ENVIRONEWS

INTERNATIONAL SOCIETY OF ENVIRONMENTAL BOTANISTS

Newsletter

LUCKNOW (INDIA) VOL. 26, No. 3 & 4 July & October, 2020

IN THIS ISSUE

ISEB NEW PROJECT

Environmental Education and Climate Change Adaptation: *Science of Pollution-Tolerant and Climate Resilient Plants*

Funded by: International Union of Biological Sciences (IUBS)

Detail of the project on Page 14

EFFECT OF COVID-19 AND ENVIRONMENT

Corona virus disease 2019 (COVID-19) has become a global pandemic. Its relationship with the environmental factors is an issue that has attracted the attention of scientists. The measures taken to control the spread of the virus and the slowdown of economic activities have significantly limited pollutant emissions and natural resource use, which has reduced the rate of environmental damage.

Positive environmental effects:

- Emission of NO_2, one key indicator of global economic activities, indicates a sign of reduction in many countries – US, Canada, China, India, Italy, Brazil.
- The measures taken like quarantine and lockdown, mandates that people stay at home, has reduced noise level in most cities. Somani et al. (2020) report 40-50% reduction of noise level of Delhi, the capital of India.
- During the lockdown and restriction period, the major industries were either shut down or shrunk in activities, leading to reduction of pollution load in rivers. Ganga and Yamuna, important rivers of India, reached a significant level of purity (Singhal and Matto, 2020).
- Due to local restrictions the number of tourists have reduced throughout the world, which has shown a drastic change in the colour and properties of sea water. Because of the pollution reduction dolphins have been reported to return in the coast of Bay of Bengal (Bangladesh) and ports of Venice (Italy) after a long decade (Rehman, 2020).

Negative environmental effects:

- COVID-19 treatment of the large number of patients and also due to the disinfection purpose huge amount of infectious and hazardous biomedical wastes are generated from hospitals. This has become a big challenge for the local authorities.
- For protection people are using face masks, hand gloves, PPE and other safety equipments. This is creating infectious waste which is generally mixed with household waste when not disposed of properly. Thus, increase the risk of disease transmission.

Once the pandemic eases, there is possibility that the environment resumes the earlier polluted condition. There is need to improve the economy but also keep in mind for the betterment of air and water quality, waste management, biodiversity protection and reduction of greenhouse gas emissions, leading to increased resilience and sustainability.

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LETTERS

Thank you for sharing the latest issue of the Enviro News. As always it is informative and full of interesting information.
Best Regards

Prof. C K Varshney, Ex-Dean, School of Environmental Sciences, JNU, New Delhi (ckvarshney@hotmail.com, ckvarshney@gmail.com)

Thank you very much for the information on the proposed webinar series. This will also be a good opportunity to be part of the Centenary of IUBS. I will send the information to our colleagues here.

Dr. Penna Suprasanna, Senior Scientist & Professor, Nuclear Agriculture & Biotechnology Division, Bhabha, Mumbai (penna888@yahoo.com)

I am extremely glad and grateful to get the invitation mail to join the coming Webinar on 2nd October. I extend my whole hearted support for the arrangement as a life member of ISEB and wish to join there.
With regards, Yours sincerely

Dr. Sukumar Sarkar, Associate Professor of Botany, Hooghly Mohsin College, Chinsurah (sarkarsdss@hotmail.com).

I take this opportunity to share one of our distinct academic achievements with ISEB fraternity.

I have been associated with an International Research Journal Physiology and Molecular Biology of Plants (PMBP: www.springer.com/journal/12298) as Executive Editor (1995-2001) and Editor-in-Chief (2002 onwards) .The journal was raised to quarterly from biannual in 2005, bimonthly from 2018 and monthly from its Silver Jubilee year 2020. It is published jointly by Springer Nature and Professor H.S. Srivastava Foundation for Science and Society (www.phssfoundation.org).

As per the recent data base the journal PMBP has been rated top amongst all Plant Science Journals of Indian subcontinent, amongst top 5 Asian Plant Science Journals and amongst the top one-third of all indexed plant journals of the world. It is ahead of 350 journals at global level. It is indexed by Clarivate -JCR (IF-2.005) and Scopus (IF-2.13) as per the announcement in June, 2020. If provisions exits and agreed by the Editor and President ISEB, I would like to share it with ISEB fraternity as a member ISEB through the next issue of its Newsletter "Environews".

Prof. Rana Pratap Singh, Dept. of Environmental Science, BBA University, Lucknow (dr.ranapratap59@gmail.com; pmbpeditor@gmail.com)

Congratulations Prof. Singh for your untiring effort to bring PMBP to this position...............ISEB Fraternity

NEWS FLASH

Prof. Saroj Kanta Barik, FISEB, President ISEB, Director CSIR-NBRI, Lucknow, has been elected as fellow of National Academy of Agricultural Sciences (NAAS), 2020. Dr Barik has made significant contributions to the understanding of plant diversity, conservation biology and forest ecosystems. He developed novel methods for cumulative environmental impact assessment and eco-restoration of shifting areas. His pioneering studies on plant meta-populations are unique to conservation biology. His research contributions on value addition of turmeric and Indian Pinax has high agriculture and industrial importance. His ecosystem level carbon sequestration data using specific biomass models have a significant impact on climate change.

Prof. Madhoolika Agrawal, FISEB, Life Member ISEB, Coordinator, Interdisciplinary School of Life Sciences, Banaras Hindu University, Varanasi has been nominated as a member (NASI Representative) of the Executive Council (2021) of Indian National Science Academy (INSA), New Delhi. Her research includes Ecology and Environmental Science (Air Pollution, Global Environmental Change, Food Chain Contamination).

Dr. Ritu Trivedi, Life Member ISEB, Principal Scientist, CSIR-Central Drug Research Institute, has been confered upon NASI - Reliance Industries Platinum Jubilee Award (2020) for Application Oriented Innovations covering both Physical and Biological Sciences.

Dr. Pradhyumna Kumar Singh, Life Member ISEB, Senior Principal Scientist, CSIR-National Botanical Research Institute, has been elected INSA Fellow 2020. Dr. Singh has made outstanding contributions towards identification of novel molecules and approaches to control pests in field crops. His work provides a complete model, from discovering new proteins to genes, making synthetic genes to develop transgenic crop lines and their performance evaluation. Transgenic cotton lines expressing three different novel genes (cry, tma12 and msc14) developed by his group provide next-generation insecticidal approaches for control of insect pests. His work provides rare research procedures developed complete in India.

WELCOME NEW LIFE MEMBERS

Prof. Gaure Saxena, Professor, Department of Botany, Lucknow University, Lucknow (gaurigupta72@yahoo.com).

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Prof (Dr.) Amritesh C. Shukla, Professor & Additional Dean (RAC), Faculty of Science, Department of Botany, University of Lucknow, Lucknow, (amriteshcshukla@gmail.comamritesh.shukla@rediffmail.com).

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Prof. Anil Kumar Gupta, Professor, Head of Environment Climate and Disaster Risk Reduction (ECDRM) Division, National Institute of Disaster Management, Ministry of Home Affairs, GoI (envirosafe2007@gmail.com).

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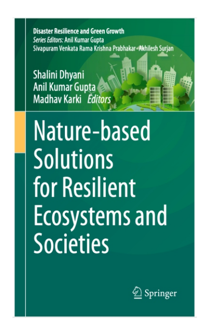
Prof. Dinesh Mohan, Professor, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi (dm_1967@hotmail.com).

Dr. Pradumn Kumar Singh, Senior Principal Scientist, Insect Defence Laboratory in Molecular biology and Biotechnology Division, CSIR-NBRI, Lucknow (pksingh@nbri.res.in)

NEW BOOK RELEASE

Nature - based Solutions for Resilient Ecosystems and Societies



Edited by: Shalini Dhyani, CSIR-NEERI, Nagpur, Maharashtra, India; Anil Kumar Gupta, Centre for Excellence on Climate Resilience, National Institute of Disaster Management New Delhi, India; Madhav Karki Knowledge-Policy Management CGED -Nepal Kathmandu, Nepal.

