supply. This method is favored for the cultivation of leafy greens and herbs.

ii. Nutrient Film Technique (NFT): In NFT systems, a thin film of nutrient solution circulates over the plant roots, delivering essential nutrients. This hydroponic approach is commonly employed for growing crops like lettuce and basil.

iii. Ebb and Flow: Ebb and flow systems involve growing plants in containers or trays that undergo periodic flooding with nutrient solution followed by drainage. This method is well-suited for cultivating a wide array of crops, including tomatoes, peppers, and strawberries.

iv. Aeroponics: Within an aeroponics system, plants are nurtured in a mist or fog of nutrient solution, with their roots suspended in the air. This highly efficient hydroponic technique is renowned for its high yields and is frequently used for growing crops like lettuce and strawberries.

v. Vertical Farming: Vertical farming entails the stacking of hydroponic systems in layers, facilitating high-density cultivation in confined spaces. This type of hydroponics finds favor in urban areas where available space is limited.

Benefits:

Soilless and hydroponic systems offer a plethora of advantages:

1. **Year-round crop production and increased yields**: Controlled environments eliminate

seasonal limitations, enabling continuous crop cultivation. According to the Food and Agricultural Organization (FAO), soilless systems yield 20-25% more vegetables compared to traditional methods due to a higher plant density per square meter.

2. **Enhanced water efficiency**: Hydroponics and soilless systems substantially reduce water usage compared to conventional agriculture, making them environmentally friendly choices, especially in water-scarce regions.
3. **Effective space utilization**: Vertical farming optimizes limited urban spaces, reducing the necessity for expansive agricultural land.
4. **Reduced resource consumption**: Lower and more efficient resource utilization allows for the widespread adoption of this alternative farming method by various stakeholders.
5. **Control of pests and diseases:** Soilless cultivation minimizes the risk of soil-borne pests and diseases, reducing the need for chemical interventions.

Challenges and Innovations

While the future of soilless and hydroponic horticulture is promising, it's not without its challenges. Maintaining the delicate balance of nutrients, managing the systems, and addressing energy consumption are areas that continue to see innovations and improvements. One of the primary constraints lies in the substantial initial capital outlay needed to establish the infrastructure and equipment for indoor farming, a financial burden that may prove impractical for small-scale farmers. Additionally, there's the issue of heightened energy consumption associated with indoor farming, resulting in increased electricity expenses and elevated carbon emissions. Water usage remains a limitation as well, given that hydroponics still demands a substantial volume of water to sustain the system effectively. The range of crops that can be cultivated is restricted due to the size and structure of the indoor growing environment.

Table 1: Compilation of crops suitable for large-scale cultivation using soilless cultivation techniques

Type of crops	Name of the crops
Fruits	*Fragaria ananassa* (Strawberry)
Vegetables	*Lycopersicon esculentum* (Tomato), *Capsicum frutescens* (Chilli), *Solanum melongena* (Brinjal), *Beta vulgaris* (Beet), *Psophocarpus tetragonolobus* (Winged bean), *Capsicum annum* (Bell pepper), *Brassica oleracea* var. *capitata* (Cabbage), *Phaseolus vulgaris* (Green bean), *Brassica oleracea* var. *botrytis* (Cauliflower), *Cucumis sativus* (Cucumbers), *Cucumis melo* (Melons), *Raphanus sativus* (Radish), *Allium cepa* (Onion)
Leafy vegetables	*Ipomoea aquatica* (Kang Kong), *Lactuca sativa* (Lettuce)
Condiments	*Petroselinum crispum* (Parsley), *Mentha spicata* (Mint), *Ocimum basilicum* (Sweet basil), *Origanum vulgare* (Oregano)
Flower / Ornamental crop	*Tagetes patula* (Marigold), *Rosa berberifolia* (Roses), *Dianthus caryophyllus* (Carnations), *Chrysanthemum indicum* (Chrysanthemum)
Medicinal crops	*Aloe vera* (Indian Aloe), *Solenostemon scutellarioides* (Coleus)

Source: Sardare and Admane, 2013, Singh and singh, 2012

Regulatory hurdles, including zoning regulations and agricultural policies, may further restrict their implementation in specific regions. Nevertheless, despite these challenges, the potential benefits offered by vertical farming and hydroponics are substantial. To overcome these limitations and promote their

broader adoption in agriculture, further investments and ongoing innovations are essential.

Conclusion: A Greener Tomorrow

The shift toward soilless and hydroponic systems in controlled environments aligns with the global push for sustainable agriculture. These methods are at the forefront of efforts to reduce the carbon footprint of food production, conserve water, and ensure food security in a rapidly changing world. As the global population continues to surge at an unprecedented pace, it becomes imperative to investigate sustainable and efficient approaches for generating an adequate food supply capable of meeting the requirements of every individual. The transformation of horticultural crop production through soilless and hydroponic systems in greenhouses and vertical farms represents a promising chapter in agriculture. It's a journey that combines technology, sustainability, and innovation to meet the ever-growing demand for fresh, nutritious produce. As we look to the future, the integration of these methods into mainstream agriculture could hold the key to a more sustainable and food-secure world. The revolution is underway, and its impact on our dinner plates and the planet cannot be underestimated.

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Geographical Indications in Horticulture

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Geographical Indication (GI) is a form of intellectual property that signifies a product's specific geographical origin, possessing qualities, reputation, or characteristics attributable to that location. A Geographical Indication (GI) is a symbol affixed to products linked to a distinct geographical source, representing their unique qualities or reputation derived from that specific place. It acts as a certification of authenticity and quality, ensuring consumers associate the product with its unique origin. GI rights protect traditional knowledge and local communities, promoting economic growth and fair trade. The registration of a GI provides legal protection, preventing unauthorized use of the geographical name on similar products. This system aids in preserving cultural heritage, fostering rural development, and encouraging sustainable production practices tied to specific regions, thus adding significant value to regional economies.

Some examples of goods are - Darjeeling Tea, Alphonso Mango, Tezpur Litchi, Kachai Lemon, Tripura Queen Pineapple, Khasi Mandarin, Jalgaon Banana, Nashik Grapes, Mahabaleshwar Strawberry, Solapur Pomegranate etc.

What can be Geographical Indications?

GI may be Agricultural product (Darjeeling Tea), Manufactured product (Kolhapuri Chappal), Food stuff (Bikaneri Bhujia), Natural product (Makrana Marble), Wine & Spirit Drink (Feni) and Handicraft (Muga Silk of Assam).

Registration of GI products

The registration and management fall under the purview of the Geographical Indications Registry as stipulated in the GI of Goods (Registration and Protection) Act of 1999. This registry is situated in Chennai. Individuals engaged in the production, processing, packaging, or trading of agricultural commodities, natural goods, handicrafts, or industrial products have the eligibility to apply for registration. Successful GI registration grants exclusive rights to the registered proprietor and authorized users to safeguard the GI on the designated goods. This market exclusivity empowers producers to regulate prices, potentially charging premiums and bolstering profits. Studies indicate that 80% of consumers are willing to pay 20-30% more for GI products, believing them to possess superior qualities compared to other goods.

Benefits of GI

Higher market price and demand: Profitability hinges on factors like product reputation, quality, market size, competition level, consumer perception, and demand elasticity. Geographical indications create a valuable avenue for commanding premium prices in the market. Research demonstrates that consumers are prepared to pay a premium for products guaranteed by their geographical origin.

Remunerative price for producers: Leveraging geographical indications can result in increased profits in international markets, and creating strong agricultural brands can give farmers a competitive edge in global markets driven by consumer preferences.

Quality products for consumers: Geographical indications ensure that consumers access high-quality products with desired characteristics, shielding them from deceptive practices. The distinctive qualities of the product establish a favorable perception among consumers, essentially transforming the product into a recognized brand for them.

Market penetration: An established and reputable brand facilitates marketers in entering new markets effortlessly. Positive feedback and endorsement from devoted customers further aid in reaching and engaging with new customer bases.

Traditional knowledge: Traditional knowledge encompasses the insights, innovations, and customs of

indigenous communities and local people. Geographical indication safeguards against the erosion of traditional ways of life, unauthorized use, and exploitation of this knowledge without fair benefit-sharing.

Improve tourism industry: Geographical indications (GI's) represent distinct products originating from specific defined regions. The cultivation or manufacturing processes involved can serve as a tourist attraction, drawing visitors to witness these unique processes. Handicrafts and handlooms, known for their distinct characteristics, are inherently appealing to tourists. Regions promoting their GI's can entice tourists to savor special GI foods or beverages and purchase unique products with enticing discounts, thereby bolstering market potential and increasing export earnings.

Rural development: Preserving Geographical Indications (GIs) holds great importance for rural development, acknowledging our exceptional biodiversity and traditional knowledge. GIs play a role in generating employment within local communities, curbing rural migration and encouraging rural tourism.

Legal Protection: This led to a surge in the export of Indian geographical indications, ensuring legal protection and paving the way for seeking similar safeguards in other WTO member nations.

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Importance of Cauliflower (*Brassica oleracea var. botrytis*) Leaf and Its Application in Food Processing

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Since ancient times the greens are being big red for the people especially by the children. As we know Green leafy vegetables are the major source of iron, folate, and other essential nutrients (Hemmige natesh *et al.* 2017). But due to its unattractive appearance and taste it is not widely acceptable by the children. To overcome this, mothers try to mask the greens into the favorite food of the children to feed them the nutrients in greens and this process emerge and developed as the major food application as food incorporation technology. According to the data in India women between 15 to 49 years of age are anemic and 79% of children of age group between 6 to 35 months age are anemic and cauliflower leaves are rich source of natural antioxidants that have been shown to help prevent cancer (Krishnaswamy, 2009). Cauliflower leaf (Brassica oleracea var. botrytis) is good in nutrients and are rich source of iron, calcium, and beta carotene which can be used in value added items (Kowsalya and Sangheetha, 1999).

Cauliflower leaf

The name cauliflower is gotten from the Latin word "caulis" for cabbage and blossom. Fresh cauliflower leaf is a seasonal, nutritious, calcium rich (626mg/100g of fresh leaf) tasty green leafy vegetable however it contains around 80% moisture which makes it unexceptionally short-lived (Gopalan et al.2004).

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Dilleniidae
Order	Capparales
Family	Brassicaceae
Genus	Brassica
Species	B. oleracea L. var. botrytis

Chemical Composition

Cauliflower leaf is good in supplements and has higher waste index. Its leaf which are discarded as waste are additionally rich sources of iron and beta carotene which can be used in the value-added product (Kowsalya and Sangheetha, 1999).

There are Phenolic intensifies that apply to countless mixes confined from plants. Phenolic compound is ordered into basic fragrant ringed mixes to enormous and complex tannins and determined polyphenols (Guerrero – Beltran et al. 2012).

Cauliflower leaf contain a sulphur compound that has additionally been appeared to kill disease causing microorganisms, thereby preventing the tumour development. A few analysts think disposing of disease undifferentiated organisms might be critical to controlling cancer (Guerrero – Beltran et al. 2012).

Nutrient content of cauliflower leaf (per 100g)

Nutrients	**Per 100g**
Protein	5.9g
Fat	1.3g
Carbohydrate	7.6g
Crude fibre	2g
Beta carotene	49.526mg
Iron	41mg
Energy	66 kcal

Therapeutic significance of Cauliflower leaf

Among all the green leafy vegetables, Cauliflower greens (Brassica olercealvar botrytis) was found to have the maximum amount of iron such as 40mg/100g.The mean haemoglobin level of the selected 20 subjects had increased from 12 to 12.5 g / dl after supplementation of 50g cauliflower greens poriyal for 90 days. The increase was statistically significant at five percent level. These results indicate more beneficial effect of cauliflower greens. (Kaviyaras et al. 2017)

Sulforaphane in cauliflower and other cruciferous vegetables has been found to fundamentally improve pulse and kidney capacities (Cohen et al. 2000; Knekt et al. 2002 and Zhang and Hamauza, 2004).

Adolescence is the transition period between childhood and adulthood. Adolescence is characterized by the growth spurt, a period in which growth is very fast. The hemoglobin level of the adolescence 11-14g/dl. The fresh cauliflower leaves contain 40 mg/100g of iron. Prevention of anemia in adolescents is important as they are the future mothers. Among the green leafy vegetable cauliflower greens (Brassica oleracea varbotrytis) which has a high amount of iron. Cauliflower leaves are rich in folate, vitamin C vitamin E and beta carotene and contain some important nutrients like indole -3-carbinol and phytonutrient sulforaphane (Kaviyarasi et al. 2017)

Cauliflower leaf contain sarcoma prevention agents and other bioactive compounds which has been indirectly connected with cardiovascular illnesses and constant sicknesses (Cohen et al. 2000; Knekt et al. 2002 and Zhang and Hamauza, 2004).

Responsive oxygen can cause lipid and protein oxidation, DNA harm and change of quality articulation in the body. They assume impotence job in etiopathology of numerous illnesses like stroke, respiratory failure, liver injury. Lop-sidedness among ROS and cell reinforcements reason of oxidative pressure might be brought about by cancer prevention agent imperfection in weight watcher expanded creation of free extremists by stress, smoking, natural defilement which move into food and water (Lee et al. 2004).

Cruciferous vegetables utilization come to bring down the danger for certain sorts of diseases, for example, renal malignant growth prostate malignancy and perhaps colorectal malignant growth (Thomson et al. 2010).

All bioactive properties introduced in these vegetables may control irritation for the explanation that they may work on various and corresponding stages for example rouse detoxification proteins search free revolutionaries and produce safe capacities (Fimognari et al. 2012).

