Department of Agriculture Development & Farmers' Welfare
Farm Information Bureau

Government of Kerala

MAY 2022
VOLUME - 9
ISSUE - 11

KERALA KARSHAKAN

English journal

The First English farm journal from the house of Kerala Karshakan

Unbelievable Health Benefits and Phytochemical properties of world's most valuable and Expensive spice

Saffron

(Crocus sativus L.)

INSIDE KERALA KARSHAKAN
English journal

MAY 2022 Volume - 9 Issue - 11

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Phone: 0471-2314358

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Unbelievable Health Benefits and Phytochemical properties of world's most valuable and Expensive spice

Saffron (Crocus sativus L.)

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Introduction

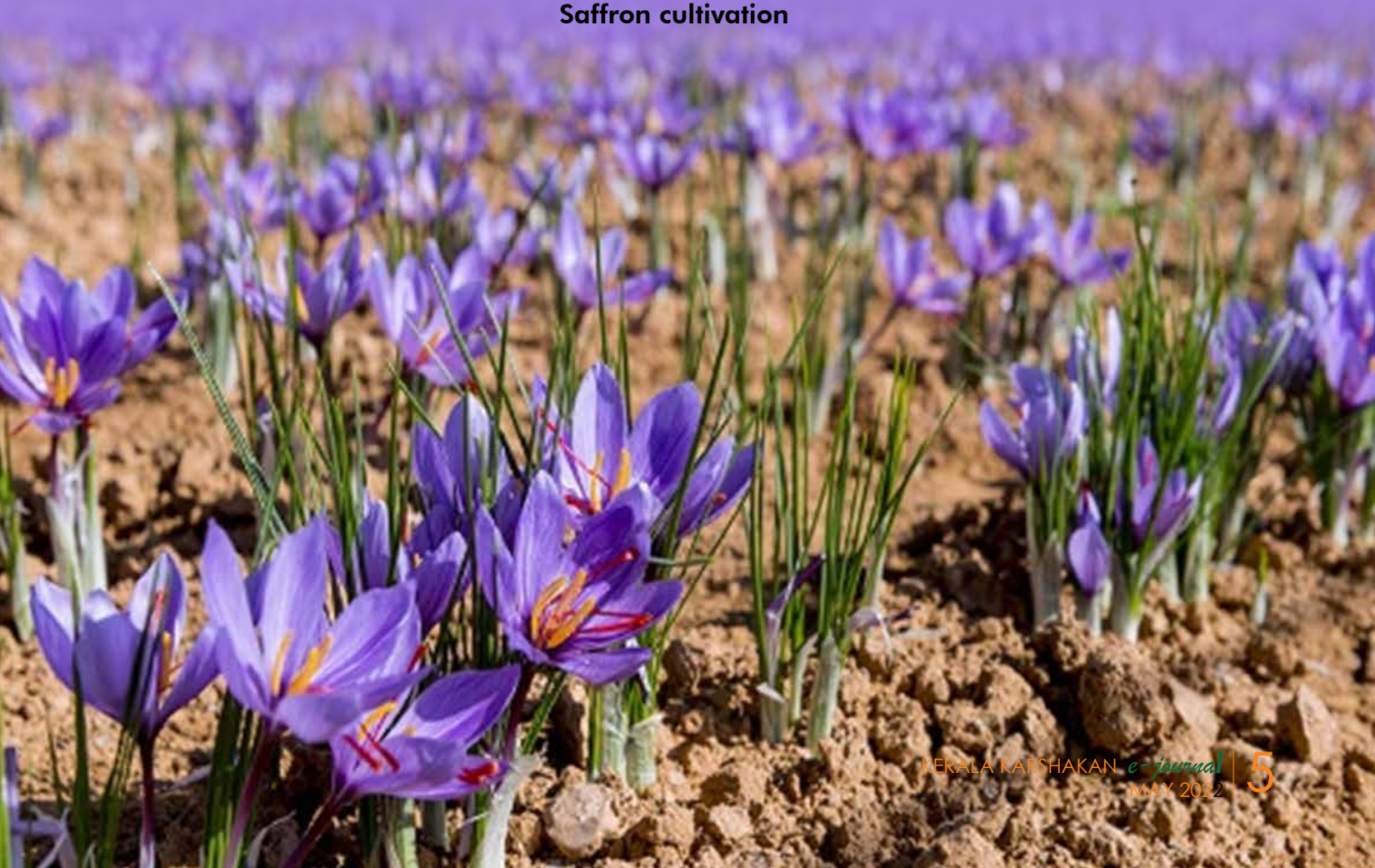
During recent times, medicinal herbs have attained great importance due to their essential role in treatment of many health problems with lower rate of side effects. Saffron is a well- known spice which has been used in traditional medicinal system for treatment of number of health problems like depression, menstruation disorders, asthma, insomnia, cardiovascular disease, digestive ailments and some others. Many recent studies resulted that saffron may have cardioprotective effects through calcium channel-blocking effects, modulation of oxidative stress, hypotensive and hypolipidemic properties (Ghaffari and Roshanravan, 2019).

Crocus sativus L. is considered as world's most expensive spice. It is a perennial herb belongs to Iridaceae family. The word Saffron originated from the Arabic word 'Zafaran' which comes from the Persian word 'Zarparan' meaning "flowers of golden petals". It is used as colouring and flavouring agent in food and other purposes as dye, perfumery and flavouring industries. Saffron is well known for a number of biological properties like anticancer, antimutagenic and antioxidant activity. The saffron flower has characteristic light purple colour with thread like reddish coloured stigmas. To get 500gm of pure saffron without contamination, almost 200000 dried stigmas are required. So, the price of saffron is very high in the world. The production of saffron is highest in coutries like Iran, Azerbaijan, Greece, Spain, Argentina, USA and newer areas being brought under its cultivation are China and Japan. Among all Iran, Spain and Kashmir are the major saffron producing regions of the world (Gohari et al., 2012; Ganaie and Yadav, 2019).

Botanical description

Saffron is herbaceous stem less plant grew up to 25-40cm. the corm, floral organs and foliar structure are the main components of the saffron plants. The plant has more than 300 volatile and non-volatile compounds like safranal, glycoside monoterpenes,picrocrocin, crocin, aldehydes and

Saffron cultivation



Harvesting

Kingdom	Plantae
Division	Magnoliophyta
Class	Liliopsida
Order	Asparagales
Family	Iridaceae
Genus	Crocus
Species	C. sativus

(Shahdadi et al., 2016)

carotenoids.

Cultivation:

The cultivation is distributed from the Mediterranean region to Europe and to Asia. Since immemorial, Iran is the principal producer (85% of worlds production) and exporter of saffron all over the world. The cold winter and warm summer especially with less humidity, are the appropriate areas of West of Asia and Mediterranean countries are suitable for cultivation of saffron. Blooming of saffron occurs only during autumn and in summer it is dormant. Warm subtropical climate and well drained sandy soils are most preferable conditions. Taste and flavour of saffron is highly affected by the harvesting and drying process. Due to its numerous pharmaceutical properties saffron is used as medicine and it is also the part of the Catalogues of Medicinal Plants in the European Pharmacopoeia (Gohari et al., 2012; Ganaie and Yadav, 2019).

Collection and processing of Flowers:

It is not easy to collect and isolate stigmas of the saffron flowers. The flowers remain only for 3-4 days. The quality of colour and odour will be highly changed if the flowers are remained under the wind, sunlight and warm conditions. Flowering period is usually

Processing of Saffron

elongated for 15-25 days and the best time for collection is before sunrise. Flowers are usually hand picked and stored in wooden baskets to prevent any other mechanical damages. The stigma should not be removed while flower harvesting as to crash or mix of stigmas with petals that decreases the quality.

Drying conditions also affects the quality of the product. Present advanced methods are used for the drying process. In which stigmas are put on the sterile silk net (150-200 g) with a 2-3 cm layer in the appropriate distance to oven (50-60°C). By using this method, the humidity of products will be equal to the standard 13%. Fast drying, high quality, and less affected by air pollution and mould are other advantages.

Saffron are usually contained with spore forming bacteria like Bacillus and Fungi such as E. coli, Staphylococcus, Lactobacillus, Micrococcus and Streptococcus. Sterilisation process affects the quality and so can't be recommended. Some studies reported that use

of microwaves, gamma and ultraviolet radiation along with fumigation with ethylene oxide was highly preferable. But the irradiated samples were also reported to decrease in aglycon content (Gohari et al., 2012).

Chemical composition:

Saffron has many aromatic and volatile compounds, many of which are carotenoids. The main components of saffron are carotenoids crocetin, β-crocetin (monoethyl ester), γ- crocetin (dimethylester), transcrocetin isomer, 13-cis-crocetin isomer; α-carotene, β- carotene, lycopene, zeaxanthin and mangiocrocin, a xanthone carotenoid glycosidic conjugate, glycosidic forms like digentiobioside (crocin), gentiobioside, glucoside, gentioglucoside and diglucoside. During drying process monoterpene aldehydes picrocrocin and its deglycosylated derivate safranal formed in saffron by hydrolysis process and are responsible for the bitter flavour and aroma respectively. It is also the source of many other compounds like anthocyanins, flavonoids, vitamins (riboflavin and thiamine), amino acids, proteins, starch, minerals (Kumar et al., 2009).

THERAPEUTIC USES OF SAFFRON:

Central nervous system: Saffron and many biologically active metabolites have impact on memory and learning, neurodegenerative diseases, depression and anxiety. Both invitro and in vivo studies found that the administration of crocetin resulted protective affect against damage to retina of the eye and inhibits degeneration and retinal dysfunction.

Diabetic properties: Neural damage is one of the most severe complications of the Diabetes. Due to antioxidant properties saffron shown protective effect against this kind of damage.

Antidepressant: Many studies reported that when compared to imipramine or fluoxetine daily administration of 30 mg of saffron could be useful in the management of depression.

