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Wish you a Happy New Year 2015

From the President's Desk

Disaster Management in Agriculture

The National Policy on Disaster Management of the Government states that India is vulnerable, in varying degrees, to several forms of disaster, both natural as well as man-made. There are five distinct regions in the country that are vulnerable, namely Himalayan region, the alluvial plains, the hilly part of the peninsula, and the coastal zone and have their own specific problems. While on one hand the Himalayan region is prone to disasters like earthquakes and landslides, the plains are affected by floods almost every year. The desert part of the country is affected by droughts and famine, while the coastal zone is susceptible to cyclones and storms.

An ever expanding population, urbanisation and industrialisation, as also development activities within high-risk zones, have increased our vulnerability to disaster risks. Vulnerability to disasters/emergencies of Chemical, Biological, Radiological and Nuclear (CBRN) origin also exists. The Vision as defined in the policy is "To build a safe and disaster resilient India by developing a holistic, proactive, multi-disaster oriented and technology driven strategy through a culture of prevention, mitigation, preparedness and response."

Natural disasters have become a global phenomenon in the recent years and these severe natural events are now a cause of concern for the international community. The occurrence and impacts of natural calamities led the *United Nations General Assembly* to designate 13th October as the International Day for Natural Disaster Reduction as part of its proclamation of the *International Decade for Natural Disaster Reduction*. It also encourages the people and government to participate in building more resilient communities and nations. The International Day for Disaster Reduction (IDDR) encourages every citizen and government to take part in building more disaster resilient communities and nations.

Water remains the key factor in agriculture and allied sectors related disasters, be it flood, drought, landslides or cyclones, affecting crops and livestock production. The risk to agriculture is even higher, especially

Flooding in Srinagar, J&K

for *kharif* season crops being chiefly dependent on the performance of the monsoon. Agriculturally significant regions of North India faced the brunt of the deficient monsoon-2014, because of late and deficient rain in the country. The deficit was 56% in both Haryana and Western Uttar Pradesh, and 50% in Punjab. In the current year, the state of J&K suffered massive flooding and damage to life and property. The wounds of the disaster were still fresh, when cyclone, *HUD HUD* struck the states of Andhra Pradesh and Odisha on the east coast, resulting in large scale destruction. Given the past experience, the NARES remain on alert to face extreme climatic events. As far as convergence is concerned, the joint teams from ICAR institutes, the SAUs and KVKs were right in the field to support the farmers with relevant advisories, technological inputs and on the spot guidance to minimise the crop losses and take up immediate remedial measures.

Diseases that assume epidemic proportions are a major public health problem in India. Epidemics including viral influenza and dengue are now commonly encountered. These can be reduced to a large extent if we have access to clean drinking water, proper sanitation and maintain clean surroundings. Along with the loss of life and property, the natural disasters cause serious setbacks to all other socioeconomic and development sectors. Given a proper understanding of causes, nature and consequences of natural disaster, the extent of damage can be considerably reduced with proper forecasting, processes and preparedness.

As part of the climate resilient agriculture and the mitigation strategy, beside the technological preparedness, there are several other interventions that help in faster rehabilitation in the affected areas. The ICAR, in partnership with states and universities prepared 580 district level contingency plans during 2014 that greatly aided in addressing the concerns of the delayed and weak monsoon. The capacity development programmes of the National Initiative on Climate Resilient Agriculture (NICRA) provided for awareness on climate change and simple adaptation measures that farmers followed to cope with climate variability. First, mobile based services for farmers and other stakeholders are being delivered through different organisations that have been brought together under a single umbrella viz. mKisan portal.

In order to effectively respond to aberrant climatic conditions, foremost is the collective and the harmonized response from the concerned agencies. The response time needs to be reduced to a minimum and the approach has to be location-specific. Several steps that can help in faster rehabilitation or reduce the impact include creation of seed banks with suitable varieties, store adequate veterinary medicines for disease outbreaks, develop fodder and other such essential supply banks at the village level. Early warning systems and disaster management plans with community participation can be of immense help. Use of GIS-based mapping application, the Global Positioning System (GPS) and use of advanced ICTs are useful in putting the rehabilitation resources and machinery in readiness. Finally, for all the resources to become functionally effective, it is important to have at hand, competent, skilled and motivated human resources, strong linkages and partnerships.

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EDITORIAL

Science Driven Organic Farming

Organic agriculture in India owes its origin primarily to the work of Sir Albert Howard, who believed that a shift from nature's methods of crop production for adoption of new methods leads to the loss of soil fertility (*An Agricultural Testament, The Oxford Univ. Press p. 233, 1940*). This retrogressive thinking possibly sowed the seeds of the organic movement in India, placing great emphasis on the use of compost and other organic sources of plant nutrients to the total exclusion of chemical fertilisers. It is a movement which avoids or largely excludes the use of synthetic fertilizers, pesticides, growth regulators and livestock feed additives, and to this list may be added the use of genetically modified (GM) crops. Movements are dogma-driven in which the first casualty is the reasoning itself. It is a matter of faith with the believer which cannot be questioned and therefore, in it there is no place for rationalisation and science.

Green revolution in the late sixties gave a tremendous boost to the agricultural production in India. During this era, the introduction of high yielding varieties, extension of irrigated areas, use of high analysis NPK fertilizers and increase in cropping intensity propelled India toward self-sufficiency in food production. In the process, the relative contribution of organic manures as a source of plant nutrients *vis-à-vis* chemical fertilizers declined substantially resulting in the occurrence of multi-nutrient deficiencies and overall decline in the factor productivity under intensive but imbalanced fertilizer use. Several such concerns and problems posed by modern day agriculture gave birth to various new concepts in farming, such as organic farming, natural farming, biodynamic agriculture, do-nothing agriculture, eco-farming etc. The essential concept of all these remains the same, i.e. back to nature.

Biodynamic Farming is another form of organic farming in which a lunar calendar developed by the missionaries of organic farming attempts to link planetary rhythms and constellation with nutrient use efficiency. Its recommendations is to apply manures with the ascending or at full moon to derive maximum advantage. (*Pathak RK and Ram KA Biodynamic Agriculture Bull No. 14, ICAR: CISH, Lucknow pp. 42, 2003*) The so called 'cow-horn technology' - using cow dung from a lactating cow, composted in the hollow of cow horn, buried in the soil at an auspicious moment and then applying it in pellet form in homeopathic doses – has been claimed to possess magical qualities increasing soil NO_3-N from 0.06% to 1.7% (*Menon, TGK and Karmarkar, VB, Organic Farming, JNKVV, Jabalpur pp. 122-129 1994*) and dramatically enhancing crop growth and yields. In the variant of organic farming involving *AGNIHOTRA* whole rice grains mixed with cow-ghee is burnt along with the chanting of mantras at sunrise and sun-set. It postulates that the cosmic energy is the only source of plant growth, and no organic manures or fertilisers are required to raise the plants. Therefore, no input has to be purchased, as one cannot purchase mother's milk in the market. This ritual is said to gather tremendous amounts of energy which goes into the atmosphere along with holy smoke, and exert dramatic benefits to the crop growth and productivity by way of injecting nutrients into the environment and mitigating ill-effects of pollution. The ash left after performing *AGNIHOTRA* is touted as a complete plant food *(Pathak RK and Ram KA, Manual on Vedic Krishi, Bull. No. 18 ICAR-CISH, Lucknow p. 45, 2003)* though the fact is that it contains mainly potash. This defies scientific logic. The scientific community must not tolerate such superstitious absurdities and treat them with the contempt they deserve.

In order to label a produce as 'organic', some rules and standards have been developed. These must be strictly adhered to but are difficult to put in practice. Even if strictly applied it will be incredulous to think if there could be something "100 per cent authentic organic produce" since plant nutrients from organic sources are converted into inorganic forms as in inorganic fertilizers before they are absorbed by plants. Unfortunately plant roots do not have built in sensors to distinguish for example if the NO3-N is coming from compost or urea. Further no plant tests are known as yet to differentiate nutrients acquired from organic or inorganic sources. The organic farming movement thus presents a challenge to the scientists, who cannot and would not accept anything not based on facts. In this movement, one has to accept a philosophy that says, "I don't want to do a particular thing". The present inbuilt lower productivity of the organic system is simply the result of constraints that its practitioners have placed upon themselves. This does not create a conflict but where the difficulty faced is with the evangelising statements that the products of the organic system-food and fibre are in some way 'better' than those from conventional agriculture.