Isothiocyanates present in cauliflower vegetable, act as good chemo preventive exercises against various constant degenerative infections along with malignant growth cardiovascular illnesses, diabetes (Fimognari et al. 2012).

Brassica vegetables as amazing source of medical property's, just as valuable impact on human wellbeing. Numerous mixes have been disengaged from cauliflower vegetables and it assume significant part in human wellbeing. Cauliflower leaf great source of iron and different micronutrients. Various micronutrient lacks are regular insufficiency mostly in developing country. Generally, individuals in the developing nations likewise experience the ill effects of various types of these nourishing issues. As per this information in India ladies between 15 to 49 years old are sickly and 79% of offspring of between 6 to 35 months age are weak (Krishnaswamy, 2009).

A brassica oleracea leaf contains a few clinical properties. It contains folate which helps in making and moving the blood and forestalls symptoms of pallor (Brittenham, 2009 and Dreyfuss et al. 2000).

These plants-based phytochemicals can be utilized as significantly good source because of its digressing healthful, useful, cancer prevention agent and other remedial properties and adds wholesome security too. There is no big esteem given to the disposed of leaf of cauliflower which is additionally rich source of dietary fibre, minerals, beta carotene, iron and calcium. utilization of green leaf of cauliflower at family level become successive then it very well may be the solid advance/solutions for destroy against micronutrient insufficiencies particularly frailty that are predominant in each nation (Sadhna Singh et al. 2019).

Value added products from Cauliflower leaf

Balaji S and Dr. M. Thamarai Selvi (2021) Formulation and Sensory Acceptability of Cauliflower Leaf Jellies which are highly acceptable by the peoples

as per the research and it is economically feasible product for the iron substitution.

Kaviyarasi and Abiramin (2017) formulated cauliflower greens poriyal supplementation on haemoglobin levels of anaemic adolescent girls and as a result the mean blood haemoglobin of the sample before supplementation was found to be 8.3mg/dl and mean blood haemoglobin of the sample after supplementation was found to be 12.9mg/dl.

Ambika chauhan and Intelli (2014) prepared hotcake, dhokla and idly which was enhanced with 2g and 5g dry cauliflower leaf powder per serving and sensory assessment was finished with the assistance of 9-point hedonic scale concerning appearance, taste, surface and flavour by 9 boards of semi trained panel members. Biochemical investigation of dry cauliflower leaf uncovered moisture 3.4 percent, protein 21.6 percent, fibre 10.23gm and iron 62mg (values according to 100gm). The research was concluded that at 2 g consolidation of dry cauliflower leaf powder the product was acceptable.

Towseef and Monika (2014) focused to use cauliflower leaf in value added item, consequently decreasing the wastage. The wheat flour was mixed with cauliflower leaf powder within the proportions of 10, 20 and 30 for half an hour for the advancement of bread rolls. The formulated bread rolls were place placed undisturbed ninety days to find out shelf life qualities. the foremost elevated moistness, rough macromolecule, unrefined fibre and crude substance of one.68, 9.49, 13.32 and 1.49% were recorded in rolls organized from 70:30: wheat flour: cauliflower leaf powder, severally. As a result, 100:00: wheat flour: cauliflower leaf powder recorded most elevated estimation of rough fat (21.96%).

Conclusion

Cauliflower leaf are one among the most valuable agricultural commodity that are thrown as the waste due to lack of knowledge among the population. Even now we can get these leaf for free from the market and most of them are now cattle feeds. There have been extensive research in the field of cauliflower leaf but only few research on the application and incorporation of these leaf on the food industry for the incorporation. There may be controversy related to the pesticide used in the production but its is not true that these are loaded with pesticides than other fruit and vegetable products good agricultural practice, washing, blanching of Cauliflower leaf will reduce the pesticides if it is present. So a attention and extensive research should be done on this highly nutritious green leafy vegetable and at the home level incorporation by the parents may help in controlling iron deficiency anaemia.

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Horticulture and its Impact on Indian Agriculture Sector and Indian Economy

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Horticulture is a sub-discipline of agriculture that includes a wide range of activities such as the cultivation of fruits, vegetables, flowers, medicinal and aromatic plants, mushrooms, plantation, forestry, landscaping, and many others. It is critical to the income security and nutrition of millions of people in India. It ranges from growing flowers and vegetables in home gardens to cultivating crops on a huge scale for sale and corporate interests. Horticulture is the study of plants, their cultivation, growth and development, and interactions with the environment. Horticulture involves elements of other branches like agronomy, botany, soil science, plant pathology and economics for its overall balanced growth. Horticulture plays a very important and crucial role in growth and development of agriculture sector and the overall economy of India. India has emerged as global leader in horticulture with the help of its rich diversity in crops and favorable climatic conditions. Horticulture generates roughly 30 percent of GDP while using just 13 percent of total cultivated land, making the horticulture sector a substantial contributor in the Indian agricultural sector and overall economy. This article explores the impact of horticulture sector on the Indian agriculture sector and overall economy, including contributing factors such as export potential, employment generation, value addition and sustainable practices.

Importance of Horticulture

Horticulture plays very important role from providing food and nutrition to income and livelihood to farmers, protecting environment, raw material to industries, development of rural economy, employment generation, gaining foreign exchange and many other. Horticulture is the backbone of agriculture just like the agriculture sector as a backbone of Indian economy. Horticulture production in India has even surpassed total food grains production of country, demonstrating the sector's potential. Horticulture sector not only meets nutritional requirements, but also generates numerous other opportunities such as job creation, income generation, and poverty relief.

Contribution to agriculture sector

Horticulture sector plays a crucial role in development of Indian agriculture sector by significantly increasing the crop diversity in the country and removing sole dependency of farmers on traditional foodgrain and cereal crops. It also plays a very pivotal and crucial role in ensuring food and nutritional security with increasing fruits and vegetable production, the change in food habits and consumption pattern of people has been on the rise. This diversification also helps farmers in mitigating crop failure risk and also improve resilience against continuous climate change risks and the price volatility.

Employment generation

The one of major impact of horticulture is significant improvement in employment and income generation in rural areas. Horticulture crops are generally labor-intensive crops and requires substantial labor, which provides a major source of income to farmers and the local labor directly and indirectly. Horticulture is boon for rural people, particularly the small-scale farmers, landless farmers, labor and women, who find employment throughout the year due to multiple crops harvesting of horticultural crops.

Income generation and poverty alleviation

The horticulture sector has played a very important and transformative role in raising incomes of farmers, labor and women and alleviating poverty in rural areas. The horticultural crops cultivation has proved as more profitable as compared to traditional farming of foodgrains and staples. Horticulture sector has increased the income and ability to pay for basic

amenities like education, health and ultimately improving living standards. This has resulted into reduction in rural-urban migration and revitalizing the rural economies.

Export potential and foreign exchange reserves

Horticulture sector has a great and enormous export potential and very high production of horticultural crops pushes India to tap this export potential. With its diverse range of crops and favorable climate, India has become a major exporter of fruits, vegetables and spices. The export earnings from horticulture contribute significantly to foreign exchange reserves, which strengthens the Indian economy. The export-oriented approach has also encouraged farmers to adopt proper quality standards, packaging and post-harvest handling to meet the stringent requirement of international markets.

Value addition and processing

Horticulture sector has opened up avenues and opportunities for value addition and processing which improves the shelf life of perishable crops and reduces post-harvest losses and ultimately helps farmers in fetching remunerative prices for their produce. The establishment of food processing and packaging industries focuses on canning, freezing, dehydrating and pickling of horticultural crops, resulted into improved market penetration and access and reduced post-harvest losses. Value added products like juices, concentrates, pickles, dried fruits etc., diversifies income options and benefits both farmers and consumers. Several initiatives have been established by the Ministry of Food Processing Industries to enhance the food processing industry, including the development of cold chain infrastructure, agro-processing clusters, backward and forward connections, preservation infrastructure, operation greens, and mega food parks. All of these schemes will offer food processing units with basic facilities of storage, testing labs, and logistics while focusing on stabilizing the supply and prices of perishable commodities and boosting their value addition to improve their overall utility.

Sustainable practices

Horticulture sector has paved the way for sustainable practices of farming by promoting organic farming through use of organic fertilizers, bio-pesticides and conserving water through use of irrigation techniques like sprinkler, drip irrigation etc. The awareness of consumers towards chemicals and demand of chemical free food makes farmers to move towards organic farming and leave chemical-intensive farming methods which are detrimental to human health and the environment. The sustainable practices such as integrated pest management, precision farming, organic farming have helped in reducing the overall ecological footprint of agriculture.

Government Initiatives

The Indian government has realized the enormous potential of horticulture sector and has taken various initiatives to promote the growth of overall horticulture sector. The initiatives such as National Horticulture Mission (NHM), Pradhan Mantri Krishi Sinchai Yojana (PMKSY) and the establishment of cold chain infrastructure, storage and warehouses, food parks and encouraging processing industries are some examples of government-driven efforts to boost development of horticulture sector. The National Horticulture Mission launched in 2005 aimed to increase the production, productivity and the overall quality of horticultural crops while promoting crop diversification. The PMKSY focuses on improving water use efficiency with help of efficient irrigation practices and water management. The establishment of cold chain infrastructure has played a crucial role in reducing post-harvest losses of horticultural crops by improving the utility through storage, transportation and processing facilities. The government initiatives help farmers by providing training, credit, subsidies and infrastructure support resulted into improved competitiveness in farmers and the overall horticulture sector. The Centre's Cluster Development Program by specialization of the

horticulture cluster, the program aims to foster and promote integrated and market-led growth of pre-production, production, post-harvest, logistics, branding, and marketing.

Conclusion

Horticulture sector has emerged as a crucial game-changer for the Indian agriculture sector and the overall Indian economy. It has brought significant and positive impact on Indian agriculture sector and the overall Indian economy that is visible through increased crop diversity, employment generation, income upliftment, increased export share, improved value addition and use of sustainable practices. As the world focuses on healthier and sustainable diets, the Indian horticulture sector has potential to continue its growth trajectory, providing a sustainable future for both farmers and the nation.

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Success Story: Market-led Intervention in Custard Apple

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India is blessed with a rich diversity of horticulture crops, which plays a vital role in securing livelihood for its 1.35 billion people by rendering a gamut of livelihood options including food, employment, traditional medicine, timber, value addition and livestock fodder. In addition, these crops also play an important role in the stability of eco systems. These underutilized horticulture crops species are often referred as underutilized horticulture crops. These underutilized fruit crops have a great potential to contribute to food security and poverty alleviation including the value addition for their diversified uses.

Arid refers to prolonged dryness, and is used with regards to the climate itself, in such regions the ability to produce agricultural crops is limited.

In general, on arid lands the potential evaporation of water from the land exceeds the rainfall. Arid environments are extremely diverse in respect of their land forms, soils, fauna, flora, water balances and human activities.

In this connection, the arid fruit crops farmers success story has been collected from the Kalaburagi region and tried to make convenience to the upcoming farming situations to the young generation of the region.

Custard apple naturally grown in hilly area of Chincholli taluk of Kalaburagi Dist. Nearly 52 ha area under cultivation. Where fruits were collected by local dwellers of the region and they use to sell in the local market at throw away prices and get very less remuneration. Custard apple highly perishable and fruit damage when stalked in basket. Realizing this problem, ICAR- KVK Kalaburagi put forth one step ahead in packaging, branding and marketing of custard apple under EDP programme during 2021-22., fruits are graded based on size and colour, packaged in CFC boxes all fruits were marketed through social media. Conducted training and awareness programme on packaging and marketing of custard apple and mango

Objectives

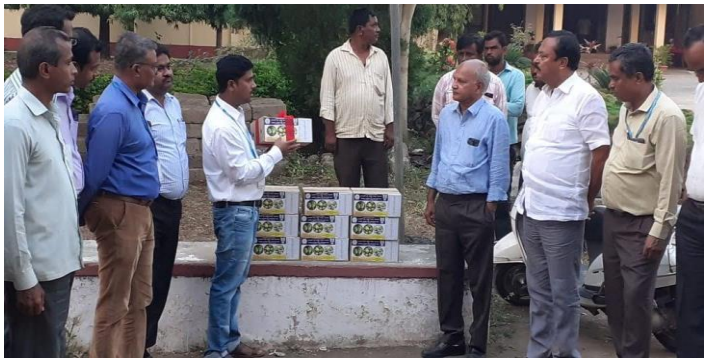
1. To get premium price for the produce
2. To reduce post-harvest losses

Intervention

1. Hands on training on packaging and value addition to unemployment youths
2. Market linkage (Govt. office and corporate office of KLB) as demand-based supply.
3. Innovative extension method.

Extension Activity

Given hands on training on packaging and branding of custard apple, Press reports and tv talk and radio talk



Created WhatsApp group

Raithara marukatte, marketed fruits based on demands of consumers, Marketing strategies is importance of custard apple in human health through youtube channel/twitter/ Radio talk/TV talk/press report and other social media were used.

Impact

1. Farmer earned net income 1.75 lakhs from half acre (80 plants)
2. Area under custard apple var. Balanagar and NMK-1Gold has been increased.
3. Visit to Telangana (Zaheerabad) state for extraction of pulp and value addition.
4. During covid-19 period 3 tonnes of custard apple sold and earned 89500/-

Because of innovative intervention by KVK scientist, farmers getting higher price for their produce and reduced the post-harvest losses by 20-30 % and reduced the marketing time (through social media) and now unemployed youths delivering custard apple based on demand of customer and among the 10 farmers undergone training 2 farmers were adopted this innovative method of packaging, branding and marketing of custard apple and mango namely.

