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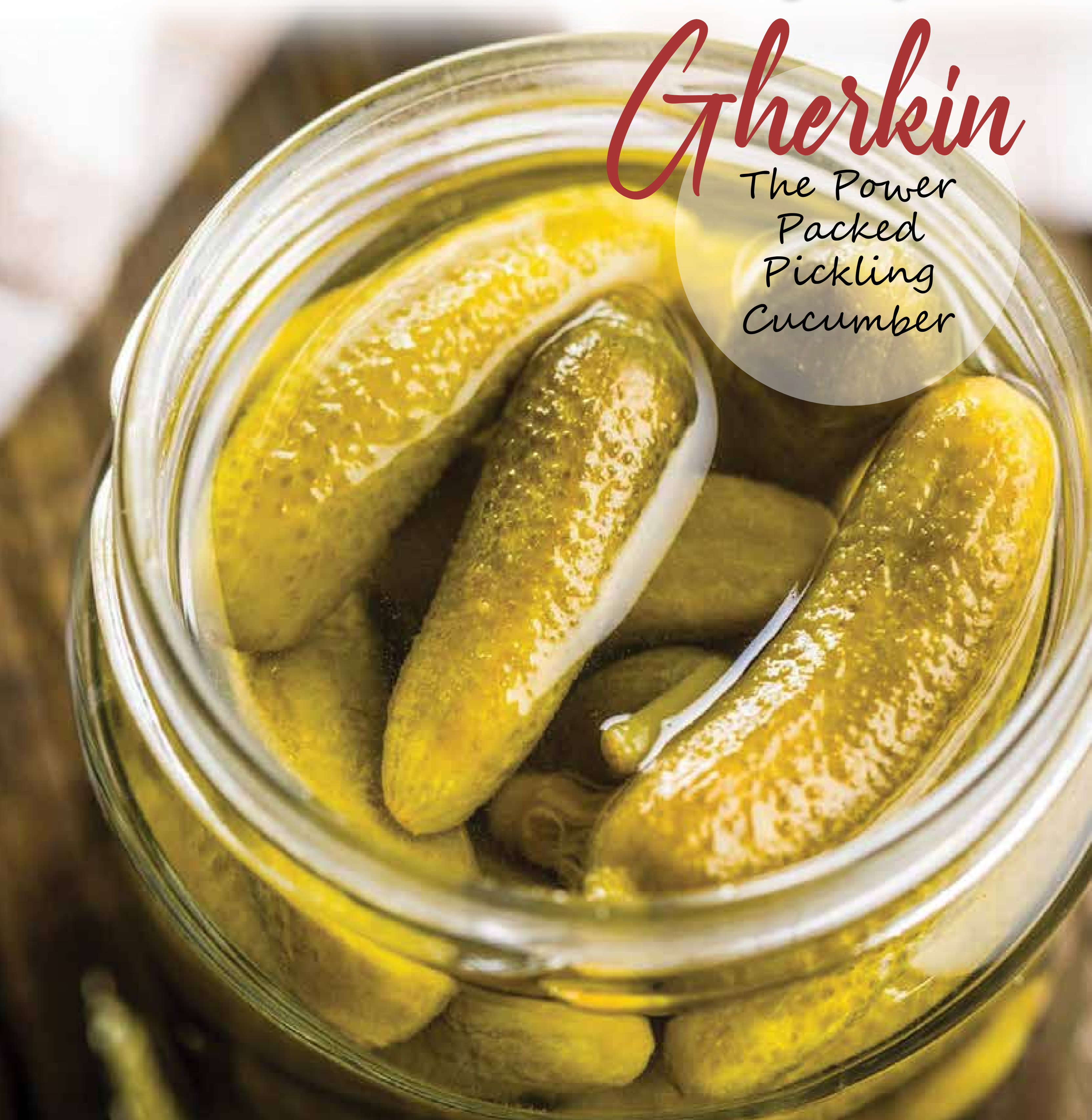
# KERALA KARSHAKAN
English journal

The First English farm journal from the house of Kerala Karshakan

## Gherkin
The Power Packed Pickling Cucumber



# INSIDE KERALA KARSHAKAN
*English journal*

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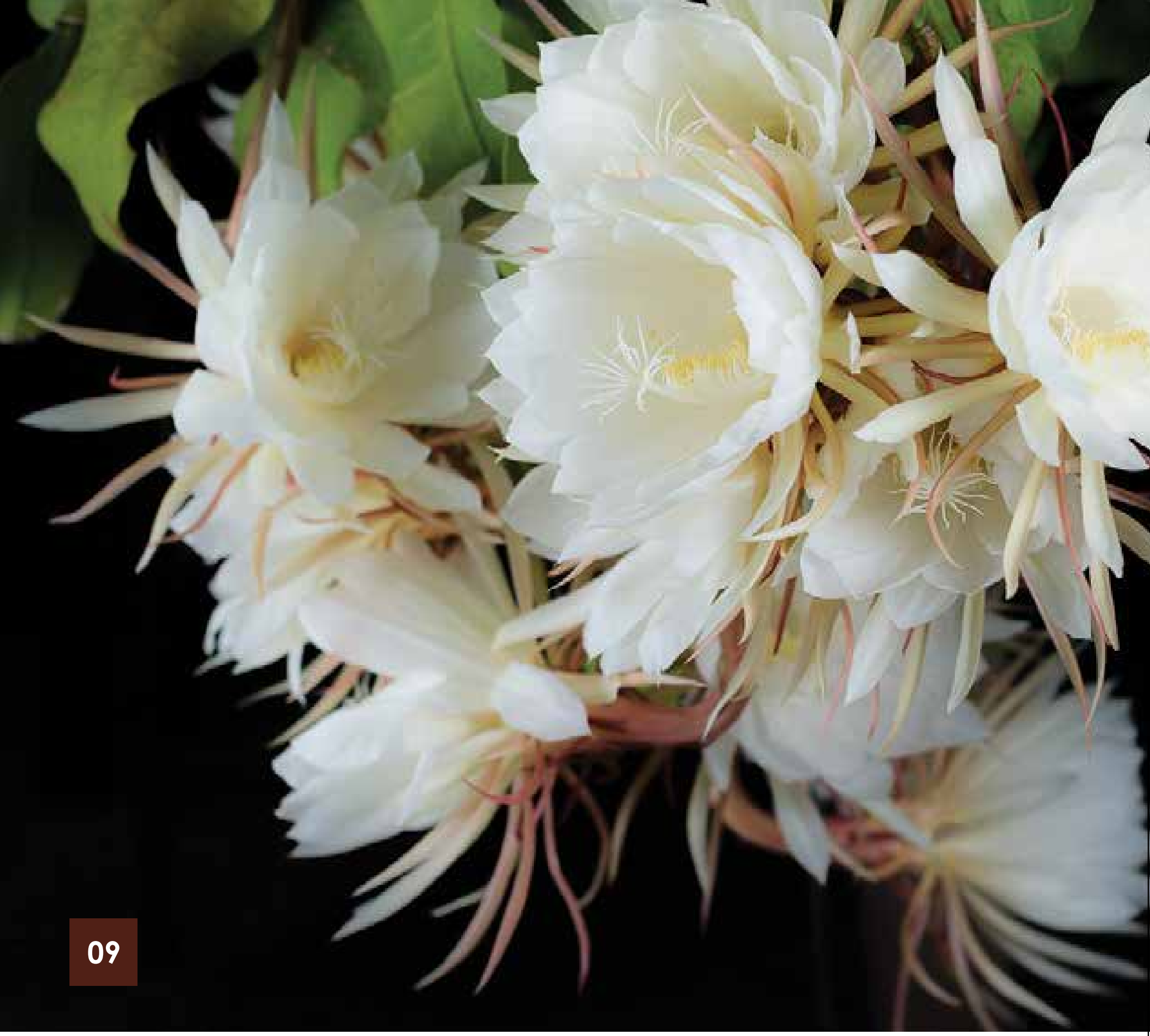



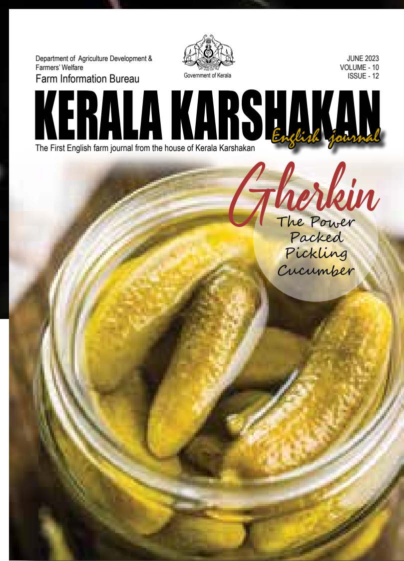




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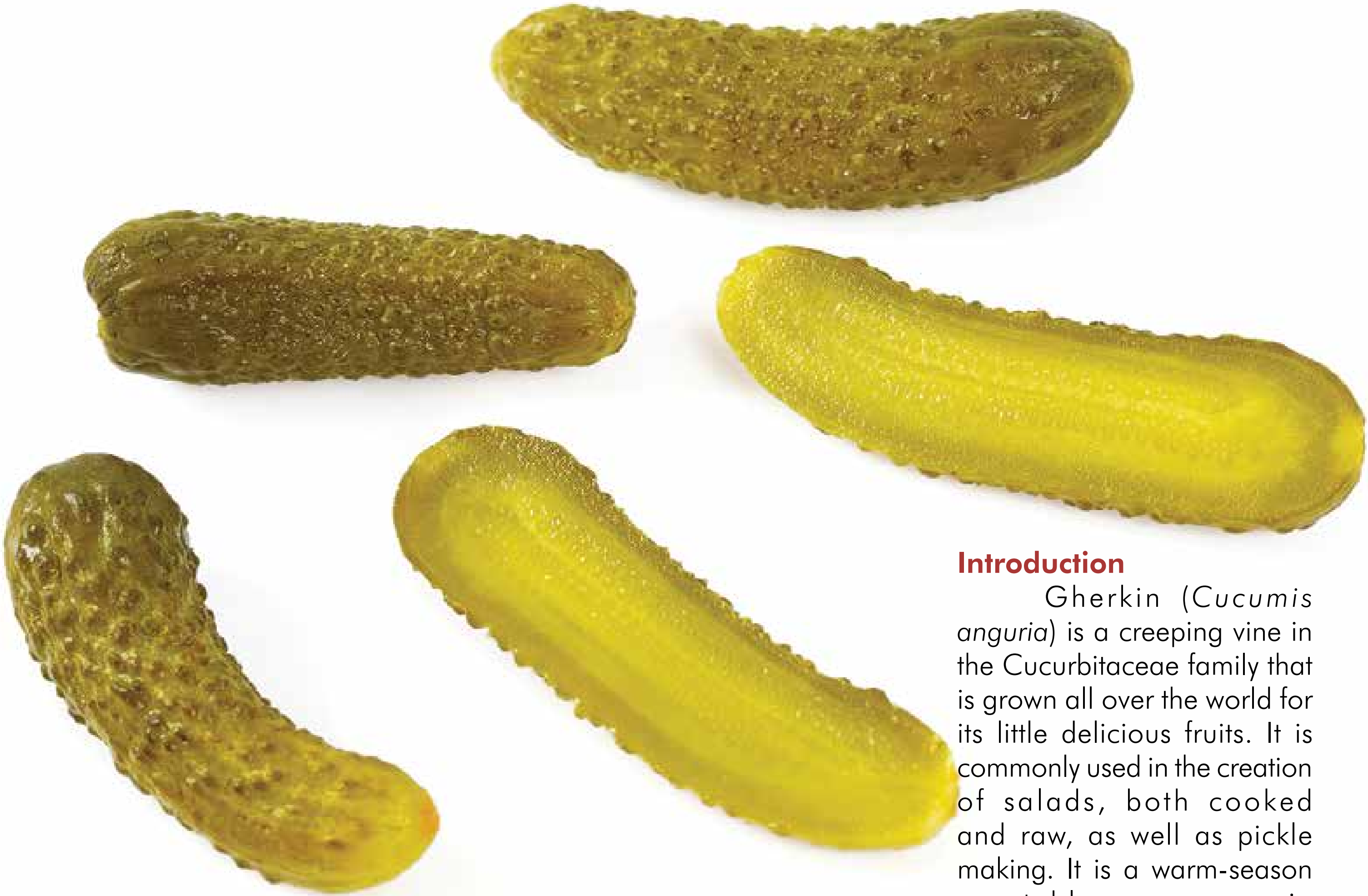
# Gherkin

## The Power Packed Pickling Cucumber



## Introduction

Gherkin (*Cucumis anguria*) is a creeping vine in the Cucurbitaceae family that is grown all over the world for its little delicious fruits. It is commonly used in the creation of salads, both cooked and raw, as well as pickle making. It is a warm-season vegetable crop grown in home gardens or greenhouses under protected cultivation or contract farming in trellis or bowers. Its popularity as a vegetable crop has grown due to its strong export potential, primarily as processed products. Young seeds and

leaves are also employed in the preparation of numerous recipes. Oil is extracted from the seeds, which have a characteristic musky flavour and numerous therapeutic benefits, and is used as a substitute or alternative form of vegetable oil. In some regions of the world, such as North America, it can be found in both wild and cultivated forms in open woodland, grassland, wasteland, savannahs, arid and semi-arid areas, semi-desert areas, and forest borders at elevations ranging from 200m to 1500m above sea level. Gherkin is known as West Indian gherkin, Bur cucumber, Bur Gherkin, Jerusalem Cucumber, Gooseberry Gourd, maroon cucumber, West Indian Gourd, Jelly Melon, Cackery, Chicken Cucumber, Horned Cucumber, Warty Cucumber, 'Pepineto' in Spanish, 'Anguria', 'Angourie des Antilles' in French It is an annual herbaceous, dicotyledonous plant with a weak, rough, succulent, fragile stem that climbs by assistance and is primarily grown on bowers and trellises. It can reach a height of 2-3 m. The first gherkin blossoms appear 6-8 weeks after planting. In general, monoecious sex forms are more common, with staminate and pistillate blooms appearing on the same plant. Depending on whether the species is wild or cultivated, they might be bitter or non-bitter. It has one of the greatest water content levels for any vegetable, at over 90%. The cavity is hollow, containing little seeds that are elliptical with pointy ends and placed in parietal placentation. The fruit is known botanically as pepo. The plants have four to five tendrillar branches.