The answer to the question whether organic farming is a viable alternative to the modern industrial agriculture in India could be both yes and no. **Yes**, it can be viable for a few small operations where modern agriculture cannot be practiced. The organic agriculture could be advocated only in certain areas and for select high value low volume crops showing promise for trade in the organic produce such as spices, medicinal plants, exotic fruits and vegetables which have potential for export. The rainfed, tribal, northeast and hilly regions of the country still practicing subsistence agriculture are potential areas for organic farming. But the profitability of the system could be possibly sustained due to the organic produce fetching higher prices. However, the answer could still be a strong **No**. The consequences of a very large scale adoption of organic farming are frightening. To maintain the present level of food grain production in India without the input of chemical fertilizers the net additional area needed to be brought under cultivation will be more than the total geographical area of the country. The country's food security will be further compromised since in this calculation the additional food demand for projected population growth has not been taken into account (*Chhonkar, PK, J. Indian Soc. Soil Sci. 51: 365-377, 2003*). A great friend of India the Noble Laureate Dr Norman Borlaug (2002) said "Switching on food production to organic would lower crop yields. We can use all organic that is available but we are not going to feed six billion people with organic fertiliser" *(http://www.scientificalliance.com/new/gm_organic_food_/organic_forests.030502.htm)*

Instead of propagating unrealistic organic farming approach it would be more appropriate to suggest policy initiatives to boost practices like composting technologies, recycling of on farm and urban wastes, biogas technology, green leaf manuring and biofertilizers. These policies and practices will go a long way in supplementing chemical fertilisers, whose use cannot be totally eliminated. Policy initiatives directed at reducing or eliminating the use of chemical fertilisers will in the long run prove disastrous for Indian agriculture. Due to its lower productivity and high cost of production, organic farming will leave many more Indians hungry and malnourished. Since, "a hungry man is an angry man", mass hunger may even lead to social strife and unrest.

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Shifting Cultivation : Coexistence of Forest and Agriculture

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Shifting cultivation (slash and burn agriculture) locally called *jhum* in North East India and Bangladesh support globally the livelihood of an estimated 300-500 million people in Central Africa, South America, Oceania, and Southeast Asia. It is practiced on about 30% of total arable land but providing food to only 8% of the world population (Kumar, 2008). It has been a primary occupation for almost all the village households within the *jhum* practicing locality in the hill states of NE India. Out of 4.0 mha of net sown area, about 1.6 mha area is under *jhumming.* The hilly terrains and the prevailing climatic conditions along with its diversified bio-resources provide a suitable milieu for the hill farmers to practice *jhum* cultivation making it inseparable from their lifestyle. The philosophy of *jhumming* involves farming practices balancing with biodiversity by protecting, preserving, and promoting co-existence of agriculture and hill forest ecosystem.

Shifting cultivation is an age-old farming practice, which involves several cultural operations such as clearing of forest biomass by slashing, release of the nutrients accumulated in vegetation over time by burning of slashed biomass, suppression of weeds, pest and diseases by soil sterilization, etc. to grow mixed crops on the hill slopes for a year or two (cropping phase) followed by abandoning the land as fallow for some years for the regeneration of natural vegetation (fallow phase) (Fig. 1). After some years, the area may be cleared and cropped again. Traditionally shifting cultivation is recognized in the literature as sustainable within an appropriate range of fallow period and associated demographic

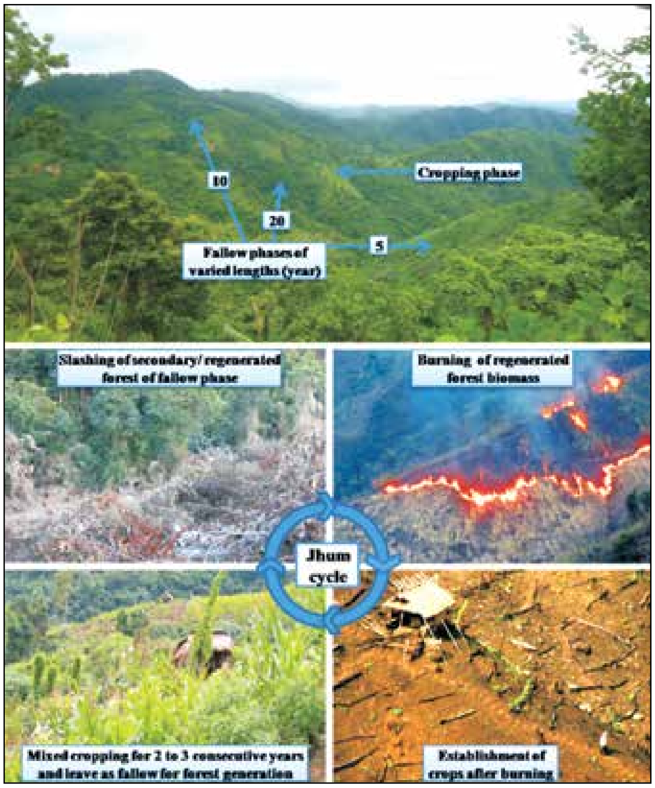

Fig. 1. Pictorial depiction of various phases of a *jhum* cycle practiced on hill slopes of North East India.

conditions. It is estimated that fallow lengths of 10-20 years or more is necessary to prevent soil erosion, loss of soil fertility and water balance, as well as to allow forest regeneration to conserve biodiversity and ecosystem stability. These conditions are normally associated with population densities of less than 20 persons per km^2 (Kumar, 2008). However, with the ever increasing population and their growing demands for food, the period of fallow phase has been reduced to 4 to 8 years in the recent years. Thus, land degradation is the most severe constraint for higher productivity of *jhum* agro-ecosystem. The extent of land degradation ranges from 28% to 89% of the total geographic area depending on the locality. Due to the shortening of *jhum* cycle to 4-8 years, the resilience of ecosystems has broken down and the land is increasingly deteriorating. The use of hill slopes for *jhum* cultivation causes on-site deforestation, loss of biodiversity, loss of fertile topsoil to the extent 46.0 t ha^{-1} $year^{-1}$ against the all India average of 16.0 t ha^{-1} $year^{-1}$, reduction of water storage capacity and exposure of infertile acidic subsoil (pH < 5.5) leading to impairment of carbon mineralization dynamics and destruction of soil structure. The off-site effects of *jhumming* are siltation and associated environmental hazards in the valley regions. Therefore, restoration of ecological soil functions, *viz*. food and fibre production, environmental interactions and, habitats and biodiversity support under *jhum* agro-ecosystems is a challenging task for achieving higher productivity. Therefore, soils of *jhum* agro-ecosystem must be managed sustainably to safeguard food security among the poor people of hills of NE India. Future strategies for increasing agricultural productivity in *jhum* fields must focus on management of soil functions and associated processes, and efficient use of bio-resources.

To achieve real development in the NEH region, scientific inputs blended with traditional jhum knowledge must go hand-in-hand. To meet the challenges of modern society, *jhum* cultivation practices must adopt to the changing scenarios. Till now, the practice of *jhumming* has been satisfactory for the hill tribes of NEH region, but it needs a fresh look in view of the new challenges posed by the needs and preferences of the society, and its impact on climate change and other natural resources. Considering the region-specific requirement, there is a need for the development of new agro-technologies based upon the principles of ecosystem sustainability, ethnic values and global market policy. The hill farmers are practicing *jhum* farming under severe pressures of '7 Fs' i.e. food, fibre, fuel, fruit, fodder, flower and forest for their survival. Thus, there is a need for traditional *jhum* practice to be improved through scientific interventions.

Eco-restoration of jhum agro-ecosystem

Soil biota is essential for nutrient cycling, soil organic matter decomposition, soil structure formation and thus plays a critical role in regulating ecosystem productivity and community dynamics. These roles are important in re-establishing function and biodiversity of the ecosystem. Measurement of the community indicates the status of the system in relation to restoration targets and the effectiveness of management interventions. Any change in the status of the community shows promise in the enhancement of the rate of recovery of degraded systems. Therefore, an assessment of functional interactions between biological inputs both above- and below- ground could be an essential part of any program that aims at the restoration of soils under *jhum* agro-ecosystem.