Table 1: Economics

Sl. No.	Cost of packaging for one box (12 fruits)								
	Practices	**Box 10 x 8″**	**Foam**	**Fruits value**	**Labour charge**	**Gross cost**	**Gross returns**	**Net return per box**	**% of increase sale price**
1.	Improved packaging	9.0	1.0	60.00 (Rs.5/fruit)	5.0	75.00	120.00	45.00	37.50
2.	Local practice	-	-	60.00 (Rs.5/fruit)	2.0	62.00	70.00	8.00	11.40

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Application of Hydroponics in Floriculture Sector

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The global urban population is predicted to get doubled in 30 years, with 60% of the world's population in cities by 2030. To meet this demand, urban horticulture (UH) is being explored as a potential solution. However, improper handling of urban farming resources could negatively impact the environment and food safety. The floriculture industry offers a higher income per unit area. Floriculture exports have grown by 10% annually, with annual consumption ranging between $40 and $60 billion. However, soil-based agriculture faces challenges like limited land availability. No-soil culture, a technique using hydroponic and aeroponic growing methods, offers benefits such as better nutrition regulation, availability in non-arable land, efficient water and fertilizer use, simplicity, low-cost sterilization, and higher density planting, increasing yield per acre.

Objective

1. To get a brief overview of application of hydroponics system in floriculture crops globally.

2. To account research directions followed till date that can serve as baseline information to guide future research.

Methodology

Research findings and publications on the application of hydroponics in flowers from journals, books, reports etc. were studied thoroughly and the data was analyzed and represented here.

Result

The method of growing plants, without soil while submerging their stems in nutrient solution, is known as hydroponics (Maharana and Koul, 2011). Common mediums include expanded clay, coir, perlite, vermiculite, brick shards, polystyrene packing peanuts, and wood fibre. Several studies have been conducted with the application of hydroponics in floriculture.

Gerbera

Tahhereh *et al.* (2020) conducted a study to investigate the effects of silica nanoparticle and Ca-chelate on gerbera under hydroponic conditions in Iran. Results showed that 20 mg/L and 60 mg/L nanoparticles resulted in the longest flower longevity, flowering acceleration and increase of leaf number, stem ash and lignin content. The treatment with 80 mg/L nanoparticle-SiO_2 and 240 mg L Ca-chelate was found as the best treatment for increasing both protein content and degree of transparency. A study was conducted in COH, Thrissur by Arathi, 2016 to find out the suitability and performance of five different gerbera cultivars, *viz.* Donna Ellen, Goliath, Stanza, Intense and Balance. Maximum plant height was recorded in Intense. Cultivar Balance took the minimum time (125 days) to open first flower. Flower stalk characters were less in hydroponic condition than in pot culture. Vase life (13.9 days) and number of flowers (6.3) were recorded maximum in Balance.

Khalaj *et al.* (2011) conducted a study on gerbera to determine the effect of different substrates on growth and yield. Fourteen treatments comprising of different growth media were used and it was found that perlite, peat & expanded clay (25%+75%+5%) media produced maximum number of flowers per plant with best quality and shortest time (15months). It was also found that quality & yield of the crop has a strong relation with physic-chemical properties of the growing media. Cocopeat combinations produced good vegetative growth and good quality early flowers. Savvas *et al.* (2003) reported that pH of the drain solution increased when low NH_4 + :N was used for gerbera (*Gerbera jamesonii*), but did not change using a high ratio. Savvas and Gizas (2002) found that

gerbera flower number and flower stem length were lower when the effluents were recycled and attributed this to reduced NH4 + in the supply solution resulting in increased pH and restricted supply of P, Fe, and Mn to the plants, and recommended higher NH_4 +: N ratios than those used for open systems.

Rose

Mattson and Leith (2007) conducted a study on hydroponically grown cut roses in USA to determine how macronutrient absorption varies in relationship to growth of new flower stems and test whether an existing mathematical model is suitable for describing nitrogen and potassium uptake across a crop cycle. Results showed that total nitrogen uptake decreased after harvest, then increased with flower stem elongation. K+ uptake decreased for 12 days, then increased with stem elongation. Ca2+ uptake decreased before harvest, and then increased before stem maturity. Farahi *et al.* (2013) conducted research to analyze the impact of polyamines on vegetative, flowering and post harvest life of rose cv. Dolcvita in hydroponic culture. They found that foliar treatment of polyamines had substantial impacts on floral stem length, fresh weight, vase life, flower bud girth, and length. The highest and lowest flower stalk lengths were measured in nutrient solutions containing 1.5mM spermidine and 100.66 and 71 cm, respectively, suggesting that polyamines have a significant impact on the qualities and properties of roses. Jiang *et al.* (2007) applied nutrient film technique (NFT) and deep flow technique (DFT) in production of rose, chrysanthemum and carnation. Das *et al.* (2012) reported that growth and flowering of rose were induced by Hoagland and Arnon composition (1950) of solution culture. With rose (*Rosa* × *hybrida*), recycling reduced NH_4 + in the solution and increased pH, which necessitated daily addition of HNO_3 - to reduce pH (Lykas *et al.*, 2001).

Chrysanthemum

Azeezahmed *et al.* (2016) conducted a study to determine the impact of different N-K concentration on flowering of chrysanthemum cv. Mother Teresa. The treatments consisted of five nutrient solution concentrations (NSC), having N (50, 100, 150, 200 and 250 ppm) and K levels (40, 80, 120, 160 and 200 ppm) during vegetative stage, and 60, 110, 160, 210 and 260 ppm during reproductive stage. The optimal therapy was found to be NSC-V of N250 C K200 during the vegetative stage and N200 C K260 during the reproductive stage, resulting in the greatest number of blossoms. Rahman *et al.* (2022) conducted a trial to find out the best media for chrysanthemum cv. Rajkumari under hydroponic system in AAU, Assam. Seven growing media combinations, *viz.* coco peat, coarse sand, cinder, coarse sand cinder, coarse sand and coco peat, coco peat and cinder, coco peat, coarse sand and cinder as growing media and two different concentrations of nutrient solutions EC 1.5dS/m and EC 1.8dS/m were utilized and the best quality and yield of flowers were produced under coco peat + cider and EC 1.8dS/m nutrient media.

Gladiolus

Agina *et al.* (2018) conducted a study in Benha University, Egypt to examine the relationship between the source of nutrients and water flow rate to determine if it is possible to grow gladiolus plants in a wastewater fish farm using nutrients that are different from those used in conventional nutrient solutions. The findings showed that in effluent fish farms as opposed to nutrient solutions, plant height rose and the average duration of a spike was longer. Additionally, the nitrate concentration in the effluent fish farm considerably rose as the flow velocity was increased. Nosir (2011) conducted an experiment in University of Aberdeen, UK to compare the effectiveness of three commercial fertilizers- Signral, 20-20-20; Nutrafin 23-33-24; and HeavyharvestBloom, Hydroempir for growth of Gladiolus in NFT system. Three purchased nutrients were used and Hoagland's solution was contrasted. The results showed that the gladioli corms demonstrated excellent adaptability to NFT cultivation during the two winter experiments, yielding high-quality blooms. This research will provide a new avenue for substituting ready-made

hydroponic nutrition solutions with commercial nutrients. Wahome *et al* (2010) conducted a study aimed to determine the effects of different hydroponics systems and growing medium components on growth, yield and quality of gladiolus where three hydroponics systems (elevated tray, ground lay bed and bag culture) were used as the main plots and sub-plots were allocated to the different medium components *i.e.*, crushed stone, sawdust, sand and vermiculite. They concluded that for the hydroponics culture of gladiolus, bag culture hydroponics system may be used with sawdust as growing medium as it showed superior results.

Lily

Moghaddam and Nasir (2020) conducted an evaluation to study the effect of different concentrations of potassium on lily growth and postharvest life. A hydroponic experiment was conducted in Islamic Azad University, Tehran, Iran. The findings showed that most plant development parameters, such as shoot dry weight, declined with potassium consumption in nutrient solution, but improved at a potassium concentration of 6 mM. Seyedi *et al.* (2013) inspected the effects of calcium concentration on qualitative & quantitative characters of Lilium cv. Tresor in Islamic Azad University, Rasht, Iran. The Asiatic Hybrid Lilium bulbs of the "Tresor" cultivar, which were used in the present study, were seeded at three distinct calcium concentrations: 2, 4, and 6 mM. The highest height of the plant, stalk diameter, height at which reproduction begins number of buds, blossom diameter, and life of cut flowers were all generated by 6 mM calcium, according to a comparison of the data's mean values. Daood *et al* (2007) conducted a study on the response of Asiatic Lily (*Lilium* × *hybrida*) 'Zsa Zsa' to concentration of urea in a closed soilless culture and reported that as urea was increased up to 616 mgL^{-1}, stem height, shoot and root weight, and peduncle length all reduced before leveling out. Over 296 mgL^{-1} of urea decreased the number of floral buds by one bud. As urea levels rose, bud weight and length decreased. There was no effect on tissue N, P, Na, Cl, Mg, Mn, Cu, and Mo. The tissue K value that was highest was 296 mgL^{-1} urea. Applying 296 or 456 mgL^{-1} urea resulted in a decrease in Fe and Zn and an increase in tissue Ca. NH_4^+ and supply solution N were reduced at urea concentrations of 296 or 456 mgL^{-1}. EC and K increased with increasing urea. The greatest Na and Ca values were found for urea concentrations of 616 and 776 mgL^{-1}, respectively.

Gypsophila

Wahome *et al.* (2011) studied gypsophila production in hydroponics systems, revealing that vermiculite and sawdust produced taller seedlings and longer flower stems, respectively. Bag culture hydroponics system yielded the best vegetative development, blossom yield, and quality. Bar-Yosef *et al.* (2001) observed cyclic fluctuations in pH when NH_4^+ and NO_3^- were used for gypsophila (*Gypsophila paniculata*) in a closed system. During the first day, NH_4:NO_3 in the circulating solution was maximal and pH dropped, but because NH_4^+ uptake was faster than NO_3^-, NH_4:NO_3 decreased rapidly and pH increased.

Marigold

Sarmah et al. (2020) conducted a study on quality of marigold flowers grown under hydroponic system at AAU, Assam. Three levels of hydroponic nutrient solution (EC 1.0, EC,1.5 dS/m, and EC 2.0) were used in five different hydroponic systems. When comparing the systems, NFT produced flowers of a higher caliber than any other system. Early bud and floral development among the nutrients was found to be superior in EC 1.0. This leads to the inference that the treatment combo of NFT and EC 1.5dS/m is best for marigold flower output of high quality.

Other ornamentals

Pansy (*Viola* x *wittrockiana* Gams.), petunia, and vinca (*Catharanthus roseus* G. Don) produced higher substrate-pH in a study involving seedlings grown in a peat:perlite substrate, while celosia (*Celosia cristata* L.), tomato (*Lycopersicon esculentum* Mill.), and zinnia (*Zinnia elegans* Jacq.) produced lower substrate-

pH (Huang *et al*., 2001). According to Johnson *et al*. (2013), impatiens was midway between geranium and petunia, with geranium being more acidic and lowering substrate-pH while petunia was more basic and resulting in a higher pH. Taylor *et al*. (2010) defined "sudden pH drop syndrome" in geranium as a sudden decline in substrate-pH caused by phosphate (P) deficit. In comparison to plants cultivated with appropriate P, plants grown with reduced P in soilless container substrate and lacking P in hydroponic solution corresponded with quick declines in root zone pH, the suppression of NO3 - N absorption, and a shift towards increased cation/anion uptake (Taylor *et al*., 2008a, 2008b, 2010). When tissue levels become low, intense H+ outflow from roots may be an adaptive reaction to solubilize P in mineral soils (Marschner, 2012, Ch 14.4). It is still unknown, though, if the pH reduction in geranium that Taylor *et al*. (2010) saw under low P circumstances was a result of increased cation/anion absorption following the limitation of a macronutrient anion supply, or if it was an adaptive response brought on by P deprivation. Miller *et al*. (2002) reported that 30-35% of the cut tulip crop is forced hydroponically for flowering.

Landscaping

Dhanasekaran (2020) evaluated the performance of foliage ornamentals on different nutrient solutions, proposed by Hoagland and Arnon (1938), Cooper (1979), Saparamadu (2010), Mattson and Peters (2014), and a control using irrigation water underneath a passive hydroponic vertical garden module. Results showed that T_3 (Cooper's solution) had the highest chlorophyll concentration, while T_2 (Hoagland solution) had the highest membrane integrity content. T_4 (Saparamadu's solution) had the lowest relative growth rate.

Conclusion

The application of hydroponics in floriculture is vast. This review is an initiative to brief the same so that future research works can get a baseline perspective. Rose, Gerbera, Gladiolus, Lily are the ones where extensive research has been practiced utilizing hydroponics system, further works can be done to get the technique exploited and economical for floriculture sector.

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Maturity Indices of Vegetable Crops

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The maturity indices are also called as "Maturity Standards" or "Signs of Maturity". Maturity signs help in judging maturity of vegetables. The signs are based on experience and skill and judgment. As the market value depends upon quality of the produce, the knowledge regarding maturity indices of right stage of harvest carries vital importance. Secondly shelf life of the produce in some fruits depends upon maturity stage of harvested produce.

The level of maturity actually helps in selection of storage methods, estimation of shelf life, selection of processing operations for value addition etc. The maturity has been divided into two categories i.e., physiological maturity and horticultural maturity.