The book discusses the concept of Nature-based Solutions (NbS) – both as a science and as art – and elaborates on how it can be applied to develop healthy and resilient ecosystems locally, nationally, regionally and globally. The book covers illustrative methods and tools adopted for applying NbS in different countries. The authors discuss NbS applications and challenges, research trends and future insights that have wider regional and global relevance. The book offers insights into understanding the sustainable development goals (SDGs) at the grass roots level and can help indigenous and local communities harness ecosystem services to help achieve them. It offers a unique, essential resource for researchers, students, corporations, administrators and policymakers working in the fields of the environment, geography, development, policy planning, the natural sciences, life sciences, agriculture, health, climate change and disaster studies.

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Lichenicolous fungi -The parasites of the lichen world

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Lichens are rich source of secondary metabolites, known for producing more than 1000 unique metabolites. These metabolites protect the lichens from abiotic and biotic stress. The abiotic stress benefits include protection from bright sun, UV radiation, extreme temperatures, draught and desiccation. Whereas biotic stress advantage includes avoidance of lichen feeding small invertebrates and infectious microbes. Lichens make surface interactions with various microbes such as virus, fungi and bacteria but due to their inbuilt capabilities due to presence of secondary metabolites these interactions mostly remain temporary. In some cases lichens can't protect themselves and become host to group of fungi and bacteria. In several occasions these microbes form an obligate association and become integral part of the lichen system. Lichenicolous fungi are one such unique group of organism that make a deliberate association with lichens. These fungi represent a highly specialized and successful group of organisms that live exclusively on lichens, most commonly as host-specific parasites, broad-spectrum pathogens, saprotrophs and commensals. Thesaprotrophs (or saprobes) are found on dead and decaying parts of lichenthallus. The parasitic lichenicolous fungi cause extensive lesions and forms circular colonies on lichen thalli, while few form galls with lichen tissue. Some lichenicolous fungi are commensals and do not cause obvious damage to lichens. During the microscopic studies one can make sure presence of lichenicolous fungi on the lichen thallus by observing blackened rings, presence of apothecia or perithecia other than that of lichen host. In case of Coelomycetes and Hyphomycetes fungi conidia can be seen on the surface of the lichen.

The zones of contact of several ascomycetes lichenicolous fungi and lichens have been studied which revealed that parasite derive the nutrition from the photobiont by developing haustorial connection. But in many cases lichenicolous fungi directly parasitize photobiont cells by attacking and killing them. Sometimes these parasites form direct haustorial connections with the lichen mycobiont also. The current accepted number of lichenicolous fungi in the world is 2319 species of which 2000 are obligate associates. Out of the total about 96% belongs to ascomycetes group and only 4% belongs to basidiomycetes. Experts' opinion that about 3000-4000 species lichenicolous fungi may be present in the world, however their exploration is far from completion. The number of currently known lichenicolous fungi in India are 179, which is very less compared to vast diversity of lichens in the country represented by 2900 species.

There are many reasons which makes lichenicolous fungi interesting as well as difficult to study which are discussed briefly in this article.

Host specificity and lichenicolous fungi: Lichenicolous fungi tend to be highly host specific and the specificity is as high as 95%. The most host specific species form a close bond with their hosts and the coevolution favours development of some characteristics that helps in unusual integration. The host specificity of some lichenicolous fungi is not known with certainty. The specificity depends upon the lichen host and range varies from species to species. For example, some lichen families harbour few obligate lichenicolous fungi (Arthopyreniaceae, Thelotremataceae) while some have moderate numbers (Caldoniaceae, Pertusariaceae), whereas some (Peltigeraceae) harbours unusually high numbers.

The differences in the number of lichenicolous fungi among lichen groups can be caused by various factorswhich include habitat, nutritional and chemical differences. Peltigerales may be more suitable for fungal parasites because of their mild secondary metabolites and higher nitrogen content. The lichens with large thalli, decaying older parts and growing in humid conditions make appropriate niche for many fungi. The property of lichenicolous fungi being host specific can help in the re-examination of taxonomy of the lichen host. For example, occurrence of *Microcaliciumarenarium*(Hampe ex A. Massal.) Tibell on lichen*Psilolechialucida* (Ach.) M.Choisy and *Micareaclavulifera* (Nyl.) Coppins& P. Jamesled to the transfer of latter into *Psilolechia*regardless of the difference in their thallus colour.

Secondary metabolites, lichen and lichenicolous fungi: The ability of lichenicolous fungi to grow on lichens and form such a specific association makes them unique. Otherwise, the antifungal activities of secondary metabolites produced by lichensdo not allow common fungal saprotrophs like *Penicillium*, *Trichoderma*, *Aspergillus*to grow on them. Experiments have demonstrated that some unrelated lichenicolous fungi grew better on lichen thalli from which secondary metabolites had been removed. Whereas, some lichenicolous fungi which are strictly host specific could tolerate the secondary compounds of that host while others could not. Some lichenicolous fungi like *Ovicuculisporaparmeliae* (Berk. & M.A. Curtis) Etayo, grows on *Puncteliarudecta* (Ach.) Krog, only when its secondary metabolites has already been degraded by another lichen parasite such as *Fusarium* sp.Another study showed that growth of lichenicolous fungi *Plectocarponlichenum* (Sommerf.) D. Hawksw.on*Lobariapulmonaria* (L.) Hoffm.decreasedproduction of host's secondary metabolites and growth.

Lichenicolous fungi also produces secondary metabolites of their own but it is still not known whether these have any role in host specificity. On comparing the composition of secondary metabolites of areas infected by 30 genera of fungi to the rest of the lichen thallus13 different compounds were found in five genera. Among them gyrophoric acid in *Sclerococcum sphaerale* (Ach.) Fr. and *Skytteanitschkei* (Körb.) Sherwood, D. Hawksw. & Coppins; pannaria in *Milospium graphideorum* (Nyl.) D. Hawksw.; lipids in *Endococcusapicicola* (J. Steiner) R. Sant. and a triterpenoid in *Marchandiomyces corallinus* (Roberge) Diederich & D. Hawksw. were common with their host.

Culture of lichenicolous fungi: The study of lichenicolous fungi depends greatly on their isolation and maintenance of axenic cultures. The routine culture methods used for isolating normal fungi can be used for isolating most of the lichenicolous fungi too. However, there are group of lichenicolous fungi such as *Epicladonia* spp, *Bachmanniomyces uncialicola*(Zopf) D. Hawksw. are difficult to isolate by culture techniques, mostly because of their strict growth requirements. Earlier the axenic cultures of lichenicolous fungi were used to establish anamorph-teleomorph connections but now due to the advancement in molecular techniques it can be used for genus or species level identification.In one of the study carried out elsewhere 1183 species of lichen forming and lichenicolous fungi from 20 countries were successfully isolated. That study observed that only 31% of lichenicolous fungi could be successfully isolated as compared to the 42% of the lichen forming fungi. Even after 25 years of this experiment the culture practice for lichenicolous fungi is still in its experimental phase and quiet challenging to get pure cultures as compared to that of lichen forming fungi. This may be because the growth of lichenicolous fungi depends not only upon the type of media, but also on the culture conditions. These culture conditions may be unique to each species. For example, *Athelia arachnoidea*(Berk.) Jülich, shows maximum growth at 20°C. Lichenicolous fungi such as *Fusarium* sp. can grow on PDA in laboratory but will form conidia only in the presence of lichen tissue having secondary metabolites. Out of all the lichenicolous fungi, saprotrophic ones are easiest to culture, followed by generalised necrotrophs (fungi having high virulence and can kill the lichen host) and biotrophs (fungi with low virulence and rarely shows their presence). Gall forming lichenicolous fungi are the most difficult to culture in laboratory because they also require axenic resynthesis of the associated lichen mycobionts and photobionts.

The lichenicolous fungi is an unexplored area of research particularly in India. As mentioned earlier only 179 species of lichenicolous fungi are known from India so far. However, huge wealth of lichen diversity, range of geography and ecological conditions indicates India may have more than 1000 species. Apart from establishing successful culturing protocol many other areas those needs to be explored are life cycle, ecology, physiology, biochemistry, genomics and evolution of these fungi. Bio prospecting possibilities of lichenicolous fungi for pharmaceutically important metabolites needs to be explored. With the path breaking techniques in the field of molecular biology and phylogenomics we should be able to solve mysteries regarding co evolution and host-parasite relationship of lichen and lichenicolous fungi.

Floristic Diversity and Ecological assessment of Freshwater algae from Jim Corbett National Park, Uttarakhand, India

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India is recognised as one of the seventeen mega diverse biodiversity rich country. Conservation of wild flora and fauna has been an integral part of Indian history. One such protected area is classified by IUCN under category-II as National Parks which is serving as foundation for conservation of biodiversity. National Parks are titled for three primary objectives: (a) Species and genetic diversity preservation (b) Maintenance of environmental services (c) Tourism and recreation. There are 104 existing national parks in India covering an area of 40501.13 km^2, which is 1.23% of the geographical area of the country.