## Related Species

Gherkin belongs to the Cucurbitaceae family, genus Cucumis and species Anguria, which is one of the largest groups of cultivated vegetables, with 98 genera and over 1,000 species spread across tropical and subtropical climates. The presence of wild progenitor and domesticated variations makes taxonomic classification of this family particularly difficult. There are several cultivated species of gherkin, with bitterness that is significantly lower due to lower levels of Cucurbitacins, although bitterness is considerable in wild forms, with the presence of long irregular spines on the surface of the fruits. Cucumis longipes, the wild, bitter type found in Africa, was originally considered a different species, although the two forms do not produce fertile hybrids. In his monograph, Kirkbride (1993) reviewed the taxonomic situation of *Cucumis anguria* for the first time. *Cucumis anguria*

can also be called *Cucumis longipes or Cucumis anguria var. longipes*. *Cucumis anguria var. anguria* and *Cucumis anguria var. longaculeatus* are the two primary horticultural variations of gherkin. The literal meaning of 'Gherkin' is 'immature,' and 'kin' is a Dutch word because the veggies are mostly consumed raw in the form of salads or pickles.

## Economic Importance

Gherkin is primarily grown for use in pickles and salads, as well as in soups, curries and stews, both savoury and sweet. Gherkins are pickled in brine, dill, and other herbs and spices, then put in cans or jars and sold at premium prices in stores. The pickles were freshly pressed in glass containers using aseptic pressing innovation and vacuum fixing and purification. They are also used as a complement to burgers, fries and sandwiches at fast food restaurants. Many classic dishes in the United States and Western nations use gherkin or pickled cucumber. Gherkins are common element in non-vegetarian dishes in northern and north eastern Brazil. Gherkins are a key ingredient in garden salad (served with fried and grilled dishes), where they are tossed in dill and olive oil and sliced over a sandwich, or used as a beginning at parties, particularly for those who choose a healthy choice in their meals. Cucumbers are fermented pickled by combining them with water, salt and bacterial culture. Following that, the bacterial culture is given enough time to ferment various components in the cucumbers into diverse beneficial chemicals. This produces a variety of probiotic and bioactive chemicals that are beneficial to the GI tract.

## Nutritional Value & Therapeutic Uses

Gherkin's nutritional composition (per 100 g edible piece) comprises 95 g of water, 4 g of carbs, 0.6 g protein, 0.1 g fat, 0.5 g of dietary fibres, 14g Calcium, 124 g Potassium, 5 g of Sodium, 0.3 g of Iron, 45 IU Vitamin A, 12 mg of Vitamin C, and around 15 kcal of calories. Gherkins are water reservoirs or vegetable water tanks since they contain over 90% water. Because it may be eaten raw or cooked, the usefulness of this vegetable cannot be overstated as it helps to preserve all of the nutraceuticals and other bioactive components even after cooking. This helps to maintain appropriate water and salt balance in the body via osmoregulation and avoids dehydration. According to alternative and Ayurvedic medical sciences, raw gherkin paste is used to soothe burns and to make herbal cosmetics and face packs to prevent redness, acne, wrinkles, puffiness and other skin disorders. Cucurbitacin B, the main component present, has anti-carcinogenic qualities by eliminating cancer cells, while gherkin peels aid to reduce the chances of colon cancer by draining out abdominal pollutants. They are high in glycolic acid, an alpha hydroxyl acid that eliminates dead skin cells from the body. They are high in more than 75 distinct kinds of phenolics, which provide several health benefits. The calorie count of gherkin is quite low owing to the presence of different beneficial substances. As a result,

ingesting them on a regular basis may help to naturally restrict hunger and decrease obesity. Gherkins also aid to maintain a healthy GI tract by lowering the risk of colon cancer due to its high fibre content. They are high in potassium, calcium, phosphorus and vitamin K, but low in sodium. Calcium absorption is improved by vitamin K. Regular and adequate consumption of these elements promotes good bone function and minimises the incidence of arthritis, osteoporosis and other degenerative illnesses. Gherkins have a low Glycemic Index (GI), indicating that they are anti-diabetic foods that may keep blood glucose levels normal. Cucurbitans found in gherkins promote insulin secretion and influence the metabolism of a crucial hormone in blood glucose processing. Cucurbitacin C is determined to be the most abundant. They are also high in folic acid and beta-carotene (particularly in the peel), which help keep the eyes healthy and protect the body from dangerous viruses and germs by promoting the creation of white blood cells. However, since they are heavy in salt, they should be taken in moderation. They also help to keep the heart healthy and prevent cancer. Potassium is one of the most important components of gherkin because it reduces muscle tiredness and maintains appropriate bone structure and function. Vitamin K is one of the most important antihaemorrhagic components present in gherkin. It possesses anti-oxidant, diuretic, and cardiotonic effects.

## Production Technology

Gherkin is a crop that thrives in tropical and subtropical climates. As a consequence, it is vulnerable to cold and frost. After 2 to 3 months of seeding, the crop is ready for harvest. It is a warm-season crop that grows in well-drained, organic-rich soil with a pH of 5.5-6.5 and an ideal temperature of 16-25 degrees Celsius. A night temperature of less than 15 degrees Celsius impedes proper crop growth and development. The seed rate is roughly 300-400g per acre, and two seeds are planted per hill at 30cm spacing with correct fungicide spray and Trichoderma @ 4 g and Carbendazim @ 2g/Kg of seeds. The recommended NPK fertiliser dosage is 150:75:100 g per hectare. Because gherkin is a warm-weather crop, it is prone to excessive evapotranspiration during the summer months, hence it is cultivated in greenhouses with drip watering. Because the crop is a creeper, it requires staking and trellising with bamboo and GI iron rods. After one month of seeding, the crop is ready for harvest and grows to an average size of 12mm. Because gherkin is a heavy feeder of nutrients and fertilisers, it should be produced with extreme caution and correct cultural methods and irrigation to realise its full potential as a highly marketable crop. Photoperiod is important in determining the number of male and female blooms, with long days and high temperatures encouraging the development of more male blossoms and short days and low temperatures encouraging the development of female blossoms. Under the right circumstances, exogenous application of a few growth regulators may also cause flowering.

## Varieties

Ajax, the most popular form of gherkin accessible globally, is one of the most regularly farmed varieties of gherkin. It has a large production and provides great quality fruits that mature in 60-80 days. Calypso, BostonPickling, Eureka, Jackson, Adam, KirbyCukes, Sassy, Home Pickles, Northern Pickles, National Pickles, Salt & Pepper, Supremo, Carolina, Burpee pickler, and Parisian are some of the pickles available. No substantial breeding programmes have been conducted in this crop so far. Minor breeding has been done, however, to increase unique characteristics, quality features, and disease-pest resistance.

## Prospects in India

Although not widely grown, gherkin farming is still practised in certain regions of India, particularly in southern states such as Tamil Nadu, Karnataka and Andhra Pradesh, with Karnataka accounting for more than 90% of total output. Gherkin agriculture in India is mostly focused on contract farming and protected cultivation. Gherkin farming started in India in the early 1990s, and the crop currently has a significant export potential. The gherkin business in India is completely focused on exporting whole, sliced, or pickled gherkins preserved in brine, spices and vinegar. Gherkin is an underappreciated vegetable that is high in nutritional content and has health-promoting characteristics. Its capacity to thrive in harsh climates may also benefit producers, consumers, and conservationists. In this context, there is an urgent need to popularise this crop at the national level by ensuring adequate supply of quality planting materials, raising awareness about production, cultivation practises, and post-harvest management, as well as genetic resource exploration and management to ensure food and nutritional security and job creation in the near future.

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# Brahma Kamal

## *[Epiphyllumoxypetalum (DC.) Haw.]*: The Queen of Night With *Elegant Flowers*

Common English Names: Night blooming cereus, Dutchman's pipe, Queen of night, Lady of night, Dutch man's pipe cactus, Broadleaf Epiphyllum, Orchid Cactus, Jungle Cactus.

Vernacular Names: India- Gul-E-Bakawali, Nishagandhi, Brahma kamal, Bakavali, Bethlehempar; Chinese- Jin Gou Lian, Qiong Hua, Tan-Hua, Yue Xia Mei Ren; French- Reine De La Nuit; German- Koniger Der Nacht; Indonesia- Wijaya Kusuma; Japanese- Gekka Bijin; Malaysia- Bunga Bakawali, Bunga Keng Wa, Bunga Raja; Spanish- Reina De La Noche; Sri Lanka- Kadapul (Sinhala); Swedish- Stor Bladkaktus; Thai- Dtohn Boh Dtan; Vietnamese- Hoa Qu□nh, Quỳnh Hoa

Taxonomic Classification

| | |
|---|---|
| Kingdom | Plantae |
| Subkingdom | Tracheobionta |
| Superdivision | Spermatophyta |
| Division | Magnoliophyta |
| Class | Magnoliopsida |
| Order | Caryophyllales |
| Family | Cactaceae |
| Subfamily | Cactoideae |
| Genus | *Epiphyllum* |
| Species | *oxypetalum* |
| Binomial name | *Epiphyllum oxypetalum (DC.) Haw.* |

Plants are the paramount gift of god to human beings. Among different species of plants, flowers and ornamentals have been integral part of the people with high cultural significance in different communities. Flower and ornamental crops have been used for several purposes, viz. fresh flowers, cut flowers, ornamentals, potted flowers, indoor plants and also used for decorations and other crafts. Great diversity is available in flower and ornamentals from commercial cultivated species to the home garden species. Globally, several species are available for the beautification of home gardens. Amongst many species, *E. oxypetalum* is one of the species cultivated mainly as an ornamental plant in many home gardens, backyards etc. The term *Epiphyllum* represents in Greek epi means upon and phullon means leaf and *Oxypetalum* means with acute petals. Despite of its immense ornamental, nutritive and medicinal value, this species is still limited to the home gardens and backyards. Hence, in this article detailed information, viz. taxonomy, origin


Figure 1. Plant with full bloom. (A) Leaves or secondary stems (B) Plant with full bloom at night during flowering

and distribution, morphology, nutritive and medicinal value, ethno-botanical importance of *E. oxypetalum* are discussed.

## Origin and Distribution

E. oxypetalum is native to Central America and Northern South America and, distributed from Mexico, Guatemala to Venezuela as well as Brazil and South East Asia. In India, the species has wide distribution and reported from different parts of the country, viz. Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Uttrakhand etc.

Botanical description

**Habit:** Epiphytic perennial shrub, freely branched, grows to a height of 2 to 6 meters with aerial roots.

**Phylloclade:** Phylloclade is the structures where stem becomes flattened resembling leaves and performing photosynthesis. In *E. oxypetalum*, phyllocaldes (about 30 cm x 12 cm) are numerously branched and erect, cylindrical flattened laterally, with midrib of 2-6 mm wide, elliptical, glossy green on upper and lower surface, glabrous, apex is acute to acuminate, with wavy and crenate margins, (Fig. 1A). Phylloclade also possess an odour with an astringent taste. The typical feature is the flowers borne on the margins of leaves.

**Flowers:** Flowers are fragrant, nocturnal, star shaped with 25 to 30 white linear petals with a size of 25-30 x 10-15 cm (Fig. 1B). Pericarpels are nude, slightly angled and green. Bracteoles are short and narrow. Receptacles are 13-18 cm with 4.0 to 9.0 mm diameter and green base. Stamens are slender with white or greenish white and stigmas are creamish in colour protrudes from the centre of the flower. The filaments (white) measures about 2.5-5.0 mm, anthers (creamish) measuring about 3.0-3.5 mm and the style are white. Flowering occurs at night begin to open at 8-10 PM,

| Synonyms |
|---|
| *Cactus oxypetalus* Moc. & Sesse ex DC. |
| *Cereus latifrons* Zucc. ex Pfeiff. |
| *Cereus oxypetalus* DC. |
| *Epiphyllum acuminatum* K.Schum. |
| *Epiphyllum grande* (Lem.) Britton & Rose |
| *Epiphyllum latifrons* (Zucc. ex Pfeiff.) Pfeiff. |
| *Epiphyllum oxypetalum* var. purpusii (Weing.) Backeb. |
| *Epiphyllum purpusii* (Weing.) F.M.Knuth |
| *Phyllocactus acuminatus* (K.Schum.) K.Schum. |
| *Phyllocactus grandis* Lem. |
| *Phyllocactus guyanensis* Brongn. ex Labour. |
| *Phyllocactus latifrons* (Zucc. ex Pfeiff.) Link ex Walp. |
| *Phyllocactus oxypetalus* (DC.) Link ex Walp. Phyllocactus purpusii Weing. |

reach their maximum fullness at 12-3.00 AM (Mahmad et al., 2017; Prajitha et al., 2019)

**Fruits:** Fruits are produced very rarely which are purple red in color, oblong in shape with 16 x 5.7 cm and seed measures about 2.0–2.5 x 1.5 mm.

## Medicinal properties

This species is mainly cultivated as ornamental plants and, several authors have estimated and, reported the medicinal significance of this species in treatment of several ailments and also nutritional significance (Jeelani et al., 2018). Upendra and Khandelwal (2012) reported the presence of saponins (anticholesterol activity), phenolic compounds (antibacterial activity), steroids, glycosides, tannins and terpenoids. They also reported that reducing sugars, alkaloids, flavanoids, sterols, phlobatanins and acidic compounds were absent. Since reducing sugars are absent plant leaf part can be used as a diet supplement to diabetic patients. Dandekar et al., (2015) estimated the phytoconstituents profile of E. oxypetalum leaves using GC-MS analysis and found different compounds in the leaves, viz. the presence of compounds such as Ethanone, 1-(2-Hydroxy-5-methylphenyl)-; 4-Hydroxy-2-methylacetophenone; Megastigmastrienone; Cycloocta-1, 3, 6-triene, 2, 3, 5, 5, 88-hexamethyl; 4-(1E)-3-Hydroxy-1-propenyl)-2-methoxyphenol; 2, 5-Dihydroxy-4-sopropyl-2, 4, 6-cycloheptatrien-1-one; n- Hexadecanoic acid; Octadecanoic acid; phytol; 6- octen-1-ol, 3, 7-dimethyl; Stigmsterol; Cholesta-22, 24-dien-5-ol, 4, 4-dimethyl; 22-stigmasten-3-one. Allyldimethyl (prop-1-ynyl) silane; Sulfurous acid, Cyclohexylmethyl hexyl ester; Hepacosane; Nonadecane, 2-Methyl-; Hexadecane, 2, 6, 10, 14-Tetramethyl-; Octadecane, 2-methyl-; Eicosane, 2-Methyl-; Spinasterone; 4, 22-stigmastadiene-3-one; tetracosane; Hentriacontane; Stigmas-4-en-3-one; testosterone cypionate

## Nutritive importance

The main aroma ingredients of E. oxypetalum flowers were found to be benzyl salicylate and methyl linoleate. Upendra and Khandelwal (2012) estimated the nutritive values of plant showed significant presence of proteins (14 mg/g), fatty acids (4.6 mg/g) and vitamins (0.18 mg/g), while carbohydrates were found to be absent.

