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Aromatherapy

The power of essential oil

INSIDE KERALA KARSHAKAN

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Aromatherapy

The power of essential oil

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Aromatherapy is the use of concentrated essential oils derived from herbs, flowers, and other plant components to treat various health conditions. The term "aromatherapy" was first coined by the French chemist Gattefosse in a book published in 1936. However, the supporters of aromatherapy assert that it is based on an ancient tradition of herbal medicine practiced in countries like Egypt and India thousands of years ago. Today, aromatherapy is commonly administered through massage, with the term typically referring to the practice of massaging the skin using a variety of aromatic

Lavandula angustifolia

plant extracts known as essential oils.

The concepts of aromatherapy include the use of pure essential oils as a central part of treatment. Aromatherapy goes beyond simply "smelling something to feel good"; it involves a deeper therapeutic approach that utilizes these concentrated plant extracts for their healing properties.

Classification of aromatherapy

Cosmetic aromatherapy

It involves using specific essential oils in skincare, body care, facial, and hair care products. These products are applied for their diverse effects, such as cleansing, moisturizing, drying, and toning. Using essential oils in facial products can help achieve healthy skin. On a personal level, engaging in a full-body or foot bath with these oils is a straightforward and effective way to enjoy their benefits. Likewise, adding a few drops of the right essential oil can provide a refreshing and invigorating experience.

Massage aromatherapy

It involves using pure vegetable oils like grape seed, almond, or jojoba oil during massage, which has been proven to have remarkable benefits. This practice is often referred to as the healing touch of massage therapy.

Medical aromatherapy

Rene-Maurice Gattefosse, the founder of modern aromatherapy, utilized essential oils to massage patients during surgery. This approach applies medical aromatherapy, which leverages the therapeutic effects of essential oils to aid in the treatment and management of clinically diagnosed medical conditions.

Olfactory aromatherapy

It involves inhaling essential oils, has been found to enhance emotional well-being,

promote calmness, relaxation, or rejuvenation of the body. This approach relieves stress through pleasant scents that can evoke odor memories. While essential oils can complement medical treatments, they should never be considered a substitute for them.

Psycho-aromatherapy

It involves using essential oils to achieve specific moods and emotional states, such as relaxation, invigoration, or recalling pleasant memories. This therapy typically involves directly inhaling the oils, often through diffusing them in a patient's room. Both psycho-aromatherapy and aromacology study the effects of aromas, whether natural or synthetic. However, psycho-aromatherapy focuses exclusively on natural essential oils.

Mechanism of aromatherapy

For centuries, essential oils have been prized for their fragrance and healing properties for the body, mind, and spirit. These potent plant compounds can purify environments by eliminating harmful bacteria, viruses, and fungi, and offer antibacterial, antiviral, and anti-inflammatory benefits. They boost the immune system and positively impact hormonal, emotional, and circulatory functions. Their energy-specific qualities allow them to retain potency over time, with their

Essential oils used in aromatherapy

Common Name	Botanical Name
Chamomile, German	*Matricaria recutita*
Jasmine	*Jasminum officinale*
Lavender	*Lavandula angustifolia*
Lemon	*Citrus limon*
Rose	*Rosa sp.*
Geranium	*Geranium dissectum*
Sage	*Salvia officinalis*
Champaca	*Magnolia champaca*
Blue lotus	*Nymphaea caerulea*
Chamomile	*Matricaria recutita*
Lilac	*Syringa vulgaris*
Eucalyptus	*Eucalyptus globulus, Eucalyptus radiata*

Eucalyptus globulus, Eucalyptus radiata

structure resembling hormones. A key feature of essential oils is their ability to penetrate subcutaneous tissues. Their complex chemical properties make their effects subtle and intricate. Inhalation of these oils triggers a biological signal in the nose, which is transmitted to the limbic system and hypothalamus via the olfactory bulb. This process leads to the release of neurotransmitters like serotonin and endorphins, affecting the nervous system and providing relief. Calming oils release serotonin, euphoric oils release endorphins, and stimulating oils release noradrenaline, each creating specific effects on the mind and body.

Modes of application of aromatherapy

1.Inhalation

Inhalation treatments are usually recommended for problems with respiration and can be done by dropping several drops of essential oil into a bowl of steaming water. The vapours are then inhaled for a few moments. This effect being enhanced by placing a towel over both the head and the bowl to form a tent to capture the

Syringa vulgaris

Magnolia champaca

humidified air and scent.

2. Massage

Using aromatic essential oils combined with base oil can be either calming or stimulating, depending on the oil used. The essential oil massage can be applied to a specific problem area or to the entire body.

3. Diffusion

It is normally used to calm or soothe nerves or treats some respiratory problems and can be done by spraying oil-containing compounds into the air or by placing a few drops of essential oil in a diffuser and turning on the heat source. A typical treatment involves sitting within three feet of the diffuser for around 30 minutes.

4.Hot or cold compresses

Hot or cold compresses containing essential oils can be used for muscle aches and pains, bruises or headaches.

5. Soaking baths

Soaking baths containing essential oils and lasting for 10-20 minutes are recommended for skin problems and for calming or soothing nerves.

Materials in aromatherapy

1.Absolutes: Fragrant oils extracted primarily from flowers or delicate plant tissues through solvent or supercritical fluid extraction (e.g., rose absolute).

2.Carrier oils: Typically oily plant base triacylglycerides that dilute essential oils for use on the skin (e.g., sweet almond oil).

3.Essential oils: Fragrant oils extracted from plants chiefly through steam distillation (e.g., eucalyptus oil).

4.Herbal distillates or hydrosols: The aqueous by-products of the distillation process (e.g., rosewater). There are many herbs that make herbal distillates and they have culinary uses, medicinal uses and skin care uses.

5.Infusions: Aqueous extracts of various plant materials (e.g., infusion of chamomile)

6.Phytoncides: Various volatile organic compounds from plants that kill microbes.

7. Raw Herbs: Typically higher oil content plant based materials dried, crushed and heated to extract and inhale the aromatic oil vapors in a direct inhalation modality.

Benefits of aromatherapy

- Relieves stress with low side

Nymphaea caerulea

effects

- Acts as anti depressant
- Boosts memory and increases energy levels
- Speeds up healing
- Reduces headaches and regulates sleep
- Anti microbial, anti larvicidal, anti mycoplasmal effects
- Increase respiratory capacity
- Decrease anxiety
- Strengthens immune system
- Antiproliferative, anticancerous activity

Matricaria recutita

Conclusion

Aromatherapy is a growing practice of people today to help reduce stress and invoke certain moods and feelings. While aromatherapy massage, bath and candles do have positive shorts term effect on most people, it is not an actual science or medicine that should be used to treat illness. Not all aromatherapy is beneficial to one 's health. More research must be done to make scientific conclusions about the use and effect of aromatherapy.

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Crop wild relatives of **Sweetpotato** *(Ipomoea batatas (L.)* Lam as a source of pest and disease resistance

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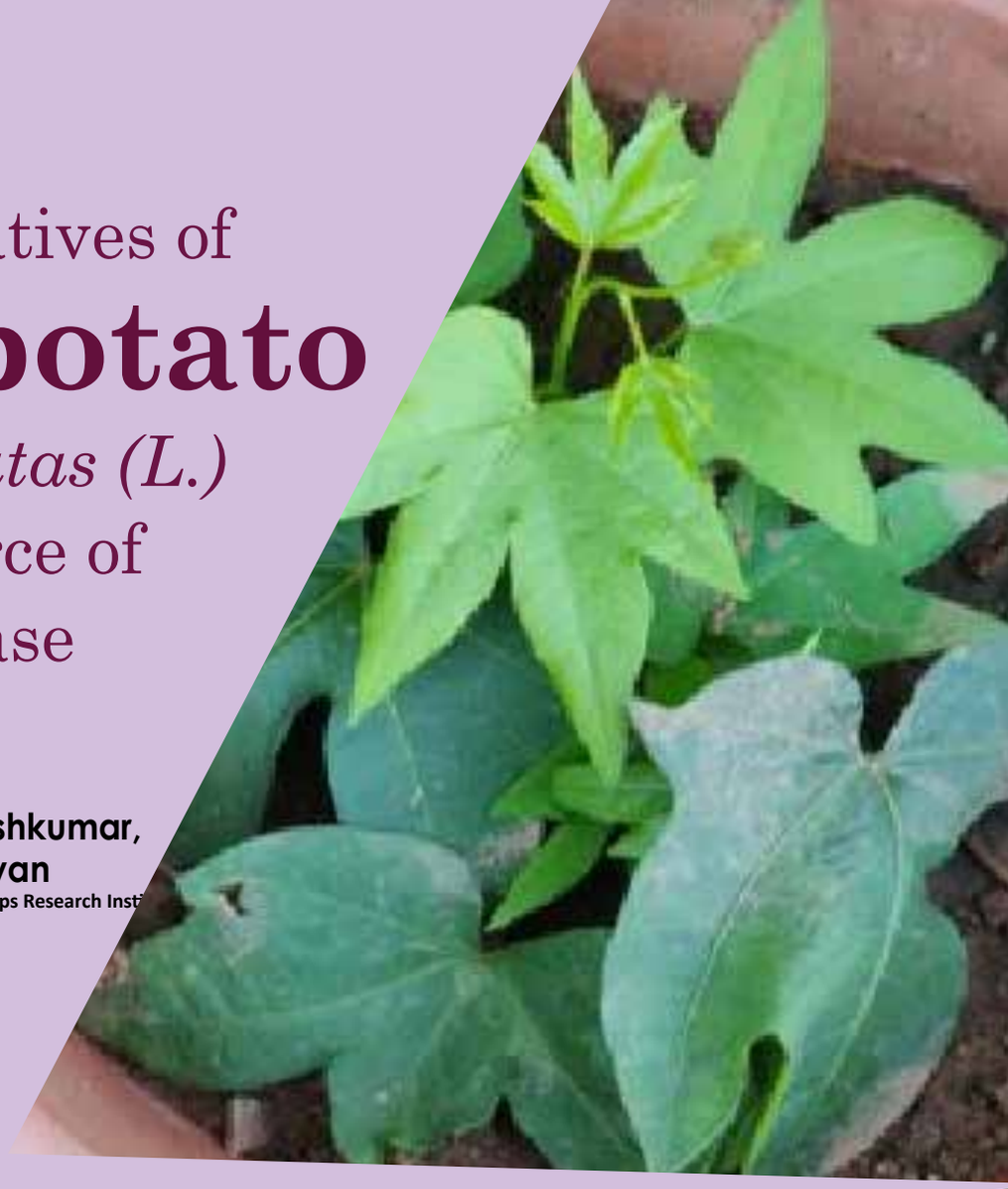


I. mauritiana

Sweet potato *(Ipomoea batatas)* is one of the most important tropical tuber crops originated in the tropics of South America. The crop serve as a source of vitamin A, C, E, calcium, iron, and number of other amino acids globally useful for humankind. The crop belongs to the family *Convolvulaceae* which comprises of the genus Ipomoea with almost 600-900 species. Sweetpotato and its close relatives were grouped into *Batatas* series of Eriospermum and the *Batatas* series of *Ipomoea* consists of

