Department of Agriculture Development & Farmers' Welfare
Farm Information Bureau

Government of Kerala

OCTOBER 2022
VOLUME - 10
ISSUE - 04

KERALA KARSHAKAN

English journal

The First English farm journal from the house of Kerala Karshakan

Kniphofia spp.

A lesser known bulbous ornamental from the foothills of Himalayas

INSIDE KERALA KARSHAKAN

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OCTOBER 2022 Volume - 10 Issue - 04

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Kniphofia spp.

A lesser known bulbous ornamental from the foothills of Himalayas

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Kniphofia spp., commonly known as Torch Lily or Red Hot Poker is a unique bulbous ornamental with attractive red, yellow and orange oval flower head on a long stalk resembling torches. It belongs to the family Asphodelaceae and comprises nearly 17 genus and 750 species. The origin of these species can be traced back to Africa as 70 species are found in Africa and 47 in Eastern Africa. This genus was named in the honor of Johannes Hieronymus Kniphof (1704-1763), who illustrated dried plant specimens of Kniphofia under the name *Aloe uvaria* in his book Botanica in Originali. Though the genus comprises of innumerable species, 72 species names are accepted till date.

Habitat and description

Torch lilies add immense value to a natural landscape and it is well evident in the foothills of Himalayas. It is highly adaptable to hilly terrains and grows well in open sunny areas as well us under partial shades. They are also observed growing near coastal areas and river beds. Both evergreen and deciduous species have been reported. Torch lilies are generally hardy with potential to withstand frost, yet ample water is required during flowering, with less or no fertigation. The leaves are linear, sword shaped quite grassy in some species and fleshy in others. Flowers are spike like racemose on elongated inflorescence with group of stalk less tubular flowers having shades of red, orange, yellow and cream. The plants are hardy, herbaceous perennials which grow from rhizomes. Generally they are propagated by divisions, Even though seed setting is also observed, the delay in flowering and not true to type flowers are produced through seed propagation.

USES

The plants are perfect for perennial beds, the attractive green foliage when planted together creates lush green round the year in the garden. During the peak blooming period either during summer or winter depending upon species, the garden turns highly showy. The unique flower head with solid and gradient colors provides warmth to the garden when back grounded with green foliage. *Kniphofia rooperi* is the most attractive among the species with oval flower head with solid red buds, which gradually turns into gradient of orange and yellow once bloomed. These plants have an extended blooming period on plants, which adds on to their utility. *Kniphofia rooperi* and *Kniphofia laxiflora* is used in indigenous medicine for chest diseases. It can also be used in flower arrangements, but now the details on vase life of the species are limited. It can also be used in foundation planting, rock gardening and xeriscaping. Torch lilies can also contribute significantly towards bio-aesthetic planning as the flower attracts butterflies and birds due to vibrant color and nectar.

CULTIVATION PRACTICES

The literature for its scientific cultivation practices isn't available because the crop is still not exploited commercially. As the crop thrives well in hilly terrain and coastal land, well drained loamy soil with rich humus having near neutral pH is considered optimum for plant growth. Kniphofias are tolerant to wide range of temperature as they survive both temperate and tropical conditions. Plants propagated by division during early spring can be planted at a spacing of 45 cm x 60 cm or wider due to its spreading and clump forming habitat. The plants are hardy in nature therefore sufficient water is well enough for perfect bloom. Apart from regular watering during summer, application of complex fertilizers in minimal

dosage can boost plant growth. No significant pests and diseases affect Kniphofia, but due to the production of nectar ants, thrips and other sucking insects can damage the flower head and also cause mottling on the leaves. It is necessary to remove spent flowering stems and dried leaves from bottom of the plant time to time as it makes the plant look healthy and vigorous.

UTILITY UNDER KERALA CONDITIONS

Torch lilies can come up well in the homestead gardens of Kerala. It can be an excellent component for container gardening and foundation planting. These plants can also grow well in marshy areas; therefore they can supplement the beauty of koi ponds in the garden. It can also be planted along riverside of famous eco tourism centers to amplify the natural landscape and also serve as specimen plant in Botanical gardens. Torch lilies are turning out to be a subject of interest for English gardeners and there are certain hybrids developed in Ireland and England like "Little Maid" (Dwarf Cream) and "Primrose Beauty" (Tall yellow) thus the potential of flower is slowly arising. Interested gardeners can gather rhizomes of indigenous species available in India and exploit its suitability. Further the utility can manifold according to a gardeners imagination, but it can be assuring that this flower can thrive well in the high hills and coastal lands of Kerala thereby redefining the use of bulbous plants in landscaping.

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What are aroids?

- Aroids are the plants from the arum family i.e., Araceae
- It is the family of monocotyledonous flowering plants in which flowers are born in special type of inflorescence called 'spadix' which are enclosed within spathe or modified leaves called as bracts
- Many of the popular collectable plant species in the rain forest

AROIDS

Plants of The Arum Family

Aglaonema

are aroids

- Aroideae is the largest subfamily of Araceae having 72 different genera and 2,300 species

Aroid is the common name for the 3300 plant species which are members of the family Araceae. Aroids include all Philodendron, Anthurium, Alocasia, Spathiphyllum (Peace Lilies), Colocasia, Calla Lily, Caladium, Amorphophallus and many other exquisitely spectacular species. The beautiful and often bizarre combination of ornate foliage with the production of an inflorescence known as a spathe and spadix distinguishes an aroid species. Aroids are among the most loved and frequently grown house plants in the world.

Origin

Aroids are said to be Indigenous to the tropics of America, Southeast Asia, The Malay Archipelago (Malaysia, Indonesia, the Philippines, Papua New Guinea, Singapore, and Brunei) and Tropical Africa.

Classification of Aroids:

i. Based on Habitat

a. Mesophytes
Eg: Amorphophalus
b. Epiphytes
Eg: Monstera
c. Hydrophytes
Eg: *Pistia stratiotes*

ii. Based on Habit

a. Herb
Eg: Anthurium spp.
b. Shrub
Eg: *Aglaonema commutatum*
c. Vine
Eg: *Syngonium podophyllum*

iii. Based on ornamental value

a. Foliage/ pot plant
b. Cut flower

Anthurium

Dieffenbachia

Table 1 : The genus and species of Araceae family with source locations of the collections

Genera	Habitat	No. of species (world)	Source locations of the collections
Aglaonema	Terrestrial	22	Sumatra, Java, Kalimantan, Sulawesi, Maluku, S.E. Asia
Anthurium	Terrestrial	950	Costa Rica, Australia, Peru, Tropical America, Brazil,
Dieffenbachia	Terrestrial	68	Costa Rica, Colombia, Belgia, USA, Singapore, The Netherlands, Brazil
Monstera	Climber	48	Mexico, Polandia, Tropical America
Philodendron	Climber	482	Colombia, England, Brazil, Italy, The Philippines, India,
Pistia	Aquatic	1	Costa Rica, Mexico, Polandia, Venezuela Circum tropical
Pothos	Climber	70	Sumatra, Java, Kalimantan
Spathiphyllum	Terrestrial	49	Sumatra, Java, Sulawesi, Maluku
Syngonium	Climber	34	Mexico

Monstera

Morphology of aroids

Roots

Often mycorrhizal, without root hairs

Stems

- Rhizomatous, cormose, tuberous, or reduced
- Can be aerial, creeping, subterranean, or appressed-climbing
- Frequently scandent, rarely erect, hardened, and armed, or not differentiated into stem or leaf

Leaves - Simple, bifacial, spiral, or distichous, sometimes highly divided or fenestrate (often exhibiting heteroblasty), with parallel, penni-parallel, or netted venation.

Inflorescence - Terminal, many-flowered spadix (with a sterile apical portion in some), usually subtended by a prominent, often colored spathe, or reduced.

Flowers - Small, bisexual or unisexual (female flowers often proximal, and the male distal on a spadix), actinomorphic, sessile, ebracteate,hypogynous, sometimes foul-smelling

Perianth- Biseriate and 2+2 or 3+3 [4+4] or absent,

apotepalous or basally syntepalous, a hypanthium absent

Fruit - Typically a multiple of berries, less often dry, e.g., of utricles

Seeds -Oily (sometimes also starchy) endospermous (rarely endosperm absent) with a sometimes fleshy seed coat

Uses of Aroids:

1. As Ornamental plant – Many spp. of the Araceae have the potential to be developed as ornamental plants due to their remarkable diversity, leaf shapes as well as attractive color of leaves or inflorescence in some spp. Several genera such as Aglonema, Syngonium, Spathiphylum are well known commercially.

2. As Food source - almost all members of Araceae contain oxalate crystals which causes irritation and itching. However, these can be removed by extensive treatment, by slicing them under running water, soak in saline water or burying them in charcoal husk. Eg.,:Colocasia, Xanthosoma spp.

3. As Medicinal plants – The utilization of Araceae for medicinal purpose has long been known. The rhizome and leaves of Alocasia can be used to treat cancer, tumours and snake bites. *Acorus calamus*, Syngonium are having antibacterial and antifungal activity.

4. As air purifiers – Aroids are widely used in interioscaping because of their ability to maintain aesthetically pleasing appearance.

They have the ability

Philodendron

Pistia

to absorb major toxins like benzene, formaldehyde and tricholoroethylene. Eg. Peace lily, ZZ plants and Aglonema spp.

5. As forages.Eg. Alocasia

6. As Essential oil source. Eg. A*corus calamus*

Some other uses includes- in terrariums, in hanging baskets, also in window boxes and table decorations.

Useful Species of the Aroids

1. Acorus calamus L. W

This species is endemic to eastern North America, temperate Asia, and northern Europe. Because of its economic and decorative worth, it is grown in many parts of the world, including the humid tropics. The sweet flag is an attractive plant of marshy ground, well known and cultivated around the world for

its sweet and aromatic rhizome.

2. Alocasia

Alocasia or gigantic taro (*Alocasia macrorrhiza (L.)* Schott) is a tropical ornamental plant that is more well-known than it is as a food source. The spear-like appearance of the leaf laminae and petioles distinguishes it.

3. Anthurium

Anthurium or Flamingo Lily is a herbaceous evergreen plant that grows to 40 cm in height. The dark green leaves are heart-shaped and glossy. The inflorescence is made up of a cream yellow tail-like spadix and waxy red spathe. Several species are popular foliage plants, and a few species are widely grown for the florist trade for their showy long-lasting floral structures.

4. Caladium

A popular ornamental, also called heart of Jesus, angel wings, or elephant ear, this species is a native of Brazil but is grown widely throughout tropical America.Caladiums are non-hardy ornamentals, used as potted plants indoors and in summer outdoor plantings.

5. Colocasia

Colocasia also called eddo or dasheen, herbaceous plant of the arum family (Araceae) and its edible rootlike corm. It is probably native to southeastern Asia.

