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English journal

The First English farm journal from the house of Kerala Karshakan

Micro bowl lotus

THE TINY LOTUS IN A CUP

INSIDE

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Micro bowl lotus

THE TINY LOTUS IN A CUP

Growing lotus is a new trend among gardeners. Miniatures and dwarfs are always the gardeners' favourite. When it comes to the lotus, the tiniest lotus that can be grown is the micro lotus. They can be grown in little bowls and are also known as bowl lotus. The first miniature lotus variety was 'Spark' developed in China.

There are four groups of lotus based on their size. Miniatures/bowl lotus are 6 inches and smaller, small types range from 7 to 18 inches, medium types range in size from 19 to 36 inches, and large types measure above 36 inches. Lotus plants of the same kind grown in larger containers will typically be larger since they have more room to grow. True miniatures are genetically dwarfs and will remain dwarf even if grown in large containers. The bowl lotus produces small leaves, small flowers, and rhizomes. Bowl lotus can be either true miniatures grown in bowls, or small type lotus planted in bowls as they eventually behave like miniatures due to the reduction in growing space, precisely like a bonsai plant. Mangala Patum, Liang Li, New Star, Budha Seat 13, Little Green Micro, Lady Binglei, Affection 16, Red Tulip, Grand Master, Little Longevity Star, and Amiry Camelia are some of the lotus varieties which can be grown in bowls.

Containers that are 6 inches tall and 12 inches in diameter can be used for growing micro lotus. If you are an expert in cultivating lotus, you could even grow them in cups of 3-inch diameter. Choose a small container or ceramic bowl for your plants and fill it with goat manure, vermicompost, or farmyard manure. Along with it, a little bone meal should be given. Fill two thirds of the pot with clay soil or backyard soil. A good quality micro lotus tuber or a lotus stem with two to three nodes (runner) cut off can be planted after the soil has been lightly moistened. With your hand, make a tiny indentation in the soil. Place the tuber into the indentation with the growing tip pointed toward the centre of the pot. Take care not to damage the growing tips. Pouring water into the pot should be done carefully to avoid disturbing the planting media. Keep the pot in the sunlight. A minimum of six hours a day sunlight should be required for blooming. It is challenging to grow lotus as a purely indoor plant because of its dependence on sunlight. During flowering, these pots can be positioned on balconies and sit outs to enjoy the beauty of their blooms.

Make sure the water in the pot doesn't dry out. Because it is planted in tiny pots, once the water runs out, the plant will quickly dry out. Immersing the micro lotus bowl to a large container will ensures continuous hydration and controls temperature. When there is a bloom, the bowl can be taken out and can be kept at our favourite places to enjoy its beauty. Any fertiliser that contains phosphorus, such as Di Ammonium Phosphate, Mono Ammonium Phosphate, or 19:19:19, can be applied once every two weeks at the rate of quarter teaspoon per pot. Be careful not to overfeed the plant. If the fertilizer touches the plant directly, the plant will get damaged. Readymade fertilizer tabs are also available in the market. Periodic removal of dried flowers and foliage

is necessary to keep the plant attractive and healthy.

Number of blooms obtained from bowl lotus are less compared to other lotus since they are tiny plants and are allowed to grow in a small amount of potting soil. The number of blooms each variety produces can differ. However, micro lotus blooming in pretty bowls are a real eye-catcher. Private space for gardening is becoming increasingly scarce as our population migrates from rural living to the skyscrapers of the thriving cities. Many of the urban gardens today are found on residential balconies. Plants such as bowl lotus are perfect for these smaller urban gardens.

Bowl Lotus Seeds – a scam

Advertisements for bowl lotus seeds for sale can be found on Facebook, WhatsApp, and online trade platforms. There are active online seed sales posts for Dutch hybrid lotus, blue lotus, and bonsai lotus. After seeing altered pictures of blue lotuses, brown lotuses, and gorgeous bowl lotuses that were obtained from other sources, many people fell for this deception. There will be comprehensive instructions on how to germinate seedlings. The seed will germinate too. But what you get is not the bowl lotus, but the ordinary lotus. Most bowl lotus species don't produce seeds and if a breeder can produce bowl lotus seeds, they will be very few in number. Genuine bowl lotus seeds should only be purchased from reputable farmers. Lotus is a cross-pollinated plant so the seedlings that emerge from the seeds will differ from that of the original variety. It is better to use the rhizomes or runners as planting material instead of the seeds.

Vijay S. P.
Suresh Kumar T

KUMQUAT

NUTRITIONAL SNAPSHOT

Kumquat is a citrus fruit that looks like an orange but is oval-shaped and much smaller (1-2 inches). In China in the 1700s, it was also called a Fortunella. Chinese terms "gam," which means gold, and "gwat," which is another word for tangerines, are combined to form the word "kumquat." In the 1800s, the tree spread to Europe and the US. It can withstand the cold yet grows best in warmer climates. The kumquat is a citrus fruit that kind of looks like an orange

but is oval-shaped and much smaller (1-2 inches) and has a sweet skin, which you can eat.

Kumquats are tangy, sour and slightly sweet citrus fruits. They are bite-sized orange flavoured fruits rich in vitamin C and fibre. They also contain some amounts of other nutrients such as iron, B complex vitamins, manganese, copper and calcium. In addition, the edible seeds of kumquats contain healthy fats like omega- 3 fatty acids. They also have a high percentage of water.

There are several types of kumquats. The most popular are:

- Nagami
- Marumi
- Meiwa

Marumi and Meiwa kumquats are rounder and sweeter than Nagami kumquats, which are oval or pear shaped and have a sour flavour.

NUTRITIONAL VALUE OF KUMQUATS

100 grams of raw kumquats contain

- Energy: 71kcals
- Carbohydrate: 15.9g
- Protein: 1.8g
- Fat: 0.8g
- Fibre: 6.5g
- Vitamin A: 15mg (2% of DV)
- Vitamin C: 43.9 mg
- Riboflavin: 0.09mg (8% of DV)
- Choline: 8.4mg (2% of DV)
- Calcium: 62mg (6% of DV)
- Iron: 0.87mg (7% of DV)
- Magnesium: 20mg (6% of DV)
- Manganese: 0.13mg (6% of DV)
- Zinc: 0.17mg (2% of DV)

NUTRITIONAL FACTS ABOUT KUMQUATS

Low Glycemic Index

Citrus fruits have a low glycemic index. Low glycemic index fruits are safe for consumption by diabetics because they do not significantly increase blood glucose levels. Kumquats are a safe and healthy fruit that is rich in antioxidants and have a very low glycemic index.

High Fibre

Kumquats are complex carbohydrates as they contain reasonable amount of fibre. Therefore, they take longer to pass through the gut as the digestive enzymes are unable to break them down in our body. Hence it will feel fuller for longer thus, preventing weight gain.

Soluble fibre is known for its role in arresting diarrhoea. It

absorbs the excess water from the intestines and forms a gel-like substance. Therefore, if you are suffering from continuous episodes of diarrhoea, have a handful of kumquats.

Healthy Fats

`Due to its low-fat content, people with heart diseases such as high cholesterol levels can add kumquats to their daily diet. In addition, the edible seeds of these fruits contain trace amounts of omega-three fatty acids. Studies have shown that omega-three fatty acids may reduce bad cholesterol and improve good cholesterol in the body.

Acts as an Antioxidant

Kumquats are rich in antioxidant vitamins like vitamin A and C. Free radicals, when present in excess, can lead to cell damage. The antioxidants present in kumquats may reduce oxidative stress caused by free radicals in our bodies.

HEALTH BENEFITS OF KUMQUATS

Good for Heart Health

Nutrients in kumquat includes Vitamin C, fiber, antioxidants and vitamin A that work together to reduce the build-up of fat in the arteries and lower the chance of blockages. Therefore, it mitigates the possibility of heart failure stroke and high blood pressure conditions. Eventually, it strengthens heart health and also reduces LDL which prevents heart ailments.

Anti-inflammatory effect

Kumquats contain a variety of flavonoids, including kaempferol, luteolin, hesperidin, quercetin and C-glycoside. C-glycoside has been found to have anti-inflammatory activities in a few investigations. It works by lowering the immune system's inflammatory reaction and the generation of dangerous free radicals.

Antibacterial Effect

According to a study, kumquat peel oil may have antimicrobial qualities. As a result, it might prevent the development of various hazardous microorganisms that grow on food like fungi and bacteria. It may be advantageous to extend the shelf life of foods by limiting microbial growth due to its antibacterial activity.

Anticancer Effects

Research suggests that apigenin, a type of flavonoid found in kumquats, may inhibit the growth of cancer. Cancer results in uncontrollable cell division and DNA alterations. In order to prevent the growth and spread of cancer cells to other cells, apigenin may act on the cancer cells via inducing cell death.

Prevents Weight Gain and Obesity

Poncirin, a different flavonoid found in kumquats, may play a key role in reducing obesity. According to a study, Poncirin may lower the risk of weight gain by inhibiting the body from producing new fat cells. Additionally, they contain a lot of fibre, which helps to feel satiety for longer because of their delayed absorption into the body.

Improves Eye Health

Kumquats contain fair amounts of vitamin A in the form of beta carotene. It is one of the eleven carotenoids present in kumquats. Carotenoids including beta carotene, zeaxanthin, and lutein have been shown in numerous studies to promote eye health. Rhodopsin is produced with the help of vitamin A, which is crucial for maintaining good vision.

May Regulate Mood Disorders

Some studies suggest that vitamin C rich foods may improve stress disorders, overall mood and regulate sleep. It functions similarly to an antidepressant and promotes mental health by lowering the risk of experiencing stress, depression, and anxiety. However, the exact mechanism by which it enhances sleep is still unclear.

Improves Bone Health

Vitamin C also has a crucial role in bone formation. In addition, vitamin C helps in formation of collagen. Calcium and vitamin C are abundant in kumquats.

According to studies, vitamin C may be helpful in reducing bone conditions like osteoporosis. Acidic foods may increase the risk of bone diseases by reducing calcium from the bones. Since kumquats are alkaline fruits, they reduce the risk of developing osteoporosis.

Improves Immunity

Beta-cryptoxanthin and L-limonene in kumquats may boost immunity, claims a study. They also function by boosting the activity of natural killer cells and lowering metabolic stress in the body.