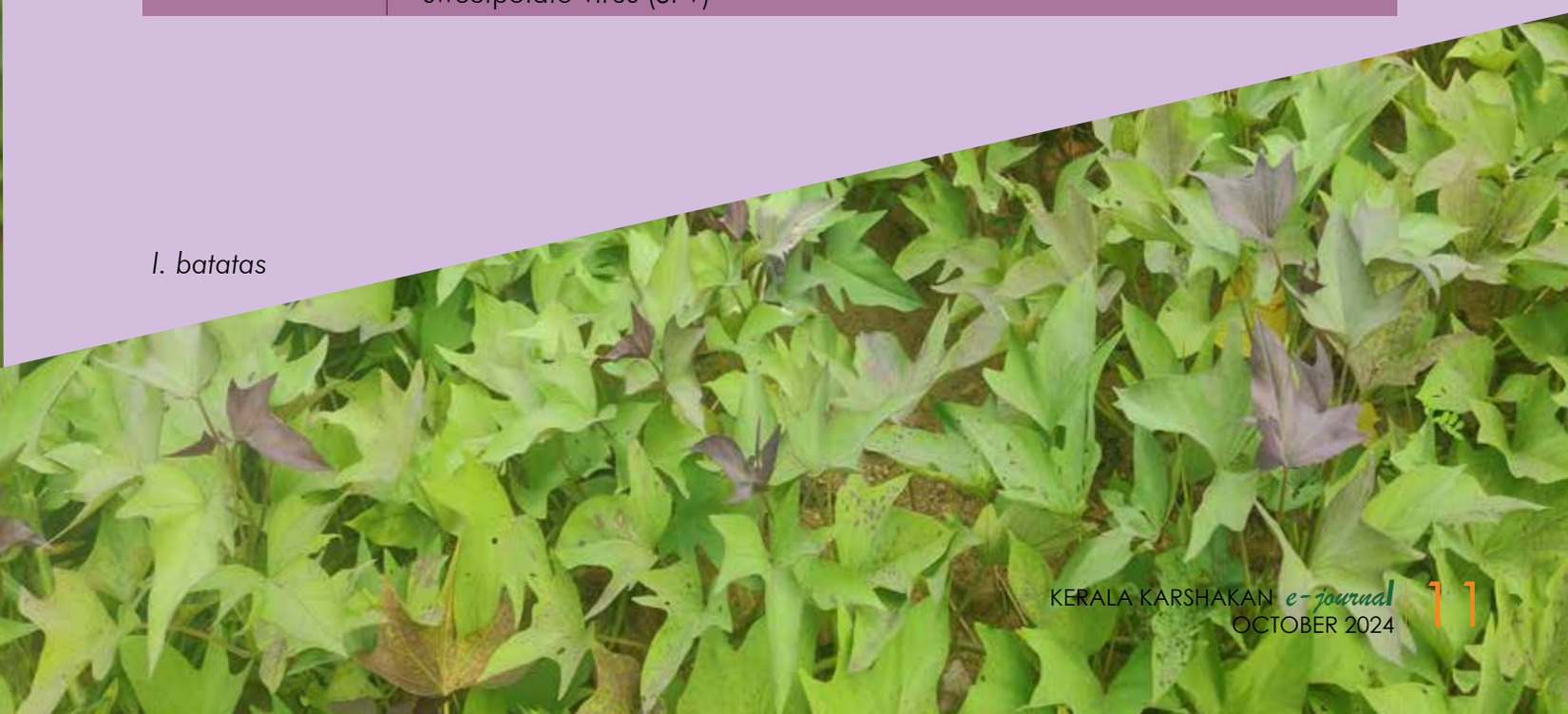
14 wild species. Many of the wild *Ipomoea spp*. are generally climbing plants found on the roadsides, swamps and forests as weeds. Unlike other crop wild relative (CWR) of cultivated crops the wild *Ipomoea spp*. are tolerant to biotic and abiotic stress. Earlier fundamental scientific data regarding the evolution and taxonomy was not completely available which is one of the reason for which many of the tuberous CWR of *Ipomoea* still remains underutilized in sweet potato improvement programme. The importance of wild relatives of Ipomoea spp. of sweet potato is gaining more importance in the present scenario for identification of novel genes related to agronomically important traits. Because of the large size of genome, complex inheritance pattern the genetic studies of this crop was difficult. But with the modern biotechnological tools the genome sequence database of various Ipomoea spp. was recently published which can be utilized for developing sweet potato varieties with economically important traits.

Wild relatives of sweetpotato utilized for interspecific hybridization

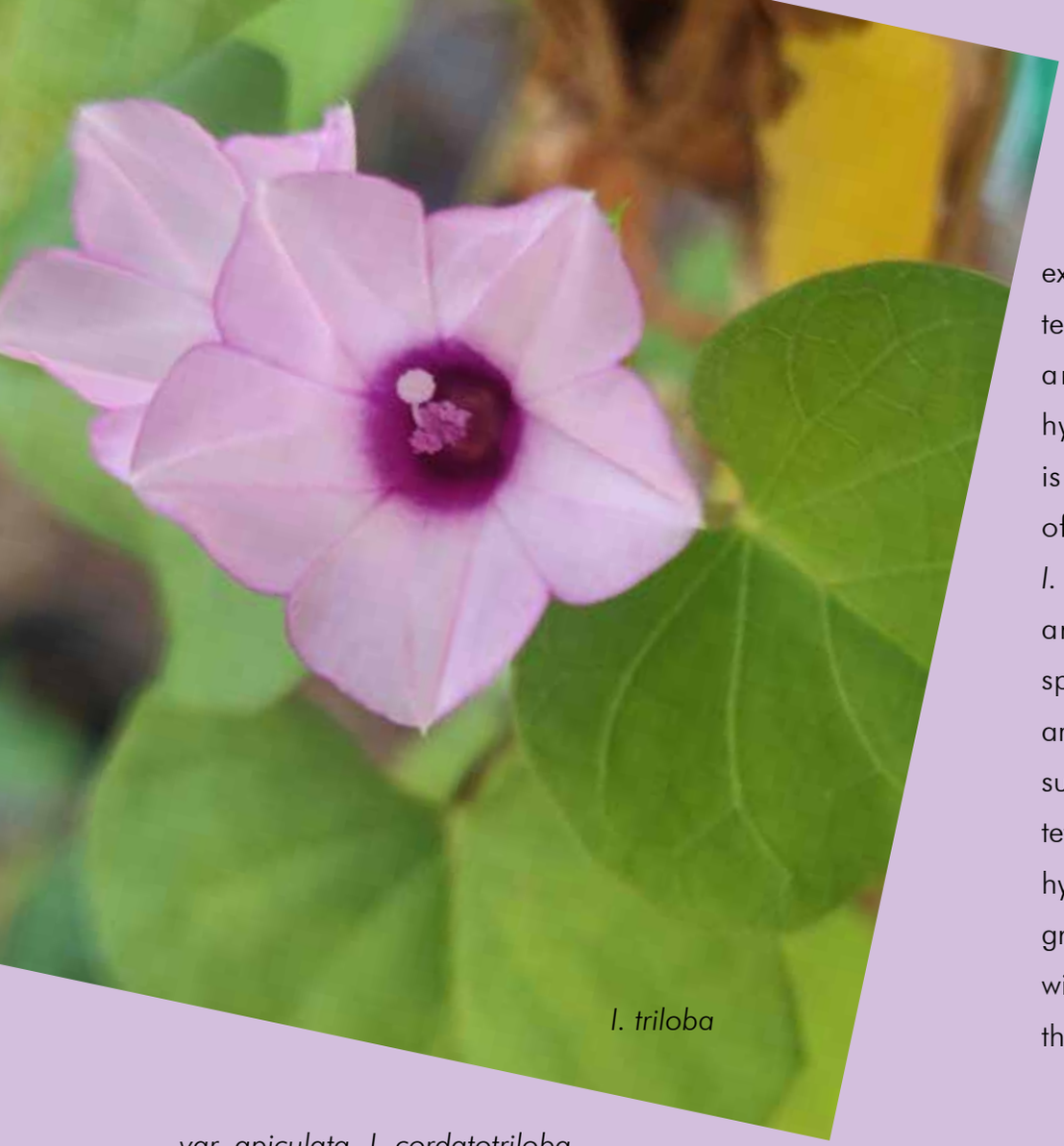
The word *Ipo* means below, beneath or under and *omoio* means similarity hence *Ipomoea* means resembling underground. The *Ipomoea* genus was classified into three subgenera Eriospermum, Quamocclite, *Ipomoea* and 400 taxa (Nimmakayala et al., 2011). The 14 wild species of sweetpotato include *I. batatas*

Table 1: List of CWRs of sweet potato reported for pest and disease resistance (Khoury et al., 2015, Ahmad et al., 2022).

Wild species	Trait
I. leucantha	Heat tolerance, sandy soil tolerance
I. trifida	High starch content, resistance to nematodes, sweetpotato weevil resistance
I. triloba	Drought tolerance resistance to root rots and foliar fungal diseases
I. purpurea	Resistant to sweetpotato stem nematode (SSN), sweetpotato virus (SPV)
I. grandifolia	Resistant to sweetpotato stem nematode (SSN), moderately resistant to sweetpotato virus (SPV)



I. batatas



I. triloba

except *I. cordatotriloba* which is tetraploid. Species in A group are self-incompatible and hybridization between species is possible. Group B consists of only four species, namely *I. batata, I. trifida, I. littoralis,* and *I. tabascana* and these species are self-incompatible and hybridization with species is successful. *I. tiliacea* is the only tetraploid species in X group and hybridization between A and X group is also possible. The use of wild species of sweet potato for the crop improvement started in

var. apiculata, I. cordatotriloba, I. cynanchifolia, I. grandiflora , I. lacunosa, I. leucantha, I. littoralis, I. ramosissima, I. splendor-sylvae, I. tabascana, I. tenuissima, I. tiliacea, I. trifida and *I. triloba*. The Ipomoea species is grouped into three distinctive groups such as A, B, and X group. More number of species are included in Group A which include *I. tribola, I. cynanchifolia, I. cordatotriloba, I. umbraticola, I. lacunosa, I. leucantha, I. ramosissima, I. grandifolia* and *I. tenuissima*. All are diploid in this group

I. triloba

I. trifida

Japan in1956 with wild Ipomoea hexaploid plants K123 (2n=90) from Mexico. These K123 derived lines became so important due to improved starch content, resistance against nematode and these lines were used for the development of number of cultivars. Minamiyutaka was one of the cultivar registered in Japan in 1975 developed from K123 lines. This marked the beginning of exploitation of wild Ipomoea germplasm for sweetpotato improvement programme. Even many other wild species of Ipomoea was found important to disease and pest resistance traits which is being utilized for the current crop breeding programme.

Crop wild relatives of sweet potato prevalent in Kerala

The phytochemical constituents of Ipomoea spp. has been studied from 1950 onwards. The secondary metabolites isolated from many wild species have defense action against pests and pathogens. The plants under Ipomoea genus also contain lot of bioactive metabolites which can be used as a source for the development of novel biopesticides against insect pests. The plants of Ipomoea genus were used for nutritional, medicinal, ritual and agricultural purposes. In many countries including India *I. aquatica* is the richest source of calcium, magnesium, iron, zinc, and

copper. Some of the other species used for nutritional purposes are *I. leptophylla, I. involucrate, I.alba and I. albivenia* (Srivastava and Rauniyar 2020). Most of the wild species are reported to have medicinal properties. One among them is tuberous *I. mauritiana* which is used for medicinal purposes and found in tropical regions of Kerala in India. The phytochemicals of *I. mauritiana* include cardiac glycosides, terpenes, anthrax quinines. *I. triloba* is reported to have antioxidant, antimicrobial, antiviral, antibacterial, antifungal, hypotensive, analgesic, laxative, anti-malarial and wound healing capacity (Srivastava and Rauniyar 2020)..

Genome sequences of crop wild species as a source of genetic improvement for pest and disease resistance

In crop breeding programme the wild species of sweet potato can be used mainly for improving traits related to storage roots, high yield, improved nutrient composition, pest and disease resistance. Even though the use of wild species for crop improvement started in 1956 with K123 lines the utilization of wild species of sweet potato remains under utilized due to lack of data regarding genetic basis of many agronomically important traits. There fore exploration of the genomic sequences of wild species for identification of genes and genetic pathway related to desirable traits is important. Recently the genome sequences of diploid species of *I.trifida* and *I.triloba* which are close progenitors of sweet potato was published to which the researchers are utilizing it for various breeding programme across the world.

CWR of many crops posses novel genes responsible for many economically important traits. The enormous genetic variation of these CWR can be used for transferring desirable traits to cultivars by using modern biotechnological tools for enhancing pest disease resistance. In the case of sweet potato recent studies were supposed to be concentrated for the exploration of novel traits from wild tuberous Ipomoea spp. for sweet potato weevil resistance. To develop resistant varieties, the identification of resistance genes and the elucidation of the genetic mechanisms underlying weevil resistance in wild tuberous *Ipomoea spp*. needs to be explored. Many of the traits such as yield, nutritional quality, pest, disease resistance and drought tolerance in sweet potato can be enhanced by identifying novel genes from CWR of sweet potato.