Cardiovascular system: The aqueous extracts of crocetin from saffron stigma showed endothelial control of the vascular hyperreactivity of hypertension. It has capability of improving the nitric oxide-endothelium-dependent vasodilation, which is damaged in hypertension. And it also has anticontractile properties, reducing over-reactive arterial response, which is a hallmark of hypertension, by endothelium modulation.

Liver health: In vivo studies found that crocetin esters attenuated the activation of caspases, essential mediators of apoptosis or cell death, and the ratio between the proapoptoticbax and antiapoptotic BCL-2 (bax/Bcl-2) proteins, which reduces hepatotoxicity (Bagur et al., 2017).

Impact on memory loss: When compared to control rats, administration of saffron extract or crocin solution significantly improved memory skills in rats. Studies of Abe's Research Group found favourable effect of saffron extract, crocin and crocetin on memory and learning skills, in ethanol-induced learning behaviour impairments in swine (Christodoulou et al., 2015).

Anticancer activity: The presence of crocin, crocetin, picrocrocin and safranal exhibited anticarcinogenic properties at concentration of 2 μm to 3 mm (Christodoulou et al., 2015).

Use of high doses of saffron should be avoided during pregnancy. It was found that intake of more than 5gm of saffron can stimulate uterine stimulant and have abortifacient effects (Bagur et al., 2017).

The food and drug administration criteria for Saffron

According to FDA, it is approved as flavouring and food dressing compound without its limitation in culinary purposes. so, the product has to follow the below criteria:

- When saffron is dried at 100°C volatiles and humidity must not be more than 14% Maximum total ash must not be more than 1%
- The amount of soluble ash not more than 1%.
- Stigmas should be yellow with foreign organic compounds not more than 10% (Gohari et al., 2012).

Adulteration of saffron:

Adulteration of saffron is done with materials such as pomegranate fibres, beet, yellow stamens of saffron, turmeric, paparika, flowers of other plants, specially *Carthamus tinctorius, Calendula officinalis* or safflower, or marigold, arnica and tinted grasses are being fraudulently mixed with the genuine stigmas. When saffron is used for therapeutic purposes, adulterations make it completely useless or even harmful (Gohari et al., 2012).

Conclusion:

Saffron is one of the important medicinal food plants grown widely in Iran. It is also cultivated for their nutritional purposes and economic significance. Due to high labour involvement in cultivation, harvesting and handling, the cost of the spice is very high.

Many pharmacological and medicinal properties of saffron attracted researchers across the world. Many conditions like relative air humidity, temperature of the surroundings, direct sunlight, and packaging are the final parameters that impact the quality of the product.

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GOODNESS OF GREEN LEAFY VEGETABLES

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Green leafy vegetables are major components of a healthy diet, and their sufficient daily consumption could help prevent major diseases. These vegetables may help to meet daily requirements of these and other essential nutrients, especially in individuals with marginal nutritional status. Vegetables can form the cheapest and most readily available sources of important fibers, vitamins, minerals, essential amino acids and substances that help protect you from disease particularly. Inclusion of greens in daily diet would help prevent anaemia and promote good health. The low caloric value of leafy vegetables makes them ideal for weight management and these are a rich source of nutrients, high in dietary fiber, low in lipids, and rich in foliate, vitamin-C (ascorbic acid), vitamin-K (phylloquinone), magnesium, and potassium. Mineral nutrients like iron and calcium are high in leafy vegetables than staple food grains. Also, leafy vegetables are the only natural sources of folic acid, which are considerably high in leaves of spinach, asparagus, lettuce, mustard green, colocasia green leaf and turnip green plants as compared to other leafy and non- leafy vegetables.

In India, nearly 30,000 children under five years of age go blind every year due to Vitamin A deficiency. Carotene in greens gets converted in the body to form Vitamin A which prevents blindness. To preserve

Nutritive value of some of the commonly eaten greens

Nutrients	Mint	Amaranth	Spinach	Drumstick Leaves	Coriander leaves	Gogu
Calories	48	45	26	92	44	56
Protein (g)	4.8	4.0	2.0	6.7	3.3	1.7
Calcium (mg)	200	397	73	440	184	1720
Iron (mg)	15.6	25.5	10.9	7.0	18.5	2.28
Carotene (microg)	1620	5520	5580	6780	6918	2898
Thiamine (mg)	0.05	0.03	0.03	0.06	0.05	0.07
Riboflavin (mg)	0.26	0.30	0.26	0.06	0.06	0.39
Vitamin C (mg)	27.0	99	28	220	135	20.2

Important Green leafy vegetables

Kale

Rich in vitamins A, C, and K, calcium, folate, potassium, and fiber. It protects the heart and can prevent or slow down cancer.

Collards

Rich in many vitamins, minerals, and antioxidants, and eating it regularly might reduce your risk of developing certain diseases

Green leaf, red leaf, and Romaine lettuce

These are full of vitamin A and folate. The darker leaves are more nutritious than lighter varieties.

Turnip greens

The tops of turnips are low in calories, and are loaded with vitamins A, C, and K, and calcium.

Swiss Chard

These vegetables have a beet-like taste and a soft texture. They contain a healthy amount of vitamins A and C.

Broccoli

It is rich in vitamins C and A, potassium, folate, fiber, protein, and iron. Broccoli also contain cancer-fighting sulforaphane.

Spinach

Spinach contains folate, vitamins A and C. Cooked spinach is more nutritious than raw.

Mustard greens

These greens have a similar nutrition profile to turnip and collards.

Small leafy greens

These greens are potent in nutrients similar to the large leafy greens noted

Vitamin C content in greens, prolonged cooking should be avoided, as this nutrient, which keeps gums in good condition is lost on overcooking. Greens also contain some of the B-Complex Vitamins.The recommended dietary allowance of green leafy vegetables for an adult women is 100g/day, adult man 40g/day, preschool children (4-6 years) and for boys and girls beyond 10 y of age it is 50g/day.

Nutritional Content of Green Leafy Vegetables

1. **Packed with Vitamins–** All leafy greens have an abundant store of nature's vitamins. However, kale, spinach, moringa, and cabbage are known for their superior vitamin content. Get a good amount of vitamin A, vitamin K, vitamin E, vitamin C,beta-carotene, folate, vitamin B1, B2, B3, B5 and, B6 from these vegetables.
2. **High mineral content–** Minerals like iron, magnesium, potassium, zinc, calcium, phosphorus, and sodium can be added naturally to diet by eating green leafy veggetables. They help to maintain the daily requirement and overcome the deficiency of dietary minerals by providing an adequate amount of minerals in every bite.
3. **Rich in dietary fibers–** Green leaves have good fiber content which gives satisfaction after you consume them. Fiber also provides various other health benefits.
4. **Low-fat content–** These leafy greens save you from consuming fats and lipids as they have nearly zero fat content.

Health Benefits

- **Weight management:** Most green vegetables are low in calories. Eat as much as you like without putting on extra weight.
- **Mortality rate:** Frequent consumption can substantially lower your mortality risk. Leafy greens contain vitamin K, Magnesium, the B vitamins, Calcium, amongst many other essential nutrients. These nutrients are critical for every cell function and hence, prevent the aging process.
- **Cardiovascular disease:** Greens are low in fat, high in dietary fiber and rich in folic acid, potassium, magnesium, vitamin C and phytochemicals. One extra serving per day can lower the risk of cardiovascular disease by 11%.
- **Type 2 diabetes:** The high level of magnesium and low glycemic index that can be found in greens is ideal for preventing and treating diabetes.
- **Bone health:** The high levels of vitamin K, Magnesium, and calcium in leafy greens produces osteocalcin, the bone builders. Middle-aged women who eat over one serving of greens per day will lower their risk of a hip fracture by 45%.
- **Immune function:** The rich beta-carotene and Vitamin A improve the immune system.
- **Protect eyes:** Children who consume inadequate amounts of Vitamin A have a higher risk of going blind. Carotenoids (lutein and zeaxanthin) found in leafy greens are concentrated in the macular region of the retina and the lenses of the eye. A diet dominant in leafy greens protects the eyes from needing eye glasses in kids to macular degeneration and cataracts in adults.
- **Cancer:** Carotenoids, antioxidants, and flavonoids found in leafy greens protect from most cancer.

Green leafy vegetables are considered to be one of the cheapest vegetables in the market and it could be rightly described as 'poor man's vegetables'. Seeing the potential of Green leafy vegetables as a cheap source of antioxidants and other nutrients.

Green leafy vegetables have plenty of vitamins, minerals and disease-fighting chemicals. Vegetables that contain beta-carotene, such as spinach, help in the growth and repair of body tissues. Green leafy vegetables are goodsources of folate, which can reduce your risk of cardiovascular disease and memory loss as well as wardingoff depression. Hence, consumption of green leafy vegeatbles benefits human health by improving nutritional status and reducing risks of specific diseases like diabetes, cancer and hepatotoxicity.

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Insects as a Nutritive Diet

Introduction

The need for quality diet and consumers preference to newer food items is increasing. Insects as food have been practiced in many countries. This can be compensated by alternative animal food known as edible insects. More than 1900 insects have been reported as edible species, the majority of which are originated from tropical countries. The widely consumed edible insect species are, Lepidoptera (18 %), Hymenoptera (14 %), Orthoptera (13%), Hemiptera (10%), Isoptera (3 %), Odonata (3 %), Diptera (2 %) and other orders (5 %). Caterpillars of Lepidoptera, larval and pupal stages of Hymenoptera, adults and larvae of Coleoptera, mature stages of Orthoptera, Homoptera, Isoptera and Hemiptera are eaten in many parts of the world (Cerritos, 2009). Insects are rich in protein and fats and high in calcium, iron and zinc and it is nutritious alternatives to chicken, pork, beef and even fish.

Nutritive value

Insect meat is rich in crude protein content than conventional meat and it can be a good source of essential amino acids out of which 76 to 96% are being digestible by the human body (Belluco *et al.,* 2015; Lehnert *et al.*, 2016). Required quantities of the amino acids viz., lysine, leucine, arginine, isoleucine, histidine, valine, threonine and tyrosine were recorded in all edible insects. The higher leucine content in beetles and phenyl alanine content in true bugs are the known sources of protein. Two-folds arginine reported in nymphs of cockroaches *(Blatta lateralis)* than to conventional livestock is beneficial to the heart and blood vessel and also act as an immunity booster.