6. Dieffenbachia

Dumb cane, (*Dieffenbachia seguine*), herbaceous plant of the arum family (Araceae), commonly grown as a houseplant.The plant is prized for its attractive foliage and ability to tolerate low light intensities.

7. Monstera

Monstera genus consists of nearly 50 species of flowering plants of the arum family (Araceae), native to tropical America.

Several are grown as popular ornamental foliage plants. Monstera plants are generally climbing and can be terrestrial or epiphytic. They have

Spathiphyllum

attractive leathery leaves that are often cut into lobes.

8. Philodendron

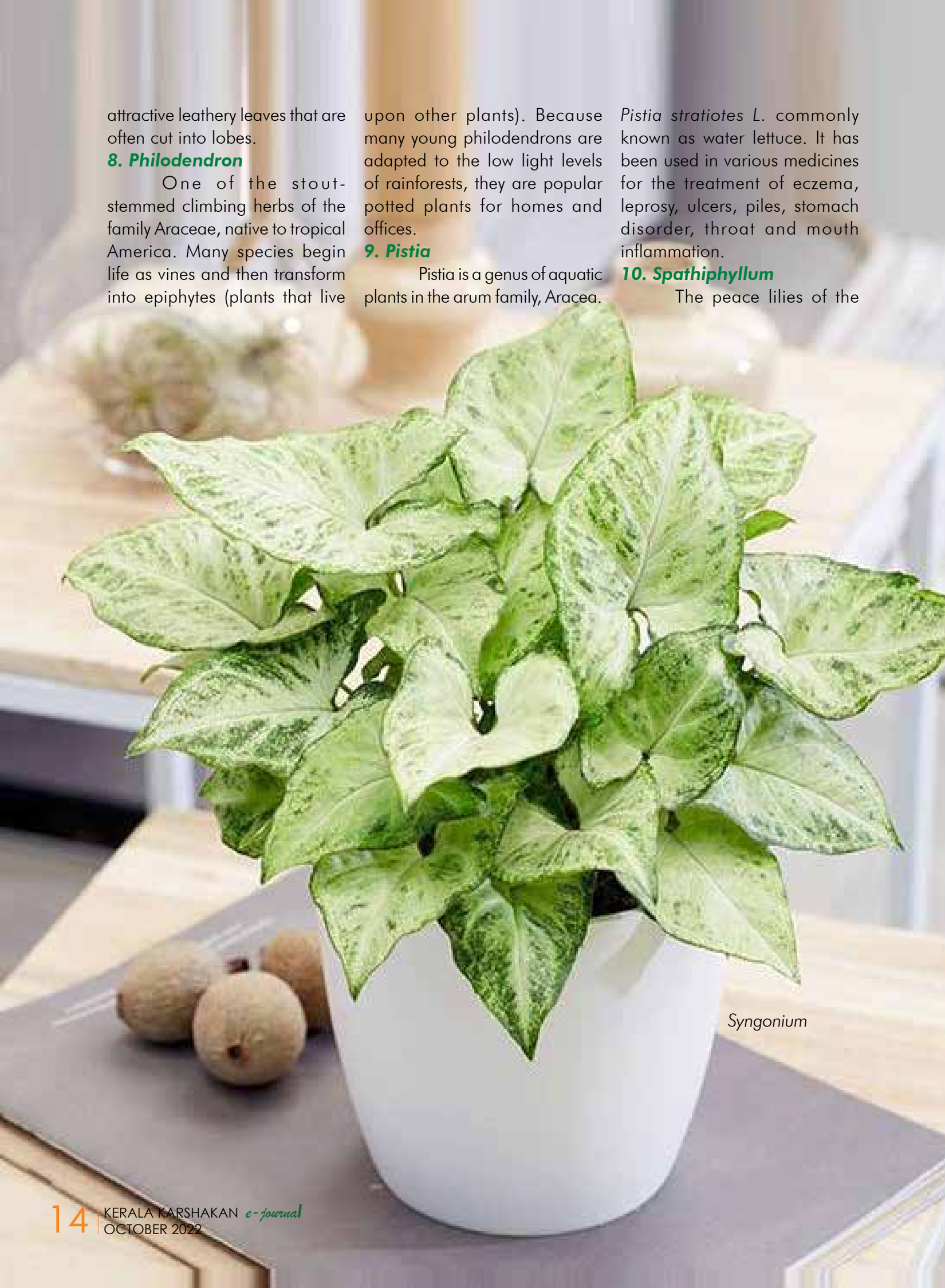
One of the stout-stemmed climbing herbs of the family Araceae, native to tropical America. Many species begin life as vines and then transform into epiphytes (plants that live upon other plants). Because many young philodendrons are adapted to the low light levels of rainforests, they are popular potted plants for homes and offices.

9. Pistia

Pistia is a genus of aquatic plants in the arum family, Aracea. *Pistia stratiotes L.* commonly known as water lettuce. It has been used in various medicines for the treatment of eczema, leprosy, ulcers, piles, stomach disorder, throat and mouth inflammation.

10. Spathiphyllum

The peace lilies of the



Syngonium

Zantedeschia/ Calla lily

genus Spathiphylla, are easy-growing, vigorous tropical herbs forming clumps; they have green foliage and a succession of flowerlike leaves (spathes), usually white.

11. Syngonium

The Syngonium is a popular trailing houseplant with attractive heart-shaped leaves. Also known as the Arrowhead, this sub-tropical plant is versatile and easy to care for, making it an ideal indoor plant at home or office.

12. Zantedeschia/ Calla lily

Zantedeschia species are rhizomatous, herbaceous, perennial flowering plants, native to southern and East Africa. This genus is popular for its striking, upright spathes that form around a solitary, finger-like spadix. Flower colours include white, yellow, orange, pink, red and purple.

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Leatherleaf fern

A WONDERFUL FLORIST'S FERN

Commonly called as leathery shield-fern,iron fern,7-weeks-fern, climbing shield fern, Knysna fern or American leather fern. The greek word "adiantum" (unwettable) referring to fronds ability to shed water. Scientifically leather leaf fern called as *Rumohra adiantiformis* (Forst.) Ching, a species of wood fern belonging to the family Dryopteridaceae. It is a shade loving plant having long symmetrical fronds that are widely used in floral decorations and bouquets.

Distribution

Rumohra adiantiformis is native to South America, the Caribbean, Southern Africa, the Western Indian Ocean islands, Papua New Guinea, and Australasia.

Among the cut foliage crops, leatherleaf fern is majorly preferred, which contributes about highest percentage of sales 41.8% because of long lasting display life (7-21 days), elegant green frond and year round availability.

It is a polymorphic terrestrial fern, which is distributed widely in Australia, South and Central America, Southern Africa and some Indian Ocean islands. In the United States, the leather leaf fern alone accounts for 50 million dollars with Florida accounting for 96% of all production volume, grows in a variety of habitats from bare sandy soil to areas with bushes, in forests, and even on rocks. Commercially grown in Costarica and Central Florida and is shipped worldwide.

Plant morphology

Leather leaf fern is a perennial and evergreen fern, which has triangular-shaped, dark glossy green, medium-textured leaflets arising from a central clump, grows up-to height of 2-3 feet, spread 4-5 feet and the whole plant is divided into rhizome, root and frond.

- **Rhizome:** underground stem, that acts like link between roots which draw moisture and nutrient from

soil

- **Root:** underground aerial division because they contain feathery leaves
- **Mature frond:** fully developed frond
- **Crozier:** is a unfurled frond have circinate vernation called as fiddlehead or crozier
- **Immature frond:** frond just began to unfurl

Parts of frond:

- **Frond:** An entire leaf of fern is called a frond, which is 50-70cm height, width-25-45cm arises from soil without stem
- **Leaf blade:** whole frond other than stipe, 30-47cm
- **Stipe:** The portion of the rachis without pinnae is referred to as the stipe (petiole), 1-2mm wide, 4-8mm long-moderate reddish brown
- **Rachis:** main axis of leaf which is subdivided into further branches
- **Pinna:** primary leaflet of frond, 25-45^0 proximal pinna, 18-28cm length, 10-22cm width, 1-2mm diameter
- **Pinnule:** secondary leaflet of frond, 5-9cm long, 1.5-3cm width
- **Coasta:** main axis of secondary pinna
- Under side of leaf, black dot like structures called as spores. Leaves are oval shape with serrated margins.

Ecological habit

Grows in shady mountains, forest areas, forest margins, as an epiphyte on rotting trunks, on rocks as lithophyte, crevices of rocks as chasmophyte and as terrestrial plant.

Importance and utility:

- **Indoor:** pot plant, hanging basket, terrarium.
- **Outdoor:** window boxes, hedge, edge, ground cover.
- **Display decorations:** vase, bouquets, stage decorations,
- **Dry foliage:** vase decoration.
- **Adornment:** wreath, buttonier, corsage.
- **Industrial application:** soaps, shampoo, oils, perfumes.
- **Cultivars:** Mayfield, Roy Ruth, Baker, Victoria's lace, Fancy fern, Cleopatra.

Production Technology:

Climate and soil: Leather leaf fern produce better quality fronds in clay, sand, loamy and acidic soil with pH: 5.5–6.5 at 20^{0}C day and 15^{0}C night temperature with 75-85% RH.

Light: 15,000-30,000 lux light intensity with PAR of 470-670μmol/m2/min, under polypropylene shade net of 60-80% light exclusion

Propagation: Generally, leatherleaf fern is propagated by dividing the root ball or rhizome and by germinating collected ripe spores.

Spore propagation: Spores are fine dust like particles similar to pollen on underside of fronds. When small capsules turn brown cut the frond and wrap it with smooth paper, after 2 days unwrap and collect the spores. Spread the spores on media. Cover the pot with lid or plastic bag to prevent contamination and to create humidity. It is essential to keep compost moist and in a shady location.

- March and July is the best months for spore propagation
- Media, Leaf mould, peat, coarse sand, loam provide better drainage and sterile media for fern growth.

Rhizome propagation:

- Rhizome 10-15 cm long with 2-3 fully developed fronds are selected
- Raised bed: 10-15cm above ground level, 5-15cm peat and compost are incorporated. Bed width of 1-1.2m, path width - 45-60cm between the beds. Apply super phosphate as a basal dose, pH-5.5-6.5.
- Rhizomes are transplanted at a spacing of 45x45cm, within 3-4month ready for harvesting.

Diseases:

Leatherleaf fern anthracnose - Colletotrichum species, ulcer-like or sunken lesions on leaves and stems visible as tiny, brown, water-soaked lesions on newly infected leaves including those recently emerged from the soil.

Management: Mancozeb and chlorothalonil (Dithane and Daconil/Echo/Thalonil) prevent spores that contact the treated leaf from germinating

and forming germ tubes, thus preventing leaf penetration and infection can be applied at 7 to 10-day intervals.