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Sea Buckthorn

The nutritional and functional gold mine of the cold desert

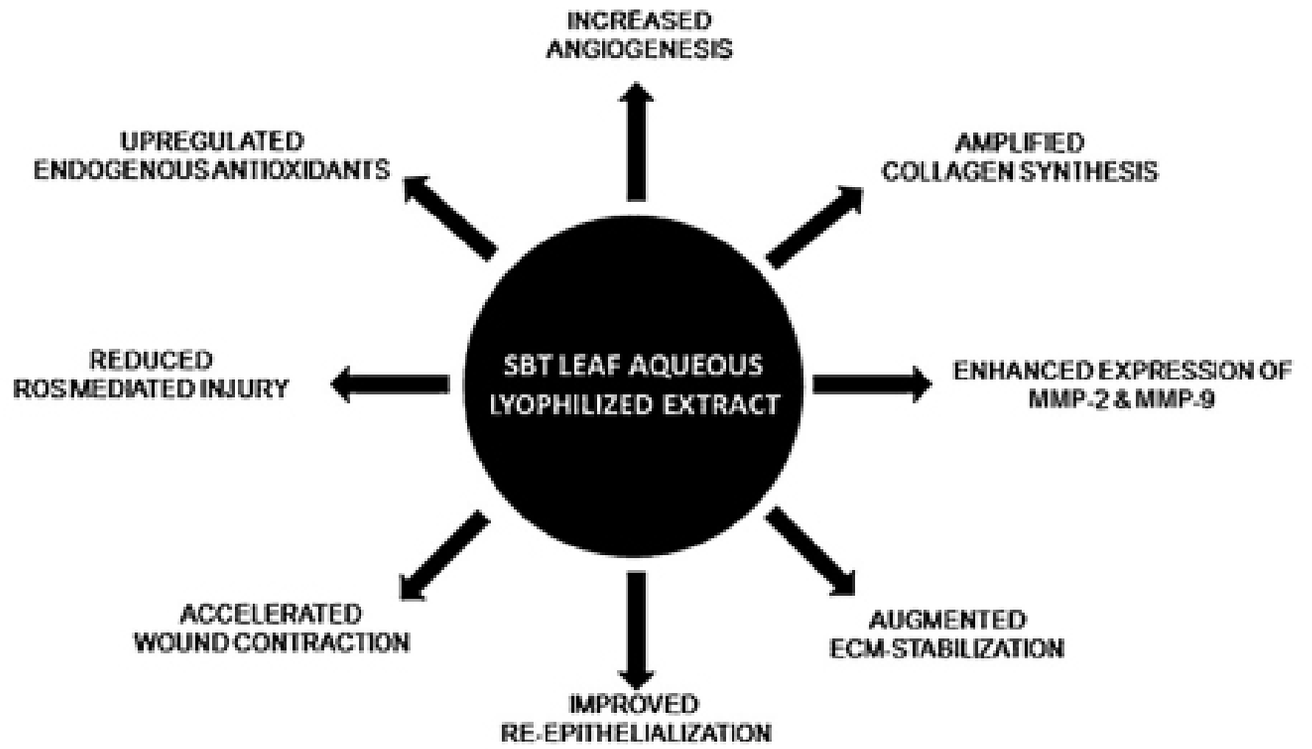
Introduction

Herbal formulations have been in use for many years globally not only as therapeutic but also as prophylactic and health promotive agents. Sea buckthorn *(Hippophae rhamnoides L.)* belongs to family Elaeagnaceae, a unique and valuable plant has recently gained worldwide attention, mainly for its medicinal and nutritional potential.

Sea buckthorn (SBT) is a thorny nitrogen-fixing deciduous shrub of cold arid region native to Europe and Asia. It includes 6 species and 12 subspecies, of which *Hippophae rhamnoides*, commonly known as sea buckthorn. It is currently domesticated in several parts of the world due to its nutritional and medicinal properties. It is a hardy plant, drought and cold resistant, useful for land reclamation and farmstead protection through its vigorous vegetative reproduction and strong, complex root system with nitrogen-fixing nodules (Li, 2003). All parts of this plant are considered to be a good source of large number of bioactive substances like vitamins (A, C, E, K, riboflavin and folic acid), carotenoids (carotene and lycopene), phytosterols (ergosterol, stigmasterol, lansterol, amyrins), organic acids (malic acid, oxalic acid), polyunsaturated fatty acids and some essential amino acids (*Pintea et al.*, 2005).

Sea buckthorn has been used in traditional Chinese medicine since the Tang Dynasty, going back more than 1000 years. In-depth survey and documentation of indigenous ethnobotanical knowledge of SBT reveal that this plant was traditionally utilized by local people of Asia, Nordic countries and the Baltic region in multidimensional aspects of food, fuel, medicine, veterinary, agricultural tools and bio-fencing

Sea buckthorn (*Hippophae rhamnoides L.*) in India, early September, branch bearing orange-red berries, thorn and leaves



The schematic diagram showing the possible effect of the Sea buckthorn leaf extract in promoting wound-healing activity (Upadhyay et al., 2011)

(Dhyani et al., 2010). This plant has been used extensively in oriental traditional system of medicine for treatment of asthma, skin diseases, gastric ulcers and lung disorders. Current research is now beginning to understand and support the traditional uses of SBT. A wide spectrum of pharmacological effects of SBT have been recently reported, including antioxidant, immunomodulatory, anti-atherogenic, anti-stress, hepatoprotective, radioprotective and tissue repair.

Nutritional properties and bioactive compounds in sea buckthorn berries and leaves

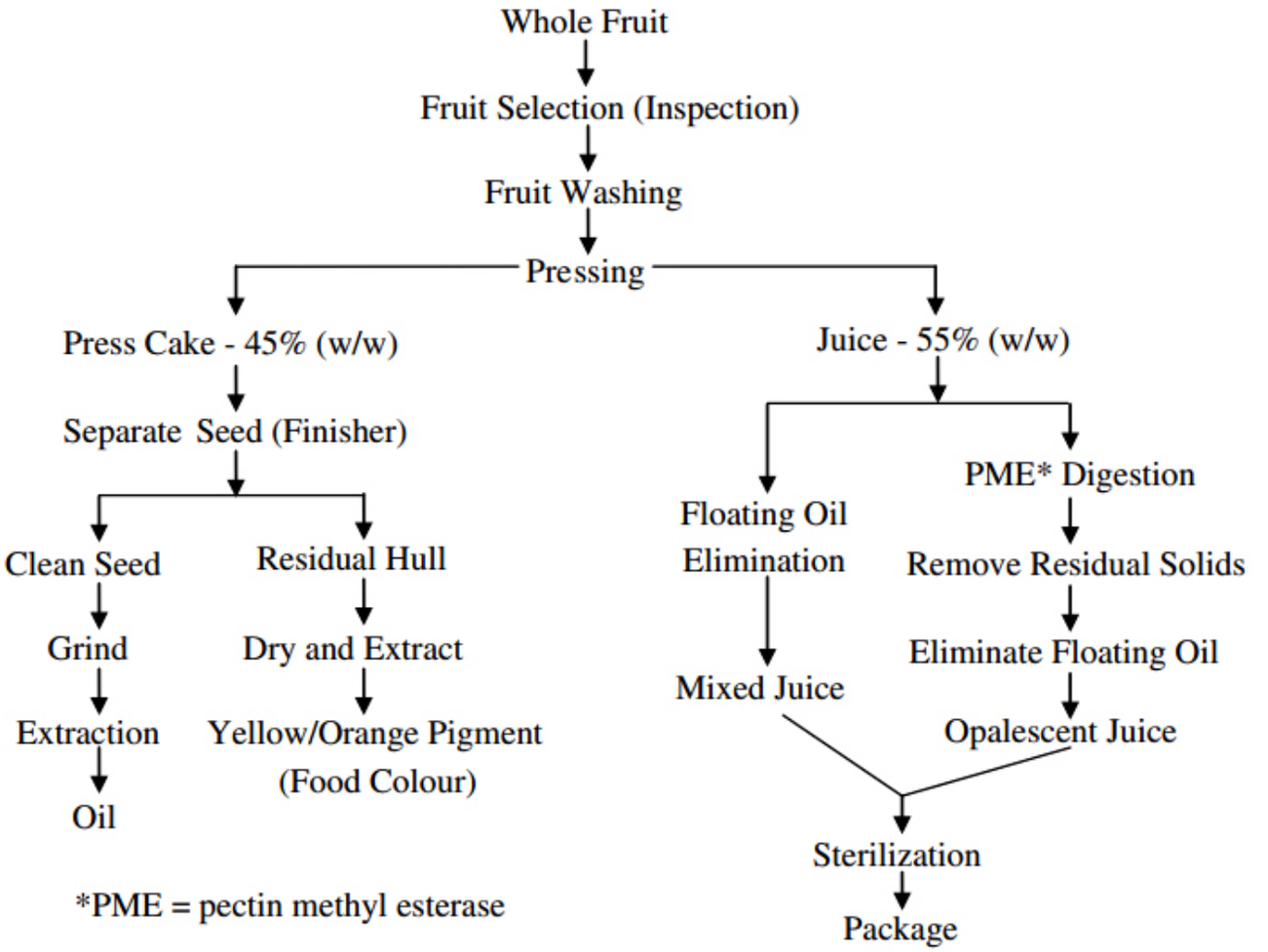
Various bioactive compounds in SBT berries and leaves are of special interest and the plant material is being screened for selected compounds. The content of carotenoids, tocopherols, tocotrienols, essential polyunsaturated fatty acids and other bioactive components in the berries and polyphenols in the leaves.

The berries are orange-yellow to red color fruits which are a rich source of valuable compounds such as multiple vitamins (C and E), carotenoids (-carotene, lycopene, lutein and zeaxanthin), flavonoids (isorhamnetin, quercetin, isorhamnetin-3-betad-glucoside; isorhamnetin-3-beta-d-glucosaminide; kaempferol, etc.) organic acids, amino acids, micro and macronutrients. Many bioactive compounds were isolated from the berries of SBT such as hippophae cerebroside, oleanolic acid, ursolic acid, 19-alpha-hydroxyur solic acid, dulcioic acid, 5-hydroxy methyl-2-furan carbox-aldehyde, cirsiumaldehyde,

octacosanoic acid, palmitic acid and 1-Ohexadecanolenin. Zeaxanthin and betacryptoxanthin esters can be used as food additives, cosmetic ingredients or nutraceuticals. In addition to the plethora of antioxidants, the berries are also rich in fatty acids (saturated 13.7% and 86.3% unsaturated) including palmitic acid, oleic acid (omega-9), palmitoleic acid (omega-7), linoleic acid (omega-6), and linolenic acid (omega-3); and phytosterols. The most recognized product of SBT is comprised of seed oil that is enriched in essential fatty acids (omega-3 and 6) and pulp oil that contains high levels of omega-7 (Zheng et al., 2009). SBT leaves contain nutrients and bioactive substances which mainly include flavonoids, carotenoids, free and esterified sterols, triterpenols, and isoprenols. The leaves are an equally rich source of important antioxidants including -carotene, vitamin E, catechins, elagic acid, ferulic acid, folic acid and significant values of calcium, magnesium and potassium.

Vitamins

Sea buckthorn berries are well known for their extraordinarily high levels of vitamin C. The vitamin C concentration in berries varies from 360 mg/100 g of berries for the European subspecies rhamnoides to 2500 mg/100 g of berries for the Chinese subspecies sinensis. The pulp of the Indian sea buckthorn berries



Processing of sea buckthorn berries (Beveridge et al., 1999)

contains 223.2 mg/100 g of vitamin C. Approximately 75% of the vitamin C in the pulp of berries was retained in the juice during processing, resulting in 168.3–184.0 mg/100 g of vitamin C in the final clear juice. The vitamin E content in sea buckthorn berries is 160 mg/100 g, juice contains 162–255 mg/100 g and seed contain 40.1–103.0 mg/100 g vitamin E for Chinese varieties. The vitamin E content in sea buckthorn is higher than that found in wheat embryo, safflower, maize and soybean (Bernath & Foldesi, 1992). They are also rich in several other vitamins, including B1, B2, K and bioflavonoids. Carotenoid content is the main parameter by which sea buckthorn oil is traded commercially. Carotenoids vary widely depending on the source of the oil, ranging from 314 to 2139 mg/100 g for Chinese grown sea buckthorn.