Caterpillars contain more amounts of polyunsaturated fatty acids and essential amino acids viz., in α-linolenic acid. α-linolenic acid and linolenic acid. These cannot be synthesized by human body. Lepidopteran larvae, honey bee pupae and adult of red palm weevil are rich in vitamins B1, B2 and B6, vitamins A and D and vitamin E respectively (Rumpold and Schlüter, 2013). House fly larvae and adult melon bugs are rich in

Edible insects

Order	Edible insects	Country	References
Coleoptera	Palm weevil, *Rynchophorus phoenicis*	Tropical & equatorial Africa	Ramos Elorduy, Pino and Martinez-Camacho (2009)
	R. ferrugineus	Asia	
	R. palmarum	Tropical America	
	Larvae of yellow mealworm, *Tenebrio molitor*	Netherlands	
	Larvae of lesser mealworm *Alphitobius diaperinus*		
	Larvae of superworm *Zophobas morio*		
Lepidoptera	Cutworm, *Agrotis infusa*	Australia	Flood,1980
	Hawkmoths, *Daphnis spp. & Theretra spp.*	Lao People's Democratic	
	Mopane caterpillar, *Imbrasia belina*	Republic Angola, Botswana, Mozambique, Namibia, South Africa, Zambia & Zimbabwe	
	Bamboo caterpillar, *Omphisa fuscidentalis* Silkworm, Bombyx mori	Asia	
Hymenoptera	Black weaver ant, *Polymachis dives*	China	Shen,Li and Ren, 2006; Nonaka,Sivilay and Boulidam, 2008
	Larvae of yellow jacket wasps *(Vespula & Dolichovespula spp*	Japan	
	Two leafcutter ant species *(Atta mexicana and A. cephalotus)*	South America	
	All stages of European honey bee, Apis mellifera	Many parts of the world	
Orthoptera	Desert locust, *Schistocerca gregaria* Migratory locust, Locusts migratoria Red locust, *Nomadacris septemfaciata* Brown locust, *Locustana pardalina*	Africa	Yhoung-Aree and Viwatpanich, 2005; Cohen,Sanchez and Montiel-ishinoet, 2009

Order	Edible insects	Country	References
	Chapulines (edible grasshoppers of the *genus Sphenarium*	Mexico & Latin America	
	Crickets Gryllus bimaculatus, Teleogryllus occipitalis & T. mitratus	Asia	
	House cricket, Acheta domesticus	Thailand	
Hemiptera	Cicada species *(Ioba, Platypleura and Pycna)*	Malawi	Van Huis, 2003a
	Cactus cochineal bug, *Dactylopius coccus* Bright red pigment also called E120 used in food products		
	Psyllid *(Arytaina mopane)*	South Africans	
	Lerp-building psyllids	Australia	
	Pentatomid *Agonoscelis versicolor*	Republic of Sudan	
Isoptera	Termite species, *Macrotermes* species	Many parts of world	Van Huis, 2003b, Paoletti and Defour, 2005
	Syntermes	Brazil	

calcium (Mustafa et al., 2008)

Conclusion

Exploring the nutritional values of different group of edible insects are the need of the hour to promote them as food source among the larger group. Recent developments in research and development show edible insects to be a promising alternative for the conventional production of meat, either for direct human consumption or for indirect use as feedstock. The increasing cost of conventional animal protein will open gateway for insect protein which will be much cheaper. Nature conservation strategies are required for the sustainable harvesting of edible insects. Habitat manipulation measures can enrich the abundance and accessibility of insect populations. The nutrient availability of insects particularly macro nutrients needs to be documented for the locally available abundant insect species.

Preservation and processing techniques are needed to increase shelf life, conserve quality and increase the acceptability of insect food products. Regulatory frameworks need to be developed. The close collaboration of government, industry and academia will be essential for success.

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Soil security, an emerging existential environmental challenge

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Six major existential environmental challenges facing the planet earth and humanity are food security, water security, energy security, climate change abatement, biodiversity protection and ecosystem service delivery. Soil has an important role to play in all these challenges considering the seven important functions that soils play. They are (i) biomass production, (ii) storing, filtering and transforming of nutrients, substances and water,

(iii) biodiversity conservation (iv) physical and cultural environment, (v) source of raw materials, (vi) carbon pool and (vii) archive of geological and cultural heritage. Over the years there has been a decline in these soil functions which affect its ability to provide ecosystem services and goods. Without secure soil, it is not possible to ensure supplies of food and fiber, clean fresh water or biodiversity. It also reduces the soil to act as a sink in carbon cycle and removes a core platform for the production of renewable energy sources.

All these promote 'soil security' as seventh existential environmental challenge. Soil security refers to the maintenance and improvement of world's soil resources so that they can continue to provide all the above mentioned seven functions. Thus, soil security can be defined as the maintenance and improvement of the world's soil resources to produce food, fiber and freshwater, contribute to energy and climate sustainability, and maintain the biodiversity and the overall protection of the ecosystem. Here, security is used in the same sense that it is used for food security or water security or energy security. As in the case of food, water and energy security, here also we have to define and establish a set of dimensions.

Soil degradation, the decline in soil function or its capacity to provide economic goods and ecosystem services, is a global environmental threat and the natural capital of soil has been undervalued. A degrading soil stock will directly impact food, fiber and fresh water provision. Soil forms the basis of the landscapes and ecosystems that provide biophysical, economic, cultural and spiritual services to humanity. Though soil contains at least twice as much carbon as the atmosphere and cycles it over much longer time scales, soil is frequently left out in climate change debates. Soil contains 98 per cent of genetic diversity in terrestrial ecosystems, however it is not given the requisite attention in many meetings and conventions.

The key aim in securing soil is to maintain and optimize its functionality: its structure and form, its diverse and complex ecosystems of soil biota, its nutrient cycling capacity, its roles as a substrate for growing plants, as a regulator, filter and holder of fresh water, and as a potential mediator of climate change through the sequestration of atmospheric carbon dioxide.

In the domain of food security, important functions that soils provide are biomass production and its ability for filtering, storing and transforming nutrients, substances and water. In water security, water retention, filtering and transforming compounds and nutrient cycling are soil's major functions to provide water for human, biomass production and ecosystem needs. In the domain of energy security, competitive uses of soils to produce energy such as crops for biofuels in addition to food production are of great concern.

In climate change abatement, managing the soil functions that affect the potential for carbon sequestration could not only mitigate climate change, but also positively affect agronomic productivity and global food security. Soil is the habitat for largest gene pool and diversity of species and these organisms participate actively in soil processes that affect its formation and function. Biodiversity contributes to nutrient and water efficiencies, improves soil structure and protects against soil-borne diseases.

The term ecosystem service emerged in the early 1980s and can be defined as the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly. It includes supporting, provisioning, regulating and cultural services. For soil the supporting service is concerned with providing support for plants, delivery of plant nutrients, and a gene pool. The major element and hydrological cycles, and disposal of wastes are embraced as regulating services. Its excavation for building materials is an example of provisioning service, while spiritual value, archeological preservation and heritage are cultural services.

Five dimensions that need to be assessed to secure a soil are the five 'C's namely capability, condition, capital, connectivity and codification. Capability of any soil refers to its potential functionality in agricultural development and land use. It is largely defined by a set of very slowly varying soil characteristics such as profile form and texture. The land evaluation systems like the land capability classification (LCC) developed during 1970s is an example of assessment of capability of a soil. Soil condition can be defined as the capacity of a soil to function, within land use and ecosystem boundaries, to sustain biological productivity, maintain environmental health, and promote plant, animal, and human health. Soil condition can be generally referred as soil health. In contrast to capability, the condition of a soil is contemporary and is measured on a short-term management time scale. Management and

intended land use affect soil condition and the productivity of a soil is the sum of its capability and condition. The condition of a soil can be assessed by a set of quickly varying physical, chemical and biological indicators.

Soil security is a concept of securing soil for the sustainable development of humanity and hence more than the biophysical stocks, functioning and ecosystem services, we also need to consider the economic, social and policy dimensions. Soil is considered as a natural capital of physical and biological resources and includes renewable (living species), non-renewable (sub-soil assets such as petroleum, coal), replenishable (potable water, fertile soils) and cultivated (crops and forest plantations) natural capitals.

Connectivity brings a social dimension around soil. It is concerned with whether the person who is responsible for the soil in any given piece of land has the right knowledge and resources to manage the soil according to its capability.

No matter how secure soil may be through proper management of condition, valuing the capital and connectivity to society, there still remains the need for public policy and regulation, at least as a safety net, and at best to synergise and positively feed back into the other aspects of soil security (dimensions). It is very important that planners and policy makers seriously understand the social welfare provided by ecosystem services of soils.

Measures to secure the soil may at many times be uneconomical for the common man and hence those who are actively involved in different activities towards ensuring soil security must be rewarded with financial incentives as well as other benefits. It is high time that soil security must find a place in our plan and policy documents in order to circumvent the six major existential environmental challenges facing humanity today.