Rhizoctonia Aerial Blight - *Rhizoctonia solani*, Spots are dark-brown to greyish, covering entire fronds and form web-like mycelium of the pathogen especially in the centre of the plants

Management - Regular harvesting that helps for better aeration of fern bush

Pythium Root Rot - *Pythium spp*, Plants are greyish-green or chlorotic in colour and may wilt Roots are brown, mushy and stunted growth

Management - Chlorothalonil+fluoxastrobin, providing better drainage facility.

Cylindrocladium Leaf Spot- *Cylindrocladium pteridis*, Spots are pinpoint to inch long and are reddish to greyish brown.

Management - Benzimidazole and triazole group

Fern distortion syndrome:

- Endophytic fluorescent pseudomonas
- Fronds become unmarketable
- July to November.

Symptoms: Bending of frond tip or twisting of the frond rachis, uneven sporulation, red and yellow streaks on upper and lower surface, necrosis at cruiser stage finally results in loss of triangular shape of frond

Management: benlate, chlorothalonil, use of diseased free planting material

Pests:

Leather-leaf spore-eater: *Calicotis crucifera* form webbing tunnels underside of leaves

Other minor pests- mealy bugs, scales, snails and slug, aphids

Management: neem powder, neem oil at 7-8 days interval, emamectin benzoate, acephate, carbaryl, imidachloprid.

Harvesting:

The fern grows densely and produces large fronds on moist, well-drained sites. Numbers of frond buds peak during spring and mature utilizable fronds in late summer. Growth rates for frond development stages varied with season. The period from the bud stage to mature utilizable fronds averaged 16 weeks. The mature stage lasts 18 weeks during summer. Picking of all mature fronds on a 22- week cycle.

- Harvest with mechanical clippers that are glossy and dark green fronds anytime during the year except spring, when new growth is tender and easily injured, and in late summer when underside of leaves is covered with rusty brown dust coming from million spore sacs along the edges of leaflets. Avoid picking discoloured fronds that are insect and disease damaged. Avoid removing more than 1/4th of leaves of any plant as it causes stunted growth.

Yield: Annual yield of average over a million leaves per ha.

Post-harvest handling:

- Leaf bunches are dipped in ice water to accelerate cooling prior to packing.
- Water, mineral oil and surfactant to clean and to extend vase life. Harvested fronds are generally durable but, at times, may be prone to rapid desiccation and short vase life. Oil-based products are being marketed that are designed to prolong frond vase life by reducing transpiration. In some cases, they may also improve the appearance of the foliage by covering frond surfaces with a shiny coating that increases glossiness.

Grading:

- Avoid wilted or yellow fronds. Fronds with minor irregularities in shape fall into a lower quality and price grade.
- Severe sporulation and moderate to severe distortions are discarded as culls.
- Typically fronds are bunched in 25's. There are no formal grade standards, but frond length, and freedom from damage or blemishes are obvious quality criteria.

Packing:

Packed in CFC boxes in wax-impregnated cartons lined with polyethylene for long distance transport.

Storage: Leatherleaf fern should be stored at 1-6°C and transported at 4^0C temperature. After being cut, the fronds can be

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MAPLE SYRUP

BETTER ALTERNATIVE FOR SUGAR

Maple syrup is a syrup usually made from the xylem sap of sugar maple, red maple or black maple trees, although it can also be made from other maple species. In cold climates, these trees store starch in their trunks and roots before winter; the starch is then converted to sugar that rises in the sap in late winter and early spring. Maple trees are tapped by drilling holes into their trunks and collecting

the sap, which is processed by heating to evaporate much of the water, leaving the concentrated syrup. Because of the large concentration factor (40 gal of sap are required to produce 1 gal of syrup) and often delicate flavour profiles involved, several off-flavours are commonly found.

Maple syrup was first made and used by the indigenous peoples of North America. The practice was adopted by European settlers, who gradually changed production methods. Technological improvements in the 1970s further refined syrup processing. Virtually all of the world's maple syrup is produced in Canada and the United States. The Canadian province of Quebec is the largest producer, responsible for 70 percent of the world's output; Canadian exports of maple syrup in 2016 were C$487 million (about US$360 million), with Quebec accounting for some 90 percent of this total. Maple syrup is often used as a condiment for pancakes, waffles, French toast, oatmeal or porridge. It is also used as an ingredient in baking and as a sweetener or flavouring agent. Culinary experts have praised its unique flavour, although the chemistry responsible is not fully understood.

HISTORY

Several different legends describe how Native Americans discovered that the sap of maple trees was sweet and could be boiled down to form maple sugar (Heiligmannet al., 2006). The most likely explanation is that they observed birds and animals cutting holes or gashes into the twigs of trees or drops of sap falling after branch breakage by snow or wind. These small wounds ooze sap in the spring, forming small drops of sap that are concentrated by the sun and wind or form sweet icicles of sap. The Native Americans undoubtedly recognized this and collected sap by cutting slashes in the trunks of maple trees and used skins, hollowed wooden vessels or clay pots

to collect the sap, which was then concentrated by boiling to form a very dark and strong-tasting sugar. At certain times of the year, maple sugar could comprise a significant portion of their total caloric intake.

Early colonists throughout New England took up the practice of making maple sugar due to the high cost of imported sugars and because the practice occurs at a time of year when other agricultural endeavours are not possible. Spouts made of hollowed out stem sections of elder or sumac twigs were inserted into holes cut in the trunks of maple trees with chisels. Later, metal spouts were produced and used in holes drilled with augers. Sap was first collected into hollowed-out tree trunks, then later wooden or metal buckets. In most cases, the final product was maple sugar (a solid) and only a relatively small amount of maple syrup (liquid) was produced.

Over the next few hundred years, the practice of tapping trees and collecting sap changed considerably. While some maple producers continue to use metal spouts and metal buckets to collect sap, plastic spouts and tubing are now relatively common. Some experimentation with metal tubing began in the late-1800s and early-1900s, however, the first successful commercial tubing systems arose in the 1950s and early-1960s with the introduction of plastic (PVC) tubing and associated plastic (Nylon) spouts and fittings to collect and transport sap to a central location, greatly reducing the labour required to collect sap. Initially tubing systems were run across the ground and vented, but continued experimentation and use resulted in tubing lines being suspended, unvented and a drop line introduced to reduce reabsorption of sap by trees further down the line in the collection system. Shortly after tubing came into use, some researchers and producers began attempting to augment sap yield by applying vacuum to the tubing systems. The early results were encouraging, but maple sap yield was greatly bolstered with the advent of a new generation of tubing composed of polyethylene, along with associated changes in spouts and fittings and increased use of vacuum pumps designed for maple applications in the

Sugar vs Maple syrup

99.8 mg	Sugars	60.46 g
0.019 mg	Vitamin B2	1.27 mg
1 mg	Calcium	102 mg
2 mg	Potassium	212 mg
0.01 mg	Zinc	1.47 mg
0.004 mg	Manganese	2.908 mg
0 mg	Magnesium	21 mg

mid-1990s. The end result is that current high-yield production methods can achieve sometimes double or more the standard yield from buckets or gravity (nonvacuum) tubing installations.

The processing of sap into maple syrup has also changed greatly from colonial days. Early settlers used a batch method to boil sap in large kettles over open fires. This required a very long time and huge quantities of wood to produce a very dark and strong-tasting maple sugar with a moderate to substantial load of impurities. Modern maple evaporators provide relatively continuous processing of sap, are very energy efficient and generally produce a much lighter-coloured and lighter-flavoured maple syrup fairly quickly.

In addition to changes in collection and processing, the product itself has also changed. Presently, most maple is made into and marketed as syrup (liquid), with much smaller sales of maple sugar, cream or candy than was historically the case.

MAPLE SAP FLOW

Under the appropriate conditions, a sweet sap can be collected from most maple (Acer) species. In general, however, only the sap of sugar, black and red maple is commonly used to make maple syrup. Where maple trees are found in abundance and weather conditions are appropriate, commercial maple production can occur. This ranges from Nova Scotia to Minnesota from east to west and from southern Ontario and Quebec in the north to areas of West Virginia in the south (Heiligmann et al., 2006). Boxelder is sometimes tapped in areas of Manitoba and the Pacific northwest.

The physiological process responsible for sap flow in maple trees probably results from a combination of physical and osmotic forces (Cirelli et al., 2008; Milburn and O'Mally, 1984; Tyree, 1983). In the physical model, fluctuations in wood temperature that span the freezing point during the leafless period (fall or spring) create alternating negative and positive pressures within the trunk and branches. When wood temperature falls below freezing, the water vapor within the billions of air-filled lumen of fibre cells freezes, forming a frost-like layer on the inside of the cell wall. Since the vapor pressure is much lower over ice than liquid water, this, and to a much lesser degree the contraction of the air bubble, create a vapor pressure gradient, causing water to move apoplastically (along cell walls) into the lumen, where it continues to freeze. Due to strong cohesion and the vapor pressure gradient, water is pulled up through vessel elements towards the lumen. Eventually, the entire wood (fibres and vessel elements) and sap freezes. Freezing occurs first in the fine branches in the crown of the tree, then progressively downward. The amount of water uptake is dictated by soil water availability and the rate of freezing. A slow freeze ensures maximum uptake, whereas in a rapid freeze vessel elements in the stem of the tree may freeze before water uptake is complete.

During the warming phase, as the wood increases in temperature above the freezing point, the frost layer thaws and the gas bubble expands. Sap pressure at the stem level increases very rapidly to a peak pressure, which is largely caused by gravitational potential and somewhat also by gas bubble expansion. This pressure may reach up to 40 psi (275 kPa). Over time, the pressure slowly recedes as sap is forced out of small wounds or into other areas of the tree, until the pressure within the tree equals the air pressure outside the tree, at

which point flow ceases. The flow rate and total yield from tapholes is proportional to tree size and to the pressure gradient, thus sap flows faster earlier in a ''run'' than later. Root pressure is not a significant factor in maple sap exudation.

Recent evidence (Cirelliet al., 2008) clearly demonstrates that there is also a considerable osmotic component to the development of sap pressure in maple due to anatomical barriers to sucrose between the vessel system and fibres. Further work is necessary to determine the precise contribution of physical and osmotic factors on sap exudation.

Maple producers exploit the sap flow phenomenon during the time of year when temperatures are expected to fluctuate around the freezing point by drilling small holes into the stem, inserting spouts

and collecting the sap in some fashion. Only trees that have reached a certain diameter (10–12 in. at breast height) are generally tapped. This ensures that the tree will be able to withstand the stress of tapping and regrow sufficient wood during the growing season to compensate for the loss due to tapping and the accompanying zone of discoloration (walling off, a normal wound response in trees to limit microbial infection). Sap will typically only +0flow for 1–2 months before microbial contamination of the taphole, or the lack of proper flow conditions (freeze–thaw) cause the flow to cease. In general, each taphole will produce about 10–20 gal of sap during the season, depending upon the collection technology employed, the environmental conditions during the season, and the size and sap sugar content of the tree.