Organic acids

The berries of sea buckthorn contain organic acids mainly malic and quinic acids together constituting around 90% of all the fruit acids in different origins.

Mineral elements

There are many mineral elements present in berries/juice and seed of sea buckthorn and at least 24 chemical elements present in sea buckthorn juice, e.g. nitrogen, phosphorus, iron,

manganese, boron, calcium, aluminum, silicon and others. Potassium plays an important role in the ionic balance and helps in maintaining the tissue excitability of the human body. Potassium is the most abundant of all the elements investigated in berries or juice. Concentration of potassium is more abundant among all the elements investigated in the fruits and seeds of H. rhamnoides. It varied between 10.12 and 14.84 ppm in the pulp and between 9.33 and 13.42 ppm in the seed of the Indian species (Dhyani et al., 2007).

Potential health benefits of sea buckthorn

Sea buckthorn berries are traditionally known for their medicinal properties as well as their high nutritional value. Although, used for centuries in its native Europe and Asia, sea buckthorn berries have recently gained worldwide attention, mainly for its nutritional and medicinal value. It is used in about two hundred industrial products including lifesaving drugs and herbs to treat cancer, heart ailments, ulcers, hepatic disorders, burns and brain disorders. Some of the health benefits cited for sea buckthorn berries products include: anti inflammation, antimicrobial action, pain relief, the promotion of tissue regeneration, boosting of the immune system, and protection against cancer and cardiovascular disease.

For its haemostatic and anti-inflammatory effects, berry fruits are added to medications for pulmonary, gastrointestinal, cardiac, blood and metabolic disorders in Indian, Chinese and Tibetan medicines. Sea buckthorn berry components have a potential anticarcinogenic activity. Fresh juice, syrup and berry or seed oils are used for colds, fever, exhaustion, as an analgesic or treatment for stomach ulcers, cancer, and metabolic disorders.

The oil from fruits and seeds is used for liver diseases, inflammation, disorders of the gastrointestinal system, including peptic ulcers and gastritis, eczema, canker sores and other ulcerative disorders of mucosal tissues, wounds, inflammation, burns, frostbite, psoriasis, rosacea, lupus erythematosus, and chronic dermatoses. In ophthalmology, berry extracts have been used for keratosis, trachoma, eyelid injuries and conjunctivitis. The sea buckthorn is also known to kill tiny parasitic mites called Demodex.

The preparations from the fruit and seeds of sea buckthorn have demonstrated great promise in the treatment of the mucous membranes including ulcers and gastro-intestinal disorders as well as vaginal problems. Additional studies have shown that sea buckthorn oils and juice have a positive effect on the cardiovascular system and cholesterol lowering activity Sea buckthorn berries oil is used in cosmetic preparations and for various skin conditions. Due to high contents of antioxidants, sea buckthorn oil is being extensively used as an anti-inflammatory, anti-bacterial, analgesic and for the promotion of tissue regeneration. Also, the rich content of essential fatty acids, antioxidants and vitamins, offer sea buckthorn oils support to women's health not only to improve menopausal symptoms but also to maintain the health and well-being of women throughout life-time.

The schematic diagram showing the possible effect of the Sea buckthorn leaf extract

in promoting wound-healing activity (Upadhyay et al., 2011) Post harvest processing of sea buckthorn berries Sea buckthorn berries when overripe carry a strong musky odour with rancid taste, detectable even in the field. Washing may reduce or change the odour. To avoid this problem, berries must be harvested at the correct stage, quickly transported to the processing plant, and be cooled immediately to temperatures around 4–6 °C to retard growth of microorganisms. However, processing method that can be used to separate useful components of the berries, yielding the key products of juice, dried fruit nutrients, and oil from the seeds and pulp; residues can be utilized as a valuable animal feed. New technologies, involving supercritical carbon dioxide extraction, are now being used to efficiently produce the oil products.

Conclusion

Currently, Sea buckthorn has gained the status of one of the most sought-after plants in the pharmaceutical and cosmetic based industries, besides health food processing industries the world over. Several countries are commercially and ecologically harnessing the potential of SBT for livelihood enhancement and environmental conservation. The amount of experimental data evidencing important properties and bioactive substances from SBT is vast and continues to increase rapidly. The presence of valuable chemicals and nutritionally important constituents in SBT, and from the scientific knowledge of their importance, it is clear that SBT should be used as alternative nutritional sources in the commercial market. SBT shows multiple pharmacological and therapeutic activities such as antioxidant, immunomodulatory, anti-inflammatory, antiatherogenic, anti-stress, cardioprotective and wound healing from its different parts (leaves, fruits and seeds). Due to immense antioxidant activities, SBT and its various products ensure the human and animal body's equilibrium through the action of its various effective components. Evidence of these uses originated in traditional knowledge and recent scientific investigations. SBT based formulations can be developed as plant drug or functional food and nutraceutical to increase the antioxidant status and strengthen the immune system which in turn may be useful in enhancing the resistance of the organisms subjected to multiple stresses.

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ICAR-Central Inland Fisheries Research Institute, Kochi Centre

Prospects on Fresh water Prawn Farming in Enclosure Systems of In land Open water bodies of India

Inland fish production has increased from 5.66 MMT in 2000-01 to 16.25 MMT in 2021-22 in India. Mean while, the overexploitation of marine fishery resources led to a drastic decline in marine fish production. At this juncture,

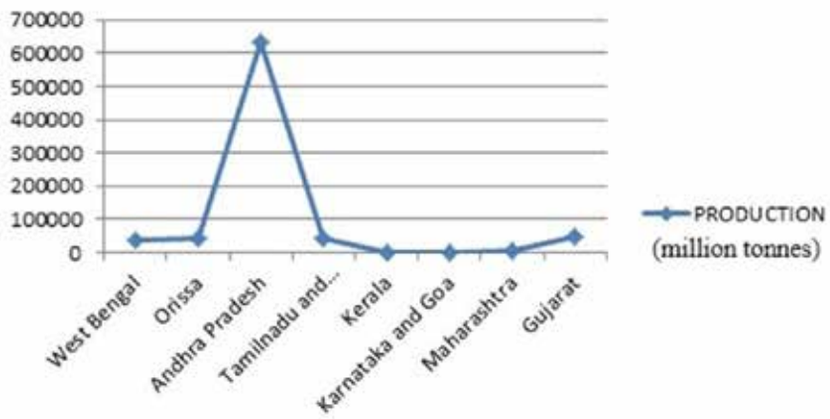

Figure 1: *L.vannamei* production in India during the year 2020-2021 (source: MPEDA)

enhancement of inland fish production is the best alternative to meet the increasing demand of fish protein requirement. The inland open water bodies such as rivers, reservoirs, lakes, streams etc. offer ample scope in the inland fisheries development sector in India. Fish harvest in an open water system depends on either culture based fisheries in reservoirs or enclosure culture techniques like cage farming in reservoirs and pen systems in wetlands and rivers.These enclosure culture systems were publicised as an alternative methodology for the stock enhancement of depleting fish stocks, enhancing fish production and improving the availability of adaptable and desirable fish species. In the present scenario, cage culture and pen culture are the two successful enclosure culture methods gaining great momentum in the arena of global world aquaculture production. The practice of cage culture in inland waters has spread throughout the world to more than 35 countries in Europe, Asia, Africa and America. The inland water pen culture is practiced on a commercial basis in the Philippines, Indonesia and China (Baluyut and Balnyme., 1995). The major species cultured in cages and pens includes carps, tilapia, salmonids, catfish, snakeheads, pangasius and milk fishes. However, enclosure culture of shellfishes like clams, freshwater prawn, crabs etc. has been done in open waters but lacks popularization and standardization in adopted methodologies.

Significance of giant river prawn, *Macrobrachium rosenbergii*

Giant fresh water prawn, *Macrobrachium rosenbergii* (scampi) is the most commonly cultured species in India while *Macrobrachium malcomsonii, M.gangeticum* are the next preferred considering size and demand in the market. The demand of *Macrobrachium rosenbergii* is so high in the export market and the commodity has an immense role in the global market. Extensive farming of Macrobrachium rosenbergii

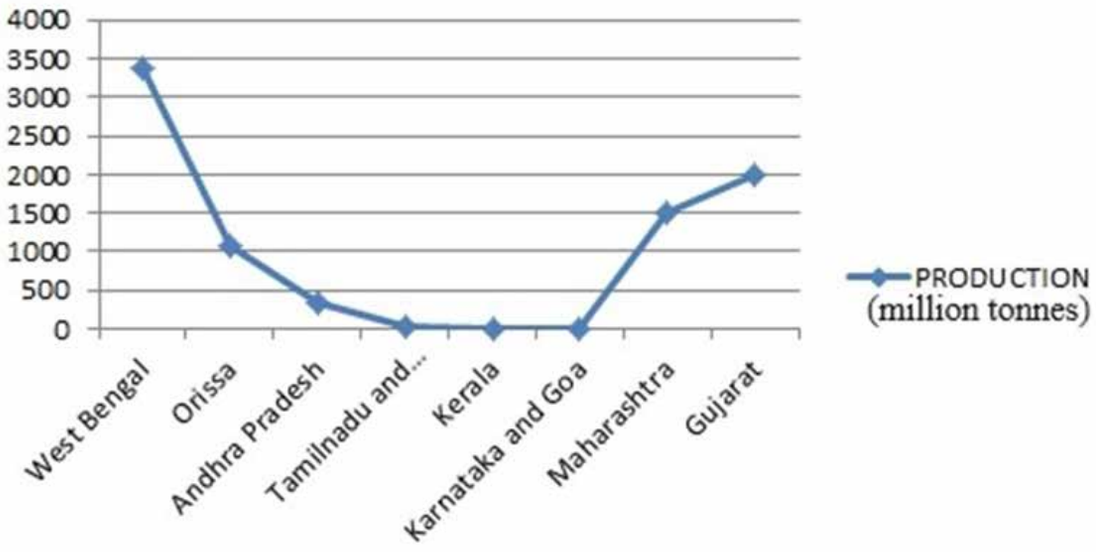

Figure 2: *M.rosenbergii* production in India during the year 2020-2021. (source: MPEDA)

in pond based culture systems starts from the 1990s in India. The species was most suitable in Indian conditions and were naturally present in the Indian waters especially in the state of Kerala, Odisha and West Bengal. It also served as a candidate species in monoculture as well as polyculture farming along with carps and tilapia. The freshwater prawn production reached a maximum value of 42,780 tonnes in the year 2005-2006 in India and the state Andhra Pradesh was the major contributor of freshwater prawn in the export market (Nair and Stalin, 2012). The occurrences of diseases and overfishing resulted in the decline of natural

stocks and caused decline in the scampi production. The culture area preferred for L.vannamei culture caused a paradigm shift to shrimp production.The production figure points out that Andhra Pradesh became the highest producer in *L.vannamei* while West Bengal topped in the production of *Macrobrachium rosenbergii* in the year 2020-2021(Figure 1 & 2).