Among them, one of the famous National Parks is Jim Corbett National Park (JCNP). It is first and oldest National Park of India established in 1936 and named after Legendary hunter Jim Corbett. Jim Corbett National Park covers Nainital and Pauri Garhwal district of Himalayan foothills, Uttarakhand. It has total area of 520.82 km^2 and lies between latitude 29°25′ to 29 °40′ N and longitude 78°5′ to 79°5′ E. The gateway of Jim Corbett National Park is Ramnagar city. It marks the site of launch of Project Tiger (1973) in India. The reserved forest areas form part of buffer zone of the JCNP. It is divided into 5 different zones - Durga Devi, Bijrani, Jhirna, Dhikala and Sona Nadi. The peripheral buffer zones (which act as buffers from developmental and other human activity) and forest gaps (fire lines, forest guard quarters, etc.) in the core areas are invaded by non-native invasive species. Climatic conditions of JCNP experiences subtropical monsoon. The average altitude of the region ranges between 360 m and 1,040 m. Rainfall in Corbett National Park ranges from 1500 mm to 1600 mm especially during the monsoon, however sometimes rain may happen in winter season. The temperature ranges between 4°C in winter to 42°C during the summer season. The lifelines of this park are rivers such as Ramganga, Sonanadi, Kosi and Mandal Palain which flow through it.

Knowledge about the plant wealth is of primary significance for any nation. The plants, whether it is algae or higher plant are present from the beginning to end of all food chain of man. JCNP is rich in biodiversity with various flora and fauna. As far as fauna is concerned, JCNP is blessed with 49 mammals species, 685 species of birds, 39 reptilian species, 10 amphibians and 36 species of pisces. The vegetation of the park is a mosaic of dry and moist deciduous forest, scrub savannah, and alluvial grassland. Flora is epic representation of the heart of bio-diversity. Among flora it has varieties of trees, palms, shrubs, bamboo, herbs, grasses, woody climbers, epiphytic orchids, wetland vegetation and no flowering plants like fern, mosses, lichen and fungi growing in luxuriantly. Apart from these, JCNP also has very favourable ecological condition for algal growth. But there are not many studies on algae available from JCNP.

There are 72,500 species of algae in the world and 7396 species of algae in India contributing to 14.96 % of Indian flora. A total of 346 species of algae have been reported from Uttarakhand. Although JCNP encompasses favourable ecological conditions for algal growth, the area has not been much explored yet, except Khare and Suseela (2004) reported 41 algal taxa from the Jhirna zone in JCNP, which included 11 blue-green algae, 10 green algae and 20 taxa of golden brown algae (diatoms). Therefore, JCNP is a virgin site for algal diversity and distribution studies.

To understand the changes in pattern of freshwater algal diversity dynamics, sampling was carried out from different habitats like soil, bark, streams and rivers etc. across different zones of JCNP. Seasonal variations of freshwater algal diversity in relation to physico-chemical parameters of different water bodies of Jim Corbett National Park were carried out for a period of 1 Year (2019) in three consecutive seasons: Winter (January); Summer (May); Monsoon (September). During our algal exploratory studies from Jim Corbett National Park, we came across many water bodies and terrestrial habitats showing rich assemblages of algae. Detailed investigation and sampling lead to identification of algae. Maximum algal taxa belonged to Chlorophyceae (35 genera with 128 taxa)out of which 52 taxa were desmids, followed by Cyanophyceae (25 genera with 40 taxa), Bacillariophyceae (45 genera with 65 taxa), Euglenopyceae (3 genera with 3 taxa), Rhodophyceae (2 genera with 2 taxa) and Xanthophyceae (1 genera with 1 taxa). It is clear that highest algal diversity was found to be from class Chlorophyceae (54%), followed by Bacillariophyceae (27%), Cyanophyceae (17%) and 1% each of Rhodophyceae and Euglenophyceae. Only 1 taxon was reported from Xanthophyceae.

In the present study, the pH of the water samples was found to be in the range of 6.65 ± 0.03 to 8.37 ± 0.026. Throughout the year, EC varied between 81.3 and 680.37 Scm^{-1}.TDS ranged from 40.37 ± 0.321 mgL^{-1} to 313.3 ± 0.265 mgL^{-1}. Seasonal variation was also observed in TDS with higher values in the summer season and lower values in the winter season.The Dissolved Oxygen of water fluctuated from 6.04 ± 0.015 to 11.23 ± 0.153 mgL^{-1}.Nitrate Nitrogen was recorded in the range 0.32 ± 0.02 to 1.64 ± 0.012 mgL^{-1} with maximum Nitrate Nitrogen during the summer season. Ammonium Nitrogen was found in the range 0.1 ± 0.006 to 0.56 ± 0.02 mgL^{-1} with maximum and minimum ammonium Nitrogen content recorded respectively. The water quality was clean, clean - moderate to moderate and classified in the oligotrophic, oligo-mesotrophic to mesotrophic status especially in the rainy season and winter season. We can already see that most of the conservation efforts and public attention, funds diverted into conservation of glamorous mega fauna species like tiger, elephant etc., and completely neglecting plant conservation while they play much more important ecological role. Plant diversity, the world's greatest renewable natural resource, is being lost at an alarming rate, and we must act with the greatest urgency to document and conserve it before it is too late.

Algae are vital group of plants in aquatic ecosystems and they are imperative component of biological monitoring programs for evaluating quality of water. Being important indicators of environment, they respond quickly to qualitative and quantitative composition of species in a wide range of water situations. The water bodies of JCNP are ideal examples of natural systems. The present review would be significant towards documentation of algal flora along with water quality assessment. The present study added 239 species to the algal flora of JCNP, Uttarakhand. The occurrence of large number of species within the park ecosystem clearly indicates rich assemblage of algal diversity. The extensive survey of algal diversity of Jim Corbett National Park will certainly contribute to more number of taxa to the algal flora of the JCNP. This research information would significantly contribute to comprehensive inventory database on freshwater algae of Jim Corbett National Park and serve as foundation for further bio monitoring studies.

100 years IUBS Unifying biology through diversity

IUBS Centenary Webinar Series

To commemorate completion of 100 years of promoting excellence in biological sciences, IUBS has launched a Webinar Series bringing the best of all disciplines to discuss evolution, taxonomy, ecology, biodiversity, and other topics that represent unified biology and the topics of prime importance to address contemporary problems such as climate change, endangered species, food and nutrition, health etc.

The first lecture of the webinar series was delivered by Rattan Lal, 2020 World Food Prize Laureate on **"Forgetting How to Tend the Soil"** on 2nd October 2020.

Prof. Rattan Lal is a Distinguished University Professor and Director of the **Carbon Management and Sequestration Centre** at The Ohio State University. He is an Adjunct Professor at the University Iceland, and holds a Chair of Soil Science and Goodwill Ambassador position with Inter-American Institute of Cooperation in Agriculture, San Jose, Costa Rica. He was President of the Soil Science Society of America (2006-2008), and the International Union of Soil Sciences (2017-2018). He researches soil carbon sequestration for food and climate security, conservation agriculture, and soil health. He has authored 955 journal articles, mentored 360 researchers, h-index of 150 and 101,811 citations. He is laureate of the 2018 GCHERA World Agriculture Prize, 2018 Glinka World Soil Prize, 2019 Japan Prize, 2019 U.S. Awasthi IFFCO Award, 2020 IICA Chair in Soil Science and Goodwill Ambassador, and the **2020 World Food Prize.**

About the Lecture

Almost one -third of the global ice free land area is prone to degradation by loss of soil biodiversity, depletion of soil organic carbon stock, acceleration of soil erosion by water and wind, increase in risks of secondary salinization, nutrient imbalance and disruption in elemental cycling by soil misuse and land mismanagement, expanding area under surface sealing by ad-hoc and expanding urbanization, and pollution by using soil as a global garbage dump for industrial effluents. The problem of soil degradation is being exacerbated by the current and projected anthropogenic climate change.

The severe problem of soil degradation is caused by the disconnect between nature and human. Mahatma Gandhi, whose 150 th birth anniversary is being celebrated in 2019- 2020, said " To Forget How to Dig the Earth and to Tend the Soil is to Forget Ourselves". Humanity is forgetting that soil is the source of all essential ecosystem services on which depends its survival.