## Ethnobotanical importance

Traditionally the species has been used for different ethnobotanical purpose. The plant is used to treat respiratory problems like cough, phlegm, shortness of breath and also has a potential to neutralize blood clotting (Prajitha et al., 2019). In Vietnam, people use the petals of the faded blooms to prepare soups due to its aphrodisiac properties (Lim, 2013; Dandekar et al., 2015; Prajitha et al., 2019). The juice of the plant has been used for bladder infections, shortness of breath, water retention and applied externally for rheumatism. Additionally, in few parts of India, called as Brahmakamal holds immense sacred value and treated as highly sacred plant.

## Conclusion

*Epiphyllum oxypetalum* one of the important plant species with immense medicinal, nutritive and ornamental value. The further improvement and research on this important species is essential to unlock and utilization of its potential.

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## Introduction

Phytoremediation is a bioremediation process that employs varieties of plants to eliminate, transfer, maintain, extract or degrade contaminants in the soil and groundwater. It is a plant-based approach, which involves the use of plants to extract and remove elemental pollutants or lower their bioavailability in soil. Plants have the abilities to absorb ionic compounds in the soil even at low concentrations through their root system.

## Classification of phytoremediation on the basis of mechanisms

There are different types of phytoremediation mechanisms that are used to eliminate or degrade contaminants from soil and water discussed as follows:

### 1. Rhizosphere biodegradation

- In this process, the plant secretes natural substances from its roots and these are nutrients needed for growth of micro-organisms in the soil.
- The micro- organisms grow speedily and stimulate

# PHYTOREMEDIATION


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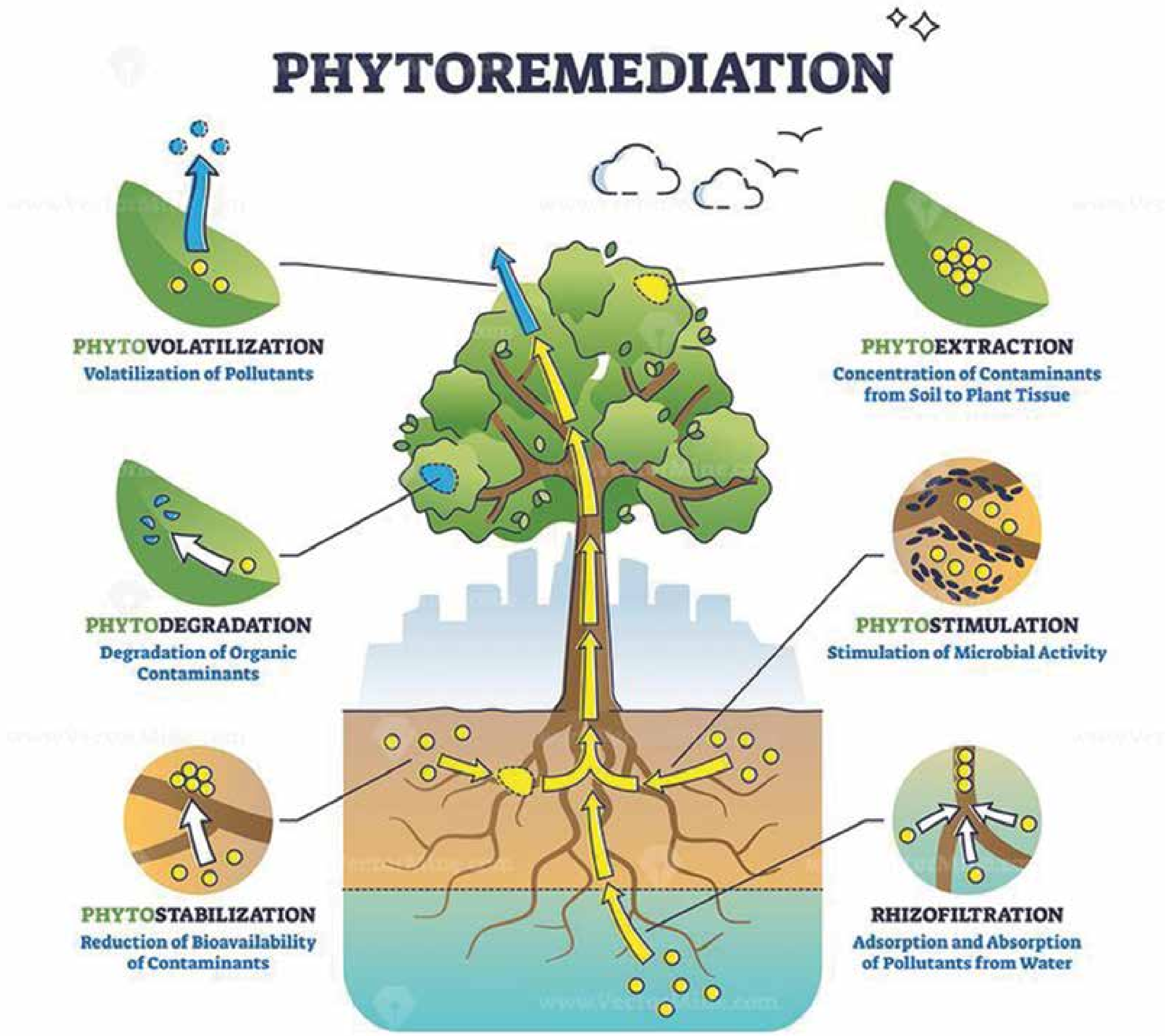



biological degradation of contaminants present in soil.

**2. Phytostabilisation:**

- The process in which certain plant species are used to immobilize the contaminants in the soil and groundwater is termed as phytostabilisation.

**3. Phytoaccumulation (*phytoextraction*):**

- The process of uptake/ absorption and translocation of contaminants by plant roots into the plant shoots, that can be harvested and metabolized to gain energy and also for recycling the metal from the ash is termed as phytoextraction.
- In this process, rhizosphere part of the plant roots function to absorb the contaminants along with other nutrients and water.
- The contaminant is not detoxified but stored in the part of plant such as shoots and leaves. This method is mostly employed for wastes consisting of metals.
- Plant species selected for their ability to take up large quantities of lead (Pb) are seen to uptake water-soluble metals.

**4. Rhizofiltration (Hydroponic systems for treating water streams):**

- The process in which

adsorption or precipitation of contaminants occurs onto plant roots or absorption and sequestration in the roots is known as rhizofiltration.

- Contaminants that are found in solution form enclose the root zone by formation of wetland for cleaning up contaminated wastewater.
- Rhizofiltration is almost identical to phyto-accumulation, but the plants used for this purpose are grown in greenhouses with their roots in water not in soil.
- This system can be implied for ex situ groundwater treatment.

**5. Phytovolatilization:**

- In this process plants uptake water containing organic contaminants and free the contaminants into the air through their leaves as volatile components.
- The uptake and elimination of a contaminant by a plant, with release of the contaminant or a modified form of the contaminant to the atmosphere from the plant during transpiration is termed as phytovolatilization.
- It takes place when growing trees and other plants uptake water along with the contaminants present in water.
- These contaminants pass through the plants to the leaves and vapour out into the atmosphere at comparatively low concentrations.
- Plants also play a major role in physically stabilising the soil with the help of their root system.
- This also aids for preventing erosion, protecting the soil surface, and decreasing the impact of rain.
- At the same time, plant roots delivers nutrients that help to enhance the growth of microbes to convert it to a rich microbial community in the rhizosphere.
- The complex interactions between soil type, plant species, and root zone location affect the presence of bacterial community and its composition in the rhizosphere region.
- Due to availability of nutrients nearby this rhizosphere part of soil and also due to a symbiotic relationship between soil micro-organisms and plants, the population of micro-organisms is generally higher in the rhizosphere compared to the root-free soil.
- Due to this symbiotic relationship, bioremediation processes can be accelerated.
- Plant roots also plays role as surface provider for absorption or precipitation of metal contaminants. In this remediation process the root zone acts as focus of interest.
- The root absorbs the contaminants to be eventually stored or metabolised by the plant.
- The plant enzymes released from the roots degrade contaminants in the soil which is also an important phytoremediation mechanism.
- Many contaminants prefer route in which passive uptake takes place, via., micropores in the root cell wall and finally into the root, where degradation occurs

**6. Phytodegradation**:

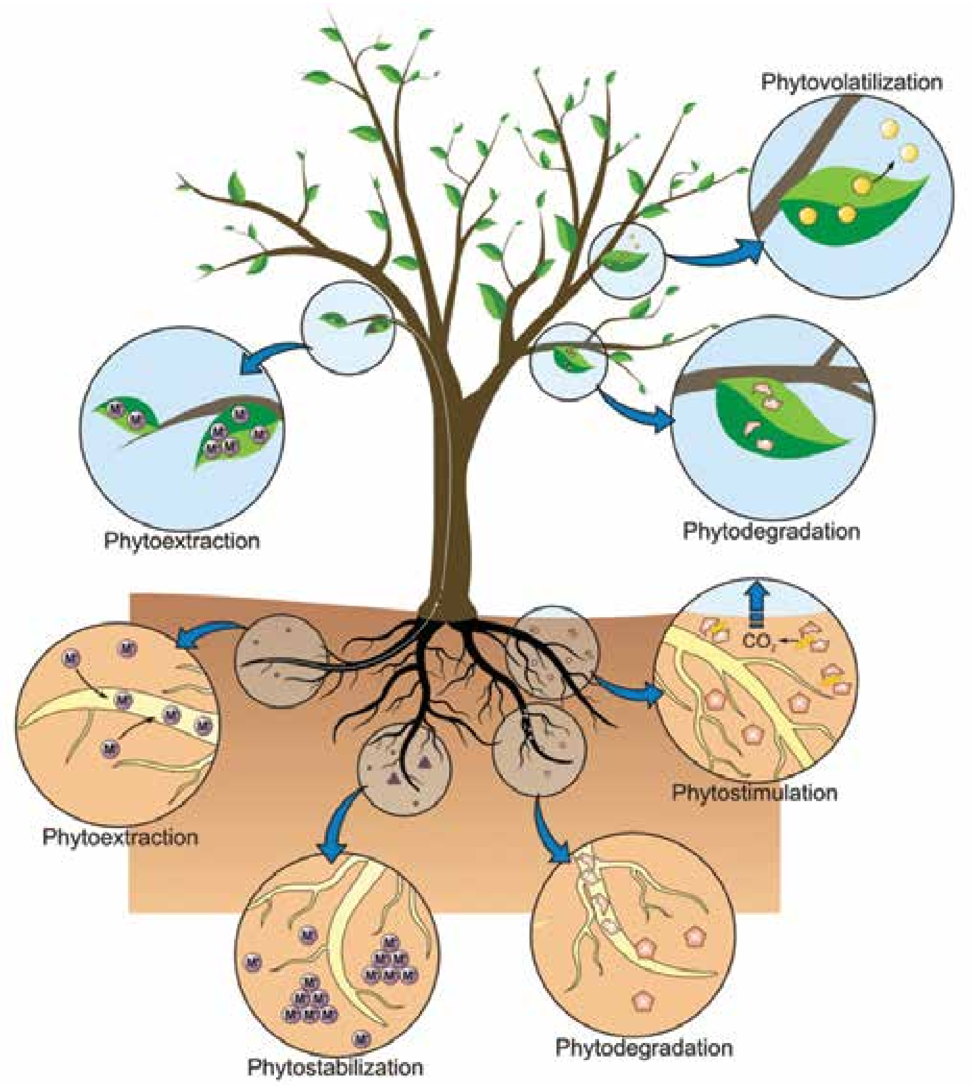
- In this process, specific plant species is used for a particular contaminant on the basis of the degradation capability of plant species.
- In this process, plants actually metabolise and deteriorate contaminants within plant tissues.

**Application of phytoremediation:**

- Phytoremediation is applied for the elimination/treatment of metals, radionuclides, pesticides, explosives, fuels, Volatile Organic Compounds (VOCs) and Semi Volatile Organic Compounds (SVOCs).
- Researchers are also working to find out how phytoremediation plays role to remediate perchlorate, a contaminant that has been shown to be consistent in surface and groundwater systems.
- It may be used to clean up contaminants present in soil and groundwater.
- For radioactive substances, chelating agents are sometimes used to make the contaminants accessible to plant uptake.

**Limitations and concerns of phytoremediation:**

- Even after biodegradation the toxicity and bioavailability of products, is not always known.
- The degraded by-products may be organized in groundwater or bio-accumulated in animals or other aquatic life.
- The determination of the fate of various compounds




released during degradation of contaminants in the plant metabolic cycle is required to make sure that plant parts/ droppings and products do not provide toxicity or harmful chemicals into the food chain.

- It is also required to understand if contaminants that get collected in the leaves and wood of trees are released when the leaves fall in the autumn or when firewood or mulch from the trees is used.
- The high contamination of metals in harvested plants can be a problem during its disposal.
- One of the limiting factors for the remediation of the contaminants is the location of contaminants inside soil.
- The plant's capacity to reach the depth determines the treatment zone. It is limited to shallow soils, streams and groundwater.
- If the plant root is unable to reach up to that depth where contaminants are present in water then pumping the water out of the ground and using it to irrigate plantations of trees may be the alternative to treat contaminated groundwater in such case.
- Generally, the application of phytoremediation is limited to sites where contaminants concentration is low and contamination in shallow soils, streams and groundwater.
- However, researchers are working to find that the use of trees (rather than smaller plants) permits them to treat deeper contamination as tree roots have capability to reach up to more depth into the ground.
- The outcome of phytoremediation may be seasonal, relying on location and climatic conditions of the area where the plants are to be grown.
- The climatic factors will also affect its effectiveness.
- The outcome of remediation also depends upon the selection of plant species from plant community.
- Bioremediation using plants is tedious process as the establishment of the plants may require several irrigation.
- It is prime to examine extra mobilization of contaminants in the soil and groundwater during bioremediation if possible.
- The other limitation to this process is the high concentration of contaminant as plants may die in high concentration of contaminants.
- Phytoremediation is not useful for strongly absorbed contaminants such as polychlorinated biphenyls (PCBs).
- Phytoremediation also needs a wide range of land for remediation.

