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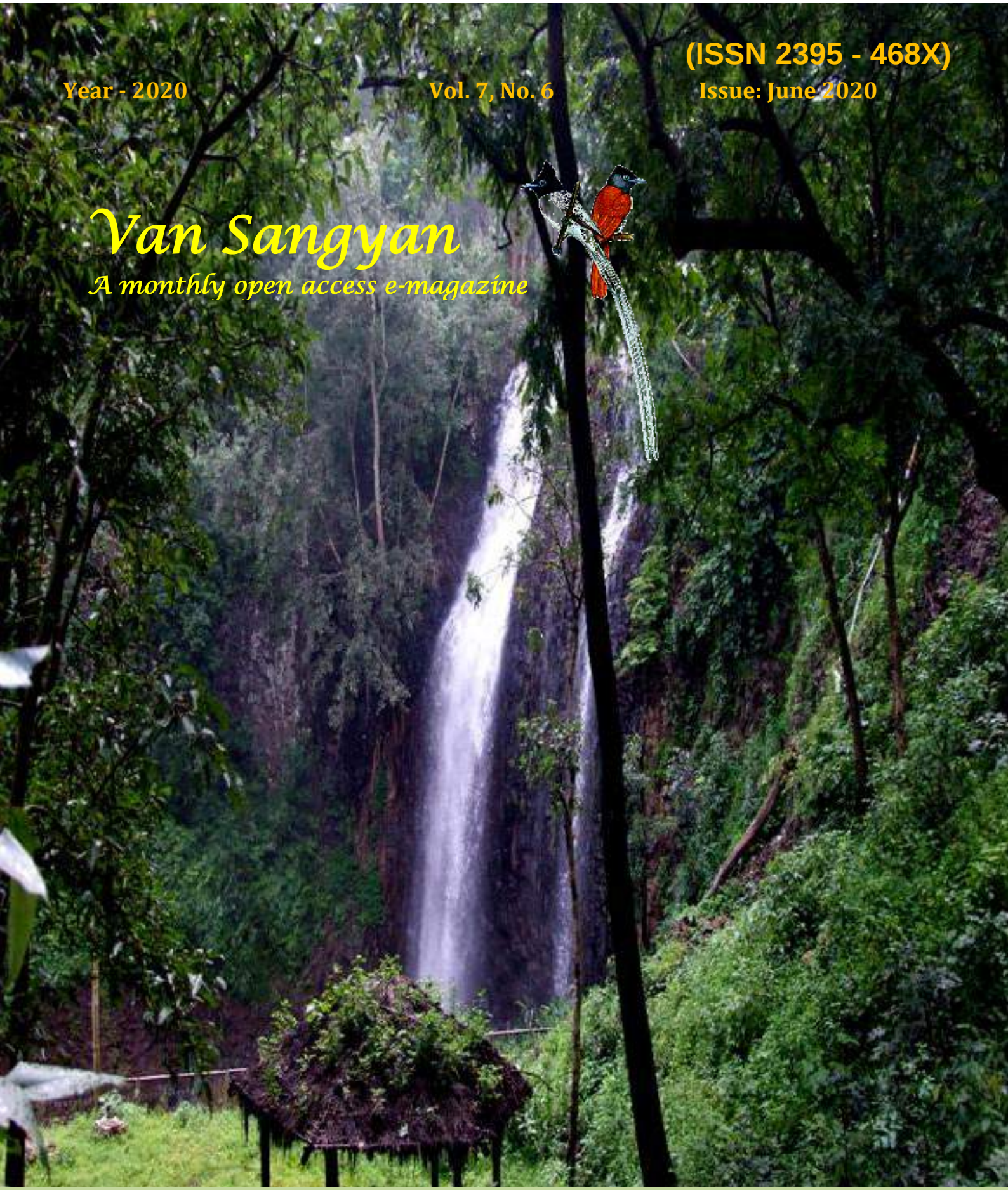

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Van Sangyan

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:

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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.)

From the Editor's desk

Sustainable agricultural systems depend on agroecological processes that promote soil fertility and pest resistance through biologically acquired inputs, and social processes that generate knowledge and incentives for producing a variety of foods and fibers within locally affordable means. Agroforestry practice, the cultivation of trees or other woody plants with crops or pasture for multiple benefits, can contribute substantially to advancing a sustainable agriculture through its influence on ecological and social processes. To realize this potential a better understanding is needed of how agroforestry practice affects soil, water, plant, animal and atmospheric relations, and the roles of management in bringing about desirable outcomes. This volume is designed to help meet the challenge and to demonstrate how perspectives of key scientists and various works in progress are shaping the field of agroforestry.

Agroforestry is a dynamic, ecologically- based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production and contributes to more resilient rural livelihoods. Drawing on the most recent science and case studies, especially from the work of the World Agroforestry Centre (ICRAF) and its partners, this chapter explores the contributions of agroforestry to the management of agricultural landscapes and the strengthening of rural livelihoods, taking account of the fine-scale variation and heterogeneity that are a feature of these landscapes. There is growing evidence from across the developing world that the adoption of agroforestry is helping to restore the productivity and resilience of landscapes, as well as contributing to the goals of food, nutrition and income security for smallholders and other vulnerable groups in society. Because development challenges are emergent properties of a complex system they can only be tackled by systems approaches, such as agroforestry, based on a sound understanding of ecology and a better understanding of the social and economic systems of the people who inhabit these landscapes. The case studies focus especially on the contributions of agroforestry to improving the agroecology of large - scale plantations as a means of testing the scalability of this body of work. Investments, including from the private sector, are helping to scale up agroforestry-based agriculture and this chapter touches on the evolving nature of these investments as an important contributor to the widespread adoption of agroforestry. It closes with an identification of opportunities and challenges for agroforestry in the context of rising populations, climate change, shifting demographics and changing consumption patterns.

In line with the above this issue of Van Sangyan contains an article on Agroforestry towards sustainable agroecosystem. There are also useful articles viz. Celtis australis for fodder security in mid hills of Himachal Pradesh, अम्लीय वर्षा: पर्यावरण के लिए चुनौती, Tulsi (Ocimum basilicum L.), Lemon grass (Cymbopogan flexuosus Nees ex steud wats), Muskdana (Abelmoschus moschatus Medic) and Changing climate with changing Sun.

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. Pawan Rana
Scientist 'E' & Chief Editor

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Agroforestry towards sustainable agroecosystem

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Abstract

The global climate change, food crisis and security, along with ever increasing demand of various products due to population rise put pressure on the various natural resources of the earth. The food requirement of the country of various countries are increasing and they trying to increase the production through intensification process and not concerning about the food quality, human health and the environment. These faulty or unsustainable practices are disrupting the ecology and natural balance by altering the various natural process and systems. Therefore, sustainable land-use, production systems and technologies are need of the present and future wellbeing of human. In this perspective, the agroforestry seems to be very promising land-use practices which not only efficiently utilizes all the available resources but protect and improves the ecology and environment of the farming systems. This also helps towards improving biodiversity, soil quality, livelihood, and economic status of the farmer through diversified products besides their ecological functions. Agroforestry is key instrument towards enhancing the vegetal cover, resource utilization, ecosystem productivity and environment resilience and stability which forms the basic pillar of agroecosystem sustainability and sustainble development.

Keywords: Agroforestry, Agroecosystem, Climate Change, Food Security, Sustainable Development

Introduction

The food production in the developing nations has expected to increase as compared to developed nation of the world but the demand of the food cannot be meet out in near future due to ever increasing population worldwide. Therefore, the production of the foods needs to be increased to bridge the demand-supply system across the world. The production in agroecosystem is regulated and limits by various factors such as soil health and productivity, water availability, suitable climate, resource input-output, production technologies, environment and ecological system, etc. Therefore, the sustainable production of agroecosystem needs to integrate with climatic information and smart practices to cope up food insecurity under changing climatic context (FAO, 2020). In this perspective, use of bioclimatology, organic farming, climate smart agriculture, conservation farming and agroforestry are the sustainble practices and ensure the eco-environmental development and prosperity of human being (Cano *et al.*, 2019; Jhariya *et al.*, 2019a, 2019b).

The prior focus on agroecosystem production has taken in India and other developing countries for accelerating agricultural productivity and food security through technological advancement in

production input systems (Khan, 2020). These transformations in the science and technology the India becomes self-sufficient in terms of food availability as well as one among the top food exporting countries as global platform. Still it would not clearly diagnose the socio-economic and eco-environmental perspectives for the welfare of farming community and the peoples in terms of sustainability (UNEP, 2015). This horde for improving the production system at national and international levels are depleting the productivity and carrying capacity of the nature and degrading the ecological balance. These also lead to severe degradation of soil, water and the environment (Khan *et al.*, 2020a, 2020b).

Therefore, the harmonized approach needs to be implementing to fulfil the required food production in one hand and eco-environmental sustainability on the other hand. In this connection agroforestry is boon for the farmers to maintain the agricultural production and ecological balance (Barua *et al*., 2019; Raj *et al*., 2020; Banerjee *et al*., 2020). The scientific management of agroecosystem with sustainble way, agroforestry is the only solution with all round development with eco-farming and eco-design.

Agroforestry and agroecosystem

The agroforestry system is continuously mentioned as holistic approach toward agricultural production and sustainble management of agroecosystem. This system has multifarious benefits of economic, social and environmental context. Besides these it offers various functions such as improves ecosystem health, soil health, hydrology, biodiversity and carbon sequestration and reduces the loss of natural forest. Agroforestry is reflected as sustainble agriculture practice which integrated agricultural crops, trees and livestock with varying site specific combination which offers the long term returns and satisfying the food demand of humans. It addressed the ecological and environmental developments along with natural resource base which affects the agricultural economy of the nation. It is also sustainble economic viable systems which enhance the economic gain of farming communities and uplift their socioeconomic condition (Mbow *et al*., 2014; Jhariya *et al.*, 2019a, 2019b).

There are several models prevalent across the globe. The agroforestry model varies as per the component and their combination. These also influenced by climatic regimes, soil, agroecology, bioclimatic component, biotic interferences and the production outputs. Figure 1 reflected some prevalent agroforestry models in India. The choice of species and component mix determined through various biotic and abiotic factors. Each model is unique in their practice and productive traits and supports the agro-production system and leads towards improving agroecosystem through better resource management. The proper management and utilization of land, soil, water resource and other available resources leads towards efficient input-output system of agroecosystems. This further improves the agroecology and leads towards agroecosystem sustainability (Jhariya *et al.*, 2019a, 2019b; Raj *et al*., 2019a, 2019b).