Enclosure culture of freshwater prawn farming

Freshwater prawn farming in cage and pen systems has been practiced from the 1980s in different parts of the world. Thailand(Limpadani et al., 1980, Sripatrprasite& Lin.,2003), Philippines(Cuvin-aralar et al., 2013) Vietnam (Phuong et al.,2006), SriLanka (Digamadulla,2023) and India (CIFRI, 2002) have reported scampi production from reservoirs, rivers and wetlands. The pen culture technology of freshwater prawn has been successfully demonstrated in Akaipur beel in India. River pen culture of giant freshwater prawn was reported in southern Vietnam. In Philippines, lake based cage scampi farming trials shows that small net mesh size of 1mm is advantageous on account of its low risk of unwanted fishes entry, better growth rate and selective harvesting of scampi stocks (Cuvin-aralar et al, 2013). Co-culturing of Tilapia and giant freshwater prawn in the lake based cages in Philippines showed desirable production with stocking densities of 12 no. /m2 fish and 2 to 4no. /m2 prawns (Romana-Eguia, 2021). Experimental trials on river pen culture of giant freshwater prawn in southern Vietnam at an average density of 62 no. /m2 resulted in year round scampi production (Son et al., 2005). Disease occurrences and standardisation of culture practices were the limiting factors in these pen systems.Contrarily, some failed attempts due to natural flooding were also reported in freshwater prawn cages in Surma river of Bangladesh (Ahmed N, 2010). Similarly, many trial attempts on production enhancement of scampi have been taken up in India. Ranching programmes in the reservoirs of Kerala (Nair et al., 2007),Telangana (Laxmappa. 2014) and Andhra Pradesh (Suguna T., 2020) reveals the significance of culture-based fisheries of freshwater prawns

in enclosure culture systems. Integrated farming of freshwater prawn and paddy farming in the low lying wetlands of the Kuttanad region of Kerala was feasible and the methodology can be adapted in the wetland areas of the country (Kurupand Ranjeet, 2002). Study by Nair et al. (2006) indicated that monoculture of all male prawns showed better results and can be adopted as a successful culture practice. Further, reports by Salin and Nair(2009) stated that partial harvesting is not possible in the extensive paddy fields where pen systems can be introduced and batch harvesting can be done.

Remarks

The adaptability to freshwater and brackish water habitat, polyculture suitability with carps and tilapia, increased susceptibility and disease resistance to White spot syndrome virus (WSSV) promulgate freshwater prawn as an alternative species to Penaeid shrimps for enclosure farming.Improved fast growing strain, CIFA-GI SCAMPI® seeds was developed by ICAR-CIFA to achieve production area of freshwater prawn scampi from 12,500 ha to 25,000 ha by 2026 (Panda et al.,2022).

The risk related with freshwater prawn farming includes the timely availability of seeds, the suitability of culture area, awareness on freshwater prawn farming practices and lack of standardised protocols on health management. Size dissimilarity in male and female prawns (Heterogeneous individual growth) is observed as an unresolved problem in the farming of this priced commodity.Standardisation of stocking density, water quality parameters and size harvesting can be adapted as management measures in freshwater prawn enclosure systems.

Conclusion

The sustainable development of giant freshwater prawn production could be achieved by way of re-establishment of depleted stocks through stock enhancement and ranching programmes, restricted fishing during breeding time and cage and pen culture interventions. These culture systems are an alternative livelihood can generate employment and source of income to riparian fishing communities, enhance the existing stock, increase the export earnings and thereby improve the economy of the country.

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Super foods of the Future-Nutrient Rich Crops to Watch

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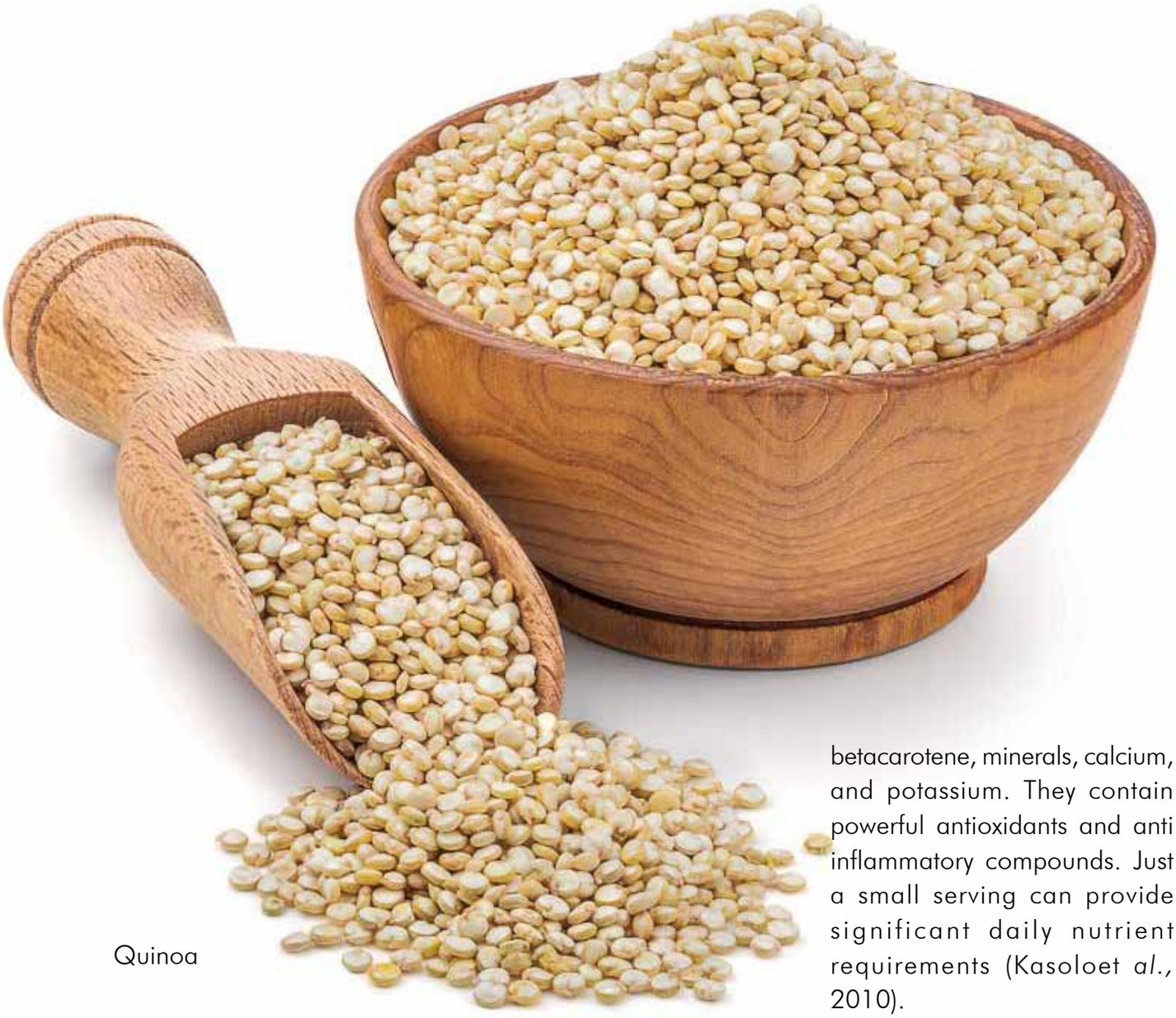
As the global population continues to grow and climate change threatens traditional agricultural systems, the search for sustainable, nutrient dense crops has never been more urgent. From quinoa's complete protein profile to the vitamin rich leaves of moringa, and the iodine loaded seaweed, these crops are poised to play a significant role in the diets of tomorrow. Here's why these superfoods are worth keeping an eye on.

Quinoa: The Ancient Grain of the Andes

Quinoa *(Chenopodium quinoa)*, often called as ''pseudo cereal'', has been cultivated for thousands of years in the Andean region of South America. It gained global popularity in recent decades due to its impressive nutritional profile and versality in cooking.

Nutritional Powerhouse: Quinoa is unique among grains as it contains all nine essential amino acids, making it a complete protein. The protein content of quinoa seeds ranges



Quinoa

between 11% and 19%(Angeli, 2020).

Adaptability: This hardy crop can thrive in diverse climates and soil types, even in high altitudes and areas with poor soil quality. Its ability to withstand drought and salinity makes it a promising candidate for regions facing climate change challenges.

Culinary uses: Quinoa's nutty flavor and versatility make it staple in both savory and sweet dishes. It can be used as a base for salads, a substitute for rice or pasta, and even ground into flour for baking.

Moringa: The Miracle Tree

Moringa oleifera, often referred to as the "miracle tree", is native to the foothills of the Himalayas but has spread to tropical and subtropical regions around the world. Virtually every part of the moringa tree is edible and packed with nutrients.

Nutritional Benefits: Moringa leaves have a high content of betacarotene, minerals, calcium, and potassium. They contain powerful antioxidants and anti inflammatory compounds. Just a small serving can provide significant daily nutrient requirements (Kasoloet *al.*, 2010).

Health benefits: Moringa has been studied for its potential to lower blood sugar levels, reduce inflammation, lower cholesterol, and protect against arsenic toxicity. Its rich nutrient profile makes it a valuable food source in regions suffering from malnutrition.

Versatility: Moringa leaves can be eaten fresh, dried, or powdered and are used in soups, stews, and teas. The seeds, pods and oil are also edible and have various culinary and medicinal applications.

Seaweed

Seaweed: The Ocean's Super food Seaweed, or marine algae, has long been a staple in East Asian diets, but it's now gaining recognition worldwide for its nutritional value and environmental benefits.

Nutrient Density: Seaweed is a nutritional powerhouse rich in essential vitamins and minerals. It provides iodine for thyroid function, magnesium for muscle and nerve health, and vitamin K for blood clotting and bone metabolism. Additionally, it contains vitamin C, folate, and vitamin A, which support immune function, DNA synthesis, and vision(Guiry and Kuipers, 2024).

Sustainable Super food: Seaweed grows rapidly and requires no fresh water, fertilizer, or land. It also absorbs CO_2 and helps combat ocean acidification, making it one of the most sustainable food sources on the planet.

Culinary Potential: They can

Moringa

Breadfruit

be used in a variety of dishes, from sushi and salads to soups and snacks. It adds a unique flavour and can be a healthy, lowcalorie addition to many meals.

Amaranth: The Resilient Grain Amaranth, like quinoa, is an ancient grain that has been cultivated for thousands of years. It was a staple food of the Aztecs and is now being rediscovered for its nutritional value and adaptability.

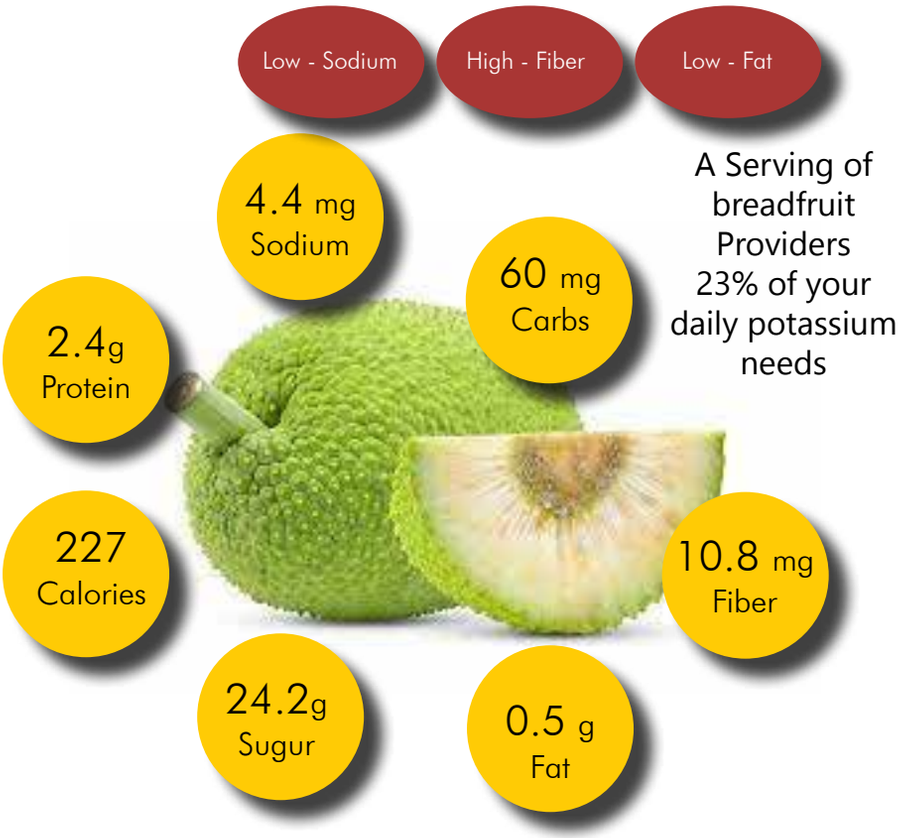
Rich in Nutrients: An excellent source of iron and β-carotene, helping to prevent iron and vitamin A deficiencies. Its high folic acid content also aids in increasing blood haemoglobin levels, and being gluten free makes it a valuable supplement for individuals with celiac disease (Raiger andJajoriya, 2023).