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# Micro oxygenation in wine

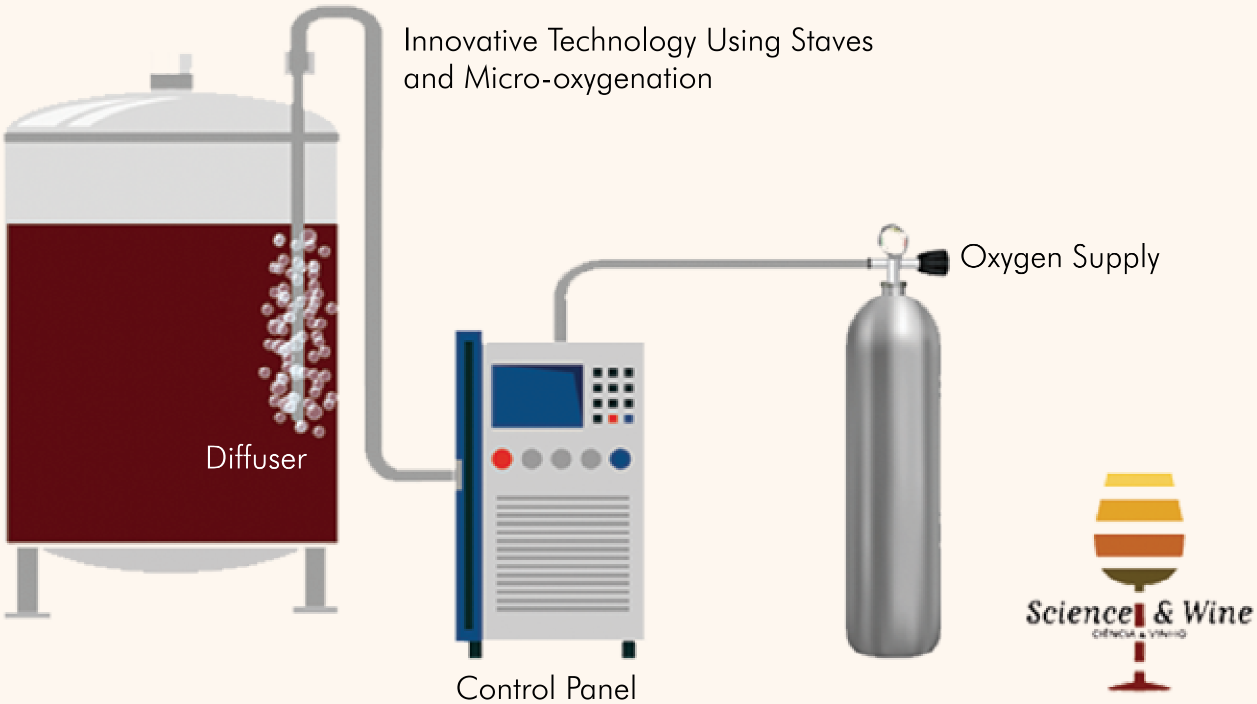
## An art of wine maturation

The production of red wine involves considerable chemical and biochemical transformation of grape and oak-derived compounds during microbial fermentations and wine maturation. Yeast fermentation typically transforms grape-derived sugars into ethanol with extraction and transformation of grape-varietal aroma compounds. Further microbial transformation of aroma compounds and their precursor molecules may arise during malolactic fermentation (MLF) and wine maturation. The wine maturation phase ideally generates body, structure and stabilizes colour while reducing astringency.

Wine micro-oxygenation (MOX) can simply be defined as the controlled addition of oxygen to wine in a manner designed to ensure that complete mass transfer from the gaseous to the dissolved state occurs and with addition rates less than the ability of the wine to consume the oxygen through preferred chemical reactions (Rudnitskayaet al., 2009). MOX was initially developed to improve the body, structure and fruitfulness in red wines with high concentrations of tannins and anthocyanins, by replicating the ingress of oxygen thought to arise from barrel maturation, but without the need for putting all wine to barrel. Winemaking is expedited and claimed to be more cost effective when MOX is employed for certain wine styles (Moutounet, 2003). Thus wines that are aged for some time in barrels are exposed to a slow oxygenation process which is considered important for inducing aldehyde-cross linkage of polymeric tannins, production of stable pigments and interactions of oak flavours (McCord, 2002). The substitution of barrels with tanks and micro-oxygenation is thus intended to provide the targeted amount of oxygen required for these reactions to occur.

## The role of oxygen

It has long been recognised that oxygen plays an important role in the numerous microbiological and biochemical events that take place during the life of a wine. These events not only facilitate the winemaking process but also ultimately affect the organoleptic characteristics of the finished wine. The principles that govern the dissolution of gases in liquid also apply to the dissolution of oxygen from the air into wine. Therefore during wine conservation quantities of oxygen are constantly dissolved




Innovative Technology Using Staves and Micro-oxygenation

in wine as a result of contact with air (Lemaire, 1995). This either occurs accidentally due to exposure of wine to air during processes such as filtering or intentionally during processes such as splash racking.

The role of oxygen in the evolution of wines, especially red wines, has been studied for a long time by comparing the behaviour of new wine in tank and barrel (Ribereau-Gayon and Glories, 1986). In tank, processes such as racking at irregular intervals during the maturation process result in the exposure of wine to large volumes of air for short periods. Alternatively wines stored in barrel are constantly exposed to small amounts of air which enters through the bunghole, during topping and arguably through the barrel staves. Sensory assessment of the same wine stored in tank and barrel,

disregarding the obvious oak aromas and flavours, typically concludes that the wine matured in barrel is superior in terms of structure and flavour.Although the availability of oxygen by either means of storage is uncertain and variable as it is considered to be a major factor in the preference of winemakers for oak ageing wines.

### Oxygen addition rates and duration of micro-oxygenation

The most critical aspect of MOX is to ensure that the dose rate and total quantity of oxygen infused into the wine does not exceed the ability of the wine to chemically react and consume the oxygen avoiding appreciable accumulation of dissolved oxygen. Excessive oxygenation has been associated with the formation of oxidation related aldehydes in wine leading to diminished sensorial qualities and accumulation of oxygen in the headspace of storage vessels may lead to the deleterious growth of aerobic spoilage micro-organisms. Early addition of oxygen immediately following alcoholic fermentation favors the production of acetaldehyde which is an important intermediate in the condensation reactions of flavonoids. During early stages of winemaking the presence of a range of reactive species capable of consuming oxygen including grape derived phenolic material, yeast hulls and wine solids is high. These species, along with dissolved carbon dioxide, will alter the rate of oxygen mass transfer, necessitating higher rates of oxygen additions to drive the preferred chemical reactions associated with MOX.

In the absence of models

that account for changes in phenolic and colloidal composition of wine and the timing of oxygen additions, dose rates from published trials best serve as guides as wines vary in their ability to consume oxygen. Oxygen application rates differ substantially depending upon the timing of oxygen addition with large doses typically between 5 to 90 ml/L/month for 10 to 25 days durations between alcoholic fermentation and MLF. Post-MLF oxygen additions are generally at lower rates with reported applications ranging from 2.0 to 9.0 mL/L/month for between 56 to 252 days. Such divergence in oxygen additions must be considered in terms of the total oxygen additions to the wine. There is no clear varietal trend, although in general the total amount of oxygen added is higher when MOX is applied pre- rather than post-MLF and when added to varieties with high flavonoid content.

Large oxygen additions prior to MLF are desirable for flavonoid condensation reactions in which acetaldehyde, an ethanol oxidation product, participates in the bridging of flavanols and anthocyanins. Such reactions are reported to improve colour stability while moderating the astringent sensations associated with low-mean polymerized flavonoid units. Low oxygen addition rates for extended periods, post-MLF, are used to mimic oxygen ingress associated with barrel maturation and have been applied in conjunction with alternative oak products (McCord, 2002). The duration of micro-oxygenation treatment is empirically determined based upon sensorial assessment and the desired wine style. Factors that may affect the duration of oxygenation include total wine volume, wine temperature, chemical reaction rates, wine composition and oxygen dose rates. Till date, there are no objective measurements that determine the optimum duration and dosage of oxygenation for a specific wine style.

## Monitoring the micro-oxygenation process

Complementary to sensorial assessment is the determination of chemical parameters that provide winemakers with information to ensure optimum conditions for chemical transformations while inhibiting undesirable microbial growth. Sampling bias can arise when monitoring wines in large non-homogenized tanks as wine collected from sample valves located on the side and near the bottom of the tank, or samples collected from the top of the tank will not represent wine that has been exposed to oxygen. Similarly the determination of dissolved oxygen using sensors lowered into the tank into the bubble plume and the intermittent injection of oxygen by bubble-plume devices may also lead to inconsistencies that prevent accurate monitoring of oxygen dosage.

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# SPEED BREEDING
## AN ADVANCED BREEDING TOOL FOR VEGETABLE CROP IMPROVEMENT

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The global population is estimated to reach nearly 8.5 billion by 2030. The challenge to meet food security still persists over the generations. Traditional crop improvement methods will not be able to satisfy the demands of world's growing population. Plant breeders and geneticists are under pressure to improve the production of the existing crops that are superior both in terms of quality, quantity and resistance against various biotic and abiotic stresses. Conventional breeding techniques can enable plant breeder for trait discovery, improve accuracy and selection intensity for desired traits in several vegetable crops. Long time requirement for generation advancement is the major drawback of conventional breeding method and is facilitated to grow single generation per year.

Speed breeding is a suite of techniques that involves the manipulation of environmental conditions under which crop genotypes are grown, aiming to accelerate flowering and seed set, to advance the next breeding generation as quickly as possible. This method saves breeding time by shortening breeding cycle and allows plant breeders to enhance the crop production through rapid generation advancement by modifying the light duration, light intensity and temperature using artificial sources. Speed breeding can achieve 3-9 generations per year over 1-2 generation in case of conventional breeding and allows for rapid production of stable and homozygous genotype. Speed breeding has a potential to integrate with advanced techniques including genotyping, marker-assisted selection, high throughput phenotyping, gene editing and genomic selection. Artificial intelligence can also be combined with speed breeding and revolutionize the processing of big OMICS data to take a step towards digital agriculture. All these advanced crop breeding techniques can be coupled with speed breeding, leading to rapid trait discovery and genetic gain of the desired traits which is necessary for enhanced yield and crop production to feed future generations.

## Evolution of speed breeding

Concept of speed breeding was inspired by the efforts of NASA to grow crops in space, using an enclosed chamber and an extended photoperiod. NASA's research mainly aimed to study plant growth in microgravity, while adding fresh food to the astronaut's diet. NASA in collaboration with Utah State University achieved success of growing wheat in space. Explored the possibility of rapid cycling, selection and population development of wheat under constant light on space stations. This joint effort resulted in the development of 'USU-Apogee', a dwarf wheat line bred for rapid cycling. Dr. Lee Hickey

from University of Queensland, Australia, inspired by the work of NASA started research and coined a new breeding strategy 'Speed breeding' in 2003 for a set of improved methods to hasten wheat breeding.'DS Faraday' first spring wheat variety developed in Australia using speed breeding was released in the year 2017.

### Principle

The principle behind speed breeding is to use optimum light intensity, light quality, temperature and day length control which accelerates the rate of photosynthesis, stimulates early flowering, seed maturity, harvesting and ultimately shortens the generation time required for crop growth and development.

### Development and standardization of speed breeding in vegetables

### Tomato

Studies on effect of photoperiod and continuous light on growth, yield and quality of tomato revealed that exposure to continuous prolonged photoperiod showed pronounced chlorosis and necrosis on leaves and affected fruit yield and quality. To study the performance of tomato genotypes under continuous light, Tomato Simulation Model "TOMSIM" was used. Introgression of CAB-13 gene enabled for continuous light tolerance, enhanced rapid vegetative growth, reproductive growth and increased yield of about 22-24% in tomatoes cultivated under greenhouse with supplemental photoperiod of 18 hours/day. Wild tomato accession *Solanum pimpinellifolium*, LA-1589 showed tolerance to continuous light condition. Discovery of CAB-13 gene introgression in tomato and other solanaceous vegetables such as eggplant and potato gives the ability to withstand continuous light and accelerates the application of speed breeding program. In vitro culture of immature seed or embryo of tomato can produce 5 generations per year, which can be coupled with speed breeding to achieve rapid generation advancement.

### Onion

Onion has a bi-annual life cycle, in which bulb formation takes place in the first year and flowering in the second year for seed production. As a result, varietal development and breeding programme in onion is very slow and it takes long period of 10-12 years to develop improved cultivar. Long day onion grown at the higher altitude requires 14-16 hour day length and vernalization requirement for flower initiation. Speed breeding protocol can be successfully employed to accelerate bulb production and to shorten the life cycle of onion. Long day condition, light with high far red spectra and elevated temperature of 25-30°C accelerates the bulb formation. Long day onions are grown at 22 hour with high far-red light spectra that leads to bulb initiation within 45 days and mature bulbs can be harvested within 80 days from date of sowing, whereas under field conditions 5-6 months is required for bulb formation. After harvesting of bulbs, dormancy of bulbs are broken using chemicals and grown at 20°C under long photoperiod and subjected to vernalization to induce early flowering in onion.

### Potato

In potato, speed breeding can be combined with aeroponics for disease free tuber multiplication throughout the crop cycle. Speed breeding in potato is achieved by growing in controlled greenhouses with long photoperiod supplementation resulting in rapid growth and development, leading to accelerated flowering, fruiting and seed maturity.

### Hot pepper

Speed breeding for hot pepper under controlled environment condition of 420 $\mu$mol $m^{-2}$ $s^{-1}$ PPFD (Photosynthetic photon flux density) and 12 hour photoperiod accelerated the growth and development of hot pepper. Low intensity of far-red light favoured early flower initiation and breeding cycle reduced up to four generations per year. Even more number of generations per year can be achieved in speed breeding of hot pepper by early harvest of immature seeds and using it to grow subsequent generation.

### Legumes

Generation acceleration protocols by speed breeding have been optimized in many legume species. Speed breeding for rapid generation cycling has received much attention in several cool season legumes including pea *(Pisum sativum)*, Faba bean (Vicia faba), lentil *(Lensculinaris)*, and chickpea *(Cicer arietinum)* and some warm season legumes including common bean *(Phaseolus vulgaris)*, cowpea *(Vigna unguiculata)*, pigeon pea *(Cajanus cajan)*, soybean *(Glycine max)* and groundnut *(Arachis hypogaea)*.

### Cowpea

Combined application of speed breeding protocol and cultivation of oven dried cow pea seeds of 11day old pods in growth chamber, 7-8 generations per year can be produced whereas in field condition it would take 8 years. As this protocol has no special technical requirements, it can be implemented in any standard growth chamber. Integration of this protocol with high throughput phenotyping and molecular breeding techniques will accelerate development of improved cowpea cultivars.