Senna

an export value laxative medicinal plant

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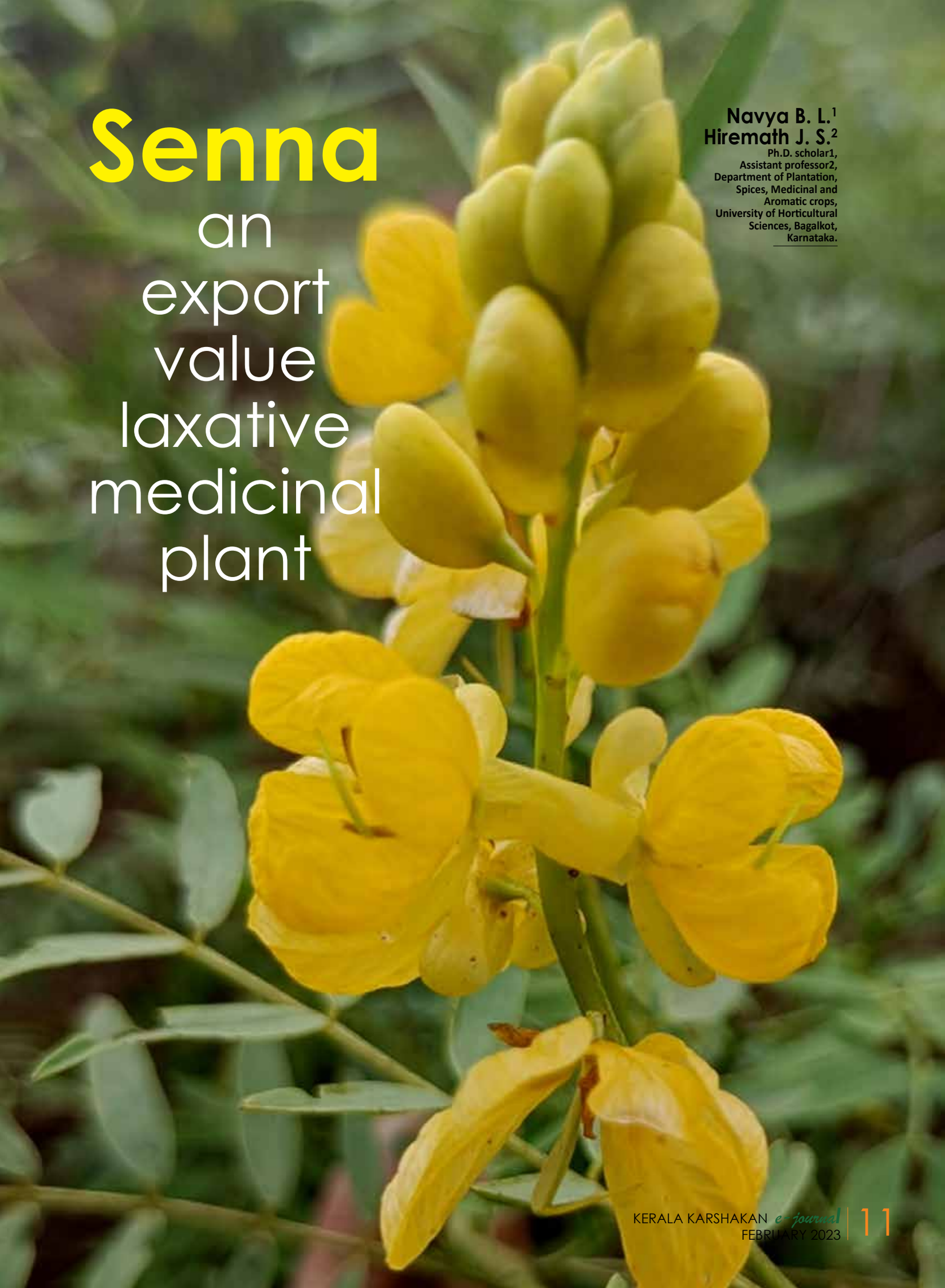

Introduction

The most prevalent gastrointestinal disease in both children and adults is constipation. It is a symptom rather than a disease caused usually due to less appetite and by receiving less of high fibre foods. The use of synthetic laxatives causes many side effects such as nausea, diarrhoea, stomach pain etc. and its use for longer time without prescription is also not advisable. Hence, use of natural laxatives with ideal dosage is viable and safe option. One such natural laxative is Senna which is used on short term basis to treat constipation. It is included in the class of stimulant laxatives and works by increasing the activity of intestines to cause a bowel movement.

Senna is scientifically called as *Cassia angustifolia* Vahl. (Synonym: *Senna alexandria* Mill.) belongs to family Fabaceae. It is locally called by different names such as Sonamukhi, Sana ka patta in Hindi, Swarna patri, Sanai in Sanskrit and Nilavarai, Nelavakari

Leaves

Plant

in Tamil. It is native to Yemen and Hadramaut province of South Arabia hence it is also known as Arabian senna. The plant is distributed wild in Tropical Africa, Arabian Peninsula, India and Somalia. The crop was first time introduced during mid eighteenth century in Tirunelveli district of Tamil Nadu hence it is referred as 'Tinnevelly Senna'. It is now being cultivated in several districts of Tamil Nadu, Andhra Pradesh, Karnataka, Gujarat, Rajasthan, West Bengal and Maharashtra. The dried leaflets and pods are economic parts of senna used in herbal medicine and pharmaceutical industry. India is one of the major exporters of Senna in the world. Senna leaves worth 11.22 USD million has been exported from over 91 countries in the year 2020-21 among which China is largest importer accounting for 35.20 % of the total market share of world followed by USA.

FlowerSeeds

Botany

Cassia angustifloia Vahl. is a perennial undershrub which grows to a height of 1-2 m. The stem is smooth, erect and pale green to light brown in colour with long spreading ascending branches. The leaves are paripinnate, alternate bluish-green to pale green in colour, compound type with four to eight pairs of leaflets. The leaves exhibit a characteristic fetid smell when crushed. The inflorescence is terminal or axillary raceme with small, zygomorphic yellow flowers. Pods are broadly oblong, green in colour and turn brown to dark brown at maturity. Each pod has 5 to 7 ovate, compressed, dark-brown seeds.

The genus Cassia is known to have 500 species out of which 26 species are known to have anthracene derivatives. There are two largely cultivated and recognised species which are known to have laxative properties one of which is *Cassia angustifolia* known as Indian or Tinnelvelly senna and other is *Cassia acutifolia* known as Alexandrian Senna and is native of Sudana and Africa.

Chemical constituents

Senna contains anthraquinone glycosides called Sennosides in leaves (2.0–3.0%) and pods (3.0–4.0%) which are responsible for laxative properties. Sennosides A and B are chiefly responsible for the 80 % of biological activity and also small quantities of sennosides C and D are present along with rhein, aloeemodine, palmidine A, kaempferol and isorhamnetin. Leaves contain β- sitosterol which is responsible for anticancerous properties and flowers of the plant contain chrysopanic acid which has antidiabetic and anticancerous property.

Medicinal properties

Senna leaves are commonly used as laxative in both modern and traditional system of medicine including Ayurveda, Unani, Homeopathy and Allopathy. The plant is included in Indian, US, British, Arabian and many other pharmacopoeias of the world. The leaves and pods can be used in the form of powder, decoction, extracts, oral infusion and many other household preparations. The drug senna is also widely used as a purgative, expectorant, wound dresser, antidysentric, carminative and in the treatment of gonorrhoea, dyspepsia, fevers and haemorrhoids. In modern

Dried pods

medicine, calcium sennoside is popularly used to treat habitual constipation. In addition to its laxative property leaves are also used to cure skin ailments and to cure pimples. Senna is used in Unani formulation called Safoof- E- Sana, Safoof-e-Mulaiyia and Majoon-e-Senaai which is widely used as laxative at dose of 3- 6 g daily. Some Ayurvedic formulations containing senna include Panch Sakaara Churna, Shtshakaar Churna and Yashtyaadi Churna. Since, it acts on large intestine to stimulate peristalsis it is always advised to use the drug under the supervision of physician. The leaves are also used in the preparation of herbal tea which is popular in Europe.

Varieties

The three important commercial varieties of senna are as follows:

1. ALFT-2: It is a late flowering and higher foliage yielding variety and has major area in the country under senna cultivation. It remains in a vegetative stage till 100 days and is suitable for growing exclusively as a leaf-crop. It is released by Gujarat Agriculture University, under the AICRP on MAP at Anand.

2.KKM (Se) -1: It is a selection from Thenkalam local type with 135-140 days duration. It contains 2.34 % sennoside. It is suitable for Tirunelveli and Tuticorin districts of Tamil Nadu.

3.Sona: An open pollinated seed variety developed by CIMAP Lucknow. It is recommended for North Indian plains. It gives leaf yield of 1.10 tonnes and pod yield of 0.4 tonnes/ha. Sennoside content in leaf is 3.51%.

4.Gujarat Anand senna-1: Released under AICRP on MAP Boriavi, Anand, Gujarat. 75% higher dry leaf yield than the local.

Cultivation

Soil and climate

Senna is deep rooted hardy plant cultivated in rain fed areas with warm and dry conditions and rarely cultivated in irrigated areas. The crop requires bright sun shine and occasional rains during its growth period. Rainfall of 25-40 cm distributed from June to October is sufficient to get a good yield. It is extremely sensitive to water logging and do not withstand heavy rainfall. Senna can be cultivated in wide range of soil with pH range of 7- 8.5 but well drained sandy loam, alluvial loam, red loam soils are most suitable. It also comes up well in black cotton soils as it tolerates high salinity.

Propagation

It is propagated by seeds. Seeds of senna have hard seed coat. In order to soften the seed coat seeds are soaked in water for 12 hours or abrading the surface can be done to achieve quick germination. Recommended seed rate for broadcasting is 15 kg per hectare for irrigated condition and 25 kg for rainfed condition. The seed rate can be reduced to 6 kg per hectare under irrigated condition by dibbling in lines.

Planting and aftercare

The land is ploughed to a fine tilth and levelled to get uniform germination. The seeds are either broadcasted or line sowing is done at a spacing of 30 × 30 cm or 45 × 30 cm. Before sowing, seeds are treated with captan/ thiram at 2.5 g/kg seeds to protect the seedlings from damping off and blight diseases. In South India it is sown in the month of September-October. In North India two sowing seasons are recognized for irrigated crop- February to March and for rain fed crop July to November. Seeds are sown soon after receiving first monsoon showers for rain fed crop.

Fertilizer dose of 50-100 kg nitrogen (N), 20-50 kg phosphorous (P) and 30 kg potassium (K) per hectare is recommended where entire dose of P, K and 50 % N is applied at the time of sowing along with 10 tons per hectare of farm yard manure and another 50 % N is applied 90 days after sowing. Senna is economically grown as a rainfed crop; however growing as semi-irrigated crop with 5-8 light irrigations increases the yield considerably. Heavy irrigations are detrimental to crop. Weeding cum hoeing at 25- 30 days, second at 75 – 80 days and third at 110 days after sowing is sufficient to keep the soil free from weeds. Senna can be grown as intercrop with sesamum, cotton, chillies, brinjal, okra and tomato. It can also be grown in rotation with paddy, mustard and coriander.

Harvesting

Leaves and pods are the economic parts in senna. The leaves are harvested when they are fully grown, thick and bluish green in colour. First harvesting of leaves is done after 50- 70 days after sowing by harvesting the growing parts which further induces branching, second harvest is done at 90- 100 days after sowing and final harvest is done at 130- 150 days where the entire plant is uprooted which includes both leaves and pods. For seed production, the pods are collected when the pods turn brown. Under irrigated conditions senna yields 15 q/ha of dry leaves and 7 q/ha of pods and 10 q/ha of dry leaves and 4 q/ha of pods under rainfed condition.

