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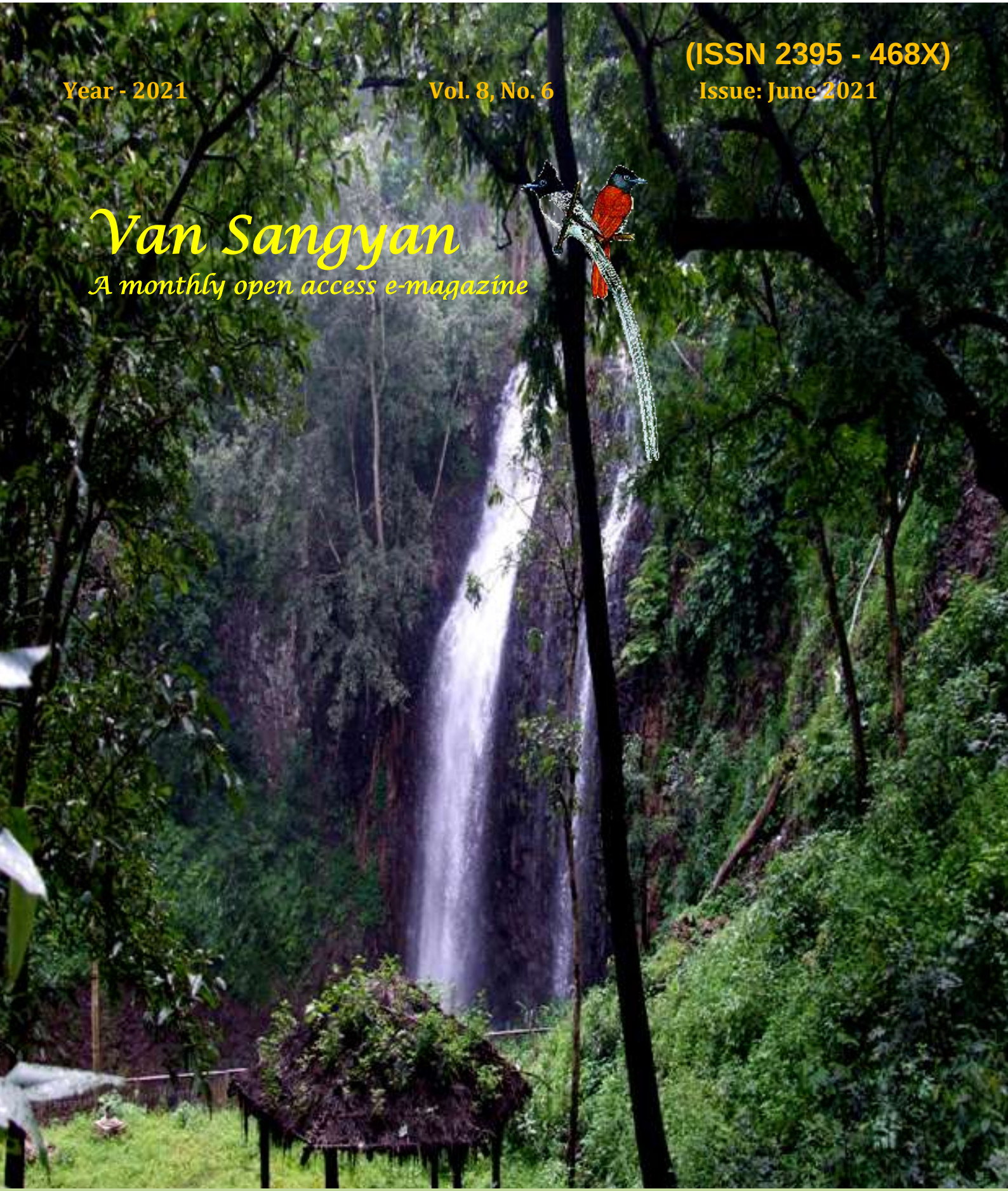

Van Sangyan

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Van Sangyan

Note to Authors:

We welcome the readers of Van Sangyan to write to us about their views and issues in forestry. Those who wish to share their knowledge and experiences can send them:

by e-mail to vansangyan_tfri@icfre.org

or, through post to The Editor, Van Sangyan,
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The articles can be in English, Hindi, Marathi, Chhattisgarhi and Oriya, and should contain the writers name, designation and full postal address, including e-mail id and contact number. TFRI, Jabalpur houses experts from all fields of forestry who would be happy to answer reader's queries on various scientific issues. Your queries may be sent to The Editor, and the expert's reply to the same will be published in the next issue of Van Sangyan.

Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve
Photo credit: Dr. N. Roychoudhury and Dr. Rajesh Kumar Mishra, TFRI, Jabalpur (M.P.)

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From the Editor's desk

Plastic pollution is one of the great environmental challenges of our era, since plastic has an extremely long lifespan in the natural environment and thus accumulates year after year in our lands, waterways and oceans. It has an adverse effect on wildlife, from obstruction and degradation of their habitat, to presenting hazards of entanglement and choking, and the poisoning caused by continuous ingestion of plastic microparticles. While plastics may have their place in the human economy and the larger ecology, the search for alternative substitutes to the use of plastic in many products is imperative, to thereby reduce the heavy load of plastic pollution which enters the natural environment every year.

Natural alternatives to plastic have been found for many products, from more traditional materials like wood, metal and glass, to newer engineered materials like bioplastics. Bamboo in particular is a great natural and sustainable alternative to plastic in a wide-variety of products and use-cases.

Bamboo plants are a very diverse subfamily of grasses, which include the largest members of the grass family (some species of bamboo can grow more than 80 feet high!) and some of the fastest growing plants in the world, with some species able to grow 3 feet per day! Taking into account bamboo's fast and large growth, it is a historically valuable, low-cost timber product and together with its growth habit and ability to handle challenging environmental conditions, it is also very useful in afforestation efforts and in the mitigation of climate change. Moreover, many species of bamboo yield edible, delicious and tender shoots for human consumption. These same qualities make bamboo an attractive sustainable alternative to more labor-intensive or environmentally less-sustainable materials like slow-growing tree timber or metal and it also makes a great alternative to plastic.

In line with the above this issue of Van Sangyan contains an article on Bamboo: A sustainable alternative to plastic. There are also useful articles viz. Indian Linaloe- aromatic tree as an option for dry land regions, Role of Mycorrhizae in forestry, Deodar looper, Ectropis deodarae and its control measures, Bamboo as a fodder for livestock and Environment, its component and issues and Growing immunity boosting herbs: Need of the hour.

I hope that readers would find maximum information in this issue relevant and valuable to the sustainable management of forests. Van Sangyan welcomes articles, views and queries on various such issues in the field of forest science.

Looking forward to meet you all through forthcoming issues

Dr. Naseer Mohammad

Chief Editor

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Bamboo: A sustainable alternative to plastic

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Introduction

Bamboo, also considered as "Poor man's timber" played a significant role in human society since time immemorial and today has contributed to the subsistence needs of over a billion populations worldwide. The bamboo has been used traditionally as fuel, fodder, fibre, fire, food, building, fencing, tools, and various other purposes. In modern days, it is being used as industrial raw material for pulp and paper industry, in construction and engineering materials, panel products, also modified innovative products etc. Bamboo which can be grown easily, is fast growing in nature, and is eco-friendly and adaptable to various locality factors, such properties made it most promising wood substitute. The first bamboo based panel was developed in China in the 1940s. Since then, over 30 panel products have been developed. For instance in China, over 10,00,000 cubic meters of panels of various types are produced annually in some 200 Mills, whereas in India, industrial scale production of panels is confined to bamboo mat board with about 2000 cubic metres board produced by just seven mills. There are also enormous environmental and socio-economic implications and benefits. For example, in India, it is estimated that if bamboo mat boards replace 1/4th of plywood, it can save 4,00,000 cubic metres of round wood, thereby preventing the disturbance to 30,000 hectares of forests per year. Furthermore, it will generate 16.7 million workdays of employment per year. Under the Namboo National Mission, bamboo cultivation was also promoted in various parts of India. The forest Department of Tripura under Tripura Bamboo mission, has developed the whole enterprise of bamboo cultivation as well as bamboo products from bamboo toothbrush to bamboo thermos flasks which can be ordered online.

Plastic v/s bamboo

Our planet has become, over the years, a dumping ground for garbage that has massive negative effects on our environment and future generations. With the "throwaway" culture becoming more of a reality, which appears to not be slowing down, we'll accumulate more and more pollution problems as time goes on. And the main culprit of all this pollution is Plastic In comparison; Bamboo not only benefits our planet in long run but also works for environment and is highly durable as well as cost effective. The industries from kitchenware to household items as well as decorations are all made possible by this incredible Bamboo.

Bamboo is found to be a rich source of vitamins, amino acids, flavine, phenolic acid,polysaccharide, trace elements and steroid, which can be extracted from bamboo culm, shoot and leaf.The Bamboo shoots is selled commercially in the form of bamboo shoot pickles, fermentated bamboo, bamboo candies and squash from North-East states of India. These products have anti-oxidation, anti-aging, anti-bacterial and anti-viral functions. These arevaluable in health care, and can be processed into beverage, medicines, pesticides, or otherhousehold items like toothpaste, soaps, etc. At present, quite a few products have found their wayinto markets:

– Bamboo leaf contains 2% to 5% flavine and phenolic compound that have the power toremove active oxy-free-radicals, stopping sub-nitrification and abating blood fat. Flavine beverageand beer have been widely accepted particularly in East Asian countries like China, Korea andJapan mainly because of their value in health care.

– Some materials extracted from bamboo can be used in fresh flavour preservation or foodstorage application.

– Some additives obtained from bamboo are used in food such as bamboo juice, beverage,bamboo flavoured rice, etc.

Due to all these chemical properties of bamboo, and its capacity to set right various globalproblems such as the pollution of air and water resources, the aging of population and increasingprevalence of old age diseases, unprecedented interest in bamboo has been aroused the worldover. Of late, research has shown that bamboo charcoal is one of the base materials for humanhealth right from water treatment to its uses as shield from electro-magnetic radiation. With theincreasing demand for a return to nature, there is an increasing preference for products processedor extracted from plants. With its high growth rate, wide range of applications and high renewingability, bamboo resources occupies a significant position in the 21st century.

Constraints

There were several constraints that were identified in the course of the roundtables and field visitsas well as from secondary sources. These can be listed as follows:

- The regulatory constraint on transit of bamboo as well as on harvesting from privateplantations,
- The irregular supply of bamboo to industries,
- Poor market linkage of the products,
- Technology application for new product design along with testing, certifying of products,
- Lack of application of known scientific methods in plantation, poor post-harvest treatment,and up-gradation of skill formation,
- Waste utilisation, and
- Competition from Chinese products.