### Leafy vegetables *(Amaranthus)*

Speed breeding protocols have been established mostly for long day crops. For short day crops protocol is yet to be developed. Rapid cycling protocols have been developed for some short-day species of Amaranthus. Growing of short-day species under long-day, high-temperature conditions promote vigorous vegetative growth, and subsequent transfer to short day conditions inducing flowering immediately. This technique has been used to synchronise the flowering times of diverse germplasm and facilitate hybridisation in amaranthus.

### Lettuce

High temperature and exogenous application of gibberellic acid treatments have been reported to induce bolting in lettuce. This could be applied in combination with environmental controls to achieve speed breeding in lettuce. Speed breeding technique has been standardized for some of the major vegetable crops and yet research work is in progress for standardization and development of speed breeding protocol for vegetables like cassava, sugar beet, legumes, leafy and herbaceous vegetable crops. Speed breeding, an advanced breeding technique emerged as an essential breeding tool that favours the rapid generation advancement of crop life cycle as compared to traditional way of breeding.

This technique needs to be standardized among various vegetable crops to meet the pace of current demand, implementing in more crops will determine its industrial potential. The coupling of speed breeding with other breeding tools could provide a new dimension to the future of vegetable breeding and improve its overall competence of breeding for feeding the world population over the next decade.

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# NEOTROPICAL INVASIVE BONDAR'S NESTING WHITEFLY *(Paraleyrodes bondari Peracchi)* IN INDIA





Figure 1: Life stages of Bondar's nesting whitefly

**ABSTRACT:** The Bondar's Nesting Whitefly (BNW), *Paraleyrodes bondari Peracchi* is a new exotic pest of coconut since December, 2018 in India. It has spread across the nation since its first report and occurring in coconut based horticultural ecosystems especially in the East and West Godavari Districts of Andhra Pradesh. A typical feature was the presence of woolly wax nests on the abaxial surface of oil palm leaflets. This whitefly is very small (< 1.0 mm) and has conspicuous X-shaped oblique grey bands


Fig.2: Occurence of Bondar's Nesting Whitefly, P. bondari in different hosts A. Coconut, B. Oilpalm, C. Banana, D. Guava, E. Hibiscus and F. Cinnamon


on the wings. The host plants observed were Coconut, Oil Palm, Banana, Guava, Hibiscus and Cinnamom etc.

## INTRODUCTION

Whiteflies *Hemiptera aleyrodidae* are leaf sap sucking, polyphagous pests of worldwide significance because they function as vector of various plant diseases and inducing secondary deposits of sooty moulds on leaf surfaces by honeydew production, thus disturbing photosynthetic activity (Dickey et al. 2015). They superficially resemble tiny flies, with more than 1550 species described worldwide (Ouvrard and Martin, 2018).

Exotic whiteflies reported in India are the spiralling whitefly, *Aleurodicus dispersus* Russell, (Sundararaj and Pushpa, 2012); solanum whitefly, *Aleurothrixus trachoides* (Back) (Sundararaj et al. 2018) and rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Sundararaj and Selvaraj, 2017) which were found breeding on coconut based palm ecosystems. In December 2018, Central Plantation Crops Research Institute (CPCRI) recorded two exotic whitefly species, *P. bondari Peracchi* and *P. minei laccarino* on coconut palms of Kerala and issued a pest alert (CPCRI, 2019). Initial incidence of the neotropical invasive Bondar's Nesting Whitefly (BNW), P. *bondari Peracchi* (Hemiptera: Aleyrodidae) in India was reported on coconut palms from Kerala (Chandrika et al. 2018) and its detailed description was given by Josephrajkumar et al. (2019).In this article, BNW incidence on different host plants and life stages are briefly presented.

## MORPHOLOGICAL FEATURES

This whitefly is very small (< 1.0 mm) and has conspicuous X-shaped oblique grey bands on the wings. The nymphs and adults are present in nesting chambers of woolly wax resemble a bird's nest (Fig.1). Adult whitefly laid stalked eggs, and the nymphs are flat with fibre glass like projections from the dorsum.

## Host Range of Bondar's Nesting Whitefly (BNW)

The invasive pest *P. bondari Perrachi* (Hemiptera: Aleyrodidae), commonly known as the Bondar's Nesting Whitefly (BNW) was firstly observed in 6 different host plants viz., Coconut, Oil Palm, Banana, Guava, Hibiscus and Cinnamon after reported on coconut in Andhra Pradesh (Fig. 2). The characteristics of BNW were shown same as observed in the coconut palm which is usually confined to the abaxial surface of palm leaflets shying away from the sunlight on account of its photo-sensitiveness.

Documentation of this invasive pest occurrence in Andhra Pradesh and its association with oil palm imparts an immense momentum for a countrywide survey to ascertain the host range, distribution pattern and damage assessment of this important species. This would prove decisive towards comprehending the threat to horticultural ecosystems posed by this pest and designing suitable IPM strategies to manage this pest.

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**Fig.3: Combined incidence of RSW and BNWA. Coconut and B. Guava**


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# Thai Nightshade *(Solanum trilobatum L.)* Boon to Various Ailments

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*Solanum trilobatum* L.commonly available in Southern India known as'Thai Nightshade'belonging to the family Solanaceae. It is distributed in various Asian countries namely, India, Sri Lanka, Indonesia, Singapore and Malaysia. The plant is a common medicinal herb and frequently gathered from the wild for domestic use in India. It is also available as a green leafy vegetable in local markets and consumed as food. People cultivate this plant in their farms, homes and gardens, for frequent use as a natural cure for cough, cold, other ailments

and also an ingredient in various recipes.

## Habitat

*S. trilobatum* is a thorny, multi-branched, bright green perennial herb, woody at the base, 2–3 m height, found throughout India, mostly in dry places as a weed along roadsides, waste lands and bio-fence. The plants are much branched spiny scandent shrubs. Leaves are deltoid or triangular, irregularly lobed. Flowers are purplish-blue in cymes. Berries are globose, red or scarlet in colour (Fig. 1).

## Synonyms

English - climbing brinjal, Thai nightshade; Sanskrit -achuda, agnidamani, alarka, vallikantakaarika; Hindi-kantakaari-lataa, Malayalam -tutavalam, putricunta, puttacunta, parachunda, tootuvila; Marathi - mothiringnee, thoodalam. Tamil – tuduvalai,singavalli, alalrkam, nittidam, sandunayattan,; Telugu -alarkapatramu, kondavuchinta, mullamustil; Kannada -kakamunji, ambusondeballi. hambusonde; Oriya -bryhoti.

## Growing of *S. trilobatum*

Seeds and cuttings are commonly used propagating materials. Seeds sown in seed bed germinates in a week and can be transplanted after a month when they are big enough to handle. Alternatively, planting wood cuttings takes only a few days to root, which is comparatively easy for propagation.The plant requires a well-drained soil and grows well in bright sunlight. Though the plants grow in dry places, regular watering especially in its growing season produces more green leaves. However, stagnation of water is harmful to the plant. Normally fertilizers are not required. Nonetheless, application of fertilizer once in a month during the growing season, from spring through summer, produces more biomass. Applying vermicompost once in a month boosts soil fertility and improves the plant growth. The plant does not have major pest or disease problems. However, the plant is prone to infestation by pests such as aphids in rainy season, spider mites and whiteflies in summer. In poor-drained soil, bacterial wilt occurs frequently. Pruning helps in enabling new growth and removing old and diseased plant parts.

## Medicinal uses

Harvested fresh leaves of *S. trilobatum* are shade dried and pulverized in powder form for preparation of various medicines. It has been used as an Ayurvedic medicine to treat respiratory issues such as chest congestion, sinusitis, bronchial asthma and tuberculosis. Thai Nightshade is regarded in Ayurveda as a natural steroid that can enhance one's physical prowess, mental sharpness, and stamina. Additionally, it is proven to enhance hearing and memory. Further, it is used in the Siddha method of medicine to treat liver problems. Studies have shown that *S. trilobatum* may have hepatoprotective properties and helps to improve production of blood

and blood circulation in the body.

The presence of triterpenoids, sugars, amino acids, saponins, phenolic compounds, phytosterols, cardiac glycosides, anthraquinone, soladunalinidine, tomatidine, solanine, sobatum, solasodine, solasonine, diosgenin and β-solamarine has been confirmed in S. *trilobatum through* studies. These chemicals have several highly intriguing qualities that could be important for following medicinal uses.

- **Antioxidant properties:** S. trilobatum has antioxidants which stops early ageing of the skin and hair.
- **Anti-inflammatory properties:** Leaf extract has anti-inflammatory qualities, and it will significantly helps to reduce inflammation.
- **Antibacterial properties:** Leaves, flowers, and fruits of S. *trilobatum* possesses antibacterial effects.
- **Anti-cancer properties:** In addition to preventing cancer, the sobatum chemical present in Thai nightshade slows the spread of cancer cells.
- **Anti-diabetic properties:** Lowers the blood sugar level and has a protective impact on our kidneys.
- **Insect control:** Leaf extracts of S. *trilobatum* act as repellent/kills mosquito, hard-bodied ticks, and some storage pests.

## *S. trilobatum* side effects

Similar to the other edible plants, the majority of species in this genus Solanum, contains poisonous alkaloids. While these alkaloids can help to cure a variety of medical disorders, they can also produce nausea, vomiting, salivation, sleepiness, abdominal pain, diarrhoea, weakness, and respiratory depression.

## Recipes

Some of the best S. *trilobatum* recipes are soup/rasam, chutney/thuvaiyal, rice mix powder and dosa. The plant is full of thorns, including its leaves, which may be slightly toxic. Thus the thorns must be removed before cooking. In markets, candies, capsules, kara-sev, legiyum syrup, dried leaves and leaf powder made from S. *trilobatum* are available for consumers.

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# “Traps

## A potentially effective tool for monitoring and management of insect pests in Integrated Pest Management programmes”

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Insect traps are simple interception devices which are used as important tool in insect pest management programs. Traps are generally used to provide an indication of insect pest incidence in crop region or field and also provide an estimate of pest density on which management decisions can be made. In some cases it is also being used as a tool for trapping the particular stage of insect pest in huge quantities to bring down the pest population under check. Basically, visual lures, semio-chemical attractants (pheromones) and food lures are

**Pheromone traps**

used as bait for trapping the insect pests so that they do not injure other animals or humans or result in residues in foods or feeds. Light, colors and shapes are used as visual lures to attract insect pests. Semio-chemical attractants (pheromones) are used as attractant for trapping specific or both the sexes of insect pests.

## Commonly used Traps in Integrated Pest Management (IPM) approaches

In a given IPM programme, traps are used for monitoring population levels of established insect pests, detection of new invasions of insect pests in time, for delimitation of area of infestation, mass trapping and mating disruption. Widely used traps includes light traps, sticky traps and pheromone traps.

### 1. Light traps

Many nocturnal insect species such as moths, beetles, bugs, hoppers, etc. are attracted to artificial light sources since the light acts as a visual cues for those insect pests. Upon many insect behavioural studies, researchers have developed various kinds of light traps, which has proven as one of the important tool in IPM programmes. These are widely used visual traps to manage the menace of insect pests in field and protected conditions. Light traps may be with or without ultraviolet light. Light sources generally includes fluorescent lamps, mercury-vapor lamps, black lights (Epsky et.al. 2008) or light-emitting diodes (Price, 2016). The main purpose of light traps is to determine the incidence of insect species in an area and to provide early warnings of Crop infestation and oviposition; obtaining quantitative estimates of population density, species composition, age and sex; determine the thresholds to take up necessary plant protection measures; suppressing the pest population load; in some cases, detecting the Migratory patterns of insect pests and collecting specimens for taxonomic studies of species distribution.


Light traps
Light traps

## Working principle of light traps

The light source (bulb, filament, etc.) attracts the phototrophic insects such as moths, flies, beetles, wasps, hoppers, etc. These insects fall into the collection chambers filled with lethal materials like insecticide solutions, soapy water solutions, etc., which gets trapped and killed inside the collection chambers.

## Advantages of Light traps

- Useful in trapping the aerial and phototrophic insect pests thereby reduce adult population and subsequent progenies in the fields.
- Helps in determining the incidence of insect pests to take decision for pest Management.
- Portable across the crop fields and also eco-friendly and economically feasible device .
- No major installation efforts

required to install the traps in the field and easy to operate. Introduction of solar light traps have proven effective alternative to the power operated light traps thereby reducing the dependence on electricity

- It is durable and can be used year after year.
- Decision making by appropriate monitoring of insect pest incidence through light traps will cut down the expenditure on insecticide use, which will also take care of biodiversity.
- Farmers can also prepare their own light traps with the locally available resources for managing various insect pests if, the farmer cannot afford the commercially available light traps.

## 2. Sticky traps

Alike light traps, sticky traps are glue-based traps which are extensively used to monitor and mass trap of flying insects /sucking pests like whiteflies, jassids, aphids and thrips and other smaller moths. Sticky traps are simple, low-cost method and an effective tool for monitoring the presence of insects and their numbers and mass trapping of the same. Sticky traps may be simple flat panels or enclosed structures, often glued, which traps the aerial insect pests. The flat sticky traps consist of a sticky glue layer and in some cases is folded into a tent-structure to protect the sticky surface. Most sticky traps contain no insecticide, although some may be impregnated with semio-chemicals designed to attract certain insect pests. Different coloured sticky traps are being used for trapping different insect pest species. The use of sticky traps for capturing herbivorous insect species is risky because they may also trap non-targeted natural enemies of insect pests and reduce their numbers. Thus, the selection of trap colour should also be based on the knowledge of what colour attracts the target insect pests. Commercially, three predominant colours are being used in sticky traps i.e., yellow, blue and white. Yellow sticky traps are used against whiteflies (Singh and Sood, 2020), aphid (Sahoo and Saha, 2018) and psyllids (Hall, 2009); blue sticky traps (Liu and Chu, 2005) and white sticky traps (Mukhtar et al. 2022) against thrips. In most of the sticky traps we find grids of definite size. The grid pattern on the traps facilitate counting of the trapped insects. If the number of trapped pest insects rapidly increases, it is time to take up immediate intervention measures to keep the insect pest population under check. If in case the farmers are unable to purchase the commercially available sticky traps, they can prepare the traps by their own, depending upon the pest to be targeted.