Post-harvest processing

The harvested leaves and pods are spread on a clean surface in open sun for 6- 10 hours to reduce the moisture. Further, drying is done under shade in well ventilated room with frequent stirring to maintain light green to yellowish green colour of leaves. Pods harvested are dried and seeds are separated by beating with sticks. The dirt and other extraneous matter are separated from the harvested produce. Grading is done based on the quality where larger leaves and bold pods with yellow green colour fetches higher price in the market, followed by leaves and pods having brownish colour and the lowest grade in commerce is leaves and pods which are small and broken. The leaves after proper drying, grading and packing are to be stored in cool and dry place. Packaging of leaves and pods are done using black polythene bags in order maintain maximum sennosides content.Pressing of leaves and pods are done using hydraulic pressure to reduce the volume for transportation.

Marketing

India, China and Spain are the major exporters of senna in the world. Whereas, states such as Tamil Nadu, Rajasthan and Gujrat accounts for majority of trade in India. Market price of senna leaves are 60 rupees per Kg and pods are 100 rupees per Kg.

Conclusion

Senna is a high potential, commercially economic, export oriented medicinal crop which can be grown in the limited water conditions as rainfed crop and can also be grown under arid and semi-arid regions of the country but its cultivation is restricted only to few states. Considering its huge demand and potential, the area under senna can be increased by increasing the area under cultivation and also expanding its cultivation in non- traditional areas through which the farmers as well the economic growth of the country can be benefitted.

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Utilization Of Processing Waste For Value Addition

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Fig 01. Different processing wastes generated during fruit processing

It is reported that one-third of the edible portion of fruits and vegetables is wasted along the food chain (FAO, 2012). Fruits and vegetable processing results in the generation of huge amounts of waste materials such as peels, seeds, pomace etc. Disposal of these waste materials in the environment creates a problem,

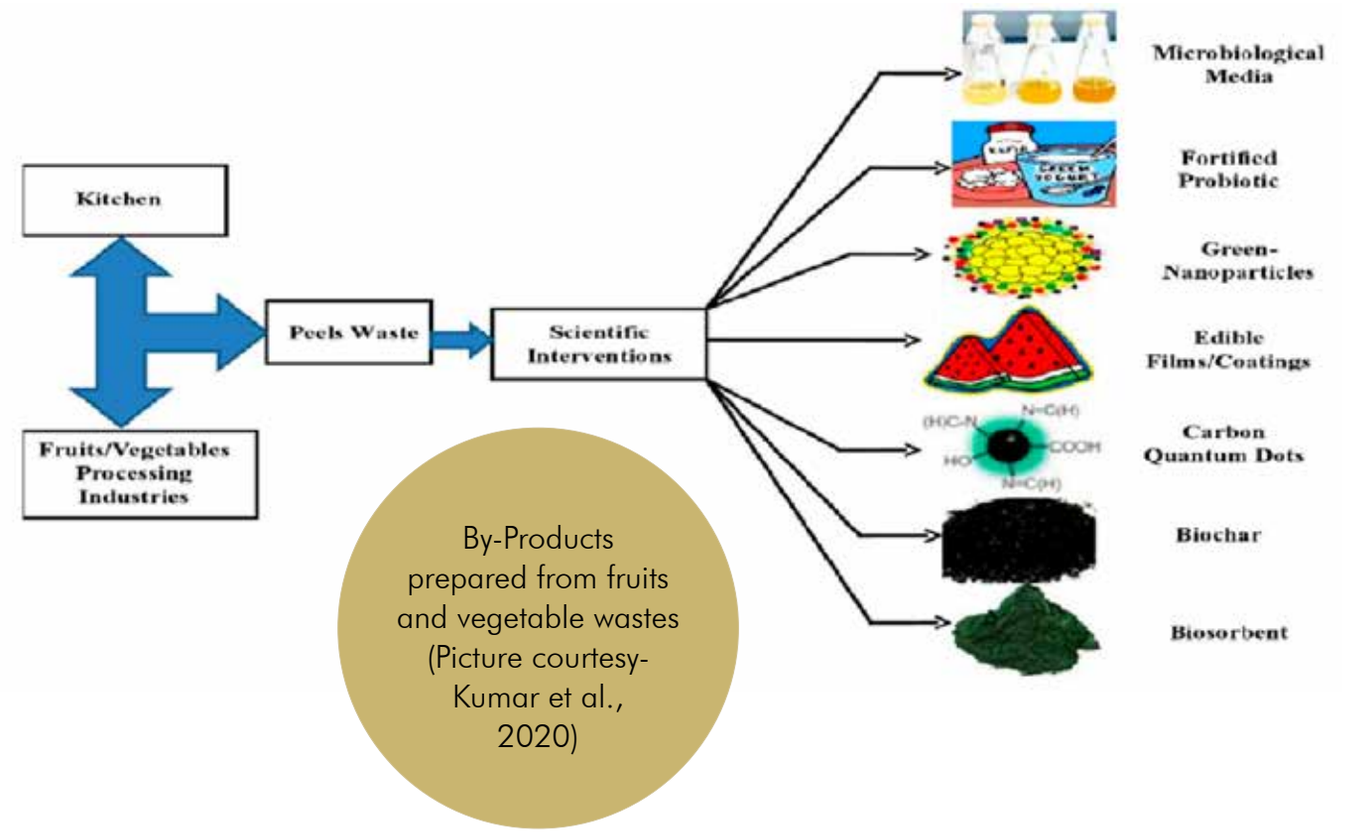
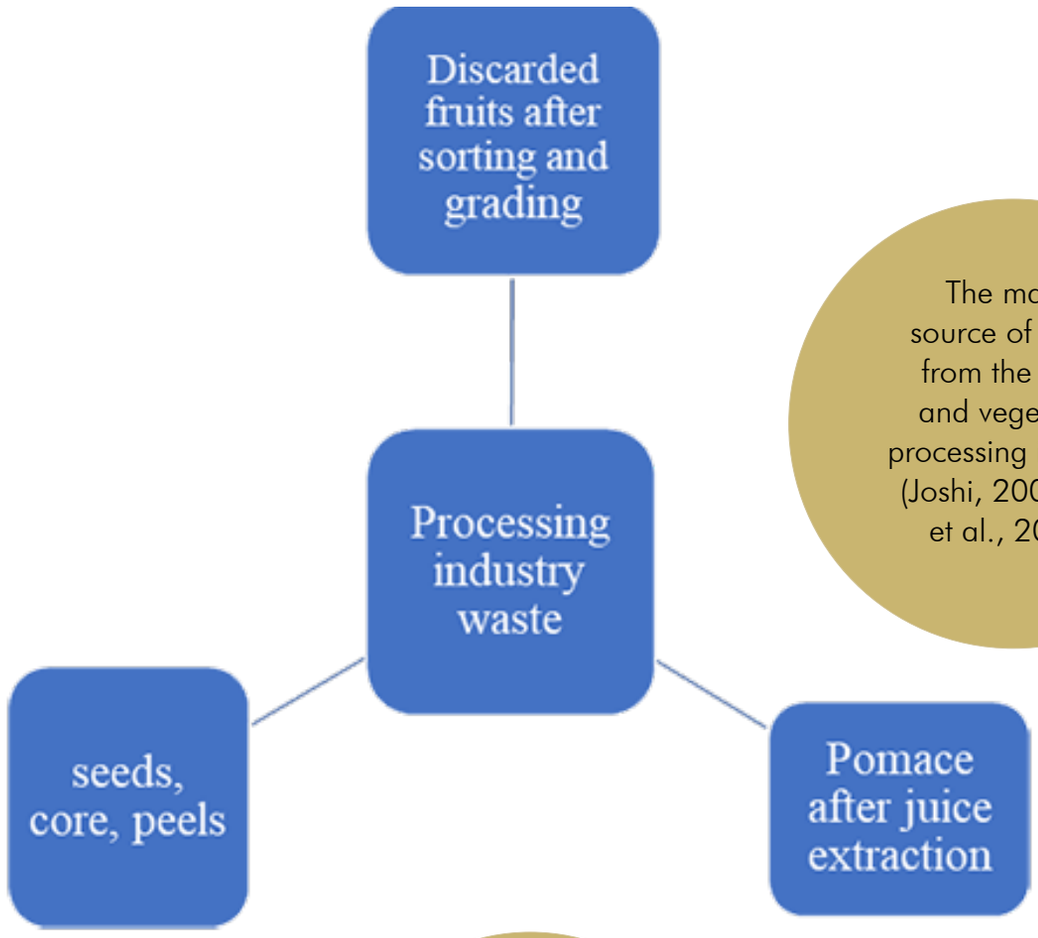


Table 1. By-products from the fruit processing industry

Commodity	Waste%	Solid waste	By- Product
Apple	20-35	Pomace	Wine, citric acid and pectin
Orange	45-50	Peels, seeds and pulp	Essential oil, cattle feed, peel candy, pectin etc.
Lime	60-65	Peels, seeds and pulp	Essential oil
Mango	40-65	Pulp and peel	Pectin
Pineapple	30-60	Shreds	Cattle feed
Tomato	20-30	Core, peel and seeds	Animal feed, seed oil and meal

Table 2. Phenolic compounds in some fruit by-products (Chaouch and Benvenuti, 2020)

Fruit by product	Phenolic compounds
Pomegranate peel	Peels are rich in Punicalagin A and B, catechin, gallic acid and ellagic acid
Banana peel	Epicatechin, gallic acid, rutin, ferulic acid, hydroxybenzoic acid, myricetin and chlorogenic acid
Grape seed	Gallic acid, epicatechin, epicatechin gallate, resveratrol, caftaric acid, catechin
Orange peel	naringin, neohesperidin, rutin and kaempferol
Lemon peel	Ferulic acid, Caffeic acid, Coumaric acid, Sinapic acid
Apple peel	Catechin, epicatechin gallate, Gallic acid, caffeic acid
Mango kernel	Gallates, gallic acid, gallotannins, ellagic acid



The major source of waste from the fruits and vegetable processing industry (Joshi, 2002; Raj et al., 2016)

Value added products from Banana pseudo stem fibre

hence utilization of processing waste for value addition and revenue generation is the area of interest. The major portion of the processing waste consists of fruit peels; example banana 20-30% and mango 30-50% (Joshi, 2020). Thus, peels are the major by-products of the processing industry which can be utilized for the extraction of bioactive

Table 3. Value-added products from Processing waste

Fruits/vegetable	Value added products
Mango Kernels	Can be used in the preparation of cattle feed and mango peels in the extraction of pectin
Citrus Rind	Used in the extraction of essential oils, Peels are also used in the production of pectins
Apple	Single-cell protein using Trichoderma viride and Aspergillus niger
Grapes and	Grape pomace from winery can be used in the preparation of cattle feed production of single-cell proteins
Banana	Used in cattle feed and pseudo stem used in the extraction of starch and fibres
Pineapple	Pineapple fibre is used in the extraction of cellulose and Hemi cellulose
Tomato	Used in the production of SCP
Kinnow peels	Alcoholic beverages with Nutraceutical properties
Banana	Stem candy and cookies
Cabbage waste	Fortified baked products
Banana stem core	Juice
Watermelon Rind	Tutti frutti