Conclusion

Bamboo can be used widely in various ways like paper, furniture, flooring, building materials, charcoal and more. It drastically reduces the use of wood, various endangered trees, natural resources and the eco-friendly use of bamboo makes living better. The popularity of it gives an opportunity to diverse cultures to enjoy the pleasures of modern amenities at an affordable cost without any irreparable dents on the environment. Unique furnitures made using bamboo are dining tables, slippers, mats, curtains, stores,

houses, sofas, stools. These are mostly hand-made and rarely machine-made, employment in rural areas increased in order to make these products which equally play an important role in the environment.

The Indian Bamboo Products Market is expected to grow at a steady rate during the forecast period by 2025 according to research and market. The Indian Bamboo Products Market is driven by the growing popularity of these products as a substitute for tropical timber on account of their numerous benefits. Additionally, government initiatives aimed at tackling the problem of erosion in forests and increasing awareness for the use of environment-friendly resources are further expected to propel the market during forecast period.

The Indian Bamboo Products Market is segmented based on species, application, end-user industry, and region. Based on species, the market can be categorized into *Bambusa Tulda, Bambusa Bambos, Dendrocalamus Strictus* and others. *The Bambusa Tulda* species is expected to dominate the market owing to its widespread use in the construction industry and for making furniture, mats, and handicrafts, among others. Additionally, this is an edible variety and is also used as wind breaks. Based on the end-user industry, the market can be fragmented into wood and furniture, construction, paper and pulp, textile, medical, agriculture and others. The paper and pulp industry is expected to dominate the market on account of the favorable government excise policy, rising government spending on education and increasing activities in print media, FMCG and pharmaceutical sectors.Major players operating in the Indian Bamboo Products Market include Kerala State Bamboo Corporation Ltd, Epitome Bamboowood Products, Ballarpur Industries Limited (BILT), Amlai Paper Mill, Green Gold Bamboo Tech Pvt. Ltd., Kolan India, Green Gold Bamboo Tech Pvt. Ltd., among others.

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Indian Linaloe- aromatic tree as an option for dry land regions

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Dry land regions characterized by poor rainfall and leading water limited water availability makes the habitat with drought adoptive species. Among many species suitable for water scares condition members of burserace family is important to consider. The Burseraceae family is considered as the incense tree family. Among them *Commiphora mukul*, *Bursera penicillata*, Boswellia *spp.* etc are having commercial importance interms of resin and oil yield. Among the members of burserace family, *Bursera penicillata* is one of peculiar tree used for extraction of essential oil from fruits.

Bursera penicillata is an aromatic essential oil plant introduced into India by Mexicans in Bangalore region. It is commonly called as linaloe tree, Indian Lavender, Copal lemon, Elemi gum and Indian Linaloe etc. It belongs to family Burseraceae. Genus name *Bursera*, is named after the Danish botanist Joachim Burser (1583-1639). There are hundreds of described species in genus *Bursera* includes

flowering shrubs and trees varying in size up to 25 m (82 ft) high. It is medium sized tree deciduous species, the tree remains leafless from November to March and starts new flush in April-May with simultaneous flowering. Trees start bearing 3 to 4 years after planting.

It is native (often for many species endemic) to the Central America (from South Mexico down to Peru) (Espinosa *et al*., 2006). It is an aromatic essential oil plant introduced into India by two private enterprising Scotsman in 1912 at Thatgunni estate near Bangalore, Karnataka State. But Karnataka state forest department has started it's cultivation since 1958 (Ashok *et al*., 2015). Even then also the cultivation is very much restricted to Bangalore region only and it also distributed in Tamil Nadu and Odisha region.

Fig. 1: Tree branch showing leaf and fruits of *Bursera penicillata*

Uses

Both the wood and mature fruit yield on steam distillation a colourless or pale yellow essential oil traded as 'Linaloe Wood Oil' and 'Linaloe Berry Oil'. They have a similar composition with an agreeable balsamic, slightly rose-like aroma used to scent perfumes, lotions, soaps and cosmetics as well as flavour foods such as baked goods, chilled dairy desserts and beverages, both alcoholic and non-alcoholic. The different parts of the plant, e.g., leaves, stems and resin, have been used in folk medicine (Peru, Costa Rica, Nicaragua, Guatemala, Cuba, Colombia), in different forms (smoked, infusions, cataplasms, compresses), as healing, abortive, anti-inflammatory, anti-tumor, analgesic, antidiarrheal, depurative, diaphoretic, expectorant, anti-bacterial, insecticidal, for thetreatment of anemia, rheumatism, dermatitis, asthma and colic as well as a mosquito repellent (Ashok *et al*., 2015). The berry oil is said to be superior to the wood oil, with a longer lasting aroma. The oil extracted from seeds in these trees is a major ingredient in making expensive perfumes abroad, especially in Russia. In Mexico the oil is distilled from the wood of wild trees that are at least twenty years old, with the best oil coming from much older trees, whereas in India the oil is distilled only from the husk of mature fruit, leaving the tree unharmed. In India, the mature fruit are hand-picked from the tree or are collected after they have fallen to the ground. They are then shade-dried and de-husked, with production roughly at 250 kilograms of dried husks per hectare. With an average oil content of 10% the yield is about 25 kilograms of oil on distillation, the equivalent of 22 pounds of oil to the acre. The tree is commonly used as living fence posts in Costa Rica. Essential oil is being used in cosmetic industries, soaps and detergent industries too use this oil.

History of seed

Bursera tree, botanically known as '*Bursera penicillata'*, native to Mexico in Central America, were said to be introduced to India by two European brothers. These European brothers surveyed entire India and found Bangalore was suitable for cultivating these plants.Initially, the brothers raised these trees in the same area and wanted to establish their monopoly in growing them. Even the local villagers were denied these seeds. Later, the artist couple bought the area and began cultivating them. Realising their importance in cosmetic industries, the forest department began growing these trees in a vast area near Hoskote near to Bangalore. Now, this tree can be found in many places in gardens but not on commercial scale. The forest department itself began extracting oil from its seeds. Oil can be extracted from the tree bark and the stem. Even by removing the bark on tree surface, scented oil starts oozing out.

Season of Aroma

In case of European lavender or true lavender flowering months will be winter but this tree yield is mostly during July and August, when thenearby areas filled with aroma of lavender disseminated from seeds. Even bark of the stem is also having essential oil that bears aroma. This plant is one of the highest essential oil yielding plant among all aromatic crops. It yields around 7-10% oil on steam distillation of berries.

Soil and climate

It grows well on much type of soils especially in lateritic red soils. It performs best on free-draining loam, sand and gravelly or limestone soils of a slightly

acid to alkaline nature, generally with a pH of 6.5 to 8.5 and on sites with full to partial sun exposure. The plant prefers arid tropical climate with temperature variation between 18 ° C and 35 ° C. the plant can survive very less water condition and needs rainfall around 450mm to 650mm annually. The climatic conditions around Bangalore and similar type are very much conducive to grow this species on a large scale.

Propagation

Plants are known to regenerate both by artificial and natural means as well as by sexual and asexual methods, cuttings being the commercial method. Seeds processes poor seed germination rate, slow seedling growth and high variability. Hence terminal stem cuttings or air layering of 15 cm length and pencil thickness are used to prepare nursery plants. Vegetative propagated plants sprout early and also come to bearing early as compared to seed propagated. Even bigger sized branches can also be planted but rooting will be less and not economical. Hence stem cuttings are mostly practiced. The cuttings are planted in 0.5m cube pits dug at 6 × 6m interval. A fertilizer dose of 40-80:20-40g of Ammonium sulphate, Superphosphate and MOP per plant per year could be applied to have vigorous growth.

Pest and diseases

No serious pests and diseases have been reported except for *Pestalotiahelerocornis* fungus which causes die-back. Proper canopy management is sufficient to manage the disease.

Harvesting and processing

Plants raised from cuttings set fruits in first year itself whereas seedlings take five years to bear fruits. Being a deciduous species tree remains leafless from November to March and new flush starts during April-May with simultaneous flowering.Trees starts bearing 3 to 4 years after planting. On an average, each tree yields 40 kg of seeds. Harvesting is done either by picking of berries or by collecting the fallen berries during August. The oil is distilled by usual steam distillation of air dried husks which yield 10 to 14% of oil. Fresh berries take five hours for distillation while dried berries take 20-25 hrs. About 25kg of oil can be expected from one-hectare plantation. The seed oil produced in India is known as Mysore Linaloe oil or Indian linalool oil. Trees attain maximum bearing 13 years after planting, when the yield of oil is expected to fetch Rs. 6000/- per hectare. Chief constituent of oil is Limonene (42.2%), pulegone (20.9%), carvone (7.5%), caryophyllene (4.1%), trans-carveol (3.8%) and other sesquiterpenes are major aroma compounds in essential oil of husk (Young *et al*., 2007). Leaf oil has sweet wafting odour and it contains 65-70% linalyl acetate. Because of stability to alkali the oil is used in manufacture of scents, cosmetics, transparent soaps. Oil is also used as fixative in perfuming lily, cananga, lavender etc. Essential oil constituents of bursera: EO from Bursera has monoterpenes as its principal compounds.

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Role of Mycorrhizae in forestry

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Introduction

Several fungi form beneficial associations with forest tree species which invade the feeder root tissues and form modified roots called mycorrhizae (fungus-roots), which greatly increases efficiency of nutrient and water uptake. Most plants require mycorrhizae for normal growth and development in natural soils. Earlier it was thought that roots absorb soil nutrients and water primarily through root hairs on the feeder roots, however, recent evidence indicates that most absorption occurs through feeder roots that are infected by beneficial fungi. The mycorrhizal fungus parasitizes the cortical tissues of the young roots, but the presence or absence of specialized beneficial fungi will dramatically affect seedling form and size and tree development. The formation of mycorrhizae aids water and mineral absorption for the tree, and the fungus in turn receives needed organic compounds from its association with the tree. Among the biological means, mycorrhiza has been reported for mobilization of P to forest trees and nurseries plants along with other nutrients like S, K, Ca, and Zn. They are usually emphasized for their beneficial effect on root function and barriers to infection by other destructive soil borne root pathogens in the nursery and in the field. Mycorrhizae are now known to be ubiquitous in the roots of trees and also in the roots of almost all higher plants (Singh *et. al*., 2007). This review critically summarizes the various aspects of mycorrhizae and varied effects on tree growth and development.