Healthy soil, being a large reservoir of biodiversity, is a living entity. Yes, "All life depends on soil: there is no life without soil, and no soil without life, they have evolved together" said Charles Kellogg of USDA. Furthermore, "health of soil, plants, animals, people" (Sir Albert Howard), and environment is one and indivisible. Once soil health is degraded that of everything else is degraded with it. John Muir, a U.S. Philosopher said "In nature when you try to pick one thing, you find it hitched to everything else". Indeed, "everything is connected to everything else" (Barry Commoner,1972).

Therefore, the long-term solution to addressing global issues (e.g., climate change, hunger and malnourishment, water scarcity and eutrophication, air pollution, and dwindling of biodiversity) lies in restoring soil health and functionality and not taking soil for granted by reconnecting humanity to soil. Being a living entity, soil has rights to be protected, restored, thrive and managed judiciously. World peace and tranquillity are being jeopardized by the global problem of soil degradation. People are mirror image of the soil they live on. When soil is degraded and not tended, people are helpless and desperate.

To survive, the modern civilization must never ever "Forget How to Tend the Soil".

http://www.iubs.org/events/conferences-supported/iubs-centenary-webinar-series/iubs-centenary-webinar-series-first-lecture.html

Recent Progress and Perspective on Drought Stress in Legumes

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Environmental stress factors, namely, heat, salinity, and drought, affect almost all aspects of the plant ranging from germination to the maturity stage. Drought is a major threat and the most unpredictable constraint, with adverse effects on crop production worldwide. Sensitivity of plants towards drought is a complex occurrence and dependent on various factors together with the developmental stages of the plant, genetic potential, exposure time and intensity of stress. Effects of drought are also seen in the leaf development, different enzyme activity, solute balance, and ultimate reduction of yield.Plants of legume family are nourishing, a good and low cost source of protein playing a vital role in agronomy because of their nitrogen fixing capability. These distinctive characteristics widen their plasticity to environments that have nitrogen deficiency. Legumes are susceptible to various abiotic stresses, and water stressis themajor constraint declining crop yield.Legume plants are generally limited to rain-fed regions, and various models (Global Climate Model) have indicated that increase in the frequency and intensity of drought, predicting the threat of water scarcity. Water deficiency at any stage can affect plant growth as a result of decliningproduction, especially during pod maturation and reproductive phase.Drought redundancy and itsintensity limits yield, biomass and its related components.The extent of decrease in yield depends on the intensity and duration of drought stress, crop developmental stage and genotypic variability. Therefore, the development of new approaches to improve drought tolerance in legumes is critical for reducing yield losses in water-deficient environments. Improvement of legume crop varieties with improved water use efficiency (WUE) may lead to increase crop yield in arid areas. The substantial development and integration of advanced approaches for dry environments are the primary elements that contribute to enhanced legume productivity in harsh environments. Approaches such as the development of various traits for drought tolerance, innovative breeding and water efficient practices, for instance, the use of drip irrigation and mulching, are promising ways to mitigate the devastating effects of drought. Our study about effects, mechanisms and management strategies may lead to managing the devastating effects of drought conditionsand to develop drought-tolerant genotypes in water deficit environments.

Effect of Drought Stress on Legumes

Legume plants differentiate in their sensitivity at the time of drought, affecting thefinal yield which is significant. This leads to reduced germination rate and decreased carbon assimilation, decreased assimilate translocation and carbon fixation, delayed flowering time and an effect on reproductive organs, pollen grain sterility, fewer pods and lower grain set and declined sink activity. Water scarcity affects numerous aspects of legume crops growth and development, including germination, shoot and root development, photosynthesis, and the reproductive stage(Farooq et al., 2016).Globalclimate changes has led drought, one of the most uncountable and an unpredicted factor continuously limiting crop production and has adverse effects on legume crops.

Several studies confirm that serious drought conditions affects plant morphology, physiology, and maturity, also moisture content plays an significant role in enzyme activity at germination time which could help to decipher the response of plants to drought at that stage.Vegetative and reproductive stages are highly responsive to water stress.The germination rate of soybean was significantly reduced during drought stress.Adecline in chickpea germination when there was a water shortage. Drought conditions usually occur at the seedling stage, and significantly reduces yield in faba bean.Photosynthesis is a fundamental process responsible for growth and development in plants and is influenced by various environmental stresses. The intensity, rate, and duration of stress will affect plant responses to water deficit. Drought affects carbon fixation by disturbing enzymatic activities of different enzymes such as *PEPCase*, and *Rubisco*. Water stress affects the photosynthetic machinery and ultimately decreases legume yield depending on the severity and extent of the stress.Thephotosynthetic rate, stomatal conductance, and transpiration rate significantly declined during drought conditions. Similarly, a recent study reported a decline in net photosynthesis in soybean under drought, which caused a reduction in dry matter accumulation and the poding rate, directly decreasing the yield. Thechlorophyll content in drought-stressed soybean plants were declined by 31% compared to non-stressed plants. In faba bean, drought conditions considerably reduced the chlorophyll content, photosynthesis rate and impaired plant growth and yield. Drought influences chlorophyll fluorescence and antioxidant enzyme activities in faba bean. Likewise, in chickpea, drought conditions affect the chlorophyll content, chlorophyll fluorescence and photosynthesis. Moreover, stomatal control is considered as a key physiological factor forlimiting water use during drought conditions, preventing excessive water loss under extended drought conditions. For example, stomatal conductance in stressed plants as compared to the non-stressed plants decreased by 60% under drought conditionsin soybean.

The impact of drought on yield is very complex and comprises different processes such as fertilization, gametogenesis, embryogenesis, and grain formation. During the plant life cycle, flowering and reproductive phases are highly vulnerable to water scarcity. Drought conditions affect flowering time, flower development and leads to pollen grain sterility by decreasing the growth of pollen tubes and pollen grain germination. Drought severely affects the ability of the plant to produce more flowers, pods and seed set; thus, the final yield is ultimately decreased. For instance, the pod per plant was reported to be reduced under water deficit by many scientists. In the beginning of pod development, drought conditions pod number declined by 92.7%, while during pod enlargement, the decrement was 81.6% compared to controls, due to the cumulative effects of a reduction in pod induction, young pod abortion, pod enlargement, and to the reduction in flower number. In previous studies, reduction in seed number per plant underwater stress was studied.The seed numbers per plant declined at higher rate in the flowering stage. Silva et al. (2018) reported that droughtnumber of flowers, fewer pods and small grains, per plant. A more recent study observed a significant decrease in seed yield (73–82%) per plant in soybean under drought conditions. For instance, water deficit significantly reduces yield in mash bean, soybean, and in chickpea.