Although sap will flow in both the fall and spring of the year, the vast majority of maple production occurs in the spring for several reasons. Sap in the spring is sweeter than in the fall, and decreasing temperatures as the season progresses from fall to winter can cause damage to equipment (split bags and buckets due to frozen sap) and frost-heaving of spouts out of tapholes. Trees should also not be tapped more than once per year.

Sap sugar content is not high at all times of the year. There is a strong seasonal pattern of production, accumulation, and utilization of non-structural carbohydrate forms in maple. Starch, the dominant form of reserve carbohydrate in sugar maple, tends to be quite low during the photosynthetic period, and accumulates in the stem and twig wood towards the end of the growing season. Soluble sugars tend to increase during the winter and early spring as a function of temperature (Cortes and Sinclair, 1965). Sucrose is clearly the dominant soluble sugar in the xylem, with only minor amounts of glucose and fructose. Still lesser amounts of stachyose, raffinose and xylose are also present (Wong et al., 2003).

Maple Syrup

- It is sweet and flavourful
- Gluten free, dairy free, vegan and paleo friendly
- Low glycaemic index sweetener compared to others
- Maple syrup allergy is relatively rare
- Pure maple syrup is free from most common allergens
- It is versatile, can be used in baking, savory recipes, smoothies and speciality cocktails

Health benefits of maple syrup

- Helps weight control
- Fights free radicals
- Boosts immune system
- Enhance liver function
- Rich in essential nutrients such as magnesium, calcium, riboflavin and zinc
- Protects against various cardiovascular diseases
- It is rich in antioxidants and anti-inflammatory properties

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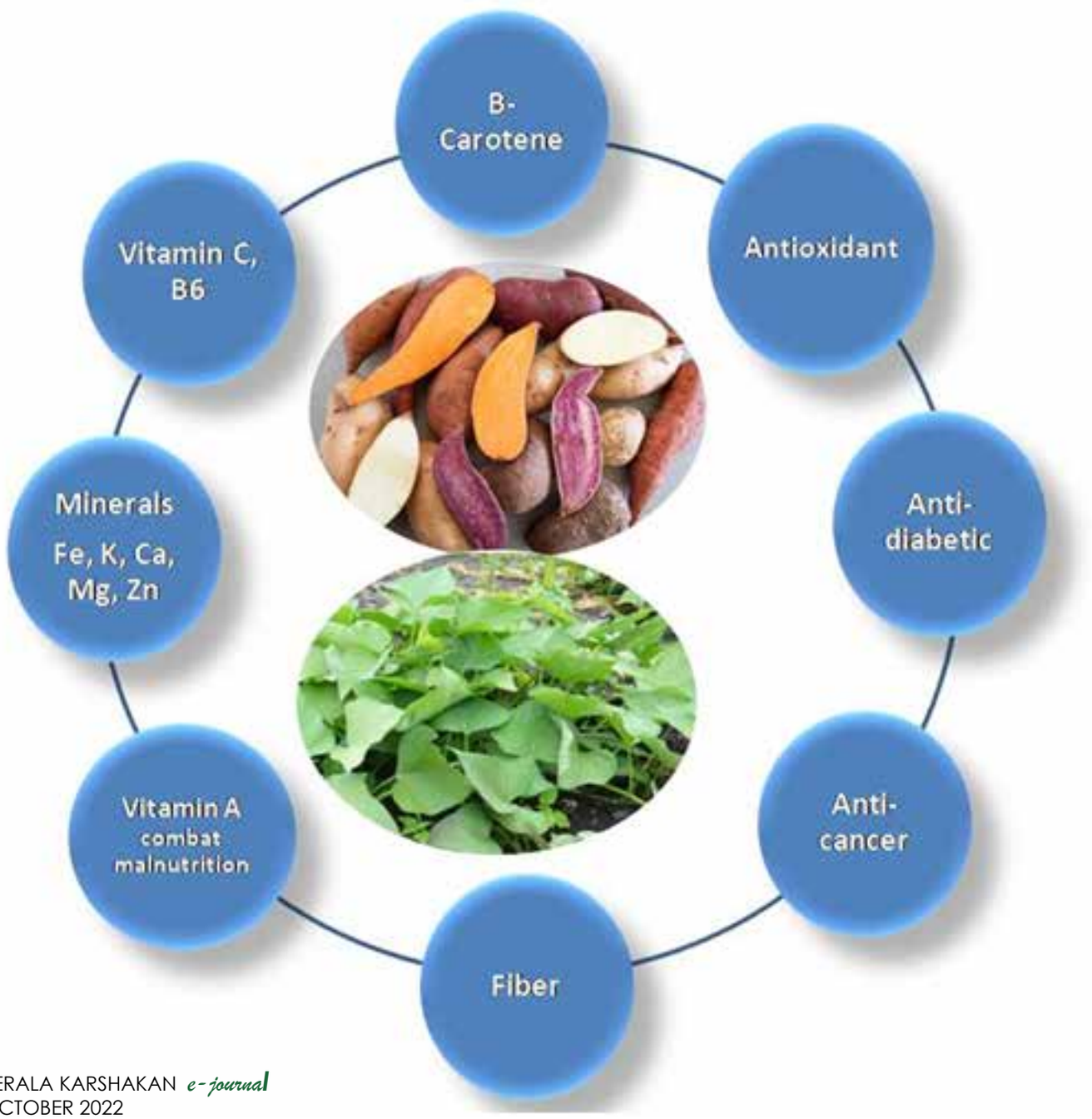
Sweet potato

HEALTH BENEFITS AND ANTIOXIDANTS

"Tell me what you eat and I will tell you what you are" is a statement that defines the relationship between human wellbeing and food. Thrive for good health; maintenance is one of the key driving factors in humans as the individual and scientific community. The fast phase modern lifestyle is accompanied by junk foods, stress, and a lack of essential nutrients in the diet resulting in various health problems along with novel disorders. Antioxidants are substances that may prevent or protect cells from the damage caused by free radicals. Free radicals are molecules with unpaired electrons that are highly unstable and chemically reactive. Reactive Oxygen Species (ROS), reactive nitrogen species (RNS) and reactive sulfur species (RSS) are generated in our body by various endogenous systems and exposure to different physicochemical conditions which have both deleterious and beneficial effects. In excess, free radicals can alter the cell membranes, DNA, RNA and other structures such as proteins, sugars, lipids, lipoproteins, etc. (Lu et al., 2010; Shadel and Horvath, 2015). Free radicals play a crucial role in cancer, heart-



related diseases, gastrointestinal dysfunctions, cancer, hypertension, neurodegenerative diseases (Alzheimer's disease and Parkinson's disease), and other diseases of aging.

Antioxidants scavenge the effects of free radicals by donating electrons to free radicals, thereby reducing their reactivity and helping to prevent degenerative diseases. Antioxidants are abundant in fruits and vegetables. Antioxidants include beta-carotene, anthocyanin, lycopene, vitamins A, C, and E, etc., which are found in many foods, including fruits and vegetables like sweet potatoes, carrots, tomatoes, squash, apricots, pumpkin and mangoes. Among different antioxidant compounds, polyphenols are the most abundant antioxidants in the diet and are found in plant products (fruits, vegetables, cereals, chocolate and beverages). This article is focused on the potential of sweet potato as an antioxidant rich tuber crop to fight several non-communicable diseases.

Sweet potato (*Ipomoea batatas*) is a starchy, sweet-tasting root vegetable mostly harvested for its tubers. The tubers are generally characterized by different flesh colors including white, purple or orange depending on the variety. Sweet potatoes originated in Central and South America but are now being cultivated in more than 100 countries including China, Indonesia, Vietnam, Japan, India, Tanzania and Uganda for its nutritional and industrial properties (Hijmans et al., 1999). It is the sixth most important food crop and chief carbohydrate source in the world and staple food source. Sweet potato yields maximum and better quality roots on a well-drained, sandy or silt loam soil with good soil aeration (Verma, 2014; Laurie and Niederwieser, 2004).

Sweet potatoes are a rich source of complex carbohydrates, dietary fiber, beta carotene and mineral nutrients such as zinc, potassium, sodium, thiamine, riboflavin, calcium, iron, vitamins A and C, manganese, calcium, magnesium and iron (Grace et al., 2014). The free radical scavenging activity of sweet potato leaves and tubers was reported in several studies (Ji et al., 2015; Tang et al., 2015). The antioxidant properties in sweet potato varieties possess potential use of pharmaceutical values including anti-oxidation, anti-tumor and prevention and treatment of cardiovascular diseases.

Orange sweet potato varieties have higher beta carotene which can be used to combat vitamin A deficiencies. Consumption of boiled and mashed β-carotene-rich orange-fleshed sweet potatoes improved the vitamin A status of children aged between 5 and 10 years (Van Jaarsveld et al., 2005). It was also reported that taking orange-fleshed sweet potato (~100g) can fulfill a child's daily requirement of vitamin A (Low, 2013).

The purple-fleshed sweet potatoes possess a high amount of anthocyanins which contribute to its antioxidant activity, anti-inflammatory and immunity boosting activities which may be able to lower the potential health risk posed by heavy metals and oxygen radicals (Ishida et al., 2000). Sweet potato showed 42.94% of total antioxidant capacity when compared to ascorbic acid (Pochapski et al 2011).

A team of scientists was awarded the World Food Prize (2016) for developing biofortified sweet potato towards fighting malnutrition in children, enhancing the nutrition and health. In India several biofortified sweet potato varieties (orange and purple fleshed) viz., Bhu Sona, Sree Kanaka and Bhu Krishna have been released by ICAR-Central Tuber Crops Research Institute (CTCRI). ICAR-CTCRI has also designed biofortified tuber crops variety scaling up program including sweet potato, viz. 'Rainbow Diet Campaign' to address vitamin A deficiency in various states (Tengli et al., 2021).

Enhanced antioxidant properties (total contents of phenolics and flavonoids as well as antioxidant activity) in sweet potato flour were observed under gastrointestinal pH conditions suggesting its possible role in vivo digestive process (Chan et al 2012). An invitro study showed that sweet potato dietary fibers showed a potential prebiotic effect with a significant increase in the concentrations of *Bifidobacterium* sp and *Lactobacillus sp* and a healthy gastrointestinal tract (Lie et al., 2020).

Sweet potato can be a potential source for developing unique natural products, as well as an ideal candidate crop in several applications such as dietary and therapeutic interventions to fight the onset of NCDs. Moreover, colored sweet potato tubers can be used as novel sources of natural colorants and as an alternative to synthetic dyes (Teow et al., 2007; Giri et al 2020). Biofortified sweet potatoes are an ideal natural resource packed with multiple health benefits with minimal production cost. However, the lower yield from sweet potato biofortified varieties is a bigger concern among the tuber crops growing community to accept as commercial industrial crop. Hence, it is important to advance breeding programs for the development of more biofortified sweet potato varieties with higher yields and improved nutritional attributes.