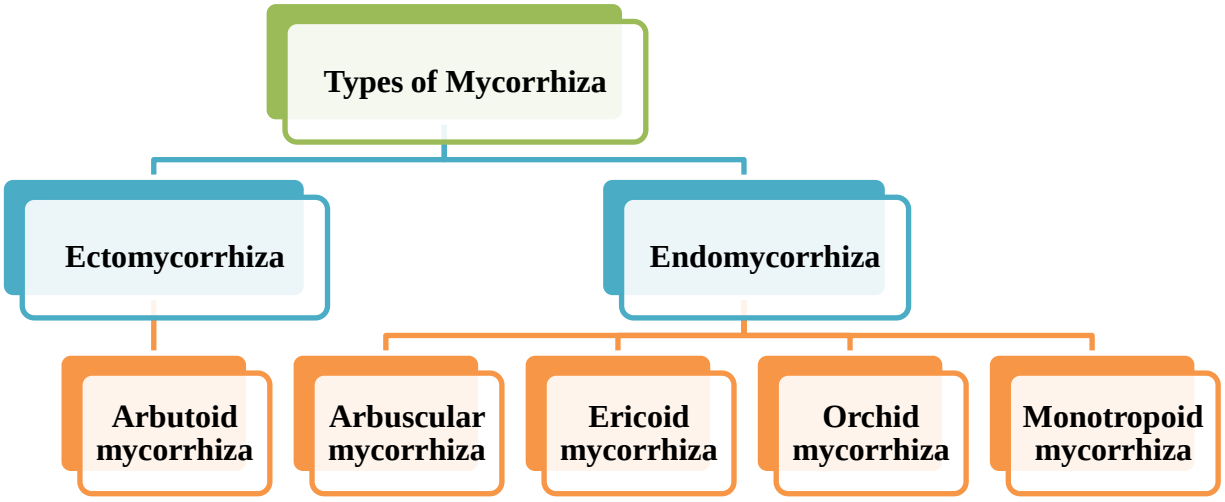
About Mycorrhizae

A powerful mechanism for plant growth

Almost 80% of plant species are engaged in symbiotic relationships with mycorrhizal fungi. Mycorrhizal associations are the predominant microbial group that infects the majority of plant species and mycorrhizal fungi-root associations have been known since 1885. Several different types of association exist among plant species. The term “mycorrhizae” means “fungus root”, “Myco” is fungus and “rhiza” is root. Mycorrhizae are highly evolved, mutualistic associations between soil fungi and plant roots, and provide a critical linkage between the plant root and soil. Symbiosis is often used to describe these highly interdependent mutualistic relationships.Mycorrhizae were first described by Theodore Harting on coniferous trees, but he did not investigate their function. Frank described the relation of mycorrhizae to the growth of trees and to the growth of fungi in the forests and coined the term mycorrhiza in 1885. Several pioneered workers *i.e.*Melin in Sweden, Bjorkman in Poland, Harley in Great Britain, and Hatch and Doak in the United States research on mycorrhizae of forest trees. The practical applications of these fungus-root relationships are maximize yields in forest and agricultural

systems. After infection of mycorrhizal fungi in conifers, the roots become swollen, branch dichotomously (Pinaceae), and may become colored due to the presence of fungal tissue. Angiosperm mycorrhizae do not often exhibit the increase in volume of degree of branching in conifer mycorrhizae. Mycorrhizae enhance plant growth through increased nutrient uptake, stress tolerance and disease resistance. VAM fungi can alter root exudation pattern, enhance chitinolytic activity and alter photosynthetic/ respiratory deficiency.

Mycorrhizal Types



Importance of mycorrhizae in forestry

Mycorrhizal infection of forest trees is essential for their healthy growth in some ecological conditions. This fact is illustrated by the failure of several attempts to grow trees in barren areas. In Puerto Rico, all attempts to introduce pines by conventional cultural practices like fertilisation, failed. However, when mycorrhizal fungi were introduced from the USA by transferring soils from successful pine stands, the results were striking: all treatments produced excellent survival and growth. Survival of inoculated slash pine was 85 percent and that of the control 36 percent. Whereas the introduction of mycorrhizal fungi has led to the success of many plantations, there have been instances wherein exotics have been successfully planted without such introductions. *Eucalyptus* has been planted extensively on poor soils and grassland sites for afforestation in southern India. Chir pine (*Pinus roxburgii)* has been successfully established as an exotic on a site previously under Sal (*Shorea robusta*) forests in central India at a distance of over 1,000 km from its indigenous home. However, in both eucalyptus and chir pine, mycorrhizae developed on their own. In such cases, mycorrhizal fungi may have been present on the sites afforested (grasslands in the former case and original forests in the latter) and the trees were able to develop symbiotic associations with these fungi. It is also possible that the spores of mycorrhizal fungi were carried by the wind to the sites and eventually established mycorrhizal associations. A plausible explanation for the poor survival and growth of seedlings without mycorrhiza on certain virgin soils is the

inadequacy of the non-mycorrhizal root system to absorb minerals in short supply, particularly phosphorus. Not only are mycorrhizae more efficient in this regard than uninfected short roots, but they expose a much larger total absorbing surface.

Importance of Mycorrhizae in forest nurseries

Raising vigorous and healthy stocks is of prime concern to nursery persons and managers all over the world. Numerous studies show that initial inoculation of nursery soil is necessary, prior to raising planting stocks. In nurseries established on agricultural sites which receive high doses of fertiliser and irrigation, the mycorrhizal fungi may be lacking or present in low densities, or the species may be less effective. Therefore, the inoculation of such soils becomes important and the introduction of a new species desirable. In these circumstances, inoculation alone is not often an effective means of improving the growth of seedlings and the establishment of mycorrhiza, unless it is preceded by the correction of soil conditions. Soil properties such as acidity, fertility or organic matter content tend to favor the growth and multiplication of the introduced fungi. In alkaline soils, the inoculation of mycorrhizal fungi has been found to be successful only with additional acidification of soil followed by foliar sprays of micronutrients like molybdenum and zinc. These induce better mycorrhizal development, besides better plant growth. It has been found that the scale at which weedicides and pesticides are applied in forestry, exerts a harmful influence on mycorrhizal fungi. In such cases, mycorrhizal inoculation becomes particularly important in improving the quality of planting stocks.

Proposed model for relationship between mycorrhizae-soil borne diseases

Based on our current understanding of the role of mycorrhizae in forest disease, a model is proposed that takes into account soil and environmental factors, plant vigour and intensity of mycorrhizal infection.

Low disease severity

a. Mycorrhizal strain effective and present in soil at optimum dose level
b. High susceptibility of host towards mycorrhizae
c. Potential dose of pathogen is moderate
d. Environmental and soil factors favourmycorrhizae development

Moderate disease severity

a. Moderate susceptibility of host towards mycorrhizae
b. Pathogen population density low/ high
c. Environmental conditions favourable
d. Soil conditions favorable
e. Mycorrhizae strain effective resulting in low/high root infection

In spite of favourable soil and environmental factors, the above situation will lead to slight loss in yield because mycorrhizae proliferation is not extensive and normal/moderate host vigor.

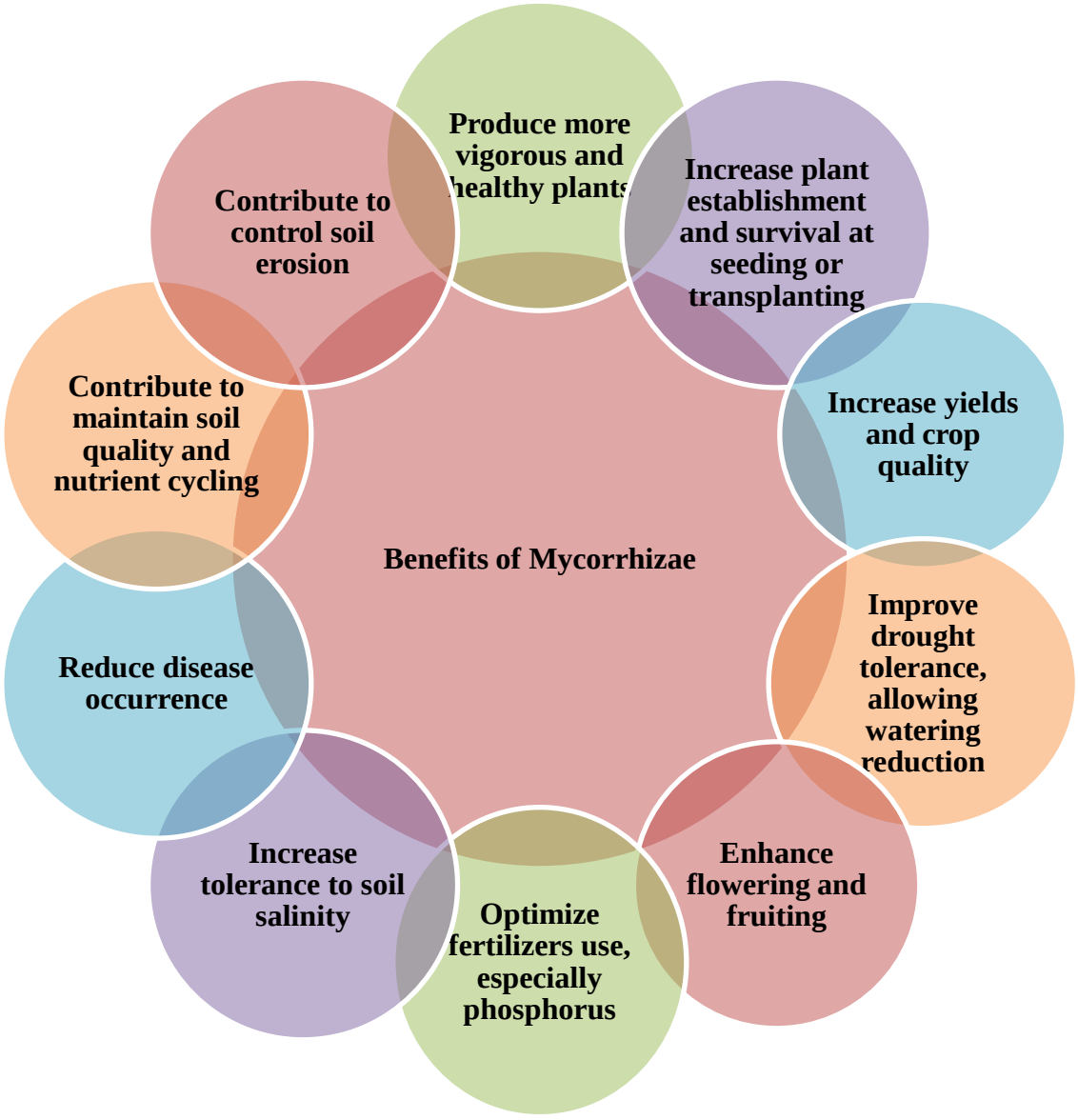
High disease severity

a. Moderate/ high susceptibility of the host towards mycorrhizae.
b. Soil conditions unfavourable leading to low mycorrhizae infection
c. Environmental factors favourable.
d. Pathogen population high

These conditions would lead to low host vigour and result in high loss in yield. This proposed model is an over-simplification

of the complex interaction but should provide a working base to make a realistic assessment of the role of mycorrhizae in especially soil borne plant diseases.