The past findings indicate that the stability of *jhum* agro-ecosystem primarily depends upon the fallow phase that allows re-growth of the secondary forest (Ramakrishnan, 1998). The regenerated forest covers contributes to the aboveground biomass through litter fall and below-ground substrates like roots and their exudates. These inputs during fallow helps in rejuvenating soil biota and their activities over time. Thus, soil restoration programme in the disturbed *jhum* agro-ecosystem must consider functional interactions between the aboveground biomass and below-ground biota and impact of such interactions on soil processes.

Fallow phase, biota communities and their interactions

The variable length of fallow phases in *jhum* fields maintained by the *jhummias* based on their traditional knowledge and practice is the time tested asset. These fallow phases can provide valuable information on how the frequency of disturbing events such as slash and burn operations followed by the effect of cropping on the process of re-establishment of the linkages between aboveground vegetation and belowground biota during fallow phases and their interactions on overall ecosystem processes. A study was undertaken comparing two adjacent *jhum* cycles (5 years and 20 years) located in Changki village, Mokok Chung district, Nagaland. The objective was to investigate the relationship of fallow phase with soil biota communities and associated soil processes. The fallow phases belonged to 5 and 20 years *jhum* cycles referred as F1 and F4, respectively. The geographic positions of the F1 and F4 fallows are 26˚33.77´N, 94˚22.26´E and 759m above msl and 26˚24.14´N, 94˚22.49´E, 716m above msl, respectively. Both *jhum* fields are located on the south facing hill slopes (slope degree ranges from 40 to 70%). Rice was the main crop with maize, ginger, chilies, brinjal, bitter gourd, sponge gourd, ridge gourd, cucumber, pumpkin, diascoria, colocasia, okra, and sesamum were grown as mixed crops during cropping phases in both jhum cycles. After completion of 2 years cropping phase, *jhummias* abandoned F1 and F4 fields as fallows for a period of 3 years and 18 years, respectively. At the end of the fallow phases (just before slash and burn operations of cropping phase), surface soil samples (0 to 10 cm depth) were collected and subjected to whole metagenomic analyses. Soil genomic DNA from F1 and F4 fallows were used for the pair-end sequencing library preparation and the libraries were sequenced on MiSeq using 2 x 300 bp chemistry kit. High quality metagenome reads of F1 and F4 fallows were assembled and analysed using MGRAST. Results revealed that higher rank abundant of taxa in F1 fallow community were Acidobacteria, Proteobacteria, Actinobacteria, Chloroflexi, Verrucomicrobiota, Firmicutes, Cyanobacteria, etc. and F4 fallow community were Proteobacteria, Actinobacteria, Firmicutes, Cyanobacteria, Tennericutes, etc. (Table 1). The enzymes - Oxidoreductases, Transferases, Lyases, etc. were abundant in F1 fallow and Tranferases, Ligases, Hydrolases, etc. were abundant in F4 fallow (Table 1).

Of the predicted functional proteins based on functional category hits distribution, 60.2% and 38.1% were metabolically related in F1 and F4 fallows, respectively (Table 1). The relative abundance of genes associated with iron acquisition and P metabolism were lower, and photosynthesis, potassium and secondary metabolisms were higher in F1 fallow communities compared to F4 fallow communities. Soils of F1 fallow housed approximately twice (108 nos.) higher bacterial orders than that (51 nos.) in F4 fallow (Fig. 2A). The results of the lowest common ancestor data indicated that soils of the F1 fallow phase were characterized by greater bacterial and archaeal abundance coupled with the lesser eukaryotic abundance compared to that in F4 fallow phase (Fig. 2B).

Higher prokaryotic abundance (archaea and bacteria) in F1 fallow was the indication of an unstabilized ecosystem exposed to environmental stresses. Due to frequent exposure of F1 fallow to slash and burnt events at every 3 years intervals, the above- and below-ground biological inputs/resources and associated biological interactions get disrupted. As a result prokaryotic communities dominated in F1 fallow phase in order to support ecosystem processes. This is also evident from the results showing of approximately 2 times higher metabolism related functional proteins in F1 fallow than in F4 fallow. The aboveground plant community can modify soil micro- and macro-food webs through their quantitative and qualitative contributions of organic matter that is returned to soil. Plant species differ greatly in their basic ecological traits and this variation is reflected in differences in the quantity and quality of resources that they produce. In the F1 fallow phase, diversity of root exudates and litter fall was greater due to aboveground plant community composition and introduced crop plants at frequent intervals. In the F1 fallow phase the above ground plant communities are mostly dominated by herbaceous plants, seasonal grass species indicative of a disturbed N-deficient ecosystem. However, F4 fallow is dominated by woody plants,

Table 1. Taxonomic diversity and functional hit distribution in soils of different *jhum* cycles

Attributes	5 years fallow phase (F1metagenome)	20 years fallow phase (F4metagenome)
a-diversity	372.7	15.8
Abundant bacterial phyla	Acidobacteria>Proteobacteria>Actinobacteria>Chloroflexi>Verrucomicrobiota>Firmicutes> Cyanobacteria >Bacteriodetes>Plancomycetes>etc.	Streptophyta>Proteobacteria>Actinobacteria>Firmicutes> Cyanobacteria >Tennericutes>etc.
Abundant enzyme class	Oxidoreductases>Transferases>Lyases, etc.	Transferases>Ligases > Hydrolases, etc.
Exclusively present enzymes	Adenylatecyclase Cytochrome-C oxidase ,Carbon-monoxide dehydrogenase	Peroxidase Pectinestarase Lysosomal pro-xaa-carboxypeptidase
Metabolism functional hits	60.2% of the annotated proteins	38.1% of the annotated proteins

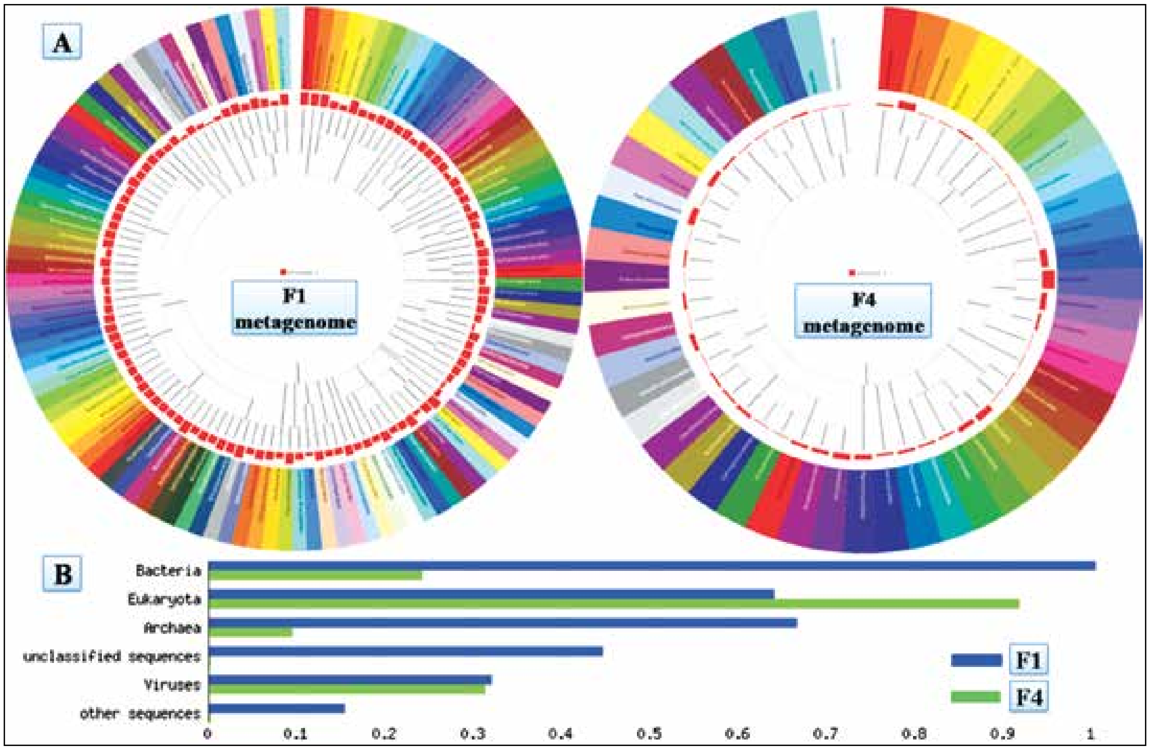

Fig. 2. Comparative tree view (A) of bacterial orders with colouring set to phylum level for F1 and F4 metagenomes obtained from soils of 5 and 20 years *jhum* cycles, respectively. Soils were analyzed at the end of the fallow phase i.e. just before slashing and burning operations of the cropping phase. Altogether 108 and 51 bacterial orders were detected in F1 and F4 metagenomes, respectively. The comparative bar-chart (B) of lowest common ancestor annotated data for F1 and F4 metagenomes.