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Bee Pollinators Of
Cashew Flowers
Recorded At Puttur, Karnataka

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Introduction

Cashew is an export oriented edible tree nut crop, grown in several regions of the country. Production of cashew is hampered by several biotic as well as abiotic factors. Inadequate pollination could be a prime factor for poor nut set and yield. Though cashew is andro- monoecious (male and hermaphrodite flowers are present in same inflorescence), it is a cross pollinated crop because of the arrangement of stamens and style in a flower. Pollen grains of cashew are sticky in nature; thus wind cannot be a pollinating agent for cashew. Thus,it requires insects especially bees for pollination. Anthesis of cashew flowers occurs between 9.00 am and 2.00 pm depending on the sun shine and over 80 per cent of the perfect flowers remain open between 10.00 am and 12.00 N. Peak period of anther dehiscence occurs between 9.30

Apis cerana indica F.

Apis florea

Braunsapis spp.

***Ceratina binghami* Cockerell**

and 11.30 hours. The viability of pollen grains of staminate and perfect flowers is high. Stigma becomes receptive one day prior to anthesis and retains its receptivity for two days.

Though cashew flowers profusely, only less than 10 % are hermaphrodite flowers in majority of genotypes and only 4-6% of hermaphrodite flowers set fruits, and the remaining shed away may be due to physiological reasons or other biotic factors. Insect visitors documented on cashew flowers at ICAR-DCR, Puttur include 40 species belonging to Hymenoptera, Coleoptera and Lepidoptera. But, bees are the important pollinators of cashew flowers. Bees include both honey bees and wild bees. Honey bees comprise *Apis dorsata, Apis cerana indica, Apis florea* and stingless bees, *Tetragonula irridipennis*. Among the wild bees, *Braunsapis spp., Ceratina spp., Pseudapis oxybeloides, Lasio glossum sp., Seledonia sp.* are common on cashew flowers. Ants are abundant on cashew flowers, but their role as pollinators is narrow and not still clearly understood.

Common bee species recorded on cashew at Puttur, Karnataka

***Apis cerana indica F.* (Apidae: Hymenoptera) (Indian bee/ Asian bee)**

Adult bee is black in colour with four yellow abdominal stripes. These bees are larger than *A. florea,* but smaller than *A. mellifera*.

It is a common bee species visiting cashew flowers. Its activity can be noticed from early morning (8.00 am onwards depending on sun shine) till 6.00 pm. Its main foraging reward is nectar.

***Apis florea* (Apidae: Hymenoptera) (Little bee / Dwarf honey bee)**

It builds a single-comb nest, smaller, vertical, in branches of bushes, hedges, buildings, caves, empty cases etc. Their nests are small, often not larger than 150-200 cm wide. This species visits cashew flowers from early morning to afternoon hours, but mainly for nectar.

***Tetra gonula sp.* (Apidae: Hymenoptera) (Stingless bees/ Dammer bees)**

These bees are the smallest of the honey-yielding bees.The entire body is black to blackish-brown. These bees build irregular combs of wax and resinous substances in crevices and hollow tree trunks. It visits cashew early in the morning and forages till evening. They collect lot of pollen grains on flowers, but also forage on leaves, inflorescences, developing nuts and fruits mostly for extra floral nectarines.

***Apis dorsata Fab.* (Apidae: Hymenoptera) (Rock bee/ Giant honey bee**

It builds a single, large,

exposed comb under tree branches, high hedges, under cliffs, rather than in cavities. They are highly ferocious. Its visits are rare on cashew flowers.

Brauns apis spp. (B. mixta and *B.picitarsis*) (Apidae: Hymenoptera)

Braunsapis bees are quite lean and black, and less than 1 cm in length. These species are solitary and nest in stems and twigs, preferably pithy stems including cashew. These tiny bees forage on cashew flowers

by its characteristic short vibrant movements. Females have a sting, but they are not aggressive and sting only if handled. These bees are more common on cashew flowers in Puttur region.

Ceratina hieroglyphica Smith (Apidae: Hymenoptera): Small carpenter bee

C. hieroglyphica is also a predominant bee species visiting cashew flowers in Puttur region of Karnataka. It is a stem nesting bee; black in colour with yellow strips. It collects lot of pollen grains to feed its larva.

Ceratina binghami Cockerell (Apidae: Hymenoptera)

This species is slightly more bluish or bright metallic green in colour. The bees nest in dried cashew stems, hollow reeds and thatch, excavate tunnels in dried pithy branches of trees to make its nest.

Pseudapis spp. (Halictidae: Hymenoptera)

There are two species of Pseudapis recorded on cashew. These are ground-nesting bees and they live independently. *Pseudapis oxybeloides* have large tegula and pale bands on the abdomen. They prefer to nest in soils, even in lateritic hardy surface. This bee species gathers pollen and nectar from a variety of flowers including cashew, and is a very good forager.

Lasio glossumsp.(Halictidae: Hymenoptera) (Sweat bees)

Lasioglossum bees are small, black and nest in the ground, but some nest in rotten logs. This species is common on cashew flowers, but can also be seen over the leaf surface at times. Though it prefers nectar in fresh flowers, it also collects nectar from the extra floral nectarines.

Seledonia sp. (Halictus sp.) (Halictidae: Hymenoptera) (Furrow bees)

These bees are shiny in nature and small. The hair bands are apical and not basal. This species is common on cashew flowers. Like most other bees, this bee also collects lot of pollen grains from cashew flowers.

Importance of bee foraging in cashew

In general, cashew flowers are not found very attractive to honey bees if other nectar and pollen sources are available. But many wild bees prefer cashew flowers and actively forage on them. Bee visits are abundant during morning hours and peak foraging period of most of the bee species is between 11.00 am and 1.00 pm. Bees after foraging on flowers in an inflorescence, move to nearby inflorescence of the same tree or nearby cashew trees then fly away, which is an ideal behaviour for effective cross pollination. High visitation frequency of bees may increase the chances of pollen delivery on the hermaphrodite flower, thus increases the chance of fruit setting. Hence, increasing the population of bees in a region will certainly improve productivity of cashew.There are studies showing the cashew flowers that were restricted for bee visits set very less fruits or no fruits. Keeping honey bee colonies were found to increase the cashew yield to a tune of 10-30 % in certain regions of Tamil Nadu and Karnataka. But several factors including available bee flora in and around cashew plantations, crop management practices adopted, cropping system and ecological factors influence bee visits on cashew flowers and the resultant nut yield.

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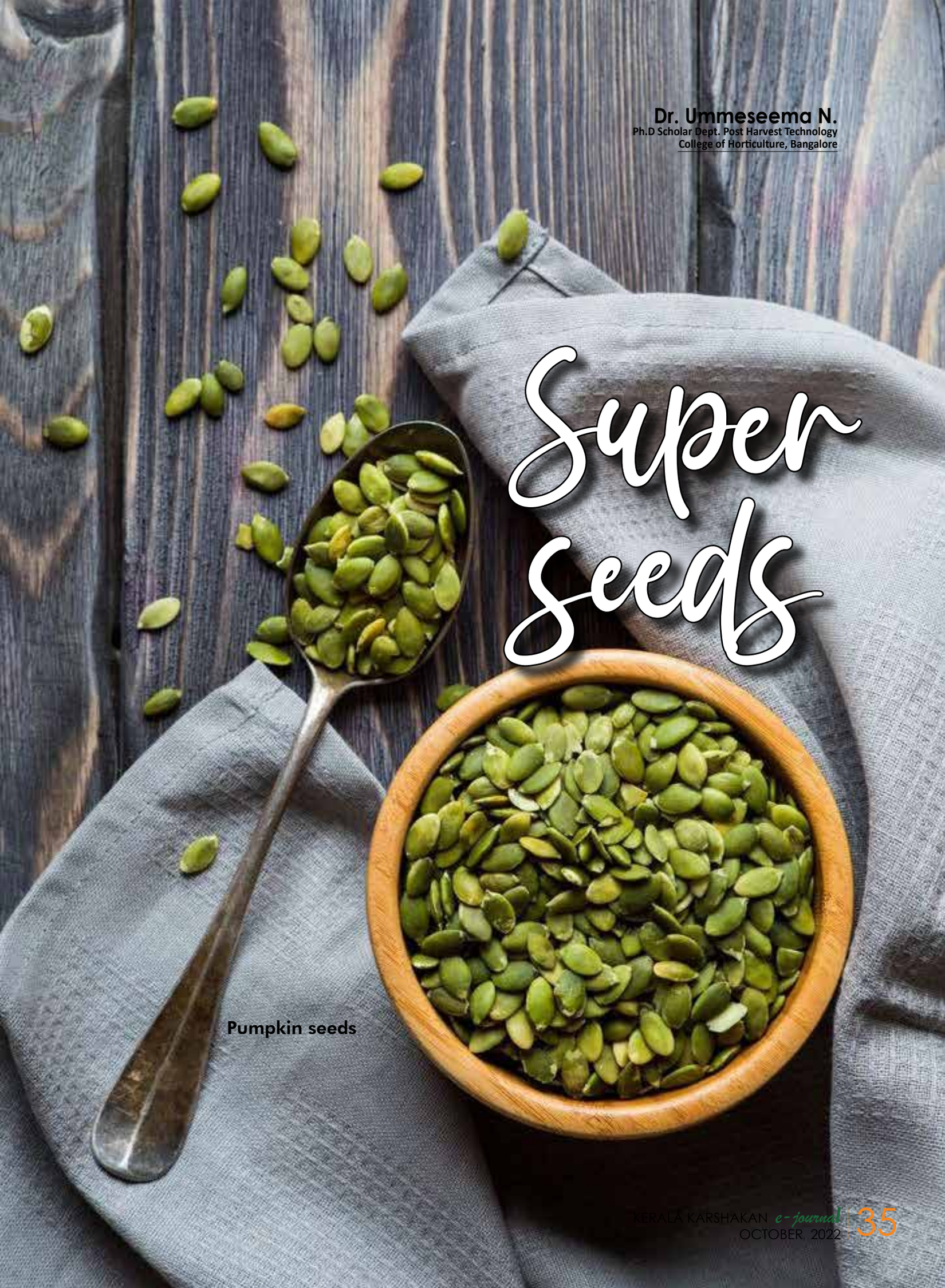
Super seeds