Benefits of Mycorrhizae



Conclusion

Plants with mycorrhizae have been invariably found to be much larger and much more vigorous that nonmycorrhizal plants. The symbiosis between the host plant and the mycorrhizal fungus is generally viewed as providing equal benefits to both partners. Generally mycorrhizae do not cause disease, but absence of mycorrhizae in certain fields result in plant stunting and poor growth, which can be avoided if the appropriate fungi are added to the plants. The benefits to plants like increased mineral and water availability resulting from nutrient exchange with the fungus, and increased root surface area, resistance to root pathogens through mantle formation and reduced carbohydrate levels in the plant root and increased populations of non-pathogenic microorganisms in the rhizosphere of the plant, resulting from mycorrhizal activities, are received without any significant investment. The benefits of mycorrhizal system can be fully reaped if they are well preserved and

their proliferation is encouraged in both nursery and forest soils. However it should also be noted that mycorrhizal fungi should not be seen as the sole provider of all the nutritional and plant protective benefits, but it should be integrated in a wider forest and nursery management strategy. Conservation of mycorrhizal fungi in forest and nursery soil should also be given priority. Factors detrimental to mycorrhizal growth have to be documented and managed accordingly. Pollution (especially ammonia pollution) may reduce the diversity of the ectomycorrhizal community (Kowalski *et al.* 19. Liming has also been shown to have a detrimental effect on the fruiting of ectomycorrhizal fungi.Many more extensive studies on different influences of mycorrhizal fungi on plants, their mode of action, their mass production and delivery system may prove more productive in harnessing better benefits from these useful fungi in future.

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Deodar looper, *Ectropis deodarae* and its control measures

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Abstract

This article deals with the pest profile of *Ectropis deodarae* Prout (Lepidoptera: Geometridae), a major insect defoliator of deodar, *Cedrus deodara* (Roxb.) G. Don (family Pinaceae). The management aspects of this insect pest are mentioned.

Key words: Deodar, *Cedrus deodara*, defoliator, *Ectropis deodarae*, control measures

Introduction

Cedrus deodara (Roxb.) G. Don (family Pinaceae), commonly known as deodar, is the most important among the Indian conifers (Tewari, 1994). The deodar is a very large coniferous evergreen handsome tree with spreading branches and dark green foliage. This is a species of cedar native to the western Himalayas. In India, it occurs in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh and the Darjeeling district of West Bengal (Farjon, 2013). Deodar is typically gregarious and is usually found in pure stands.

Overview of insect pests

Deodar has been extensively studied for insect infestation. About 60 species of insects belonging to 22 families of six orders, such as Coleoptera, Hemiptera, Isoptera, Hymemoptera, Lepidoptera and Orthoptera have been recorded feeding deodar at different stages of plant development (Beeson, 1941, Browne, 1968; Tewari, 1994). Insect defoliation is a serious problem in the trees of all age groups. Frequent defoliation of epidemic nature not only kills the small trees but also affects growth increment considerably. Deodar foliage furnishes food for a number of defoliating insect species. Main defoliating insect pest is *Ectropis deodarae*. The pest profile and control measures of this insect are mentioned as hereunder.

Pest profile

***Ectropis deodarae* Prout (Lepidoptera: Geometridae)**

Ectropis deodarae is commonly known as deodar looper. It is one of the most damaging defoliating pests of deodar distributed all along north-western part of India in outer as well as inner ranges of Himalayas. Adult female has only very small vestigial wings, the male has broad, white wings mottled with black and a span of about 35-40 cm (Beeson, 1941, Browne, 1968; Tewari, 1994). The generation is annual. The moths emerge in March and the fertilized females crawl up in to the crown of the host tree to lay eggs in the needles. The larvae, which are green, white-haired loopers, attaining a fully grown length of about 25 mm, feed openly on the foliage until June, when they descend on silken threads and pupae, without forming cocoons in the soil litter.

Large areas of deodar forests in the north western and western Himalayan regions are often defoliated completely by *E. deodarae*, causing heavy mortality. The history of epidemics of this insect has been compiled by Thakur (2000). The epidemic defoliation of *E. deodarae* was recorded in

Himachal Pradesh during the year 1901-1903 then subsequently in 1906-1907, 1922-1924 and 1961-1962. An epidemic of this defoliator was reported during 1982-83 from the Lolab Valley, Kamraj Forest Division, Jammu and Kashmir (Singh et al., 1989). Tree mortality was as high as 30 percent. Epidemics occur at about 10 year intervals and may last for 2 or 3 years (Beeson, 1941; FAO, 2003). An outbreak was also noticed in June 1994 in the Neldehra forest in Mashobra range and Badmain forest in Bhajji range near Shimla in Himachal Pradesh (Verma and Chander, 1995**)**. The caterpillars feed on the needles from the tip to the base scraping the basal portion of the needles. As a result, the needles turn brown, dry up and fall to the ground prematurely. In the later stages of attack, the trees, branches and the undergrowth were covered with the webs and veils of silk, and the plantation had a brown, scorched appearance. The attack was so heavy that complete defoliation of 8-10 ha of a 60-70 year old stand occurred. Beeson (1941) identified some biotic and abiotic factors, viz. grazing, removal of litter, excessive thinning and most important of all, the natural climatic conditions and natural enemy complex, which influence to a great extent, the incidence of epidemic defoliation in deodar forests.

Control measures

The attack of this defoliator can be checked by putting grease-bands on the main trunk which prevent the wingless female moths from crawling up the trunk and egg laying on the needles (Beeson, 1941). Moths and eggs, collected below the greasy bands, can be destroyed during regular patrolling. The epidemic of *E. deodarae* was effectively controlled by an aerial spraying of fenitrothion @ 1 litre/ha (Singh et al., 1989). The deodar defoliator is subject to a most efficient control by its natural enemies (Tewari, 1994). Among the important natural enemies, *Calosoma beesoni* Andr. (Coleoptera : Carabidae) is an effective predator which in the adult form eats the caterpillars and as larvae feed the pupae embedded in the humus. The main parasites are *Dusona deodarae* Cush (Hymenoptera: Ichneumonidae), *Brachymeria obscurata* Wlk. (Hymenoptera: Chalcidae) and *Campsilura concinnata* Heigh (Diptera: Tachinidae). Some insectivorous birds like Jackdaws, *Corvus monedula* Linn. (Aves: Corviidae) are also recorded to feed on deodar defoliator (Singh et al., 1989).

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Bamboo as a fodder for livestock

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Abstract

Although bamboos are consumed as food, used for energy, building material, pharmaceuticals, and certainchemicals and provide wildlife habitat, it is also considered as pasture or fodder for livestock throughout the world. Bamboos are rich in non-structural carbohydrates and protein, as well as minerals that suit fodder. Still,the potential of bamboos is not utilized properly and very few studies have been done in bamboo as fodder. There is a need for furtherstudies to develop effective management practices to introduced bamboos in pastures sustainably.

Introduction

Bamboo is a group of arborescent grasses comprised of about 1250 species within75 genera all over the world. Out of that about 125 species occurs in India. After China, India has the richest bamboo resources in the world. Within India, the Northeast is endowed with more than 50% of the bamboo genetic resources. The bamboo used as poles in cottage industries, crafts as well as in domestic uses. Italso prevents soil erosion and conserves soil moisture and thus considered as important in environmental protection (Singhal*et al*., 2011).Various ungulates, primates, rodents and insects also feed on bamboo. Though bamboo was used as fodder in many areasearlier, it recently gains attention as an alternative to concentrates in face of fodder deficit, especially in pinch periods.

Bamboo as fodder

Shortage in feed is mainly responsible for a decline in milk productivity in livestock. This fodder deficit is intense during in dry season, making farmers use low quality and less nutritive crop residues and pasture for milk production which declined productivity and health of livestock (Andriarimalala*et al*., 2019). Fast-growing ability, wide adaptability, high biomass production bamboo leaves could be a better replacement for the source of livestock fodder for dairy cattle to maintain their milk production during the dry season. In several parts of the world, bamboo is offered as fodder such as yak and cattle in Bhutan, cattle and sheep in Japan, cattle and buffalo in Nepal, gayals in Pakistan and cattle in some parts of Africa. Bamboos can easily be integrated intothe forage system to enhance feed sufficiency. It gives other benefits like bamboo culms and its low input too. In some areas, bamboo leaves form an important diet of elephants and are valued as fodder for pandas (Singhal *et al*., 2011). Bamboo leaves can form an important component of ruminant rations and can provide green fodder almost throughout the year (Datt*et al*., 2006). Bamboo yields an average of 11.7 metric tonnes DM leaf biomass as compared to natural pasture

which yields about 1-3 metric tonnes. Additionally,bamboo leaves contain high crude protein (16-20%). Halvorson *et al*.(2010) found that fiberand protein content in bamboo leaves were enough to cater to the maintenance needs of adult goats in central Appalachia. Bamboo maintains nutritive value and remains green during winter thus considered as potential winter forage for goats in cooler areas.

Fig. 1: Bamboo leaves were lopped and feed to cattle (Source: Rao *et al*., 2018)

Nutritive value

Chemical composition study by Sahoo*et al*. (2010) proved that promising capacity of *M. baccifera*, *D. hookerii*, *D. hamiltonii* and *D. asper* as fodder for livestock in the sub-Himalayan region of India. To fulfillthe nutritional need of livestock, especially in scarce seasons, promoting suitable and nutritionally rich bamboo species could be a practical approach. Datt*et al*. (2006) reported that bamboo leaves are rich in crude protein (9-19%), Zn, Ca, Cu, Mg and Mn and low in crude fiber (18-34%). The leaves of yellow bamboo (*B. vulgaris)* are very rich in N and considered as valuable feed and cattle and horses reported to be feed leaves of yellow bamboo with zest. It was reported that *B. vulgaris* and *B. ventricosa* are good sources of vitamin A (Farrelly, 1984). Bhandari *et al*.(2015) found that *B. nutans*, G. *albociliata* and D. *hamiltonii* can be considered as moderate good fodder. Leaves of *B. nutans* and *D. hamiltonii* have been commonly used by the locals as fodder for cattle during winter drought in the hills and foothills of Himalayas. While this study reported that *B. balcooa* and *B. bambos* is poor quality fodder based on chemical composition thus should be mixed with good quality fodder tree species before feeding to animals.

Table 1: Average chemical composition of leaves (g kg^{-1} dry matter [DM]) of some bamboo species (source: Sahoo*et al*., 2010).

Species	Crude Protein	Ether Extract	Carbo-hydrates	Neutral Detergent Fibre	Acid Detergent Fibre	Ash	Acid Deter lignin
Bambusa nutans	182	25	675	785	439	118	73
Bambusa bambos	184	27	645	784	443	144	443
Phyllostachysaurea	180	34	627	742	457	159	79
Bambusa tulda	146	20	702	783	466	132	84
Dendrocalamus asper	176	36	635	762	469	153	59
Dendrocalamus strictus	161	14	678	775	532	147	86
Melocanna baccifera	191	17	675	654	416	117	49
Dendrocalamus hookerii	179	42	693	742	457	86	72
Bambusa vulgaris	193	32	622	765	453	153	92
Dendrocalamus hamiltonii	204	47	611	732	417	138	57

If the feed formulation is done properly considering the CP content in the fodder, there is a great potential to reduce the concentrate feed in the ruminant diet.