asparagus, epiphytes and bryophyte communities indicating a more stabilized N-rich ecosystem. Again, plant inputs to soil vary greatly in terms of carbon components of differing degradability such as: (1) the most easily degradable carbon is the most labile low molecular weight fraction that includes sugars and amino acids, which provide a soluble and readily usable resource for microbes; (2) the intermediate fraction includes moderately labile substances such as cellulose and hemicelluloses, which are the most abundant constituents of plant residues; and (3) the most recalcitrant fraction is structural materials, such as lignin. The dominance of woody species in F4 fallow may favour lignin decomposer community, which can be supported by the occurrence of peroxidases and pectinestarases as the most exclusive enzymes in the system (Table 1). Therefore, the extent of plant species influence on soil microbiota and their activities will be maximized when differences in such ecological traits of plant species between fallow phases is highest. This might be the reason of higher prokaryotic diversity in F1 fallow phase. Further, longer the fallow phase allows an ecological succession of plant species towards a stabilized N-sufficient ecosystem and with time such effects exert a selective pressure on certain functional groups of microbial community to be more abundant. This is truly reflected in the F4 fallow phase. Recently, a microcosm study on grassland ecosystem has shown that the growth of the individual plant species in the soil can lead to the selection of specific microbial communities in the root zone (Liliensiek *et al*., 2013). Plant species of grassland had markedly different effects on the abundance and structure of rhizosphere microbial communities, depending on the soil type. Bacteria were positively affected by the growth of various grasses and herbs in fertile grassland soil, but the same plants negatively affected these microbes when grown in less fertile soil. The interplay between aboveground and belowground diversity is of key significance for ecosystem function, and hence needs to be considered in understanding the importance of diversity in terrestrial ecosystems. As the most comprehensive metagenomic survey on shifting cultivation cycles, this study demonstrates clearly the role of the regenerated aboveground vegetation during the fallow phase in shaping the soil biodiversity and thereby regulating ecosystem processes towards a stabilized ecosystem.

Conclusion and Recommendations

Ecological traits of the plant community in the fallow phase are the driving force in shaping the microbial communities in soils of *jhum* fields and allowing longer fallow length in rejuvenating the biological interactions over time. Detection of greater microbial taxonomic diversity during the shorter fallow length (5 years *jhum* cycle) does not necessarily indicate the stability of the ecosystem. In fact, the results of our work based on metagenomic analyses clearly demonstrated that greater microbial taxonomic diversity might be an indication of the state of an ecosystem under environmental stresses. A stabilized ecosystem (20 year *jhum* cycle) is characterized by dominant phylum Streptophyta. Thus, any restoration programme for *jhum* agro-ecosystem must pay attention on re-establishing the linkages between the above- and below-ground biological inputs and their biological interactions. Fast growing N_2-fixing trees and herbs needs to be explored from the adjacent forest ecosystem and also to trap the microbial colonizers of the early successional plants so that these biological components can be a driving force for early stabilization of *jhum* agroecosystem leading to the realization of coexistence of forestry and agriculture in harmony.

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Programmes Held

Brainstorming Session on Breeding Policy for Bovines in India (Conveners: M.L. Madan and M.P. Yadav)

A Brainstorming Session on Breeding Policy for Bovines in India was organized by the National Academy of Agricultural Sciences (NAAS) at NASC, New Delhi on 12th July, 2014. The session was chaired by Dr. S Ayyappan, President NAAS and Co-chaired by Dr. R B Singh, former President NAAS. At the outset, Dr. Ayyappan welcomed all the participants and explained the purpose of the meeting and urged for greater focus to the contribution from livestock sector (LS). Prof.

M L Madan made a SWOT analysis of the breeding policy for bovines. He opined that LS has far-reaching implications for the rural poverty alleviation, women empowerment, combating protein hunger, production system sustainability and ecosystem stability. As livestock is mostly owned by resource poor population; inclusiveness in growth and development are possible at a faster pace through livestock R & D activities.

The recommendations and action points emanated were reducing the number of unproductive animals through reproductive health control and regulating male births through semen sexing technology; fast up scaling of productivity, grading up and conservation of our precious descript breeds, and crossbreeding of the nondescript population with indigenous dairy breeds or by using exotic germplasm; control of stray male and female animals; identification of animals in their breed tracts, registrations of these animals, and formation of breed societies and ensuring specific breed wise improvement policy across the states; intensification of selective breeding of defined indigenous dairy breeds of high milk yield or excellent draft abilities to improve their production and reproduction potential, developing draft breeds for more milk using semen of high genetic merit, relaxation in the level of exotic inheritance above 62.5 per cent level as per the need and capability of the farmer, laying minimum production and health standards for the semen, embryos and animals imported into the country; breeding of pure bred exotic animals using semen of high merit bulls, preferably using semen from animals with A2 beta casein inheritance; taking up bull/semen production program for each of the recognized breeds prioritized by each state; identification, selection and registration of elite females (bull mothers) representing the top 10 per cent animals of the breed in its eco-region; issuance of identity card/ certification of the animal enrolment in the bull production program, providing incentives commensurate with the milk producing capacity of the bull mother for the male calf produced with buy back arrangement.

All non-descript indigenous population which does not fall within the breeding tract of the defined breeds should be bred by inseminating with semen from the best indigenous dairy breeds of the country, namely Sahiwal, Red Sidhi, Gir, Rathi. Similarly, crossbred population should be bred with semen of either Jersey × Zebu or Holstein Friesian × Zebu crossbreds, exploitation of the potential of the vast nondescript population to higher production within a single generation time span using high potential recognized indigenous or exotic or cross bred semen (Friesian × Sahiwal or available alternate crossbred semen. Bovine breeding policy of the states should be in tandem with national policy.

The breeding policy should be supported by adequate feed and fodder, nutrient, mineral supplementation, optimum management of the animals, timely vaccination and health care; storage and transport, marketing of the produce, insurance and risk coverage of the valuable animals. Production of breeding males from elite females among each of the recognized breeds having high genetic potential should be an essential part of the breeding policy for each breed and making this available for coverage of all breed able females. All cross bred animals of different exotic inheritance should receive crossbred semen of only the same parental breed of high genetic merit, progeny tested or having one of the parents with a milk production record of over 5000 liters/ lactation yield.

In view of the consistent rising demands for milk, meat and eggs; livestock sector deserves better focus and funding support at least to the tune of 25% of the total agricultural allocation as against around 6 per cent at present. Adequate financial support should be ensured for using advanced techniques of ETT, ONBS, IVF, cloning and sexing for fast multiplication of elite animals and breed improvement.

A specific Breeding policy implementation document in tune with national perspective and demand scenario should be developed. It should include breeding policy for indigenous purebreds, graded, non-descript, exotic and cross bred along with a time frame with defined breeding goals, financial implications, quality evaluation of the bulls/semen, design of the breeding scheme – identification, selection and recording of animals; genetic evaluation and monitoring of genetic improvement; nutritional, healthcare and other infrastructure inputs requirement including storage and marketing of the produce; qualitative and quantitative identification of economic benefits; documentation, data recording and information retrieval system; a strong research content encompassing fertility evaluation and management, intensive bovine production and management systems, application of genomic tools/chips for selection, processing of products from buffalo milk; selection technique among buffalo, sexing procedures and production of sexed semen, climate/environmental change effects and their amelioration; review and periodic monitoring of the National breeding schemes as well as the State breeding policy implementation for specific breeds.

Buffalo selection should, henceforth, have the added criteria of selection for body weight, weight of the calf and growth of the calf (0-6 month's body weight gain). Buffalo milk should be processed and sold separately as buffalo milk. The buffalo breeding protocols and policies with focus on the above issues will mostly be in conformity with those of indigenous cattle.