Physiological maturity: It is the stage when a fruit is capable of further development or ripening when it is harvested i.e., ready for eating or processing.

Horticultural maturity: It refers to the stage of development when plant and plant part possesses the pre-requisites for use by consumers for a particular purpose i.e., ready for harvest.

Importance of maturity indices

- ✓ Ensure sensory quality (flavour, colour, aroma, texture) and nutritional quality.
- ✓ Ensure an adequate postharvest shelf life.
- ✓ Facilitate scheduling of harvest and packing operations.
- ✓ Facilitate marketing over the phone or through internet. (Dhatt *et.al*, 2007)

Maturity indices of Vegetable crops

Tomato: Depending upon the purpose for which they are used and market distance, tomatoes are harvested manually by plucking the fruits at different maturity stages.

- ➢ **Green stage:** The mature green fruits are generally harvested to send them to the distant market.
- ➢ **Pink Stage:** At this stage colour turns to pink or red at the blossom end. They are picked for local market.
- ➢ **Ripe stage:** At this stage surface of the most of the fruits is red and the soften of fruits begins.
- ➢ **Fully Ripe:** At this stage fruits have approached maximum colour development and are soft. Starch is charged into sugars. They are generally consumed or used for canning and processing.

Brinjal: It matures after 40 days from flowering, glossy appearance. (Dhatt *et. al*, 2007)

Chilli: Depending on purpose chillies are harvested at two stages, one for green vegetables and the other as dry chillies.

- ➢ Green Chillies are harvested when they are fully mature and before they change from green to red.
- ➢ Chillies for drying should be harvested when colour changes from green to red.

Okra: Desirable size reached and the tips of which can be snapped readily.

Potato: Tops beginning to dry and topple down.

Cucumber: Fruits can be harvested from 45 days after sowing. The tender fruits (for salad) can be harvested on 8th to 10th day of flowering. (Ramjan *et. al*, 2017)

Pumpkin: Pumpkin fruit are usually fully mature and ready for harvest about 3 months after sowing, or approximately 45 days after flowering.

Bottle gourd: Fruits should be light green, 30-35 cm long, tender with little pubescence persisting on the skin. (Ramjan *et. al*, 2017)

Bitter gourd: Fruits mature 55 to 110 days to harvest. Picking is mainly done when the fruits are tender and green.

Ridge gourd: The crop matures 60 days after planting. Fruit attains maximum size.

Water Melon

- The portion of fruit resting on ground starts turning colour from creamy white to yellow.
- The sugar content of fruit measured as soluble solids using hand refractometer is reached 10 % or more in flesh near centre of fruit.
- On thumbing, the immature fruits give out metallic ringing sound and the ripened dull hollow sound (Chauhan, 1972).

Musk melon: Muskmelon is generally picked at 'half-slip' stages for commercial marketing (part of the pedicle remains attached to the fruit, i.e., abscission layer is not fully developed). Full slip is stage at which the pedicle separates easily from the fruit with little or no pulling. (Rana, 2008)

Amaranthus: Usually starts in about 3-4 weeks after sowing.

Palak: Green succulent tender leaves come at 25-30 days after sowing. It may continue to 15-20 days interval.

Onion and Garlic: Maturity can be judge by the neck of the plants drying up, tops falling over while the leaves are still green (Rana, 2008).

Carrot and Radish: European type is ready for harvesting within 30 days from sowing and Asiatic type within 45 to 60 days from sowing. At this stage roots are mild, tender and crisp and usually of the proper marketable size.

Beet root: Most beetroot varieties mature in 55 to 70 days and harvesting generally starts when the roots are about 5 cm in diameter (golf ball size).

Cabbage: Solidity, firmness, squeaking of heads indicates maturity (Kalia, 2011).

Cauliflower: Curd size and colour are deciding factors. Snow white or creamy white, compact curds surrounded by turgid green leaves (Kalia, 2011).

Dolichos bean: Well, filled pods that are beginning to lose their greenness.

French bean: Pods mature and ready for harvest 2 to 3 weeks after first blossom. Pods are harvested when they are young, tender and delicate.

Cluster bean: Crop starts bearing pods 40 days after sowing depending upon variety. Pods are picked at tender stage.

Garden pea: The pods are harvested when they are filled, tender, having high sugar content and changing colour from dark green to light green.

Conclusion

Harvesting should be done at proper stage of maturity because it not only determines the quality of product but also prolong its shelf life. If it picked immature lacking in normal brix acid ratio or sugar acid ratio, taste and flavour on the other hand if the vegetables are harvested over mature or full ripe they are easy susceptible to microbial and physiological spoilage and their storage life is considerably reduce. Therefore, it is required to pick up the vegetables at correct stage of maturity to facilitate distant transportation and maximum storage life.

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Indoor Gardening - Best Way to Avoid the Hidden Pollutants

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Growing plants indoors is the only true definition of indoor gardening. Any enclosed space, whether an office building, a restaurant, or a private residence, could be used for this.

Importance of indoor air quality

According to the Environmental Protection Agency, we spend around 90% of our time indoors, whether we're sleeping, relaxing at home or working in an office. This time spent indoors exposes us to indoor air pollution.

- furnishings
- carpet
- cushioning
- dry-cleaned clothing
- paint
- synthetic building materials
- cleaning products
- pesticides
- bacteria
- mold
- outdoor pollution that enters

A home or office may also contain additional things that emit volatile organic compounds (VOCs), such as formaldehyde, such as paint on the walls, furniture padding and particle board coffee tables etc.

All of us are subject to some degree of indoor air pollution, and it's probably not a problem. However, it can sometimes make you feel nauseous if the ventilation is poor or if you're a particularly sensitive person likely causing headache, dizziness, nausea, eye, nose or throat irritation, dry cough, dry or itching skin, difficulty in concentration, fatigue, sensitivity to odours, hoarseness of voice, allergies, cold, flu-like symptoms, increased incidence of asthma attacks and personality changes it is sometimes called sick building syndrome.

Common Indoor Pollutants

Trichloroethylene – Found in printing inks, paints, lacquers, varnishes, adhesives, and paint removers. Symptoms associated with short-term exposure include: excitement, dizziness, headache, nausea, and vomiting followed by drowsiness and coma.

Formaldehyde – Found in paper bags, waxed papers, facial tissues, paper towels, plywood paneling, and synthetic fabrics. Symptoms associated with short-term exposure include: irritation to nose, mouth and throat, and in severe cases, swelling of the larynx and lungs.

Benzene – Used to make plastics, resins, lubricants, detergents, and drugs and found in tobacco smoke, glue, and furniture wax. Symptoms associated with short-term exposure include: irritation to eyes, drowsiness, dizziness, headache, increased heart rate, confusion and in some cases can result in unconsciousness.

Xylene – Found in rubber, leather, tobacco smoke, and vehicle exhaust. Symptoms associated with short-term exposure include: irritation to mouth and throat, dizziness, headache, confusion, heart problems, liver and kidney damage and coma.

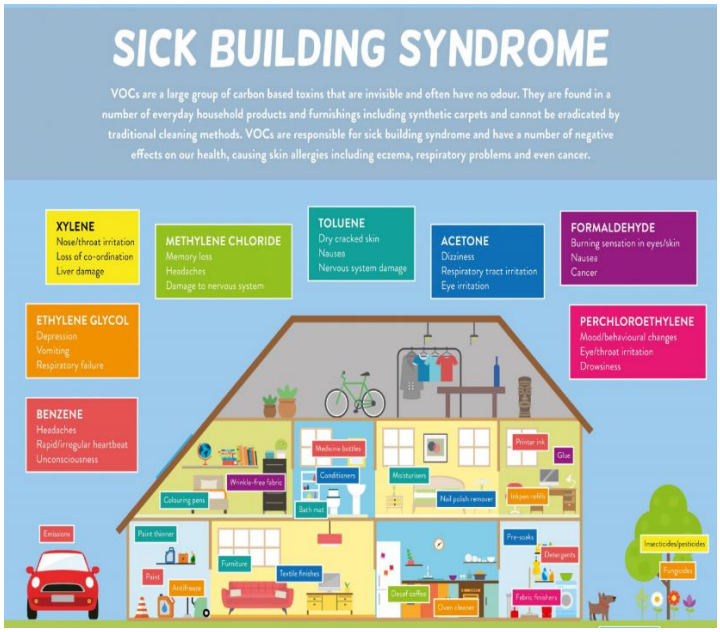
Ammonia – Found in window cleaners, floor waxes, smelling salts, and fertilizers. Symptoms associated with short-term exposure include: eye irritation, coughing, sore throat.

Nitrogen Dioxide (NO2) – This harmful gas is formed by emissions from vehicles and factories during the burning of fuel. It is high in concentration in regions that are congested with vehicles and traffic. The gas is a respirator irritant, causing specific damage to the cardiovascular and respiratory system. It is known to

cause airway inflammation among healthy individuals.

Sulphur Dioxide (SO_2) – A highly reactive gas that carries a smell which is pungent and irritating, Sulphur dioxide is formed by the burning of fuels in industries and factories. Its presence in the air results in the irritation of the lining of lungs, throat and nose, worsen the symptoms of patients with existing respiratory diseases such as asthma, and other cardiovascular problems.

Suspended Particulate Matter – Suspended Particulate Matter, or SPM, refers to the suspended solid and liquid particles in the air that are too small in size to be seen with the naked eye. Its short effects include irritation of the eyes and the respiratory tract, with the long-term exposure causing asthma and weaker cardiovascular function.



Health benefits of air-purifying indoor plants

Indoor plants can still improve your air quality even though it would take ridiculously massive amounts of foliage to impact VOC levels in your home or workplace.

- reduce irritation to eyes, ears, nose and throat
- prevent or ease coughing and blockage
- lower your stress
- boost your attention capacity

Indoor plant purification raises relative humidity and lowers CO2 levels. They function as a natural humidifier and assist in eliminating stale air, which can lessen or prevent irritation of your throat, eyes, nose, and even lungs. Foliage does more for people's health than only improve the quality of the air. Stress can be decreased by interacting with your home plants.

Top 10 recommended air-purifying indoor plants for pots

Chrysanthemum

- Chrysanthemum are the perinnial plants with attractive blooms.
- They are inexpensive and available at any nursery
- Pollutants removed: ammonia, benzene, formaldehyde, xylene.

Spider plant

- Scientifically know as *Chlorophytum comosum*
- Easiest air-purifying plants to grown in pots as well as hanging baskets they love bright and indirect sunlight
- Pollutants removed – formaldehyde and xylene

Dracaena – *Dracaena spp.*

- Comes in more than 40 different varieties
- Toxic to cats and dogs when eaten
- Pollutants removed- benzene, formaldehyde, trichloroethylene, xylene.

Ficus/weeping fig – *Ficus benjamina*

- Loves bright, indirect sunlight
- Pollutant removed: benzene, formaldehyde, trichloroethylene.

Peace lily -*Spathiphyllum sp.*

- Blooms fragrant flowers throughout summer
- Grows best in shade areas
- Pollutants removed-ammonia, benzene, formaldehyde, trichloroethylene.

Boston Fern- *Nephrolepsis exaltata*

- Need to stay moist
- Prefer high humidity and indirect light
- Pollutants removed: formaldehyde, xylene.

Snake plant- *Sanseveria trifasciata*

- Require occasional watering
- Prefer drier- conditions and some sun
- Pollutants removed – Benzene, formaldehyde, trichloroethylene, xylene.

Bamboo palm- ***Chamaedorea seifritzii***

- Thrive in full sun or bright light
- Pollutants removed-benzene, formaldehyde, trichloroethylene.

Aloe vera – ***Aloe vera***

- Leaves hold a fluid that has anti-inflammatory, antibacterial, wound healing properties
- Pollutant removed- formaldehyde
- If you're looking for a fast cure for burns, you should keep this plant in your kitchen window. Just split a leaf and apply near the burnt area.

Money plant

- Commonly known as golden pothos and devils ivy
- It removes the toxins like xylene, formaldehyde, carbon monoxide, benzene.
- In addition, the plant is said to draw luck, prosperity, and good positive vibes.
-

Repotting of indoor plants

The best time to repot a plant is in the spring or summer when the plant is at active growth. The first step to be identify whether the plant shows the signs of pot-bound condition and others symptoms like drying out of potting mixture quickly even at cooler parts of the day and the foliage and stems stop growing.

If the above signs are likely then remove the plant from the container and examine the roots. If the roots are circling around the rootball and densely packed that it is difficult to see any potting mix in the bottom third of the root ball then it is necessary to remove the outer section of plant roots, return the rootball to the container with some new potting mix and cut back some of the top growth. Prepare to repot the plant if the intention is to allow it to grow larger.

******* Plant Indoor Plants to Create a Healthy Environment*******

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Review on Major Physiological Disorders of Cole Crops

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Brassica or cole crops are one of the world's most significant vegetable crops. The Brassicas offer the widest range of products that can be produced from a single genus. They produce vegetables such as leaves, flowers, stems, and roots that can be eaten raw or cooked [4]. *Brassica oleracea* (Cole or cabbage group) and Oriental types (Chinese cabbage and its relatives), which contain vitamins and cancer-preventing compounds, are of vital importance for human nutrition. The wild species found along the Mediterranean shoreline, whose progenitor was an annual herb gave rise to the species *Brassica oleracea* (with the exception of rape = *Brassica napus*), which was developed in Central and Western Europe [13]. Broccoli, cabbage, cauliflower, and Brussels sprouts are examples of varieties of the *Brassica oleracea* species that belong to the Brassicaceae family. Most cole crops grow best at temperatures between 60 and 65 °F [15]. The fact that these plants are related and have comparable climatic needs as well as common pests and diseases should be kept in mind. Although they are similar, they are not the same. Between broccoli varieties, there could be more variation than between broccoli and cauliflower. Each group has had many varieties created, varying in terms of pest susceptibility, temperature tolerance, shape, color, and growing season. To find out which varieties are suitable, speak to other farmers in your community or your Extension agent. Regardless of the season in which the crops are grown, they are susceptible to a number of diseases and physiological problems that lower the quality of the produce. The majority of physiological disorders are frequently brought on by mineral deficiencies, usually micronutrients, as well as environmental stress brought on by erratic and uncontrollable weather conditions [16]. The absence of physiological disorders in Brassica crops is crucial, not only for aesthetic reasons but also because they may have an impact on other qualities like nutritional value and shelf life.