Bamboo and animal health

A feeding experiment conducted by Andriarimalala*et al*. (2019) found that mixing bamboo leaves in the basal diet of cattle did not affect their milk production, instead maintain milk production equivalent to that of maize silage and concentrates ration. Replacing 25% of ration with bamboo leaves improved the dry matter intake and digestibility of maize silage to the detriment of bamboo leaves in cattle. It was reported in the study that bamboo leaves promote milk production and ghee content. Bamboo leaves were considered to have positive effects on livestock especially on young calves (Thapa*et al*., 1997). Feeding chicken with organic ration mixed with bamboo leaves enriched body weight by 70% that of standard organic ration (Bersalona*et al*., 2015). Bamboo mitigates the effects of gastrointestinal nematodes of small ruminants in the southern USA (Halvorson *et al*., 2010). Thus bamboo could play an important role as supplementary fodder in livestock without compromising its health.

Harvestingand management of bamboo fodder (as suggested by INBAR**)**

- Young and soft leaves from 2-3 yrs old culms should be preferred as they are more nutritive
- Avoid harvesting in the earlymorning as animals not eat if dews deposited on leaves

De-topping

- Buds should be present on lower nodes
- Cut new culm longer than 3 m at 1-1.5 m height

- Effective if done before leaves emerges from top of poles
- Sometimes entire culm is cut for profuse branching

Lopping:

- Remove tertiary and secondary branches by sharp knife
- Directly fed to the livestock

Thinning

- Remove old (above 3 yrs) and mature poles
- Promotes the growth of new culms

Pruning

- Pruned at 75 cm to form a table-top shaped crown
- Bushy crown makes picking easy

Bamboo silage

- Harvest bamboo leaves
- Retain moisture upto 40-80 %
- Pack tightly and ferment in an oxygen-less environment
- The end product is a ruminant forage called as silage
- Bamboo silage contains 7.65% starch and 1.12% digestible proteins
- More fibrous but higher in digestible protein than maize silage
- Can be used in pinch periods

Bamboo leaves and shoots can be mixed with common grainfeed or any other grain silage to decrease the cost of feed and also fulfillthe optimum nutrient demand of livestock. Bamboo fodder can be utilized as a bufferstock for livestock feed. Bamboo can be a source of organic feed and foliage to fulfill rising global demands for organic, healthier animal meat and dairy products. It also provides medicinal properties for livestock. Bamboo leaves can be mixed with other silage in a 3:1 or 1:1 ratio to produceconcentrated livestock feed (Rao *et al*., 2018). Rural farmers can easily cultivate and manage bamboos near their home steads and on-farm boundaries and used them as green feed and fodder forlivestock or processedto silage to use in pinch periods. It also generates livelihoods and employment in rural areas.

Conclusion

Bamboo has enormous capability to become quality fodder due to its high biomass production and nutritive value. Raising bamboos in a marginal land to produce evergreen biomass round the year for fodder purposes and along with fertility improvement could be a good strategy. Bamboo leaves can reduce concentrates if properly formulated with a diet considering crude protein content. Identification of optimal stage and harvesting interval is crucial to obtain a moderate fiber content and improve intake and digestibility of fodder. Further evaluation and development of bamboo leaves as livestock fodder in various parts of India is needed to promote bamboo as fodder.

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Environment, its component and issues

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Introduction

The term environment has been derived from a French word "Environia" means the surround. Environment is the complete range of external conditions, physical and biological, in which an organism lives. It includes social, cultural, and (for humans) economic and political considerations, as well as the more usually understood features such as soil, climate, and food supply (Allaby 1994). It is an environment that encompasses the interaction of all living species. It encompasses also climate, weather and natural resources that affect human survival and economic activity (Johnson *et al* 1997). The word environment is most commonly used describing "natural" environment and means the sum of all living and non-living things that surround an organism or a group of organisms at a given point of time and space. In a narrow sense, it is an environment that is not influenced by people. The environment that is influenced by human can be called "the built environment" or cultural landscape. A cultural landscape is defined as a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or persons or exhibiting other cultural or aesthetic value. In other words, it is the cultural properties that represent the combined work of nature and of man (UNESCO 2012).

Components of environment

Environment can be roughly divided into two types such as (a) Micro environment and (b) Macro environment. It can also be divided into two other types such as (c) Physical and (d) biotic environment.

(a) Micro environment refers to the immediate local surrounding of the organism. It is also known as a microhabitat, a very small, specific area in a habitat, distinguished from its immediate surroundings by factors such as the amount of incident light, the degree of moisture, and the range of temperatures. It is the immediate small-scale environment of an organism or a part of an organism, especially as a distinct part of a larger environment.

(b) Macro environment refers to all the physical and biotic conditions that surround the organism externally and affect it. In other words, it refers to major external and uncontrollable factors that influence an organization's decision-making, and affect its performance and strategies. These factors include the economic, demographics, legal, political, and social conditions, technological changes, and natural forces.

(c) Physical environment refers to all abiotic factors or conditions like temperature, light, rainfall, soil, minerals etc. and consequently includes the factors that have an influence in organisms' survival, development and evolution. The biophysical environment can vary in scale from microscopic to global in extent. It

can also be subdivided according to its attributes. Examples include the marine environment, the atmospheric environment and the terrestrial environment. The number of biophysical environments is countless, given that each living organism has its own environment.

(d) Biotic environment includes all biotic factors or living forms like plants, animals, micro-organisms viz. biosphere and the study of it involves an understanding of the complex ways organisms interact with each other and with the abiotic components of the same environment. Photosynthesis, for example, is a way that plants take energy from the abiotic environment and incorporate it into the biotic environment by synthesizing sugars and proteins from it. Other components of the biotic environment, such as herbivores, eat the plants and transfer the nutrients further along the chain. When herbivores are consumed by parasites, carnivores or decomposers such as bacteria, the energy originally derived from sunlight circulates throughout the biotic ecosystem.

Everything in Earth's system can be placed into one of four major subsystems: land, water, living things, or air. These four subsystems are called "spheres. All four major geological subsystems of Earth can function independently from each other, but for the most part, there is some type of interaction between them. In some cases, it may be an interaction between all four subsystems, but it could be an interaction between just two. An example of an interaction between the geosphere/lithosphere and the hydrosphere would be the creation of a tsunami. Tsunamis are created when a large volume of water is displaced due to a disturbance under the water such as a landslide, earthquake, or volcanic eruption. The disturbance that causes the tsunami takes place within the geosphere and the water that is displaced is within the hydrosphere. When large waves from the tsunami hit the shore, the hydrosphere is interacting a second time with the geosphere. The water is often strong enough to cause damage to the solid earth. Another example of interaction would be plants (biosphere) draw water (hydrosphere) and nutrients from the soil (geosphere/lithosphere) and release water vapor into the atmosphere. Because these subsystems interact with each other and the biosphere, they work together to influence the climate, trigger geological processes, and affect life all over the Earth. Earth' scientists divide the outer layers of the Earth into four main spheres or realms, which are the atmosphere (the sphere of air), hydrosphere (the sphere of water), lithosphere/geosphere (the sphere of rock, soil, minerals etc.), and biosphere (the sphere of living organisms).

Interactions in the Earth's system

	Atmosphere	**Lithosphere**	**Hydrosphere**	**Biosphere**
Atmosphere		Ozone change	Ozone change ELNino	Ozone change Photosynthesis
Lithosphere	Hurricanes, tsunamis, Volcanoes, Wave actions	Volcanic eruptions	Hurricanes, tsunamis, Tectonics. Volcanoes,	Hurricanes, tsunamis, Coal, Nutrient cycles, Volcanoes

			Earthquakes, Wave action	
Hydrosphere	ELNino	Waves	Wave action	Photosynthesis
Biosphere			Photosynthesis	

Atmosphere

The atmosphere is a mixture of nitrogen (78%), oxygen (21%), argon (0.9%), and other gases (1%) surrounding Earth that is retained by Earth's gravity. High above the planet, the atmosphere becomes thinner and thinner with increasing altitude, with no definite boundary between the atmosphere and outer space. It is divided into five layers. Most of the weather and clouds are found in the first layer. It maintains heat balance, provides oxygen for respiration and carbon dioxide for photosynthesis of plants. Average composition of the atmosphere up to an altitude of 25 km is given below.

Average composition of the atmosphere up to an altitude of 25km (Pidwirny, M. 2006)

Gas Name	Chemical Formula	Percent Volume
Nitrogen	N_2	78.08
Oxygen	O_2	20.95
Water*	H_2O	0 – 4
Argon	Ar	0.93
Carbon dioxide*	CO_2	0.0360
Neon	Ne	0.0018
Helium	He	0.0005
Methane	CH_4	0.00017
Hydrogen	H_2	0.00005
Nitrous oxide*	N_2O	0.00003
Ozone*	O_3	0.000004

*Variable gases

The atmosphere has a mass of about 5.15 X 10^{18} kg (Lide 1996, Trenberth and Smith 2005) three quarters of which is within about 11 km of the surface. The Karman line, at 100 km is often used as the border between the atmosphere and outer space.

In general, air pressure and density decrease with altitude in the atmosphere. However, temperature has a more complicated profile with altitude, and may remain relatively constant or even increase with altitude in some regions. Because the general pattern of the temperature/altitude profile is constant and recognizable through means such as balloon soundings, the temperature behavior provides a useful metric to distinguish between atmospheric layers. In this way, Earth's atmosphere can be divided into five main layers. On the basis of temperature gradients, the atmosphere can be segmented as follows:

- Exosphere: 700 to 10,000 km
- Thermosphere: 80 to 700 km
- Mesosphere: 50 to 80 km
- Stratosphere: 12 to 50 km

- Troposphere: 0 to 12 km

Nearly all atmospheric water vapor or moisture is found in the troposphere, so it is the layer where most of Earth's weather takes place. It has basically all the weather-associated cloud genus types generated by active wind circulation, although very tall cumulonimbus thunder clouds can penetrate the tropopause from below and rise into the lower part of the stratosphere. Water vapour varies in concentration in the atmosphere both spatially and temporally. The highest concentrations of water vapour are found near the equator over the oceans and tropical rain forests. Cold polar areas and subtropical continental deserts are locations where the volume of water vapour can approach zero per cent. Most conventional aviation activity takes place in the troposphere, and it is the only layer that can be accessed by propeller-driven aircraft. About 80% of the total mass of the atmosphere is contained in the troposphere.