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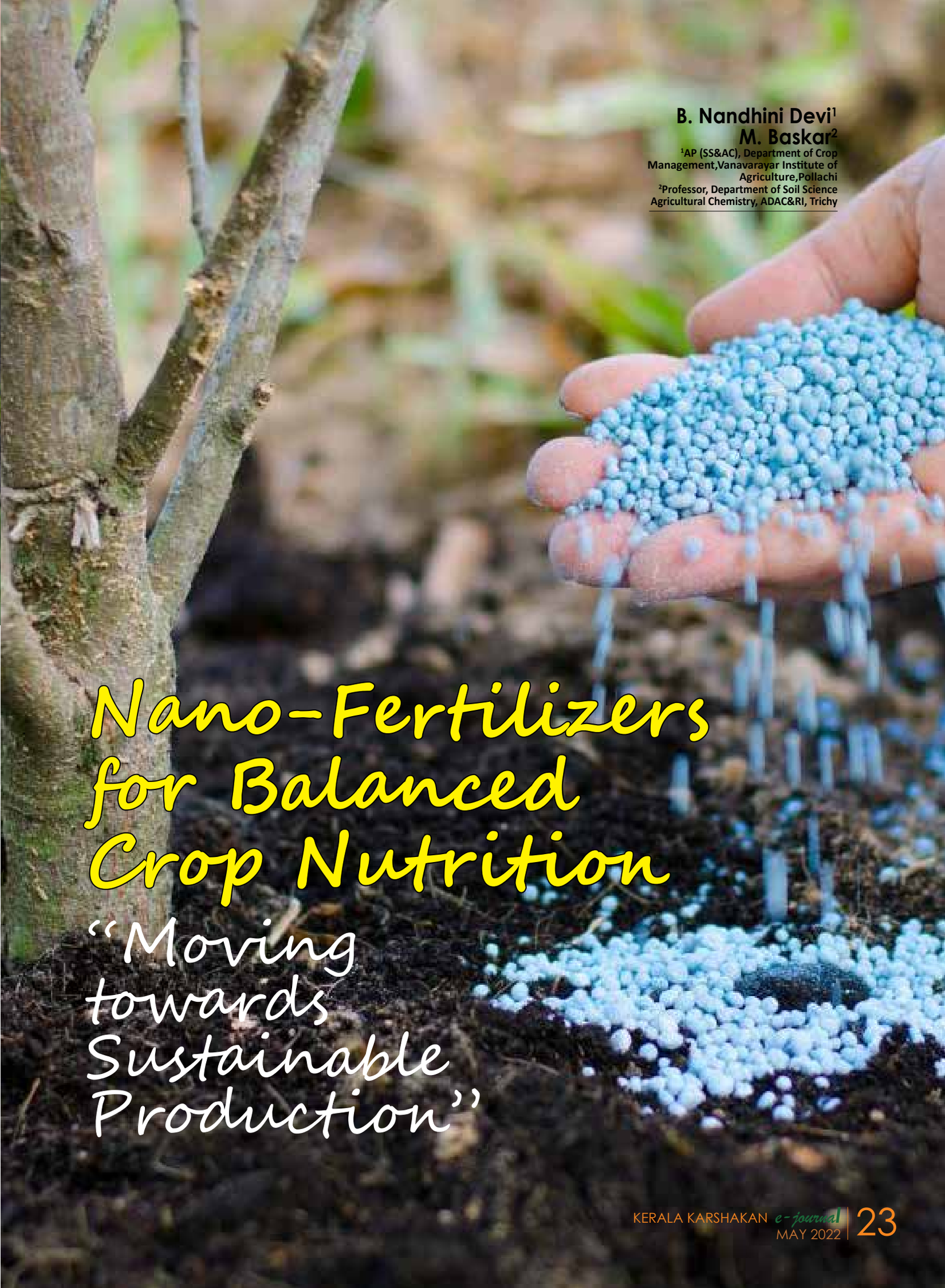

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Nano-Fertilizers for Balanced Crop Nutrition

"Moving towards Sustainable Production"

Abstract

Fertilizers play a pivotal role in improving the productivity across the spectrum of crops. The nutrient use efficiencies of conventional fertilizers hardly exceed 30-35%, 18-20% and 35-40% for N, P and K which remained constant for the past several decades. Nano-fertilizers intended to improve the nutrient use efficiencies by exploiting unique properties of nano-particles. The nano-fertilizers are synthesized by fortifying nutrients singly or in combinations on to the adsorbents with nano-dimension. Both physical (top down) and chemical (bottom up) approaches are used to produce nano-materials and the targeted nutrients are loaded as it is for cationic nutrients (NH4+, K+, Ca++, Mg++) and after surface modification for anionic nutrients (NO3-, PO4--, SO4--). Nano-fertilizers are known to release nutrients slowly and steadily for more than 30 days which may assist in improving the nutrient use efficiency without any associated ill-effects. Since the nano-fertilizers are designed to deliver slowly over a long period of time, the loss of nutrients is substantially reduced vis-a-vis environmental safety. The work done on nano-fertilizers is very limited across the globe but the reported literature clearly demonstrated that these customized fertilizers have a potential role to play in sustaining farm productivity. This topic focuses on macro and micronutrient carrying nano-fertilizers and their application in achieving balanced crop nutrition.

The extent of multi-nutrient deficiencies is alarmingly increasing year by year which is closely associated with a crop loss of nearly 25-30%. The extent of nutrient deficiencies in the country is of the order of 90, 80, 50, 41, 49 and 33% for N, P, K, S, Zn and B, respectively. Thus from all sources, the country will have to arrange for the supply of about 40-45mt of nutrients by 2025.

Fertilizers are inevitable factor in improving soil fertility and productivity of crops regardless of nature of cropping sequence or environmental conditions. It has been unequivocally demonstrated that one third of crop productivity is dictated by fertilizers besides influencing use efficiencies of other agriculture inputs. In the past four decades, nutrient use efficiency (NUE) of crops remained constant despite our relentless efforts. The nutrients that are left the soil may enter into the aquatic environment causing eutrophication. In addition to the low nutrient efficiencies, agriculture in developing countries including India is facing a problem of low organic matter, imbalanced fertilization and low fertilizer response that eventually caused crop yield stagnation.

Nanotechnology deals with particles measuring a dimension of one-billionth of a metre or one-millionth of amm. This enables atom-by-atom manipulation and thus processes & products evolved from nanotechnology are very precise& hardly possible to achieve through conventional methods. This fascinating field of science has been exploited widely in engineering, health, electronics and material sciences and agricultural scientists have begun to use it as a tool to improve the input use efficiencies by integrating nanotechnological approaches in the conventional production system. In this context, there would be greater importance of the information how to increase the nutrient use efficiency of fertilizers by nanotechnology in the coming years.

Nano-fertilizers are nutrient carriers of nano-dimensions ranging from 30-40 nm (10-9 m or one-billionth of a metre) and capable of holding bountiful of nutrient ions due to their high surface area and release it slowly and steadily that commensurate with crop demand. Researchers reported that nano-fertilizers and nanocomposites can be used to control the release of nutrients from the fertilizer granules so as to improve the nutrient use efficiency while preventing the nutrient ions either get fixed or lost to the

environment. Nano-fertilizers have high use efficiency and can be delivered in a timely manner to a rhizospheric target. There are slow-release and super sorbent nitrogenous and phosphatic fertilizers. Some new-generation fertilizers have applications from crop production & on long-duration human missions to space exploration. Recently, studies have shown the nano-clay based fertilizer formulations (zeolite and montmorillonite with a dimension of 30-40 nm) are capable of releasing the nutrients particularly N for a longer period of time (> 1000 hrs) than conventional fertilizers (< 500 hrs). Clay particles are adsorptive sites carrying reservoir of nutrient ions. Major portion of nutrient fixation occurs in the broken edges of the clay particles. Zero valence nano-particles adsorb on to the clay lattice thereby preventing fixation of nutrient ions. Further, nano-particles prevent the freely mobile nutrient ions to get precipitated. These two processes assist in promoting the labile pool of nutrients that can be readily utilized by plants. Fertilizer particles can be coated with nano-membranes that facilitate in slow and steady release of nutrients. This process helps to reduce loss of nutrients while improving fertilizer use efficiency of crops.

Nano-composites have been developed in order to supply wide range of nutrients in desirable properties. These compounds are capable of regulating the inputs depending on the conditions of soil or requirement of crops. Zinc–aluminium layered double-hydroxide nano-composites have been used for the controlled release of nutrients that regulate plant growth.

The addition of nanocomposites benefits the soil, and raises the utilized efficiency of fertilizer because of its excellent characteristics. The physical adsorption and chemical combination occurred between nutrient elements and nanocomposites due to surface reaction and small size reaction of nanocomposites. They formed efficient multifunctional fertilizer, which heightened the adsorption of nutrient elements by plants, lowered the leaching in soil, and the fixation of fertilizer in the soil. The nano-subnanocomposites significantly affected or controlled the structure and penetrability of the soil, increased the organic mineral granule of the soil, improved fertilizer storage and water holding capability in the soil, promoted action of microorganisms, regulated the ratio of C/N, enhanced the fertility of the soil and so on. Improved yields have been claimed for fertilizers that are incorporated into co-chleatenano-tubes (rolled-up lipid bilayer sheets). The release of nitrogen by urea hydrolysis has been controlled through the insertion of urease enzymes into nanoporous silica. Nano-silica particles absorbed by roots have been shown to form films at the cell walls, which can enhance the plant's resistance to stress and lead to improved yields.

Conclusion

Nanotechnology is an emerging field of science being exploited to derive solutions to highly complicated unresolved issues in engineering and biological sciences. In agriculture, nanotechnology is least investigated but the reported literature strongly suggest that nanoscience is expected play a critical role in developing smart delivery systems. This will enable the plants to produce larger biomass utilizing the available nutrients in the rhizosphere without associated ill-effects in the environment. Regulated and sustained release of nutrients assists in improving the nutrient use efficiencies. Though nutrient release is regulated through physical and chemical processes, the biological significance of nutrient release is yet to be clearly understood. More research is needed to address the smart delivery of nutrients, nutrient interactions at the physiological and molecular levels, antagonistic and synergistic interactions among nutrients and biosafety of nano-fertilizers besides long-term impact of nano-fertilizers on physical, chemical and biological properties of soils are yet to be determined.

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Crop Wild Relatives (CWRs) refer to the progenitors of crops as well as other species that are closely related to them. CWRs have been of great importance to plant breeding and are being consistently used in crop improvement since early 1980s. Several classic examples of benefits obtained through use of CWRs are available in multiple crops. The traits for which CWRs have been successfully used for crop improvement include primarily biotic stress tolerance (80% of total cases of successful utilization); remaining 20% were for abiotic stress tolerance, quality improvement, yield improvement and as source for Cytoplasmic Male Sterility (CMS). Prevalence of undesirable agronomic traits in the crosses derived using CWRs, is a major hindrance in their utilization.