Adaptability: This drought resistant crop can grow in a variety of environments, from arid lands to high altitudes, making it an excellent option for regions facing water scarcity.

Culinary Versatility: Amaranth seeds can be cooked like rice or popped like popcorn. The leaves are also edible and can be used in salads or cooked like spinach.

Breadfruit: A Starchy Staple for the Tropics

Breadfruit *(Artocarpus altilis)* is a tropical fruit with a starchy texture and mild flavor, often compared to potatoes or bread. It has been a staple



Amaranth

food in the Pacific Islands for centuries.

Nutritional Value: Breadfruit is rich in complex carbohydrates, dietary fiber, and essential vitamins and minerals like potassium and vitamin C. It is also a good source of antioxidants.

Productivity and Sustainability: A single breadfruit tree can produce up to 450 pounds of fruit per year. It requires minimal input once established and can thrive in poor soils, making it a sustainable food source for tropical regions.

Culinary Flexibility: Breadfruit can be boiled, roasted, baked, or fried. It can also be ground into flour and used in various baked goods, making it a versatile ingredient in both sweet and savory dishes.

The Road Ahead: Integrating Superfoods

While these superfoods hold great promise, widespread adoption requires overcoming several challenges. Cultural acceptance, accessibility, and affordability are key factors. Efforts must be made to educate communities about these crop's benefits and to develop infrastructure and markets that support their production and distribution.

Conclusion: Embracing Diversity for a healthier future The superfoods of the future are more than just trendy health foods, they are potential solutions to global challenges like malnutrition, food security and environmental sustainability. By embracing these nutrient rich crops, we can create more diverse and resilient food systems that support both human health and the health of our planet. As we look to the future, let's celebrate the incredible potential of these crops to nourish our growing world.

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Moonlight Garden

Garden of Eternal Gloaming

A moonlit garden is a beautiful serene space designed to enjoyand appreciate the light of moon during night. The garden is named as twilight

Fragrant flowering plants

garden, evening garden, night garden, moonlight garden, moon gate, moon window, or moon bridge, or dream garden, however the purpose designed for night or evening time experience. The key idea behind a moonlight garden is to create a serene and enchanting space that comes alive after sunset, using plants and design elements that reflect moonlight, emit fragrance and add texture and movement that are highlighted by the gentle glow of the moon. And also to feel the different effects produced by moonlight compared to sunlight in human color perception emphasize the colors of certain flowers more than others, bringing out different tones which are not available during daytime or with artificial lights. A moon garden is not just about sight, but about all the senses. Strong scents, the feeling of a breeze or sound of movement will enhance the experience of a garden during the evening or night.

By typically incorporating plants with pale, reflective foliage and flowers that appear to glow in the moonlight provides a tranquil escape, encouraging reflection and relaxation under the night sky. It involves selecting plants and design elements that will thrive and look enchanting under the soft glow of the moon.

Cultural and Historical Context

- Moonlight gardens have roots in various cultures and traditions, where they have been appreciated for their beauty and tranquility. In Persian, Mughal, and

Foliage Plants

Japanese time period, moonlight gardens had significant value, created for royalty and as places for contemplation and evening relaxation. The Mughals added pools and water devices to their moonlight gardens and outlined the raised paths, platforms, and pavilions with small oil lamps.

- In India, the MehtabBagh, meaning 'moonlight garden', was built around 1530 by Emperor Babur and later became part of the Taj Mahal complex, this was built to reflect the beauty of the Taj Mahal in the moonlight creating a mirror image in the Yamuna River. It featured night-blooming plants, white plastered walkways, an octagonal reflecting pool, and a pavilion.

Common features of a moonlight garden

- Incorporation of plants with light-colored flowers, silver or grey foliage and that release fragrance in the evening making them stand out at night.
- To enhance the sensory experience, moonlit gardens often include aromatic plants such as lavender, gardenias, and night-blooming jasmine, which release their scent in the evening that creates a relaxing and inviting atmosphere
- Arbours or pergolas and trellis covered with white-flowering climbers like clematis, jasmine, or climbing roses, these structures add height and structure.
- A small pond, reflecting lily or lotus pool, or fountain can reflect moonlight on water add a layer of depth and interest, making the garden feel more alive and dynamic.
- Place lights under trees or shrubs to cast interesting shadows and highlight foliage.
- Use white marble for benches, statues or pathways to reflect light and add a touch of elegance.
- Hanging lanterns, solar-powered lights along pathways, around water features, and near fragrant plants with intricate designs can cast beautiful patterns of light and shadow, enhancing

Ornamental Grasses

the ambience.

- Include plants that attract nocturnal pollinators used in moonlight gardens, such as moths and bats, contributing to the ecological balance and offering opportunities for observing nighttime wildlife. These moths acts as day light butterflies in moon garden at nights.

Plants suitable for moon light garden

Fragrant flowering plants: The flowers reflect the light of moon and add elegance to garden, while sweet fragrance attract nocturnal pollinators and add movement in the garden. Moonflower (Ipomoea alba), jasmine, Gardenia, Evening Primrose (Oenotherabiennis), White rose var. like 'Iceberg' or 'White Dawn', Chandni (Tabernaemontanadivaricata), Raat Ki Rani (Night-Blooming Jasmine, Cestrum nocturnum), Frangipani (Plumeria alba), Mogra (Jasminumsambac), White water lily(Nymphaea alba), Tuberose (Polianthestuberosa), Datura (Angel's Trumpet), Shasta Daisy (Leucanthemum × superbum), Honeysuckle (Lonicera japonica), Parijat (Nyctanthesarbor-tristis).

Foliage Plants: Silver and Grey foliage plants mainly preferred, Lamb's Ear (Stachysbyzantina), Dusty Miller (Senecio cineraria), Artemisia, Russian Sage (Perovskiaatriplicifolia), Texas sage (Leucophyllumfrutescens).

Flowering plants for moon light garden

Foliage plants for moon light garden Ornamental Grasses: Japanese Forest Grass (Hakonechloamacra), Blue Fescue (Festucaglauca), Silver Grass (Miscanthus)

Famous Moon Gardens in the World

- MehtabBagh in India
- Sonnenberg Gardens in New York
- Four Arts Botanical Gardens in Florida
- Edison and Ford Winter Estates in Florida
- Chihuahuan Desert Nature Center and Botanical Gardens in Texas
- The Gardens on Spring Creek in Colorado
- San Francisco Botanical Garden in California

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ABSTRACT

Agrivoltaics is a technology that combines agricultural production with renewable energy generation, potentially increasing income per unit of land. Agrivoltaic systems can utilize solar and other local renewable energy sources. It is renowned as "Climate Smart Agriculture" option for Indian farmers especially because of wide variations in climatic conditions. This technology supports large-scale unmanned precision agriculture and smart farming by providing on-site power, reducing chemical inputs

Agrivoltaics

New Avenue for Sustainable Crop Production

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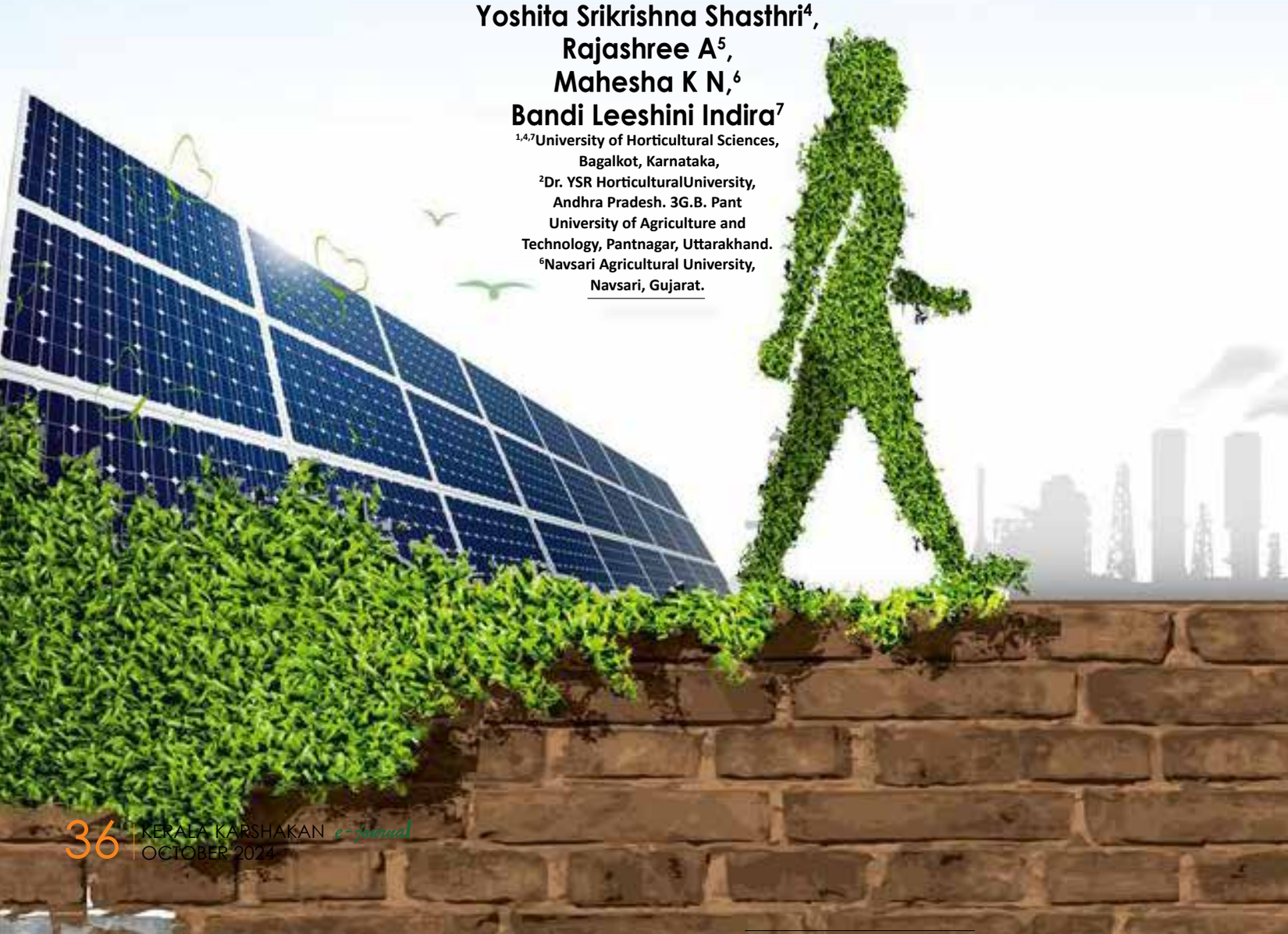

and enabling on-site yield processing, which lowers carbon emissions. The integration of automation in agri/horticulture has the potential to revolutionize logistics, add value to production chains and resolve legal disputes related to land use. In the current scenario, agrivoltaics farming has emerged as a recent innovation in the farming sectorviz., tomato, pepper, zucchini, potato, sweet potato, watermelon, lettuce, spinach etc.