Marmalade from citrus peel

Pineapple jam from fruit core

compounds viz dietary fibres and phenolic compounds (Table 2). Horticultural-based farming systems and processing industries generate huge amounts of crop residues and processing wastes. Though the data on all the horticultural crop residues and wastes are not available, it is estimated that during mango processing approximately 32-45% of the weight of mangoes used goes as various forms of waste like peels, pulper waste and stones (Figure 01). Similarly in banana cultivation, approximately 65% of biomass goes as field waste. Ripe banana peel waste constitutes about 20%, while 35-40% of peel waste is generated in the banana (plantains) chips industry. Among the vegetables, the waste index of cauliflower is 48-58%. Similarly, the crop residues of various crops range from 25 to 50% besides processing waste and post-harvest commodity handling waste Few examples showing products prepared from fruits waste

Citrus- 50- 60% waste

Products prepared – candies, Marmalade, mosquito repellent, essential oils

Marmalade from citrus peel

Pine apple – 30- 40% waste

Products prepared – candy, bromelain enzyme extraction, wine, pine apple core jam

Pineapple jam from fruit core

Banana – 70-80% waste

Products- banana peel pectin extraction, banana peel jam

In conclusion, we can state that the processing waste generated can be used in the preparation of several by-products and value-added products, and the bioactive compounds extracted have significant benefits in several industries. Many processing technologies viz drying, extraction, fermentation, and enzymatic degradation are used to utilize fruit and vegetable nutrients that are useful for recycling and upgrading waste in the fruit and vegetable market.

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PHENOMICS

An Innovative approach in Crop Improvement

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Introduction:

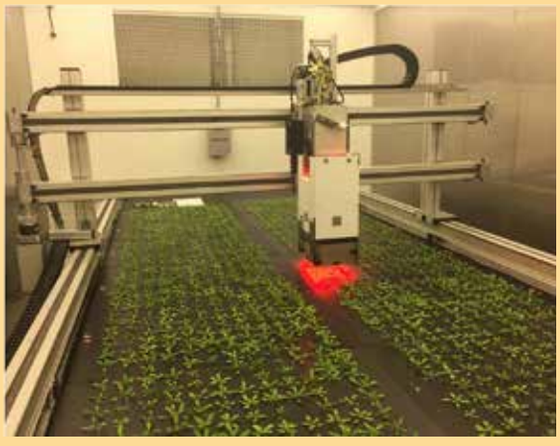
Annual increases in yield achieved from traditional breeding programs worldwide are no longer sufficient to meet projected demand for all three major cereal crops: rice *(Oryza sativa)*, maize (*Zea mays*) and wheat (*Triticum aestivum*) (Tester and Langridge, 2010). To harness this wealth of genomic information for agricultural application, has to be carefully and comprehensively linked to phenotype in a 'real world' environment.

Phenomics

Phenomics is a field of study concerned with the characterization of phenotypes, which are characteristics of organisms that arise via the interaction of the genome with the environment. Phenomics, a relatively new scientific term, describes the study of how the genetic makeup of an organism determines its appearance, function and performance. Phenomics could be described as simply 'high-throughput plant physiology'. As a result, field evaluation of plant performance is much faster, and facilitates a more dynamic, whole-of-life cycle measurement less dependent on periodic destructive assays.

Disadvantages of Conventional Phenotyping

Phenotyping the populations is widely recognized as the most laborious and technically challenging part of this process. For a population to be screened for a valuable agricultural trait (such as grain size, abiotic stress tolerance, product quality or yield potential), replicated trials are necessary across multiple environments over a number of seasons. Phenotyping tools currently in common use requires destructive harvests at fixed times or at particular phenological stages and are slow and costly.



Advantages of Phenomics

1. Phenomics relieves the

'genomics bottleneck'

2. It speeds up plant breeding through the use of automated systems that can screen thousands of plants in a short time.
3. High throughput, controlled-environment facilities has the potential to improve precision and reduce the need for replication in the field. It is more than a high throughput sieve to select better germplasm (Furbank and Tester, 2011).
4. Plant phenomics: Plant phenomics is the study of plant growth, performance and composition. It is a cross-disciplinary approach to studying the connection from cell to leaf to whole plant and from crop to canopy. This will enable breeders to develop new agricultural germplasm to support future agricultural production.

Applications of Phenomics in Crop Improvement

1. High throughput plant breeding
2. Biofuel and bioenergy
3. Carbon sequestration
4. Breeding plants for a changing environment
5. Prognosis of plant performance in global change
6. Innovative plant production for present and future crops based on the understanding of the complex interaction of plants with their environment and its dynamics
7. Monitoring of plant performance in natural systems

CONCLUSION: Plant phenomics can, in fact, be considered as simply plant physiology in 'new clothes', but it promises to bring physiology up to speed with genomics by introducing the incredible recent advances made in computing, robotics, machine vision and image analysis to the wider field of plant biology. The future of plant phenomics is largely determined by the four major challenges facing global agriculture: food security, water availability, appropriate biofuel, feedstocks and climate change.

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AZOLLA

A POTENTIAL FEED SUBSTITUTE FOR LIVESTOCK

INTRODUCTION

Livestock is an integral component of agriculture economy which contributes about 4.11 per cent to total GDP and possess 15 per cent of world's livestock population (DAHD &F, 2012). The success of dairy farming and animal husbandry depends largely on regular supply of good quality fodder in sufficient quantities. Unfortunately, there is acute shortage of green as well as dry fodder. "Azolla", which holds the promise as a sustainable feed substitute for livestock can be used effectively as an alternative to bridge this gap between demand and supply. It contains most of the nutrients which are required for all classes of feed for livestock and can be fed to these animals without any adverse effects. Since it contains more of cell wall fractions, animals can be supplemented with cellulolytic enzyme preparations to achieve better performance and productivity.

AZOLLA

Azolla is a free-floating, rapidly growing aquatic fern on the water surface. It is also known as duck weed belonging to the family, Azollaceae. Species of *Azolla include Azolla pinnata, Azolla caroliniana, Azolla filiculoides, Azolla microphylla, Azolla nilotica*. It can be effectively used as a potential feed substitute for livestock. It can be fed to livestock, poultry, and fish. It floats like a small, flat, compact green mass and under ideal conditions, grows exponentially, doubling its biomass in every three days. It is rich in proteins, essential amino acids, vitamins (A, B12, Beta

Azolla pinnata

Azolla caroliniana

Azolla filiculoides

Azolla microphylla

Azolla nilotica

Table 1: Comparison of Azolla with different fodder species

Fodder	Annual production of biomass (t ha-1)	Dry matter content (t ha-1)	Proteincontent (%)
Hybrid Napier	250	50	4
Lucerne	80	16	3.2
Cowpea	35	7	1.4
Sorghum	40	3.2	0.6
Azolla	730	56	20

(Soodet al., 2012)

carotene) and growth promoter intermediaries and minerals like calcium, phosphorus, potassium, ferrous, copper, magnesium etc. Azolla through its symbiotic association with blue green algae, *Anabaena azollae*, helps in atmospheric nitrogen fixation and assimilation. This unique symbiotic relationship makes azolla, a wonderful plant with high protein content. Its cultivation can also help the farmer to reduce the cost of livestock feed supplements.

MAIN ABIOTIC AND BIOTIC FACTORS AFFECTING AZOLLA GROWTH

ABIOTIC FACTORS

The abiotic characteristics influencing the growth of Azolla can be classified into two main categories: structural habitat and physical chemical factors.

STRUCTURAL HABITAT FACTORS

Water: Water is a vital and important factor for the survival of Azolla as this small aquatic fern needs to float on the water surface to stay alive.

Air and water temperature: The optimum temperature for Azolla growth is 25-30°C. Higher temperature leads to pest infestation whereas at low temperature growth is retarded. It prefers to grow in partially shaded conditions.

Light intensity: Light intensity lower than 10-13 Klux will reduce nitrogen fixation in Azolla. When light intensity is high and amount of nutrients in water is low, Azolla will turn red.

Humidity: A relative humidity between 70 and 75% is optimal for Azolla growth.

Growing seasons and day length: The long photoperiods together with optimum temperature support the growth and increases its nitrogen-fixation potential in azolla. Overall production of Azolla is found to be higher in summer season than in other seasons as its growth could be limited by winter death.

Wind and Waves: Wind and waves are not favourable for its growth. Water agitation can break up the fronds. This fragmentation as such can have a negative effect on nitrogen fixation capacity. Therefore, wind and turbulent water can fragment and kill Azolla.

PHYSICAL-CHEMICAL FACTORS

Phosphorus: Phosphorus is an important nutrient to yield a successful and rapid growth of Azolla. If there is enough phosphorus in the aquatic environment, Azolla will be able to grow without the need to provide combined nitrogen such as NH_4NO_3.

Salinity: Azolla is extremely sensitive to NaCl. Salinity drastically decreased biomass production in all 6 species. *Azolla microphylla* showed high tolerance to salinity than other species.

pH: Azolla can grow well in a pH range between 5 and 8.

Macronutrients: Macronutrients like potassium (K+), calcium (Ca2+) and magnesium (Mg2+) are also very important to yield a successful and rapid growth of these species. A good source of macro and micronutrients could be cow manure which is suitable for Azolla growth. Compared to the other nutrients sources, biomass production of Azolla can be increased by providing cow manure to the growth medium.

Micronutrients: Wagner (1997) examined that the threshold levels of the micronutrients such as Fe, Mn, Mo, and B for Azolla growth were 50, 20, 0.3, and 30 μgL-1, respectively.

BIOLOGICAL FACTORS

Macrophytes like *Phragmites* spp and *Typha* spp occupy the shallow part of wetlands. They provide a good opportunity for the distribution of Azolla because Phragmites creates a wind break and shelter to this species. In contrast, insects such as Lepidoptera (caterpillars) and Diptera, as well as Cephalapoda, Crustaceae and snails affect growth of Azolla

by "grazing" on its biomass.

NUTRITIONAL ASSESSMENT OF AZOLLA

CHEMICAL COMPOSITION

The crude protein content of Azolla varies between 15.4 to 27.93%, crude fibre content varies between 9.07-22.25%, on an average the ether extract value for various species varies between 1.60-5.05 % while total ash was in the range of 10.15-36.10% and NFE values were found to vary between 30.08-52.46%. The cell wall composition of Azolla is highly variable depending upon the species and the season of cultivation of Azolla. NDF content of Azolla was found to be in the range of 36.88-70% while ADF was reported to be in range of 25.24-47.08%. Cellulose and hemicelluloses content was found to range between 6.8-36.7% and 10.09 to 17.8% respectively. Lignin was reported to vary between 9.27-28.24% and silica content varies between 4.8- 16% (Chatterjee et al., 2013).