Sticky traps

fruit fly trap

### Procedure for preparing sticky traps at farmer's level

The materials required for preparing sticky traps includes, Ply wood board or hard board or card board (1.5 ft X 1.0 ft size) or used empty oil tin (1 or 2 litre size); Yellow/blue/white colour oil paint; glue/white grease/ pongamia oil; bamboo poles and wire or rope. Take new or used sheet of plywood board or hardboard or card board or used oil tins. Paint it with Yellow/ blue/white colour oil paint. Allow it for drying. Apply grease/glue/ Pongamia oil on the painted board. Erect these traps above crop canopy with the help of bamboo poles. Clean the tin or plywood or hardwood traps by dipping into the hot water for 3-5 minutes to soften the sticky coating. Discard dead insects by using brush. Dry the traps completely and recoat with similar glue for reinstallation. Note that the cardbord traps should be discarded after use since it cannot be reused.

### 3. Pheromone traps

Pheromone traps are a critical tool for the early detection and monitoring of insect pests. Pheromones are chemical substances produced naturally by a variety of animals to the outside environment and received by the other individual of the same species for communication purpose and hence acts as a chemical messengers. In case of insects, pheromones are of various types and functions. For example, aggregation pheromones helps in congregating insects to come together on a host (bark beetles) and trail pheromones in social insects helps in marking foraging pathways (ants). Some pheromones regulate reproductive behavior (honey bees), and sex pheromones attract mates of the same species (many moths). Sex pheromones are released slowly over extended periods and are active at limited distances from the source. The most important function of sex pheromones is to allow organisms to identify mating partners of the opposite gender. Commercially Sex pheromones are being used in large number in any given IPM programme. These chemicals are also called as ectohormones. Pheromones are identified by extracting them from the insects and latter synthesized artificially to use the same in preparing sex pheromone traps. Pheromone traps are used for three purposes i.e., monitoring, mass trapping and mating disruption.

### Different types of pheromone traps used in IPM

**Delta trap:** It is an ideal trapping device for the monitoring of lepidoptera pests in both field and protected cultivation conditions that are commonly affected by lepidopteran pests. This trap is made up of durable and corrugated plastic, which is UV and rain resistant, enabling its use across different seasons. The trap is quick and easy to assemble and simply requires the addition of a pheromone lure, which when placed in the centre of the trap will attract and trap the moths of lepidopteran pests. Example of insect pests trapped using delta traps is brinjal shoot & fruit borer.


Water trap

**Funnel trap:** Funnel traps are very good tools for monitoring lepidopteran pests. They give information on the population density of the insect pest and help the farmers to determine the optimal management strategy. These traps are designed for multi-season use and are resistant to severe weather conditions. They are very easy to assemble and clean. Funnel trap, as the name suggests, is a funnel-covered at the top by a canopy that holds the pheromone dispenser, with radial openings all around for entry of the Moths. Moths attracted by the pheromone enter the funnel, strikes to the sides of trap while in flight and drop down into the transparent polythene bag attached to the lower end of the funnel and get trapped and die within the bag over a period. The polythene bag can be cleaned and replaced occasionally, depending on the insects caught. Examples of insect pests which can be trapped using funnel traps are fruit borers, leaf eating caterpillars, etc.

**Water trap:** Water traps are specially designed for mass trapping moths of lepidopteran pests in both field and protected


Delta trap

cultivation conditions. It comprises of a round tub/ basin like container to hold water (mixed with kerosene/ detergent/insecticide) with a central hub onto which the pheromone basket or cage is fitted. While the cage holds the pheromone dispenser, the tub/ basin holds water mixed with oil or an insecticide. The base of the trap is provided with a hole to assemble the trap on a single pole. Install the trap at 45 cm above the ground level and pull upwards as crop grows. Replace the pheromones at an interval of 4-6 weeks. Insert pheromone lure to the space provided below protected lure holder and then insert the duffel over. Fix entire unit on upper central part of the water trap. Fill the trap with water to the brim mixed with kerosene/detergent/ insecticide to avoid escape of trapped moth. Regularly check trap water level. Water traps are used for trapping insect pests like South American tomato pinworm, brinjal shoot & fruit borer, diamondback moth, etc.

**Different types of pheromone dispensers used in pheromone traps.**

**a. Rubber septas:** Rubber septa is made up of low-density natural rubber that are used to withhold mild organic solvents and aqueous solutions, dispense the chemical substance embedded into it slowly over a period of time.

**b. Hollow fibers:** Small thermo-plastic tubing sealed at one end and filled with pheromone. Pheromone release depends on evaporation through open-end.

**c.Twist tie ropes:** 15 cm long plastic tube containing pheromones sealed at both ends is attached to the crop manually. The high concentration of pheromone provides a relatively long persistence of release.

**d. Laminated flakes:** two layers are of vinyl sandwiching central porous layer with pheromone. Flakes are applied with stickers and thickening agents through special equipment or by hand.

**e. Microcapsules:** microencapsulation of small droplets of pheromone done by using polymer can be easily manufactured on a large scale. Readily applied over a large area with conventional sprayers (Sinha et al. 2021).

## Fruit fly traps

In case of fruit flies, male attractant – 'parapheromones' known as Cuelure (p-Acetoxyphenylbutanone-2) (melon fruit fly) or methyl eugenol (oriental fruit fly) is used for trapping the adult male flies (commonly known as MAT-Male Annihilation Technique) due to which there will be reduction in mating to a greater extent which leads to suppress the outbreak and development of new generation of fruit flies.

## Procedure to prepare fruit fly trap

A plastic box (15 x 10 cm) with lid and two window holes (1 inch each) at the parallel walls of the box is used for devising the fruit fly trap. A small hole at the center of the lid needs to be done for inserting a metal hook into the trap. A 15 cm length metal wire (preferably aluminum wire) has to be inserted from inside to outside of the lid of the box through the hole and a loop has to be done for hanging the trap and at the other end a hook like bending has to be done for placing/hanging the lure inside the plastic box. A wooden block (lures) of 5 x 5 cm with a whole at the centre of the block has to be treated over night with luring chemical i.e., ethyl alcohol + cuelure / methyl eugenol + malathion 50 EC / Cypermethrin 25 EC at the ratio of 6:4:2 in proportionate manner. About 04 ml luring chemical solution is required to treat one wooden block. The treated wooden blocks are then hanged to the metal hook inside the box and the lid of the box has to be closed tightly. Finally, the fruit fly trap is ready for installation in the field condition, where one single fruit fly trap has the capacity to trap around 3000-4000 male flies (Raghavendra et al. 2022).

## How to use fruit fly traps

- Install the fruit fly traps @ 10-12 traps per acre during fruit setting stage.
- The traps should be kept in the fields till the final harvesting of the fruits/ vegetables
- Traps should be hanged to the supporting stick/wires used for training the crop at an height of at least 1-1.5 meter from the ground and at a place receiving no direct sunlight
- The wooden blocks/lures has to be replaced/changed at every 25-30 days intervals to obtain maximum catch per trap.
- Remove the trapped fruit flies (dead ones) from the traps when they are 65-70 percent filled, as this will help in maintaining the efficiency and durability of the traps.

## Advantages of fruit fly traps

- Fruit fly trap is an eco-friendly tool for management of melon fruit fly wherein there will be no pesticide residue in vegetables/fruits
- Fruit fly traps can be used for both monitoring and mass trapping
- Mass trapping of male fruit flies will reduce the chances of mating to the maximum extent leading to reduction in new population build-up of fruit flies
- Installation of fruit fly traps is cheaper than using insecticides in cucurbitaceous crops
- Fruit fly traps are much compatible with other pest management strategies in IPM programmes.
- High quality marketable commodity can be achieved due to fruit fly traps and also there will be a significant increase in the marketable yield of the crops
- The traps provide effective management of melon fruit flies for longer period (commendable shelf life of the lures i.e., 25-30 days)
- Fruit fly traps are target specific and safer to beneficial insects
- The fruit fly traps has a longer durability and also can be reused (only the treated wooden blocks/lures needs to be replaced timely).

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# Exploring Synthetic Biology and its potential in Agriculture

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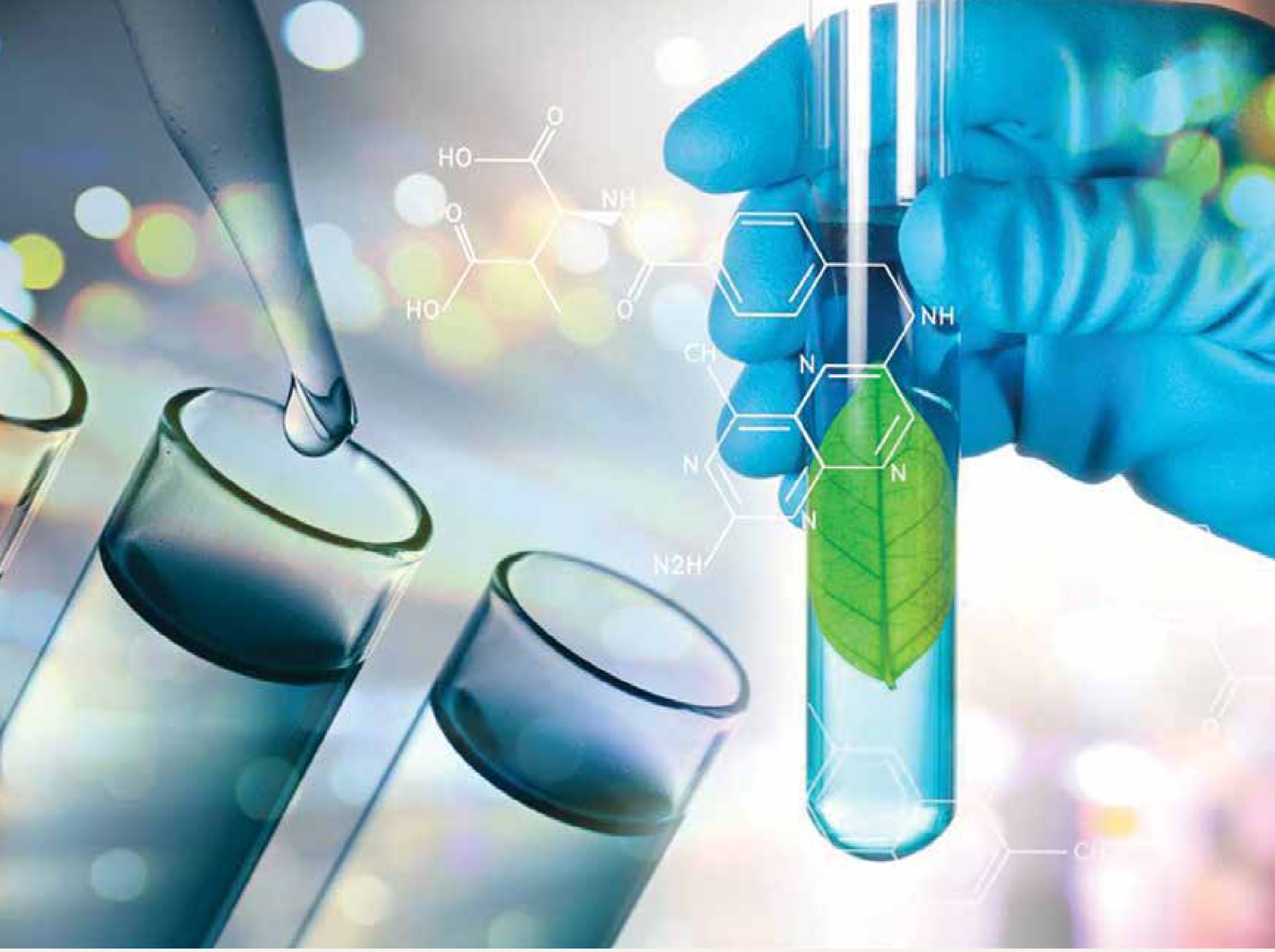
Synthetic biology is a multidisciplinary field that combines principles of biology, engineering and computer science to create new biological systems or modify existing ones for practical applications. It involves designing and building biological systems with desired functions using a combination of engineering principles and genetic manipulation. It is a denovo modelling of existing biological systems (Andrianantoandro et al. 2006).

The approaches in synthetic biology includes: top-down and bottom-up. Top-down synthetic biology involves modifying existing biological systems to perform new functions by making changes to their genetic code. On the other hand, bottom-up synthetic biology involves constructing entirely new biological systems from scratch using basic building blocks, such as DNA, RNA and proteins (Roberts et al.2013).

Synthetic biology is a relatively new field that has gained significant attention in recent years due to its vast potential in various industries. It involves




engineering living organisms, such as bacteria and plants, to create new biological systems that can perform specific functions. These engineered organisms can then be used in various applications, including agriculture, medicine and biotechnology. The technology has the potential to revolutionize the industry by making farming more sustainable, efficient and environmentally friendly.

In agriculture, synthetic biology has the potential to address many of the challenges faced by farmers. One of the significant challenges is the overuse of chemical fertilizers, which can harm the environment and human health. Synthetic biology can help in solving this problem by engineering microbes that can break down organic matter in the soil, making nutrients more available to plants, reducing the need for chemical fertilizers. Additionally, researchers are engineering crops that are more resistant to pests, diseases and environmental stresses, such as drought or extreme temperatures, which can improve crop yield and reduce the use of pesticides and other chemicals.

Another exciting application of synthetic biology in agriculture is the development of plant-based alternatives to traditional animal-based products. Researchers are engineering plants to produce proteins that mimic the taste and texture of meat, dair and other animal-based products, providing a sustainable and environmental friendly source of food.

The scope of synthetic biology on agriculture is enormous. The increasing demand for food can be met by making farming more sustainable, efficient, and environmentally friendly and thus reducing the impact of agriculture on the

environment. However, there are also concerns about the safety, ethical issues and potential unintended consequences of synthetic biology in agriculture. Like any other emerging technology synthetic biology must be thoroughly studied and carefully regulated to ensure its safe and responsible use.

Some of the methods used in synthetic biology includes; DNA Synthesis and Assembly, Genome Editing, Protein Engineering, Metabolic Engineering, Systems Biology etc.(Liang et al. 2011)

**1. DNA Synthesis and Assembly:** One of the primary methods used in synthetic biology is DNA synthesis and assembly. This involves the design and construction of DNA sequences that can be used to create new biological systems or modify existing ones. DNA synthesis can be done using different techniques such as Polymerase Chain Reaction (PCR), which allows for the amplification of specific DNA sequences. Once the DNA sequences are synthesized, they can be assembled using various methods, such as Gibson Assembly or Golden Gate Assembly.