Physiological disorders of Cole Crops

Buttoning

In broccoli and cauliflower, buttoning is an early form of heading. Foliar growth stops, and small heads (1 to 4 inches in diameter) form. The heads are of poor quality, though they may continue to grow. There aren't enough leaves on the cauliflower to blanch the curds. Buttoning can happen at any time from seeding until the plants are almost fully grown, but it usually happens within a month of field transplantation. Young plants are under stress due to low or high temperatures, moisture stress, transplant shock, or nutrient deficiencies, which leads to this issue. By cultivating varieties that are well suited for that climate and taking good care of the plants in the greenhouse and field, the seedlings to be transplanted should not be more than six weeks [17].

Whiptail

Whiptail is a physiological disorder of cole crops, such as cauliflower, broccoli, cabbage, and Brussels sprouts. It is caused by a molybdenum deficiency in the soil. Molybdenum is an essential micronutrient for plant growth and development. It is involved in the metabolism of nitrogen and phosphorus, which are essential macronutrients for plants. The main symptom of whiptail is the narrowing of the leaf blades. The leaves become strap-like and the midrib becomes prominent. The growing point of the plant may also be deformed, resulting in a lack of head formation in cauliflower and broccoli. Leaf margin chlorosis can cause the entire leaf to turn white. The leaf blades don't grow out correctly [6]. Molybdenum deficiency typically happens in acidic soils when the pH is under 5. To control this condition, it is helpful to apply 0.5–1.0 kg of sodium or ammonium molybdate per hectare, or 0.1-0.3%

ammonium molybdate with 0.1% teepol as a sticker. To increase the pH to 6.5, add lime to the soil.

Browning (brown rot or red rot)

Cauliflower turns brown when it lacks boron. Typically, after curd formation, plants show external signs of boron deficiency. On the stem and curd, the water-soaked areas first appear early in the stage. As the plant matures, the stem becomes hollow, and tissue soaked in water coats the interior walls of the cavity [18]. At an advanced stage, the curd surface exhibits brown or pink surfaces. It can be managed by adding borax. The quantity of borax varies depending on the type of soil, pH, and degree of deficiency. While alkaline soil may need large amounts of borax, acid soil only needs 10–15 kg/ha.

Bolting

When young plants of biennial vegetables, such as cabbage and cauliflower, are exposed to low temperatures for an extended period of time, between 50 and 55 degrees Fahrenheit, bolting (early flowering) is likely to occur later in the season [11]. Plants that are bolted have no market value. When plants are about four weeks old, plant them in the field. Bolting can be reduced by adhering to the same temperature recommendations that were provided above for the prevention of buttoning. To prevent and manage bolting in cole crops, following measures can be adopted-

- Choose varieties that are resistant to bolting.
- Plant at the appropriate time of year- Planting too early or too late can make plants more susceptible to bolting.
- Provide adequate spacing between plants- This will allow for good air circulation and help to reduce stress on plants.
- Maintain adequate soil moisture and fertility- This will help to reduce stress on plants and ensure that they have the nutrients they need to produce a healthy head or curd.
- Avoid over fertilizing with nitrogen-Too much nitrogen can promote bolting.

Hollow stem

Tissues become discolored and exhibit the appearance of being wet. The affected stem is completely clear and white and shows no signs of deterioration. It is caused by boron excess or deficiency [12]. Closure spacing, the best use of nitrogenous fertilizers, and borax at 0.3-0.4% can all help to correct it.

Riceyness

The term "riceyness" describes the early appearance of flower bud initials on the curd surface of cauliflower, which is regarded as unfavorable for the market [19]. Cauliflower which is too ricey makes the curds uneven and fuzzy, which lowers their marketability. This disorder is caused by warm temperatures (> 68° F) during curd development. At 68 to 80°F, some more recent hybrids can start to grow heads. The ability to develop mature floral structures is momentarily inhibited during the curd development stage [4,5], whereas the iterative proliferation of apical meristems of branches causes a rapid increase in curd size. When the curd reaches the post-maturity stage, some pedicels begin bolting along with the differentiation of floral meristems, and the plant then starts to bloom [3,6].

Fuzziness

The lengthening of the leafy floral bracts of the bud or flower causes fuzziness, giving the curd's surface a velvety or hairy appearance. Before appearing elsewhere, it frequently first appears around the curd's edges [1].

Hollow Stem

Insufficient boron or high nitrogen levels are the main causes of this. The stem exhibits the symptoms. The stem's thick, fleshy center splits, creating a cavity. This cavity creates openings to the outside environment at both ends. It can be controlled by using close spacing, the necessary amount of nitrogen, or by spraying 0.25 to 0.50% borax [8].

Blindness

Blindness in cauliflower is a physiological disorder that prevents the formation of the head (curd). The plant may produce leaves, but the curd does not develop. By storing carbohydrates, the leaves grow larger, thicker, darker greener, and leatherier while the plant remains vegetative stage [9]. Cutworms and the low temperature are to blame for this [10]. Insecticides that kill the insects, protect the buds from damage, and prevent exposure to low temperatures can be used to control this.

Pinking

The curd shows a pink tinge because of exposure of the curds to high light intensities. anthocyanin pigment develops which imparts pink color to curd. Blanching is the best way to control pinking.

Splitting or Cracking

Early cabbage often experiences splitting when moisture stress is followed by heavy rain. Splitting can occur as a result of rapid growth brought on by rain, high temperatures, and high fertility. Splitting might be avoided with appropriate irrigation and deep cultivation [2]. The susceptibility of various cultivars to this issue varies significantly.

Tip Burn

Tip burn is the term used to describe the browning of the internal leaf edges or tips found within the heads of cauliflower, broccoli, and cabbage [14]. During storage or transportation, these brown spots frequently disintegrate, allowing secondary organisms to decompose the product. Rapid growth brought on by too much nitrogen, a high temperature, water stress, and a calcium deficiency is the issue [7]. Although calcium can be found in the soil, it can only move a small amount to the plant before it becomes unavailable to support rapid growth. Applications of additional nitrogen should be timed to prevent rapid growth in the plant's later stages of development.

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Biotechnology as a Tool to Enhance Shelf Life and Quality of Fruit Crops

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The quality of fruits can be defined as the combination of fruit attributes or characteristics which have significance in determining the degree of consumer acceptance. Fruit quality includes organoleptic and nutritional aspects closely related to their biochemical composition, especially low molecular weight organic compounds like metabolites, including sugars, organic acids, amino acids, phenolic compounds, isoprenoids, alkaloids, besides minerals, starch and cell walls. Among the various pre- and post-harvest factors which improve the postharvest quality of fruit crops, biotechnology can play an important role in enhancing the shelf life as well as quality of fruit crops.

Term "Biotechnology" refers to the technology that utilizes biological systems, living creatures or components of this to develop or create different products. It is a modern tool for the improvement of any fruit crops in the terms of quality and quality of the produce. It uses cellular and biomolecular mechanisms to produce technology and goods that enhance both the quality of our life and environment and also it shortens the time and improves precision.

Need of biotechnological approaches in fruit crops

- Overcome distant hybridization barriers
- Production of true to types
- Short breeding cycle
- More precise and selective
- Eliminates long field trial
- Easy to enhance the quality of fruit

Plant biotechnology has the potential to play a key role in the quality improvement of fruit crops. To create fruit crops with a higher yield and better fruit quality, biotechnology involves the application of tissue culture and genetic engineering. Biotechnologically improved fruits have been developed with unique characteristics that are often difficult to achieve by conventional breeding and are designed to meet the specific needs of growers or customers. By reducing the time required to obtain improved values, it advances the improvement approach.

Tissue culture

Tissue culture is based on the principle of totipotency, by which a new plant can be grown from a single cell of that plant. Anthers/microspore culture, somaclonal variation, embryo culture, meristem culture and somatic hybridization are some basic techniques of tissue culture that are being used to provide beneficial genetic variability for achieving incremental improvements in commercial cultivars.

At present, practically all fruit crops can be micro-propagated. In many horticultural crops, meristem culture has made it possible to provide planting material free of viruses. The strawberry is the first fruit crop for which the micro-propagation method has been standardized but this technique is commercially exploited mainly in banana and pineapple and at some places in strawberry also.

Through tissue culture, bananas are propagated for commercial purposes. Controlling the BBTV disease is absolutely necessary for the country's banana sector to thrive in the future. The best option is to replace contaminated areas with productions of disease-free banana plants using in vitro methods. G-9 is the most common variety of banana used for tissue culture. The produce from the tissue cultured plant get better price in market due to better quality and uniformity and in addition, this plant matures early and ratooning is unique features in them.

Genetic engineering

Genetic engineering also known as genetic modification or genetic manipulation, it is the technological modification and manipulation of an organism's gene. It is a set of technologies used to alter the genetic composition of cells, including the

exchange of genes across and within species to produce improved or novel organisms.

An organism that is produced through genetic engineering is considered to be genetically modified (GM) and the resulting entity is a genetically modified organism (GMO). The resulting organism is referred to be transgenic if it contains genetic material from another species and an organism is referred to as cisgenic, if it is created using genetic material from another member of the same species as the host or another species that can naturally breed with it.

There are many fruits which have been developed by genetic engineering with unique characteristics. Some of them are Pink glow pineapple, Super banana, Arctic apple, Honey sweet plum and transgenic papaya.

Pink glow pineapple

Pink glow pineapple is a transgenic pineapple developed by Del Monte Fresh Produce in the early 21st century. It received approval in 2016 and officially released to consumers in October 2020. Pink glow pineapples grow in Costa Rica but can be purchased in the United States and Canada. The skin of the Pink glow pineapple also has a combination of green, yellow, orange and red colors, whereas conventional pineapple is green and yellow while the flesh is pink in colour due to higher lycopene content. In conventional pineapples, lycopene, a naturally occurring enzymes, gets transformed into beta-carotene to impart yellow colour to fruit. Whereas the Pink glow pineapples contain lower levels of enzyme that causes this transition and make the pineapples pink. It is sweeter, juicier and less tart as compared to the regular pineapple. It is also aromatic and have low acidity, emitting a pleasant, fruity and subtly floral flavor with a lingering candy-like sweetness. There is delayed in ripening due to low ethylene production. The crown is removed from these pineapples prior to shipping so that the farm may sustainably transplant the crop and produce more. As a result, they are sold without their crown.

Non browning apple

Arctic apple is the trademark for a group of patented apples that contain a non-browning trait introduced through biotechnology. It is developed by Okanagan Specialty Fruits Inc by the process of genetic engineering that involved inserting modified apple DNA (that controls browning) in it. The enzyme responsible for browning is suppressed by RNA interference (RNAi) and reduced PPO to less than 10% of what would typically be found.

In 2015, it is approved for sale by USDA in America. The United States Department of Agriculture (USDA), the Food and Drug Administration (FDA), and the Canadian Food Inspection Agency (CFIA) have all declared that Arctic Apple are "as safe and healthy" as regular apple types. Arctic apple development will result in a decrease in food wastage because it maintains its crispness and appearance for a longer amount of time despite exposure or physical damage. Arctic Golden Delicious, Arctic Granny Smith and Arctic Fuji are three commercial varieties of Arctic apple.

Super banana (Golden banana)

Super banana or Golden banana is a bio fortified banana which was initiated at Queensland University of Technology (QUT), Australia to develop provitamin A (β- carotene) rich varieties. It is modified with the phytoene synthase gene (PSY2a) found in asupina banana which is naturally high in beta carotene, and introduced into Cavendish banana.

Biofortified bananas have the same yellow peel as the ordinary fruit, their flesh is more orange in colour, as a result of the high Vitamin A content and so also termed as golden banana (Super banana). Bananas' beta carotene content can be increased by the gene construct to 20 µg per gram dry weight. Being densely packed with vitamin A, it is important for our body functions including vision, skin health and the proper working of our immune system. Banana is the stable food for many African countries and this golden banana can be very helpful for making the population free from malnutrition.

Honey sweet plum

Honey sweet plum is a genetically modified plum developed by the US Department of Agriculture, which is resistant to plum pox virus (PPV). It is developed by RNAi technology and patented in the US in 2004. The gene for PPV coat protein was separated from the PPV virus and inserted into the plum DNA, which was then regenerated and grown into complete plum trees. These trees now had the additional gene in their DNA and became resistant to PPV. It contains a gene from the virus that protects the plant through acquired immunity, much like vaccination in animals. The fruit quality and quantity of Honey sweet plum was not affected by PPV infection, even when researchers added other severe plum viruses to increase the viral load. Its fruit is large and oblong in shape with a very sweet and flavorful taste.