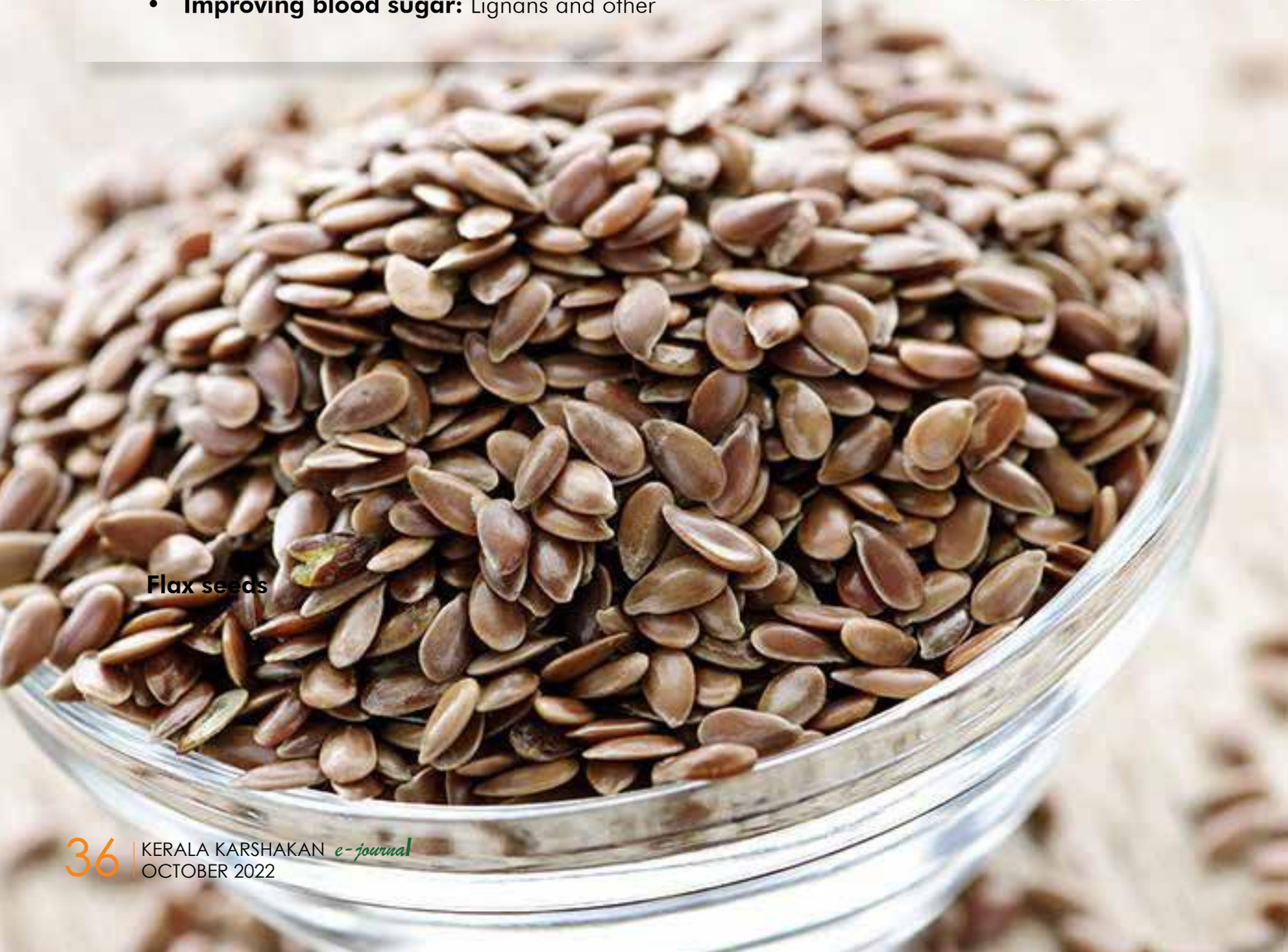
Pumpkin seeds

1. Flax seeds

Flax seed commonly known as linseed, which has a nutty flavor and cultivated in ancient Egypt and China. Two tablespoons flax seed contains three grams of protein, four grams of carbohydrate and six grams of fat (omega-3 fatty acid alpha-linolenic acid) and four grams of fiber (soluble and insoluble). It is also rich in thiamine, magnesium, potassium, phosphorus and best sources of antioxidant called lignans (hundreds of times more than other plant foods), which may protect against cancer.

Health benefits

- **Preventing constipation:** Flax seed is a good source of insoluble fiber which helps in digestive issues like constipation
- **Improving cholesterol and heart health:** Flax seed also contains phytosterols; consuming phytosterols help to reduce levels of low-density lipoprotein in the body.
- **Reducing the risk of cancer:** Flax seed has anticancer compounds called lignans, which are polyphenols that help to manage certain types of cancer, including breast cancer.
- **Improving blood sugar:** Lignans and other



Flax seeds

Flax seeds

phytoestrogens may help reduce the risk of chronic conditions such as diabetes.

2. Chia seeds

Chia seeds have a neutral flavor and a bit of a crunch, native to Mexico and were a staple food of Mayan, who thought of them as an energy booster. One of the health benefits of chia seeds is its power punch of fiber, at eight grams of fiber, four grams of protein and nine grams of fat in just two tablespoons of chia seeds and also a good source of calcium and magnesium. Due to its high antioxidant value, helps to stop the free radical activity and prevent skin ageing. Chia seeds provide more omega-3fatty acid, calcium, phosphorus, and fiber than other plant produce.

Health benefits

- **Weight loss:** Chia seeds contain nearly 5 grams of fiber per tablesoon and their high levels of omega-3-fatty acids and alpha-linoleic acid may help for weight loss
- **Treating diverticulosis:** High-fiber diets have been shown

Chia seeds

Sunflower seeds

to decrease the prevalence in flare-ups of diverticulitis by absorbing water in the colon and making bowel movements easier to pass

- **Cardiovascular disease and cholesterol:** Chia seeds rich in fibre, increased fiber intake help to lower blood pressure and cholesterol levels.
- **Diabetes:** Chia seeds may have the ability to convert glucose into a slow-release carbohydrate and have a positive effect on people with type 2 diabetes. High-fiber diets are associated with a lower risk of developing diabetes, and eating high-fiber meals helps to keep blood sugar stable.
- **Omega-3s to fight heart disease:** omega-3s can decrease the risk for thrombosis and arrhythmias, disorders that can lead to heart attack, stroke, and sudden cardiac death.

3. Pumpkin seeds

Pumpkin seeds are a great source of fibre, protein, unsaturated fats, including omega-6 fatty acids and 50% of the recommended daily requirement of magnesium. They also contain a good range of nutrients, including iron, calcium, B2, folate and beta-carotene, which the body converts into vitamin A and also a rich source of tryptophan it is used to treat insomnia where the body converts it to serotonin (the sleep-inducing hormone).

Health benefits

- **Help to blood sugar balance:** helpful in preventing diabetic complications, such as high cholesterol and blood sugar levels
- **Help to regulate blood pressure:** excellent source of magnesium, pumpkin seeds may help regulate blood pressure
- Pumpkin seeds are a good source of unsaturated fats, including alpha-linolenic acid, beneficial for the heart and the prevention of cardiovascular disease
- Pumpkin seeds are a good source of antioxidants, which can help to scavenge

the 'free radicals' that can damage cells

4. Sunflower seeds

Sunflower seeds are one of the most popular seeds in the world because of the number of benefits it has to offer. Seeds are white and have a tender texture. Known for their distinct nutty flavor and high nutritional value It's also an excellent source of Vitamin E, Vitamin B1, Vitamin B6, Iron, Copper, Selenium, Manganese, Zinc and Potassium

Health benefits

- **Reducing Inflammation:** For those with short-term or chronic inflammation, sunflower seeds can offer anti-inflammatory benefits. Sunflower seeds contain vitamin E, flavonoids, and other plant compounds that can reduce inflammation
- **Supporting the Immune System:** Sunflower seeds are a source of many vitamins and minerals that can support your immune system and include both zinc and selenium which plays a vital role in the immune system, helping the body maintain and develop immune cells. Selenium also plays a role in reducing inflammation, fighting infection, and boosting immunity.
- **Boosting Energy Levels:** High levels of protein in sunflower seeds already help boost your energy levels, other nutrients like vitamin B and selenium can help keep you energize

5. Hemp seeds

Hemp seeds are very nutritious. They have a mild, nutty flavor and are often referred to as hemp hearts. It contains over 30% fat. They are exceptionally rich in two essential fatty acids, linoleic acid (omega-6) and alpha-linolenic acid (omega-3). They also contain gamma-linolenic acid, which has been linked to several health benefits.

Health benefits

- **Reduce Risk of Heart Disease:** Hemp seeds are a great source of arginine and gamma linolenic acid, which have been linked to reduce risk of heart disease .
- **Skin Disorders:** Hemp seeds are rich in healthy fats. They have a 3:1 ratio of omega-6 to omega-3, which may benefit skin diseases and provide relief from eczema and its uncomfortable symptoms
- Digestion: seeds contain high amounts of fiber(both soluble and insoluble) which benefits digestive health.

6. Sesame seeds

Sesame seeds are rich in

Hemp seeds

protein, vitamins, minerals, and antioxidants. They are commonly added to certain foods to provide a nutty flavor and crunchy texture. Sesame seeds are an excellent source of manganese and calcium, both of which help your bones grow healthy and strong. Calcium also plays a role in nerve signal transmission, muscle movement, blood vessel function, and hormone release.

Health benefits

- **Lowers Cholesterol:** Sesame seeds contain lignans and phytosterols, which are plant compounds that can help lower cholesterol. Phytosterols are also believed to enhance your immune response and decrease your risk of certain cancers.
- **Fight Infections:** The antibacterial activity of sesame seeds is proven to fight against staph infections and strep throat as well as common skin fungi, such as athlete's foot.
- **Aid in Diabetes Treatment:** Type 2 diabetes is a lifelong disease that doesn't allow your body to make insulin in the way it should. One aspect of this condition is high blood sugar, which is called hyperglycemia. Eating healthy foods like sesame seeds can help people with type 2 diabetes reach their target blood sugar levels. Additionally, the antioxidants in sesame oil reduce the amount of sugar in your blood.

Sesame seeds

AUTONOMOUS ROBOTIC WEED CONTROL SYSTEMS

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Agriculture is in the race of acquiring advanced technologies in order to increase the productivity and improve use efficiency. Agricultural productivity has increased significantly over the years as a result of intensification, mostly aided by mechanization and automation (Bechar and Vigneault, 2016). Among the various problems experienced in the cultivation of crops in the field, weed maintenance act as a major barrier in the crop production. Weeds should be controlled properly in time as they compete with plants for moisture, nutrients and sunlight producing detrimental effects on crop yield and quality.