**2.Genome Editing:** Another method used in synthetic biology is genome editing, which involves making precise changes to the genetic code of an organism. This can be done using techniques such as CRISPR-Cas9, which uses RNA-guided nucleases to cut and modify specific DNA sequences. Genome editing has the potential to revolutionize fields such as medicine and agriculture by allowing for the targeted modification of genes associated with diseases, environmental stress resistance and crop yield.

**3.Protein Engineering:** Protein engineering is a method used to modify and design new proteins with specific functions. This can be done using techniques such as directed evolution, where an enzyme is evolved in the laboratory to perform a specific task. Another technique used in protein engineering is rational design, where researchers modify protein structures to achieve specific properties, such as improved stability or activity.

**4. Metabolic Engineering:** Metabolic engineering is a method used in synthetic biology to design and optimize metabolic pathways in cells. This can be done by introducing new genes or modifying existing ones to create novel pathways or improve existing ones. Metabolic engineering has many applications, such as the production of biofuels, pharmaceutical and chemicals.

**5.Systems Biology:** Systems biology is a method used in synthetic biology to understand how biological systems function as a whole. This involves using computational models to simulate the behavior of biological systems and to make predictions about their behavior under different conditions. Systems biology can be used to design and optimize biological systems for specific applications.

## Advantages of Synthetic Biology:

One of the primary advantages of synthetic biology is its ability to design and build biological systems with precise control over their behavior. This opens up new avenues for medical treatments, environmental remediation, and industrial applications. For example, synthetic biology can be used to create custom-designed drugs that can target specific diseases or to engineer microbes that can break down pollutants in the environment.

Synthetic biology can also be used to develop sustainable solutions to global challenges, such as food security, energy, and climate change. For instance, synthetic biology can help develop crops that are more resilient to climate change, reduce the use of pesticides and herbicides, and increase the yield of crops.

**Disadvantages of Synthetic Biology:** Despite its potential benefits, synthetic biology is not without its challenges. One of the primary concerns is the safety and ethical implications of manipulating living organisms. There is a need for careful regulation and oversight to ensure that synthetic biology is used responsibly and safely.

Another disadvantage of synthetic biology is its high cost and complexity. Synthetic biology requires significant investment in specialized equipment and personnel, making it challenging for small-scale projects to get off the ground. Additionally, there is a risk of unintended consequences and the potential for engineered organisms to interact with the natural environment in unpredictable ways.

In conclusion, synthetic biology has the potential to revolutionize agriculture, medicine, and biotechnology by engineering biological systems with desired functions. By making farming more sustainable, efficient, and environmentally friendly, synthetic biology can help address the challenges faced by farmers and meet the increasing demand for food. While the field offers numerous advantages, such as precise control over biological systems and sustainable solutions to global challenges, it is not without its challenges.

Safety, ethical considerations and careful regulation are crucial in ensuring the responsible use of synthetic biology. As the field continues to evolve, it will be essential to weigh its potential benefits against its potential risks and to proceed with caution.

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# CARBON FARMING

## A CARBON MITIGATION APPROACH FOR BOOSTING FARMERS WITH CARBON CREDITS

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### Introduction

The adage "there are no free meals" perfectly captures the profound effects that industrialized agriculture has left on our planet. We have been able to broaden our horizons and our "palates", thanks to the modern gift horses of industrialization and worldwide supply chains, which have transformed the erstwhile "life source and a public common" into a global economic opportunity. But compared to small-scale organic farming, industrial agriculture produces food with fewer nutrients, less effectively, more expensive and with higher environmental damage. Or, to the contrary, modern agriculture externalizes its full costs onto others. Living soil requires our tenderness, just like any other relationship. Soil is one of the most affordable methods of storing carbon. The environmental impact of agriculture is immense. Agriculture is the only economic sector with the potential to switch from being a net emitter of $CO_2$ to having net negative emissions. A revolutionary new agricultural business model known as "carbon farming" has the potential to combat climate change, generate employment, and keep in operation farms that might otherwise fail. In essence, a climate solution is right beneath our feet, together with expanded income generation opportunities and a guarantee of a population-wide safety net for food.

## Carbon farming

Carbon farming, synonymous with "regenerative agriculture," is a whole-farm strategy that is known to accelerate the rate at which carbon dioxide is extracted from the atmosphere and sequestered in plant parts and/or soil organic matter to streamline carbon accumulation on functioning landscapes. Carbon farming is also a business approach that strives to scale up climate mitigation by reimbursing farmers for implementing climate-friendly farm management techniques. Farmers can be encouraged by carbon farming to adopt regenerative practices, shifting their attention away from increasing yields and toward maintaining healthy ecosystems and storing carbon that can be exchanged or sold in carbon markets. In addition to enhancing soil health, it can also lead to higher-quality, chemical-free food (farm-to-fork models) and increased/secondary revenue from carbon credits for marginalized farmers. Stowing away carbon in the soil is one of the main goals of carbon farming. Agronomists frequently suggest the following methods because of their efficacious benefits on soil carbon sequestration.

**1. Reduced tillage:** Frequent and vigorous tilling accelerates the rate at which carbon dioxide is released from the soil. Regenerative tillage maintains soil quality and boosts carbon storage in the soil, which is beneficial to crop output when done with little to no-tillage and leaving crop leftovers on the soil surface.

**2. Cover cropping:** Planting of cover crops reduce surface disturbance and strives to aid in the collection of nutrients to increase soil fertility and organic carbon.

**3. Agroforestry:** Agroforestry practices can help to reduce emissions by storing carbon in soils and trees. Agroforestry not only delivers above-ground benefits in the field, but it also provides critical below-ground benefits. It accomplishes this while simultaneously increasing farm productivity, protecting soil, improving air and water quality, giving wildlife habitat, and diversifying revenue.

**4. Rotational grazing:** This entails allowing animals to graze through different pastures to allow grasses to recover and build up soil organic matter, which can improve carbon storage in the soil.

**5. Composting:** This involves the decomposition of organic matter, which can be used as a soil amendment to improve soil health and increase carbon storage.

Farmers' soil carbon content improves after a few seasons of using these practices. As a result, the yield rises as well. Farmers, on the other hand, may require an incentive to adopt these methods because they can be time-consuming, costly, and unprofitable in the short run. This incentive can be provided by the opportunity to sell carbon credits on voluntary carbon markets.

## Carbon farming impetus carbon credit monetization:

Indian farmers struggle with declining revenues and unhealthy soil. Selling carbon credits could provide a solution to these issues.

The Lok Sabha passed the Energy Conservation (Amendment) Bill, 2022, which was introduced and had the goal of expanding the domestic carbon market. Although the bill concentrates on the renewable energy sector, it can also indirectly help the nation's farmers.

Since improving soil health is inextricably related to increasing soil carbon levels, attaining it necessitates constant monitoring of soil carbon levels and incentivizing its improvement.

Understanding carbon credits is essential for monetizing soil carbon. Carbon credits are certifications that show the amount of greenhouse gases kept out of the atmosphere or removed from it. One carbon credit certifies the removal of one metric tonne of $CO_2$ from the atmosphere. Advances in remote sensing data and AI have enabled the prediction of carbon levels using satellite data, and this is one of the approaches used to calculate carbon credits. Companies and governments buy carbon credits to meet their climate responsibilities.

## Benefits to the Farmers:

The direct benefit is that farmers receive cash incentives for the carbon sequestered on their grounds. At current market prices, a farmer who sequesters one carbon credit can earn around INR 780, but large

firms are expected to provide greater rates—as much as INR 2,000—to farmers when directly acquiring huge chunks of carbon credits. Farmers that adopt carbon farming can sequester one to four carbon credits per acre.

Farmers get the benefit indirectly from improved soil health as a result of carbon captured in the soil. This progress can be measured by observing whether the soil exhibits any of the following characteristics: Increased water-holding capacity, lower soil density, increased water infiltration, increased nutrient availability and decreased soil surface temperature.

While carbon farming can bring many benefits, there are also several challenges that farmers may face in implementing these practices. Some of the main challenges include:

- **Lack of knowledge and education:** Many farmers may not be aware of the benefits of carbon farming or how to implement these practices effectively. The company supporting the sale of carbon credits must demonstrate that the farmer engaged in novel procedures in addition to the customary practices to boost soil carbon levels. This makes it difficult to verify and accurately account for carbon increases in the soil when proving additionality. Providing education and outreach programs can help to address this challenge. Technology advancements have hastened the process of measuring and validating the carbon stored in the soil. The measuring and verification process may become much easier as technology advances.
- **Financial barriers:** Some carbon farming practices, such as cover cropping or agroforestry, can require significant upfront investment or may have higher labour costs. It takes eight to twelve months for cash incentives to reach farmers and FPOs/ non-profits after the initiative is listed. Further more, it may take 12 to 18 months for a project to be listed. Farmers may find this long wait onerous. Financial incentives or assistance programs can help to overcome these barriers. According to McKinsey analysis, demand for carbon credits is predicted to increase more than triple by 2030. As a result, carbon credit market prices may rise dramatically. The cost and risk of participation for a single farmer are decreased because farmer groups rather than individuals are typically accepted into carbon credit programs.
- **Lack of infrastructure:** An Indian farmer's average

landholding size is slightly more than one hectare. As a result, the number of carbon credits obtained may be insufficient for a small farmer to embrace regenerative agriculture practices. Furthermore, as carbon credit trading is still in its early stages, farmers are unaware of this possibility. Some carbon farming practices, such as composting or biochar production, require specialized equipment or infrastructure that may not be available everywhere. Developing infrastructure and support networks can help to address this challenge.

- **Market access:** While there is growing demand for carbon sequestration services, such as carbon credits, some farmers may struggle to access these markets or receive fair compensation for their efforts. Developing transparent and accessible markets for carbon credits can help to overcome this challenge.
- **Climate variability:** Changes in weather patterns and extreme weather events can impact the effectiveness of carbon farming practices. Developing adaptive management strategies can help farmers to navigate these challenges.

Addressing these challenges will require a collaborative effort from farmers, policymakers and other stakeholders to create a supportive environment for carbon farming practices.To encourage farmers to take part in carbon credit programs, state and central governments could try to coordinate the existing carbon farming, natural farming and organic farming systems. To make the measurement and verification processes easier, scheme guidelines may, for example, require the routine calculation of soil carbon levels. The data obtained could then be shared with carbon credit verifiers.

## Carbon credit programmes for farmers

While it is difficult for individual farmers to pursue this path, non-profit organizations and farmer producer organizations (FPOs) can assist them in reaping the benefits of carbon credit programs.

- **Follow carbon farming as a group:** Non-profits and FPOs' first step is to encourage carbon farming among their farmer groups, with a focus on increasing soil organic matter and carbon. This can take time and may result in decreased yields;thus it is critical to assist and support farmers during the early years. It is critical to demonstrate that these activities were implemented to obtain carbon credits.
- **Carbon credit onboarding and third-party verification:** Third-party agencies, such as Verra, validate the projects after they have been found and listed. These credits are sold in credit markets after they have been verified and approved, and the incentives are dispersed to both the FPO and the farmers. This typically takes between eight and twelve months from the moment the project is listed.

## Conclusion

One-third of the world's arable land is used for agricultural cropping systems and grazing, which can absorb a significant quantity of atmospheric $CO_2$ for storage as soil organic carbon (SOC) and to improve the soil carbon budget. A better soil carbon balance has the dual benefits of enhancing soil health, which improves agricultural yield, and creating a pool from which carbon can be transformed to recalcitrant forms for long-term storage as a global warming mitigation strategy as well as generating additional revenue to the farmers. The interaction between carbon credit markets and farmers is anticipated to change over the next few years as more and more nations make climate pledges. However, given the numerous advantages of increasing soil carbon levels, it might be the push that encourages the growth of carbon farming methods and contributes to the fight against climate change.

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# COMPARISON OF SOIL FERTILITY STATUS OF PRE AND POST FLOOD SOILS OF SOUTH CENTRAL LATERITES (AEU 9) OF KERALA

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## INTRODUCTION

Monsoon rain was part of Kerala state every year. Yet the south west monsoon of 2018 had a different impact which resulted in a disastrous flood. The agroecological unit 9 (south central laterites) in Pathanamthitta includes Mallappally, Koipram, Elanthoor, Parakkode, and Panthalam blocks and Adoor municipality. The soils of theSouth central laterites (AEU 9) exhibit some spatial variability in their properties. These soils are strongly acidic, gravelly, contains lateritic clay and underlined by plinthite. Major crops includes rubber, coconut, banana, tapioca, Paddy and vegetables such as amaranth, brinjal, bhindi, cowpea, cucumber, bottle gourd, snake gourd, ash gourd, chilli and tomato. Parts of Manimala, Pamba and Achankovilriver passes through AEU 9. The devastating flood heavily impacted the agricultural sector in the south central laterite area of Pathanamthitta district. Farmers should be made well aware about the changes that had occurred to the soil due to the flood and their management strategies for the effective implementation of post-flood management activities in agriculture sector. A detailed study on soil fertility of post-flood soils of various agro ecological units covering predominant cropping systems prevailing in those AEUs will help in formulating sustainable crop management strategies in these flood affected areas. Hence the present study has been undertaken to assess the soil fertility of post-flood soils of AEU 9 in Pathanamthitta district and to develop maps on soil characters using GIS techniques.

## RESULTS AND DISCUSSION

Soil texture: The proportion of sand, silt and clay indicates the texture of soil. Sand, silt and clay content exhibited wide variations in the soils of AEU 9. Loam was the predominant textural class observed in 62.7 percent of soils in AEU 9 of Pathanamthitta district, followed by clay loam (21.3 %), sandy loam (13.3%) and sandy clay loam (2.7 %).Sandy loam texture was observed in Kalloopara where high amount sand and silt were deposited. Clay loam texture was exhibited by Kulanada and Panthalam where deposition of sand and clay occurred. All other panchayats showed loam texture. In post-flood soils a slight shift from sandy clay to loam texture was noticed in majority of surface soil which can be attributed to the sediment deposition of sand and silt due to flood.

**Soil pH:** The pH of soil varied between 4.60 and 5.60 with a mean of 5.16. Majority of soils (90.6 %) were in the range of very strongly acidic to strongly acidic category. Leaching of basic cations from the soil might have led to increased acidity. Soil acidity was observed to be lower in areas with sediment deposits where concentration of basic cation like Cawaso bserved to be higher. Acidity falls into very strongly acidic, strongly acidic and moderately acidic categories after flood. Extremely acidic and slightly acidic categories vanished after flood (KSPB, 2013). Leaching of basic cations from the soil might have led to increased acidity and also the soil acidity lowered in regions where sediment deposits with high basic cations occurred. Similar results were reported by Akpoveteet al., (2014).