Transgenic papaya

Transgenic papaya was developed by Dennis Gonsalves which is resistant to Papaya ring spot virus (PRSV). It was developed by particle bombardment mediated transformation technique. Papaya ring spot is a devastating viral disease in papaya and Rainbow and Sun Up are the transgenic variety which is resistant to it. Sun Up papaya was crossed with 'Kapoho', a non-engineered cultivar, yellow-flesh 'Rainbow' papaya, which is also resistant to PRSV. Currently, transgenic Papaya is being grown in Hawaii and accounts for more than 70% of Hawaii's Papaya acreage.

Altogether, the combined exploitation of genetic variability and innovative biotechnological tools may facilitate breeders to improve fruit quality taking more into account the consumer standards and the needs to move forward into more sustainable farming practices.

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Unlocking the Benefits of Ash Guard Juice: A Health Revelation

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The ash gourd plant grows as a trailing vine every year. Benincasa hispida (Thunb) is its scientific name, and it is a member of the Cucurbitaceae family. It has a distinctive fruit that resembles a melon and is frequently consumed for its therapeutic and practical benefits. In South East Asia, including India, Japan, China, Myanmar, Malaysia, China, Indonesia, and Taiwan, ash gourd plants are grown in warm, humid tropical regions.[1,2]

Did you know that the ash gourd fruit is also known as the wax gourd because of the waxy sheen on its skin and the ash color of its skin. It is commonly cultivated during the rainy season and is also known as the Winter melon. The Ayurvedic concoction of ash gourd, called "Kushmanda" in Sanskrit, was regarded to have therapeutic powers in prehistoric medical systems. The ripe ash gourd fruit is steeped in sugar syrup before being used to make the most well-known dessert, "Agra ka Petha." You may be familiar with some of the other names for ash gourd, including Donggua in Chinese, Beligo in Indonesian, White gourd, White pumpkin, and Ash pumpkin. [1,2]

Let's read more about the beneficial properties and potential uses of this Ayurvedic ash gourd juice.

Nutritional value of Ash gourd juice

The essential nutrients of ash gourd fruit are proteins, flavonoids, carotenes, vitamins, minerals, volatile oils, etc. Ash gourd fruit is majorly composed of 96% water; the reaming nutrients are as follows:[1,3]

Table 1: Nutritional Value of Ash gourd fruit per 100 grams.[1]

Nutrient Components	Value/100 grams
Carbohydrate	3.96 g
Protein	12 g
Fibre	2.9 g
Zinc	0.6 mg
Calcium	30 mg
Iron	11.8 mg
Vitamins B1	0.04 mg
Vitamin B3	0.528 mg
Vitamin B2	0.145 mg
Vitamin C	17.2 mg
Vitamin B6	0.046 mg
Vitamin B5	0.176 mg

Properties of Ash gourd juice

A typical vegetable with potential health benefits is the ash gourd fruit. The bioactive nutrients may provide potential advantages in treating a number of chronic disorders.3 Ashe gourd juice has the following qualities:

- It could have prebiotic (good bacteria producing) potential.
- It may reduce acidity by acting as an antacid.
- It could function as a detoxifier, clearing the body of toxins.
- It could possibly have an anti-inflammatory effect.
- It could lower fever.
- It could have anxiolytic (anxiety-relieving) effects.
- It may help prevent seizures by having an anticonvulsant effect.
- It might be beneficial for depression
- It could function as an antioxidant and reduce blood glucose levels.
- It might aid in decreasing blood lipids.
- It could possess potential antibacterial and antiparasitic properties.
- It could bronchodilate, which would ease breathing.[1,3]

Potential Uses of Ash gourd juice

Ash gourd might be utilized as a functional meal since all of the fruit's components appear to have health-promoting qualities, according to certain research.[3,4] However, more extensive research is required to determine how useful they are for people.

The following is a list of possible applications for ash gourd juice:

Potential uses of ash gourd juice for diabetes

Juice from ash gourds has no fat, few calories, and few carbs. Due to its nutritional profile, it can be a fantastic option for diabetic sufferers. The fruit's pulp may be anti-diabetic thanks to the minerals it contains. The fruit's dried powdered peel, when combined with honey, may help reduce blood sugar levels.

According to a human research by Majumdar et al. (2010), people with Type 2 diabetes can lower their blood glucose levels by drinking ash gourd juice. To demonstrate the advantages of ash gourd juice for diabetes, additional research is needed.[1,2].

Potential uses of ash gourd juice for weight loss

Ash gourd juice's different qualities may aid in weight reduction control. Because ash gourd juice is low in calories and fats, it may be good to persons trying to reduce weight. Ash gourd juice's lipid-lowering characteristics and high dietary fibre content may help lower blood cholesterol and lipid levels, which may help lower body fat.

According to Waidyarathna *et al*. (2020), using pulverized peeled raw ash gourd fruits and seeds with an equal amount of water and little salt may help you lose weight rapidly. [1,2,4] Although this knowledge is minimal, additional research is needed.

Potential uses of ash gourd juice for ulcers

People suffering from peptic ulcers (connected to the digestive tract and stomach) may benefit from the health advantages of ash gourd juice. Shredding the fruit and combining it with water yields ash gourd juice. Drinking ash gourd juice on an empty stomach may assist with peptic ulcers; after drinking the juice, avoid eating for at least three hours. Ash gourd has been mentioned as a good medication for gastric ulcers in the Ayurvedic medical system. [2] Because this information is outdated and limited, large-scale human investigations are required to substantiate these advantages.

Potential uses of ash gourd juice for skin

The skin-beneficial characteristics of ash gourd juice are related with its advantages. The fruit extract is used to make face cream; it may be beneficial and successful in preventing the degeneration of skin cells as we get older. Huang et al. (2004) discovered that several fruit constituents (pulp, peel, seeds) contribute to antioxidant activity, which may help combat ageing-inducing free radicals. It may also help to reduce oxidative damage and manage the effects of skin cell deterioration. [4] More research is needed to prove the skin-beneficial effects of ash gourd juice.

Other Potential uses of ash gourd juice

- Ash gourd juice may be beneficial in cases of food poisoning.
- It may aid with unpleasant urination (dysuria) and pain relief in sensitive areas.[4]
- It may alleviate symptoms of a common cold, fever, cough, sinusitis, and other illnesses.[2]
- Ash gourd juice may aid in the relief of constipation, inflammation of the stomach, and general digestive system function.[2,4]
- Ash fruit juice is a delightful drink that can help with a variety of brain-related ailments such as seizures and insanity (mental illness).[4]

Ash gourd may have antacid action; it may be beneficial in maintaining the pH of the body and the acid levels in the stomach by reducing the acidity caused by meals such as soft drinks and fried food.[2]

Ash gourd fruits can be used as a laxative (to relieve constipation) and although some research demonstrate that ash gourd juice is beneficial in a variety of illnesses, this knowledge is inadequate.

As a result, additional research is needed to prove the health advantages of ash gourd juice.As a result, before consuming ash gourd juice for any medical ailment, please visit a doctor.

How to Use Ash gourd juice?

Ash gourd juice includes important elements that are necessary for healthy health.1 It has the following applications:

The fruit of the ash gourd can be eaten fresh, like cucumber, or cooked with meat.

1. It may be used in the preparation of ice cream, jams, sauces, beverages, and desserts.
2. The peeled, immature fruit can be stir-fried, braised, or steamed and utilized in spicy meals.
3. The fruit of the ash gourd is also used to manufacture sweet candies (Petha) and nuggets (Bari).
4. The pulp of the fruit is used to make herbal gruel and chutney.
5. Deep-fried ash gourd stems are eaten like chips or papad.[4]

Side Effects of Ash gourd juice

The side effects of ash guard juice are as follows: Ash gourd contains anti-nutritional elements (phytates, oxalate, and so on) that may impair the body's capacity to absorb nutrients. A diet high in ash gourd juice may increase the risk of calcium deposition, which can lead to kidney stones[1]. Various animal toxicological studies reveal that ash gourd juice is harmless and may not have any negative effects. However, if you experience any harmful reaction, immediately contact an Ayurvedic doctor and get appropriate treatment.

Precautions to Take With Ash gourd juice

If consumed in small doses, ash gourd is considered harmless. However, there are certain precautions to take when drinking ash gourd juice.

- As a result, those with renal difficulties should limit their use of ash gourd juice.
- There is insufficient data to determine the safety of ash gourd juice for pregnant or nursing women. As a result, it is critical to get the opinion of an Ayurvedic physician before using it as a herb.
- Small children and the elderly should be given ash gourd juice with extreme caution.
- We advise you to consult an Ayurvedic physician who will recommend you a safer dosage form.

Interactions with other Drugs

There is insufficient information. However, it is not suggested that ash gourd juice be consumed orally in conjunction with any mineral medications.[4]

It is always recommended to seek the guidance of an Ayurvedic physician who can advise and suggest a more effective manner to take this herbal drink.

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Value-added Products from Jackfruit and Papaya for Food Security and Sustainable Development

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Jack trees are seen in India, Bangladesh, Malaysia, Myanmar, Srilanka, Indonesia and Philippines in Asian region and they are also seen in western forests of Africa, northern part of Australia and also in the states of Florida and California in USA.

A survey conducted at IRTC on jackfruit availability in Kerala revealed that around 2.5 million tons of jackfruit is produced annually in Kerala of which around 30% is getting wasted due to various reasons like difficulty involved in plucking the fruit from tall trees and the time consumed in processing the same. Jackfruit is seasonal.However papaya is a perennial fruit.

Materials and Methods

Jackfruit and papaya which are the major raw materials are plenty available locally. Ingredients like sugar, jaggery, vinegar etc. are purchased from local markets. Digital refractometer was used for measuring the concentration of sugar in the sugar solution (Brix unit). Jackfruit pulping was done in a pulper for making jackfruit toffee. Tray drier with air flow at controlled temperatures (50^0, 60^0, 70^{0}C) was used for drying the products.

Analysis of fruits for their sugar and fibre content was carried out by wet chemical analysis using standard Techniques[1] and calcium content estimated by atomic absorption spectrophotometer (Elico Model SL243).

Steam sterilization and osmotic dehydration techniques were employed during the processing of these fruits[2,3].

Results and Discussion

Jackfruit and papaya are rich source of vitamins and minerals. Steam sterilization which is done to arrest enzyme action as well as to preserve the texture.Osmotic dehydration is effectively used in preparing some of the products (jackfruit snack and tutti-frutti).This is a processing step used for partial removal of water from plant tissues by immersion in a hypertonic (osmotic) solution.Process details of some of the products are indicated below.

Dried Jackfruit Powder

Deseeded bulbs –> cut into required size –> steam blanched –> dried-pulverised packed (This powder can replace "Atta" by 25% which makes chapati, poori etc. more tasty and palatable).

Jackfruit toffee

Deseeded ripe and sweet jackfruit–>pulped –> mixed with jaggery and corn flour-heated over a flame for uniform mixing –> the thick viscous mass spread in a tray drier –> dried at 60^{0}C for 12 hrs–> cut into toffee shape and packed

Jackfruit biscuit

25% of maida is replaced by jackfruit powder –>mixed with egg butter and sugar –> kneaded thoroughly–> cut into shapes –> baked at 160^{0}C for 28 minutes.

Papaya tutti-frutti

Raw papaya–>cut into 0.5 cm cubes –> kept in 1% $CaCl_2$ solution for 3 hours –> strain and wash thoroughly subjected to osmotic dehydration first at 40^{0}Brix solution and increase sugar concentration to 70^0 Brix –> Strain the cubes –> dried in a hot air oven for 6-8 hours. It is a ready-to-eat snack.

Jackfruit Powder

Jackfruit Toffee

Papaya Tutti-frutti

Shelf life studies:

Product	Shelf life
Jackfruit Powder	**1 year** (under room temperature)
Jackfruit Toffee	**6 months** (under refrigeration)
Tutti-frutti (without preservatives)	**3 months** (under refrigeration)
Jackfruit biscuits	**2 months** at room temperature

All the above products are tasty and healthy. These Studies indicated that have reasonably good shelf life.The dietary fibre content in ripe Jackfruit was 1.5-1.7% and the calcium content were found to be 0.02%.Regular trainings are conducted at IRTC to impart the knowledge to entreprenuers.

Results

Procedures and flow sheets for the production of jackfruit powder, jackfruit based toffee, biscuits, pickle, osmotically dehydrated sweetened jackfruit and papaya snacks (tutti-frutti) have been standardised. Jackfruit powder can replace 'Atta' by 25% which makes chapati and poori extremely soft and palatable. Papaya tutti-frutti is a healthy snack for everybody-both children and elderly equally well.

Jackfruit Biscuits /Cookies

Conclusion

This work established the possibility of popularising nutritive and fibre rich Jackfruit and papaya products with no added preservatives and colours.

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Hydrangea Flower- A Natural pH Indicator

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Hydrangea, *Hydrangea macrophylla* (commonly named as the hortensia, is a genus of more than 70 species of flowering plants native to Asia and the Americas. Most are shrubs 1–3 m (3 ft 3 inch – 9 ft 10 inch) tall, but some are small trees, and others lianas reach up to 30 m (100 ft) by climbing up trees. They can be either deciduous or evergreen, though the widely cultivated temperate species are all deciduous. Due to their versatility and ability to thrive in various zones, hydrangeas are a popular choice for home gardens as well as popular landscape plants in coastal areas. Hydrangea, native to Asia and the Americas, is one of the most popular and widely grown and marketed plants in the nursery and floriculture industry, owing to its beautiful flowers that come in a variety of shapes, colors, and sizes. Hydrangeas are popular shrubs with colourful flowers that bloom through summer and into fall. They usually bloom in shades of blue, purple, and pink, with some selections in white, green, or red. Most hydrangea bushes are easy to grow in Zones 3-9 and prefer partial shade. There are numerous species of deciduous and evergreen hydrangea shrubs, small trees, and climbers, which include approximately 1000 cultivars and hybrids (Fulcher *et al*. 2020). Many new selections are introduced annually worldwide due to their increasing popularity. Hydrangea flowers are produced from early spring to late autumn; they grow in flowerheads (corymbs or panicles) most often at the ends of the stems.