Brainstorming Session on Water in Agriculture (Conveners: H. Pathak and B.P. Bhatt)

Water is the basic necessity for all living beings and key to food security. It plays the role of a creator and cleaner but also as a polluter and destroyer, if not managed properly. The nation witnessed significant growth in agricultural production and food security in the past half-century broadly limited to irrigated areas. Irrigation makes up over 80% of fresh water use. India with 2.4% of the world's total land area and 4% of the total replenishable fresh water (about 4000 km^3) has to cater to 17% of the world's population. With tremendous increases in population coupled with industrial growth, the water demand in urban, industrial and agricultural sectors is increasing at a tremendous pace. The envisaged Second Green Revolution is difficult if adequate irrigation water is not ensured. This challenge is even more severe when rainfall variability is increasing due to climate-change, ambient temperature is increasing due to global warming, ground water is depleting because of over-exploitation and water holding capacity of soil is deteriorating due to intensive tillage. The quality of water for irrigation is also becoming unfit due to increased pollution loads.

The National Academy of Agricultural Sciences organized a Brainstorming Session on 'Water in Agriculture' during October 7-8, 2014 at ICAR Research Complex for North East Hill Region, Barapani, Meghalaya under the convener-ship of Dr. H. Pathak, Professor, Center for Environment Science and Climate Resilient Agriculture, IARI, New Delhi and Dr. B.P. Bhatt, Director, ICAR-RC-ER, Patna. The Session was attended by more than 60 participants discussed current status of water in agriculture; technological frontiers; water management in various sectors including livestock and fisheries and regions such as North East Hill region, Eastern India and north west India; water, climate change and pollution; and water policies, institutions and governance. Experts including Dr. J.S. Samra; Dr. A.K. Sikka; Dr. A.K. Singh; Dr. S.M. Virmani; Dr. K.M. Bujarbaruah; Padma Bhushan Shri C.P. Bhatt; Dr. B.R. Sharma made presentations and gave valuable inputs. The following recommendations and action points emanated from the discussion.

- Water management in agriculture has to be looked into holistically including crop production, horticulture, fishery and livestock. There is an urgent need to optimize water use and enhance water productivity in all these sectors. Economic water productivity (Rs. m^{-3}) in addition to physical productivity (kg m^{-3}) should also be considered.
- Besides water availability, water accessibility is also a major concern. Water availability needs to be converted into accessibility through technological options and policy support.
- In the race of modernization, several time-tested water management methods are either on the verge of extinction or neglected, therefore there is a need to adequately blend indigenous knowledge with modern approaches to enhance the water productivity.

- Management of water in the rainfed and dryland agriculture should be given more importance. Increasing water productivity in irrigated, limited irrigated and dry land production systems should be the key to enhance agricultural productivity.
- Over-exploitation of ground water is a major concern. Thus, national ground water improvement initiative should focus on aquifer mapping and participatory stakeholder aquifer management.
- Climate change is a major challenge for agricultural productivity and food security. Water holds the key for adaptation and mitigation of climate change to reduce the adverse impacts of climate change.
- Availability of quality data and harmonization of data on water from various sources are the major concern to develop adequate strategy and policy options. Thus, there is a need for a robust quality data base and adequate planning for acquiring quality data.
- As water harvesting has seen limited success, de-silting of reservoir/rivers may be a better option to increase the availability of water and increase storage capacity. This would have multiple service functions such as in floods, increase in irrigated areas, increase diversification, etc. Validation, refinement and scaling up of seepage control mechanism to hold water especially during dry season.
- There is an urgent need to look into the water management perspective of the Himalaya region separately than other parts considering its agro-ecology, topography and vulnerability.
- Along with water availability, energy availability and access is important for overall development in which eastern India is severely deficient. Solar energy may open vast opportunities for water use in agriculture and increase efficiency and productivity.
- Draft National Water Policy (2012) has little about water use in agriculture. Since over 80% of fresh water is used in agriculture, there should be a separate water policy for agriculture.

National Workshop on Energy in Agriculture (Conveners: Anwar Alam and P. Chandra)

Agriculture in a way is an energy conversion industry, where plants through photosynthesis generate carbohydrates, proteins, fats, cellulose, dietary minerals and fibers, vitamins and phytomins of food, feed, fuel, fiber value and industrial raw materials. Agriculture and allied activities sustain about two-third of the country's 1.2 billion population, provide food, feed and nutritional security. Traditional agriculture used essentially animate energies – humans and draft animals besides natural resources of solar, wind, water and hydraulic energies. However, modern agriculture is largely dependent on commercial energies – electricity and petrochemicals. Electricity is the most desirable form of energy generated from coal, diesel, hydroelectric and nuclear energy. But it is in short supply. There is close nexus between energy and agricultural production and productivity.

Unlike industry where men and material are brought under one roof to carry out industrial activities, in agriculture men and materials have to be moved from farm stead to every individual farm and field, and within fields from farm stead to carry out unit operations of agriculture. It makes tractive power essential requirement using tractors and power tillers. Elective motors are diesel energies are used in large number in Agriculture for stationary farm operations like pumping of irrigation water, operating processing equipment etc.

Two day workshop was organized at The National Academy of Agricultural Sciences (NAAS) on September 15-16, 2014 to deliberate and draw out a road map on the vital subject of energy in Agriculture under the convener-ship of Dr. Anwar Alam, Former Vice-Chancellor, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Srinagar, J&K, and Dr. P. Chandra, Ex. Director, Central Institute of Agricultural Engineering, Bhopal. Sri Suresh Prabhu, Chairman, Council for Energy, Environment and Water addressing Energy Status in India observed that over a period of time energy intensity in agriculture has gone up considerably because we are using more of ground water, lifting from great depths. Ground water is depleting rapidly increasing lift ultimately increased use of commercial energy – diesel and electricity. Half the people live without electricity. Modern agriculture is not possible without commercial energy. Both power and water used should be metered and monetized. Solar power will be half the cost of coal power. Recalling Rio+20 Declaration, he told goal is 'green energy', 'green agriculture', and 'green economy'. Fossil and living energy should exist together.

Prof. Anwar Alam presented a comprehensive paper on Energy Foot-Prints of Indian Agriculture. Dr. P. Chandra and Dr. K.C. Pandey elaborated Potential of Fossil Feed Replacement in Agriculture by Green Energy. Scope of Renewable Feeds for Engine Power was brought about by Dr. Murari Shyam. The following recommendations and action points emanated from the discussion.

Development of Data Base: (a) Region wise energy and mechanization use data and periodic update, (b) Best estimates for regional energy demand of diesel, electricity and other feeds. Extension of Grid power supply to energy starving states/regions. Decentralized power generation of 100kw-1mw for situation out of Grid power reach. Establishment of metacentric power supply and management practices for states/regions with higher energy demand. Unmetered grid power supply be stopped and suitable Tariff for rural sector be evolved and energy security through biofuels.

NAAS Chapter Meetings

Inaugural Meeting of NAAS – Karnal Chapter and Seminar on "Application of Animal Biotechnology for Sustained Agricultural Productivity" (Convenor: Dr. A.K. Srivastava)

A one day inaugural meeting of NAAS-Karnal Chapter incorporating seminar on *"Application of Animal Biotechnology for Sustained Agricultural Productivity"* was organized by the National Academy of Agricultural Sciences (NAAS) and NDRI jointly at NDRI, Karnal on 26th July 2014 Dr. A.K. Rawat, Director (DBT) was a special invitee. A total of 60 participants attended the

meeting. At the outset Dr. A.K. Srivastava Director (NDRI) and Convener; NAAS-Karnal Chapter welcomed the gathering and thanked the President NAAS for choosing Karnal as its regional chapter which will look into the issues related to agriculture and animal science including fisheries in Haryana and Himachal Pradesh. He highlighted the need of deliberation on issues related to post harvest and food technology, transgenesis and role of biotechnology in food production. He emphasized that different agencies working in that region for the welfare of farmers and livestock keepers should come at a common platform with the NAAS Karnal Chapter. He congratulated the team of scientist on their successes in cloning a buffalo calf, Rajat. Dr. A.K. Rawat, Director, DBT delivered a lecture on "*Application of Animal Biotechnology for Sustained Agricultural Productivity*" The salient outcome of the meeting is as below:

- Major activity of NAAS-Karnal Chapter should be related to activities of scientists and their role in crisis management in agriculture. The scientists should encourage the younger students in nearby schools and colleges to develop interest in science. NAAS-Karnal Chapter should encourage youth of the region for taking agriculture as a profession.
- The Chapter should educate the local community about the usage and science of probiotics.
- Inclusion of agriculture science as a subject in the school curriculum to be taken up by NAAS and may be flagged to planning commission or UGC.
- All ICAR institutes located in Karnal may fix a day for visit by school and college students.
- The NAAS-Karnal Chapter to bring out newsletter incorporating news and views of its members. Suggestions given by the scientists from time to time may be incorporated in the Newsletter to be published.
- Eminent scientist/Nobel laureates/ figure prominent in the field of agriculture and allied science may be invited to deliver a talk/lecture / participate in the brainstorming session.