Oryza nivara

IMPORTANCE OF CROP WILD RELATIVES IN CROP IMPROVEMENT

Table 1:List of CWRs of rice that have contributed to crop improvement (Source: Maxted and Kell, 2009 FAO publication)

CWR	Application(s)
Oryza australiensis	Brown plant-hopper resistance, bacterial blight
O.brachyantha	Bacterial blight
O.glaberrima	Stress tolerance, nutritional and grainquality improvement
O.grandiglumis	Grain quality improvement
O.glumaepatula	Yield improvement
O.glumaepatula,O.parennis	Cyto plasmic male sterility
O.longistaminata	Drough tresistance and yield increase
O.longistaminata,O.nivara,	Grassy stunt virus, bacterial blight,
O.officinalis,O.rufipogon	brown plant hopper resistance,white backed plant hopper
O.minuta	Bacterial blight
O.minuta	Improve dagronomic traits
O.nivara	Grassy stunt virus resistance
O.nivara,O.rufipogon	Grassy stunt virus resistance
O.nivara,O.rufipogon	Cytoplasmic male sterility
O.ridleyi	Bacterial blight, tungro, yellow stemborer and leaf folder resistance
O.rufipogon	High acidic sulphate content soil tolerance
O.rufipogon	Yield improvement
O.rufipogon	Rice stripenecrosis virus, soil borne diseases
O.rufipogon	Aluminium toxicity tolerance

Manihot glaziovii

Some examples for use in biotic stress tolerance

In the case of rice, the single source of resistance to Grassy Stunt Virus was an accession of *Oryza nivara* (CWR of cultivated rice), conserved at International Rice Research Institute, Philippines, which was originally collected from India. IR28, IR29, IR30,IR32,IR34,andIR36 are some of the major rice genotypes having this source for virus resistance. Similarly, *Lycopersicon pimpinellifolium* was a major source of resistance against several diseases affecting tomato. The resistance to Late Blight, a very devastating disease of potato was obtained from *Solanum demissum*.

The cassava mosaic disease and bacterial blight was controlled to a great extent in African countries by use of *Manihot glaziovii*, in varietal development. Banana crop also has a classic example of having Indian material as a major resistance source. The highly devastating Black Sigatoka disease was curtailed through the use of a CWR accession belonging to the species *Musa acuminata*, called 'Calcutta 4'.

Some examples for use in abiotic stress tolerance

In rice, drought tolerance has been conferred in cultivated varieties through genes introgressed from *Oryza longistaminata* and for tolerance against acidic soils, *O. rufipogon* was used as source. In tomato, *Lycopersicon chilense* and *L-pennellii* was used successfully as sources of drought and salinity tolerance. *M. angustiloba* and *M. davisiae* were used as the source of drought tolerance in Cassava whereas, for Banana, *M.balbisiana* and *M.nagensium* were the sources. Water logging resistance in cultivated banana was rendered from *M.itinerans*.

Use in other traits

CWRs also serve as a major source of cytoplasmic male sterility (CMS), a highly

Solanum demissum

desirable trait for hybrid seed production. China, the largest producer of hybrid rice, uses *Oryza sativa ssp.spontanea* as the CMS source in more than 90% of its hybrids. The CWR of Cassava, *Manihot oligantha* was used for doubling protein content in a Brazilian cultivar, whereas *M. tristis*, *M. carthagenensis* and *M.glaziovii* have been used for protein enhancement in several other cultivars. In tomato, its wild relative *Solanum habrochaites* was used for enhancing fruit colour, which is a very important trait for this crop.In pepper, *Capsicum frutescens* was used for successful yield improvement. Success stories are many in pulses also. In pigeon pea, *Cajanus lineatus* was used for introgression of cleistogamous trait and *C.scarabaeoides* for dwarfism.The nuclear and cytoplasmic male sterility traits in pigeon pea are also from its CWRs viz., *C. cajanifolious*, *C. scarabaeoides*, *C. sericeus* and *C. volubilis*. (Details of extensive use of CWRs in rice crop have been depicted in Table 1.) India has several rich CWR resources which have high potential for use in crop improvement, but are yet to be successfully utilized. *Vigna mungo var. silvestris* and *V. radiata var. sublobata*, wild relatives of *cultivated V. mungo* (urd) and *V. radiata* (mung), respectively from Ghats and adjacent areas, exhibit tolerance to yellow mosaic virus; *Cicer soon garicum* (*C. microphyllum*), a wild relative of *C.arietinum* (chickpea) from high altitudes of Himalaya exhibit cold hardiness and more seeds/ pod; *Sesamum laciniatum* from coastal Andhra and Tamil Nadu, a wild relative of cultivated *Sesamum indicum* (sesame) have potential for resistance against diseases and pests; *Abelmoschus tuberculatus*


Musa acuminata

and *A. manihot*, wild relatives of *Abelmoschus esculentus* (lady's finger) from northern India, have tolerance/resistance to yellow vein mosaic virus and fruit borer.

CWRs prevalent in Kerala

Kerala too, has an abundance of CWRs in multiple crops. The Silent Valley area, Nilambur and Wayanad are home to several CWR species. Some of the identified CWRs prevalent in Kerala is listed here. Cinnamon(*C.travancoricum, C. zeylanicum, C. filipedicellatum* and *C.walaiwarense*), Curcuma (*Curcuma amada, C. aromatica, C.cannanorensis, C. malabarica, C. neilgherrensis, C. thalakaveriensis*), Piper (*P. nigrum* with bisexual flowers, *P.hapnium*), Sesamum (*S. prostratum, S. laciniatum, S. mulayanum*), Garcinia (*Garcinia imbertii*), Solanum (*Solanum nigrum* and *S. torvum*), Syzigium (*Syzygium bourdillonii* [species rediscovered after 100 years]), Dioscorea (*Dioscorea tomentosa, D. wallichii* and *D. oppositifolia*) and Vigna(*Vigna bourneae*, *V. radiata var. sublobata*, *V. hainiana* and *V.trilobata*). *Oryza rufipogon*, CWR of rice is prevalent in weedy form in South-central Kerala. *Cucumis prophetarum* a CWR of cucurbit family has been found in various tropical parts of Kerala. This list is only a tip of the ice-berg. Concerted efforts should be made by involving local communities, for collection, conservation and documentation of available CWRs in all relevant crops.

There is also a need to explore the scope of in situ conservation in cinnamon and curcuma, for which Kerala has very high diversity of CWRs.

Genebanks play an important role in enhancing utilization of CWRs through effective collection and conservation of various species belonging to primary and secondary genepools of each crop.

Every Genebank needs to identify gaps in their CWR conservation status and develop strategies to overcome these. It is important to document and conserve these treasure troves of valuable genes, before they perish due to habitat destruction. Further, with the advent of high-throughput genotyping and next generation sequencing technologies, a huge amount of genotype data can be generated on these conserved accessions, which would in turn enable its effective introgression in breeding programmes.

MACADAMIA NUT
THE QUEEN OF NUTS

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Macadamia nut (*Macadamia sp.*) is mainly cultivated for its edible nutsand commonly known as "Queensland nut or Australian nut belongs to family Proteaceae and having diploid chromosome number 2n=48.

There are seven species of Macadamia nut, namely *Macadamia claudiensis, M. grandis, M. integrifolia, M. jansenii, M. ternifolia, M. tetraphylla, M. whelaniiseven*. Among them, only two species, *M. integrifolia* (smooth-shell) and *M. tetraphylla* (rough-shell) are of commercial importance and grown commercially. The remaining species in the genus produce poisonous or inedible nuts.

Production statistics of macadamia

Macadamias are commercially grown in Australia, Hawaii, South Africa, Malawi, Kenya, Brazil, Fiji and California. In India, the ideal location for growing on a commercial scale is available in Tamil Nadu, Karnataka, Kerala, Andhra Pradesh, North-Eastern States, Himachal Pradesh and Uttar Pradesh. Worldwide the production of macadamia nut seeds accounts for 48,544 metric tons (kernel basis), (International nuts & dried fruits statistical yearbook 2017). 70 per cent of

Flower morphology

world macadamias production is from Australia, South Africa and Kenya. Australia ranks first in the production, accounting for 15,600 MT, followed by South Africa and Kenya (International nuts & dried fruits statistical yearbook 2017). The global demand for macadamia nuts is growing over the years and its production has not kept pace with demand. The international price of macadamia nut is U.S. dollar 14 per kg. Hence, farmers are enthusiastic to grow exotic fruits such as macadamia nut for crop diversification and economic returns.

Botany of macadamia nut

Macadamia is a tropical evergreen tree, having medium statured spreading habit reaching 5-10 metres of width and 2-12 metres tall. Leaves are linear obviate, 10-15 cm long, with a sharp tip with or without spines. Flowers are borne on long, fragrant racemes (8-10 cm) and flowering occurs during mid-winter. Each raceme produces 100 to 300 sweet scented white blossoms. Flowers are bisexual, most cultivars are self fruitful, but yields better when cross pollinated. Two to ten nuts per inflorescence develop into spherical nuts encased in green fibrous husks; inside which contains smooth brown very hard shells enclosing nut kernels. Fruit is a drupe and round with a conical tip. Depending upon the cultivar type, its shell possesses a smooth or rough outer surface of 0.5 to 1-inch nut size. Macadamia kernel features a smooth buttery surface and sweet, nutty taste.Harvested 7-8 months after flowering.

Climatic requirement

Macadamia are more adaptive to cooler climate and thrives well in a region with temperature ranging between 13 – 31 ^{0}C and mean annual rainfall of about 125 cm. It generally prefers well-drained loamy soils. Macadamia is propagated through seeds and vegetative means. Trees begin to bear within 4-5 years and have productive lifespan of 50-75 years.