Hydrangeas are the natural indicators that can also tell you whether something is acidic or basic. Hydrangeas turn blue in acidic soil, purple in neutral soil, and pink in basic soil.

Hydrangeas come in several varieties. It's not every hydrangea that changes color. It's the flowers of some Bigleaf hydrangeas (*H. macrophylla*)—especially Mophead and Lacecap types and *H. serrata* cultivars whose colors change based on the pH of the soil.

Mophead hydrangeas are the most popular and come in different colors, including white. The flowers of many hydrangeas act as natural pH indicators, sporting blue flowers when the soil is acidic and pink ones when the soil is alkaline. White flowers do not react to the pH of the soil; there is no way to alter their natural color outside of dyeing the plant. Pink and blue varieties, however, can be changed, and the color of these blossoms is directly related to the pH of the soil. Blue flowers indicate acidic soil while pink flowers indicate alkaline. Some other plants can be used as pH indicators for solutions, like red cabbage and butterfly pea flowers. But hydrangeas are the only plant that changes color based on soil pH. That is important because the blossom color will give you an idea of what other kinds of plants you can grow in your soil. They are water-demanding plants and are best suited for moderate water-use landscape zones.

Why do hydrangea flowers change color according to soil pH?

Most major plant nutrients are more accessible at a pH of 6 to 6.5. A pH that is too high or too low can keep plants from absorbing nutrients from the soil. The nutrients are unavailable or not absorbable to the plant because of soil's chemistry. This problem can manifest itself in a variety of ways, but in the case of hydrangeas, the bloom color changes. Color variation in hydrangeas is due to the presence or absence of aluminium compounds in the flowers. If aluminium is present, the color is blue. If it is present in small quantities, the color is variable between pink and blue. If aluminium is absent, the flowers are pink. Soil pH indirectly changes flower color by affecting the availability of aluminium in the soil. When the soil is acidic (pH 5.5 or lower), aluminium is more available to the roots, resulting in blue flowers. Hydrangeas respond to several, light applications of fertilizer during the growing season.

Traditional production of potted hydrangeas with blue flowers involves the use of water-soluble aluminium sulphate to cause the blue pigmentation of flower sepals. This technique has proved very effective for over a century but presents some problems related to high leachability in a greenhouse environment. Innovations in controlled release

technology already in use in the fertilizer industry are now being applied to the niche market of blue hydrangea production promising to nearly eliminate the problems with conventional aluminium sulphate applications.

Colors variability depends on soil conditions

Hydrangea flower color can change based on the pH in soil. As the graph depicts, soil with a pH of 5.5 or lower will produce blue flowers, a pH of 6.5 or higher will produce pink hydrangeas, and soil in between 5.5 and 6.5 will have purple hydrangeas. White hydrangeas cannot be color-manipulated by soil pH because they do not produce pigment for color. In other words, while the hue of the inflorescence is variable and dependent upon cultural factors, the color saturation is genetically predetermined. In most species, the flowers are white. In some, however, (notably *H. macrophylla*), they can be blue, red, or purple, with color saturation levels ranging from the palest of pinks, lavenders & and powder blues, to deep, rich purples, bordeauxs, and royal blues. In these species, floral color change occurs due to the availability of aluminum ions, a variable which itself depends upon the soil pH. For *H. macrophylla* and *H. serrata* cultivars, the flower color can be determined by the relative acidity of the soil: an acidic soil (pH below 7), will have available aluminium ions and typically produce flowers that are blue to purple,[13] whereas an alkaline soil (pH above 7) will tie up aluminium ions and result in pink or red flowers. This is caused by a color change of the flower pigments in the presence of aluminium ions which can be taken up into hyper accumulating plants. In neutral soil (pH 6 to 7), hydrangea may be purple or a mix of blue and pink on a single shrub.

Hydrangea flowers will be pink in alkaline soil, but change to blue in acidic soil. So, mix up some apple cider vinegar and water, and give all the acid-loving plants a treat. Or change colors of your hydrangeas on a whim from pink to blue. Hydrangeas are the only plants that can be manipulated to change color while growing. You can change a flower's color by altering its plant cells' pH levels. By changing the soil to be more acidic or alkaline, you can change the flower's color. Hydrangeas are the only flowers that react to changes in soil conditions. In neutral soil (pH 6 to 7), hydrangea may be purple or a mix of blue and pink on a single shrub. Red or pink blooms result from neutral or basic soil (pH 7 and above), whereas blue blooms indicate acidic conditions (pH less than 7). The flowers of this plant are sensitive to soil pH and change colour to reflect changes in acidity. Pink Hydrangeas indicate soil that is alkaline to neutral. Blue flowers indicate soil that is acidic. In some species of Hydrangea, flower color ranging from blue to red, is influenced by soil pH. In soil with low pH, aluminum ions (Al3+) are more available for uptake by plants, altering the flower pigments to reflect more blue. In less acidic soil, the aluminum is less available for uptake, resulting in the flower pigments reflecting more red. Myrtillin, a red pigment produced by the plant, is bound by aluminium to co-pigments which are blue. Without aluminium, Myrtillin alone reflects red.

Fig.1. Different colours of hydrangea flowers

Cultivation and uses

Hydrangeas are popular ornamental plants, grown for their large flowerheads, with *Hydrangea macrophylla* being by far the most widely grown. It has over 600 named cultivars, many selected to have only large sterile flowers in the flowerheads. *Hydrangea macrophylla*, also known as bigleaf hydrangea, can be broken up into two main categories; mophead hydrangea and lacecap hydrangea. Some are best pruned on an annual basis when the new leaf buds begin to appear. If not pruned regularly, the bush will become very 'leggy', growing upwards until the

weight of the stems is greater than their strength, at which point the stems will sag down to the ground and possibly break. Other species only flower on 'old wood'. Thus, new wood resulting from pruning will not produce flowers until the following season. Hydrangea root and rhizome are indicated for treatment of conditions of the urinary tract in the Physicians' Desk Reference for Herbal Medicine and may have diuretic properties. Hydrangeas are moderately toxic if eaten, with all parts of the plant containing cyanogenicglycosides. *Hydrangea paniculata* is reportedly sometimes smoked as an intoxicant, despite the danger of illness and/or death due to the cyanide. The flowers on a hydrangea shrub can change from blue to pink or from pink to blue from one season to the next depending on the acidity level of the soil. Adding organic materials such as coffee grounds, citrus peel or eggshells will increase acidity and turn hydrangea flowers blue, as described in an article on Gardenista. A popular pink hydrangea called Vanilla Strawberry has been named "Top Plant" by the American Nursery and Landscape Association.The hybrid "Runaway Bride Snow White", bred by Ushio Sakazaki from Japan, was named Plant of the Year at the 2018 RHS Chelsea Flower Show.

Used as aesthetic and medicinal purpose

In Japan, *ama-cha*, meaning sweet tea, is another herbal tea made from *Hydrangea serrata*, whose leaves contain a substance that develops a sweet taste (phyllodulcin). For the fullest taste, fresh leaves are crumpled, steamed, and dried, yielding dark brown tea leaves. Ama-cha is mainly used for *kan-butsu-e* (the Buddha bathing ceremony) on April 8 every year—the day thought to be Buddha's birthday in Japan. During the ceremony, ama-cha is poured over a statue of Buddha and served to people in attendance. A legend has it that on the day Buddha was born, nine dragons poured Amrita over him; ama-cha is substituted for Amrita in Japan. In Korean tea, *Hydrangea serrata* (hangul hanja) is used for an herbal tea called sugukcha or isulcha. The pink hydrangea has risen in popularity all over the world, especially in Asia. The given meaning of pink hydrangeas is popularly tied to the phrase, "You are the beat of my heart," as described by the celebrated Asian florist Tan Jun Yong, where he was quoted saying, "The light delicate blush of the petals reminds me of a beating heart, while the size could only match the heart of the sender. *Hydrangea quercifolia* was declared the official state wildflower of Alabama in 1999. Hydrangeas were used by the Cherokee people. A mild diuretic and cathartic, it was considered a valuable remedy for removal of stone and gravel in the bladder.

The metal key of colour variation

Soil acidity actually is not the underlying chemical mechanism behind the color change of Hydrangea sepals. It ultimately depends on the availability of aluminum ions (Al^{3+}) within the soil. In acidic soil, Aluminum ions are mobile and reacts with the readily available ions so that it can be taken up into the hydrangea bloom to interact with the red pigment. But in neutral to basic soil, the aluminium ions combine with hydroxide ions (OH^-) to form immobile aluminum hydroxide, $Al(OH)_3$.

So, for the bluing of hydrangea blooms, one needs both aluminum ions and acidic soil. The best soil additive for bluing is one that contributes both, e.g., commercially available aluminum sulfate, $Al_2(SO_4)_3$. Oppositely, addition of lime (calcium hydroxide, Ca (OH)2) changes the bloom-color from blue to red.

Fig.2. Hydrangea colour chart

Color change with pH

Hydrangea blooms possess blue sepals when the shrub grows in acidic soil, but develop red or pink sepals when grown in neutral to basic soils. This means that Hydrangea's bloom color acts as a natural pH indicator for the soil. In fact, a hydrangea can

have different bloom colors on the same bush if the roots of the plant sample soils of differing pH.

Fig. 3. Flower colour change with pH

Hydrangeas are ubiquitous— but they are not what they seem. For starters, the bloom of the hydrangea is not a true flower, but an inflorescence: Sepals, or modified leaves, make up most of the bloom and overshadow the small, almost unnoticeable fertile floral portions at the center.

The bloom colors are what really make the hydrangea stand out: They range from pink to blue, including all shades of color. Only yellow and orange remain absent.

How to Change Your Soil to Get Blue Hydrangeas

To get blue blossoms, your soil needs to be acidic, ideally from 5.0 to 5.2. This pH allows the hydrangeas to better absorb aluminum in the soil. Blueberries, raspberries and other common flower varieties do well in acidic soil. So, if you are looking to plant those in your garden, blue blossoms indicate your soil is ready. Adding aluminum sulfate to your soil will lower the pH and give your hydrangeas the aluminum needed to produce the blue hue. Lowering your soil's pH is not an overnight fix; it takes time. If you simply want the blue flowers, consider planting them in pots where you have much more control over the soil pH.

More Alkaline Soil Will Result in Pink Blossoms

Most plants prefer a soil pH of 6.0 to 7.3. Getting the pH to the top of this range will result in a slightly alkaline composition. This means any aluminum in the soil will be harder for the plant to absorb, and so the flowers will be pink. If your soil pH is between 5.2 and 6.0, you may end up with pink and blue blossoms. Lilacs, garlic and asparagus all prefer more alkaline soil. Pink flowers are a good indicator the soil is ready for them. If your soil is not already alkaline, add lime to raise the pH. As with the blue flowers, if you'd rather not wait for the soil pH to adjust, consider putting them in pots rather than directly in the ground.

Conclusion

There is still much to learn about natural changes in the color in hydrangea blooms. By considering the coloring of Hydrangea, it is visible that metal ions as well as pH play a key role to create designer colors for flowers. Yet when it comes to hydrangea colors, there are always more chemical mysteries awaiting a solution.

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Metal Organic Frameworks as Ripening Controller in Fruits and Vegetables

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Controlling the ripening of fresh fruits and vegetables (especially climatic fruits) during storage and transportation is very difficult and important to maintain the required quality. Developing packaging material for climatic fruits is a major challenge faced by researchers because of its quick ripening nature. It is seen that ethylene can be used as a regulator in this situation However, because of safety issues, ethylene cannot be applied directly to climatic fruits. A MOFs was developed by Zhang, et al. (2016) for encapsulation ethylene and its controlled release for ripening at the required stage. MOF functionalities suggest a potential for application in MAP systems such as scavenging or releasing biologically active volatiles in packages of fresh produce (Fruits and vegetables).

What are metal organic frameworks (MOFs)?

Metal-organic frameworks (MOFs) are a class of porous polymeric materials. They are made up of organic bridge ligands linked together with metal ions such as Ca, Mg. This creates an open crystalline framework with stable porosity. MOFs have large surface area in a small volume and are highly porous. The surface areas of typical MOFs range from 1000 to 10,000 m^2/g (size of a football field). Commonly used metal ions for the fabrication of chemically stable MOFs are aluminum, iron, zirconium, titanium, copper, and zinc. Commonly used Organic linkers such as Potassium chloride, Fumaric acid, Isophthalic acid.