Keywords: Agrivoltaics, sustainable, productivity, technology

Introduction

In 2015, all United Nations (UN) Member States adopted the 2030 Agenda for Sustainable Development, establishing 17 Sustainable Development Goals (SDGs) aimed at promoting global peace and prosperity (UNGA, 2015). By 2018, the UN's progress report highlighted that conflict and climate change were significantly hindering progress, increasing hunger, forced displacement and limiting access to basic water and sanitation services (UN-SDG Report, 2018). According to the IPCC, human activities have caused around 1.0°C of global warming over pre-industrial levels. Renewable energy has the potential to reduce climate change by decreasing fossil fuel consumption and contributing

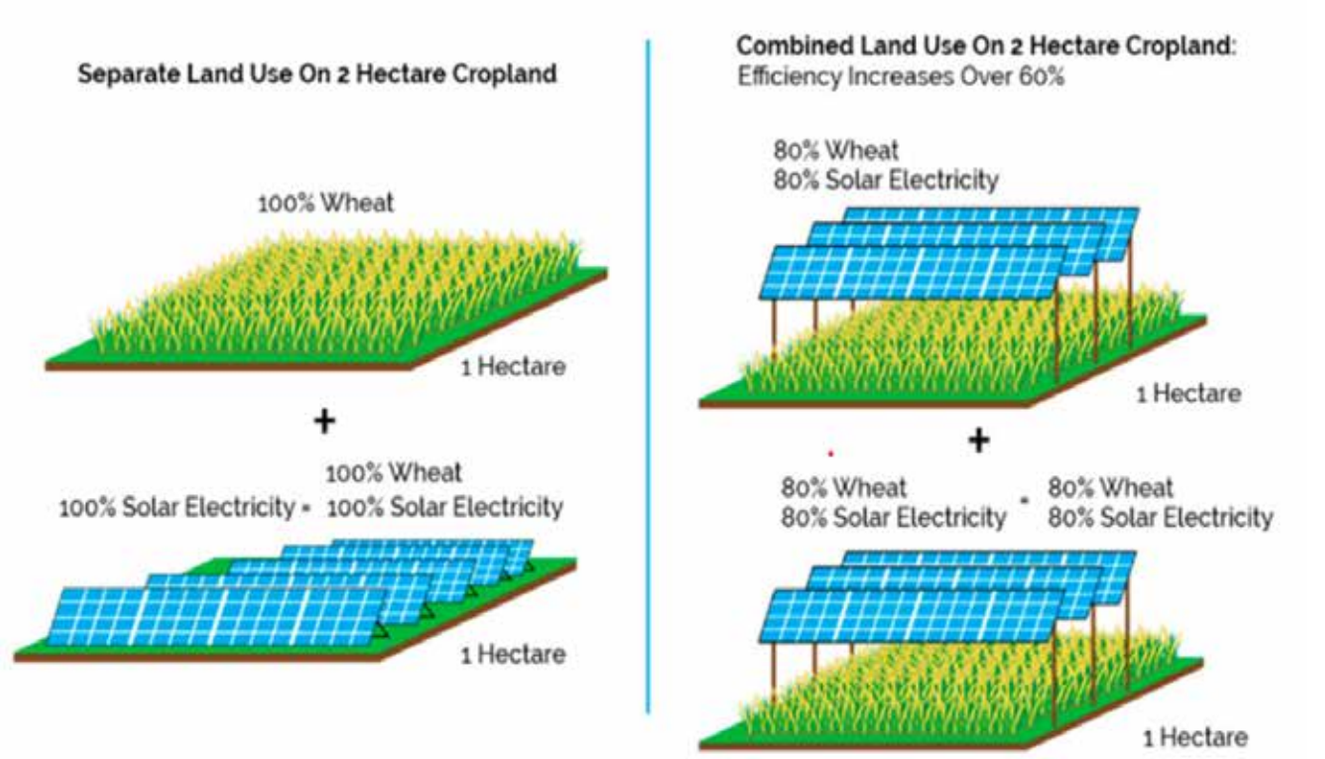

Figure 1: Comparison between Traditional farming vs Agrivoltaics (Abidin et al., 2021)

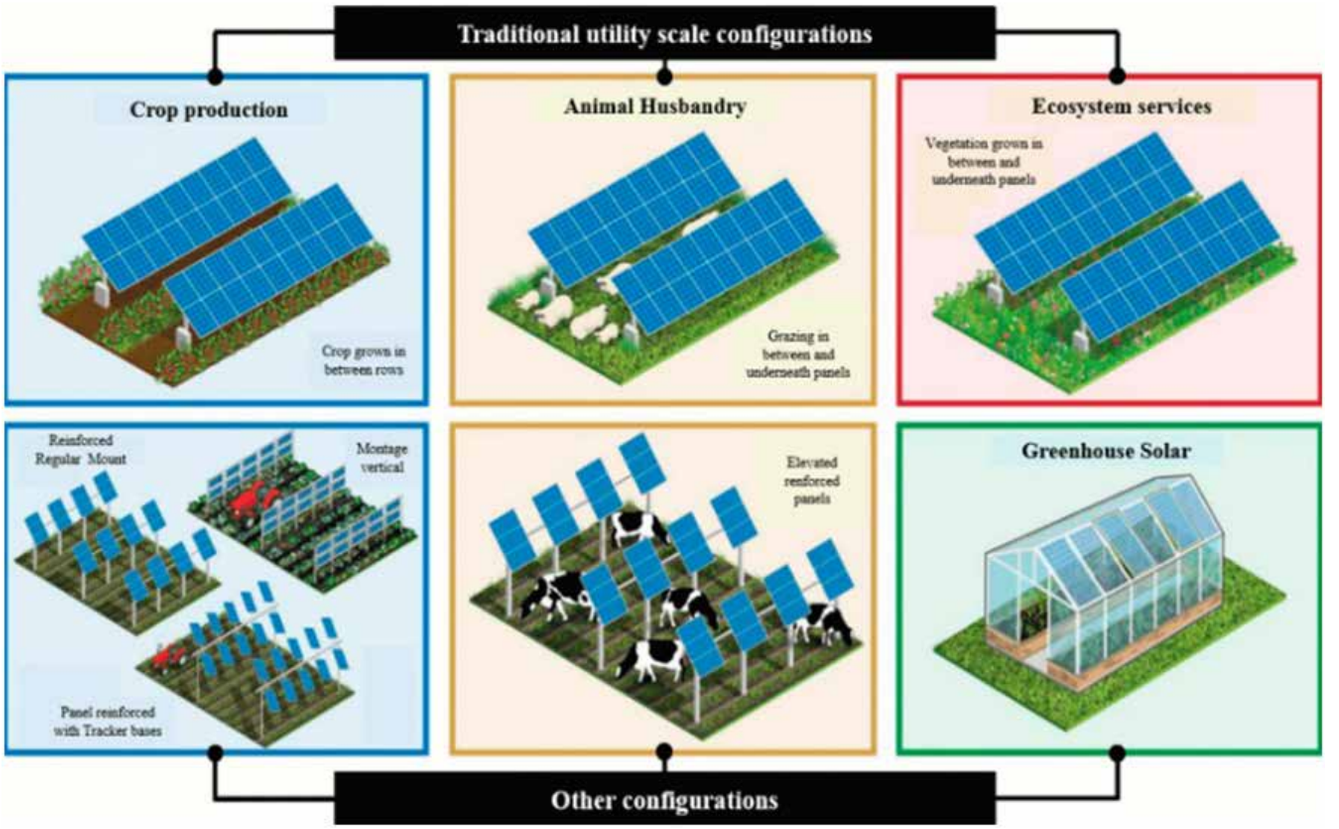

Figure 2: The different agrivoltaic systems

to development, but faulty implementation can result in increased GHG emissions and other environmental trade-offs (Agostini et al., 2021).Renewable energy generation is becoming increasingly significant as energy demand rises and worries about climate change. Solar energy, particularly photovoltaic panels (PVPs), has emerged as an important secondary power source since1970s. However, enormous expanses of land are required, which influences agriculture. Agrivoltaics (AV) provides a solution by integrating solar electricity with agriculture/ horticulture in the same area, hence reducing rivalry for land resources.The agrivoltaism technique is based on the intercropping strategy used in agriculture to improve land equivalent ratio and income. AVS technology is becoming popular for its reliability in variable-scale applications (Abidin et al., 2021).

Agrivoltaic farming

Agrivoltaic practices were initiated in 1980 where it integrates solar energy production with agriculture, optimizing land use for both food and energy. This approach, known as "Agrophotovoltaics". AV's have been developed and tested in Germany, Japan, the United States, Italy, Malaysia, Egyptand Chile. By early 2020, around 2200 AV systems with a total capacity of 2.8 GW had been built worldwide, outpacing all floating and concentrator PV power facilities combined. Japan, South Korea, China, Franceand the United States have all embraced AV systems, while India and Germany are now contemplating their introduction (Schindele et al., 2020).

Three basic strategies for developing AV systems

1. Semi-transparent solar module roof type structure

2.Cylindrical solar cell roof type structure

3. Conventional solar panel type roof structure

are identified by the National Renewable Energy Laboratory (NREL): (1) power generation (continuous rows of PV modules with minimal gaps are characteristic); (2) agricultural/ horticultural crops (stand-alone PV with two-axis trackers) and (3) joint effect(Klokov et al., 2023). The primary idea behind the AV system is that crops can withstand partial shadowing from panels and that the design of the system may regulate the amount of water used by the plants during summer months when drought conditions are common (Jain et al., 2021). Under AV systems, photosynthetically active radiation (PAR) falls at midday but stays constant in the morning and nighttime. Under AV systems, the average air temperature drops by 1.65°C,

and the noon relative humidity remains relatively unchanged. However, the air temperature rises in the early morning and nighttime. In semi-arid and dry environments, where AV systems may power water pumps and promote land reclamation, these effects are especially advantageous (Klokov et al., 2023).

AV systems provide additional money from energy generation, with agricultural income increasing by 60% on average, but it can also either decrease or reach a 15-fold increase. While shade and soil moisture fluctuations might have a detrimental influence on certain crops, they can also assist others by minimizing the impact of dry or wet seasons and stabilizing farmer's income through diversified revenue and assured energy sales. Furthermore, agrivoltaics have a smaller environmental effect than traditional agriculture and are less sensitive to the deterioration of photovoltaic converters over time (Klokov et al., 2023).

Agrivoltaic Methods

There are two types of AV methods: Solar PV modules can be mounted on the ground or near the ground to accommodate farming equipment and alternatively, they can be mounted on an elevated structure with an agricultural area beneath the stilts.

Case studies related to vegetables

Integrating vertical farms (VF) for baby leaf lettuce into commercial closed agrivoltaic systems (CA)boosted production by 13 times and resulted in an average land equivalent Ratio (LER) of 1.31. However, only 12% of the VF's energy demands were covered by the CA's energy, implying that VF regions should not exceed 7-18% of the CA area to attain energy self-sufficiency. This needs land usage five to fourteen times more than the VF area. Photovoltaic (PV) energy assistance is critical to the profitability of VFCAs. Design enhancements were recommended to increase the agronomic and economic sustainability of VFCAs. VFs may rehabilitate unused CAs with high PV cover ratios into productive systems, however, energy output and land usage must be balanced for environmental sustainability (Cossu et al., 2023).

The yield and quality of kimchi cabbage and garlic under both open field and agrivoltaics conditions were reported by Ko et al., 2023. The results revealed an average weight loss of 17% for kimchi cabbage and 15% for garlic in agrivoltaics conditions. However, sensory-related compounds remained unaffected in both crops.Kumpanalaisatitet al., 2022 reported that bok choy in control plots grew better and yielded 17.31 kg, surpassing those under solar panels. The agrivoltaic system, with an average solar radiation of 569 W/m^2, produced 2.28 kW. Despite lower bok choy yield, cultivation under solar panels reduced module temperature by 0.18°C, boosting power generation by 0.09%.

Under AVs, soil temperature dropped, but PAR declined by 43% in semitransparent and 67% in conventional, resulting in yield decreases of tomatoes by 28% and 58%, respectively. Despite the decreased fruit size, AVSs increased fruit quality and reduced the demand for irrigation by more than 15% in semitransparent and 20% in conventional (Mohammedi et al., 2023).AVs enhance farmer's profits through broccoli visual quality and electricity production without dramatic changes in yield, antioxidant capacity and glucosinolates (Chae et al., 2022). The crops studied in combination with AV were beans, potatoes,

sweet potatoes, beetroot, welsh onion, basil, spinach, celery, fennel, chard, tomato, pepper, zucchini, cucumber, eggplant, watermelon, pumpkin, various cabbages, and mushrooms etc(Klokov et al., 2023).