Salient Decisions of 88th and 89th Meeting of the Executive Council

Election of the Office Bearers and Members of the Executive Council

The following new Office Bearers and Members of the Executive Council were elected for the year 2015-17:

Vice-President	-	Prof. Anupam Varma
Secretary	-	Dr. K.V. Prabhu
Editor	-	Dr. K.K. Vass
Members	-	(i) Prof. S.P. Adhikary
		(ii) Dr. C.D. Mayee
		(iii) Dr. C.S. Prasad
		(iv) Dr. B. Venkateswarlu

Election of Fellowship and Selection of Associates for 2015

Fellows

Section I : Crop Sciences

1. Dr. B.C. Viraktamath
2. Dr. C.L. Gowda
3. Dr. Arvind Kumar
4. Dr. Devendra Kumar Yadava
5. Dr. Gyanendra Pratap Singh
6. Dr. (Ms) Shelly Praveen

Section II : Horticultural Sciences

1. Dr. Major Singh
2. Dr. Tusar Kanti Behera
3. Prof. Gyana Ranjan Rout

Section III : Animal Sciences

1. Dr. Rudra Nath Chatterjee
2. Dr. Manmohan Singh Chauhan
3. Dr. Aditya Kumar Mishra
4. Dr. Yadhishthir Singh Rajput

Section IV : Fisheries Sciences

1. Dr. Joykrushna Jena
2. Dr. C.N. Ravishankar

Section V : Natural Resource Management

1. Dr. Surinder Singh Kukal
2. Dr. Madhab Chandra Manna
3. Dr. Pramod Wasudeo Ramteke
4. Dr. Amaresh Kumar Nayak
5. Dr. Harmit Singh Thind

Section VI : Plant Protection Sciences

1. Dr. Jitendra Kumar
2. Dr. Rakesh Pandey
3. Dr. Jagadish Sanmallappa Bentur
4. Dr. Jatinder Kumar Dandona

Section VII : Agricultural Engineering & Tech.

1. Dr. Arun Kumar Sharma
2. Dr. Tridib Kumar Goswami

Section VIII : Social Sciences

1. Dr. Kuppannan Palanisami
2. Dr. Krishnapillai Madhavan Nair

Foreign Fellows

Dr. Kadambot Hazma Mohamed Siddique (Australia)

Prof. Robert S. Zeigler, (Philippines)

NAAS Associates

	Name	Section
1.	Dr. M. Senthil-Kumar	Crop Sciences
2.	Dr. A. Kumaresan	Animal Sciences
3.	Dr. Anup Das	NRM
4.	Dr. N.K. Lenka	NRM

Announcement of Academy Awards

Executive Council approved the following names mentioned against each award:

Name of Awards	Awardee
Memorial Awards	
Dr. B.P. Pal Award	Dr. B.S. Dhillon
Dr. K. Ramiah Award	Dr. N.K. Singh
Dr. K.C. Mehta Award	Dr. P.B. Kirti
Dr. M.S. Randhawa Award	Dr. Gurbachan Singh
Dr. N.S. Randhawa Award	Dr. J.C. Tarafdar
Dr. P. Bhattacharya Award	Dr. A.K. Misra
Recognition Awards	
Subject Area	**Awardee**
Crop Sciences	Dr. T. Mohapatra
Plant Protection	Dr. S.R. Niranjana
Soil, Water & Environmental Sciences	Dr. Ch. Srinivasarao
Animal Sciences	Dr. A.K. Verma
Agricultural Engineering & Technology	Dr. Rajendra Singh
Social Sciences	Dr. P.S. Birthal
Young Scientists' Awards	
Crop Sciences	Dr. S.K. Parida, Staff Scientist II, NIPGR, N. Delhi
Animal Sciences	Dr. G. Venkatesan, Scientist, IVRI, Mukteswar
Endowment Award	
Shri L.C. Sikka Award	Dr. S.K. Chakrabarti, Director, CTCRI, Trivandrum

Other Activities of the Academy:

Following programmes were approved with the names of Conveners mentioned against each:

- Lecture Series by NAAS Fellowship in SAUs (Convener: Dr. P.L. Gautam).
- Mentoring by NAAS Fellows (Convener: Dr. S.N. Puri).
- Excellence in Science (Convener: Dr. N.K. Singh).
- Science Communication Strategy (Convener: Dr. P.K. Chhonkar).
- Agri-pedia enrichment by NAAS (Convener: Dr. S.L. Mehta).
- Commissioning short-term studies (Convener: Dr. B.S. Dhillon).
- Profiling of Institutions and Scientists in NARS (Convener: Prof. R.B. Singh; Dr. S.M. Virmani & Dr. A.K. Srivastava, members).
- To plan impact assessment, monitoring and evaluation (Convener: Dr. Mruthyunjaya).
- Consultancy services and agripreneurship development (Convener: Dr. K.K. Singh & Dr. K.V. Prabhu).
- Agri-Roadshows at SAUs (Convener: Dr. S.N. Puri & Dr. T.A. More).

- Organizing a meeting with Professional Association of Agricultural Sciences (PAAS) and editors of select journals (Conveners: Prof. Anupam Varma and Dr. I.P. Abrol).
- Dialogue/workshop on Preparation of National Action Plan for Genetic Resource Management in India (Convener: Dr. K.C. Bansal).
- Lectures by eminent persons (Convener: Dr. H.S. Gupta).
- Press Meet with the assistance of DKMA, ICAR (Convener: Dr. Prem Dureja).

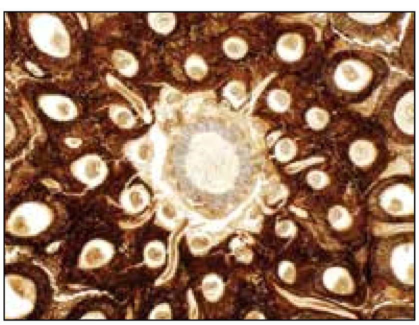
The following Brainstorming Sessions (BSS) have been approved for the year 2015:

- *Augmenting Forage Resources in Rural India: Policy Issues and Strategies* (Convener : Dr. P.K. Ghosh)
- *Integration of Medicinal and Aromatic Crop Cultivation and Value Chain Management for Small Farmers* (Conveners: Prof. Anil K. Tripathi and Dr. E.V.S. Prakasa Rao)
- Issues and Challenges in Shifting Cultivation and its Relevance in the Present Context. (Conveners: Dr. K.M. Bujarbaruah and Dr. U.C. Sharma)
- *Practical and Affordable Approaches in Implement Precision* (Convener: Dr. K.K. Singh, FNAAS and Co-conveners: Dr. S.R. Verma and Head, Farm Machinery & Power Engineering, PAU, Ludhiana).
- *Climate Resilient Livestock Production* (Convener: Dr. Khub Singh and Co-conveners: Dr. Kusumakar Sharma and Dr. C.S. Prasad).
- *Organic Farming* (Convener: Dr. B.S. Dwivedi and Co-conveners: Dr. P.K. Chhonkar & Dr. R.K. Pathak).
- Symposium on *GM Technology* (Convener: Dr. K.V. Prabhu).

Global Science and Technology News

Unique chromosomes preserved in Swedish fossil

Researchers from Lund University and the Swedish Museum of Natural History has made a unique discovery in a well-preserved fern that lived 180 million years ago during the Jurassic period."The preservation happened so quickly that some cells have even been preserved during different stages of cell division". The researchers have found cell nuclei, cell membranes and even individual chromosomes. Such structures are extremely rare finds in fossils. These results have considerably refined previous radiometric dating conducted on nearby volcano cones. In addition, the research study shows that spores from royal ferns, as well as pollen from coniferous trees, including cypress and cycad, are found in large quantities in the volcanic rock. This is evidence of varied vegetation and a hot, humid climate at the time when the area was engulfed by a disastrous volcanic eruption.