In the Earth's stratosphere, the temperature increases with altitude. It extends up to a mean altitude of 50km. On Earth, ozone causes the increasing temperature in the stratosphere. The zone making end of this temperature increase is the stratopause. The temperature becomes 0 °C at stratopause. Ozone is concentrated around an altitude of 25 kilometres. The ozone molecules absorb dangerous kinds of sunlight, which heats the air around them. The stratosphere is located above the top of the troposphere. About 90% of the ozone in the Earth's atmosphere is found in this region. This is the atmospheric layer between 16 and 48 kilometres above the Earth's surface. Ozone forms a kind of layer in the stratosphere, where it is more concentrated than anywhere else.

In the Earth's mesosphere, the air is relatively mixed together and the temperature decreases with increase in altitude. The atmosphere reaches its coldest temperature of around -90°C in the mesosphere. This is also the layer in which a lot of meteors burn up while entering the Earth's atmosphere. The mesosphere is on top of the stratosphere. The upper parts of the atmosphere, such as the mesosphere, can sometimes be seen by looking at the very edge of a planet. The zone making end of this temperature profile is the mesopause.

The thermosphere is the fourth layer of the Earth's atmosphere and is located above the mesosphere. The air is really thin in the thermosphere. A small change in energy can cause a large change in temperature. That's why the temperature is very sensitive to solar activity. When the sun is active, the thermosphere can heat up to 1,500° C or higher.

The Earth's thermosphere also includes the region of the atmosphere called the ionosphere. The ionosphere is a region of the atmosphere that is filled with charged particles. The high temperatures in the thermosphere can cause molecules to ionize. This is why an ionosphere and thermosphere can overlap.

Hydrosphere

A hydrosphere is the total amount of water on a planet. The hydrosphere includes water that is on the surface of the planet, underground, and in the air. A planet's hydrosphere can be liquid, vapor, or ice. On Earth, liquid water exists on the surface in the form of oceans, lakes and rivers. Water is a molecule with one oxygen atom and two hydrogen atoms, bonded together by shared electrons. Water is a liquid at standard ambient temperature and pressure, but it often co-

exists on Earth with its solid state, ice, and gaseous state, steam (water vapour). It also exists as snow, dew and cloud. It covers about 70 per cent of the Earth for a total of approximately 1.386 million cubic km (source: U.S Geological Survey). It is vital for all known form of life. On Earth, 96.5% of the planet's crust water is found in seas and oceans, 1.7% in ground water, 1.7% in glaciers and the ice caps of Antarctica and Greenland, a small fraction in other large water bodies and 0.01% in the air as vapour, clouds and precipitation (Gleick 1993). With two thirds of the earth's surface covered by water and the human body consisting of 75 percent of it, it is evidently clear that water is one of the prime elements responsible for life on earth. Water circulates through the land just as it does through the human body, transporting, dissolving, and replenishing nutrients and organic matter, while carrying away waste material. Further in the body, it regulates the activities of fluids, tissues, cells, lymph, blood and glandular secretions.

Water on Earth moves continually through the water cycle of evaporation and transpiration (evapo-transpiration), condensation, precipitation, and runoff, usually reaching the sea. Evaporation and transpiration contribute to the precipitation over land. The water cycle or the hydrologic cycle refers to the continuous exchange of water within the hydrosphere, between the atmosphere, soil water, surface water, groundwater, and plants.

Lithosphere

The lithosphere is the solid outer section of Earth, which includes Earth's crust (the "skin" of rock on the outer layer of planet Earth), as well as the underlying cool, dense, and rigid upper part of the upper mantle. The lithosphere extends from the surface of Earth to a depth of about 70–100 km. This relatively cool and rigid section of Earth is believed to "float" on top of the warmer, non-rigid, and partially melted material directly below.

The lithosphere is subdivided into tectonic plates. The uppermost part of the lithosphere that chemically reacts to the atmosphere, hydrosphere and biosphere through the soil forming process is called the pedosphere. The lithosphere is underlain by the asthenosphere which is the weaker, hotter, and deeper part of the upper mantle. The boundary between the lithosphere and the underlying asthenosphere is known as the Lithosphere-Asthenosphere boundary and is defined by a difference in response to stress: the lithosphere remains rigid for very long periods of geologic time in which it deforms elastically and through brittle failure, while the asthenosphere deforms viscously and accommodates strain through plastic deformation. The study of past and current formations of landscapes is called geomorphology.

There are two types of lithosphere:

- Oceanic lithosphere, which is associated with oceanic crust and exists in the ocean basins (mean density of about 2.9 grams per cubic centimeter). Oceanic lithosphere is associated with oceanic crust, and is slightly denser than continental lithosphere.
- Continental lithosphere, which is associated with continental crust (mean density of about 2.7 grams per cubic centimeter). Continental lithosphere, associated with continental crust, can be much, much thicker than its oceanic cousin, stretching more than 200 kilometers below Earth's surface.

The cool, brittle lithosphere is just one of five great "spheres" that shape the environment of Earth. The other spheres are the biosphere (Earth's living things); the cryosphere (Earth's frozen regions, including both ice and frozen soil); the hydrosphere (Earth's liquid water); and the atmosphere (the air surrounding our planet). These spheres interact to influence such diverse elements as ocean salinity, biodiversity, and landscape.

Biosphere

The biosphere is the biological component of earth systems, which also include the lithosphere, hydrosphere, atmosphere and other "spheres" (e.g. cryosphere, anthrosphere, etc.). It is the global sum of all ecosystems. It can also be termed the zone of life on Earth, a closed system (apart from solar and cosmic radiation and heat from the interior of the Earth) and largely self regulating. It is the part of the Earth's environment in which living organisms are found, and with which they interact to produce a steady-state system, effectively a whole planet "ecosystem". Sometimes it is termed ecosphere to emphasize the interconnection of the living and non-living components. Relative to the volume of the earth, the biosphere constitutes only a very thin surface layer, which extends from 11,000 meters below sea level to 15,000 meters above it. In general, biosphere includes most of the hydrosphere as well as parts of lower atmosphere and upper lithosphere. The biosphere contains large quantities of elements such as carbon, nitrogen and oxygen. Other essential elements like phosphorus, calcium and potassium are present in smaller amounts.

The biosphere includes all living organisms on earth, together with the dead organic matter produced by them. The biosphere concept is common to many scientific disciplines including astronomy, geophysics, geology, hydrology, biogeography and evolution, and is a core concept in ecology, earth science and physical geography. A key component of earth systems, the biosphere interacts with and exchanges matter and energy with the other spheres, helping to drive the global biogeochemical cycling of carbon, nitrogen, phosphorus, sulfur and other elements. From an ecological point of view, the biosphere is the "global ecosystem", comprising the totality of biodiversity on earth and performing all manner of biological functions, including photosynthesis, respiration, decomposition, nitrogen fixation and denitrification.

Bulk of the functioning in the eco-system is based on the input of solar energy and there is continual recycling of materials at the ecosystem and biosphere levels. For example, green plants use carbon dioxide for photosynthesis and release oxygen into the atmosphere, which is then inhaled by the animals for respiration who in return release carbon dioxide. In the biosphere, there exist interactions among the organisms. When an organism interacts with members of its own kind, it is an intra-specific interaction like colonization and then aggregation, etc. On the other hand, interaction between different species is known as inter-specific interaction like neutralism, competition and prey-predator relationships. The interactions may be harmful or beneficial to the participants but are very important for the survival, growth, reproduction and continuance of the species.

The biosphere is dynamic, undergoing strong seasonal cycles in primary productivity and the many biological

processes driven by the energy captured by photosynthesis. Seasonal cycles in solar irradiation of the hemispheres are the main driver of this dynamic, especially by its strong effect on terrestrial primary productivity in the temperate and boreal biomes, which essentially cease productivity in the winter time. The biosphere has evolved since the first single-celled organisms originated 3.5 billion years ago under atmospheric conditions resembling those of our neighboring planets Mars and Venus, which have atmospheres composed primarily of carbon dioxide. Billions of years of primary production by plants released Oxygen from this carbon dioxide and deposited the carbon in sediments, eventually producing the oxygen-rich atmosphere we know today. Free oxygen, both for breathing (O_2, respiration) and in the stratospheric ozone (O_3) that protects us from harmful UV radiation have made possible life as we know it while transforming the chemistry of earth systems forever. As a result of long-term interactions between the biosphere and the other earth systems, there is almost no part of the earth's surface that has not been profoundly altered by living organisms. The earth is a living planet, even in terms of its physics and chemistry (Ellis 2013).

The biosphere has a great impact on the climate because the biosphere is closely connected to the atmosphere. When plants harness the Sun's energy through photosynthesis, oxygen is released into the atmosphere and carbon dioxide is taken out. When plants and animals respire, carbon dioxide gas is added to the atmosphere and oxygen is taken out. As humans' burn fossil fuels, forests etc, greenhouse gases such as carbon dioxide and nitrous oxide are released into the atmosphere.

The biosphere supports between 3 and 30 million species of plants, animals, fungi, single-celled prokaryotes such as bacteria, and single-celled eukaryotes such as protozoans. However, according to new study of UNEP (2011), the latest estimated total number of species on Earth is 8.74 million. Around 6.5 million species are found on land and 2.2 million dwell in the ocean depth. The report says that 86% of all the species on land and 91% of those in seas have yet to be discovered, described and catalogued. Only about 1.4 million species have been named so far, and less than 1 percent has been studied for their ecological relationships and their role in ecosystems. A little more than half the named species are insects, which dominate terrestrial and freshwater communities worldwide. Hence, the relationships of organisms to their environments and the roles that species play in the biosphere are only beginning to be understood.

Environmental issues

Environment and organisms are two dynamic and complex components of nature. Environment regulates the life of the organisms including human beings. Human beings interact with the environment more vigorously than other living beings.

Human or anthropogenic environmental impacts affect the biophysical environments, biodiversity and other resources. In order to understand the character and extent of human impacts on the biophysical environment it is necessary to have a well defined understanding about how the natural systems function. This requires ecological monitoring conducted systematically over a long term. These environmental studies are the systematic

study of interaction of humans with their environment. It is a broad field of study that includes the natural environment, built environments and social environments. On a broad scale the most notable of these include: agriculture, fishing, water use (irrigation, power generation, sewer treatment, etc.) transportation systems, urbanization, manufacturing, mineral/oil extraction, and deforestation.

Human caused impacts that have degraded ecosystems are common and natural ecosystems are relatively rare. The impacts of human activity generally affect the biological parts of an environment. These are often first to experience these impacts. They cause changes in the composition and populations within a biological community. Biological impact assessments are undertaken to predict loss of genetic resources, habitats, ecosystems etc and to suggest mitigating measures to a proposed activity. Biological impact assessments are also done while a project is underway and at the end of the project period as a part of the restoration work.