Amio acid composition

In Azolla Leucine, lysine, arginine and valine were the predominant essential amino acids while tryptophan and the sulphur-containing amino acids were deficient. Azolla as rich source of protein with all essential amino acids, including a rich source of lysine, along with arginine and methionine.

MINERAL AND VITAMIN COMPOSITION

Azolla is a rich source of calcium, phosphorous, potassium, ferrous, copper, magnesium and zinc. Calcium content of Azolla varies between 0.8- 4.99 %, while phosphorus between 0.3- 1.3%, Mn-0.27%, Fe - 0.25 %, Mg-0.17%, Na-0.49%, K-4.93%, cu-17.6 ppm, Zinc 71.8 ppm. Lejeune et al.,(2000) reported that on fresh material, the carotene content ranged from 206 to 619 mgkg-1 on a dry matter (DM) basis and differed significantly between strains. Carotene content was maximal during the linear phase of growth and minimal during the stationary phase for the all strains.

AZOLLA CULTIVATION

Azolla can be cultivated in shallow cement tank or pits lined with polyethene sheets. Pits or tanks of convenient length and breadth and 15 cm depth are made. Soil has to be spread with uniform thickness at the bottom of the tank at the rate of 7 kgm-2. Fresh cow dung at the rate of 2.5 kgm-2 has to be made into a slurry and poured uniformly to the soil in the tank. Rajphos or Mussoriphos at rate of 15gm-2 has to be given along with cow dung slurry. Water has to be added to the tank to a depth of 8 cm. Healthy Azolla at the rate of 250 to 500 gm-2 has to be spread uniformly in the tank. Azolla start multiplying after a period of one week.

Azolla cultivation can also be done in partially shaded place on terrace.

- Approximately 50% shade is required
- Polythene sheets of thickness of minimum 150 guage is conducive for making azolla tanks.
- Once start multiplying, 250-450 g of azolla can be harvested daily from one sq. metre area.
- The harvested azolla can be used as feed for livestock.
- Removal of little quantity of water from azolla tank and addition of fresh water, addition of cow dung slurry and phosphorus at the rate of 0.5 kg and 10 g respectively per square meters area of tank are to be done at weekly interval.
- Removal of one fifth of soil and addition of same quantity of fresh soil to the tank has to be done at monthly intervals.
- The whole tank needs to be replaced with new tank once in six months.

Harvesting and Preparing Azolla as Livestock Feed

- Harvest the floating Azolla plants using a plastic tray having holes of 1 cm^2 mesh size to drain the water.
- Wash the Azolla to get rid of the cow dung smell. Washing also helps in separating the small plants which drain out of the tray. The plants along with water in the bucket can be poured back into the original bed.
- Azolla can be fed to the livestock either in fresh or dried form, the fresh Azolla should be mixed with commercial feed in a 1:1 ratio to feed livestock. After a fortnight of feeding on Azolla mixed with concentrate, livestock may be fed with Azolla without added concentration.

AZOLLA AS FEED

Supplementation of good quality protein to milch animal is always challengeable as it increases the cost of milk production. The rare combination of high nutritive value and rapid biomass production make Azolla a potential and effective feed

substitute for livestock. While introducing azolla as feed, the fresh azolla should be mixed with commercial feed in 1:1 ratio. After a fortnight of feeding with azolla mixed with concentrate, livestock may be fed with azolla without added concentrate. It was found that the milk production in cattle increased by 10-12 per cent when they were fed with azolla and there was 20-25 per cent savings on buying commercial feeds. Kololgi et al., (2009) conducted experiment in lactating buffaloes and fed Azolla @ 2 kg / animal/day by replacing 25% concentrate. It has been found that there was 10% increase in milk yield and 0.5% Fat and SNF in milk by feeding Azolla. There was saving of Rs. 6/ animal/day due to 25 % replacement of concentrate by Azolla and additional earning of Rs.9/animal/day due to increase in quantity and quality of milk. There was significant increase in milk production of dairy cows supplemented with fresh Azolla. The milk productivity started to increase after one week of Azolla supplementation, which further increased for next four weeks and thereafter it became constant at increased level. All the treated animals were apparently healthy during the course of supplementation. There was no adverse effect on palatability of azolla mixed feed for animals (Rawat et al., 2015). Azolla, could safely be used for economical raising of the sheep and goats to improve growth as a source of non- conventional creep mixtures. Dried azolla can be incorporated up to 20% of the concentrate mixture of kids without any adverse effect (Tamang, 1993). Azolla can be incorporated up to 30% in the ration of desi pigs without any considerable adverse effect on growth (Parthasarathy, 2006). It has long been recognized as a feed for wildfowl in the USA and for domesticated ducks in China and it has been used as a feed to domestic fowl in Vietnam. By feeding broiler with Azolla, a significant positive effect was seen in total feed intake and total returns (Ramdan, 2021). Azolla could replace about 20% of commercial feed in the diet of young chickens (Ramdan, 2021). Broilers can readily digest the crude fiber in azolla. The nutrient constitution of azolla is almost identical to that of commercial poultry feed. 20–25% of commercial feed could be replaced by supplementing it with fresh azolla and 10-15% increase in egg laying capacity can be achieved by this. (Kumar and Chander, 2017).

CONCLUSION

Azolla is the most promising aquatic plant for livestock feed due to its ease of Azolla cultivation, productivity, and nutritive value. It is very rich in proteins, essential amino acids, vitamins (vitamin A, vitamin B12, Beta Carotene), growth promoter intermediaries, and minerals including calcium, phosphorous, potassium, ferrous, copper, magnesium. Azolla's composition, therefore, makes it one of the most economical and efficient feed substitutes for livestock, particularly as it can be easily digested by livestock due to its high protein and low lignin content. It is popular and cultivated widely in other countries like China, Vietnam, and the Philippines, but has yet to be taken up in India, in a big way. Dairy farmers in South Kerala, Kanyakumari and Northern parts of Karnataka have started to take up the low-cost production technology and hope that the azolla technology will be taken up more widely by dairy farmers, in particular those who have too little land for fodder production.

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Stability of Food flavours During processing

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Flavour is defined as the sum of characteristics of any material taken in the mouth, perceived principally by the sense of taste and smell and also the general, pain and tactile receptors in the mouth, as received and interpreted by the brain (European Council).

Flavor is the entire range of sensations that we perceive when we eat a food or drink a beverage. It encompasses a substance's taste, smell, and any physical traits we perceive in our mouths, such as "heat" (for example, cinnamon) or "cold" (for example, spearmint) (FEMA). Flavourings products are added to food to impart, modify, or enhance the flavour of food (with the exception of flavour enhancers considered as food additives under the Codex).

Important Criteria for Understanding Flavour Stability

- The composition of flavourings
- The raw materials
- The characterisation of the

Types of Flavourings

Type	Description
Flavouring substance	Chemically defined substances either formed by chemical synthesis or obtained from materials of plant or animal origin.
Natural Flavouring Complexes	Preparations that contain flavouring substances obtained by physical processes that may result in unavoidable but unintentional changes in the chemical structure of the flavouring (e.g. distillation and solvent extraction), or by enzymatic or microbiological processes, from material of plant or animal origin.
Thermal Flavouring	Prepared for its flavouring properties by heating raw materials that are foodstuffs or constituents of foodstuffs. This process is analogous to the traditional home cooking of ingredients of plant and animal origin.
Smoke flavouring	Complex mixtures of components of smoke obtained by subjecting untreated wood to pyrolysis in a limited and controlled amount of air, dry distillation or superheated steam, then subjecting the wood smoke to an aqueous extraction system or to distillation, condensation, and separation for collection of the aqueous phase.
Flavour Enhancers	Substances added to supplement, enhance or modify the original taste and aroma in food, without impacting characteristic taste and aroma of its own.
Spices	Any aromatic vegetable substances in the whole, broken or ground form

flavouring.

- How to estimate flavour changes.
- The factors responsible for flavour changes.
- How to prevent flavour changes

The quality attribute of food aroma is influenced by three factors:

1. Chemical reactivity of food flavor
2. Environment of food such as availability of light and atmospheric oxygen and
3. Food matrix system and its constituents such as protein, fat, carbohydrate, transition metal, radical, and other polymers in food such as brown melanoidins formed

during thermal processing of food.

Factors affecting the stability of Flavours

The most important factors influencing stability of flavourings are:

- Heat treatment (evaporation of volatiles, formation of new flavouring components)
- Oxidation (of terpenes, lipids) i.e. A high oxygen concentration will make fat-containing products rancid
- Enzyme activity (degradation and formation of flavouring components)
- Low pH i.e. A low pH, as in most beverages, will help acid-catalysed reactions to occur like hydrolysis of esters in an acid and an alcohol or acid-catalysed rearrangements like citral into p-cymene Fat absorption of liposoluble components
- Protein reactions.

Various Aspects of Flavour stability

Physical stability

- Evaporation of volatile components
- Crystallization of non-soluble material (mainly in liquid flavourings)
- Phase separation (in emulsions)
- Solubility (in fat-containing food)
- Absorption and adsorption effects in complex food systems

Chemical stability:

- Reactions with food components.
- Reactions of Flavouring components through degradation, rearrangement, oxidation.

Sensory stability:

- What is the standard sample to compare with (how is it stored?)
- What does the customer expect and remember.
- How does the customer evaluate the samples

Effect of Packaging on flavour stability

The flavour stability will also be affected by packaging. A classic example here is sun-struck flavour, 3-methyl-2-butene-1-thiol (3-MBT or prenylmercaptan) in beer (Blocksman et al., 2001). In the proposed pathway for 3-MBT formation, hop derived isohumulones are decomposed to 3- methyl-2-butenyl radicals due to sunlight exposure. Sulfur-containing amino acids and proteins decompose to SH radicals through riboflavin-photosensitized reactions. These two radical types then combine and form 3-MBT.

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Tiny flowers of *Cuphea hyssopifolia* entice diverse pollinators an observation at Puttur, Karnataka

Cuphea hyssopifolia an introduction

Cuphea hyssop ifolia Kunth belongs to Lythraceae family. It is commonly known as Mexican heather, false heather, elfin herb and Hawaiian heather. It is native to Mexico. The Latin specific epithet 'hyssopifolia' means "hyssop-leafed", referring to the fine, narrow leaves of that plant (Donn, 1809).

This plant species is evergreen, adaptable to various soils, moderately salt-and heat-tolerant, and grows well with regular watering. It is present in hot, semi-warm and temperate climates between 500 and 2240 meters above sea level (PlantCES, 2022). This plant has gained the Royal Horticultural Society's Award of Garden Merit (AGM, 2020). The plant can be easily multiplied by its cuttings and layerings, and it roots readily in the moist soil medium.