This is a fern fossil.

Source: *B. Bomfleur, S. McLoughlin, V. Vajda. Fossilized Nuclei and Chromosomes Reveal 180 Million Years of Genomic Stasis in Royal Ferns. Science, 2014; 343 (6177): 1376 DOI: 10.1126/science.1249884*

Fruit flies show ability to sniff out chemical hazards

The 'nose' of the common fruit fly could soon be used to detect drugs and explosives. New research has revealed the fly's impressive ability to sniff out a range of hazardous chemicals.

In a study published in Bioinspiration and Biomimetics, researchers have shown that the fruit fly (*Drosophila melanogaster*) can not only detect the familiar smell of rotting fruit, but also a whole host of chemicals associated with explosives, combustion products and illicit drugs.It is hoped that the sensors on the antennae of the fruit fly could be integrated into future electronic noses (e-noses), making the devices much faster and more sensitive to a whole host of chemicals. The e-noses could be used in a variety of applications, from law enforcement and health monitoring to food quality testing and environmental management.

Source: *(http://iopscience.iop.org/1748-3190/9/4/046007)*

Genetic history of tomatoes revealed by new sequencing

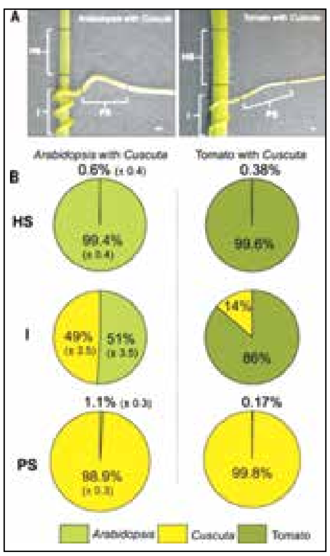
The tomato genome sequence -- both the domesticated type and its wild ancestor, *Solanum pimpinellifolium* -- has been sequenced for the first time by a large

Domestic tomatoes (left) and three wild relatives *S. pennellii* is on the far right.

international team of scientists. The sequences provide the most detailed look yet at the tomato genome, revealing the order, orientation, types and relative positions of its 35,000 genes. The sequences will help researchers uncover the relationships between tomato genes and traits and broaden their understanding of how genetics and environmental factors interact to determine a field crop's health and viability.

Source: *Nature Genetics, 2014; DOI: 10.1038/ng.3117*

Genomic-scale exchange of mRNA between a parasitic plant and its hosts



Transcriptome compositions of host and parasite tissues at and near the region of haustorial attachment.

Movement of RNAs between cells of a single plant is well documented, but cross-species RNA transfer is largely unexplored. *Cuscuta pentagona* (dodder) is a parasitic plant that forms symplastic connections with its hosts and takes up host messenger RNAs (mRNAs). We sequenced transcriptomes of *Cuscuta* growing on *Arabidopsis* and tomato hosts to characterize mRNA transfer between species and found that mRNAs move in high numbers and in a bidirectional manner. The mobile transcripts represented thousands of different genes, and nearly half the expressed transcriptome of *Arabidopsis* was identified in *Cuscuta*. These findings demonstrate that parasitic plants can exchange large proportions of their transcriptomes with hosts, providing potential mechanisms for RNA-based interactions between species and horizontal gene transfer.

Source: *Science 15 August 2014: Vol. 345 no. 6198 pp. 808-811 DOI:10.1126/science.1253122*

A faster Rubisco with potential to increase photosynthesis in crops

This tobacco plant uses genes taken from bacteria for photosynthesis

Researchers have completed the second of three major steps needed to turbocharge photosynthesis in crops such as wheat and rice, something that could boost yields by around 36 to 60 percent for many plants. Because it's more efficient, the new photosynthesis method could also cut the amount of fertilizer and water needed to grow food. Researchers at Cornell University and Rothamsted Research in the United Kingdom successfully transplanted genes from a type of bacteria—called cyanobacteria—into tobacco plants, which are often used in research. The genes allow the plant to produce a more efficient enzyme for converting carbon dioxide from the atmosphere into sugars and other carbohydrates. Scientists have long known that some plants are much more efficient at turning carbon dioxide into sugar than other plants. These fast-growing plants—called C4 plants—include corn and many types of weeds. But 75 percent of the world's crops (known as C3 plants) uses a slower and less efficient form of photosynthesis. Researchers have been attempting for a long time to change some C3 plants—including wheat, rice, and potatoes—into C4 plants.

Source: Nature 513,547–550 (25 September 2014)

The shape of nitrogen to come

Although Earth's atmosphere consists of nearly 80% dinitrogen (nitrogen gas, N_2), most living organisms cannot use this form of the element and require it to be converted into usable forms, such as ammonia. Humans have long exploited the ability of leguminous crops to fix dinitrogen into usable reactive nitrogen compounds, improving soil fertility. But the amount of reactive nitrogen produced in this way is now greatly exceeded by that produced industrially. China is experiencing intense air pollution caused in large part by anthropogenic emissions of reactive nitrogen. These emissions result in the deposition of atmospheric nitrogen (N) in terrestrial and aquatic ecosystems, with implications for human and ecosystem health, greenhouse gas balances and biological diversity.

Average annual bulk deposition of nitrogen in China has increased by 8 kg of nitrogen per hectare from the 1980s to the 2000s. Nitrogen deposition rates in the industrialized and agriculturally intensified regions of China are as high as the peak levels of deposition in north western Europe in the 1980s, before the introduction of mitigation measures. Nitrogen from ammonium (NH_4^+) is the dominant form of N in bulk deposition, but the rate of increase is largest for deposition of N from nitrate (NO_3^-), in agreement with decreased ratios of NH_3 to NO_x emissions since 1980. The impact of N deposition on Chinese ecosystems includes significantly increased plant foliar N concentrations in natural and semi-natural (that is, non-agricultural) ecosystems and increased crop N uptake from long-term-unfertilized croplands. China and other economies are facing a continuing challenge to reduce emissions of reactive nitrogen, N deposition and their negative effects on human health and the environment.

Source: Nature 494, 435–437 (28 February 2013) doi: 10.1038/nature11954

Science Spectrum - The Editors' Pick

Enzyme from wood-eating gribble could help turn waste into biofuel and food

Scientists have discovered a new enzyme that could prove an important step in the quest to turn cellulosic waste such as paper, scrap wood and post harvest residues into fuel and food. To accomplish this miracle a group of 15 scientists from National Bioenergy Centre, National Renewable Energy Laboratory, Golden, CO, USA and drawn from several other research centers turned to the destructive power of tiny marine wood-boring crustacean called 'gribble' (*Limnaria quadripunctata*), which have been known to destroy seaside piers. The gribble (Fig. 1), a wood-boring marine isopod for long has been considered nothing more than a nautical nuisance. Its specialty is boring its way into the wooden hulls of ships. It ingests small fragmented wood particles which are deposited in their guts (Fig. 2). It is hydrolysed by these small marine isopodes to form glucose used as an energy source. Gribble is a voracious consumer of wood and produces all the enzymes needed for its digestion.

Using advanced biochemical analysis and X-ray imaging techniques, researchers have determined the structure and function of a key enzyme used by gribble to break down wood. The enzymes attach to a long chain of complex sugars and then chop off small soluble molecules that can be easily digested or fermented. The researchers identified a glycoside hydrolase (GH) an enzyme that converts polysacchorides into glucose from gribble that has some unusual properties. Based on crystallographic and computational comparison gribble GH exhibits an extended substrate binding motif at the tunnel entrance which aids in substrate acquisition (Fig. 3). Its stability and activity remains unchanged under adverse conditions of reaction and high salt concentration.