**Organic carbon:** Organic carbon content varied from 0.40 to 3.50% with a mean value of 1.63%. Majority (57.3%) of the post flood soils are having medium organic carbon status followed by 38.7% soils with high status (Fig 4). Most of the sample (96 %) falls under medium and high status after flood. Percent of sample low in organic carbon status decreased after flood compared to pre flood soil (KSPB, 2013). Organic carbon was high in Kaviyur(2.53%) followed by Aranmula (2.43%). This can be due to the deposition of sediments rich in organic matter under the inflow of flood water and is in compliance with the findings of Kalshettyet al. (2012).

## PRIMARY AND SECONDARY NUTRIENTS

**Available nitrogen:** Available nitrogen was medium in 54.7 % samples and low in 46.7 % of the post flood soils. The reason for low available nitrogen observed in some panchayat seven though they showed medium to high organic carbon status may be attributed to low mineralization of organic matter as the soils are highly acidic. These results are in confirmation with those of Usha and Jose (1983)in laterite soils. The low availability of nitrogen in soil might also be due to leaching of nitrate nitrogen present in soil in the study are a which received high amount of rain fall and also under the an aerobic conditions nitrogen loss would have occurred due to nitrate reduction and denitrification

**Table 1. Nutrient index ratings**

| Nutrient index | Range | Remarks |
|---|---|---|
| I | <1.67 | Low |
| II | 1.67-2.33 | Medium |
| III | >2.33 | High |

**GIS based thematic maps were prepared using ArcGIS 10.5.1 software following Inverse Distance Weighting method (IDW).**

(Unger et al., 2009).

**Available phosphorous:** The available phosphorous was found to be medium in37.3 % of the soils, high in 58.7 % and low in 4% soils. Soils with medium status of available phosphorous increased in post-flood (37.3) compared to pre-flood (17%) where as high phosphorous soils decreased from 65% to 58.7% (KSPB, 2013). The phosphorus availability in these soils have reduced after flood which can be attributed to change in soil pH. The phosphorus availability is highly dependent on soil pH and P availability will be maximum at a pH of 6.5. Organic matter deposition in the soils may have also contributed to phosphate sorption and reduction in phosphorous availability. This agree with the findings of Sah and Mikkelsen (1989) who reported that flood induced P deficiency in soil is caused by high P sorptivity.

**Available potassium:** Majority (50.7%) of the soils were medium in available K, 44.0 % were high and 6.7 % low. Available Kstatusin soil increased in post-flood soils compared to pre-flood soils. Samples low in potassium status were reduced compare to pre flood soil. Similar findings were reported by Kalshettyet al.(2012). Low activity clays such as kaolinite and iron and aluminium oxides and hydroxides are pre dominant in laterite soils. These tropical soils can store K even without a large content of high activity clays and avoid leaching losses (Rosolem and Steiner,2017). Which have contributed to increased availability of potassium.

**Available calcium:** Available

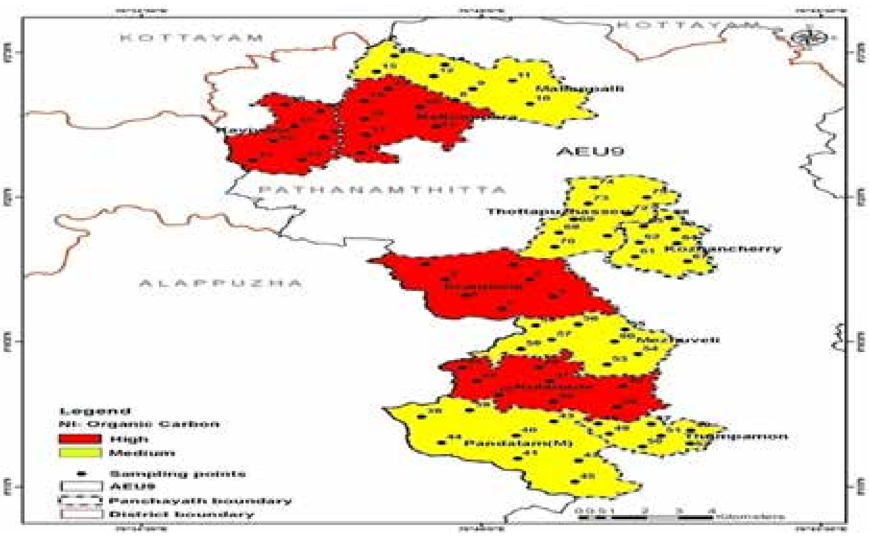


**Fig 1. Spatial distribution of nutrient index for organic carbon in the post-flood soils of AEU 9 in Pathanamthitta district**

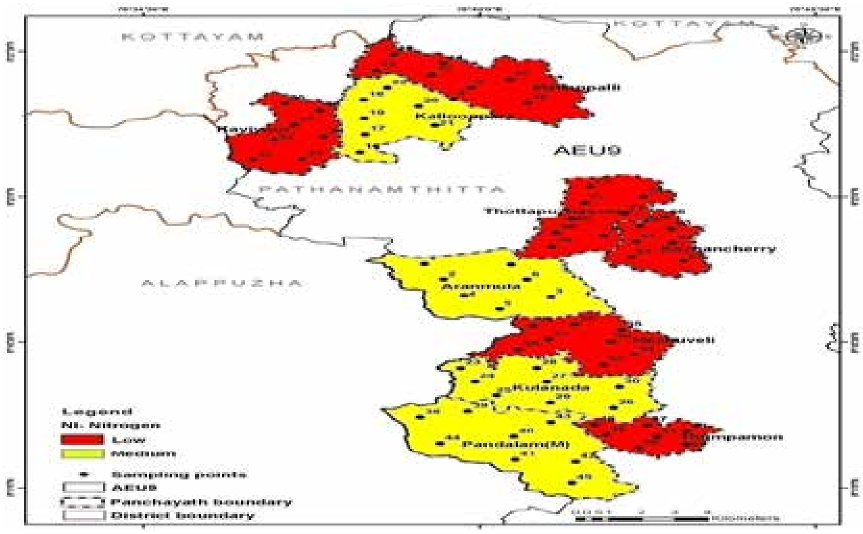


**Fig 2. Spatial distribution of nutrient index for nitrogen in the post-flood soils of AEU 9 in Pathanamthitta district**

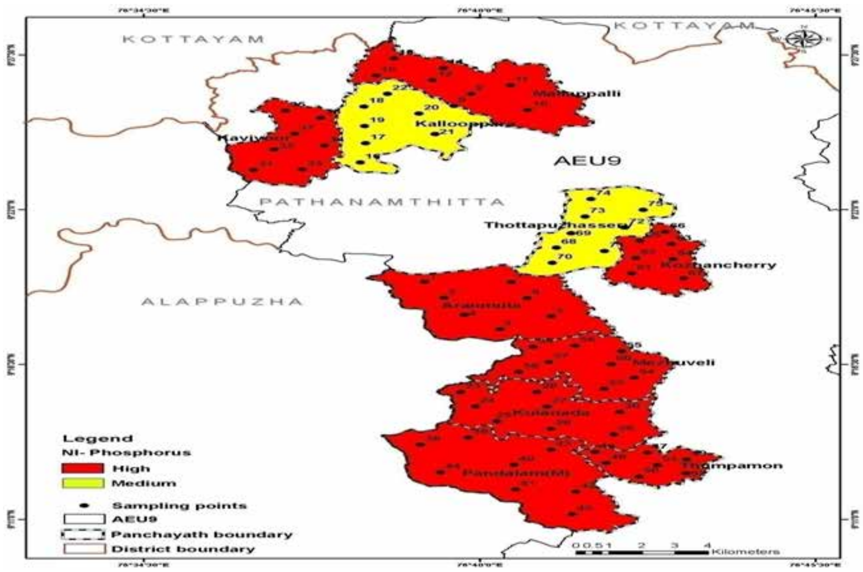


**Fig 3. Spatial distribution of nutrient index for phosphorus in the post-flood soils of AEU 9 in Pathanamthitta district**

Ca was deficient in 36 % of post-flood soils and adequate in 65.3 % but in pre flood soils 30% were deficient and 70% adequate in calcium. Decrease in calcium content after flood was due to the leaching of basic cations in flood water. These findings were in accordance with those reported by Lenoetal. (2013) and Mengeletal. (2011).

**Available magnesium:** There was a decline in available magnesium in soil due to the flood. Available magnesium was found to be deficient in 68 % of the post flood soils. Percent of sample deficient in Mg reduced (68%) compared to pre-flood soils (74 %). This reduction in Mg deficiency is due to the deposition of sediments and organic matter. Most of the samples are deficient in Mg in both pre and post flood conditions. Magnesium being a weak competitor of exchange sites with aluminium and calcium, appearsto accumulate insoil solution and is subject to leaching loss in acid soils(Edmeadesetal.,1985) whichmight be the reason for lower magnesium levels in soils despite the high calcium content observed in the same areas. Similar findings were also reported by Natarajanet al. (2013).

**Available sulphur:** Available sulphur was found to be adequate in 91.7% soils. The higher levels of available sulphur might be due to the accumulation of organic matter and sediments in these soils. Available S was significantly and positively correlated with silt content. Similar results were reported by Kalshettyet al. (2012). The combined effects of decreased adsorption, increased mineralisation and accumulation of sulphur bearing minerals from sediments would have increased in available sulphur levels in soil.

## MICRONUTRIENTS

**Available iron:** Available iron content was adequate in all the soil samples. The sufficiency of available iron in the post flood soil might be due to the reason that insoluble form of Fe is reduced to more soluble form ($Fe^{2+}$) under submerged condition (Fageriaet al., 2011). Presence of iron rich parent material and leaching of basic materials from the surface layers of the soils may also leads to the high available iron.

**Available manganese:** Available manganese content was adequate in 100% of samples. Manganese content remained high in the study area in both pre and post flood period. The sufficiency of available Mn in the post flood soil might be due to the reason that insoluble form of Mn is reduced to more soluble form ($Mn^{2+}$) under submerged condition (Fageriaet al., 2011).

**Available zinc:** Available zinc content was adequate in

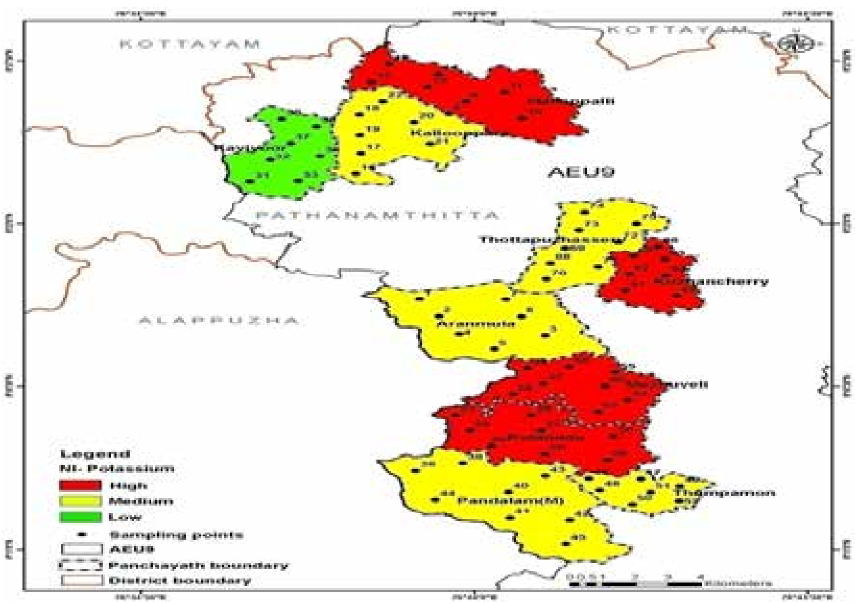


**Fig 5. Spatial distribution of nutrient index for potassium in the post-flood soils of AEU 9 in Pathanamthitta district**

66.7% and deficient in 33.3% of samples. Deficiency of Zn increased after flood (33.3%) compare to pre flood condition (10 %) (KSPB, 2013). This deficiency may be due to leaching losses occurred during flood. Similar reduction in availability of Zn reported by Fageriaet al. (2011) in submerged soils.

Available copper: Available copper content was adequate in all the samples, which was deficient in 13 % samples of pre flood soil. This may be due to accumulation of organic matters and sediments after flood.

**Available boron**: Available B became deficient in all the soils of AEU 9 after the flood earlier deficiency was 59 % (KSPB, 2013). This can be attributed to the higher mobility of boron in soils and also leaching losses which led to B deficiency in these soils. High intensity rainfall will lead to loss of soluble forms of boron by leaching (Mengelet al., 2011).

## Nutrient index

Nutrient Index was worked out for organic carbon, available nitrogen, phosphorous and potassium contents in soil. Nutrient indices for organic carbon was medium for Mallapally, Panthalam, Thumbamon, Mezhuveli, Kozhancheryand Thottapuzhasseryand high for Aranmula, Kalloopara, Kulanada and Kaviyurpanchayats. (Fig.1). This can be attributed to the deposition of sediments rich in organic matter under the inflow of flood water. The results are in line with the findings of Gryboset al. (2009). Nutrient indices for available nitrogen were low for Mallapally, Kaviyur, Thumbamon, Mezhuvely, Kozhanchery and Thottapuzhassery and medium for Aramula, Kalloopara, Kulanada and Panthalam (Fig.2). This can be attributed to the losses of nitrogen that has occurred and also the low mineralization of organic matter in highly acidic soil which requires replenishment for sustaining soil productivity (Liji,1987). Nutrient indices for available phosphorous medium for Kalloopara and Thottapuzhassery low for other panchayats. (Fig.3). This is attributed to low pH, phosphate sorption and also fixation of soluble inorganic P in the soils Sah and Mikkelsen (1989). Nutrient indices for available potassium were low for Kaviyur and high for Mallapally, Kulanada, Mezhuvely and Kozhanchery and medium for remaining panchayats.

## CONCLUSION

The results of the study revealed that the nutrient status were slightly altered in the soils of AEU 9 in Pathanamthitta district after the 2018 flood. Soil acidity increased in some areas due to the leaching of basic cations and erosion by flowing flood water. Organiccarbonand availableKwereincreased andavailableP slightly decreased after the floods and widespread deficiency of available nitrogen were observed. Deficiency of calcium and magnesium increases after flood. The entire study area showed deficiency of boron.Nutrient index for nitrogen was low in most of the panchayats, medium and high for phosphorus, potassium and organic carbon. Theresultsoutlinetheneedforregular liming to control soil acidity and to alleviate Ca deficiency. The soils should be supplementedwithMgandBinadditiontorecommendeddoseofN,PandKfertilizers.

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