Flowers of *C. hyssopifolia* - floral biology

The plant produces tiny, single and trumpet shaped flowers which are lavender-purple in colour. It flowers throughout the year even during heavy rainy season at Puttur, Karnataka, a region in west-coast Karnataka. The tiny flowers of Cuphea are visited by a large number of insects belonging to many different orders, including insect pests and pollinators throughout the day.Life span of flower is long, and it varies from 17 to 20 days. According to Safriya and Karunaratne (2011), the stigma stays receptive from 8.00 to 11.00 am; anthers dehisce between 8.00 - 8.30 am and pollen is available until 5.00 pm. That study also showed existence of entomophilous syndrome of flower characteristics of *C. hyssopifolia* which facilitates the insect visits to gather its resources and thereby facilitating pollination of its tiny flowers.

Pollinators visiting the flowers of *C. hyssopifolia*

The flowers produced by the plants are found to be attractive to various pollinators including bees, butterflies, hawk moths and humming birds. Pollen and nectar are the two resources obtained by bees and other pollinators upon visit to the flowers of *C. hyssopifolia*.

The bee species noticed on flowers of *C. hyssopifolia* at a small bee park of ICAR-Directorate of Cashew Research,

Indian bee collects nectar

Table 1. Foraging period and relative abundance of pollinators of *C. hyssopifolia*

Pollinator species	Foraging duration	Peak activity period	Relative abundance
Apis cerana indica	8.00 am - 6.00 pm	10.00 am - 1.00 pm & 3.00 - 5.00 pm	47.04
Apis florea	9.00 am -5.30 pm	11.00 am - 1.30 pm & 3.00 - 4.30 pm	14.25
Braunsapis picitarsis	8.30 am-5.00 pm	10.00 am-1.00 pm	18.28
Braunsapis mixta			
Ceratina hieroglyphica	8.30 am-5.00 pm	10.00 am-1.00 pm	13.98
Ceratina binghami		-	0.54
Ceratina sp.1		-	0.81
Butterflies (Pierids)	10.00 am-4.30 pm	-	1.88
Skippers	10.00 am-4.30 pm	-	1.34
Hawk moth	10.00 am-4.30 pm	-	1.08
Syrphids (Paragussp. and others)	10.00 am-4.30 pm	-	0.81

(- Not observed, as their visits was less).

Puttur are Indian honey bee, *Apis cerana indica*, little bee, *Apis florea* and solitary wild bees like *Braunsapis picitarsis, Braunsapis mixta, Ceratina hieroglyphica, Ceratina binghami* etc. Among these bees, *A. cerana indica* was the abundant bee species visiting *Cuphea* flowers followed by *Braunsapis mixta* and *C. hieroglyphica*. Apart from bees, butterflies (especially

Hawk moth visiting flower

Little bee forages on flower

pierids and Lycaenids) and hawk moths, syrphids, skippers also visit the flowers but not as frequent as bees. The rock bees and stingless bees have not visited the flowers of Cuphea, though these bees were observed on few other flora in the bee park.

Among the bees, Indian bees (*A. cerana indica*) were more abundant on Cuphea flowers followed by *Braunsapis spp.* and little bees. But other species including butterflies, skippers, syrphids were less abundant.

Foraging activity of bees

The bees are noticed to move frequently among the flowers from morning till evening. Foraging of the bees especially honey bees, *A.cerana indica* is noticed from morning 8.00 am onwards, depending on the sunshine till 6.00 pm in the evening. Activity of bees are generally less during cloudy days and intermittent rains.

In a single plant, activity of *A. cerana indica*, *A. florea, Braunsapis mixta, Ceratina hieroglyphica* and a Pierid butterfly was noticed at the same time. A total of 10 bees were seen foraging on a single small plant of Cuphea around 11.30 am. Many bees foraged actively on the same plant and the same flower was visited by many pollinators during the observation. Activity of solitary bees was at peak during 10.00 am and 1.00 pm. While honey bees, *A. cerana indica* were noticed throughout the day and peak activity during 10.00 am and 1.00 pm, but less activity during the afternoon hours compared to the morning hours. In general, foraging activities of bees largely dependent on the prevailing environmental conditions, besides food resources such as nectar, pollen and other ecological and crop management measures. Activity of bees was very less during cloudy and rainy days compared to sunny days.

At the bee park of ICAR-DCR, Puttur, most of the pollinators activity was noticed on the flowers of *Antigonon leptopus* and *Cuphea hyssopifolia* compared to any other flora present.

Adult bee collects nectar

Other flowering plants at the bee park consists of plants and weeds, including *Vedalia trilobata*, *Caesalpinia sp.*, *Ixora sp.*, Rangoon creeper, cosmos, *Lantana camara, Alternanthera sessilis, Leucas aspera, Melastoma malabathricum, Hemelia patens, Mussanda roxburgii, Coleus sp., Clerodendrum sp.*etc. which also attracts pollinators.

Conclusion

Cuphea hyssopifolia is an efficient bee friendly flora, the flowers of which attract lot of pollinators including bees and butterflies throughout the year. It is found amenable for easy multiplication and establishment in the field borders, hedges, parks, sides of walkways,in the corridors and even in pots including hanging pots. This plant species can be very well utilized for conservation of honey bees as well as wild bees.

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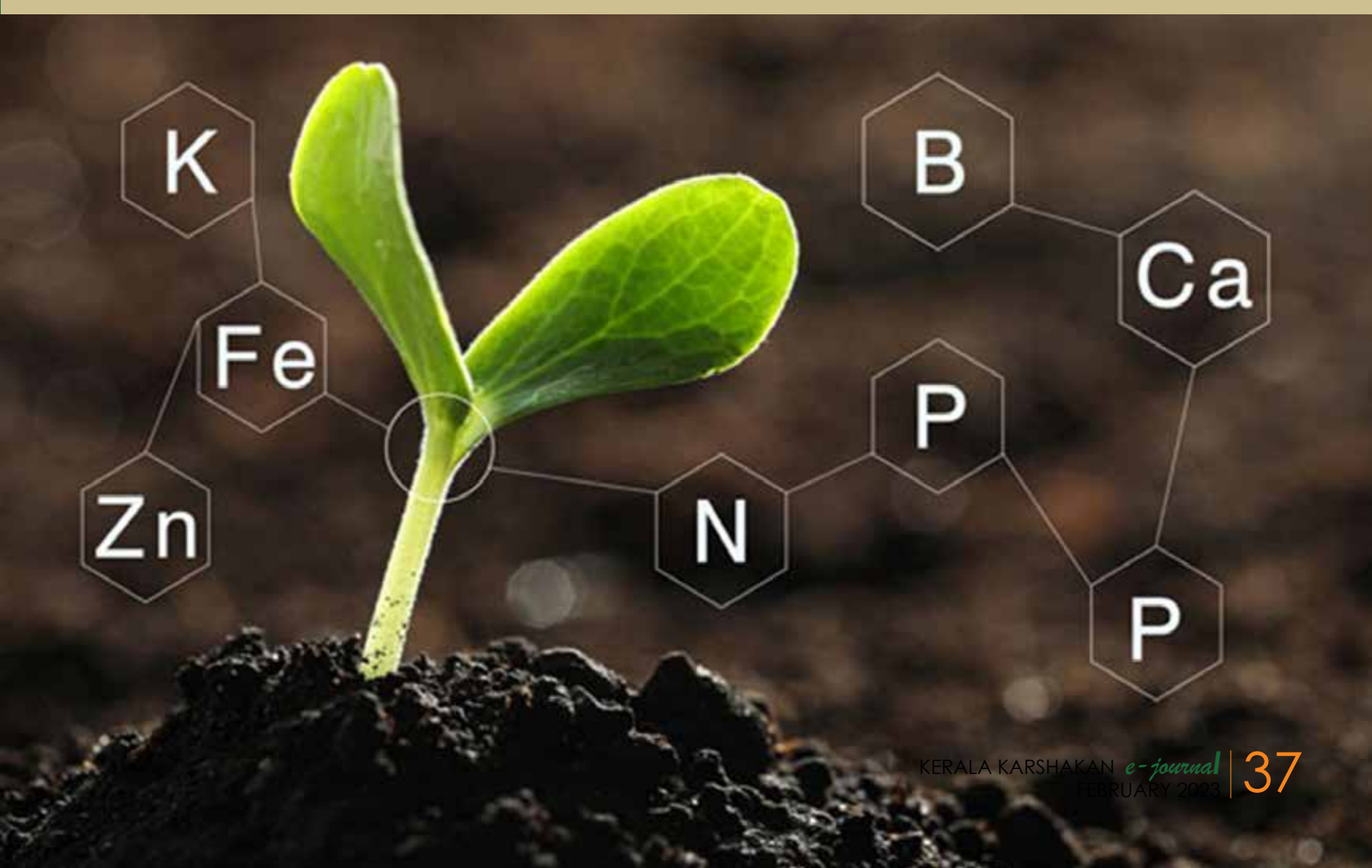
Farmers to be compensated for soil ecosystem services @ Rs. 15000 per ton soil carbon sequestered

Soil organic matter (SOM) comprises approximately 58% soil organic carbon (SOC) and is the basis of all physical, chemical, biological and ecological transformations in soil. It is the reservoir for essential nutrients needed for plant growth and development, such as nitrogen, phosphorus and sulfur and micronutrients, and is one of the major binding agents for soil aggregation. Sir Albert Howard, who worked as agricultural advisor in Indore from 1905 and is considered as father of 'organic agriculture', stated that "the health of soil, plant, animal



Functions of soil in the provision of ecosystem service

Soil fertility	Soil nutrient cycles ensure fertility renewal and delivery of nutrients to plants
Water quality	Water is purified when soils fix and store solutes passing through micro- and macro-aggregates
Structural	Physical support to plants for root development and anchoring
Climate regulation	Through soil carbon sequestration and regulation of greenhouse gas emissions
Biodiversity conservation	Soil provide habitat for diverse biological species and activities that affect soil structure, nutrient cycling and detoxification
Pharmaceutical	Soil microbes are sources of antibiotics
Cultural	Soil is an inspiration to art and culture with spiritual values

and man is one and indivisible". He realized the importance of SOM and recycling biomass to soil quality and productivity though it has been practiced for millennia in India. Kautilya (Chanakya), who was the prime minister of Emperor Chandragupta during 326-301 before Christ, in his book Artha Sastra wrote elaborately about agricultural production and irrigation.

The global soil carbon pool is estimated to be 2500 billion tons of which 1550 billion tons is SOC and 950 billion tons is soil inorganic carbon (SIC). This pool is more than atmospheric pool of 760 billion tons and biotic pool of 560 billion tons (1 billion = 100 crore). On average, the SOC pool to a depth of 1-m is 50-150 tons per hectare. Soil quality and provisioning of essential ecosystem services are determined by soil organic carbon and its dynamics.