Tree and leaf morphology

Nutritional contents of macadamia nut

Sweet, delicious and flavourful macadamia nut is one of the best edible nuts packed with important health-benefiting nutrients. They contains higher amount of oil (High level of mono-unsaturated fatty acids). The human nutrition research in Australia has reported that, the macadamia nut has the capacity to lower the total and LDL cholesterol levels in blood. Macadamia nuts are rich source of energy. 100 grams of nuts provide about 718 calorie per 100 g, which is one of the highest calorific values for the seeds and kernels.

They are packed with many health-benefiting nutrients, minerals, antioxidants and vitamins that are essential for optimum health and wellness.100 grams of macadamia provides 8.6 g or 23 per cent of daily recommended levels of dietary fiber. Additionally, they are an excellent source of phytosterols such as ß-sitosterol and having no bad cholesterol.

The nuts are good source of monounsaturated fatty (MUFA) like oleic acid (18:1) and palmitoleic acids (16:1). Macadamias are an excellent source of minerals such as calcium, iron, magnesium, manganese, zinc and selenium which is a cardio-protective trace element and an essential antioxidant co-factor for the glutathione peroxidase enzyme. Furthermore, the nuts are also rich in many important B-complex vitamins that are vital for metabolic functions. 100 grams of nuts provide 15 per cent of niacin, 21 per cent of pyridoxine (vitamin B-6), 100 per cent of thiamine and 12 per cent of riboflavin. These fat-soluble vitamins are potent antioxidants and help protect cell membranes and DNA damage from harmful oxygen-free radicals.

Health benefits of macadamia nut

- Boost the heart health
- Reduces the risk of metabolic syndrome
- Helps in weight loss
- Improves digestive health
- Providing anticancer properties
- Improves the brain function
- Reduces bad cholesterol level
- Improves bone and teeth health
- Relieves stress and inflammation
- Prevents risk of anaemia
- Prevents diabetes.

Bougainvillea

One plant with many use

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The name *Bougainvillea* comes from a French navigator and military commander "Louis Antoine de Bougainville', who was the first European to take note of the plant in Brazil in 1768. The genus *Bougainvillea* comprises of 15 species and belongs to the family Nyctaginaceae. It is popularly known as Glory of garden and flowers are valued for their colorful bract.

Out of the 15 species in the genus only 4 species namely *Bougainvillea spectabilis*, B. glabra, B. peruviana and B. buttiana possess colorful bracts and have ornamental value.

Important species

B. spectabilis

This species was the first identified by German botanist "Carl Ludwig Willdenow" from Brazil. This species is popular due to heavy leaves and stems. The flowering bracts are red, dark pink, or purple, while the small flowers are cream colored and the colorful bracts appear up and down the branches. The bloom cycle is seasonal, with plants blooming after the dry season or after a cool spell.

B. glabra

This species is evergreen climbing and introduced from Brazil, The elliptical leaves are green orvariegated, with a glossy sheen.They are glabrous (smooth, hairless), find some puberulence (presence of smallhairs). Its bracts come in manysizes and shapes. Typically they are triangular and purple or mauve, and whitein colour.

B. peruviana

It is thought that this climbing, evergreen member from peru. The long, thin leaves are strongly ovate and glabrous. The rounded bracts are magenta to pink and may have some distortion or wrinkling, and the flowers are yellow.This species is not as vigorous as some of the hybrids and often requires pruning to promote substantial branching. The plants may bloom several times a year if subjected to dry periods between flushes.

B. buttiana

This species is native to Colombia; and probably a cross between B. glabra x B. peruviana. There are several attractive cultivars like Golden Glow, Louis Wathen, Mrs. Butt, Mrs. Mc Clean, Praetoria, Crimson Lake etc., In this species the cultivar "Scarlet Queen" was first introduced in India in 1920.

Important cultivar

Mahatma Gandhi (pink tinged mauve color) Partha (deep orange color) Usha (magenta rose color) Baby Margaret Rose (Red color) Sonnet (orchid purple color) Srinivasa (orange color) Jubilee (purple color) Lalbagh (brick red to orange color)

Landscape uses

Bougainvillea as a Pot plant

Sholay (deep rose)

Plant description

Bougainvillea is a tropical and subtropical woody, evergreen, shrubby vine. Typically multi-trunked or with clumping stems, it has a spreading, round plant habit with a height of up to 3 to 20 feet. As they age, the stems turn from mid-green to dull green-brown. Bougainvillea is deciduous when grown in areas with a long dry season. Their colorful "flowers" are really bracts or modified leaves, 1⁄2–2-inch long structures to which the true flowers are attached at the mid-rib. Bracts may retain their

color for several months after the flowers have finished, gradually fading to resemble the color and texture of paper.

Leaves are simple and alternate, with an undulate leaf margin, globular, elliptical, obivate, ovate or cordate. Leaves are mid- to deep green, although some cultivars have variegated foliage. The fruit is an elongated achene less than 1⁄2 inch long. It is rather inconspicuous, not showy, and has a dry, hardfruit cover.

Growing condition:

Bouganvillea plant need full sun light and High light intensity for good flowering. Low light and shady areas are not suitable, as the plants will drop their bracts. Bougainvillea can tolerate a hot temperature up to 35-40°C. Bougainvillea grows well in rich, well drained, acidic soil with a pH of 5.5–6.0, It does not thrive in soil that is constantly wet.

Landscape uses

It can be used as Shrub, Climber, Pot culture, Topiary, Hedge, Standard, Mass planting, Screening plant, Bonsai and Ground covering.

Cultural operation:

Watering

Bougainvillea tolerates drying and if possible irrigation should be adjusted to be a little on the dry side. They aresensitive to overwatering but should not be allowed to completely dry out.

Fertilizer

For best results, use organic fertilizer amendments At planting, amend the soil with a fertilizer high in phosphate. Too much fertilizer will promote vegetative growth and inhibit blooming.Bougainvillea needs regular fertilizing with formulation shaving NPK ratios of 1:1:1 or 2:1:2.

Pruning

Bougainvillea responds well to pruning and to prevent overcrowding,cut out any


Cultural operation

Pruning

unneeded shoots. Regular pruning is necessary to shape the plant and direct its growth because the shoots often grow vigorously. Pruning should be done after flowering has finished, as this encourages the new growth on which the next flush of flowers will occur.

Flowers are borne on new growth, so pinching back and pruning is necessary to induce new growth.

Bougainvillea as a Pot plant:

Light

Plants should be placed in bright light or near a window with at least 4000 foot-candles of light. low-light interior environments leadto leaf drop and Bracts will be a lighter color than those grown in full sunshine.

Media

Any well drained potting medium is suitable for growing bougainvillea. Peat and perlite in the ration of 1:1 is best suitable. The media needs to be well drained to prevent a poor root system and reduced flowering. Avoid media with high peat content and water-retention levels.

These types of media retain too much water and will contribute to rootrot. Media pH should be 5.5–6.0.

Watering

Plants should be watered when the medium surface becomes dry. The amount of water needed depends on the medium type, environmental conditions, size of the plant, and pot size.

Fertilizing

In pot cultivation, an evenly balanced fertilizer (8-8-8 or 10-10-10 NPK) can be applied every three months. Water-soluble fertilizer formulations canbe applied weekly or bi-weekly at half-strength to provide a low nutrient concentration.

Pruning

Frequent pruning helps maintain the desired plant size and shape and keeps new growth soft and thorns to a minimum. Frequent cutting back promotes constant flushing of new growth and flowers.

Prune and shape plants after they flower, keeping them about 3 feet high and removing all spindly and twiggy growth. Cut out any weak or damaged growth.

Propagation:

5-6 cm length and more thick Stem cuttings having at least three to five nodes are best for propagation. If the stems are more mature, rooting hormone such as IBA (3-indolebutryic acid) at 2000–6000 ppm is commonly used

Pests: Aphids, Mealy bug, Scales, white fly and Bougainvillea loopers

Diseases: Leaf spot, Root rot and Chlorosis.

SNAILING THEIR WAY THROUGH THE CROPS

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Introduction:

Snails *(class Gastropoda)* are among the most destructive pests found in farms, plantations, gardens and landscapes. According to the Carnegie Museum of Natural History, there are about 35,000 species of land snails in the world and more yet to be traced and identified. In India alone, according to estimates, there are about

Macrochlamysindica

Subulinaoctona

2,000-3,000 species of land snails.

Giant African Snails *(Achatina fulica)* is one of the four species of giant snails belonging to the Achatinidae gastropod family native to Africa and is listed as one of the top 100 invasive species. The giant African land snail is locally known as shankuhoola (conch worm) due to the shape of its shell. This is a common sight in Western Ghats. Kerala one of the most active biological hot-spots in the world and rain forests helped preserve most of the endemic fauna. Apart from that, Indian land snails, especially *Macrochl amysindica, Glessulasp.* and *Subulinao ctona* were also commonly observed.

Identification and botany:

A fully grown Giant African snail measures 20 cm in length, 7 cm in thickness, and can weigh up to 750 gm. The shell length of these snails ranges from 5 cm to 10 cm, though some adults may exceed 20 cm. These molluscs move by gliding along on a muscular foot. This muscle constantly secretes mucus, which facilitates their movement and later dries to form the silvery slime trail that signals the recent presence of the pest. This mollusc possesses a well-developed tongue (called radula) covered with tiny spikes. It is classified as an obligate-out crossing hermaphrodite, which means that just one externally fertilised snail can establish a population.

Reproduction:

The snails begin laying eggs at six months of age and can lay around 100 eggs in their first year, and up to 500 in the second year. Their life

expectancy is around five years, and one snail can produce up to 1,000 eggs by then. Adults tend to lay more clutches of eggs when subjected to erratic rainfall patterns and the hatched snails tended to be weaker and less adaptable to harsh climatic conditions. Whereas, when subjected to regular watering, the adults grow healthier, lay lesser eggs and the hatchlings were of superior quality. Darker coloured eggs can be identified as close to hatching (Flint, 2018).