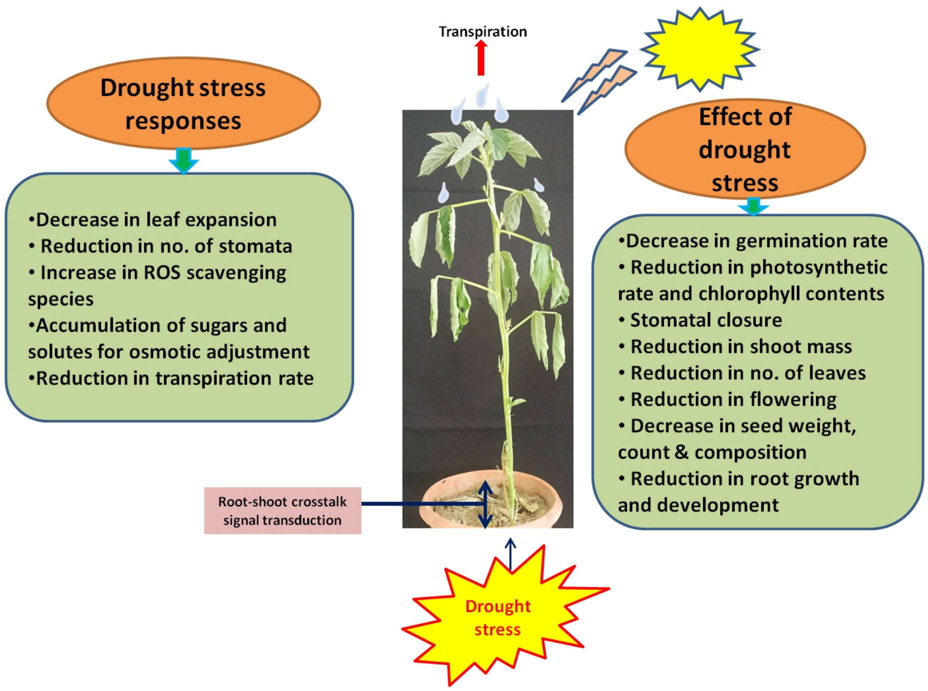

Fig: Effect of drought stress on legumes

Potential Traits for Screening Legumes for Drought tolerance

The ever-increasing water scarcity and frequent drought occurrence in agricultural ecosystems has been causing significant yield losses for many crops worldwide. Great efforts and substantial progress have been made through innovative research findings and rapid development of many novel techniques and methodologies in drought-resistance breeding. However, accumulated knowledge about drought-resistance in field crops as well in legumes is quite limited so far, and we still know little about the complex genetic architecture of drought tolerance and need to reveal the genetic basis of traits related with drought-resistance in crops, which can be applicable in crop improvement. Various traits have been used to screen for drought stresstolerance, including smaller leaf area, leaf area maintenance, water use efficiency, root and shoot biomass, osmotic adjustment, pod number per plant, and 100-grain.

Among many factors that are strongly associated with drought tolerance in legumes, architecture of roots is one of the most promising traits for drought escape and could be used positively in drought tolerance breeding programs. This aims to improve drought-resistance, enabling the plant to mine water efficiently from deeper soil layer under catastrophic dry environments and could be introduced or manipulated by a single gene. For example, in soybean, experiments suggested that roots and root nodules are indispensable sensors of drought tolerance, and the feedback of these crucial organs on drought tolerance is the key feature. Direct screening of roots and nodule traits in the field along with identification of genes, proteins and metabolites will be necessary in order to gain a comprehensive and thoughtful understanding of regulation of root architecture. In the context of drought-root cohesive drought conditions, this was investigated in common bean (*Phaseolus vulgaris L.*), and revealed negative impacts of drought on bean roots growth and ultimately decreased reproduction. This implies the existence of a core relationship between root traits and reproductive growth. Results showed reduction in rooting depth (14%), root biomass (29%), total root length (35%), volume (41%), pod set percentage (53%), and pod weight (43%) and illustrate how drought conditions effects on root and shoot traits and pod set percentage in common bean, and root traits have a correlation with reproductive success under drought(Farooq et al., 2017). Thus, drought conditionsadversely impacts bean yield, with severity of its intensity dependent on time duration, type, and plant growth stage as we have also discussed earlier. Therefore, root traits could be included in legume drought stress breeding programs. In another study, 12 chickpea genotypes were evaluated under drought for root traits, and root: shoot ratio was estimated.Variationsobserved for root length depth, deep root dry weight and root shoot ratio under drought conditions were huge.Results showed successive contributions of root length depth (after 45 days after sowing), and root shoot ratiofrom early pod filling stages to yield under drought. Ramamoorthy and co-worker (2017) concluded that breedingfor the more perfect combination of profuse (at surface soil depths), would be best selection strategy, for efficient water use and boosted terminal drought tolerance in chickpea. In mungbean (*Vigna radiate L.*), where twenty-five genotypes were tested under drought conditions treatment at vegetative and reproductive stages. There is a significant decline in the relative water content (RWC), membrane stability index (MSI), proline content of leaves, leaf area plant height, and yield. They investigated direct links of these traits to drought tolerance as varieties which have retained high in values of RWC, MSI, protein, proline content, leaf area, plant height, and yield traits were identified as drought tolerant. Moreover, slow canopy wilting has also a significant importance in drought tolerance. Slow canopy wilting(SW) is a water conservation trait controlled by quantitative trait loci (QTLs) in plants, for instance, late maturity group of soybeans (*Glycine max L. Merr*.). Two exotic soybean landraces were identified as new SW lines in early maturity groups. They shared the same water conservation strategy of limited maximum transpiration rates. Yield trials of selected recombinant inbred lines from two top exotic crosses have also given the indication to support the advantage of SW in favor of drought resistance. Therefore, importance of SW under drought conditions provides a genetic means for improving drought tolerance in early maturity group soybean. Generally, soybean cultivars vary in how swiftly they wilt in water scarcity situations and this pivotal trait may lead to improvement in yield under drought conditions. Previously researchers designed an experiment to determine the genetic mechanism of canopy wilting in soybean and they used the plant material of a mapping population of recombinant inbred lines (RILs). They sum up that the genetic mechanism regulating canopy wilting is polygenic and environmentally sensitive and it would provide new insight in future research to scrutinize the genotypes for canopy wilting in drought tolerance of soybean and other legume crops. Quantitative description of plant anatomical, ontogenetical, physiological, and biochemical properties refers to plant phenotyping. Discovering and exploiting phenotyping traits also considerably contribute to drought tolerance in different legume crops. That has been witnessed in extra-early erect cowpea cultivars to escape terminal drought and should be recommended in regions with short rainfall period. Similarly, in climatic zones with limited rainfall in the middle of the growing season, delayed-leaf-senescence traits could be valuable characters for resistance to mid-season drought. Likewise, genetic mechanisms of early flowering and maturity time, seedling vigor, and high SPAD value (chlorophyll content), biological yield, and harvest index are exploited as primary traits for high seed yield in lentil in drought-prone environments. In addition, early maturity (drought escape) and root trait (drought avoidance) drought tolerance in chickpeas and pigeon peas were also reported. Furthermore, water use efficiency (WUE) is a key factor in determining crop yield, and is believed to relate to crop drought tolerance in many production systems. For example, in soybean, genotypes that possessed high WUE not only high yielded but also increased root penetrability of hardpans. In conclusion, traits associated with drought tolerance in legumes could be a most promising way for positive use in drought tolerance breeding programs.

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Commercial Production of Domestic Waste Material For Composting: A Gravel Approach

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Composting is best suited to people with a bit more space in their yard, and households that produce garden waste such as lawn clippings and leaves. Composting is the one system that you can place small amounts of soil into. It is a 'hot' form of processing organic matter, meaning that an effective compost system will reach 60 degrees at the core. That is why you sometimes see steam coming off the top of a compost heap. The larger the compost heap, the better chance of it reaching the optimal heat. The heat is actually caused by two things – the breaking down of organic matter, and the millions of microorganisms and bacteria processing the organic matter. There is no need to add worms to your compost. Worms will visit when they conditions are right, and move out when it is too hot. Composting can be done in a number of ways. Historically, a compost heap has been used – either just heaped in the garden, or with a wall or barrier around it made from recycled materials such as brick, timber or even chicken wire. These days, with space more limited, compost bins offer a convenient solution.

Composting is an easy way of recycling that involves decomposing everyday kitchen waste into a rich soil known as compost. Step 2- Segregate your Waste: Start separating your edible kitchen waste like vegetable peels, fruit peels, and small amounts of wastes. The composting process involves four main components: organic matter, moisture, oxygen, and bacteria. Organic matter includes plant materials and some animal manures. Organic materials used for compost should include a mixture of brown organic material (dead leaves, twigs, manure) and green organic material (lawn clippings, fruit rinds, etc.). Brown materials supply carbon, while green materials supply nitrogen. The best ratio is 1 part green to 1 part brown material. Shredding, chopping or mowing these materials into smaller pieces will help speed the composting process by increasing the surface area. For piles that have mostly brown material (dead leaves), try adding a handful of commercial 10-10-10 fertilizer to supply nitrogen and speed the compost process. Moisture is important to support the composting process. Compost should be comparable to the wetness of a wrung-out sponge. If the pile is too dry, materials will decompose very slowly. Add water during dry periods or when adding large amounts of brown organic material. If the pile is too wet, turn the pile and mix the materials. Another option is to add dry, brown organic materials. Oxygen is needed to support the breakdown of plant material by bacteria. To supply oxygen, you will need to turn the compost pile so that materials at the edges are brought to the centre of the pile. Turning the pile is important for complete composting and for controlling door. Wait at least two weeks before turning the pile, to allow the centre of the pile to "heat up" and decompose. Once the pile has cooled in the centre, decomposition of the materials has taken place. Frequent turning will help speed the composting process.