Environment often changes after some time and therefore many organisms have ability to adapt to these changes. However, tolerance range is not the same with all species and exposure to environmental conditions at the limit of certain organism's tolerance range represents environmental stress. Stress occurs when an event and stimulus requires us to change in some way. Stress varies based on the individual and situation. Most stress is temporary although there are situations where stress can last for a long time. Stressors that are found in our surroundings are called environmental stressors. Every time a physical environment is changed, all the plants and animals in that environment must adapt to the changes or become extinct. Slow changes give living things time to adapt by the process of evolution over many generations. Fast changes usually don't give living things time to adapt, so they must either move elsewhere or become extinct. Everyday life is full of environmental stressors. Environmental stress can be characterized as a force shaping adaptation and evolution in changing environments, and it is a property of both the stressor and the stressed (Bijlsma and Loeschcke 2005). Environmental stress is considered to be primarily a response to physical features of the environment. Extrinsic stress that results from changes in abiotic factors such as temperature, climatic factors and chemical components, either naturally occurring or man-made, is regarded as the most important stress agents (Lindgren and Laurila 2005, Sorensen *et al.* 2005). In addition, biotic stresses, such as competition, predation, and parasitism, can also cause stress (Ralyea 2005). Although abiotic and biotic stress can act independently, these two types of stress often act synergistically, as organisms that have suboptimal fitness because of abiotic stress often suffer more from predators and parasites. However, environmental stress can only be valued in relation to the organism experiencing the stress, and therefore stress also has an intrinsic component. Genetic changes in organisms and populations brought about, for instance, by inbreeding or other changes in the genetic architecture of organisms or populations, can drastically change the perception of an otherwise unchanged (stress) environment, resulting in what is sometimes called 'genetic stress' (Bijlsma ***et al.***, 1997, 2000). Consequently, inbred

populations may suffer greatly from changes in the environment that by noninbred populations would be perceived as nonstressful. This indicates that intrinsic and extrinsic stress may often strongly interact, and there is increasing evidence that this leads to a strong synergism between the two stresses causing normally no severe stresses to become harmful when combined (Jiménez ***et al.***, 1994; Bijlsma ***et al.***, 2000; Keller ***et al.***, 2002). As the extrinsic and intrinsic causes of stress generally occur together in a nonadditive manner, they should preferably be investigated jointly. This is particularly important as the growing human population causes major changes in the biotic and abiotic environment at an unprecedented scale and a fast rate. Global warming causing thermal stress and pollution exerting chemical stress go hand in hand with destruction and fragmentation of natural habitats. As the latter will inevitably go together with smaller and more isolated populations that become subject to genetic erosion, many populations and organisms will simultaneously experience deteriorating environmental conditions and genetic stress (Frankham, 2005). Therefore, understanding the nature, interactions and consequences of these stresses at a global scale from an ecological and evolutionary perspective is of the utmost importance, not only to understand the processes involved, but also to develop and evaluate possible countermeasures.

Environmental issues are harmful effects of human activity on the biophysical environment. These are problems with the planet's system (air, water, soil etc.) that have developed as a result of human interference or mistreatment of the planet. Two broad categories are first identified between natural and environmental resources and environmental problems. Natural and environmental resources generally describe all the elements available in nature that are used or can be used in the economic system. These can be:

- physical such as soil, water, forests, fisheries, and animals, minerals (e.g. copper, bauxite, etc.);
- gases (e.g. helium, hydrogen, oxygen, etc.); and
- abstract such as solar energy, wind energy, landscape, good air, clear water, and so forth.

Environmental problems are mainly related to the impacts of human activities on environmental resources. These generally have impact on climate system, hydrological system and nutrient cycling, and also take the form of pollution, depletion or degradation of water, air and soil. Soil erosion, water salinity and pollution, desertification, forest depletion, coastal degradation is accounted for as the major environmental problems in the developing countries.

A climate change like global warming is the result of human practices like emission of Greenhouse gases. Global warming leads to rising temperatures of the oceans and the earth's surface causing melting of polar ice caps, rise in sea levels and also unnatural patterns of precipitation such as flash floods, excessive snow or desertification. Climate change is yet another environmental problem that has surfaced in last couple of decades. It occurs due to rise in global warming which occurs due to increase in temperature of atmosphere by burning of fossil fuels and release of harmful gases by industries. Climate change has various harmful

effects but not limited to melting of polar ice, change in seasons, occurrence of new diseases, frequent occurrence of floods and change in overall weather scenario. The impacts of climate change on temperature, precipitation, and agricultural productivity are likely to diminish food security in some places. Recent research suggests that climate change will have negative impacts on staple crops – especially in Asia and Africa where widespread hunger is greatest (Labell *et al.* 2008, PAI 2011).

Pollution of air, water and soil require millions of years to recoup. Industry and motor vehicle exhaust are the number one pollutants. Heavy metals, nitrates and plastic are toxins responsible for pollution. While water pollution is caused by oil spill, acid rain, urban runoff; air pollution is caused by various gases and toxins released by industries and factories and combustion of fossil fuels; soil pollution is majorly caused by industrial waste that deprives soil from essential nutrients. Soils become polluted either through direct contact with contaminants or non-point source pollution (NSP). NSP is pollution from a source that may not be directly identifiable such as runoff from roads, mines or agricultural lands. Air pollution also pollutes soils by contributing to the formation of acid rain which is then absorbed into the soil.

Our forests are natural sinks of carbon dioxide and produce fresh oxygen as well as helps in regulating temperature and rainfall. At present forests cover 30% of the land but every year tree cover is lost amounting to the country of Panama due to growing population demand for more food, shelter and cloth. Deforestation simply means clearing of green cover and makes that land available for residential, industrial or commercial purpose. Deforestation has long posed a threat to our Earth. Forests provide vital protection from sandstorms and flooding as well as the substantive natural habitat for wildlife. They are one of our greatest resources for offsetting some of our outrageous carbon emissions and without the canopy we leave areas vulnerable to intense heat, further driving climate change.

The population of the planet is reaching unsustainable levels as it faces shortage of resources like water, fuel and food. Population explosion in less developed and developing countries is straining the already scarce resources. Intensive agriculture practiced to produce food damages the environment through use of chemical fertilizer, pesticides and insecticides. Population growth is driving all of our resource problems, including water and energy. Energy and water use are intimately related. As water tables decline, we have to use more energy to lift the water out of the ground. Therefore, more people mean more water use, more food, and more energy. Ground water, fossil fuel resources, cropland and forests all are being depleted or degraded due to overpopulation. The impact of overpopulation on environment is twofold. First, humans influence the environment by the increasing demand for raw materials, energy, living place, services, and consumer goods. Second, human activities destroy the environment by producing toxic chemicals and generating non-biodegradable trash (plastic and other substances). These activities have devasting consequences for all life on Earth. Environmental destruction means toxic pollution of air, water, and soil. Deforestation and timber harvesting are advancing at the very fast pace in different parts of the globe due to overpopulation.

Other raw materials (oils, natural gas, minerals etc.) are in short supply. The Earth is approaching a breaking point and there is a nonlinear relationship between demand and supply. Thus, overpopulation is one of the crucial current environmental problems**.**

Natural resource depletion is another crucial current environmental problem. All the materials and energy essential for the survival and welfare of living beings including humans are provided by nature. They are called natural resources. A thing becomes resource only when it is used by humans to perform a function. Man lives in nature and depends on the resources of nature. Resource depletion is the consumption of a resource faster than it can be replenished. Natural resources are commonly divided between renewable resources and non-renewable resources. Use of either of these forms of resources beyond their rate of replacement is considered to be resource depletion. Resource depletion is most commonly used in reference to farming, fishing, mining, water usage, and consumption of fossil fuels. Fossil fuel consumption results in emission of Greenhouse gases, which is responsible for global warming and climate change. Globally, people are taking efforts to shift to renewable sources of energy like solar, wind, biogas and geothermal energy. The cost of installing the infrastructure and maintaining these sources has plummeted in the recent years.

The over consumption of resources and creation of plastics are creating a global crisis of waste disposal. A typical solid waste management system in a developing country displays an array of problems, including low collection coverage and irregular collection services, crude open dumping and burning without air and water pollution control, the breeding of flies and vermin, and the handling and control of informal waste picking or scavenging activities. These public health, environmental, and management problems are caused by various factors which constrain the development of effective solid waste management systems (Bartone 1995). Developed countries are notorious for producing an excessive amount of waste or garbage and dumping their waste in the oceans and, less developed countries. Nuclear waste disposal has tremendous health hazards associated with it. Plastic, fast food, packaging and cheap electronic wastes threaten the well being of humans. Waste disposal is one of urgent current environmental problem**.**

Human activity is leading to the extinction of species and habitats and loss of bio-diversity. Eco systems, which took millions of years to perfect, are in danger when any species population is decimating. Balance of natural processes like pollination is crucial to the survival of the eco-system and human activity threatens the same. Habitat destruction is the alteration of a natural habitat to the point that it is rendered unfit to support the species dependent upon it as their home territory. Many organisms previously using the area are displaced or destroyed, reducing biodiversity. Modifying habitats for agriculture is the chief cause of such habitat loss. Other causes of habitat destruction include surface mining, deforestation, slash-and-burn practices and urban development. Habitat destruction is presently ranked as the most significant cause of species extinction worldwide (Pimm and Baven 2000). Additional causes of habitat destruction include acid rain, water pollution, introduction of alien species, overgrazing and overfishing.

Another example is the destruction of coral reefs in the various oceans, which support the rich marine life (Kleypas *et al.* 2001).

The ozone layer is an invisible layer of protection around the planet that protects us from the sun's harmful rays. Depletion of the crucial Ozone layer of the atmosphere is attributed to pollution caused by Chlorine and Bromide found in Chloro-floro carbons (CFC's). Once these toxic gases reach the upper atmosphere, they cause a hole in the ozone layer, the biggest of which is above the Antarctic. The CFC's are banned in many industries and consumer products. Ozone layer is valuable because it prevents harmful UV radiation from reaching the earth. This is one of the most important current environmental problems.

Acid rain occurs due to the presence of certain pollutants in the atmosphere. Acid rain can be caused due to combustion of fossil fuels or erupting volcanoes or rotting vegetation which release sulfur dioxide and nitrogen oxides into the atmosphere. Acid rain is a known environmental problem that can have serious effect on human health, wildlife and aquatic species. The global environment is, thus, experiencing a wide range of perturbations/disturbances. Disturbances often act quickly and with great effect, sometimes resulting in the removal of large amounts of biomass. Major ecological disturbances may include fires, flooding, windstorms, insect outbreaks and trampling. Earthquakes, various types of volcanic eruptions, tsunami, firestorms, impact events, climate change, and the devastating effects of human impact on the environment (anthropogenic disturbances) such as clear cutting, forest clearing and the introduction of invasive species (Dale *et al.*2001) can be considered major disturbances. Alien invasive species have had severe impacts on local aquatic flora and fauna, and can upset the natural balance of an ecosystem. Disturbance forces can have profound immediate effects on ecosystems and can, accordingly, greatly alter the natural community. Because of these and the impacts on populations, these effects can continue for an extended period of time.