Weed management and related issues

A number of factors affect the magnitude of yield and quality loss which include,

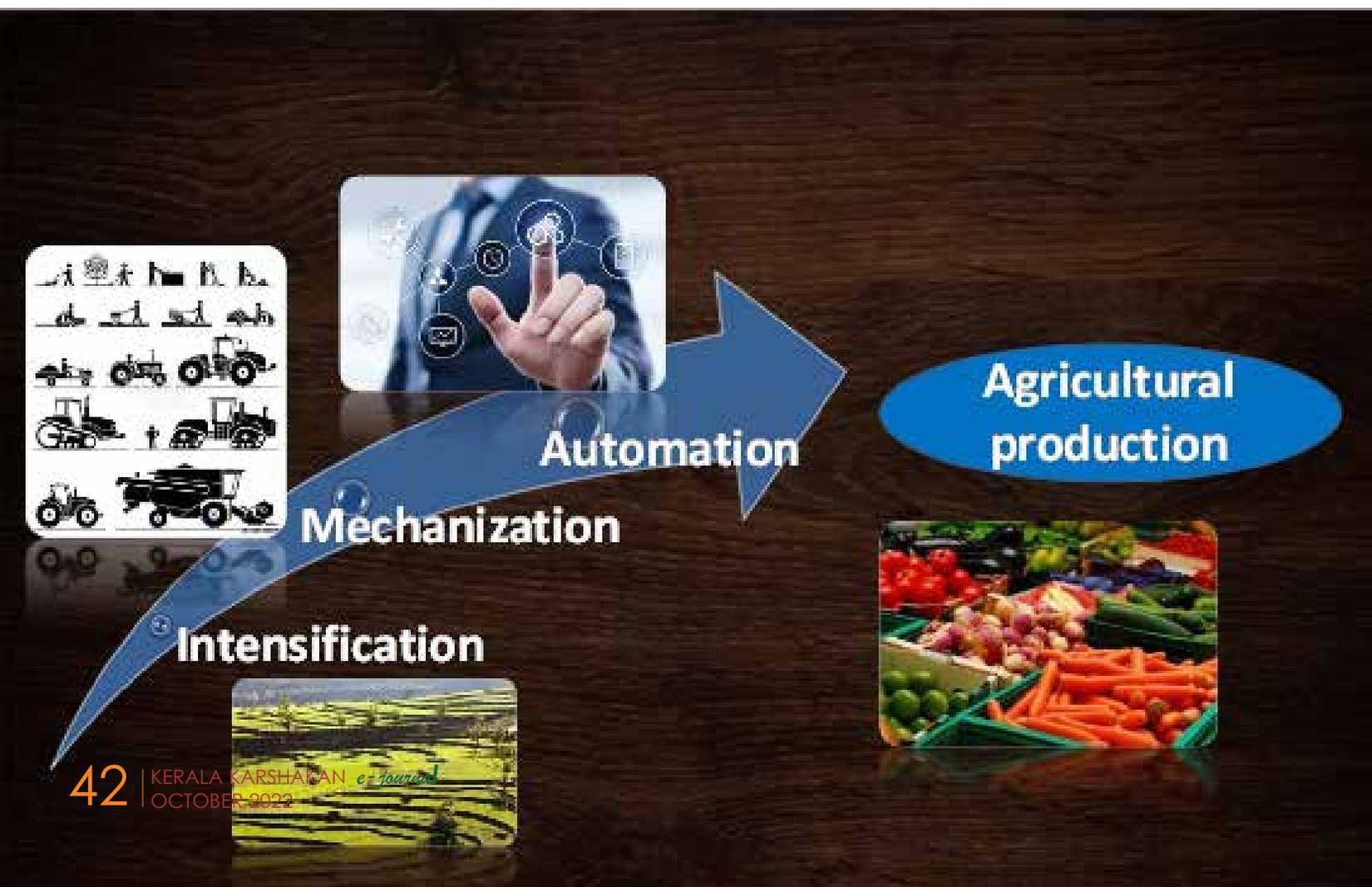
competitiveness of crop to the weeds present, relative densities of crop and weed plants, time of emergence of the weeds relative to the crop, life duration of the weeds and proximity of weeds to the crop plants. A recent estimate revealed that weeds cause annual loss of Rs. 1980 crores to Indian Agriculture which was more than the combined losses caused by insects, pests and disease (Patel et al., 2018).

Weed management plays a vital role in agricultural economy. It is one among the critical issues and can significantly affect crop production. Weeds can be controlled by mechanical and chemical processes. In Mechanical process, farmers generally use different kinds of hoes and hand tools for removing weeds. In chemical processes farmers use weedicides. Another less popular method is flame weeding in which weeds are destroyed by applying a flame of fire.

From the point of view weeds could be categorized into two types:- inter-row weeds and intra row weeds. Inter-row weeds are those growing between crop rows and are relatively easily controlled by non-chemical means. Inter-cultivation using mechanical weeders having tines or blades is the most common method to control inter-row weeds. Intra- row weeds which grow within the line of row crop plants are not affected by inter-row cultivation and require a large amount of labor.

Weed infestations are often distributed non-uniformly in agricultural fields. The non-uniformity in weed populations has both temporal and spatial aspects that provide an opportunity for the application of site-specific weed control technology to reduce environmental and economic costs associated with weed control (Thompson et al., 1991). Currently no equipment is available that replaces manual weeding completely. The labor required for manual weeding involves high costs and it is often difficult to organize. Replacing manual weeding by a machine requires advanced technology, because the machine has to

Fig: Aids in agricultural production



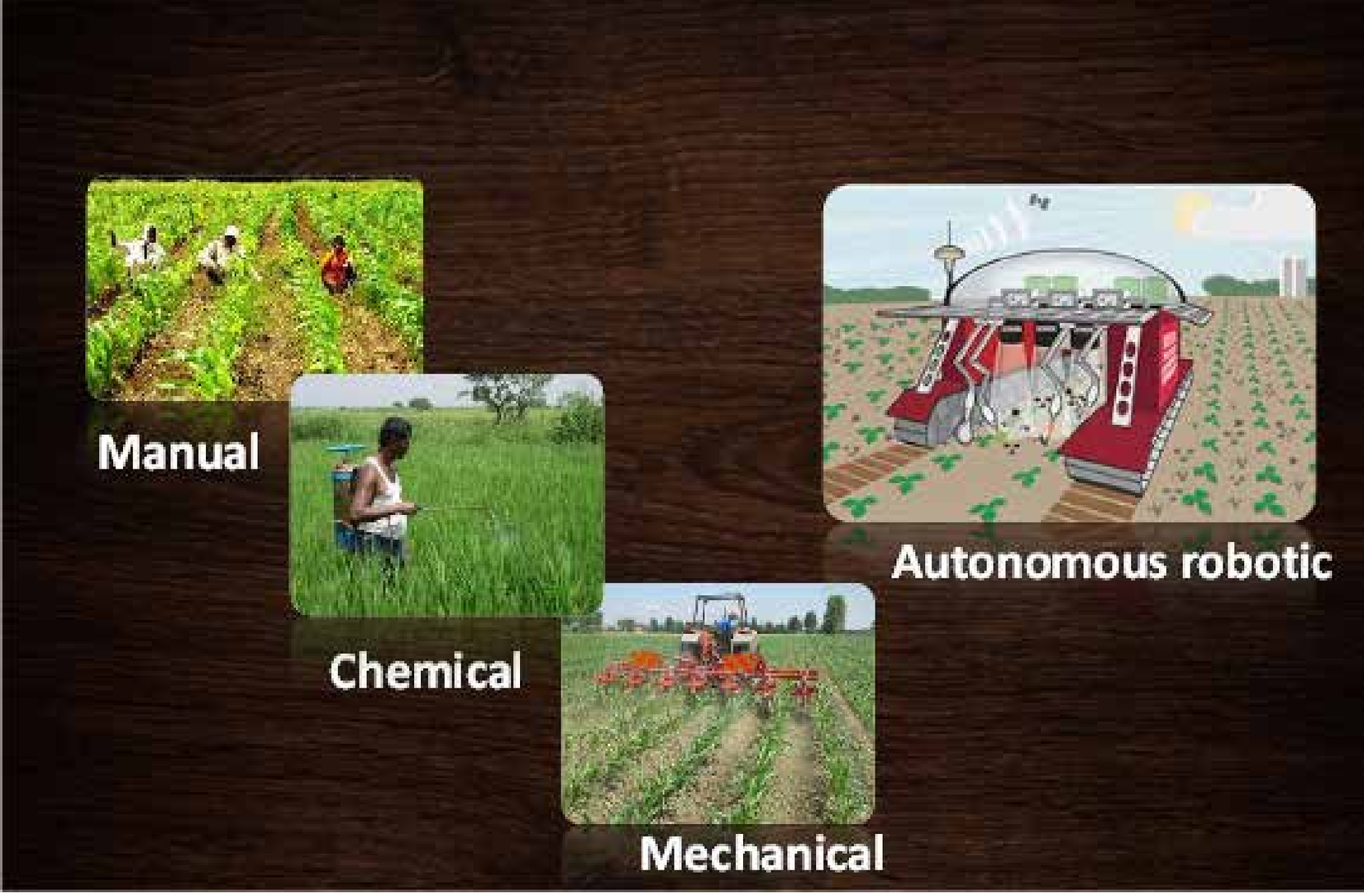


Fig: Different weeding methods

differently locate the crop plants and weed plants to remove the weeds with a precisely controlled device.

Automation and robotics in agricultural operation

Robotics is a quickly growing field, as technological advances continue. As research, the design and production of new robots serve numerous practical purposes in domestic, commercial and military sectors, modern agriculture also will be utilising the technological advances in this sector at an increasing rate.

As agriculture is suffering from the lack of trained workers, the problems can be addressed by the use of artificial intelligence techniques such as robotics and automation. Automation has considerably increased the productivity of agricultural machinery by increasing efficiency, reliability and precision simultaneously, and reducing the need for human intervention (Bechar and vignetan, 2016). These techniques have a favorable impact on the quality of life of the farmer and attract the younger generation due to its reduction in drudgerous operations under harsh conditions.

Agricultural Robots or agribot is a robot employed for agricultural purposes. The main areas of application of robots in agriculture include transportation and autonomous tractors , seedling transplantation systems, pruning and thinning, weed control and disease monitoring, harvesting, traceability and geo-positioning as well as multi-robot interactions to perform a common agricultural task (Bechar and Vignetan, 2017). These have many benefits for the agricultural industry, including low production cost, and reduction of manual labour (Pushpavalli et al., 2016).

Autonomous weed control systems

Autonomous robotic weed control systems can replace the labour and can also reduce the current dependency on herbicides, which can improve the sustainability of agriculture and reduce its environmental impact (Slaughter et al., 2008).

Fig: Vehicle of weeding system

Detection of weeds based on its characteristics and guiding the robot to the detected weeds are the major challenges in the research area of robotic weed removal techniques. Increasing range of weeds as well as crops has enhanced these challenges to work on detecting different varieties of weeds for all types of field crops.

Recently, two major types of robotic weeding devices have been developed, namely tractor drag devices and self-powered machines. For the first type, the weeding device is dragged with a tractor which requires a driver for the tractor. For the second type, the machine is often automatically guided and weeding tasks are performed automatically with the support of a combined application of sensor systems, communication technologies, positioning systems (GPS) and geographical information systems (GIS).