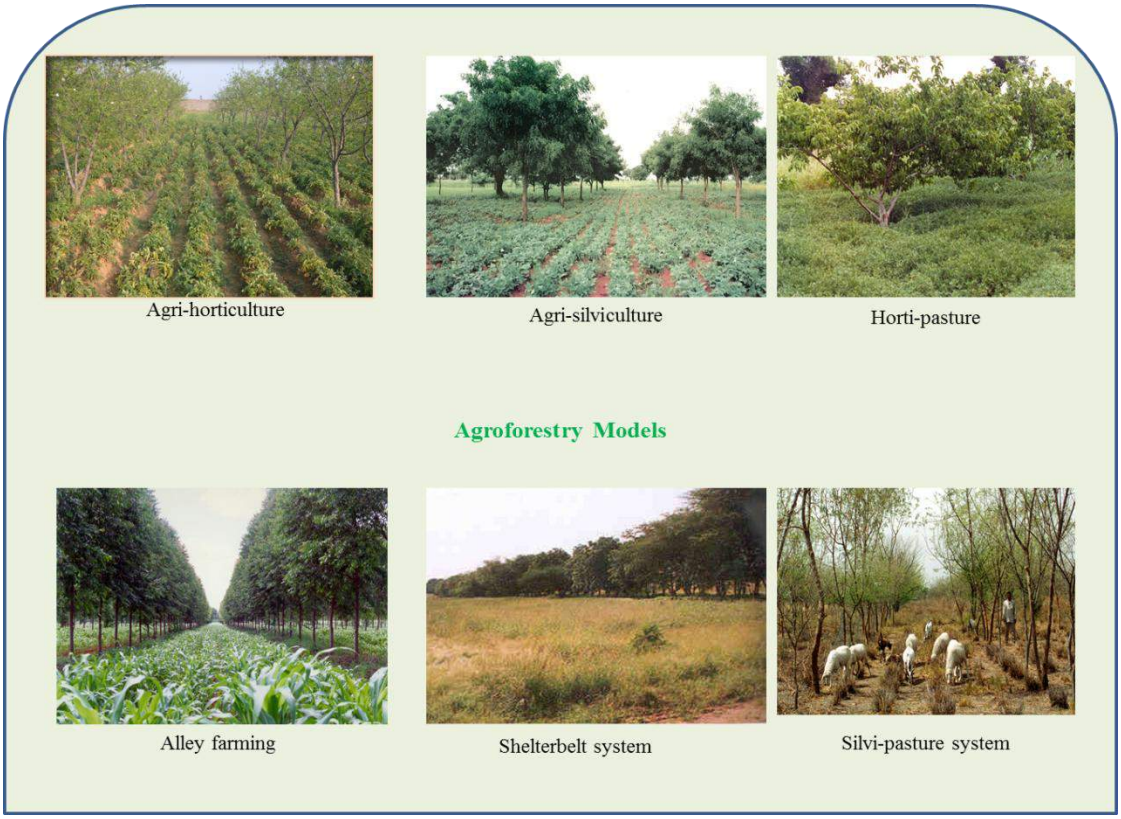

Fig. 1: A schematic presentation of various prevailing agroforestry models

Agroforestry for Sustainble Agroecosystem Management

The developing nation of the world is reflected traditional farming systems and facilitates livelihoods to people (Altieri and Nicholls, 2017). In the present climatic change scenario these monocropping system is threating the ecosystem and human welfare to a great extent. Due to mismanagement and faulty agricultural management system would putting the pressure on the natural resources and the quality food production at global scale. This practice is also accelerating to climate change and affects the food security by influencing the agricultural production (FAO, 2018).

Therefore, a balanced and harmonized approach like agroforestry is need of the hour towards sustainable agroecosystem management. Agroforestry is not only promoting sustainable production but also helps in adapting and mitigating the climate change which seems to be more prominent in the tropics of the world. This is cost-effective practices which conserve the resources and make the agroecosystem more resilience to climatic variability and improve the sink of nutrients and carbon. Agroforestry is sustainable land-use system which can improve the agroecosystem through improvement of soil, water, floral and faunal biodiversity, ecosystem health and resilience and through carbon sequestration which ameliorate the harse environmental conditions through various functions and services (Figure 2).

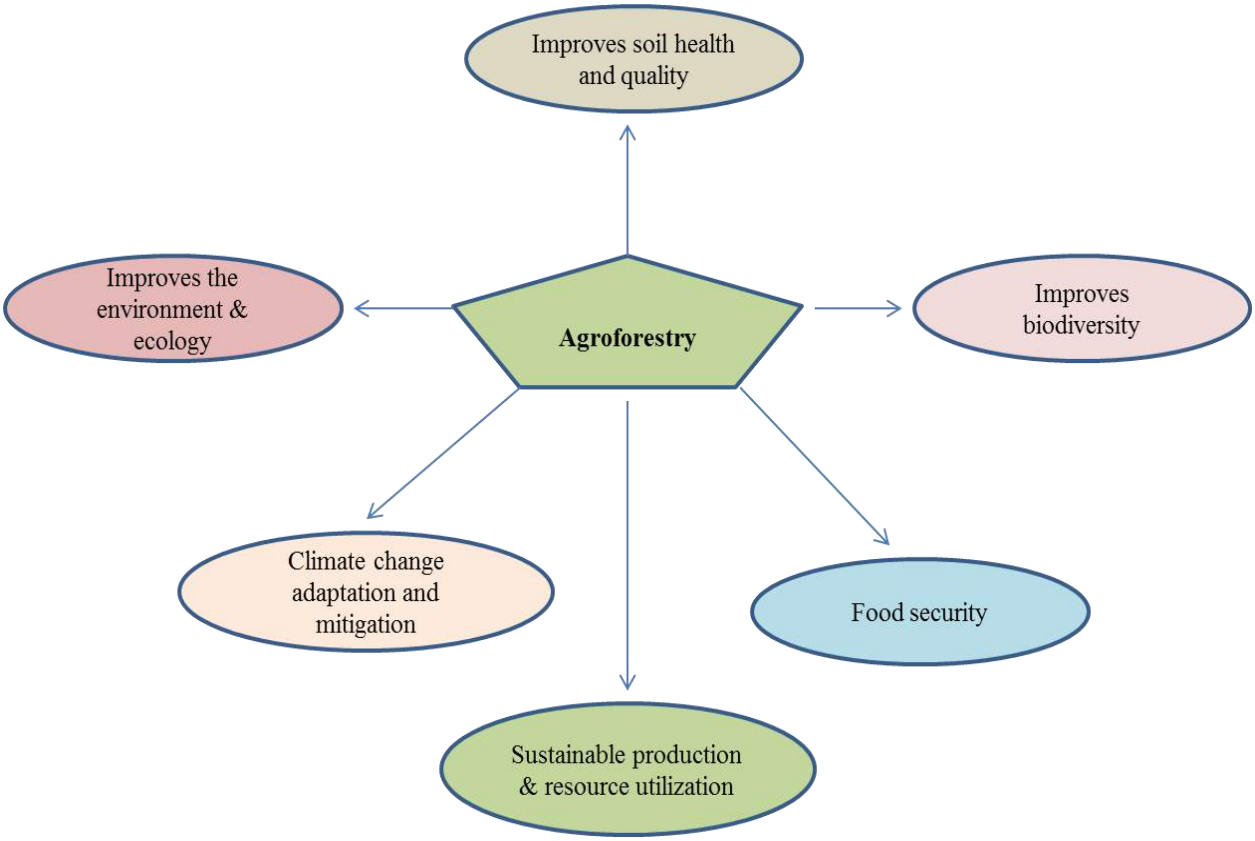

Figure 2: Agroforestry towards sustainable agroecosystem management

Conclusion

Agroforestry practice is a sustainble land-use management system which has multidimensional output in agroecosystem which enhance the eco-efficiency by efficient utilization of natural resources. Further it helps to reduce the nutrient and resource loss through various processes and accelerates the resource use and agricultural production. It is also prove to be efficient performer in economic and environmental point of view. This also increases the socio-economic upliftment of the farming community. Therefore, it is known to be sustainble practice due to its social, economical and environmental dimensions. Further policy should be framed towards marketing mechanism of agroforestry based product for strengthening the farming community towards adoption of these models across the country.

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Celtis australis for fodder security in mid hills of Himachal Pradesh

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Introduction

Celtis australis Linn. (Family: Ulmaceae) locally known as Kharik or Khirak is a fast growing native tree of Western Himalayas and is found growing in subtropical to temperate regions of Himachal Pradesh, Jammu and Kashmir and Uttarakhand. Its altitudinal distribution zone ranges between 500 to 2500 m amsl and rainfall ranges between 1200-2500 mm/year (Luna, 1996). In the mid hills of Himachal Pradesh, *C. australis* is traditionally grown on agriculture field bunds and agricultural border areas to supply timber, fodder and fuel wood. It ensures supply of highly nutritious, highly palatable, mineral rich, green fodder for livestock during summer and autumn season in mid hills of Himachal Pradesh (Singh, 2004).

However, livestock in Himachal Pradesh is facing low productivity due to scarcity of fodder, mineral deficiencies, heath issues and the vagaries of climate change, etc. Lack of quality and adequate amount of fodder has been reported to main cause low productivity in livestock sector (National livestock policy, 2013). Livestock is the main component of agriculture in Himachal Pradesh and provides draught power in hilly terrain of the state, where machineries cannot be deployed for carrying out the agricultural activities. Besides this, livestock act a source of manure, milk, wool, meat and an additional source of income to the hilly people. As, per the 20th livestock census (2020), total livestock population in Himachal Pradesh is 4411.17 thousand and this livestock is largely dependent on natural grasslands locally known as "*ghasnis*", crop residues, tree leaves and forests for sourcing fodder. Fodder cultivation is almost negligible in the state with 0.05 percent of the total cultivated area which is limited to the lower altitude and is focused on cultivating only barseem and oat crops. Continuous shortage of green and dry fodder has been observed in the state and it has been estimated that shortage of 20.30% green fodder and 53.61% dry fodder exists in Himachal Pradesh (Kumar et al., 2019). Due to scarcity of quality fodder throughout the year, poor livestock productivity and high cost of market based feed, decrease in livestock population in the state has been observed in the current livestock census in comparison to the previous census conducted in year 2011(Livestock population ; 2011: 4844.43 thousand; 2019: 4411.17 thousand). However, the demand for livestock based products especially milk is increasing day by day in the state due to increase in the human population.

In addition to the fodder tree leaves in the mid hills, the natural growing grasses i.e.

Apluda mutica, Chrysopogon fulvus, Heteropogon contortus, Themeda arundinella. Apluda mutica, and *Cymbopogon spp.* growing on the "*ghasnis*" are fed to the livestock during rainy season and these are also cut and dried for utilization during winter season in the form of hay. But now these natural "*ghasnis*" are also facing issues of decreased fodder biomass production due to overgrazing, weeds infestation and besides this, number of fodder trees grown on farm bunds is also declining. Therefore, to address fodder shortage in mid hill region especially during lean period and to sustain livestock production, high leaf biomass yielding fodder trees that are rich in mineral and crude protein can be utilized via planting them on farm bunds, agricultural border lands, local grazing lands "*ghasnis*", and village community lands in mid hills. One of such potential tree for sustaining fodder security in mid hills is *Celtis australis*, if planting as a component of existing land use system can play a substantial role as a quality fodder for livestock production in the mid hills.

Habit, distribution and ecology

C. australis is a moderate sized deciduous tree**,** reaching a height of upto 25 m and 50 cm in diameter with a smooth, light colored, straight stem. Crown of *C. australis* is round and spreading outwards as well as irregular and branches are robust and upward growing. Its leaves are green, alternate, with serrate margin, ovate shaped, pinnate showing reticulate venation. *C. australis* is found growing naturally in Himalayan moist temperate forests, in north western Himalayas (Champion and Seth, 1968). However, the population of *C. australis* is declining in the natural habitats, as the seedlings are grazed by cattle which lead to the poor regeneration and less number of species individuals. The subtropical to temperate climate is suitable for its growth; therefore *C. australis* can be seen growing on agricultural lands, villages- forest fringes in sub tropical to temperate regions of Himachal Pradesh. It prefers deep, moist and well drained loamy silt & clayey soil and avoids shallow soil with gravels (Luna, 1996).

