Science Last Fortnight

Fungi Play a Supporting Role
Partnership for phytoremediation

Plants, such as the sunflower, that can absorb heavy metals, are grown in contaminated areas to improve soil quality. However, when the concentration of metal is high, plant growth is compromised. There is stunting and loss in biomass. Recently, Muthusamy Govarthanan from the Mahendra Arts and Science College, Tamil Nadu in collaboration with South Korea isolated a fungus that, when added to soil, could prevent many of these adverse effects.

The fungus, *Trichoderma,* produces substances such as indoleacetic acid, siderophores and ACC deaminase that promote plant growth. The scientists searched wood from a heavy metal contaminated area in Namakkal, Tamil Nadu, to isolate a metal-resistant variant of this fungus. Three species of *Trichoderma,* isolated from the trunks, were cultured in the presence of heavy metals. Thus, they found a variant, *Trichoderma* MG, which was resistant to both arsenic and lead.

To test its usefulness in phytoremediation, the researchers grew sunflower saplings in arsenic and lead rich soil that either contained or lacked these fungal spores. They found that the fungus enhanced plant growth. The plants had longer roots, shoots and more biomass. The soil itself exhibited improved enzymatic activity.

This fungus could both remove arsenic and lead and produce growth inducing substances that could limit the effects of heavy metal toxicity on crops. The scientists believe that this strategy can be used to improve phytoremediation naturally.

Ecotoxicol. Environ. Saf., **151**: 279–284

PAHs Attack DNA Integrity
SOS from Goa beaches

Polycyclic aromatic hydrocarbons (PAH) are toxic substances produced when coal, oil, and biomass are burned. Industrial discharge, oil spills and transport vessels pour PAHs into marine ecosystems. There have been reports about the damaging effects on sea urchins and marine gastropods. Now, scientists from Goa, Kolkata and Sydney reveal their DNA damaging effects on marine rock oysters.

The team collected oysters from 10 different locations in Goa, with different human and/or commercial activities. They extracted DNA and studied their integrity using a combination of partial alkaline unwinding and comet assay. They also looked for correlation between PAH and toxicity in local oysters. As control, they used oysters collected from Betul beach, the most undisturbed site.

The scientists also looked for other pollutants – heavy metals and pesticides – which could have contributed to the observed DNA damage. However, they did not find any meaningful associations. Instead, anomalies in DNA structure were strongly correlated with total PAH concentrations. The highest damage was observed in oysters from Hollant, Bogmalo and Velsao beaches – all popular tourist destinations. Sailing and water sports could, perhaps, be a source of PAH contamination. The vessel, MV River Princess, grounded in the Arabian Sea, near Goa, could be another source.

Chemical pollutants accumulate quickly within oysters and could mediate toxic effects in their bodies. The scientists suggest that DNA integrity can be used as proxy for measuring the intensity of PAH contamination in marine environments. The study raises an early alarm for taking action.

Ecotoxicol. Environ. Saf., **151**: 132–143

Jute–Rice–Mustard–Mung Bean
Agriculture for carbon capture

Soil microorganisms use organic carbon to grow and to convert organic nitrogen into mineral nitrogen that can be readily taken up by plants. There is more carbon in the soil than in the atmosphere or in plants. Soil organic carbon improves soil stability and is a key indicator of soil health. Properly managed, it can improve food production, and regulate water and climate. Crop rotation, conservation tillage, quality crop residue, water management and soil erosion control can maintain the balance between carbon in soil and carbon in atmosphere.

The carbon–nitrogen ratio of soils in the eastern Indo-Gangetic Plain is of great concern. Stretching from east Bihar to Bangladesh, this is a globally important agricultural eco-region with intensive rice based cropping systems. Soil fertility in the region has reduced because of indiscriminate use of inorganic fertilisers. This has led to a continuous decline in organic content.

Recently, Mukesh Kumar and team from the ICAR-Central Research Institute for Jute and Allied Fibre Crops, Kolkata examined carbon and nitrogen mineralisation of a jute–rice cropping system under different nutrients. The field experiment was conducted on institute land in Barrackpore.

Source: Wikimedia Commons

The scientists studied five cropping systems: Fallow–rice–rice, jute–rice–wheat, jute–rice–baby corn, jute–rice–garden pea and jute–rice–mustard–mung bean. For their experiments, they adopted four levels of nutrients and crop-residue management techniques with recommended doses of fertilisers. They collected soil samples before the experiments and after four years of crop rotation. Then, they investigated the release of carbon dioxide and the amount of mineralised nitrogen in the soil samples.