Bacteria and other microorganisms are the real workers in the compost process. By supplying organic materials, water, and oxygen, the already present bacteria will break down the plant material into useful compost for the garden. As the bacteria decompose the materials, they release heat, which is concentrated in the centre of the pile. You may also add layers of soil or finished compost to supply more bacteria and speed the composting process. Commercial starters are available but should not be necessary for compost piles that have a proper carbon to nitrogen ratio (1 part green organic material to 1 part brown organic material).In addition to bacteria, larger organisms including insects and earthworms are active composters. These organisms break down large materials in the compost pile.

Composting organisms require four equally important ingredients to work effectively:

- **Carbon** — for energy; the microbial oxidation of carbon produces the heat, if included at suggested levels. High carbon materials tend to be brown and dry.
- **Nitrogen** — to grow and reproduce more organisms to oxidize the carbon. High nitrogen materials tend to be green (or colourful, such as fruits and vegetables) and wet.
- **Oxygen** — for oxidizing the carbon, the decomposition process.
- **Water** — in the right amounts to maintain activity without causing anaerobic conditions.

Slow and rapid composting: There are many proponents of rapid composting that attempt to correct some of the perceived problems associated with traditional, slow composting. Many advocate that compost can be made in 2 to 3 weeks. Many such short processes involve a few changes to traditional methods, including smaller, more homogenized pieces in the compost, controlling carbon-to-nitrogen ratio (C:N) at 30 to 1 or less, and monitoring the moisture level more carefully. However, none of these parameters differ significantly from the early writings of compost researchers, suggesting that, in fact, modern composting has not made significant advances over the traditional methods that take a few months to work. For this reason and others, many scientists who deal with carbon transformations are skeptical that there is a "super-charged" way to get nature to make compost rapidly.

Both sides may be right to some extent. The bacterial activity in rapid high heat methods breaks down the material to the extent that pathogens and seeds are destroyed, and the original feedstock is unrecognizable. At this stage, the compost can be used to prepare fields or other planting areas. However, most professionals recommend that the compost be given time to cure before using in a

Organic solid waste (green waste): Nursery for starting seeds or growing young plants. The curing time allows fungi to continue the decomposition process and eliminating phytotoxic substances. An alternative approach is anaerobic fermentation, known as bookish. It retains carbon bonds, is faster than decomposition, and for application to soil requires only rapid but thorough aeration rather than curing. It depends on sufficient carbohydrates in the treated

Animal manure and bedding: On many farms, the basic composting ingredients are animal manure generated on the farm and bedding. Straw and sawdust are common bedding materials. Non-traditional bedding materials are also used, including newspaper and chopped cardboard. The amount of manure composted on a livestock farm is often determined by cleaning schedules, land availability, and weather conditions. Each type of manure has its own physical, chemical, and biological characteristics. Cattle and horse manures, when mixed with bedding, possess good qualities for composting. Swine manure, which is very wet and usually not mixed with bedding material, must be mixed with straw or similar raw materials. Poultry manure also must be blended with carbonaceous materials - those low in nitrogen preferred, such as sawdust or straw.

Human waste and sewage sludge: Human waste can be added as an input to the composting process since human excreta is a nitrogen-rich organic material. It can be either: composted directly, as in composting toilets, or indirectly (as sewage sludge), after it has undergone treatment in a sewage treatment plant. Feces contain a wide range of microorganisms including bacteria, viruses and parasitic worms and its use in home composting can pose significant health risks. Urine can be put on compost piles or directly used as fertilizer. Adding urine to compost can increase temperatures and therefore increase its ability to destroy pathogens and unwanted seeds. Unlike feces, urine does not attract disease-spreading flies (such as houseflies or blowflies), and it does not contain the most hardy of pathogens, such as parasitic worm eggs.

Vermicomposting: Vermicompost is the product or process of organic material degradation using various species of worms, usually red wigglers, white worms, and earthworms, to create a heterogeneous mixture of decomposing vegetable or food waste (excluding nitrogen-rich meat or dairy and fats or oils), bedding materials, and vermicast. Vermicast, also known as worm castings, worm humus or worm manure, is the end-product of the breakdown of organic matter by species of earthworm. Vermicomposting can also be applied for treatment of sewage sludge.

Composting toilets: A composting toilet collects human excreta. These are added to a compost heap that can be located in a chamber below the toilet seat. Sawdust and straw or other carbon rich materials are usually added as well. Some composting toilets do not require water or electricity; others may. If they do not use water for flushing they fall into the category of dry toilets. Some composting toilet designs use urine diversion, others do not. When properly managed, they do not smell. The composting process in these toilets destroys pathogens to some extent. The amount of pathogen destruction depends on the temperature (mesophilic or thermophilic conditions) and composting time.Composting toilets with a large composting container (of the type Clivus Multrum and derivations of it) are popular in United States, Canada, Australia, New Zealand and Sweden. They are available as commercial products, as designs for self-builders or as "design derivatives" which are marketed under various names.

Black soldier fly larvae: Black soldier fly (Hermetiaillucens) larvae are able to rapidly consume large amounts of organic material when kept at around 30 °C. Black soldier fly larvae can reduce the dry matter of the organic waste by 73% and convert 16–22% of the dry matter in the waste to biomass. The resulting compost still contains nutrients and can be used for biogas production, or further traditional composting or vermicomposting . The larvae are rich in fat and protein, and can be used as, for example, animal feed or biodiesel production. Enthusiasts have experimented with a large number of different waste products.

Bokashi: Bokashi is not composting as defined earlier, rather an alternative technology. It ferments (rather than decomposes) the input organic matter and feeds the result to the soil food web (rather than producing a soil conditioner). The process involves adding Lactobacilli to the input in an airtight container kept at normal room temperature. These bacteria ferment carbohydrates to lactic acid, which preserves the input. After this is complete the preserve is mixed into soil, converting the lactic acid to pyruvate, which enables soil life to consume the result

Compost tea: Compost teas are defined as water extracts leached from composted materials.[Compost teas are generally produced from adding one volume of compost to 4–10 volumes of water, but there has also been debate about the benefits of aerating the mixture.[Field studies have shown the benefits of adding compost teas to crops due to the adding of organic matter, increased nutrient availability and increased microbial activity.[They have also been shown to have an effect on plant pathogens.

Worm Hotels: Organic ingredients intended for composting can also be used to generate biogas through anaerobic digestion. This process stabilizes organic material. The residual material, sometimes in combination with sewage sludge can be treated by a composting process before selling or giving away the compost.

Commercial composts

The term “compost” can also refer to potting mixes which are bagged up and sold commercially in garden centres and other outlets. This may include composted materials such as manure and peat, but is also likely to contain loam, fertilisers, sand, grit, etc. Varieties include multi-purpose composts designed for most aspects of planting, John Innes formulations, growbags, designed to have crops such as tomatoes directly planted into them. There are also a range of specialist composts available, e.g. for vegetables, orchids, houseplants, hanging baskets, roses, ericaceous plants, seedlings, potting on etc.

Advantages of Compost

Using compost as mulch, in the soil or as potting media is beneficial in many ways.

- Compost contains macro and micronutrients often absent in synthetic fertilizers.
- Compost releases nutrients slowly—over months or years, unlike synthetic fertilizers
- Compost enriched soil retains fertilizers better. Less fertilizer runs off to pollute waterways.
- Compost buffers the soil, neutralizing both acid & alkaline soils, bringing pH levels to the optimum range for nutrient availability to plants.

Compost helps bind clusters of soil particles, called aggregates, which provide good soil structure. Such soil is full of tiny air channels and poor's that hold air, moisture and nutrients.

- Compost helps sandy soil retain water and nutrients.
- Compost loosens tightly bound particles in clay or silt soil so roots can spread, water drain & air penetrate.
- Compost alters soil structure, making it less likely to erode, and prevents soil spattering on plants—spreading disease.
- Compost can hold nutrients tight enough to prevent them from washing out, but loosely enough so plants can take them up as needed.
- Compost makes any soil easier to work.

Compost brings and feeds diverse life in the soil. These bacteria, fungi, insects, worms and more support healthy plant growth.

- Compost bacteria break down organics into plant available nutrients. Some bacteria convert nitrogen from the air into a plant available nutrient.
- Compost enriched soil have lots of beneficial insects, worms and other organisms that burrow through soil keeping it well aerated.
- Compost may suppress diseases and harmful pests that could overrun poor, lifeless soil.

Healthy soil is an important factor in protecting our waters. Compost increases soil's ability to retain water & decreases runoff. Runoff pollutes water by carrying soil, fertilizers and pesticides to nearby streams.