Carbon sequestration in soil and vegetation is one of the promising options to mitigate climate change and it has many cobenefits too. Soil carbon sequestration means transfer of atmospheric CO_2 into long-lived pools and storing it securely so that it is not immediately reemitted. Judicious land use and recommended management practices (RMPs) are the two options for soil carbon

sequestration. It is estimated that during the 7800 years of preindustrial and 200+ years of post-industrial agriculture era, the total carbon emission is about 500 billion tons and the historic SOC loss is between 55 and 78 billion tons. Hence it can be assumed that the potential soil carbon sink capacity is 55-78 billion tons and the attainable capacity is 50-66% of the potential capacity. With RMPs, the soil carbon sequestration rate can be maintained up to 150 kg carbon/hectare/year for 20-50 years or until the soil sink capacity is filled. Any management practices that add high amounts of biomass to the soil, cause minimal soil disturbance, conserve soil and water, improve soil structure, enhance activity and species diversity of fauna and strengthen mechanisms of elemental cycling result in soil carbon sequestration. Mulch farming, conservation tillage, agroforestry and diverse cropping systems, cover crops and integrated nutrient management including the use of manure, compost, biosolids, improved grazing and forest management are the common RMPs that lead to soil carbon sequestration.

Ecosystem services are the provisioning, regulating, supporting and cultural functions that soil, water, vegetation and other natural resources provide. The SOC stocks are critical to the provisioning and regulating services that underlie the production of food, fresh water, air quality, erosion prevention, climate regulation, biodiversity and nutrient cycling. Soil management decides its capacity to deliver various ecosystem services needed to assure a sustainable environment.

It may be noted that biochemical transformation of biomass (crop residues, plants and animal wastes) into SOC requires additional nutrients, especially nitrogen, phosphorus and sulfur. Crop residues of cereals have C:N, C:P and C:S ratios of 100:1, 200:1 and 500:1 which are very wide in comparison with that of SOM at 12:1, 50:1 and 70:1 respectively. Without the availability of these essential nutrients, SOC concentration will not increase even with long term addition of crop residues. If we want to increase SOC by one ton/ha into humus, it requires 73, 17 and 11 kg/ha of N, P and S respectively. This means that nutrients are required both for crop production as well as for carbon sequestration which means that there are significant and hidden costs of additional nutrients required for carbon sequestration.

The monetary equivalent of ecosystem services provisioned by unit amount of SOC is known as the societal value of soil carbon. It is a major challenge to assess the monetary value of these services. In comparison, the inherent value of SOC can be estimated as the so called 'hidden cost' of all inputs including crop residues, fertilizers and labour. It is possible to calculate the inherent or societal value of SOC based on the hidden costs of the inputs involved.

Carbon farming is becoming the new agriculture where the carbon sequestered in soil or trees or wetlands can be traded just as any other farm produce.

Alternatively, farmers should be compensated for provisioning of ecosystem services through carbon sequestration in soil or biomass. It is very important to assign appropriate societal value to SOC and we have to develop and implement policies for its judicious management so that we will be able to restore SOC concentration to above 2% in the root zone which is needed for provisioning of essential ecosystem functions such as food and nutrition security, resilience to climate change, water quality and biodiversity.

The SOC is a finite and essential natural capital and it must be used, increased and restored by land use and management systems that create a positive soil or ecosystem carbon budget. This can be achieved by decreasing losses (erosion and decomposition) and increasing input (crop residues, cover cropping and manuring) and RMPs. It is estimated that, on average, the monetary equivalent of the inherent cost or societal value towards the cost of crop residues or biomass and nutrients is about Rs. 15/kg of SOC.

This means that a farmer who sequester 300 kg/ha of SOC, which is the average carbon sequestration rate, through BMPs should be given a compensation for provisioning of ecosystem services at the rate of Rs. 5000/ha or Rs. 15000/ ton of SOC sequestered.

Earthworms the naturalist

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"It may be doubted whether there are many other creatures which have played so important a part in the history of the world." -
Charles Darwin, 1881

Some scientists estimate that there are approximately 1,25,000 earthworms per hectare of moist soil. Earthworms live in deep, dark, long, and narrow tunnels or burrows under the ground. They cannot tolerate heat and sun and so during the summer they come up to the surface only at night. They also leave their burrows when it rains because it is easier for them to move on the wet surface. After a rain you will notice multitudes of earthworms on the surface. The wet ground allows them to move without drying out.

BENEFITS OF EARTHWORMS

Gardeners, farmers, foresters and soil scientists all love the earthworm because of

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the good they do for flowers, crops, and plants and animals of the forest. Earthworms are active animals and feed by bringing organic debris into their burrows from the surface and by eating their way through the soil. The leaf litter (dead leaves and animals) they digest contains nutrients made by plants during photosynthesis and includes calcium, nitrogen, potassium and phosphorus, and organic minerals and nutrients from dead animals. Their excrement, called castings, is deposited on the surface and is rich in nutrients, providing food for other animals and microorganisms. This organic material is then further broken down by microorganisms of the soil, releasing nutrients in a form available for absorption by plants.

In this way, earthworms have helped produce the fertile humus that covers the land. As a result the layers of soil are thoroughly mixed, seeds are covered and enabled to germinate, and over long periods of time stones and other objects on the surface are buried. This process has even buried and preserved ancient buildings. Each year earthworm castings cover each acre with as as much as 18 tons of rich soil. When earthworms die, usually in the dry summer, the organic material making up their bodies is gradually released providing additional nutrients for plants. These minerals are essential to healthy plant growth.

EARTHWORM BURROWS

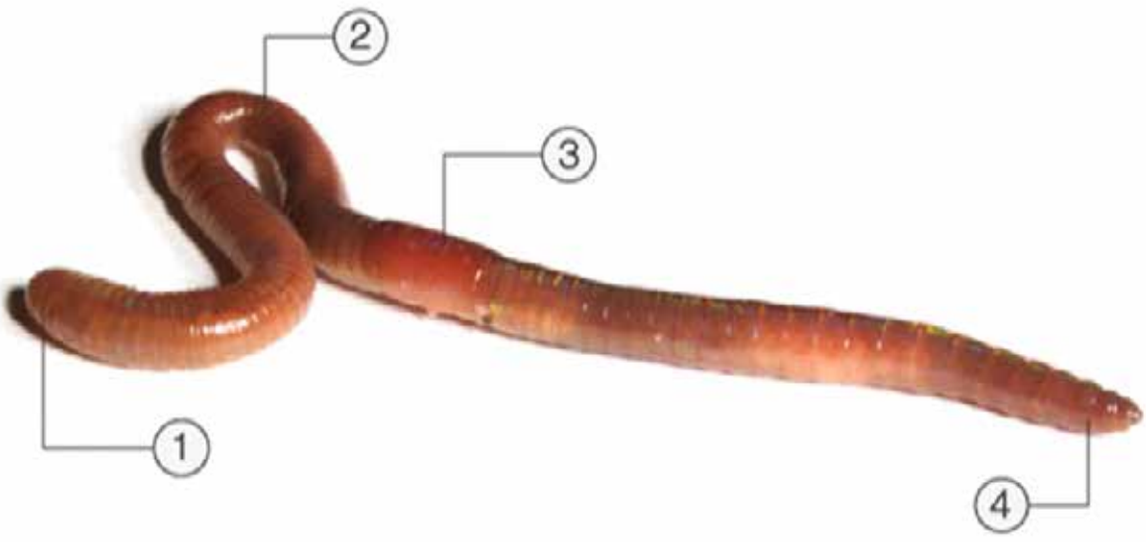
The tunnels earthworms make beneath the topsoil do a tremendous service to the trees and plants above. Their burrowing aerates the soil, which is why earthworms are called "nature's plough". They not only help bring oxygen down into the soil, but their tunnels allow rainwater carrying organic and inorganic nutrients down deep into the soil where the roots lie. The roots then take up the water and the minerals and recycle them back to the herbaceous plants and woody trees.

DESCRIPTION

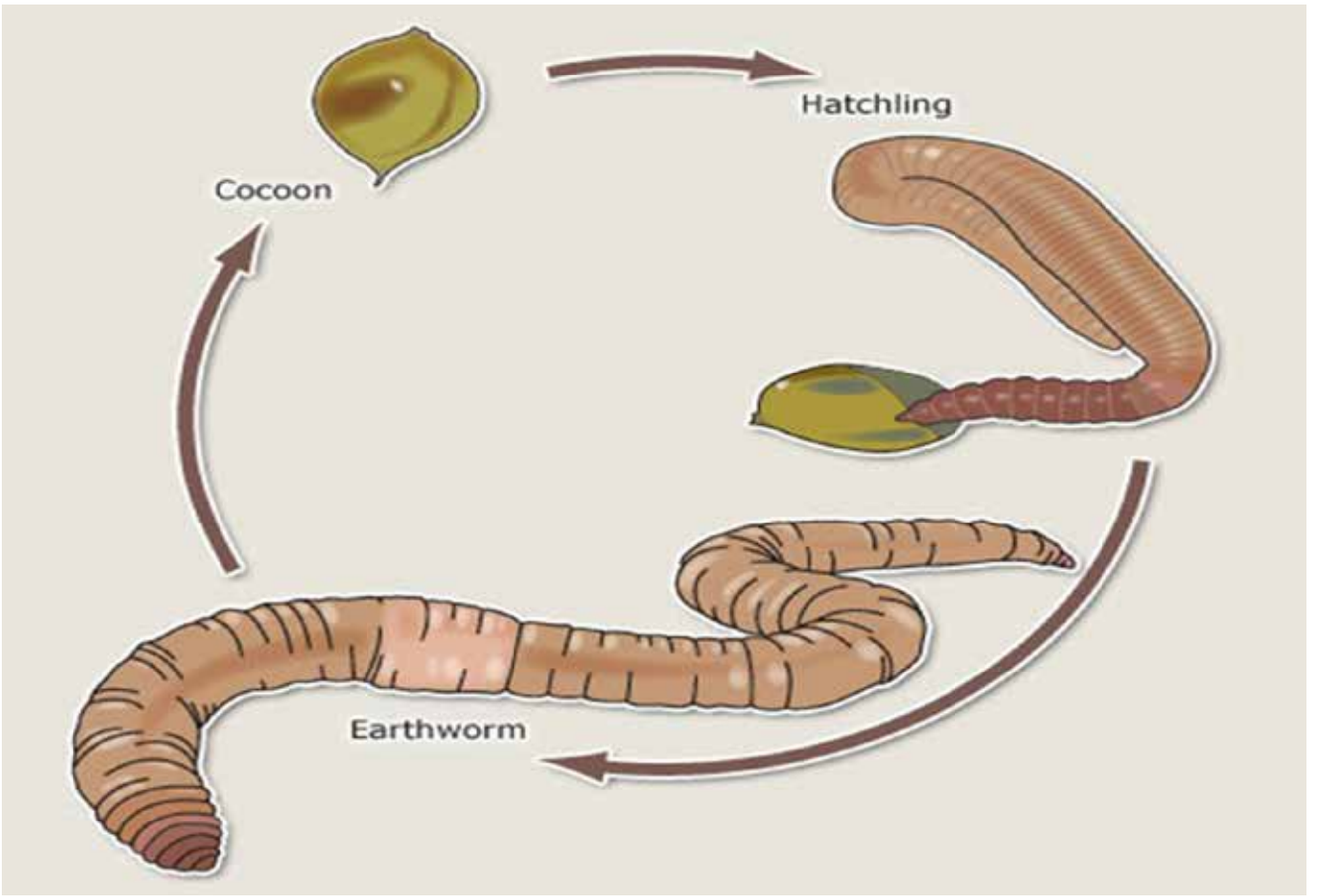
If you watch an earthworm move, you will most likely see it move forward, with its pointy end in the front. This is its mouth and prostomium (area in front of the mouth). There is a concentration of sensory cells at this anterior end around the prostomium. And though it has no eyes, it possesses light sensitive cells and can "sense" light. As mentioned above, it cannot hear, but feels vibrations of animals moving nearby.