Application of metal organic frameworks as ripening controller in fruits and vegetables

Ethylene gas was captured by copper terephthalate MOFs (CuTPA) with 0.39 cm^3g^{-1} porosity. CuTPA was synthesized by the solvothermal synthesis method using methanol as a reactive solvent. The study identified that 654 µL of ethylene was

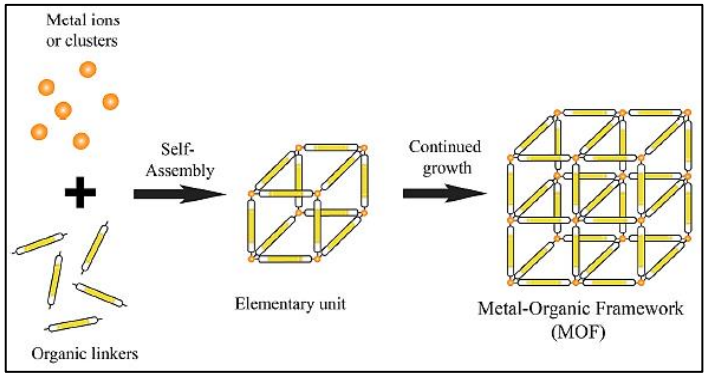

Fig 1: Metal Organic Framework (MOF) Structure

absorbed and released by 50 mg of MOFs, which created an atmosphere enriched with adequate ethylene to control fruit ripening but also a safe level of ethylene (<27,000 µL L^{-1}) was maintained. More significantly, reduction in tissue firmness and ripening related color change acceleration was noticed by using MOF-ethylene treatment. Whereas, on the other case, selective adsorption and desorption of required chemicals which are responsible for ripening is done by MOFs due to their potential utility in the assortment of chemicals and unique porous structure. Since MOFs are formed from matrix materials and functional species, matrix materials allow MOFs to recover and reuse by enhancing the formability of MOFs materials (Li & Huo, 2015). Chopra's team (2017) filled polyolefin bags with BasoliteC300 and added the bags to banana packaging. Ethylene-induced banana ripening due to the ethylene bound to the C300 demonstrates that releasing volatile compounds from an MOF is feasible for practical applications. In a proof-of-concept, it was identified that Basolite C300 exhibited a lofty performance for ripening of produce as an ethylene releasing agent with high-water content in the packaging headspace. On the other hand, bound 1-MCP (17.6% w/w) was not released by the exposure of humidity due to its highest affinity towards Basolite C300. Therefore, active packaging of fruits and vegetables can be

regulated for repining by encapsulating ethylene in Basolite C300, so that interference from 1-MCP is minimized via compound removal from package headspace. Basolite C300 is also called MOF-199, and it is a copper-based ultra microporous structure with blue cubic crystals synthesized by the electrochemical method (Van Assche et al., 2012). Basolite A520 is an aluminium-based metal-organic framework which is synthesized by a microwave-assisted technique of MOFs synthesis. The outcome suggested that MOFs encapsulated ethylene can be used in the post-harvest application to maintain the quality of climatic fruits at the consumer level. Many other adsorbent methods are used in food packaging and are the basis for the advancement in the field of food packaging technologies. Convential adsorbents, such as activated charcoal and silica gels mostly used for moisture control (Mehyar & Han, 2011). It has been revealed that zeolites and MOFs have the potential for selective desorption and adsorption of bioactive compounds. These two materials signify a growing class of advanced bioactive adsorbent (ABAs) used for the active packaging of light processed produce. Yan Zhang *et al.*, (2023) team studied on MOFs to adsorb ethylene for fresh produce active packaging. The MOFs was evaluated at two levels. The first evaluation was at the MOF powder level, where the ethylene adsorption capacities of eight commercial MOF powders were measured using gas chromatography (GC). As a result, Mg formate MOF (MgF) and Al (OH) fumarate MOF (AlF) were found to have much higher ethylene adsorption capacities than the other six MOFs. Overall, MgF was the best ethylene adsorber due to its stable ethylene adsorption under various temperatures, relative humidities, and ethylene concentrations. The second evaluation was at the packaging film level, where MgF powder was embedded into three different packaging films. The results showed that MgF-embedded LDPE film had higher ethylene adsorption than MgF-embedded PLA and PVA films. Furthermore, a bio-efficacy study confirmed that MgF-embedded LDPE film could effectively delay banana ripening and extended their shelf life. In conclusion, this study indicates that MgF has promising potential as an ethylene adsorber for shelf-life extension of bananas and probably other fresh produce.

Advantages of Metal Organic Frameworks (MOFs)

- MOFs are their large specific surface area, huge porosity, and easy adjustment of pore size and shape from microporous to mesoporous scale, which can lead to high extraction efficiency.
- Better water stability.
- Different metal ions and diverse organic ligands make MOFs structurally diverse and therefore have the potential for selective adsorption.

Disadvantages of Metal Organic Frameworks (MOFs)

- Adaptation of MOF-based materials as efficient electrocatalysts has been generally hampered by low electronic conductivity, limited accessibility of active sites, and insufficient chemical stability.

Conclusions

MOFs' potential to be embedded in packaging films as ethylene adsorbers to control ripening and extend the shelf life of fruits and vegetables during distribution. However, there are still big challenges in scaling up their use in large-scale ripening controller food packaging application: the selectivity of separating similar gas molecules through MOFs is limited; the fabrication of MOF-based packaging materials is difficult to integrate into large-scale industry methods and metal ions and organic ligand functional groups are toxic, which requires more safety characterization for direct application in food packaging.

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Vineyard Pruning Residue Mulcher: A natural Resource Management Machinery

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Pruning is one of the important operations for vineyards. As discussed already it generally done by selectively removing unsuitable or extraneous spurs, while retaining an adequate number of good spurs to produce fruitful shoots in the coming season, and to produce healthy shoots from which a good fruiting cane can be selected for next pruning. Pruning can produce residue in the range of 0.45 to 1.34 kg per plant (1850–5360 kg ha^{-1}) depending on variety of grape, age, climate and other agronomical conditions (Manzone *et al.* 2016, Cetin et al. 2011, Velazquez-Marti et al. 2011, Giacomo and Taglieri, 2009, and Brito et al., 2014). These pruning generally burned or composted in the same field worldwide. Since the pruning residue is good source of energy, it is also considered to collect and use directly or after densification or after conversion to biofuel.

Traditional methods of grape pruning residue management

Burning is easy and old method to dispose the pruning and, prevent the pathogen spread from infected cut pruning to the healthy shoot and enrich the soil with minerals (Adamchuk, 2016). Most of the owners of vineyards collect the pruning residue manually and burn it openly by making pile outside the orchard (Fig.1 a). In some areas of Europe mostly in France and Spain, pruning waste is used to burn simultaneously during pruning operation using conventionally popular wheelbarrows (Fig.1 b) made up of old oil barrel to prevent it from dropping on the ground and save the time of collection (Evineyard, 2018). After combustion, ash produced is in the range of 2.4% to 4.2 % (Nasser et al. 2014) which is potential mineral rich source of mainly Ca, Si, Cl, Mg, Al, K, P oxides (Fernandez-Puratich et al. 2015). However, it creates environmental issues attributed to harmful emissions from open burning of residue. If burnt immediately after pruning, pruning residue emittes about 131 g/kg (db) carbon mono oxide (CO), 25.2 to 40.3 g/kg (db) particulate matter, 5.3 g/kg (db) of Nitrogen oxides (Nox), and other harmful emissions, while the quantity may alter depending on moisture content (Pizzi et al. 2018). In recent years, due to environmental regulation and strict rules related to open burning of pruning residue have diverted many growers to alternate sustainable management.

Fig.1: a) Open burning of grape vine pruning residue (Lutz, 2017), b) On the go burning of pruning residue using traditional equipment during pruning activity (Photo Source: www.evineyardapp.com, 2018)

Mulching and incorporating into soil

Since grape vine canes of irregular size are generally left scattered on inter row area, it becomes obstacle for intercropping and other operations. This residue can be used as organic mulching for cover crops which eventually get decompose releasing nutrients into soil.

Pick-Up Wood Choppers (Adamchuk *et al.* 2016)**:** (Fig.2 a)

Working principle: This machine collects pruned grape vine residue from ground using pick-up

attachment, and convey the material to the machine's chopping chamber and then spread chopped material of average size of 4.8 cm on the ground from rear end of machine.

Power consumption: 15 kW

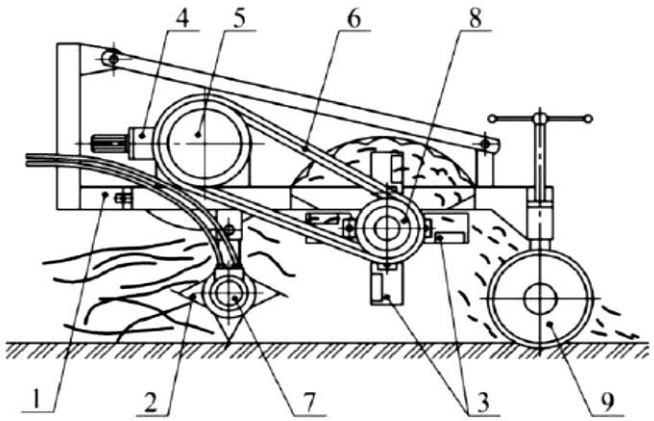

Fig. 2: Schematic of the grape vine pruning residue pick up chopper (1-frame; 2-pick-up system; 3-chopping chamber; 4,5-drive and intermediate gear; 6-belt; 7- hydraulic motor; 8- clutch for chopping unit; 9-gauge wheel) (Adamchuk, 2016).

Components and its function

- The frame (1) on the chopper is a welded assembly that is fabricated from rectangular tubes and channel beams.
- The front of the frame features a rigidly-fixed standard three-point linkage for hinging to the aggregating tractor.
- The collecting unit (2) consists of a tubular shaft with welded rods which are installed on the lower part of the frame (1) with the use of telescopic struts, which allow adjustments to be made in the vertical position of the collecting unit in steps to a total of 200 mm by repositioning the locking pins.
- The chopper drum with chopping blades (3) consists of a tubular shaft, to which clevis lugs made from angled sections are welded.
- In the clevis lugs, two types of chopping blade are installed so that they pivot: straight blades and L-shaped blades.
- The chopper drum shaft rotates on two bearing supports which are attached to the frame (Fig. 2).
- The actuation of the chopper drum is provided by the aggregating tractor's PTO shaft (at 540 rpm) which drives the step-up gear (4), and then the intermediate gear (5), the belt transmission (6), and the free-wheel clutch (8).
- The last item is mounted directly onto the shank of the chopper drum.
- The described chopper design utilizes a single-stage step-up bevel gear (with four positions) that increases the speed of rotation at a gear ratio of 2.4.
- The other end of the shaft of the intermediate gear (5) features the attached greater pulley for the V-belt transmission (6).
- The pick-up unit (2) is driven by the hydraulic motor (7) which is mounted onto the collecting unit's support bracket and is connected by pipelines to the aggregating tractor's hydraulic system.
- Two supporting gauge wheels (9) provide for the adjustment of the positioning of the frame (1) in relation to the soil's surface, depending on the height of the windrow of pruned grape vine canes or fruit tree branches and twigs.

Commercially available machines:

KUHN TRP-175 grape vine cane shredder

- This pick up the residue and grind into 14 mm size using hammer mill with the power consumption of 29 kW.
- **Pick up attachments** can be rake type equipment or rotor type equipment (Adamchuk, 2016). KUNH also have a different models of shredders (Model VK-95,115,135,155)
- **Row spacing**: Different row spacing from 925 to 1525 mm
- **Offset distance**: 225 to 2025 mm (KUHN, 2018).
- Rotor type equipment can be drums with fingers or belts with spikes.

A reversible blades mulcher (Fig.2 b) is also available commercially for front and rear mounting with tractors of 90 to 140 hp. It has hydraulically powered pick up roller designed for pruning waste up to 5 cm in diameter (Zanon, 2018,p:1-2).

Table 1: Operational feature of the shredder machine and TRP -175 shredder (KUHN)

Sr. No.	Parameter	TRP -175 shredder (KUHN)
1	Field capacity (ha/h)	1.43
2	Operational travel speed (m/s)	1.24
3	Effective width (mm)	1,750
4	Weight (kg)	950
5	Diameter of collecting drum at rod ends (mm)	350
6	Type of wood chopper drum	Hammers
7	Diameter of wood chopper drum (mm)	465
8	Revolution rate of wood chopper drum (rpm)	1960
9	Number of blades/hammers (pcs)	28
10	Power consumption (kW hp-1)	49/67

TLK reversible blades mulcher (Zanon Machine Agricole)

The TLK reversible mulcher is designed for front or rear mounting on high power tractors (70-120 hp), and incorporates a pick-up roller for feeding waste material into the machine. The TRK is ideal for shredding pruning waste up to 5/6 cm in diameter and can be used over all kinds of terrain, including stony ground. It boasts a robust steel frame and an electronically balanced rotor mounted on fully enclosed, self- aligning bearings.

The TRK features blades arranged in six self-covering rows, high strength steel pick-up rollers and an oil bath gearbox with double freewheel. Possibility of working with both directions of the PTO (specify whether 540 or 1000 rpm).

Parts and components

- Gearbox with double freewheel clutch PTO
- Rotor with helical cutting system
- 3-point linkage fixed
- Cutting system with blade and counter-blade crossing
  Fixed skids
- Fixed steel wheels
- Hydraulically powered double pick-up roller
- Opening hood (for inspection only)
- Protective equipment as per EC safety rules

Fig. 3: TLK reversible blades mulcher (Zanon, 2018)

After a chopping operation, to enhance the in situ decomposition, couple of passes of disc harrow or rotavator to mix and pulverize the chopped residue into soil are generally performed. Some rotavators are commercially available with chopper attachment can be used directly for disposal of grape vine pruning waste into field.

Conclusion

Burning of vineyard residue is seeking attention due to environmental and health issues caused by its harmful emissions. Pruning residue utilization for mulching is much followed as an organic farming to conserve the nutrients in the pruning biomass and soil moisture. Also, this mulching reduces weed infestation reducing the nutrient and water intake and eliminating weeding operation. New principles of pruning crushers can be designed for reduction in power requirement can be point of research for energy efficient vineyard mulching.s

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