- Compost encourages healthy root systems, which decrease runoff
- Compost can reduce or eliminate use of synthetic fertilizers
- Compost can reduce chemical pesticides since it contains beneficial microorganisms that may protect plants from diseases and pests.
- Only a 5% increase in organic material quadruples soils water holding capacity.

Disadvantages of Compost

When that first batch of finished compost is ready to spread, congratulate yourself for your efforts because you are ecological minded, and know that organic materials should be recycled into the soil instead of being put in a garbage can. BComposting is widely regarded as one of the best methods of maintaining and enhancing the fertility of your garden soil. There is certainly great value in transforming organic waste products into a humus-rich soil amendment teeming with beneficial microbes. Composting does have its disadvantages, and you should be fully informed before you plan your entire garden around the use of large quantities of high-quality compost.

According to Waste 21, organic domestic waste constitutes a resource that is not sufficiently utilized today for composting or biogas treatment. The short-term target (year 2004) is recycling of organic waste corresponding to 7% of the total quantity of domestic waste, or corresponding to 150,000 tons/year. Of this quantity, approx. 100,000 tons/year should be recycled by biogas treatment. The long-term target is recycling of organic domestic waste corresponding to 20-25% of the total quantity of domestic waste.

Waste 21 mentions as one of the major barriers to achieving the targets mentioned above, the lack of introduction - for organisational and technological reasons - of compulsory separated collection of organic domestic waste and residual waste for composting and biogas treatment.

PROJECT

Environmental Education and Climate Change Adaptation Science of Pollution-Tolerant and Climate Resilient Plants Funding Organization – International Union of Biological Sciences (IUBS)

IUBS was established in 1919 as a non-governmental and non-profit organization comprising of National Academies and International Scientific Associations and Societies. One of the IUBS main activities is to initiate and coordinate research and other scientific activities necessitating international, interdisciplinary cooperation with its Ordinary and Scientific members.

ISEB is Scientific Member of IUBS in the category "Ecology & Environmental Biology" since 2004. ISEB in collaboration with CSIR-NBRI submitted a project "Environmental Education and Climate Change Adaptation: Science of Pollution-Tolerant and Climate Resilient Plants" to IUBS for funding under the IUBS Scientific Programmes Triennium 2019-2022. Dr. Vivek Pandey, one of the leader of the project presented the project at IUBS Centenary and Conference which was held recently Oslo, Norway from 30 July to 2nd August 2019. The grant to implement the project was approved on 21st July, 2020.

The project aims to develop capacity for screening pollution tolerant and climate resilient plants for climate change adaptation at local level, as well as to enhance awareness on climate change adaptation strategies.

Leader(s): India – S.K. Barik, N.Singh, R.D. Tripathi, V. Pandey, A. Raghvendra; Germany – S.Saha; Mexico- M.A.H. Campos; U.S.A. – T. Lumbsch, O.P. Dhankar; Nepal – N.K. Agarwal; Finland – E.Oksanen; China – X. Wei; Bangladesh –M. Hasanuzzaman, Spain – P.K. Diwakar; Ecuador – J.P.S. Chacòn.

IUBS Scientific Member Organisations involved in the project:

1. International Society of Environmental Botanists, India (ISEB)
2. International Association for Lichenology, USA (IAL)

The Objectives of the project are:

1. To understand science of pollution tolerant and climate resilient plant species.
2. To develop simplified methods for screening pollution tolerant and climate resilient crops.
3. To select pollution-tolerant and climate-resilient plants in different climatic and edaphic environments.
4. To develop e-books and e-documentaries for environmental education.

Thus, the project would focus on the following two outputs for effective climate change education:

1. Making climate change information available to learners.
2. Engaging learners in activities and interventions addressing pollution mitigation and climate change adaptation using appropriate plants/crops.

The identified college teachers/researchers will be imparted intensive training for undertaking action research on the following:

Module 1: Selection of pollution-resistant plants (based on morphological, anatomical, biochemical and ecophysiological traits)

Module 2: Selection of climate-smart crop varieties (based on functional and morphological traits)

Module 3: Selection of forest tree species for climate change mitigation (based on their carbon sequestration potential)

Module 4: Use of plants/lichens as pollution indicators (taking air pollutants such as SOx as an example)

NEWS & VIEWS

Flower colors are changing in response to climate change

As the world's climate changes, plants and animals have adapted by expanding into new territory and even shifting their breeding seasons. Now, research suggests that over the past 75 years, flowers have also adapted to rising temperatures and declining ozone by altering ultraviolet (UV) pigments in their petals.

Flowers' UV pigments are invisible to the human eye, but they attract pollinators and serve as a kind of sunscreen for plants, says Matthew Koski, a plant ecologist at Clemson University. Just as UV radiation can be harmful to humans, it can also damage a flower's pollen. The more UV-absorbing pigment the petals contain, the less harmful radiation reaches sensitive cells.

Previously, Koski and colleagues found that flowers exposed to more UV radiation—usually those growing at higher elevations or closer to the equator—had more UV pigment in their petals. He then wondered whether two factors affected by human activity, damage to the ozone layer and temperature changes, also influenced the UV pigments.

To find out, Koski and colleagues examined plant collections from North America, Europe, and Australia dating back to 1941. In all, they examined 1238 flowers from 42 different species. They photographed flower petals from the same species collected at different times throughout their natural range using a UV-sensitive camera, which captured changes in UV pigment. They then matched these changes to data on the local ozone level and temperature.

On average, pigment in flowers at all locations increased over time—an average of 2% per year from 1941 to 2017, they reported this month in *Current Biology*. But changes varied depending on flower structure. In saucer-shaped flowers with exposed pollen, like buttercups, UV-absorbing pigment increased when ozone levels went down and decreased in locations where ozone went up. But flowers with pollen concealed within their petals, such as the common bladderwort, decreased their UV pigment as temperatures went up—regardless of whether ozone levels changed.

Though surprising, the finding "makes total sense," says Charles Davis, a plant biologist at Harvard University who was not involved with the work. Pollen hidden within petals is naturally shielded from UV exposure, but this extra shielding can also act like a greenhouse, trapping heat. When these flowers are exposed to higher temperatures, their pollen is in danger of being cooked, he says. Reducing UV pigments in the petals causes them to absorb less solar radiation, bringing down temperatures.

Although such pigment changes may be indistinguishable to the human eye, they stand out like a beacon to pollinators like hummingbirds and bees. Koski says most pollinators prefer flowers with a "bull's-eye" pattern: UV-reflecting petal tips and UV-absorbing pigments near the center of the flower. Though scientists don't fully understand the appeal of this pattern, they think it could help distinguish flowers from the UV-absorbing background of other plants.

As a result, flowers with less pigment may pop even more to pollinators, Koski says. But flowers that dial up their pigment could lose that contrast, ultimately making them less attractive to passing flyers. These pigment changes may help protect pollen, Davis says, but "pollinators might miss the flowers entirely."

(By Lucy Hicks Sep. 28, 2020 (Science)

Rice genetically engineered to resist heat waves can also produce up to 20% more grain

As plants convert sunlight into sugar, their cells are playing with fire. Photosynthesis generates chemical byproducts that can damage the light-converting machinery itself—and the hotter the weather, the more likely the process is to run amok as some chemical reactions accelerate and others slow. Now, a team of geneticists has engineered plants so they can better repair heat damage, an advance that could help preserve crop yields as global warming makes heat waves more common. And in a surprise, the change made plants more productive at normal temperatures.

"This is exciting news," says Maria Ermakova of Australian National University, who works on improving photosynthesis. The genetic modification worked in three kinds of plants—a mustard that is the most common plant model, tobacco, and rice, suggesting any crop plant could be helped. The work bucked conventional wisdom among photosynthesis scientists, and some plant biologists wonder exactly how the added gene produces the benefits. Still, Peter Nixon, a plant biochemist at Imperial College London, predicts the study will "attract considerable attention."

When plants are exposed to light, a complex of proteins called photosystem II (PSII) energizes electrons that then help power photosynthesis. But heat or intense light can lead to damage in a key subunit, known as D1, halting PSII's work until the plant makes and inserts a new one into the complex. Plants that make extra D1 should help speed those repairs. Chloroplasts, the organelles that host photosynthesis, have their own DNA, including a gene for D1, and most biologists assumed the protein had to be made there. But the chloroplast genome is much harder to tweak than genes in a plant cell's nucleus.