The worm's body is

Earthworms, though in appearance a small and despicable link in the chain of nature; yet, If lost would make a lamentable chasm



1 Posterior | 2 Segments | 3 Clitellum | 4 Anterior



divided into 100 or more body segments. As the worm works its way forward, successive peristaltic or contracting waves of thickening and thinning (7-10 per minute) pass down the body. At each place where the body bulges out at a given moment, the bristles, or setae, are extended and grip the burrow walls. Setae, which are not true legs but pairs of bristles attached to each segment, push against the ground with each contraction and help the animal move.

When we try to pull an earthworm out of the ground, the worm uses these bristles to hold on tight to the wall of its home. Sometimes the worm holds on so tight and pulls so hard that the worm comes apart. If a bird pulls off the first 7 or 8 rings of the worm's body, new segments will grow. If a worm is pulled in half, the head end will grow back.

The earthworm has no lungs and takes in oxygen through its moist skin - it is a skin breather. If it dries out it will suffocate. Its skin is covered by mucus-secreting cells. The mucus serves not only in respiratory exchange, but it also lubricates the worm's body and eases passage through the burrow.

The mucus covered skin helps bind soil particles together and prevents the walls of the burrow from collapsing.

LIFE CYCLE

Earthworms are hermaphrodites with both male and female reproductive organs. On warm, moist spring and summer nights, you can often seen hundreds of mating worms coming up out of their burrows. Once they have mated, the girdle like ring around the front of an earthworm, called the clitellum slides along the worm's body, picking up fertilized eggs. When it finally falls off the worm into the soil, it forms a well protected nest or egg case within which the embryo worms develop.

PREDATORS

Because the body of the earthworm is 70% protein, they are a sought after prey by birds, especially Robins, and by burrowing animals like moles. If you watch a Robin hunting, it pauses, cocks its head, then strikes with its bill, pulling a worm from the ground. The Robin, with its keen eyesight, detects the earthworm's movement in the grass.

The earthworm, both sightless and ear-less, can feel the vibrations of the bird on the surface of the ground. Earthworms have some other natural enemies such as ants, centipedes, snakes, toads, carabid beetles and nematodes.

ROLE OF LEGUMES ON WEED SUPPRESSION UNDER MAIZE INTER CROPPING

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Fig. 1 Type of intercropping

Strip intercropping

Relay intercropping

Maize (*Zea mays L.*) is the third most important cereal crop of India and the world after rice and wheat. It has the highest genetic yield potential among cereals, earning the epithet "queen of cereals". It is grown on 9.99 million hectares in India, with a productivity of 3199 kg/ha and a production of 31.64 million tonnes (2020-21). Maize possesses wider adaptability and can be grown from mean sea level (MSL) to 3000 m from MSL. The USA is the highest maize producer followed by China while India ranked 6th in terms of production. However, the productivity of maize in India is slightly more than half of the world's average productivity (5815 kg/ha). The reason behind the poor productivity of maize is due to the unavailability of quality planting material on time, and poor agronomic management. Among different agronomic management practices, weed management is very important. Weed infestation is a serious problem that limits the maize yield as well as its quality. The maize crop is infested with diverse weeds flora; narrow and broad-leaved weeds (BLWs) that cause yield losses from 18-85% or sometimes complete crop failure. It also harbours many insects, pests and diseases.

The critical period of maize-weed competition

Maize is sown at wide spacing and the slow growth during early growth stage allows the weeds to grow easily as compared to other cereals crops. The critical period of maize-weed competition is the most susceptible stage of maize phenology from weeds competition during which crop

Fig.2 Effect of legume intercrop with maize on weed smothering and crop performance

Maize without weeding

Maize with HW at 20, 40 and 75 DAS

Maize + groundnut (2:2, 45/75) with HW at 20 DAS

Maize + cowpea (2:2, 45/75) with HW at 20 DAS

Maize + french bean (2:2, 45/75) with HW at 20 DAS

Maize + rice bean (2:2, 45/75) with HW at 20 DAS

must be weed-free to prevent from yield losses. Studies have shown that the crucial time for maize-weed competition is between 7 and 56 days after seedling emergence.This usually corresponds to 8-10 leaf stages of maize.

Predominant weeds of maize and its chemical control measure

Maize is usually grown in all seasons viz., Kharif, Rabi and Summer. The spectrum of weeds associated with maize varies with season, soil type, cropping systems and their management practices, nutrient and moisture status of the soil etc. During kharif season, maize plant is infested with a number of grassy weeds viz., *Dactyloctenium aegyptium, Cynodon dactylon, Eleusine indica, Panicum spp., Digitaria ciliaris,Fimbristylis miliacea,Echinochloa colona* etc.; BLWs weeds viz., *Phyllanthus niruri, Amaranthus spp., Euphorbia hirta, Portulaca oleracea, Digera arvensis, Trianthema portulacastrum, Eclipta alba, Cleome viscosa, Xanthium strumarium* and *Commelina benghalensis* etc., whereas, *Cyperus rotundus*, *Cyperus iria* and *Cyperus difformis* are common sedges predominant in maize field. To control the above weeds, herbicides such as alachlor @ 1.5-2.5 kg a.i./ha (0-3 DAS), atrazine @ 0.5 kg a.i./ha (0-3 DAS), 2,4-D dimethyl amine salt @ 0.5 kg a.i./ha (pre, post-emergence), 2,4-D sodium salt @1.0 kg a.i./ha (pre, post-emergence), 2,4-D ethyl ester @ 0.9 kg a.i./ha (pre, post-emergence), diuron @ 0.8kg a.i./ha (pre, post-emergence), paraquat @ 0.2-0.5 kg a.i./ha (pre-plant or post-emergence directed inter-row application on weeds of 2-3 leaf stage), tembotrione@ 0.120 kg a.i./ha (post-emergence) and topramezone @ 0.0252kg a.i./ha (post-emergence) are recommended. However, the appropriate selection of herbicides, their quantity and time of application are very important. Apart from this, continuous application of herbicides may increase the change of herbicide resistance in weeds, add to higher production costs, and have a negative impact on soil health, agroecosystem, animals and human health. Therefore, alternative eco-friendly management practices are very important that reduces weed infestation, improvessoil health, agroecosystem and overall system productivity, additionally reducing the cost of production.

Intercropping of legumes with maize

Maize is a wide-spacing crop that allows a high portion of ambient light to penetrate resulting in more weed competition. If such inter-row space of maize could be covered with intercropping with short-duration legumes, it will cover inter-row space and suppress weeds. Intercropping is a multiple-cropping practice that involves growing two or more crops in proximity, which is one of the options for cropping diversification. It can be broadly categorized into strip intercropping, in which crops are cultivated simultaneously in different strips, and relay intercropping, in which second crops are planted by row at a later stage of growth of first crops (Fig. 1).

Benefits of legume intercropping

1. Increases the overall productivity per unit area per unit time
2. Diversifies sources of food, lowers the risk of crop failure and increases food and feed security
3. Efficient utilization of available natural resources
4. Decreasing dependency on herbicides in weed management
5. Improves soil physio-chemical and biological properties
6. Reduces pest and disease incidence
7. Reduces soil erosion

Legumes for weed management under maize intercropping

While selecting legumes for maize intercropping, it should be quick growing - germinating and emerging rapidly, having the potential to produce more biomass in a shorter period and preferably early maturing compared to maize crop. Legumes should be shade tolerant, deep-rooted with high N-fixing capacity, having spatial and temporal differential requirements and need the least management. Generally, most of the legume crop can

be intercropped with maize due to its wider spacing. However, to sustain the productivity of the maize crop, the integration of legumes as intercrops with maize necessitates rearranging the planting patterns through substitutive or additive designs.Some of the suitable combinations are maize + groundnut (2:2), maize + cowpea (2:2), maize + french bean (2:2), maize + rice bean (2:2), maize + soybean (2:2), maize + black/green gram (1:2 or 2:1 or 1:1), maize + red gram (2:1), maize + pea (2:1) etc. However, crop combination and its proportion, and row arrangement may vary with soil types, climatic conditions and other agronomic management practices. The finding from the series of field experiments at ICAR RC NEH Region,Kolasib showed that under maize with legume intercrops viz., cowpea, groundnut, french bean and rice bean (pole type) at 2:2 paired row cropping (45/75) with hand weeding (HW) at 20 DAS resulted in weed smothering efficiency of 45-70% and 35-88% at 60 and 90 DAS, respectively with highest under maize + rice bean (pole type) (Fig. 2). The possible reason behind this is the competitive advantage of legume crops over weeds that have high plant vigour that cover the soil quickly, thus suppressing weed populations. Weed suppression in maize + legume intercropping is given by smothering of weed by physical means and chemically by releasing allelochemicals. Legume intercropping in maize increases competition for light, space, nutrients, and water, which makes intercropping, an effective alternative to control weed growth over sole maize crop.

Selection of the right crop species combination, particularly legumes on predominantly rainfed maize-based intercropping systems (e.g. optimum planting density or row spacing in the uplands)is crucial in enhancing the productivity, food grain vis-à-vis nutritional security of the small farm holdings in Mizoram. The result shows that maize + groundnut (2:2 paired row cropping 45/75) with hand weeding at 20 DAS shows higher grain yield (276% higher than weedy check i.e 1022 kg/ha and 7.8% lower than sole maize with hand weeding at 20, 40 and 75 DAS) and higher system productivity (600% higher than weedy check and 76% higher than sole maize with hand weeding at 20, 40 and 75 DAS). However, all the legumes intercrop with maize perform better than sole maize without hand weeding.

Conclusions

The main goal of intercropping is to prevent intra- or interspecific competition while promoting interspecific compatibility to spur growth and increase yield of both component crops, suppressing weeds associated with the system and conserving the ecosystem. Maize-legume intercropping is very useful in terms of enhancing system productivity, reducing weed infestation, and conserving the environment, soil and biodiversity.

Based on results obtained from the study, it could be inferred that intercropping of maize with legumes viz., cowpea, groundnut, french bean and rice bean provides nearly 50% weed smothering efficiency at different crop growth stages, provides better yield and higher system productivity.

Acknowledgement

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