Silvicultural characteristics and phenology

C. australis is a moderate light demander during seedling stage but beyond pole stage it needs complete overhead sunlight for optimum growth and performance (Luna, 1996). Seedlings and trees of the species are frost hardy but drought susceptible. Due to presence of thin bark, trees are also susceptible to damage caused by fire. Being palatable its seedling and saplings are prone to damage caused by animals which is one of the reasons for its poor survival and regeneration in the forest areas facing grazing issues. Besides this, the tree is well suited for pollarding and coppicing.

Trees of *C. australis* start shedding leaves in the month of December-January and the new leaves flush starts from the month of mid March till April end. Floral buds development takes place along with emergence of new leaves i.e. during mid of April month. Fruit development is completed by July - August and they remain green till September and finally shed off on maturing in October month.

Utilization

C. australis is utilized for its wood which is quite tough and of good quality. Wood is utilized for making agricultural tools, cups, churners, sticks and even for carving. Weight of its wood is around 750kg/m^3 and specific gravity ranges between 0.61-

0.71 respectively (Luna, 1996). Being a good fuel wood with calorific value of 18.22 ± 0.29 KJ/gm, its branches are utilized as fuel wood in Himachal Pradesh and other north western Himalayan states. Fruit of the species tastes sweet and a source of food for Himalayan birds, monkeys and squirrels. Leaves of the tree are highly palatable and nutritious, therefore are utilized as livestock fodder in Himalayas.

Potential as a fodder tree for mid hills of Himachal Pradesh

The mid hills of Himachal Pradesh are facing issues of low productivity of livestock and in surge in the population of stray cattle due to shortage of quality fodder especially during lean periods. But demand for livestock based products especially milk is increasing in the state due to increase in population. Thus, a viable option for ensuring fodder security is required in mid hills of the Himachal Pradesh. Trees like *C. australis* are traditionally grown on agriculture field bunds and agricultural border areas to fodder for livestock during lean period but their population is declining rapidly. Therefore there is need for mass scale planting of nutritious fodder yielding trees like *C. australis* for meeting out demand for quality fodder and for enhancement of livestock productivity. Leaves of *C. australis* are highly nutritious and palatable to livestock and this tree is a potential fodder species for ensuring fodder security in mid hills of Himachal Pradesh. Fodder yield and fodder quality of this species has been discussed in detail as below:

Fodder quality traits

Celtis australis is a potential fodder tree for the mid hills of the Himachal Pradesh due to its leaves being highly nutritious and palatable to livestock. Leaves of this species are rich in mineral like calcium, potassium copper, iron, zinc, manganese etc. and crude protein content (15.56 %); high quality fodder traits and contain almost negligible amount of tannin and other anti-nutritional compounds. In addition to this, leaves of *C. australis* are fed during summer season, and the best lopping time as leaves are highly palatable during this time than autumn season. *In-vitro* dry matter digestibility of its leaves has been found to be good (49.3 %). Fodder quality traits of *C. australis* have been presented in the table 1.

Fodder yield

Well grown single, tree of *C. australis* have been reported to produce 5-7 kg fresh leaves and the production increases as the number of branches increases with further growth of trees (Misri, 1997). Under *silvi*-horticulture system established in Uttarakhand hills, ten year old *Celtis australis* trees have been observed to yield 5.7 to 7.7 kg/tree green fodder yield (Bisht et al., 2000). *C. australis* trees on combining with *Digitaria decumbens* grass on natural grasslands has been reported to increase forage production to 1800-2450 g/m^2/annum in comparison to the natural grasslands (300 g/m^2 /annum) (Sharma and Koranne, 1988). On marginal lands in hilly area of Uttarakhand, *C. australis* based silvipastoral have been reported to yield 18-25 t/ha/year green forage yield (Bisht and Gupta, 2002).

Thus, it is quite evident that *C. australis* is a potential fodder tree in mid hill region of Himachal Pradesh. Moreover, it is fast growing tree species and can be easily propagated via seeds and stem/branch cuttings and can produce good amount of

nutritious fodder for sustaining livestock production.

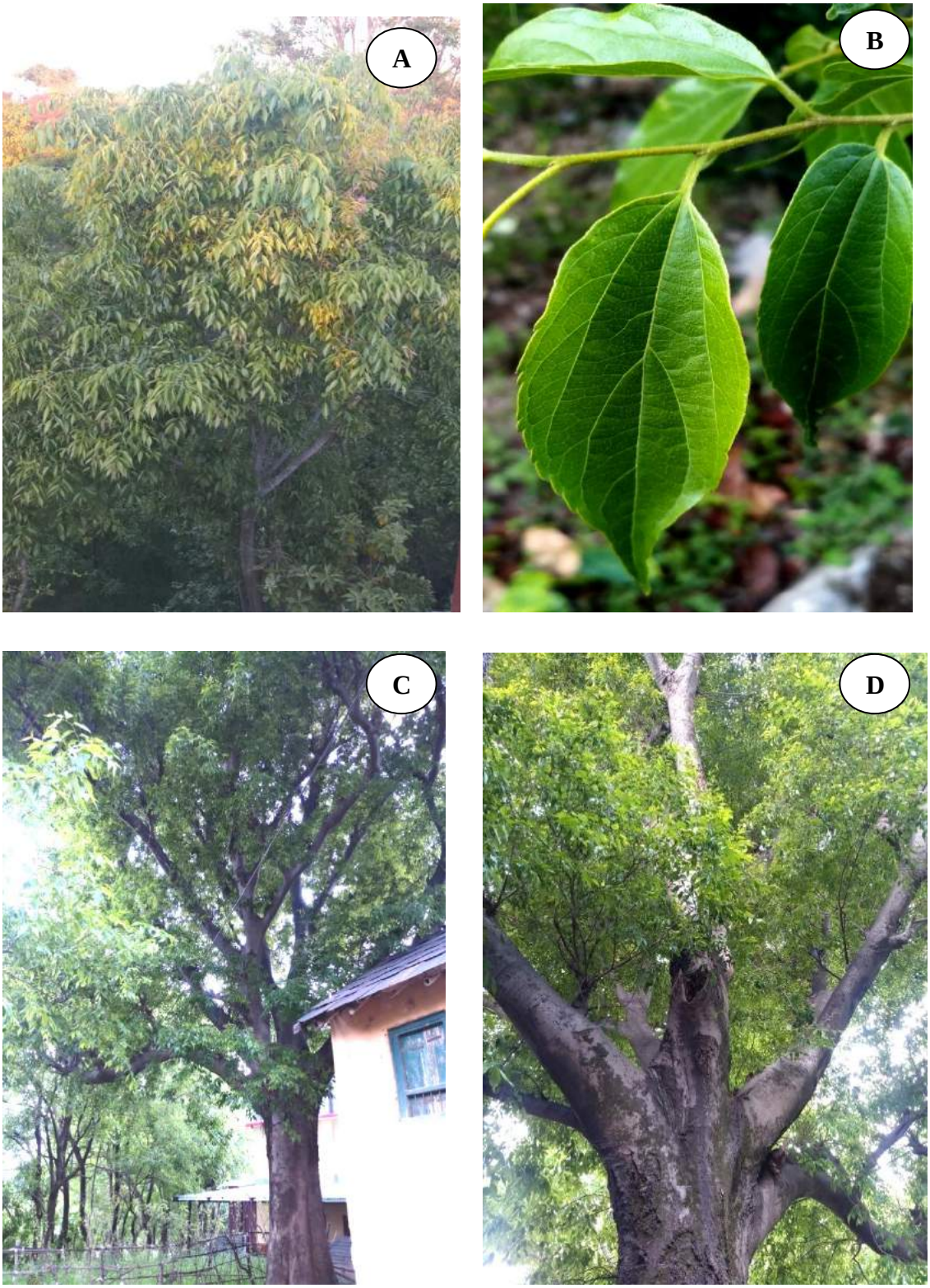

Fig. 1: ***Celtis australis*****:** a. Tree b. Leaf c & d Giant tree growing in mid hills of Himachal Pradesh (age: > 120 years; Girth at breast height: 2.8 meter; height: 13.7 m)

Table 1. Fodder quality traits of *Celtis australis* leaves

Traits	Content (Dry Matter Basis)
Dry matter	48.05 %
Organic matter	80.41 %
Total ash	19.59 %
Nitrogen free extract	39.68 %
Total carbohydrate	61.45 %
Ether extract	3.40 %
Crude protein	15.56 %
Neutral detergent fiber	39.01 %
Acid detergent fiber	23.94 %
Crude Fiber	21.77 %
Calcium	10.53 %
Potassium	1.29 %
Phosphorus	0.22 %
Copper	17.50 ppm
Iron	665.53 ppm
Manganese	30.60 ppm
Zinc	19.26 ppm
Digestibility coefficients	
In vitro Dry matter digestibility	49.3 %
Anti nutritional compounds	
Phenols	3.30 %
Tannin	1.80 %
Saponin	11.76 %
Hydrocyanic acid	0.08 $mg100g^{-1}$
	References: Navale, 2017

Propagation technique

C. australis can be propagated via seed as well as vegetatively through cuttings. Seeds are sown in poly bags during March-April month after treating with hot water followed by soaking in water at room temperature for 48 hours. Planting out is carried out during winter when species remains leafless (Luna, 1996) in 30 m^3 pits, when seedlings are leafless or during monsoon season. Six months old seedlings have been reported to perform better in terms height growth as well as survival and growth has been found fast on moist and fertile soils. For vegetative propagation, 15 – 20 cm long & 1.5-2.0 cm thick stem cuttings are used after treating them with 500 ppm IBA or IAA. IBA and IAA treatment is necessary for ensuring successful rooting and growth of cuttings. For field planting, pits are dug and filled with FYM and Soil (1:2) and then well grown seedlings or rooted cutting are planted. Initially protection should be provided to planted seedlings/rooted cuttings from animals, weeding should be carried out to avoid any

competition and to ensure successful establishment of the species.

Options for utilizing *Celtis Australis* for fodder security in mid hills

Due to existing fodder shortage problem in mid hills of Himachal Pradesh mass planting of *C. australis* can be promoted on following land areas to ensure fodder security in the region and to ensure sustainable livestock production:

- *C. australis* can be planted under Silvipasture system with other grasses and legume species on wastelands of mid hills of Himachal Pradesh. The Silvipasture can be managed by local people on participatory basis for sourcing fodder.
- Small and marginal farmers can utilize their farm bunds farm bunds for planting of *Celtis australis* trees for fodder security.
- Border of agricultural land that usually remains covered with bushes and unpalatable species can be utilized by farmers for growing *C. australis* and its utilization of the fodder purpose.
- Grazing lands are losing their productivity in mid hills of the state owing to miss-management and over grazing. Therefore in such areas *C. australis* can be planted as a component which will not only ensure nutritious quality fodder during lean period but also restore grazing lands productivity via improving soil fertility through addition of leaf litter. Leaf litter decomposition will restore top soil fertility and ultimately grass biomass production will increase.
- *C. australis* tree can also be planted near cattle shed or homestead by villagers/farmers as lot of space is available near cattle shed and houses in Himalaya. Planting this species near to cattle shed will provide shade for livestock during summer season.

Conclusion

C. australis is a promising nutritious fodder yielding tree species of mid hills of Himachal Pradesh. Since, Himalayan region is facing shortage of quality green fodder; therefore, *C. australis* can be planted on large scale on wastelands; agricultural border areas; farm bunds; grazing lands (*Ghasnis*) and near homesteads for ensuring quality fodder supply during lean periods in mid hills region.