The researchers observed that potentially mineralisable carbon was higher in jute–rice–mustard–mung bean followed by fallow–rice–rice. Potential and active nitrogen fractions were also higher in jute–rice–mustard–mung bean. The next best combination was jute–rice–garden pea.

They conclude that, in the jute–rice ecosystem, a legume crop should be included in the crop rotation. The crop residue should be blended into the soil with a proper dose of nutrients. This helps sustain the carbon–nitrogen dynamics in the soil.

These findings are useful to improve soil fertility in the Indo-Gangetic plains and increase agricultural production. The crop rotation system and management practices can also help mitigate climate change, say the scientists.

Soil Till. Res., **178**: 108–117

Economic Loss Due to Weeds
A pan India investigation

Weeds are a threat to agricultural productivity. Though there are studies that estimate yield and economic loss due to weeds in particular localities or crops, they tend to focus on short-term effects. Such studies may not reveal the magnitude of the problem.

Source: S. Suresh Ramanan

Now, scientists from the ICAR-Directorate of Weed Research and the Krishi Vigyan Kendra, in Jabalpur, compiled data from 1581 field trials to provide a more holistic picture. The data were collected from the trials conducted by centres of the All India Coordinated Research Project on Weed Management 2003 to 2014. The study covered 18 Indian states. The scientists focused on ten major field crops: transplanted rice, direct-seeded rice, soybean, groundnut, sorghum, pearl millet, green gram, sesame, wheat, maize and mustard.

Two types of treatments were applied in all the field trials. One was a completely weed-free condition achieved by combining mechanical weeding and herbicide application. The other adopted either mechanical

weeding or herbicide application or no weeding at all, as per the practice of local farmers. The scientists also maintained control plots where no mechanical or chemical weeding was done. Thus, they could collect data related to potential loss (weed free plots vs control plots) as well as actual loss (weed free vs farmers' practice of weed removal). 'Among the ten crops evaluated, we found that both potential as well as actual yield loss are more in groundnut and soybean', says Yogita Gharde, ICAR Directorate of Weed Research.

The team collected field data to determine the most critical factors contributing to yield loss. They found that crop, soil type and location significantly influenced yield loss due to weeds.

They used the minimum support price from 2014–2015 to compute economic loss based on yield at the different treatment trials. And they found that economic losses at an all India level can go as high as Rs 29,446 crores for rice and Rs 22,490 crores for wheat.

The magnitude of loss in agricultural productivity due to weeds is a wake-up call to policy makers. Now, it is up to agricultural scientists to devise methods to control weeds using ecologically sustainable approaches.

Crop Protect., **107**: 12–18

Easier Diagnosis from EEG
New hardware removes noise

The electroencephalogram is a cost-effective and non-invasive tool to explore brain regions and to identify cognitive and other event-related activities. However, relevant EEG signals are mixed with other biological signals, including that from a blink and other muscle artefacts. This makes it difficult to extract diagnostic features. During offline visual observation, medical practitioners, thus, have to learn to discard EEG channels containing these artefacts.

Recently, scientists from the IIT Hyderabad collaborated with researchers from the UK and Australia to develop a simple hardware for the reliable and automated removal of ocular and muscular artefacts from EEGs. They based the method on wavelet decomposition,

using the Haar function – a simple threshold-based wavelet domain de-noising and artefact removal scheme.

They used practical experiments, with their hardware system, to demonstrate that the system can, indeed, remove low-frequency blink artefacts as well as high-frequency muscle artefacts.

The hardware complexity and computational delay of the system are less than in conventional methods. This makes it favourable for real-time hardware design to diagnose neurodevelopmental disorders and to enhance brain-computer interface.

The hardware gives satisfactory results when prototyped on a field-programmable gate array prototyping platform – a method for hardware verification and early software development. This shows that the methodology can be easily translated into a chip in the near future.

Comput. Meth. Prog. Biomed., **158**: 123–133

A Marker for Brucellosis
Advantages of T4SS antigen

Brucellosis is caused by a Gram-negative bacterial species of the genus *Brucella*. The infection is zoonotic and spreads from animals, mainly cattle, to humans. The symptoms, fever and malaise, are often clubbed as fevers of unknown origin and symptomatic treatment is prescribed. However, the disease can lead to abortion, infertility and neurological disorders. Since there are no easy methods for accurate diagnosis, timely therapeutic intervention for the disease is, often, not received.