SWOT Analysis of Agrivoltaics (Source: Mahto et al., 2021)

Future Prospects

Agrivoltaics extends beyond merely powering agricultural machinery to optimizing plant growth through shading effects and providing structural support for plants etc. It facilitates extraterrestrial farming, enhances growth simulation, integrates with advanced sensors for real-time monitoring and refines the value chain to boost farmer efficiency.

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Lotus Silk

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Lotus silk, also known as lotus fibre or lotus fabric, is a fascinating and luxurious textile material derived from the lotus plant (*Nelumbo nucifera*). Renowned for its exceptional beauty, softness, and sustainability, lotus silk holds a unique place in the world of textiles. Lotus silk is intricately crafted through a meticulous production process that involves harvesting lotus fibres, spinning them into yarns, and weaving them into exquisite fabrics. This assignment explores the origins, production process, characteristics, and significance of lotus silk, shedding light on its captivating allure in the realm of fashion and sustainability.

Lotus has its origin in Asian countries such as Myanmar, Thailand etc and they are generally found in aquatic environments such as in ponds, lakes and swampy areas.

Production process

Collection: Quality stems are collected for fibre extraction without harming the plant. The stems

fully bloomed, deep pink coloured flowers are preferred.

Cutting: The stems are collected as a bunch and slightly cut using a knife.

Twisting: The cut stems are twisted to expose the fibres.

Rolling: The twisted fibres are rolled.

Spinning: The extracted fibres are spun into yarns which are creamy in colour.

Weaving: Cambodian loom is used for weaving. Dyeing can be done with suitable colours. About 1 m lotus fabric is woven by an experienced weaver in a day.

Characteristics of Lotus silk

- It is very breathable i.e. it promotes air circulation easily.
- The fabric is hypoallergenic.
- It is elastic, smooth and soft.
- Natural fabric and thus eco-friendly in nature.
- Easy to maintain and dry.
- The fabric is lightweight and wrinkle free.

Significance and Uses

Cultural Significance: Lotus silk holds cultural significance in countries like Cambodia and Myanmar, where it is associated with religious

Origin of lotus silk

ceremonies and traditional clothing.

High-End Fashion: Lotus silk is considered a luxury fabric and is often used in high-end fashion garments, such as evening gowns, scarves, and shawls.

Art and Crafts: Lotus silk is also used for various art and craft applications, including embroidery, tapestries, and decorative pieces.

Sustainable Fashion: Due to its eco-friendly production process, lotus silk is gaining attention as a sustainable alternative to conventional textiles.

Challenges and Future Prospects

Limited Production: Lotus silk production is labour-intensive and time-consuming, resulting in limited quantities of the fabric.

Cost: The rarity and intricate production process make lotus silk an expensive textile.

Research and Innovation: Continued research and innovation in lotus silk production techniques could lead to increased efficiency and availability in the future.

Lotus silk is a unique and rare textile material known for its beauty, softness, and sustainability. Its production process involves harvesting lotus fibres, spinning them into yarns, and weaving them into luxurious fabrics. Lotus silk has cultural significance, is used in high-end fashion, and offers sustainable fashion alternatives. Despite the challenges, lotus silk continues to captivate the fashion industry and eco-conscious consumers with its exquisite qualities.

Mutation breeding

way for creating new variation

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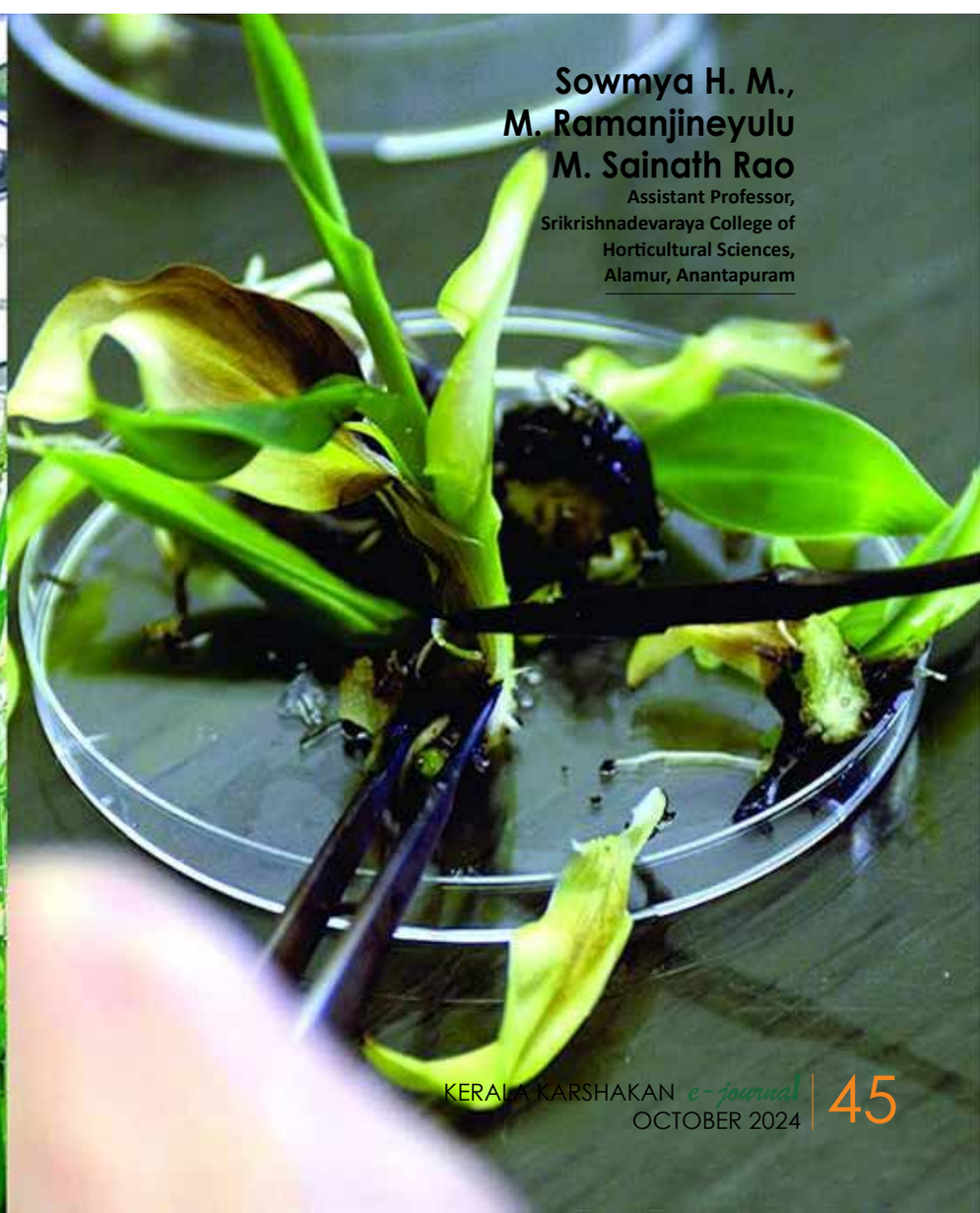

Introduction

As predicted result of increasing population worldwide, plant breeding strategies are valued mandatory. With the increasing life expectancy in era of modern science the available agriculture land is not enough to feed the growing population. So, we have to increase our crop yields. The crop yield cannot be improved by management alone but practices plant breeding activation also should be adopted. The first step in plant breeding is to identify suitable genotypes containing the desired genes among existing varieties, or to create one if it is not found in nature. In nature, variation occurs mainly as a result of mutations and without it, plant breeding would be impossible. In this context, the major aim in mutation-based breeding is to develop and improve well-adapted plant varieties by modifying one or two major traits to increase their productivity or quality.

Importance of mutation in creating variation

- We depend on recombination and independent assortment of favourable alleles to produce new and unique

individuals from which to select and produce the lines that will serve as our cultivars.

- With tens of thousands of genes within each crop species genome, the possibilities seem limitless.
- Recombination per se cannot produce novel traits. This ability is only attainable through the act of mutation.
- The occurrence of mutations within the genome of plants is rare, and in natural settings can be lethal.

Mutation

Mutation refers to sudden heritable change in the phenotype of an individual. In molecular term mutation is defined as the permanent and relatively rare change in the number or sequence of nucleotides due to transition and transversion.

Mutation breeding

Mutation breedingis the process of exposing seeds to chemicals or radiation in order to generate mutants with desirable traits (or lacking undesirable ones) to be bred with other cultivars. Plants created using mutagenesis are sometimes called mutagenic plants or mutagenic seeds. From 1930 to 2014 more than 3200 mutagenic plant varieties were released that have been derived either as direct mutants (70%) or from their progeny (30%). Crop plants account for 75% of released mutagenic species with the remaining 25% ornamentals or decorative plants. However, although the FAO/IAEA reported in 2014 that over 1,000 mutant

varieties of major staple crops were being grown worldwide, it is unclear how many of these varieties are currently used in agriculture or horticulture around the world, as these seeds are not always identified or labeled as being mutagen or having a mutagenic provenance. Mutagenesis is an important tool that can be employed to create variations in genetic material for various purposes including;

1.When the natural variability does not exist in the population.

2.To improve one or two specific defects in cultivated varieties without alteration in its genetic background.

3.To break tight linkage between desirable and undesirable genes.

4.To create desired variation in asexually propagated crops.

5.To improve fruit crops without change in its taste and colour.

6.To develop attractive flower and foliage colours in ornamental plants.

7. To introduce blocks at specific stage of biochemical pathway.

8.To study plant pathogen interaction.

9.Mutation is useful where hybridization is difficult because of its small flower size.

10.Varietal development through mutation breeding is faster since trait fixation is faster.

11. Mutation breeding can be directly used to release varieties.

Characteristics of mutation

- Mutant alleles are recessive, random, harmful, pleiotropic, recurrent and occur at any stage in the development of an organismat a low frequency (10-7 to 10-4 / gene /generation)

Classification of mutation

Visible effect - macro and micro mutations.

Survivability - lethal, sub-lethal, sub-vital and vital.

Cell origin - somatic and germinal.

Conditional - auxotrophic, temperature and antibiotic resistant.

Gene expression - amorphic, antimorphic, hypomorphic, neomorphic.

Origin - endogenous and exogenous.

Expression of adjacent gene - polar and nonpolar.

Gene function - missense, nonsense, splice site and silent.

Chromosome aberrations - structural and numerical aberration.

CAUSES FOR MUTATION

- spontaneous mutations (molecular decay): Spontaneous mutations occur with non-zero probability even given a healthy, uncontaminated cell. They can be characterized by the specific change,

(1) Tautomerism
(2) Depurination
(3) Deamination
(4) Slipped strand mispairing

Error-prone replication bypass: There is increasing evidence that the majority of spontaneously arising mutations are due to error-prone replication (translation synthesis) past DNA damage in the template strand. Naturally occurring oxidative DNA damages arise at least 10,000 times per cell per day in humans and 50,000 times or more per cell per day in rats. In mice, the majority of mutations are caused by translation synthesis. Likewise, in yeast, Kunz et al. found that more than 60% of the spontaneous single base pair substitutions and deletions were caused by translation synthesis.

Errors introduced during DNA repair: Although naturally occurring double-strand breaks occur at a relatively low frequency in DNA, their repair often causes mutation. Non-homologous end joining (NHEJ) is a major pathway for repairing double-strand breaks. NHEJ involves removal of a few nucleotides to allow somewhat inaccurate alignment of the two ends for rejoining followed by addition of nucleotides to fill in gaps. As a consequence, NHEJ often introduces mutations.

Induced mutations caused by mutagens: Induced mutations are alterations in the gene after it has come in contact with mutagens and environmental causes.

APPLICATIONS OF MUTATION BREEDING

- Development of improved varieties.
- Induction of male sterility.
- Creation of genetic variability.
- Overcoming self incompatibility.
- Improvement in adaptation.
- Developing disease resistant varieties.

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