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अम्लीय वर्षा: पर्यावरण के लिए चुनौती

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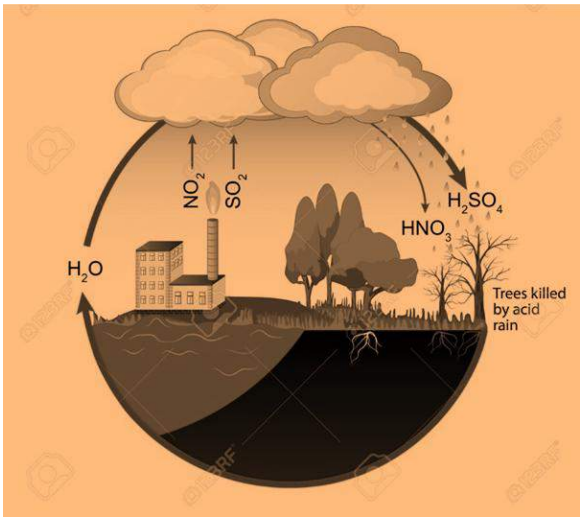
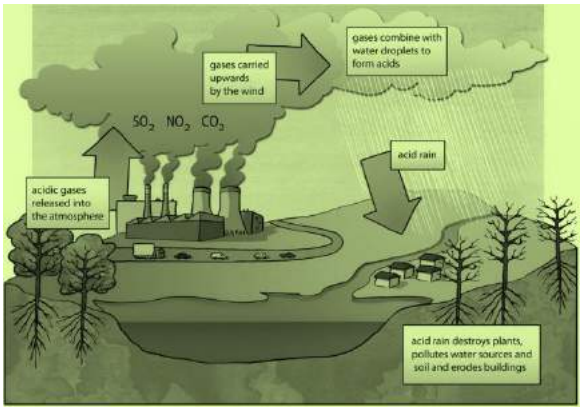


जब वर्षा जल में कार्बन डाइऑक्साइड के साथ वायुमंडल में प्रदूषित हवा में मौजूद सल्फर डाइऑक्साइड और नाइट्रोजन ऑक्साइड की मात्रा मिश्रित होती है, तो यह वर्षा जल से क्रिया करके सल्फ्यूरिक एसिड और नाइट्रिक एसिड में बदल जाती है और यही जल जब पृथ्वी पर गिरता है, तो इसे एसिड रेन अथवा अम्लीय वर्षा कहते है। वर्षा जल में अम्लों की बड़ी मात्रा को या उपस्थिति को अम्लीय वर्षा कहा जाता है। प्राकृतिक कारणों से भी शुद्ध वर्षा का जल अम्लीय होता है। इसका प्रमुख कारण वायुमंडल में मानवीय क्रियाकलापों के कारण सल्फर ऑक्साइड व नाइट्रोजन ऑक्साइड के अत्यधिक उत्सर्जन के द्वारा बनती हैं। यही गैसें वायुमंडल में पहुँचकर जल से रासायनिक क्रिया करके सल्फेट तथा सल्फ्यूरिक अम्ल का निर्माण करती है। जब यह अम्ल, वर्षा के साथ धरातल पर पहुँचता है तो इसे अम्ल वर्षा कहते हैं। शुद्ध जल का Ph स्तर 5.5 से 5.7 के बीच होता है। अम्लीय वर्षा जिसकी पी. एच. स्तर 5.5 से कम होती है। यदि जल का पी एच मान 4 से कम होता है तो यह जल जैविक समुदाय के लिए हानिकारक होता है।

सामान्य तौर पर वर्षा जल का स्वाद तथा उसका रासायनिक संघटन परेशान करने वाला नहीं होता परन्तु यदि कहीं पर वर्षा जल का स्वाद तथा संघटन अम्लीय हो तो यह पर्यावरण के लिए चिन्ता का कारण बन जाता है। भारतीय मौसम विभाग के कुछ वैज्ञानिकों ने विश्व मौसम संस्थान के सहयोग से भारत के दस नगरों के वर्षा जल के नमूनों का विश्लेषण कर यह बताया है कि पूना, नागपुर, विशाखापट्टनम ,श्रीनगर, इलाहाबाद, जोधपुर, कोडईकनाल, मिनिकोय (लक्षद्वीप) मोहनबारी तथा पोर्टब्लेयर के वर्षा जल में सल्फर डाई आक्साइड तथा नाइट्रोजन आक्साइड उच्च मात्रा में विद्यमान हैं, जिसके कारण इन शहरों की पहली बरसात को अम्लीय वर्षा के रूप में परिभाषित किया गया है। आखिर यह अम्लीय

वर्षा है क्याघ् अम्लीय वर्षा शब्द का प्रयोग सामान्यतः सल्फेट तथा नाइट्रेट के नमए शुष्क अथवा कोहरे के रूप में निक्षेपण की व्याख्या करने के लिए किया जाता है। जब जीवाश्म ईंधन के जलाये जाने से उत्पन्न होने वाली सल्फर डाई आक्साइड तथा नाइट्रोजन आक्साइड वायुमंडल में विद्यमान जल के संपर्क में आते हैं तो वे सल्फर तथा नाइट्रोजन आधारित अम्लों में परिवर्तित हो जाते हैं तथा पृथ्वी पर वर्षा कोहरा या हिम के रूप में गिरते हैं । इस अम्लीय वर्षा का प्रभाव पर्यावरण के लिए खतरनाक हो सकता है । अम्लीय वर्षा से पशु-पक्षी, पेड़-पौधों, पत्थर से निर्मित इमारतों,जलीय जीव-जंतुओं तथा मनुष्यों पर बुरा प्रभाव पड़ता है।

अम्लीय वर्षा के प्रभाव उन इलाकों पर अधिक पड़ता है जहां औद्योगिक प्रदूषण, भारी यातायात के कारण वाहनों से निकलने वाले धुओं से वायु प्रदूषण अधिक होता है या फिर बेतरतीब ढंग से शहरीकरण हुआ हो । जिन उद्योगों में कोयला अधिक जलाया जाता हैए जैसे कि थर्मल पावर प्लांट इत्यादिए वहां अम्लीय वर्षा का प्रभाव व खतरा अधिक बढ़ जाता है। वायुमंडल में विद्यमान सल्फेट तथा नाइट्रेट के सूक्ष्म कण हवा द्वारा दूर-दूर तक ले जाये जा सकते हैं। ऐसी हवा में गहरी-सांस लेने वाले व्यक्ति के फेफड़ों तक ये सूक्ष्म कण पहुंचकर कई प्रकार की बीमारियों को जन्म देते हैं । सल्फेट तथा नाइट्रेट के सूक्ष्म.कण वायु द्वारा घर के भीतर तक पहुंचा दिए जाते हैं। यही नहीं अम्लीय वर्षा के होने से वन तथा भूमि के साथ-साथ नदियों और तालाबों को भी भारी नुकसान उठाना पड़ता है। वनों में विभिन्न प्रकार की वनस्पतियां अम्लीय वर्षा से प्रभावित होती हैं तथा नदियों, तालाबों का पानी अम्लीय हो जाने के कारण विशेष रूप से मछलियों पर बहुत बुरा असर पड़ता है। कई जगहों पर यह देखा गया है कि अम्लीय वर्षा के प्रभाव से मछलियां भारी मात्रा में मर भी जाती हैं। अम्लीय वर्षा के प्रभाव से भवन, ऐतिहासिक स्मारक तथा कारें भी क्षतिग्रस्त हो जाती हैं। अम्लीय वर्षा के जल को



यदि पी लिया जाये या फिर ऐसी सब्जियों का प्रयोग किया जाये जो अम्लीय वर्षा से प्रभावित भूमि या जल में उगाई गयी हों तो व्यक्ति को अल्जाईमर नामक बीमारी भी हो सकती है । अम्लीय वर्षा के प्रभाव के कारण जल आपूर्ति की पाइप लाइनें भी क्षतिग्रस्त हो जाती हैं।

पूरे विश्व में अम्लीय वर्षा की समस्या गहराती जा रही है। जर्मनी, स्वीडनए स्वीट्जरलैंड, नीदरलैंड तथा ब्रिटेन जैसे राष्ट्रों को अम्लीय वर्षा की समस्या से लगातार जूझना पड़ रहा है । अमेरिका, रूस, कनाडा, नार्वे जैसे राष्ट्रों के साथ-साथ अब भारत, चीन, मैक्सिको तथा दक्षिण

पूर्वी एशिया के कई राष्ट्रों को भी इस समस्या से जूझना पड़ रहा है । इन राष्ट्रों में बढ़ते औद्योगीकरण, शहरीकरण तथा वाहनों की अधिक संख्या के कारण वायु प्रदूषण की मात्रा भी मानकों से कहीं अधिक होती जा रही है । ऊर्जा की आवश्यकताओं को पूरा करने के लिए थर्मल पावर संयंत्रों में भारी मात्रा में कोयला जलाया जाता है । जिन इलाकों में ऐसे संयंत्रों की संख्या अधिक है वहां वायु में सल्फर डाई आक्साइड और नाइट्रोजन आक्साइड की मात्रा भी अधिक पायी गई है जो कि अम्लीय वर्षा के मुख्य कारक हैं । अम्लीय वर्षा के प्रभाव के कारण न केवल मौसम चक्र पर कुप्रभाव पड़ता है बल्कि मिट्टी तथा जल के रासायनिक गुणों पर भी कुप्रभाव पड़ता है । सल्फर डाइ आक्साइड तथा नाइट्रोजन आक्साइड जब जल, आक्सीजन तथा अन्य आक्सीडेन्टों से क्रिया करते हैं तो सल्फ्यूरिक अम्ल तथा नाइट्रिक अम्ल का हल्का विलयन तैयार हो जाता है । सूर्य के प्रकाश के कारण यह अभिक्रिया और भी तेज हो जाती है । जब यह आकाश से धरती की ओर बरसती है तो इनकी बूंदों के साथ वायु में विद्यमान अन्य हानिकारक रसायनों के कण भी घुल जाते हैं । वायु में विद्यमान कार्बन डाई आक्साइड जैसी गैस से जब अम्लीय वर्षा की बूंदें अभिक्रिया करती हैं तो वर्षा का pH मान 5.6 से भी कम हो जाता है जिसके कारण अम्लीयता और भी बढ़ जाती है ।

गौरतलब है कि जितने प्रदूषक वायुमण्डल में विद्यमान हैं उनमें से सभी अम्लीय वर्षा के साथ घुलकर पृथ्वी की सतह तक नहीं पहुंचते । आधे से अधिक अम्लीयता वायुमंडल से पृथ्वी की सतह तक वर्षा के रूप में ना होकर शुष्क निक्षेपों जैसे गैस या शुष्क कणों के रूप में पहुंचती है । हवा इन अम्लीय कणों तथा गैसों को भवनों, कारों, घरों तथा वृक्षों पर जमा कर देती है । कभी.कभी ये अम्लीय कण तथा गैसें जिस वस्तु पर जमा होती हैं उसे बुरी तरह क्षतिग्रस्त कर देती हैं । शुष्क रूप में निक्षेपित गैसें तथा अम्लीय कण कभी-कभी बरसात के दिनों में उन स्थानों से धो दिए जाते हैं जहां ये जमे हुए रहते हैं । ऐसी स्थिति में बहने वाला जल और भी अधिक अम्लीय हो जाता है। अम्लीय वर्षा तथा शुष्क निक्षेपित अम्लीय कणों के सम्मिश्रण को अम्लीय निक्षेप का नाम दिया गया है ।