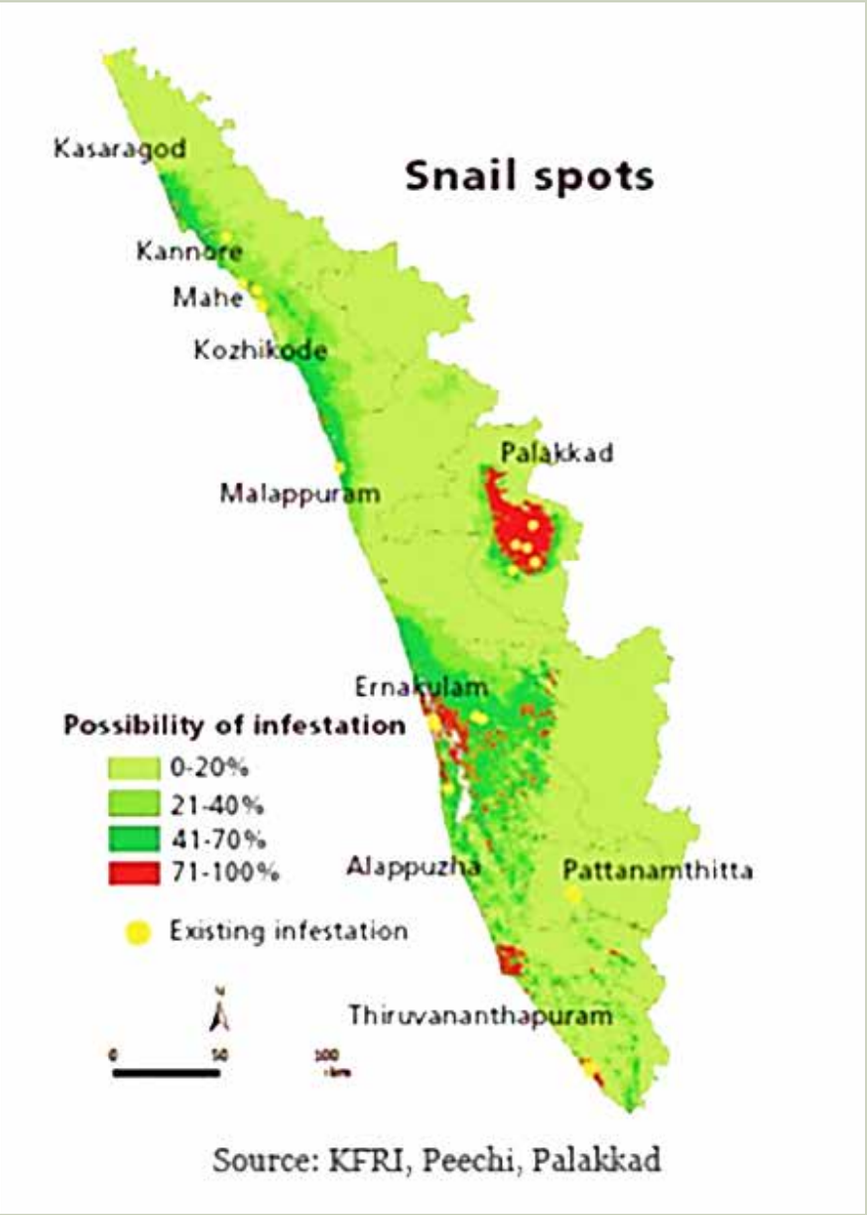
A snail hibernates in winter, emerges with the summer showers and multiplies as soon as monsoon sets in. Snails prefer wet weather but can seal themselves to prevent water loss and become dormant during dry spells. Snails are mainly active at night, which helps preserve water balance, a critical survival factor for these animals. Aestivating during the summers and hibernating

Achatinafulica

through the winters, Indian land snails are active only during the monsoons and reproduce only through late May to early August. Certain species such as *Macrochlamysindica* tend to migrate in groups towards greener pastures or a year-round source of water.

Entry and distribution:

Konni in Pattanamthitta district, Kerala once famous as a centre for taming elephants is now reputed for having a multiplying population of Giant African Snails *(Achatina fulica)* which were originally from Kenya and Tanzania. This snail, a major problem in kerala, may have found its way from Myanmar, where 85% of the timber import to India originates. The depot at Willingdon Island in Ernakulam, where the imported timber is unloaded from ships, is heavily infested with giant snails since



the past few years.

Following globalisation, boom in export and import of timber and neglected quarantine procedures in the 1980s helped distribute the gastropodin Tamil Nadu, Karnataka and the North East. Since the giant snail is an exotic species, its natural predators do not exist that resulted in their unhindered multiplication and invasiveness.

Damage:

1. To humans:

Snails are the obligate intermediate hosts of the rat lungworm, *Angiostrongy luscantonensis*. This nematode is the causative agent of human angiostrongyliasis and the most common cause of human eosinophilic meningoencephalitis (Robert et al., 2013). Humans can become infected by eosinophilic meningoencephalitis through accidental consumption of snails & slugs (Hollyeret al., 2010). According to some reports at Kerala Forest Research Institute (KFRI), in the past 5-6 years, seven children and at least one adult have been reported to have contracted meningitis through contact with giant African land snails.

Adult Subulina octona,is a roundworm host and its slimy secretion causes itching, discolouration of skin and nausea.

2. To plants:

The snails devour 500 types of vegetation. They create irregular holes with smooth edges on leaves and flowers by scraping with their rasp-like tongues. Snails prefer succulency, making them primary pests of seedlings (including turfgrass), herbaceous plants; ripening fruits close to ground, young plant bark and foliage. Citrus are especially susceptible to damage.

The giant African snail, in particular, devours crops like paddy, basil, beans, cabbage, dahlia, delphinium, hosta, lettuce, marigolds, strawberries, and many other vegetables preferring the families Cruciferae, Leguminosae and Cucurbitaceae along with mulberry and tea. Snails can be destructive in bean cultivation, particularly during the first 20 days.

Coffee plantations in northern parts of Kodagu district in Karnataka have been troubled by an infestation of giant African land snails in recent years. Planters lose up to Rs 12,000 per acre in efforts to get rid of the pest. In 2017, 300 acres in 45 plantations in Shanivarasanthe area of northern Kodagu were severely affected by this mollusc. Snail and slug damage can be confused with feeding by other pests such as earwigs, caterpillars, or other chewing insects. Glessula sp., however, has adapted itself to eat man-made products and it is often

Lower Impact Pesticide Snail and Slug Treatments

Treatment	Hazards	Formulation
Bordeaux Mixture	A mixture of copper sulfate and lime, it poses a moderate acute oral toxicity risk. Toxic to fish, invertebrates, and aquatic organisms. Brush a Bordeaux mixture onto tree trunks to repel snails; one treatment should last a year.	Dust, Spray
Boric Acid	Boric acid and other borates occur naturally in the diet and have relatively low acute toxicity. They are not absorbed through the skin; however, ingestion of small amounts of boric acid every day over several months has been shown to reduce sperm counts in laboratory animals. Borates are toxic to plants.	Bait pellets, Granules, Dust
Diatomaceous Earth	Causes lung irritation when inhaled. Long-term exposure to diatomaceous earth dust is associated with lung cancer in occupational settings.	Dust
Iron Phosphate	Low acute toxicity to humans, pets and wildlife. Pets that eat bait may get an upset stomach.	Bait pellets, Granules

Pesticide Snail and Slug Treatments With Significant Adverse Effects

Treatment	Hazards	Formulation
Carbaryl	Toxic to the nervous system of pets, people, and bees. Classified as a likely carcinogen by the EPA. Carbaryl is often added to metaldehyde bait to increase its toxicity. Highly toxic to bees and other beneficial insects.	Bait Pellets
Metaldehyde	Moderate acute oral toxicity for humans. Metaldehyde is toxic to dogs, cats and birds. Pelleted baits can cause non-target poisoning in pets and wildlife.	Bait Pellets, Granules, Dust, Spray
Methiocarb	High acute oral toxicity and moderate acute inhalation toxicity. Highly toxic to birds, bees and other beneficial insects. Methiocarb is also highly toxic to aquatic species.	Bait Pellets, Granules, Powder

(Source: National Pesticide Information Center, California)

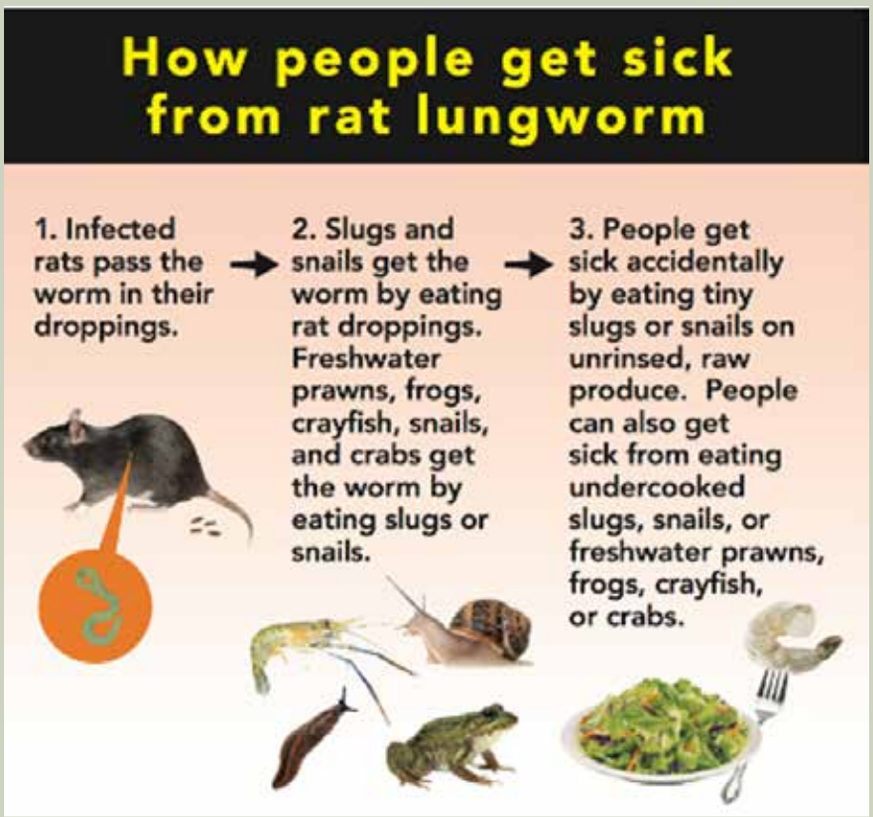
seen thriving on nothing but moist paper and cardboards.The snails like to nibble on lime and cement walls, in their search for calcium for their shells.