A team led by plant molecular biologist Fang-Qing Guo of the Chinese Academy of Sciences bet that D1 made by a nuclear gene could work just as well—and be made more efficiently, as its synthesis in the cytoplasm instead of the chloroplast would be protected from the corrosive byproducts of photosynthetic reactions. Guo and colleagues tested the idea in the mustard *Arabidopsis thaliana*. They took its chloroplast gene for D1, coupled it to a stretch of DNA that turns on during heat stress, and moved it to the nucleus.

The team found that modified *Arabidopsis* seedlings could survive extreme heat in the lab—8.5 hours at 41°C—that killed most of the control plants. The same *Arabidopsis* gene also protected tobacco and rice. In all three species, photosynthesis and growth decreased less than in the surviving control plants. And in 2017, when Shanghai exceeded 36°C for 18 days, transgenic rice planted in test plots yielded 8% to 10% more grain than control plants, the team reports this week in *Nature Plants*.

The shock was what happened at normal temperatures. Engineered plants of all three species had more photosynthesis—tobacco's rate increased by 48%—and grew more than control plants. In the field, the transgenic rice yielded up to 20% more grain. "It truly surprised us," Guo says. "I felt that we have caught a big fish."

Veteran photosynthesis researcher Donald Ort of the University of Illinois, Urbana-Champagne, says the group presents credible evidence of plant benefits, but he's not yet convinced that the D1 made by nuclear genes could have repaired PSII in the chloroplast. "Anything this potentially important is going to be met with some skepticism. There are lots of experiments to do, to figure out why this works," he says.

Guo plans further tests of the mechanism. He also has a practical goal: heftier yield increases in rice. The productivity boost his team saw in modified *Arabidopsis* was the largest of the three species—80% more biomass than controls—perhaps because the researchers simply moved *Arabidopsis*' own D1 gene. Guo thinks rice yield might also burgeon if it could be modified with its own chloroplast gene rather than one from mustard—further heating up these already hot results.

By Erik Stokstad Apr. 21 (Science)

China's rare birds may move north as the climate changes, new data suggest

China's growing army of amateur birdwatchers is a dedicated bunch—and that dedication could eventually pay off in better protection for their feathered friends. A new study uses more than 2 decades of bird sightings by China's citizen scientists to map the ranges of nearly 1400 species, from the endangered red-crowned crane to the pied falconet. Spinning those maps forward to 2070, researchers have determined what their future ranges might be—and pinpointed 14 priority areas for new nature preserves.

Researchers have used such citizen science data from bird lovers before, but experts say this study is the first in China to use it on a nationwide scale. "One of the highlights of this paper is really the use of the citizen science data set for research and conservation purposes," says Jimmy Choi, an ecologist at Southern University of Science and Technology who was not involved in the study.

Birding is a relatively new endeavor in China, but it has grown rapidly over the past 20 years. Many universities now have birdwatching teams. The birdwatchers file their sightings on the Bird Report website, where experienced birders screen the contributions for accuracy. Although lagging behind similar databases in countries with longer birding traditions, "there is no better source of data on bird species distribution" in China, Choi says.

Using those data, Ruocheng Hu of Peking University and colleagues created distribution range maps for more than 1000 species. They then modeled what may happen to their ranges under two warming scenarios, one in which global temperatures rise by less than 2°C by 2100, and a worst case scenario in which temperatures increase by 3.7°C or more. The model, which includes variables such as daily and monthly temperatures, seasonal rainfall, and elevation, found that warming temperatures will drive many birds northward and to higher ground, the researchers report this month in *PLOS ONE*. Although nearly 800 species will enjoy expanded ranges, most of those ranges are in heavily populated and industrialized areas unsuitable for birds. Roughly 240 species will see their ranges shrink.

Migratory birds and birds found only in China will be particularly hard hit. In particular, the iconic red-crowned crane will lose half of its territory nationwide, the authors say. "The existing national nature reserves are not sufficient for protecting important bird habitats, especially after range shifts," the authors write. To counter such losses, they have identified 14 priority areas for new conservation preserves scattered across the county.

"This is a great paper with a lot of data," says Amaël Borzée, a behavioral ecologist at Nanjing Forestry University, who is not a co-author. He says the paper will be "very useful for conservation," especially because the establishment of protected areas in China is generally science-based. But creating new preserves will still face challenges. Local stakeholders will have to be convinced, and there will limitations on how much space can be carved out of crowded regions. The authors suggest China will need to explore innovative approaches such as making urban parks and farmlands more bird-friendly.

(By Dennis Normile Oct. 16, 2020)

World's oldest camp bedding found in South African cave

Border Cave is a deep gash in a cliff face, high in the Lebombo Mountains of South Africa. Sheltered from the elements, the spot has yielded bones, tools, and preserved plant material that paint a detailed picture of the lives of human inhabitants for more than 200,000 years. Now, there's a new sketch emerging: Plant remains point to evidence that the cave's occupants used grass bedding about 200,000 years ago. Researchers speculate that the cave's occupants laid their bedding on ash to repel insects.

The preserved bedding will join the ranks of other "incredible discoveries" from the African archaeological record, says Javier Baena Preysler, an archaeologist at the Autonomous University of Madrid.

Lyn Wadley, an archaeologist at the University of the Witwatersrand, made the discovery when excavating Border Cave with her team. One morning, she noticed white flecks in the brown earth of the sediment as she was digging. "I looked up at these with a magnifying glass and realized that these were plant traces," she says.

Wadley carefully removed small chunks of the sediment and stabilized them in little "jackets" of gypsum plaster. Under the microscope, she identified that plant matter as belonging to the Panicoideae family of grasses that grows in the area.

Archaeologist Lyn Wadley saw small white marks in the Border Cave sediment that turned out to be compressed, preserved plant material.

The quantities of grass suggest people brought it into the cave intentionally, Wadley says. The sediment showed repeating layers of plant and ash, she says, suggesting to her that the material was used to create a clean and comfortable floor surface.

The researchers can't know for sure that people slept on the grass. But they describe it as "bedding" because it seemed likely that humans would use the comfortable floor surface for sleeping. It's "the most plausible interpretation," Baena Preysler agrees.

The layer of sediment containing the grass lies deep within the excavated layers in the cave, close to the bedrock. Researchers have dated two isolated teeth found within the same layer to about 200,000 years ago by measuring how much radiation the tooth enamel had been exposed to. The date ranges for the two teeth are broad, with one slightly older than 200,000, and the other slightly younger.

If the dates hold up, the Border Cave beds would be the earliest evidence of humans using camp bedding. The second oldest known plant bedding, in South Africa's Sibudu Cave, has been dated to 77,000 years ago, although there is tentative evidence of bedding like plant layering from about 185,000 years ago in Israel.

The bedding itself "doesn't really tell us anything about the complex cognition of humans," Wadley says. Plenty of other animal species, including birds, rodents, and other primates make nests. But material discovered alongside the grass does hint at more elaborate behaviors. Ash, as well as burnt grass, wood, and bone, suggests the cave's inhabitants may have periodically burned the bedding, possibly to rid the site of "smelly bedding and pests," Wadley says. Some of that burned wood came from the broad-leaved camphor bush, a species still used as an insect repellent in South Africa.

The repeated layers of ash and plant material suggest ancient humans deliberately laid bedding over ash, Wadley says. People around the world, including in present-day Cameroon, have long used various kinds of ash to repel and kill insects by blocking their breathing and biting apparatus. The evidence in Border Cave suggest humans deliberately used ash and medicinal plants to keep their camps clean and pest-free, Wadley and her colleagues report today in *Science*.

However, "It's very difficult to prove this," says Dan Cabanes, a microarchaeologist at Rutgers University, New Brunswick: "You can't ask these people."

Still, he says, the discovery highlights how much of the botanical record is probably being missed in archaeological sites worldwide. Plants make up a huge part of modern humans' diets, alongside a range of other uses from clothes to medicine, so there is good reason to think that our ancestors relied heavily on plants in their daily lives, Cabanes says. But the subtle traces of ancient plants can be easily overlooked, he says: "How much of this story are we missing?"

(By Cathleen OGrady Aug. 13, 2020)

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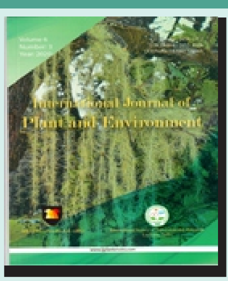

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