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Growing immunity boosting herbs: Need of the hour

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Through ancient times, Acharyas promoted the use of Rasayana (Rejuvenation) to enhance the Ojas. Rasayanas are rejuvenating agents that produce resistance against diseases, both physically and mentally, thus improving overall health. The uses of different types of ojas-promoting Medicinal Plants have been described in Ayurveda. These can be quite helpful in improving overall immunity. Herbs are known for their several health benefits. They are anti-oxidants, immunomodulators, anti-microbials, anti-inflammatory, aid in digestion and list can go on. However, one very important function of herbs is they help cleanse toxins and in-turn help boost our immunity.

Herbal plants that boost immune system stimulate the activity of cells responsible for fighting infections. These natural immune boosters are an important tool in our current war against coronavirus infection. Antibiotics are used to kill bacteria not viruses. About boosting immunity naturally over 80% of the earth's population depends on plants that increase immunity and promote healing. The immune system is one of the more complex systems within the human body. It helps keep us healthy by tackling viruses, bacteria and abnormal cells, all while distinguishing between our own healthy tissue and the invading pathogen. Plants that boost the immune system naturally help keep us healthy. The key to using these plants is prevention. The role of plants that increase immunity is just that, to support and strengthen our body's natural immune system.

Our global food system is dominated by industrial agriculture. Food manufacturing facilities make highly processed and refined foods that do not provide much nutritional value. The lack of a nutritious and wholesome diet has not only led to the drastic increase of chronic diseases such as heart disease, obesity, and diabetes - it also negatively affects our immune systems.

Taking vitamin C during flu season has long been a popular way to stay healthy. Adequate vitamin C consumption can help immune cells identify and kill viruses and bacteria. Instead of merely purchasing vitamin C capsules at your local pharmacy, however, incorporating different types of fruits, plants, and other medicinal herbs that are high in essential vitamins and minerals can help maintain a robust immune system throughout the year. A healthy diet that focuses on wholesome nutrition can help to create a strong and robust immune system.

Another good reason to grow our immune-boosting herbs and medicinal plants is to reduce dependence on antibiotics. Some health experts are already beginning to warn that antimicrobial resistance might be the next major pandemic to sweep across the globe. Healthy immune systems can fight off many types of minor microbial infections without the need to prescribe

antibiotics. A host of plants and herbs has natural antimicrobial functions that can help effectively fight off minor infections. Some of the commonly describe herbs, which help to boost our immunity are as follows:

Echinacea

Echinacea is a plant long used to strengthen immunity, specifically upper respiratory tract infections and effectively shortens their duration and severity. It also has antimicrobial properties and regulates inflammation. It should be used daily during cold and flu season. Echinacea is a plant long used to strengthen immunity, specifically upper respiratory tract infections and effectively shortens their duration and severity. It also has antimicrobial properties and regulates inflammation. It should be used daily during cold and flu season.

Echinacea, also known as the purple coneflower, is one of the best immune-boosting plants. WE can most likely find Echinacea extract at your local pharmacy, as many have come to appreciate the positive effects that this plant has on the immune system. Studies have shown that regular Echinacea consumption can increase the number of white blood cells, which fight infections. A review of more than a dozen studies concluded that this popular herbal remedy did show benefits in preventing colds.

Besides its important medicinal and immune-boosting effects, the purple coneflower is a beautiful addition to any flower garden. It is a great option to help attract beneficial pollinators to our garden and is extremely easy to grow. Because Echinacea seeds need a cold and moist period to germinate, it is best to plant them in the fall. When started from seed, it will usually take two years for Echinacea plants to flower. We can also begin with transplants that we can purchase at nurseries for quicker flowering time. Once established, Echinacea is a perennial plant that will continue to give our home pharmacy a reliable supply of flowers.

The best way to reap the medicinal benefits of Echinacea is via tinctures or teas. For teas, use the flowers, stems, and roots of the Echinacea plant and boil with water for an immune-boosting herbal remedy. Tinctures can be made by mixing Echinacea leaves and flowers with 80-proof alcohol, vodka, for example. This strategy allows for long-term storage.

Elderberry

Elderberry trees and shrubs grow wild in thickets, hedges, and forests in most areas around the country. This easy-to-establish tree is a favorite for birds and other wildlife. Fortunately for humans, the white flowers and dark-colored berries are another fantastic immune-boosting remedy. Both the berries and flowers of elderberry trees have high levels of

antioxidants and vitamins that may boost your immune system. For hundreds of years, people have relied on homemade elderberry syrup to help prevent and ease cold and flu symptoms.

We can make elderberry syrup by simply mixing water, elderberries, ginger, cloves, and honey. Simmer this mixture for an hour in a large pan and mash occasionally to extract the medicinal elements from the elderberries. Once cooled, strain the thick syrup into glass mason jars and take a spoonful of this syrup once a day, especially during flu season.

Ashwagandha (*Withania somnifera*)

All parts of the ashwagandha plant like leaves, roots, bark, fruit, and seeds are consumed for their medicinal properties but the root is most commonly used. This herb has traditionally been prescribed to strengthen immunity post an illness. Ashwagandha has strong anti-inflammatory action that helps in conditions like rheumatoid arthritis, autoimmune diseases and certain skin diseases. This herb has proven its efficacy in nervous system disorders. It has shown to improve brain cell function, nervous exhaustion, anxiety and depression. It also refreshes the body by relieving fatigue. Researchers are exploring the role of ashwagandha in degenerative conditions like Alzheimer's and Parkinson's. It is ideally recommended to be had with warm sweetened milk.

Mulethi (*Glycyrrhiza glabra*)

Liquorice or yashtimadhu, also known commonly as mulethi is an excellent home remedy for a number of disorders like cough and cold. According to Ayurveda, mulethi is sweet to taste, it's slimy and heavy, and is efficacious in treating vata disorders. Glycyrrhizin – a saponin found in mulethi is known for its anti-microbial action. The root is powdered and had with honey and ghee to improve immunity. It is believed to be a natural revitaliser and anti-ageing agent. Some studies have also shown positive effect of mulethi in relation to brain function.

Mulethi possesses anti-inflammatory, antimicrobial, antiulcer, antidiabetic, antidepressant along with these it also improves immunity, heart function, control cholesterol level etc.

Amla (*Emblica officinalis*)

It is perhaps one of the richest sources of vitamin C and is perfect for the overall immunity, as it can rejuvenate and revitalize the body systems. Amla is cooling in nature and can help remove excess body heat, thus often recommended in pitta conditions. It is also helpful in afflictions of the gastro-intestinal tract.

Amla is also believed to stimulate regeneration of red blood cells and help improve haemoglobin content in body. Due to its anti-inflammatory properties, it can help soothe joint pains. Amla is often used in powder form but is also available as tablets or liquid extracts. It is best to consume amla in raw form. Amla powder can be consumed by mixing with honey, twice a day. Chyawanprash is a well-known Ayurvedic formulation that can be taken to reduce mental and physical fatigue and boost immunity also contains amla.

Ginger (*Zingiber officinalis*)

Ginger is hot in potency and thus aids in decreasing the aggravated vatta and kapha doshas. Ginger is very versatile – it can be had fresh, powdered or oil form or in dry candied/ juice form. Dry ginger powder mixed with sesame oil is used to relieve joint or muscle pains. It is also used for hot fomentation in gout, oedema, arthritis or other joint pains. Anti- microbial compounds in ginger helps fight infections, and boost immunity levels. Ginger is also recommended for many respiratory ailments like cold, cough, pneumonia, asthma and bronchitis. This amazing herb has been used in ancient medicinal systems for the treatment of numerous ailments, such as colds, nausea, arthritis, migraines, and hypertension.

Tulsi (*Ocimum sanctum*)

Ocimum sanctum is the primary form of Tulsi used for its medicinal purposes, due to its anti-infective properties and its use in respiratory tract infections like cough, cold, sore throat, asthma etc. It helps remove excess kapha from lungs. This natural stimulant energizes our body, increases circulation, and has been proven to be beneficial in skin diseases and ulcers. Fresh tulsi juice taken twice a day may help to boost health. Adding a few drops of ginger and honey to tulsi juice may help further improve immunity. Tulsi is scientifically proven that this wonder herb can fight against chemical stress due to pollution along with other benefits. This is a perfect herb to be used during monsoon with chai, food and even on your skin.

Tulsi also known as the queen of herbs is such an inexpensive leaf found in almost all home gardens and has such powerful

immunity boosting and anti-viral properties. Fresh tulsi leaves are known to help with chronic fever and when they are mixed with honey and ginger juice, they are useful in treating cough.

Mint

Mint is known for its carminative, antiseptic, antibacterial, antiviral, antispasmodic, antioxidant, anti-inflammatory, myorelaxant, expectorant, analgesic, tonic, and vasodilatator activities.

Coriander (Dhania)

This easy to grow herb is a must have for any home garden not only for its culinary benefits but also for medicinal values it possesses. It provides antimicrobial, antioxidant, hypoglycemic, hypolipidemic, anxiolytic, analgesic, anti-inflammatory, anti-convulsant and anti-cancer activities, among others.

Garlic

Garlic is another plant that boosts the immune system. It contains allicin, ajoene, and thiosulfinates that help prevent and fight infection. Historically, garlic has also been used to treat fungal infections and disinfect wounds. The best way to receive the benefits of garlic is to eat it raw, which might be quite a feat for some. Add raw garlic to pesto or other sauces and in homemade vinaigrettes to reap its benefits. Garlic has been shown to contain high allicin levels, a critical plant compound that acts as a germicide. One recent scholarly study found that garlic can "enhance the functioning of the immune system by stimulating certain cell types, such as macrophages, lymphocytes, natural killer cells, dendritic cells, and eosinophils, by mechanisms including modulation of cytokine secretion, immunoglobulin production, phagocytosis, and macrophage activation." In layman's terms, this essentially means that garlic can boost is not only a natural antibiotic but can also act as a preventive measure to colds, cases of flu, and other viral and bacterial infections by boosting your body's immune system response. To get the most medicinal benefits of garlic, consume it raw or lightly cooked. Overcooking garlic causes it to lose some

of the potency of its antibacterial and immune-boosting effects.

These are only a few of the many potent, immune-boosting plants that can grow. Virtually any fruit that is high in antioxidants can also be considered to be an immune booster. Even if we only have one sunny windowsill, these immune-boosting plants can go a long way in helping to protect your health.

With COVID-19 emerging as a global pandemic, leaving its impact in each family across the planet, the implications of its spread have become far more serious than envisaged. At such times, it's important to follow the protocols of wearing a mask, using sanitisers, staying indoors and strengthening immunity. Wondering how to boost your immunity against the virus? Get back to the old nuske using our age-old herbs and spices.

A wholesome diet, good sleep, yoga or exercise and stress management techniques like pranayama and meditation are the foundation of a strong immune system. Ayurvedic herbs can further act like boosters to support a healthy immune function. It's time to switch to these miraculous solutions that Ayurveda provides and have those wonder concoctions.

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