अम्लीय वर्षा के प्रभाव के रूप में वायु प्रदूषण को परिवर्तित करने वाली रासायनिक क्रियाएं कई घंटों से लेकर कई दिनों का समय ले सकती है । जब चिमनियों की ऊंचाई बहुत कम होती थी तो वायु प्रदूषकों को आसपास की जमीन पर पहुंचने में अधिक समय नहीं लगता था । ऐसे में कम ऊंचाई वाली इन चिमनियों के धुएं से आसपास की वनस्पतियां तथा प्राणी तत्काल प्रभावित हो जाते थे । परन्तु इस स्थिति से बचने के लिए चिमनियों की ऊंचाई बढ़ाई गयी । इसके लिए सरकार की ओर से कानून भी बनाए गये । लोगों ने सोचा कि कारखानों से निकलने वाले धुएं को ऊँचाई पर छोड़ने से वायु प्रदूषण से कुछ हद तक मुक्ति मिल जाएगी । परन्तु वैज्ञानिकों ने इस

अवधारणा को सही नहीं पाया है । प्रदूषकों को ऊंचाई पर ले जाकर छोड़ने के कारण उन्हें वायु में बने रहने का अधिक समय मिल जाता है । जितने अधिक समय तक प्रदूषक वायु में मौजूद रहेंगे उतने ही अधिक इसके अम्लीय वर्षा के रूप में परिवर्तित होने के अवसर बढ़ते जाएंगे । औद्योगिक इलाकों से दूर बसे क्षेत्र भी अम्लीय वर्षा के प्रभाव से प्रभावित होते हैं । शुष्क निक्षेपों की मात्रा सामान्यतः उन शहरों तथा औद्योगिक क्षेत्रों के समीप अधिक होती है जहां से प्रदूषक वायु में छोड़े जाते हैं ।

मानव जनित औद्योगिक तथा वाहन प्रदूषण के कारण उत्पन्न अम्लीय वर्षा के प्रभाव के अतिरिक्त, अम्लीय वर्षा के प्राकृतिक स्रोतों के रूप में ज्वालामुखियों, प्राकृतिक गीजरों तथा गर्म पानी के झरनों के उदाहरण प्रस्तुत किए जा सकते हैं । इन प्राकृतिक स्रोतों से उत्पन्न अम्ल को पुनः चक्रित करने की विधियां प्रकृति में स्वयं ही विद्यमान हैं । इन अम्लों का विघटन तथा इनका अवशोषण प्रकृति में होता रहता है । प्राकृतिक स्रोतों से उत्पन्न होने वाले अम्ल की यह अल्प मात्रा, खनिजों तथा अन्य पोषक तत्वों को मिट्टी में घोलने में सहायक होती है जिससे कि वृक्ष तथा अन्य वनस्पतियां पोषक तत्व प्राप्त करती हैं ।

अम्लीय वर्षा के प्रभाव के विषय में सन् 1800 में यूरोप वासियों को पता चला । यूरोप तथा उत्तरी अमेरिका में अम्लीय वर्षा के प्रभाव सबसे अधिक दिखाई दिये हैं । यहां के कुछ विशेष पारितंत्र विशेष रूप से अम्लीय वर्षा से कुप्रभावित हुए हैं । जिन स्थानों पर मिट्टी की परत बहुत पतली है, कैल्शियम की मात्रा बहुत कम है और वे ठोस चट्टानों के मध्य स्थित हैं वहां के सभी प्राणी, वनस्पतियां तथा बैक्टीरिया तक अम्लीय वर्षा के प्रभाव हुए हैं । वैसे विश्व भर में अम्लीय वर्षा के प्रभाव सबसे अधिक मीठे जल वाले तालाबों, सरिताओं तथा नदियों वाले पारितंत्र पर पड़े हैं और वहां के प्राणियों तथा वनस्पतियों पर इसका कुप्रभाव अधिक देखा गया है । जल आधारित पारितंत्र की तुलना में भूमि आधारित पारितंत्र अम्लीय वर्षा के प्रभाव से उतना अधिक प्रभावित नहीं हुआ है ।

अम्लीय वर्षा के प्रभाव के कारण जलीय जीवन के लिए जान बचाना मुश्किल हो जाता है । वहीं पर मिट्टी के रासायनिक गुणों में परिवर्तन आ जाने के कारण वनस्पतियों के विकास पर भी कुप्रभाव पड़ता है । अम्लीय वर्षा सागर के तटीय क्षेत्रों में स्थित एस्चुअरी के जल की गुणवत्ता पर भी प्रभाव डालती है । नाइट्रिक अम्ल के कारण जल में घुलित आक्सीजन की मात्रा कम हो जाती है । इस प्रक्रिया को हाइपोक्सिया के नाम से जाना जाता है । अम्लीय वर्षा के प्रभाव से कृषि उत्पादों पर विपरीत प्रभाव पड़ता है तथा इसके कारण वनों में वनस्पतियों के विकास पर भी कुप्रभाव पड़ते हुए देखा गया है ।

अम्लीय वर्षा के कारण मनुष्यों में अनेक प्रकार के रोग जैसे कैंसर रोग का होना ,फेफड़ों पर बुरे असर के कारण श्वसन प्रक्रिया में कठिनाई आना, हृदय से सम्बंधित रोग आदि हो सकते हैं ।

अम्लीय वर्षा का जल नदियों तथा अन्य महत्वपूर्ण जल स्रोतों में मिलकर जल को ख़राब कर देता है और जब हम इन्ही जल स्रोतों से प्राप्त पानी का प्रयोग करते है तो यह हमारी पाचन क्रिया के साथ-साथ अन्य महत्वपूर्ण अंगो पर बुरा प्रभाव डालता है । अम्लीय वर्षा का जल मिटटी में अम्लीयता को बढ़ा देता है जिसका असर पेड़-पौधों के साथ-साथ उसमें लगाने वाले फलों में भी पहुंच जाता है, जिसका प्रयोग करने पर हमारे शरीर को नुक्सान होता है।

संपूर्ण विश्व अभी ओजोन क्षरण और ग्रीन हाउस प्रभाव के दुष्परिणाम से उबर भी नहीं पाया है, कि अम्लीय वर्षा ने पर्यावरण को संकट में डाल दिया है । यह समस्या अभी विकसित देशों में तबाही मचा रही है, लेकिन वह दिन दूर नहीं, जब यह समस्या विकासशील देशों के आगे खड़ी हो जाएगी।

अम्लीय वर्षा पर्यावरण के सभी घटकों (भौतिक एवं जैविक) को खतरे में डाल देती है। जब मानव जनित स्रोतों से उत्सर्जित सल्फर डाई ऑक्साइड (एस ओ 2) एवं नाइट्रोजन ऑक्साइड (एन ओ 2) गैस वायुमंडल की जल वाष्प के साथ मिलकर सल्फ्यूरिक एसिड व नाइट्रिक एसिड का निर्माण करती हैं तथा यह अम्लश जल के साथ पृथ्वी के धरातल पर पहुंचता है, तो इस प्रकार की वर्षा को अम्लीय वर्षा कहते हैं।

प्राकृतिक पर्यावरण को नष्ट करने में अम्लीय वर्षा की प्रमुख भूमिका होती है। यह वर्षा मुख्यतया कनाडा, स्वीडन, नार्वे, फिनलैंड, इंग्लैंड, नीदरलैण्ड, जर्मनी, इटली, फ्रांस, तथा यूनान जैसे विकसित देशों में विगत चार-पांच दशक से एक गंभीर पर्यावरणीय समस्या बनी हुई है । इसने धारातल पर मौजूद संपूर्ण भौतिक एवं जैविक जगत को खतरे में डाल दिया है।

अम्लीय वर्षा का दुष्प्रभाव एक स्थान विशेष तक ही सीमित नहीं रहता और न ही यह सल्फर डाइ ऑक्साइड तथा नाइट्रस ऑक्साइड उगलने वाले औद्योगिक एवं परिवहन स्रोतों के क्षेत्रों तक ही सीमित रहता है । यह स्रोतों से दूर अत्यधिक विस्तृत क्षेत्रों को भी प्रभावित करती है, क्योंकि अम्लीय वर्षा के उत्तरदायी कारक गैसीय रूप में होते हैं, जिन्हें हवा तथा बादल दूर तक फैला देते हैं। जिससे ब्रिटेन एवं जर्मनी में स्थित कारखानों से निकली सल्फर डाइ ऑक्साइड एवं नाइट्रस ऑक्साइड के कारण नार्वे, स्वीडन तथा फिनलैण्ड में विस्तृत अम्लीय वर्षा होती है, जिसके फल स्वरूप इन देशों की अधिकांश झीलों के जैवीय समुदाय समाप्त हो चुके है, इसीलिए ऐसी झीलों को अब जैविकीय दृष्टि से मृत झील कहते हैं।

अम्लीय वर्षा नामक यह पर्यावरणीय आपदा भारतवासियों को भी झेलनी पड़ सकती है । नई दिल्ली स्थित भारतीय प्रौद्योगिकी संस्थान के

वायुमंडलीय विज्ञान केंद्र के वैज्ञानिकों द्वारा किए गए वैज्ञानिक अधययनों के अनुसार भारत के कुछ हिस्सों में वर्षा जल की रासायनिक प्रकृति धीरे-धीरे अम्लीयता की ओर बढ़ रही है । रिपोर्ट के अनुसार राजधानी दिल्ली, उत्तर प्रदेश, महाराष्ट्र मध्य प्रदेश, तमिलनाडु एवं अंडमान द्वीपों में वर्षा जल की अम्लीयता लगातार बढ़ती जा रही है ।

भारत के प्रमुख औद्योगिक शहरों मुंबई, कोलकाता, कानपुर, नई दिल्ली, आगरा, नागपुर, अहमदाबाद, हैदराबाद, जयपुर, चेन्नई एवं जमशेदपुर आदि नगरों के वायुमंडल में अम्लीय वर्षा उत्पन्न करने वाली विषाक्त सल्फरडाइ ऑक्साइड गैसों की सांद्रता काफी बढ़ गई है । एक अनुमान के अनुसार सन् 1990 में हमारा देश 4400 किलो टन सल्फर हवा में छोड़ता था, जबकि आज इसकी मात्रा बढ़ कर 7500 किलो टन के आसपास है जो सन् 2015 एवं 2020 में बढ़ कर क्रमश: 10900 किलो टन एवं 18500 किलो टन हो जाएगी ।

भाभा एटामिक रिसर्च सेंटर व वर्ल्ड मीट्रोलॉजिकल ऑरगनाइजेशन द्वारा किए गए अध्ययनों से ज्ञात हुआ है कि अधिकांश भारतीय नगरों में वर्षा जल में अम्लता का स्तर सुरक्षा सीमा से अभी कम है, लेकिन वह दिन दूर नहीं, जब अम्लीय वर्षा विकसित देशों की तरह भारत में भी तबाही मचाना शुरू कर देगी । भारत में भी हानिकारक गैसों की सांद्रता पर रोकथाम पूरी तरह प्रभावी नहीं हो पा रही है । अम्लीय वर्षा का पारिस्थितिक तंत्र पर दुष्प्रभाव पड़ता है । इससे जल प्रदूषण बढ़ता है, जिससे इसमें रहने वाले जीव-जंतु नष्ट होने लगते हैं ।

कनाडा के ओन्टोरियों प्रांत में 2, 50, 000 झीलों में से 50, 000 झीलें अम्लीय वर्षा से बुरी तरह प्रभावित हैं जिनमें से 140 झीलों को मृत घोषित कर दिया गया है । अम्लीय वर्षा का वनों पर प्रतिकूल प्रभाव पड़ता है, क्योंकि इससे पत्तियों की सतह पर मोम जैसी परत नष्ट हो जाती है, साथ ही पत्तियों के स्टोमेटा बंद हो जाते हैं ।

इस समस्या का समाधान एक ही प्रकार से संभव है । इसके लिये घातक वायु और पदार्थ के स्त्रोत जहाँ से ये प्रदूषक उत्पन्न हो रहे है, उनकों वहीं पर नियंत्रित करना, और वे सभी व्यक्ति और संस्थाएं जो इस विषय पर कार्यरत है उन्हें सारी जानकरी देना । अम्लीय वर्षा को नियंत्रित करने के लिए हमें अपने वायुमंडल से सल्फर डाइऑक्साइड और नाइट्रोजन ऑक्साइड की मात्रा को नियंत्रित करना होगा । इसके लिए औधोगिक कारखानों से निकलने वाले प्रदूषित धुँए, डीज़ल तथा पेट्रोल के वाहनों द्वारा एवं कोयले के जलने के कारण उत्सर्जित प्रदूषित धुआं आदि पर नियंत्रण करना होगा ।

Tulsi (*Ocimum basilicum* L.)