Last fortnight, Thavaselvam from the Defence Research and Development Establishment, Gwalior, scientists from the Defence Institute of High Altitude Research, Leh and the Jiwaji University, Gwalior reported overcoming this challenge in diagnostic ease and accuracy.

The scientists focused on Type IV Secretion Systems – T4SSs – strong virulent factors required by the pathogen to create infection in the host system. They are coded by a set of 11 genes. The researchers cloned and expressed one of the genes and purified the denatured form of the

recombinant T4SS protein. Then, they assessed the potential of this recombinant protein, as diagnostic marker, in sera samples of field cattle and experimental rodents, infected by two different isolates of *Brucella melitensis*.

The team found a time-dependent response of infection towards the diagnostic marker. The sera samples showed highest response towards T4SS after 60 days of infection starting with minimum response after two weeks of infection.

The scientists say that the marker is very specific to *Brucella* infection as it did not receive any response when checked with sera samples of experimental animals infected with another closely related bacterial pathogen – *Yersinia enterocolitica*. The conventional serological marker shows response with *Y. enterocolitica* also, leading to misdiagnosis.

The team hopes that this marker may translate into a diagnostic system, for brucellosis. It will help early detection and treatment of the disease. This will also be a good tool for epidemiologists and move towards eradication.

Prot. Exp. Purif., **145**: 53–58

Water Hyacinth Biogas
Improving production

Water hyacinth is a common weed in fresh and wastewater resources worldwide. Its high growth rate clogs water bodies resulting in oxygen and nutrient depletion, and, thus, affects aquatic ecosystems. Yet, water hyacinth biomasses are looked at as resources for producing biogas, biofertilisers and animal feed. They can also be used to treat effluents.

Recently, researchers from the CSIR-National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram, reported improving biomethane production from water hyacinth. To understand the impact on total biogas yield, they co-digested the biomass with food waste and primary sludge.

The team harvested water hyacinth from the Aakkulam Veli backwaters, Thiruvananthapuram and characterised total solids, volatile solids, nitrogen, phosphorus and cellulose content. They used a two-step reactor for biomethanation. A Leach Bed Reactor first digests the water hyacinth biomass into soluble organics. Then, a Sludge Blanket Reactor generates methane biogas.

Image: Ted Center, via Wikimedia Commons

The researchers got 36 L of biogas from 4 kg of crushed water hyacinth biomass in 12 days. They performed continuous mode experiments, for one year, regularly replenishing the bioreactor with fresh biomass. They estimated the biogas yield at 8.85 L/kg wet weight of water hyacinth.

The scientists experimented with different factors involved, such as the use of sun-dried plants and fermented biomass.

Using gas chromatography and high performance liquid chromatography, the team characterised the produce, and analysed the volatile fatty acids of the ensiled and wilted biomass samples.

They observed that co-digesting with food waste and activated sludge improves biogas yield from water hyacinth.

A cost-effective production of renewable fuels from water hyacinth is a paradigm shift, converting a weed to wealth. The report provides an initiative for efficiently using non-conventional water hyacinth biomass which, otherwise, is an impenetrable foliage in water bodies. The improved biogas yield has increased the feasibility of cost-effective scaling-up of the technology.

Bioresour. Technol., **255**: 288–292

Textile Meets Nanoparticle
Antimicrobial clothing is born

Scientists have reported developing antimicrobial textiles, using nanoparticles. However, the question is: how long can such fabric retain the property?

Recently, Kamlesh Panwar, Manjeet Jassal and Ashwini Agarwal from the IIT, Delhi developed a process to incorporate silver nanoparticles into cotton fabric. Silver nanoparticles are highly antimicrobial. They are non-toxic and, unlike the case with antibiotics, the probability of microbes becoming resistant to silver is negligible.

When nanoparticles are applied on textile, they agglomerate and show weak attachment. The distribution of the particles on fabric is non-uniform and durability is poor. The particles have to be maintained in a low concentrate liquid dispersion. These dispersions are unstable and have low shelf-life which makes them inconvenient to store or transport.

To overcome these problems, the team incorporated the silver nanoparticles into the fabric as Janus particles. They have two faces with distinct functionalities. One side attaches tightly to the fabric and the other holds the nanosilver. The scientists prepared the Janus particle with amine, thiol and epoxy groups.