Basic components of a robotic system

A robotic system consists of sensors, drive or actuators, controller, arm and end effectors (Bechar and Vignetan, 2016). In the case of a weeding robot, the components may be as given below:

- A vehicle as a platform for carrying e.g. weeding tools for in row weeding.
- A control unit, with input from Vision, GPS, and other necessary sensors, are providing the vehicle and the tools with the necessary control signals.
- A GPS module that provides the vehicle with its global position in real time.
- A vision system detecting the position of the crop relative to the vehicle position
- Sensing system to measure important physical and biological properties of agricultural system.
- Actuators to manipulate the agricultural system accordingly
- Communication aids to facilitate transfer of data to a user.

Communication with user

The communication between robot and user differs in who is taking the initiative for communication, the type of information to be exchanged and the distance of the user to the robot.

Core technologies for autonomous weed control (Slaughter et al., 2008)

A general-purpose autonomous robotic weed control

Machine vision based row guidance

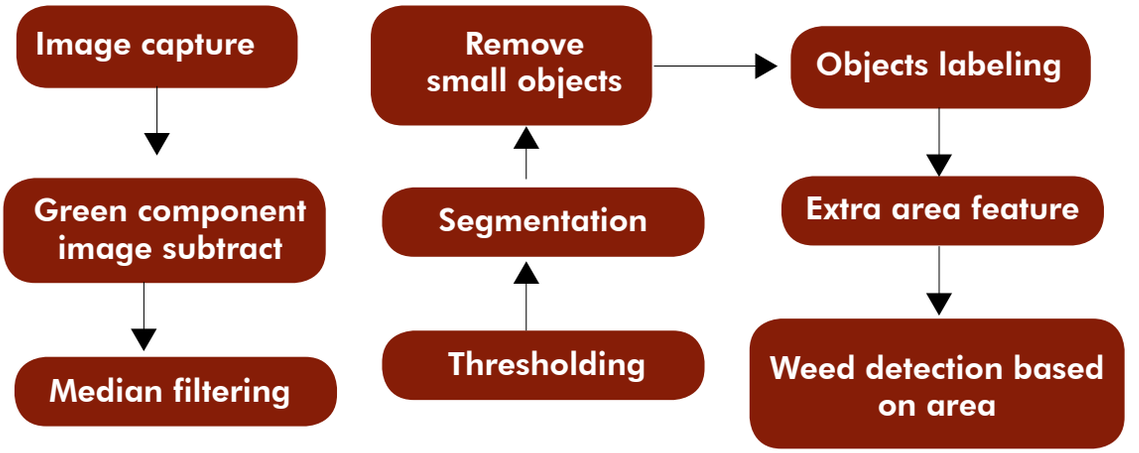
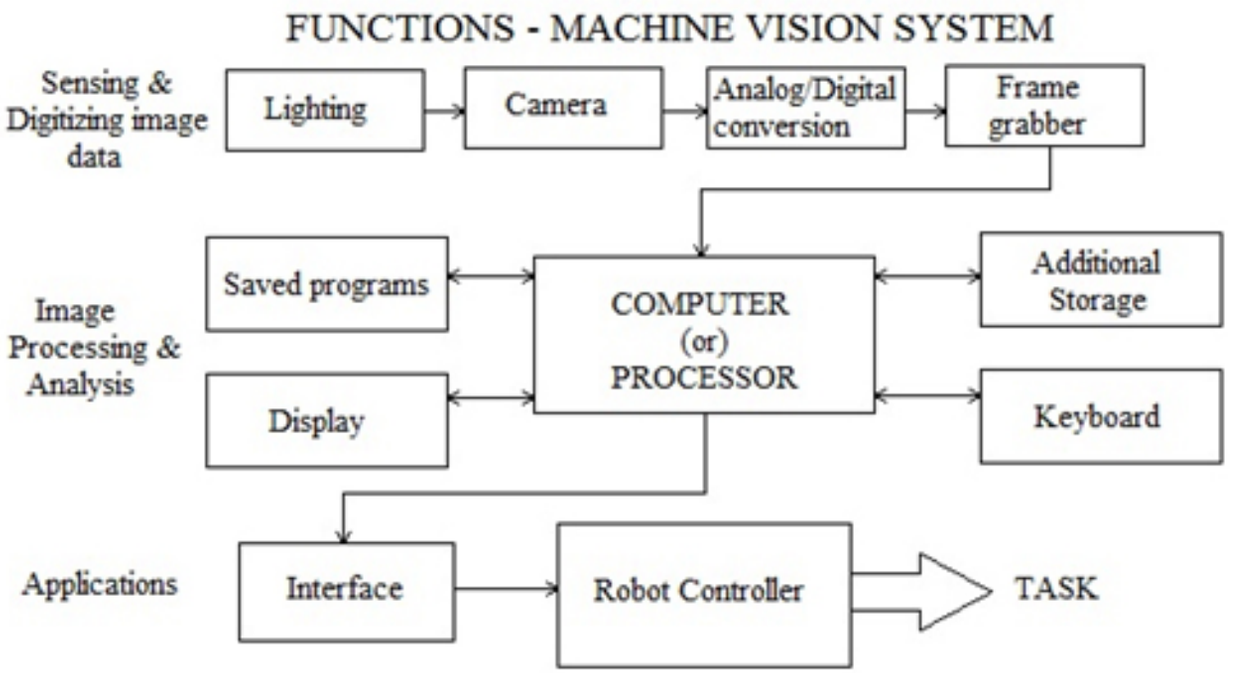


Fig.2 Vision system flow chart



system had four core operations such as guidance, weed detection and identification, precision in row weed control and mapping. Different techniques used for the respective operations were as follows:

Row guidance systems

Row guidance systems mainly utilises two types of technologies like Machine vision and Real-time Kinematic Global Positioning System (RTK GPS).

Real-time Kinematic Global Positioning System-based row guidance (Slaughter et al., 2008)

Real-time Kinematic Global Positioning Systems (RTK GPS) can provide a level of lateral positioning accuracy along the row comparable to machine vision guidance systems. GPS systems provide an absolute guidance system and in contrast to the relative guidance provided by machine vision, it require that the crop should be planted using an RTK GPS guided planting system or the crop rows mapped using some type of geo-referenced mapping techniques.

Identification of plant species

In order to identify weeds several visual characteristics are used. They are mainly biological morphology, spectral characteristics, visual texture and pattern recognition of plant spacing.

Biological morphology

Leaf shape is the most frequently used shape attribute for identification of plants with machine-vision systems. In some cases, it may be the difference in shape between the cotyledons and the first true leaves that provides useful information for seedling identification.

Plant reflectance

Reflectance of crop, weeds and soil differ in the visual and near infrared wavelengths, so this spectral information has potential to be used for discrimination. One of the greatest potential advantages of the spectral reflectance based techniques is that pixel based color are robust to partial obstructions. In addition, the method tends to be less computationally intensive than shape-based techniques.

Visual texture

Hue and saturation value (HSV) helps to classify the weeds on the basis of colour contrast which is a texture feature. In this technique texture features of the image such as, energy, entropy, contrast, homogeneity, and inertia are used for detection of plant. By using the support vector algorithm texture features can be extracted and thus weeds can be classified. Different ANN (Artificial Neural Network) gives different accuracies of finding texture features like energy, contrast, homogeneity, inertia, entropy.

Intra-row weeding mechanisms

Four types of weed removal mechanisms were found suited for selective intra-row weed control by robotic systems such as mechanical, thermal, chemical and electrical. These systems typically used mechanically actuated switches, interrupted light beams, reflected light or completion of an electronic circuit through the plant to earth ground to sense the location of crop plants.

The following alternatives were adopted to perform intra-row removal of weeds (Bakker, 2010):

Mechanical: Mechanical knives that could be rapidly positioned in and out of the seedling line to cut unwanted plants or a rotating hoe that could be lowered to cut unwanted plant material or raised above desired plants.

Air: Pressured air could be used to remove weeds from the intra-row area.

Flaming: The plants in the field can be exposed to flames generated by burning of a fuel in such a way that the heat injury causes the weeds to die allowing the crop plants to survive.

Electrical discharge: Weeds can be killed by producing an electrical discharge. An electrode producing electrical discharges of 15 kV and 30 mA for 200 ms is commonly used for single leaf. The system was able to eliminate 100% of the small weeds, but on bigger plants damage was seen only on the affected leaves to some extent.

Hot water: Weeds can be exposed to hot water so that heat injuries kill the weeds.

Freezing: Weeds can be controlled by freezing them.

Microwaves: Weeds can be killed by exposing them to microwave radiation.

Laser: Laser can be used as a weed stem cutting device or for stopping or delaying weed growth by directing a laser towards the apical meristem of the weeds.

Water jet: Weed stems can be cut with high-pressure water-jets. Flaming, hot water, infrared, freezing, microwaves and pressurized air are normally applied non-targeted.

The effect of these techniques is based on a difference between crop plants and weeds in resistance to the applied dosage.

Weed mapping

Weed mapping is a valuable tool for optimizing resource utilization in the management of weed control efforts. Traditionally, weed mapping is done manually, using random sampling techniques by a weed expert walking through a field. A robotic weed identification system with GPS mapping capability has the potential to automate this process, allowing increased sampling and providing more accurate estimates at low cost (Slaughter et al., 2008).

Requirements for a weeding robot

In order to replace hand weeding in organic farming, a device working autonomously at field level should be developed. For the purpose following

Fixed requirements	Variable requirements
Replace hand weeding	Remove more than 90% of the weeds in the row.
Applicable in combination with other weed control measures	The costs per hectare need to be. comparable to the costs of hand weeding.
Manual control of the vehicle should be possible	Damage to the crop is at least as low as with hand weeding.
Weeding a field autonomously	Wheel pressure of the weeding robot must not be higher than for mechanical weeding.
Ability to work both day and night	Energy efficiency should be at least as high as mechanical weeding.
The weeding robot must not cross the field boundaries	Noise emission should not be higher than mechanical weeding.
The weeding robot must be self restarting after an emergency stop	Should be safe for people, animals and property.
The weeding robot informs the farmer when stopped definitely	Supervision requirement should be at least lower than hand weeding
The weeding robot sends its operational status to the user at request	Complexity of operation not higher than mechanical weeding. Reliable functioning, Suitable as research platform.

Advantages and Disadvantages of weeding robots

Advantages	Disadvantages
It will not take too much time for training as in the case of labourers	High cost for short-term
Reduce one of the largest farm expenses which is labour cost	Difficult to find the spare parts since, it is not widely used around the world by the farmers
Doing repetitive tasks like cultivating and other forms of mechanical weeding operator to operate the machine	Reduce the job opportunity of humans Need professionally
Efficient use of herbicides, thus reduce herbicides cost	Only used in small scale farming
It can work in place where humans cannot work It will not take too much time for training as in the case of labourers	Difficulty in maintenance Technical error can harm entire crop

requirements are needed:

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