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Introduction

The Tulsi or Sacred basil or Holi basil is a biennial and triennial shrub belonging to the family Lamiaceae.The plant is found throughout the India. The tulsi plant is worshiped by the Hindus of India. The leaves of this basil on steam distillation yield a bright, yellow volatile oil possessing a pleasant odour characteristic of the plant with appreciable notes of cloves.

Vernacular name

Sanskrit: Ajaka, Manjari Hindi: Babui tulsi, Gulal tulsi, Kali tulsi, Marua, Pavitra Tulsai (Kannada), Thulasi (Tamil) Bhutulsi, Rudrajadu, vepudupachha (Telgu), English: Sweet basil, Common basil

Botanical Description

Basil and Tulsi plant is an erect, herbaceous, much branched softly hairy, biennial or triennial plant, 30-90 cm high. The leaves are elliptic -oblong, acute or obtuse, entire or serrate, pubescent on both sides, minutely glanddotted, the flowers are purplish or crimson, in racemos, close - whorled, the nutlets are subglobose or broadly ellipsoid, slightly compressed, nearly smooth, pale brown or reddish with small black markings.

Varieties

There is two types of Ocimum are under cultivation: the Green type (Sri tulsi) is the most common; the second type (Krishna Tulsi) bears purple leaves and is preferred in the trade for its higher potency of the drug.

The genus ocimum can be broadly divided into two main groups viz basilicum group and sanctum group based on the basis of following differences:

S.No.	Particulars	Basilicum Group	Sanctum Group
1.	Habit	Species are mostly herbaceous perennials	Biennials or triennals or woody perennial under shrubs.
2.	Flower	Bracts are petiolate flowers	Bracts are sessile Flowers are small

	Characters	more conspicuous	
3.	Seed	Mucilagenous	Non-mucilagenous

Floral characters of all Ocimum species are similar in basic structure. Flowers are protandrous. The duration between opening of flowers, dehiscence of anther and maturity of style varies between species to species. Flowers are mainly entomophilus, thus they are mostly outcrossing types.

In India O. amricanum, O. basilicum, O.canum, O. gratissimum and O. sanctum are distributed, O. gratissimum, is mostly cultivated in north India and O. sanctum being considered as sacred platn by Hindus and is cultivated in almost every part of India. The important species and varieties developed by RRL Jammu are presented below:

S.No	**Name of The Species**	**Variety**	**Fresh Herb yield (t/ha)**	**Oil yield Kg/ha**	**Oil Recovery (F.W. basic %)**	**Major Constituents**	**Other chemical compound**
1.	O. americanum	RRL-02	40-42	175 TO 200	0.44	Methyl chavicol	Linalool Geraniol Borneol Edesmol
		RRL-07	40	400 Kg	0.44	Methyl Chavicol (70-75%)	Caryophyllene-oxide, Linalyl acetate Y-cadenine 1,8 cineol terpenol Lemonene Ocimene
2.	O.basilimum	RRL-07	40	200	0.50	Citral (75-80%)	Pinene Cineole Geraniol Linalool
		RRL-011	50	220	0.50	Linallol (50%) and Methyl chavicol (35%)	Camphor, Methyl chavicol, Eugenol Sesquiterpene Methycinnamate Ocimene leaves contain Protein Carbohydrate, Volatile oil Fixed oil, Cellulose, Mineral matter vit. A, B and C
3.	O. canum	RRL-01	40	200	0.5	Linalool	Linool, Campher pinene, Elemal,

							Methyl chavicol Geranylacetate, Linalyl acetate, Tricycline, Myrcene Ocimene and Boranyl actate
4.	O. gratissimum	RRL-08	40	160	0.40	Eugenol (75-80%)	Ocimene, Myrcene, Methyl chavicol
	(O.gratissimum O. x o. viride)	RRL-15	40	250	0.50	Eugenol (75-80%)	Carveol, Caryophyllene oxide, α pinene, Limonene, Phellandrene, Citral
5.	O. viride	RRL-08	42	200	0.50	Thymol (65-70%)	Thymol, d-imonene,
		RRL-09	42	200	0.50	Thymol (65-70%)	α-γ-terpenol Phellandrene myrcene, 4-terpenol α-terpinol Geranylacetate caryophyllene oxide, α-penene, Carveol and Careen.

Soil

It thrives well on a variety of soils pH 5.0 to 8.5. Rich loam to poor laterite, saline and alkaline to moderately acidic soils are all well suited for its cultivation. Well drained soil aid in better vegetative growth. Water logged conditions can cause root rot and result in stunted growth.

Climate

The tulsi can be grown well in varied climatic conditions. It flourishes well under fairly high rainfall and humid condition. Long days and high temperatures have been found favorable for the plant growth and essential oil production. Tropical and subtropical climate (at altitudes upto 900m) are suited for its cultivation where this crop is grown in winter. In the plains of north India it is grown in summer. The most suitable temperature for its growth is 30 ^{0}C. This is not grown in the areas where possibilities of fall snow or frost.

Propagation

The plant is propagated by seeds and seeds should be fresh. The seeds are initially sown in the nurseries in the plains of North India in April - May. First the seeds are mixed in 8-10 times more soil and spread in the prepared plain beds. 600- 800g seeds are sufficient for sowing in one hectare. Later the seeds are mixed in the bed soil with the help of a broom or hands. Thirty days after sowing, the seedling

becomes ready for transplantation in the fields.

Nursery raising

Raised nursery: beds of 4.5 X 1.0X0.20m size should be prepared thoroughly and well manured by addition of FYM. About 200-300 g seeds are enough to raise seedlings for planting one hectare of land. The seeds should be sown 2 cm deep in the nursery beds. After sowing the seeds in the nursery a mixture of FYM and soil is thinly spread over the seeds and irrigated with a sprinkler hose. The seeds germinated in 8-12 days and seedlings are ready for transplanting in about 6 weeks time at the 4-5 leaf stage. A foliar spray of 2% urea solution on the nursery plants 15-20 days before transplanting helps in raising very healthy plants for transplanting.

Transplanting

When the plants are gown upto 15-20 cm height, they can be transplanted in prepared field at a distance of 40 cm X 40 cm, 40 cm X 50 cm and 50 cm X 30 cm to get high herbage and oil yield per hectare. The fields are irrigated immediately after transplanting. The seedlings will establish well by the time of second irrigation. At this stage, gap planting and replacement of the poor plants is, done so that a uniform stand is achieved.

Manures and fertilizers

The application of 120 Kg N, 60 Kg P_2O_5 and 60 Kg K_2O is optimum recommended dose for this crop. Half the dose of nitrogen and entire doses of phosphorous and potash is given as basal dose whereas remaining nitrogen is applied in two split doses, after the first and second cuttings. The foliar application of the micronutrients Co and Mn at 50 and 100 ppm concentrations respectively is reported to increase the oil yield significantly.

Irrigation

The irrigation depends upon the moisture status of the soil. The summer season three irrigations per month are necessary whereas, during the remaining period. It should be done as and where required except in the rainy season when no irrigation is necessary. About 12-15 irrigation in a year are sufficient for optimum growth and yield of oil.

Interculture

One hoeing two months after planting is sufficient. The crop may also be earthed up at this stage.

Weeding

The first weeding is done one month after planting and the second 4 weeks after the first. After this stage, no further weeding is required as the plant become bushy, naturally suppressing the weeds. However, after each harvest, weeding should be done so as to avoid weed growth in the interspaces, if any

Pest and diseases

In general the crop is a hardy in nature. Thus, the affects of pests, insects and diseases are comparatively less. Sometimes it is affected by powdery mildew caused by oidium spp., seedling blight caused by *Rhizoctoia bataticola*. Powdery mildew can be controlled by spraying wettable sulphur (4g/litre of water) and later two diseases are managed by improved phytosanitary measures and by drenching the nursery bed with a solution of fungicides.

Among the insects; the larvae of leaf rollers sticking to the under surface of the leaves fold them backwards length wise thus, webbing them. Malathion (0.2%) may be sprayed to control this insect.

Harvesting

The crop is harvested at full bloom stage by cutting the plant at 15 cm from ground

level to ensure good regeneration for further harvest. The first harvest is done at 90-95 day after planting and it may be harvested at 65- 75 days intervals. Harvesting should be done on bright sunny days in order to obtain good quality oil yield. The harvest produce may be allowed to wilt in the field itself for 4-6 hours to reduce the moisture content and the bulkiness. About 5 tonnes /ha of fresh herage can be obtained twice or thrice a year.

Distillation

The harvested produce is usually distilled in its fresh form. However the oil quality and yield do not diminish upto 6-8 hours, after harvest, but any further delay may cause considerable loss in yield and quality of oil. Steam distillation is found to be superior to water distillation. By distillation of full plant gives yield of oil 0.25% in leaves and 0.4% in flower and inflorescence. The yield of oil varies with the type, season and place of origin. The oil yield will be approximately 10-25 Kg/hac.

Chemical composition

The plant contains maily phenols, aldehyde, tannins, saponins and fats. The leaves contain pale yellow green essential oil which becomes crystalline over a period. It is called as basil camphor. The essential oil components are eugenol (about 71%), eugenol methyl ether (20%), nerol caryophyllene, selinene, α-pinene, β -pinene, camphor, cineole, linalool and carvacrol (3%). A terpeneneurobsolic acid possessing anticancer properties has also been isolated. The seeds of this plant give a greenish yellow fixed oil and also contain antistaphylocoagulase which can be extracted with water and alcohol.

Medicinal uses

The leaves, seeds and roots are medicinally useful. The juice of the leaves possesses diaphoretic, antiperiodic stimulating, expectorant and antipyretic properties. It is used in catarrh, bronchitis and earache etc. A decoction of the root is given as a diaphoretic in malarial fever. The juice of whole plant parts are considered to be good antidoles for snakebite and scorpion sting. The volatile oil is reported to possess antibacterial and insecticidal properties.