They produced the Janus particles in powder form, which is stable for long durations without deteriorating. They then tested the antimicrobial efficacy of the fabric against *Staphylococcus aureus*. The nanoparticle incorporated cotton fabric showed no bacterial growth.

The fabric was washed and tested to check durability. The bacteria could not colonise the fabrics, indicating high antibacterial activity and good wash durability of the particle on the textile.

The team tested the physical attributes of the treated cloth such as whitening index, stiffness and tensile strength. The treated cloth showed a marginal decrease in whiteness while the tensile strength of the yarn increased slightly, compared to the case with the untreated cloth.

The team suggests that these Janus particles, with different functional groups, can have multifaceted applications. The antimicrobial silver nanoparticles could be attached to various substrates and the efficacy modulated as required.

Such nanosilver Janus particle incorporated fabric could find versatile use in the clothing, medical dressing,

cosmetic and food industries, hopes the team.

Carb. Pol., **187**: 43–50

Neutron Radiography
An efficient non-destructive technique

Neutron radiography is an imaging technique for the non-destructive testing of materials. It can efficiently characterise nuclear fuels and engine turbine blades. Researchers commonly use the technique to deal with fuel cells, archaeological artefacts and geological formations. Neutron tomography and phase contrast imaging are used to produce and distinguish between similar 3D images. However, these imaging techniques fail with objects that have poor neutron absorption.

Last fortnight, scientists from the Bhabha Atomic Research Centre, Mumbai addressed the problem by tweaking different components of the beam line at the Dhruva reactor.

In general, any neutron imaging beam line consists of a collimator, a shielding material, a sample manipulator and a digital imaging system. The collimator is designed with reactor-grade aluminium cone shaped housing. Then, it is filled with a mixture of sand, boron carbide powder, lead rings, and boral rings for absorbing scattered neutron and gamma radiation. A combination of sapphire and bismuth single crystals, with a thickness of 90 mm each, is used to achieve high neutron/gamma ratio.

Radiography/tomography studies using neutrons can be performed using this fixed collimator. For phase contrast imaging studies, the team fabricated a thin-walled cadmium-lined, cone-shaped structure with a pin hole. They inserted this component in the conical space within the main collimator.

Using this advanced collimator with both neutron and gamma filtering, they achieved a high cadmium ratio of ~250 and a collimation ratio of ~160.

They also tested the instrument to find hydrogen concentration in Zr-alloy, aluminium foam and ceramic metal seals and found it fit for quality assurance checks. The researchers say that this imaging system, in combination with data acquisition and image processing software, can be used for neutron radiography, neutron 3D tomography and neutron phase contrast imaging.

Nuclear Inst. Methods Phys. Res., **889**: 63–68

Automatic Speech Recognition
Mapping the child's pitch

Research on speech recognition is a thriving field. Automatic speech recognition is necessary for developing digital assistants and robots that respond to human speech. The present systems are trained using adult voices. And they fail to recognise the speech of children. In children, the variability in acoustics, such as pitch and tone, and linguistic aspects, such as accent and choice of words, make automatic recognition a daunting task. 'The main problem in automatic recognition of children's speech is pitch', says Hemant Kumar Kathania, from the National Institute of Technology, Sikkim.

While adult speech predominantly uses a small bandwidth between 100 to 200 Hz, children use higher frequencies and bandwidth – between 200 to 350 Hz. Automatic speech recognition systems have been trained using adult speech and, therefore, there are errors when the system is confronted with the pitch variations in the speech of children.

For a decade now, scientists from the National Institute of Technology, Sikkim and the National Institute of Technology, Patna have been working on speech recognition. They felt that it is not easy to train the system separately for children, considering the difficulties in getting child volunteers. So they decided to tackle the problem by an easier route: pitch mapping the speech of children onto an adult speech recognition platform.

'Mapping pitch can be done in two ways and we decided to try both', says Shahnawazuddin, NIT Patna.

The team realised that, in scaling pitch, extra compensations must be done for the higher frequencies in the speech of children. 'After making these tweaks, when we tested the speech of children using the voice recognition system trained on adult voices, we found that the word error rate came down by half!', beams Samaddar, NIT Sikkim.

This, we hope will prove to be a step forwards to making the digital world more accessible for children, an inclusive world where children are also heard and understood, says Waquar Ahmad, NIT Sikkim.

Circuits Syst. Signal Process., **37**: 2021–2044

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