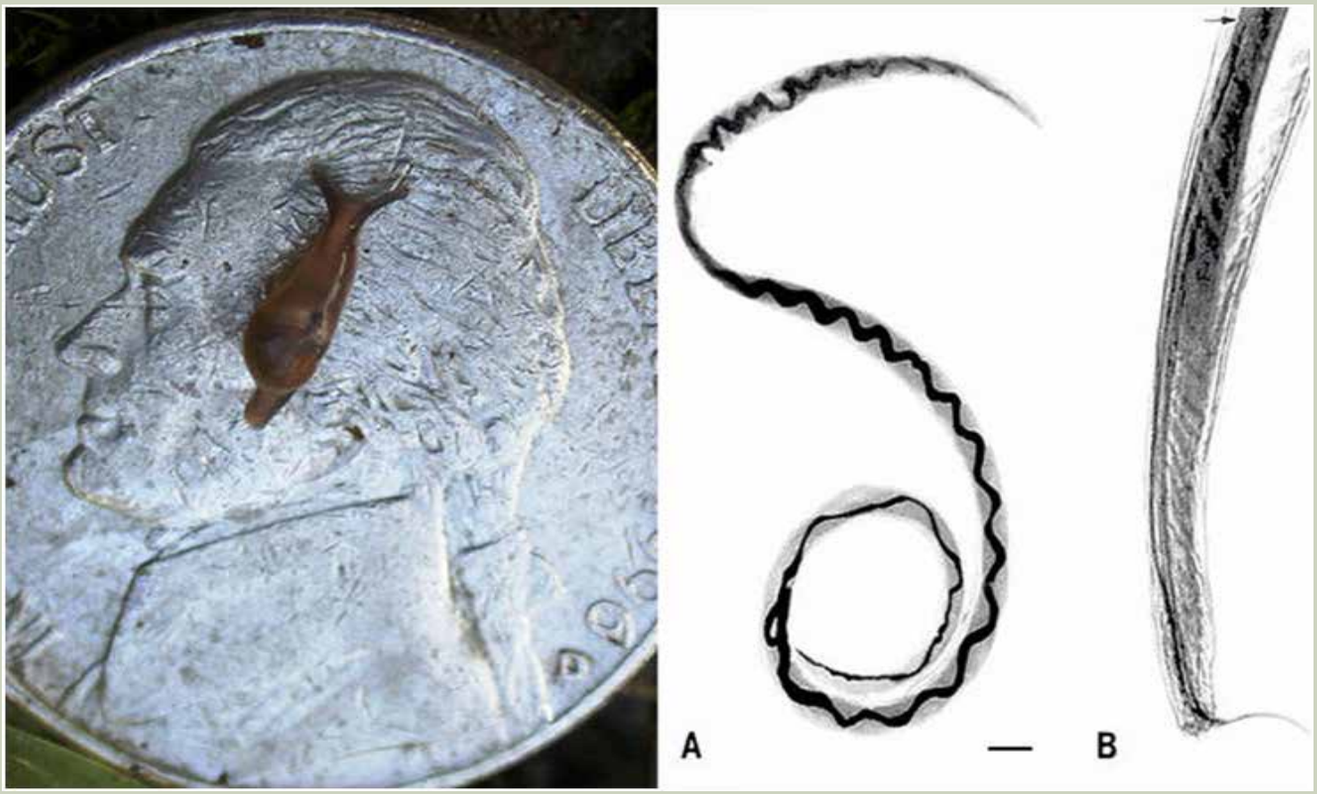
Management:

Snails can be controlled indirectly by reducing their habitat or directly by removing them. One of the reasons for the snails making a comeback each year in increasing numbers is slackening of vigilance once the snails go into hibernation.

1. Cultural control:

A good method for reducing snail populations is to limit the number of moist hiding places and breeding sites viz., unnecessary ground cover, small pools, vegetation, heaps of waste, rocks and fallen wood.





Conversely the same could be used to lure and destroy them. Drip irrigation will make the habitat less favourable for these pests. Solarizing the soilis a good way to kill eggs in raised beds. Avoid minimum tillage and straw-retention techniques as they encourage these pests to survive and make seedlings more susceptible to damage.

2. Resistant plants:

Most ornamental woody plants and ornamental grasses can be a hiding place for snails. Choose plants that are not attractive to snails, such as highly scented foliage plants (lavender, rosemary, and sage) and some commonly grown plants (ferns, cyclamen, hydrangea, California poppy, nasturtium and lantana) (Wilen and Flint, 2018).

Saponins, tannins, alkaloids, alkenyl phenols, glycoalkaloids, flavonoids, sesquiterpene lactones and terpenoids have been found to be poisonous to snails at acceptable doses. Plants containing those compounds belong mostly to the families Euphorbiaceae, Phytolaccaceae, Polygonaceae, Rutaceae and particularly Mimosaceae, Papilionaceae and Caesalpiniaceae and are known to control snails.

3. Hand picking:

Regular hand picking helps in keeping the snails in check. Sprinkling the salt or coffee grounds on top of the soil will deter snails and aid in easy picking. The Coffee Board advocates the burial of dead snails in a pit that's one-and-a-half feet deep and applying salt over the dead ones. Drowning snails for several days in a covered bucket filled with soapy water or 15% salt water or 5 to 10% diluted ammonia solution is a convenient and safe way to kill snails.

It has been considered that hand-picking is impractical for most species except giant African snail, partly because they sometimes feed high in foliage and not encounter poison bait pellets applied on the ground. (Burch, 1960)

4.Barriers:

Copper foil or tape of at least 2 inches tall wrapped around planting boxes, headers, or trunks will repel snails until it becomes tarnished as copper reacts with the slime that snails secrete, causing a disruption in their nervous system similar to an electric shock.

Granular barriers like diatomaceous earth (1" high and 3" wide), sawdust, powdered lime, wood ash (15 cm wide) crushed eggshells, wood chips (5-6 cm wide and 1-2 cm high) and when applied as a continuous thick band about around a plant & area and kept dry, protects the plants from snails.

5.Biological:

Much of fauna depends upon snails as a source of food firefly larvae, frogs, toads,

A) Copper foil around the structure bottles, copper tape and mesh

B) Seedling Guards made from recycled plastic

rodents, salamanders, snakes and most importantly, birds, ground beetles, rats, toads, turtles, and both domestic and wild birds. As parrots and parakeets require lots of calcium in their diet, and in the wild, there is nothing richer in calcium than snail shells. Domesticated fowl (such as ducks, geese, or chickens) kept penned in infested areas can be effective snail predators that significantly reduce problems.

Under certain conditions the plant-eating Chinese grass carp *(Ctenopharyngodon idella)* may be suitable for the biological control of aquatic plants that may provide niche for snails in waterbodies.

Use of predators like devil's coach horse (Ocypusolens), a Staphylinid beetle and predatory decollate snail (Rumina decollate) to control snails especially young brown garden snails. Avoid snail baits as they will kill decollate snails.

6. Sprays:

Application of plant based sprays viz.,neem, coffee(double strength), *Artemisia absinthium,* garlic. Sprays containing silicate salts and copper (Bordeaux mixture, copper sulphate or copper oxychloride) can only be sprayed onto tree trunks and vine canes, not onto foliage.The KFRI has been spraying an organic decoction of tobacco mixed with copper sulphate on snails that are lured with crushed papaya and cabbage leaves as bait.

A mixture of half in half vinegar and water can also be sprayed on the plants. Liquid forms of metaldehyde are used as a foliar spray or pot drench but are not allowed on edible crops(South, 1992). Currently only one chemical molluscicide, niclosamide 0.6-1 mg/l is recommended to control snails with an exposure time of eight hours (WHO,1997).

7.Baits:

Snails can be lured and killed by using boards or pieces of plywood, overturned flowerpots, overturned melon rinds, or orange peels etc, that should be checked regularly (Port and Port, 1989).

Use of metaldehyde or iron phosphate or a chelated form of iron (sodium ferric EDTA) as active ingredient in baits are recommended to control the snails. Relative performance will vary by pest species (which can affect bait acceptance), bait formulation, and environmental conditions following application (eg., temperature and moisture), which affect survival associated with contact exposure to metaldehyde (Hollingsworth, 2009). The best time to bait is in autumn so that the adult snails get killed before they get a chance to lay their eggs.

A catch-and-kill bait method devised by the Central

a) Devil's coach horse (Ocypusolens) **b) predatory decollate snail (Rumina decollate)**

a) Turned-over board trap **b) Beer trap**

Coffee Research Institute in Chikmangalur district of Karnataka has been successful in killing 90% of snails.The bait is made of rice bran, jaggery, castor oil and thiodicarb mixed together and balls of it are placed between four coffee plants. They are even offering bait kits to all the affected planters at a subsidised rate of Rs. 100. The kit consists of a pair of gloves, 25 kg of rice bran, 100 g of Larvin branded thiodicarb, 3 kg of jaggery and 100 ml castor oil.

8.Traps:

Place beer traps or yeast mixture at soil level @ 6 traps per 200 m2 land and replace them every three days to control snails. Milk trap(mix 4 litres of water with 1 litre of milk and soak a piece of rough cloth) is spread to trap snails that can be collected and destroyed. Inverted melon rinds and wooden traps (12×15 inch boards at 1-inch from ground) also make good traps. Molluscicides that have sulfur as the active ingredient (e.g. Bug-Geta Snail & Slug Killer) also reduce feeding damage caused by snails and slugs, but to a lesser extent than the iron-based products.

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National Pesticide Information Center (California): Provides objective, science-based information about slug and snail pesticides and othercontrol methods to facilitate informed decisions.

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