Lemon grass *(Cymbopogan flexuosus Nees ex steud wats)*

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Introduction

Lemon grass (*Cymbopogan flexuosus* Nees ex steud wats) is a tropical perennial grass which is the source of lemon grass oil obtained from the leaves and shoots of the plant. The name of lemon grass is given to this crop because of typical strong lemon like odour of the plant which is predominantly due to high citral content in the essential oil present in the leaves. The essential oil is popularly known as Cochin oil in the world trade as 90% of it comes from Cochin ports.

Vernacular name

Lemon grass, (Hindi) Nimbe hullu (Kannad), Lemon grass (English), Trade - Lemon grass

Botanical Description

Lemon grass belongs to family poaceae (Graminae) and the genus cymbopogan which has three identified species

Cymbopagan flexuous

It is known as east India, Cochin or Malabar grass. Under this species two varities are identified based on the stem color.

***Cymbopogan flexuous* Var. flexuosus**

The red grass locally known as chumanna pullu. The stem is reddish; or purplish in colour. It is recognized as true lemon grass and is commercially cultivated. The citral content is very high (75-90) in essential oil although oil yield is poor.

***Cymbopogan flexuous* Var. albescens**

The White grass; locally known as vellapullu, is characterized by the white colour of the stem. The oil yield is high but poor in citral content (60-75%). The oil is also poor in solubility.

Cymbopogan citrates

It is known as West Indian and American lemon grass. It is stem less perennial grass with numerous stiff tillers arising from shoot rhizomatous root stocks making large tussocks. It seldom flower in cultivation.

Cymbopogan pendulus

It is known as Jammu lemon grass. It is white- stemmed and dwarf in stature. The plant is frost resistance and suited to sub Himalaya areas of northern India.

Cymbopogan khasianus

It is discovered recently and is important for its geraniol content.

Varieties

Pragathi, Nima, Cauvery, Krishna, NLG 84, Sugandhi (OD- 19), ODP-1

Soil

It is generally grown on poor soils along hill slopes; though it flourishes on a

variety of soils ranging from rich loam to poor laterite. This grass grows best on well drained sandy loam soil. Calcareous and waterlogged soil should be avoided as they are unsuitable for its cultivation.

Climate

It requires a warm humid climate with plenty of sunshine and a rain fall ranging from about 2000-2500mm, well distributed over the year. In areas where rainfall is poor; it requires irrigations. This crop is well suited for rainfed agriculture. It grows well at altitudes between 1000 to 1200 meter.

Propagation

Lemon grass is generally propagated through seeds, vegetative propagation and rooted slips. It is reported that both the seedling and rooted slips performed equally well; with respect to growth and yield. But due to the high cost of transplanting, direct seeding is wildly practiced.

For raising the crop direct seeding a seed rate of 20-25 kg is recommended. While sowing the seeds must be thoroughly mixed with dry river sand in a ratio of 1: 3 to ensure the uniform distribution of seeds during sowing.

Nursery raising

For raising the seedling required for planting 1 ha of land 1000 m^2 area is required. The nursery area is well prepared and raised beds of 1 to 1.5m width and of convenient length are made. The recommended seed rate is 3 to 4kg/ha. The seeds are uniformly broadcasted in the beds and are covered with a thin layer of soil, followed by watering at regular intervals. The seeds collected during the months of January-February are usually sown in the nursery during April - May

Planting

The field is prepared by repeated ploughing and harrowing and beds of 1 to 1.5 m with and convenient length are made with a spacing of 30 to 50 cm between beds. Three to four leaved 50 - 70 day-old seedlings are planted during the monsoon season. A spacing of 30×30 cm with a plant density 1, 11, 000/ha is recommended. A wider spacing of 60×45 cm for seedlings and 90×60cm for slips have been recommended for fertile, irrigated land under north Indian conditions.

Manures of fertilizers

Lemon grass is an exhaustive crop and it requires a heavy dose of fertilizers ie 275 kg N, 25 kg P2O5 and 175 kg k2o/ha/annum. Under south Indian condition it was found that an application of 100 kg N in 3 to 4 split doses was found to be optimum; though a response upto 200 kg was recorded.

Intercultural

The earthing-up of the plant after about 4 months of planting and again after every harvest is beneficial, as the root region of lemon grass has a tendency to grow above the soil. The field is kept stubble free generally 2-3 weeding are necessary during the year. Herbicide, Diuran@1.5 kg a.i. /ha and oxyflurofen@1.5kg a.i./ha are effective for weed control Interculturing can be done by a tractor-dawn cultivator or a hand-held hoe in row planted crop.

Irrigation

After planting of seedling or slips in the field; if there are no rains the crop should be irrigated every alternate day for about a month. It is recommended that 4 to 6 irrigations are given during the period February to June under north India condition, for an optimum growth and oil yield.

Pests and Disease

Insect and nematode pests' infestation is very low for this crop. However the infestation by spindle-bug (*Clovia bipunctata* from south India and sever damage by the stemboring caterpillar of chilotrea under north Indian conditions have been reported. Spraying with Malathion (0.2%) can control the insects. Nematodes have also been found to infect grass; but the extent of damage to the crop is not known.

Diseases

Several diseases are reported to lemon grass, but none are serious enough to a cause major reduction in oil yield. Little leaf, malformation of inflorescence is reported to reduce the seed yield. Leaf spots, leaf blight smut, grey blight, clump rot, root rot, leaf-speck are some other diseases reported. These leaf diseases can be controlled by prophylactic sprays of Diethane M-45 and Diethane Z-78 @ 3G/lit trice, at intervals of 15 days.

Harvesting and yield

The lemon grass crop is perennial in nature and gives good yield for 5 years. Harvesting is done by cutting the grass 10 cm above the ground level. During the first year of planting, 3 cutting are obtained and subsequently 5-6 cuttings per year are taken subject to weather condition. The harvesting season begins in May and continuous till end of January. The first harvest is done about 90 days after planting.

The interval from sowing to harvest exerts a considerable influence on the yield and quality of oil. Both immature and over matured grass gives a lower quality of oil.

A herbage yield of 15t/harvest and recovery of oil about 0.3 to 0.5% from fresh grass. The oil is extracted by steam-distillation. An oil-yield of about 350-400 kg/ha from the second years onwards is considered satisfactory.

The following factors influence the oil production during distillation:

(1) Storage of the plant material

(2) Treatment of the material

(3) The method of distillation

- The major source of loss is by oxidation and rensification of the essential oil. So if the herb material is to stored before processing, it should be kept in a dry atmosphere within limited air circulation.
- The cut- grass when stored in a shade can increase the oil recovery up to 96 hours and storages for a further period will only decrease the oil yield.
- The essential oils are enclosed in a oil glands; oil- sacks and glandular hairs of the plant. Therefore, before distillation the herb material must be cut into small pieces to enables them to directly expose as many oil glands as is practically possible.
- Once the herb material has been reduced in size, it must be distilled immediately. Otherwise the essential oil, being volatile, will be lost by aerial evaporation.
- Dipping the chopped lemon grass in sodium chloride solution for 24 hours at 1-2 % concentration before distillation has been found to increase the citral content

Utilization of spent material

- The plant residue thrown out after the extraction of the essential oil is called spent material of lemon grass.
- Cattle relish it when it is hot or is converted into silage by adding a dilute solution of molasses.

- It is also a excellent source of manure it is applied either after composting or in the form of ash by burning.
- The waste lemon grass also used a fuel for distillation after drying.
- It is also a cheap packaging material for glass ware or other fragile objects.

Chemical composition of essential oil of lemon grass

The gas chromatographic analysis of oil showed the presence of the terpinene (0.5%), beta terpineol (0.40%), alpha terpineol (2.25%) triphenyle acetate (0.90%) borneol (1.90%) gereniol+ nerol (1.50%), citral-b (27.7%) , citral-a (46.60%), farnesol (12.80%) and farnesal (3.00%) with rest being unidentified compounds.

Commercial uses of essential oil

- The essential oil of lemon grass is mainly used in the manufacturing of perfumes for soaps, hair oils, scents and medicines. It has also antibacterial properties
- Ionone prepared from the citral present in lemon grass oil is one of the most important raw materials for the preparation of vitamin A.
- It is also use in perfumery; Ionone is used in certain types of confectionery and liquors. The oil can be used to improve the flavors of some fish and can be used to flavour wines and sauces.
- The essential oil can also used for headaches, toothaches, baths, fomentations, as a diuretic agent for fever and as an insect repellent especially mosquito and house flies.

Muskdana *(Abelmoschus moschatus Medic)*

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Introduction

Muskdana belongs to family Malvaceace, popularity Known as musk mallow yields musk like scented seeds. Its seeds yield an essential oil, contain mainly ambrettolic acid, and give a strong flowery musky brandy-like odour of remarkable tenacity because of the presence of ambretollide, macrocyclic lactose in the seed coat.

Vernacular names

Sanskrit-Lata Kasturika, Hindi-Muskidana, Lata Kasturi, Tamil- Kattu kasturi, Malyalam- Villilai kasturi, katta kasturi, Bengali-Muskdana, Marathi-Muskbhindi, Telgu-Kasturi benda vittalu, Kannada- Kadukasturi, English-Maskmallow, Trade- Muskdana

Botanical description

Muskdana is an erect hirsute or hispid annual herb attends a height up to 180-190 cm; stem possesses long deflexed hairs, leaves simple, polymorphous, cordaite, the lower ovate, acute or rowdish angled, upper palmately 3-7 lobed, divided nearly to the base. Flowers are long usually solitary, axillary, mucilaginous hairy, yellow with purple centre Seeds are scent sub- reniform greenish brown in colour with numerous raised brown striate.

Soil climate

Muskdana crop prefers well drained fertile rich loam to sandy loam soil. Clayey and sandy soil, waterloged conditions are not good for its proper growth. It requires tropical warm and humid climate and canbe grown up to 1000m altitude. It required sufficient rainfall during growth but compartivity dry weather during flowering and fruiting stages. The optimum temperature ranges between 20-28^0 C which is best suitable for vegetative growth.

Soil Preparation

The land should be ploughed twice and field should be cleaned thoroughly of

weeds before cultivation of muskdana 15-20 t. of FYM/ha may be incorporated in to the soil at the time of last ploughing.

Mode of propogation

Muskdana is propagated by seeds

Sowing

The seeds are sown in early June for better growth 5 kg seeds are required for sowing one hectare land under irrigated conditions. Seed are sown about 2-2.5 cm deep in rows in well prepared field.

Manures and fertilizers

A fertilizers dose of 120 kg N: 100 kg P_2O_5 and 75 kg K_2O is recommended for

obtaining good yield. The Nitrogen when applied in split dose during growth stages gives good responses in terms of seed yield per hectare.

Irrigation

If monsoon rains are regular and sufficient, usually no irrigation is given till December; Irrigation at one month's interval may be given after that, to meet out the water requirements of the crop.

Intercultural

During early stages of crop growth, weeding cum hoeing is done at 3-4 week intervals for 3 months. Thereafter crop becomes tall and do not allow the seasonal annual weeds to grow for competition the crop growth.

Pest and Disease

A number of pest and disease are reported to affect this crop from the time of germination to fruit ripening stages. The foliar application of Dimethoate etc reduces the risks of aphids, thrips, and pink bollworms. Similarly, foliar spray of 0.5% Diethane z-78 can control several disease of muskdana which cause reduction in yield.

Harvesting and storages

The crop is a kharif season crop and sown in June and begins to flowers in October and the fruit setting is almost simultaneous which continues till April. The crop is matured within 6-7 months. As soon as the fruits attend blackish colour the mature fruits are plucked and seeds are taken out manually as otherwise seeds fall off.

Yield

The averge yield of seeds ranged between 8-10 q/ha.

Chemical constituents

Leave; flowers and seeds of the plant contains betasitosterol and its glucosides campestrol, stigmasterol; cholesterol, ergosterol. The seed contains an essential oil (0.3%) which is comprised up of sesquiterpene alcohol arnesol, lactone ambrettolide and ambrettolic acid.

Medicinal uses

Mushkdana seeds are used as tonic; apphrodisiac, antiseptic, diuretic Stomachic, demulcent and carminative They allay thirst, check vermitting and care disease due to kapha and vata and also useful in treating intestinal disorders, dyspepsia, urinany discharge, nervous debility, hysteria and skin diseases like itch and leucoderma The leaves and roots are useful for treating gonorrhea. Aqueous and raw infusions of seeds are used for intestinal worms snake bite, rhuematism, flu asthma. Its seeds absorbent capacity inactivates snake venom. The root powder is used to poultice boils and swelling muskdana seeds are mixed with coffee as a flavouring agent, Besides seeds are also used to protect woolen cloths against moth and impart musky odour to sachet hair powder, pan masala and aganbatti etc.

Changing climate with changing Sun

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Since it is the Sun's energy that drives the weather system, scientists naturally wondered whether they might connect climate changes with solar variations. Yet the Sun seemed to be stable over the timescale of human lifetimes. Attempts to discover cyclic variations in weather and connect them with the 11-year sunspot cycle, or other possible solar cycles ranging up to a few centuries long, gave results that were ambiguous at best. These attempts got a well-deserved bad reputation. Jack Eddy overcame this with a 1976 study that demonstrated that irregular variations in solar surface activity, a few centuries long, were connected with major climate shifts. The mechanism remained uncertain, but plausible candidates emerged. The next crucial question was whether a rise in the Sun's activity could explain the global warming seen in the 20th century? By the 1990s, there was a tentative answer: minor solar variations could indeed have been partly responsible for some past fluctuations but future warming from the rise in greenhouse gases would far outweigh any solar effects.

The Sun so greatly dominates the skies that the first scientific speculations about different climates asked only how sunlight falls on the Earth in different places. The very word climate originally stood for a simple band of latitude. When scientists began to ponder the possibility of climate change, their thoughts naturally turned to the Sun. Early modern scientists found it plausible that the Sun could not burn forever, and speculated about a slow deterioration of the Earth's climate as the fuel ran out. In 1801 the great astronomer William Herschel introduced the idea of more transient climate connections. It was a well-known fact that some stars varied in brightness. Since our Sun is itself a star, it was natural to ask whether the Sun's brightness might vary, bringing cooler or warmer periods on Earth? As evidence of such a connection, Herschel pointed to periods in the 17th century, ranging from two decades to a few years, when hardly any sunspots had been observed. During those periods the price of wheat had been high, he pointed out, presumably reflecting spells of drought.

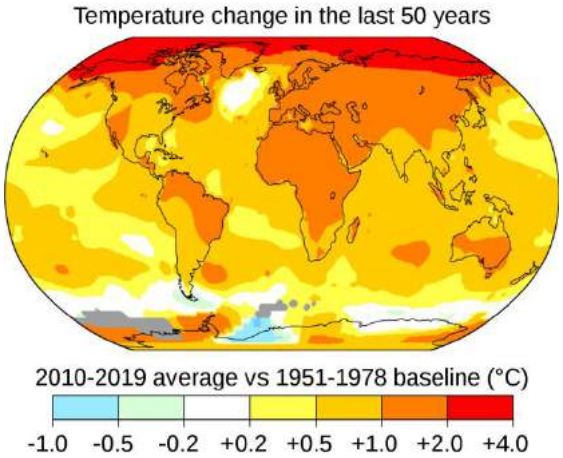
Speculation increased in the mid-19th century, following the discovery that the number of spots seen on the Sun rose and fell in a regular 11-year cycle. It appeared that the sunspots reflected some kind of storminess on the Sun's surface violent activity that strongly affected the Earth's magnetic field. Astronomers also found that some stars, which otherwise seemed quite similar to the Sun, went through very large variations. By the end of the century a small community of scientists was pursuing the question of how solar variability might relate to short-term weather cycles, as well as long-term

climate changes. Attempts to correlate weather patterns with the sunspot cycle were stymied, however, by inaccurate and unstandardized weather data, and by a lack of good statistical techniques for analyzing the data. Besides, it was hard to say just which of many aspects of weather were worth looking into.

At the end of the 19th century, most meteorologists held firmly that climate was stable overall, about the same in one century as in the last. That still left room for cycles within the overall stability. A number of scientists looked through various data hoping to find correlations, and announced success. Enthusiasts for statistics kept coming up with one or another plausible cycle of dry summers or cold winters or whatever, in one or another region, repeating periodically over intervals ranging from 11 years to several centuries. Many of these people declined to speculate about the causes of the cycles they reported, but others pointed to the Sun.

Confusion persisted in the early decades of the 20th century as researchers continued to gather evidence for solar variation and climate cycles. For example, Ellsworth Huntington, drawing on work by a number of others, concluded that high sunspot numbers meant storminess and rain in some parts of the world, resulting in a cooler planet. The present variations of climate are connected with solar changes much more closely than has hitherto been supposed, he maintained. He went on to speculate that if solar disturbances had been magnified in the past, that might explain the ice ages.

Meanwhile an Arizona astronomer, Andrew Ellicott Douglass, announced a variety of remarkable correlations between the sunspot cycle and rings in trees. Douglass tracked this into past centuries by studying beams from old buildings as well as Sequoias and other long-lived trees. Noting that tree rings were thinner in dry years, he reported climate affects from solar variations, particularly in connection with the 17th-century dearth of sunspots that Herschel and others had noticed. Other scientists, however, found good reason to doubt that tree rings could reveal anything beyond random regional variations. The value of tree rings for climate study was not solidly established until the 1960s.



Through the 1930s the most persistent advocate of a solar-climate connection was Charles Greeley Abbot of the Smithsonian Astrophysical Observatory. His predecessor, Samuel Pierpont Langley, had established a program of measuring the intensity of the Sun's radiation received at the Earth, called the "solar constant." Abbot pursued the program for decades. By the early 1920s, he had concluded that the solar "constant" was misnamed: his observations showed large variations over periods of days, which he connected with sunspots passing across the face of the Sun. Over a term of years the more active Sun seemed brighter by nearly one percent. Surely this influenced climate. As early as 1913, Abbot announced that he could see a plain correlation between the

sunspot cycle and cycles of temperature on Earth. Self-confident and combative, Abbot defended his findings against all objections, meanwhile telling the public that solar studies would bring wonderful improvements in weather prediction. He and a few others at the Smithsonian pursued the topic single-mindedly into the 1960s, convinced that sunspot variations were a main cause of climate change.

Other scientists were quietly skeptical. Abbot's solar constant variations were at the edge of detectability if not beyond. About all he seemed to have shown for certain was that the solar constant did not vary by more than one percent, and it remained an open question whether it varied anywhere near that level. Perhaps Abbot was detecting variations not in the solar constant, but in the transmission of radiation through the atmosphere. Still, if that varied with the sunspot cycle, it might by itself somehow change the weather.

The study of cycles was popular in the 1920s and 1930s. By now there were a lot of weather data to play with, and inevitably people found correlations between sunspot cycles and selected weather patterns. Respected scientists and over-enthusiastic amateurs announced correlations that they insisted were reliable enough to make predictions.

Sooner or later, every prediction failed. An example was a highly credible forecast that there would be a dry spell in Africa during the sunspot minimum of the early 1930s. When that came out wrong, a meteorologist later recalled, the subject of sunspots and weather relationships fell into disrepute, especially among British meteorologists who witnessed the discomfiture of some of their most respected superiors. Specialists in solar physics felt much the same. As one of them recalled, purported connections with weather and climate were uniformly wacky and to be distrusted there is a hypnotism about cycles that draws all kinds of creatures out of the woodwork. By the 1940s, most meteorologists and astronomers had abandoned the quest for solar cycles in the weather. Yet some respected experts continued to suspect that they did exist, lurking somewhere in the data.

Sun could affect climate on much longer timescales. During the 1920s, a few people developed simple models that suggested that even a modest change in solar radiation might set off an ice age, by initiating self-sustaining changes in the polar ice. A leading British meteorologist, Sir George Simpson, believed the sequence of ice ages showed that the Sun is a variable star, changing its brightness over a cycle some 100,000 years long. There has always been reluctance among scientists to call upon changes in solar radiation to account for climatic changes. The Sun is so mighty and the radiation emitted so immense that relatively short period changes have been almost unthinkable. But none of the terrestrial causes proposed for ice ages was at all convincing.

The eminent astrophysicist Ernst Öpik wrote that none of the many explanations proposed for ice ages was convincing, so we always come back to the simplest and most plausible hypothesis: that our solar furnace varies in its output of heat. Öpik worked up a theory for cyclical changes of the nuclear reactions deep inside the Sun. The internal fluctuations he hypothesized had a hundred-million-year timescale that seemed to match the major glacial epochs. Manwhile, within a given glacial epoch "a kind of 'flickering' of solar radiation" in

the Sun's outer shell would drive the expansion and retreat of ice sheets. In the 1950s, when reviews and textbooks listed various possible explanations of ice ages and other long-term climate changes, ranging from volcanic dust to shifts of ocean currents, they often invoked long-term solar variation as a particularly likely cause. The problem of predicting the future climate of Planet Earth would seem to depend on predicting the future energy output of the sun.

Meanwhile some people continued to pursue the exasperating hints that minor variations in the sunspot cycle influenced present-day weather. Sunspot variations, the only possible single factor of climatic control which might be made to account for all of these variations. Others thought they detected sunspot cycle correlations in the advance and retreat of mountain glaciers. Willett admitted that the physical basis of any such relationship must be utterly complex, and is as yet not at all understood. Climate changes could be due to solar variation in the ultraviolet of the sort which appears to accompany sunspot activity. As another scientist had pointed out a few years before, ultraviolet radiation from the explosive flares that accompany sunspots would heat the ozone layer high in the Earth's atmosphere, and that might somehow influence the circulation of the lower atmosphere.

In the 1950s and 1960s, instruments on rockets that climbed above the atmosphere managed to measure the Sun's ultraviolet radiation for the first time. They found the radiation did intensify during high sunspot years. However, ultraviolet light does not penetrate below the stratosphere. Meteorologists found it most unlikely that changes in the thin stratosphere could affect the layers below, which contain far more mass and energy. Still, the hypothesis of atmospheric influence remained alive, if far from healthy.

A few scientists speculated more broadly. May be weather patterns were affected by the electrically charged particles that the Sun sprayed out as solar wind. More sunspots throw out more particles, and they might do something to the atmosphere. More indirectly, at times of high sunspot activity the solar wind pushes out a magnetic field that tends to shield the Earth from the cosmic rays that rain down from the universe beyond. When these rays penetrate the upper reaches of the atmosphere, they expend their energy producing sprays of charged particles so more sunspots would mean fewer of these particles. Either way there might be an influence on the weather. Meteorologists gave these ideas some credence. But the solar wind and ultraviolet carried only a tiny fraction of the Sun's total energy output. If they did influence weather, it had to be through a subtle triggering mechanism that remained altogether mysterious. Anyway variations connected with sunspots seemed likely to bear only on temporary weather anomalies lasting a week or so (the timescale of variations in sunspot groups themselves), not on long-term climate change.

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