Fig. 1. Wood-boring Crustacean gribble (*Limnaria quadripunctata*)

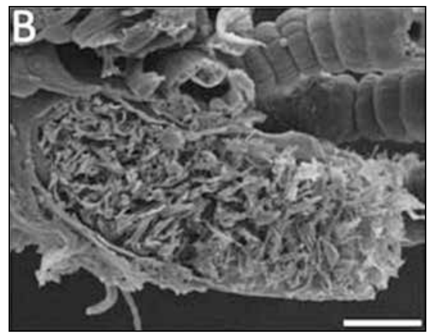


Fig. 2. Scanning electron micrograph showing an obliquely sectioned hindgut packed with wood particles. (Scale bar, 50 μm.)

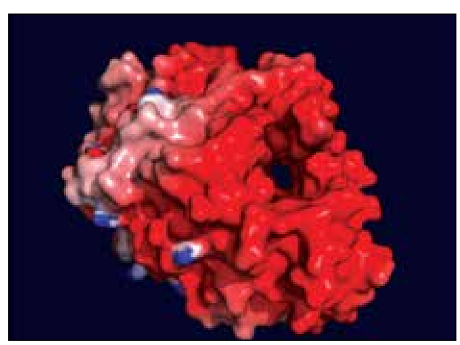


Fig. 3. The 3-D structure shows the tunnel where the enzyme feeds in the cellulose chains for digestion. The red color represents the highly acidic surface that allows it to be stable and active in very high salt condition.

Their function is determined by their three-dimensional shape. While similar cellulase has been characterized from wood-degrading fungi, the enzyme from gribble shows some important differences. In particular, the gribble cellulase is extremely resistant to aggressive chemical environments and can last much longer when working under industrial conditions. To create liquid fuel from woody biomass, such as wood and straw, the polysaccharides (sugar polymers) that make up the bulk of these materials must be broken down into simple sugars. These are then fermented to produce liquid biofuels. This is a difficult and expensive process. This is the first functionally characterized animal enzyme.

This enzyme looks superficially similar to equivalent ones from fungi, closer inspection highlights structural differences that give it special features, for example, the enzyme has an extremely acidic surface and this is one of the features that contribute to its robustness. The ultimate aim is to reproduce the effect of this enzyme on an industrial scale. Instead of trying to get the cellulase from gribble, the team has transferred the genetic blueprint of this enzyme to an industrial microbe that can produce it in large quantities, in the same way that enzymes for biological washing detergents are made. By doing this they hope to cut the costs of turning woody materials into biofuels.Professor McQueen-Mason added: “The robust nature of the enzymes makes it compatible for use in conjunction with sea water, which would lower the costs of processing. Lowering the cost of enzymes is seen as critical for making biofuels from woody materials cost effective. Its robustness would also give the enzymes a longer working life and allow it to be recycled. Marine cellulases offer significant potential for utilisation in high solids industrial biomass conversion.

This is an exciting step way forward in realizing the potential of these important enzymes. If we can harness them effectively, waste materials could be used to make sustainable fuels and food. It’s a double bonus; avoiding competition with land for food production as well as utilizing unused materials from timber and agricultural industries.

Reference

Marcelo Kern and others (2014). Structural Characterization of a Unique marine animal family 7 Cellobohydrolase. Proc Natl Acad Sci USA 110(25)10189-10194

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Editor’s Note:

The discovery of a strain of fungus *Trichoderma* viridi later named *T. reesi* producing high amounts of cellulases in early 1950s raised hopes for its industrial application for decomposition of lignocellulase for producing glucose. However, enzymatic hydrolyses proved uneconomical. The hopes were belied due to short life of fungal enzyme and low output. Present report raises hopes of industrial application using enzyme analogs from gribble. A parallel is observed between symbiont bacterial protists producing cellulase in the guts of termite to hydrolyse wood particles to form glucose but unlike gribble the termite themselves do not produce the enzyme which is of bacterial origin.

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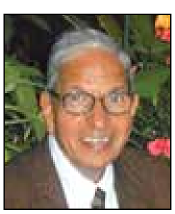
Fellows’ Views

A Dialectical View of Agriculture



The NAAS Newsletter of July-September 2014 is memorable in more than one respect. Firstly, it tells us the 10 Commandments given by Hon’ble Prime Minister of India on the happy occasion of the 86th Foundation Day, the 29th July, 2014 of the ICAR. Secondly, it highlights the importance of water use efficiency in agriculture from the President’s Desk. Among several other important contributions is the Editorial on the negative effect of *population pressure* on agriculture.

Increased population is a central issue. Today we have 1.26 billion people as against global population of 7.33 billion. This is expected to become 1.81 billion against global population of 9.54 billion by 2050. The present food grain production of 257 million tons would need to be doubled to meet the requirement of the expected population by 2050. Not only agriculture, in fact, almost all sectors are affected by it. We may go for any activity we have *crowds*, *crowds,* and *crowds*. Demographers and population scientists have no doubt been making efforts to arrest the growth of the population by adopting relevant policies. Even when they succeed, the population will still grow for a long time by sheer momentum. So the problem of agriculture is in fact to produce more and more *in spite of population pressure*.

We have already reached the limits of increasing food production by expansion of acreage - the horizontal dimension. And since g*reen revolution* we have been exploiting the vertical dimension of increasing productivity. Prospects seem good if we are able to adopt biotechnological methods and advantages of genetic modification in crop plants, livestock, poultry, and fishery etc. But there is a catch. We may not be able to achieve quantum jump in productivity as we need to increase productivity in a sustainable manner. This means development and adoption of technologies that would meet short-term requirements while maintaining the ability to meet long-term needs. In other words the country's natural resources- the land, water and genetic endowment- are to be used in a manner that is environmental friendly, economically viable and meets the concerns of the society. This puts a constraint on the use of inputs indiscriminately for increasing production. To see this we need to take a *dialectical view* of the agriculture.

For example, the process of grain production is taken normally as unidirectional in which relevant inputs are responsible for the output - the production - much like independent (cause) and dependent (effect) variables in statistics determining the direction of the causal relationship. But what happens if cause flows in both directions? The process of production affects the environment in terms of the soil health and the ecosystem surrounding the plants, in addition to being affected by them. Plants make ecosystem and ecosystem makes plants. The dialectical view requires treating them together as a 'whole' with individual 'parts' which are internally heterogeneous but not fixed natural homogeneous units. They both make and are made by each other and continue changing in response to each other. In other words, 'parts' and 'whole' evolve as a consequence of their relationship and the relationship itself evolves. In intensive cropping systems for instance, plant growth extracts nutrients from the soil that adversely affects its health. If the soil health is to be preserved at some desired level for future use, the production process gets constrained in that the production would become *less* than what it would be if we ignore the effect of increased production on the characteristics of the soil. We have then to determine by how much the production gets lowered in maintaining the soil status. At the same time when the soils deteriorate, as a feedback, the plant productivity goes down. We need then to determine by how much the soil erosion is to be prevented to maintain the productivity at the same level. This means the sustainable growth strategy would have to take into account both, the environmental effect of crop production process as well as the feedback from the quality of environmental resources to crop productivity in much the same way as the dialectical view point stated above.

It may seem that the above description implies a system-theoretic approach to the problem. It is not. Take for example the Farming Systems Research and Extension (FSR&E) approach in which the whole farm of a given household is treated as a system with interdependent components under the control of the members of the household and their interactions with the physical, biological and socioeconomic factors not under the household's control. Intimate interaction between the scientists and extension personnel is insured by undertaking technology development for identifying appropriate genotypes and agronomic practices for the given region, using statistically sound experimental designs, on operational-scale plots in farmers' fields. Systems modeling can be undertaken by the mathematics of feedback and other relevant details about the interactions among the various components of the farming system. But this approach is not likely to include in the analysis the *anxiety* or the *conditions* that produce it due to lack of the format for the necessary equations. Agriculture is a life and death problem for farmers. If conditions turn out to be hostile to their farming practices, they are beset with anxiety. Such emotions are known to have their effects on their farms' productivity. In dialectics, however, one can approach the problem of such complexity even without knowing the exact form of the equations. This is because here the 'processes' are given more emphasis than the 'things' regarding things as snapshots of the process. The process means change and so the dialectics cover dynamics as well in its approach. The relation of continuity and discontinuity in the process is an aspect of dialectics that systems theory does not deal with at all. In a way systems approach is to be subsumed under dialectics.

In view of the above it is apparent that there are hindrances in the exploitation of vertical dimension and even if we are able to overcome them the issue is how long it will last. Sooner or later the limits will be reached as has happened in the case of horizontal dimension. It seems we need to look for another dimension even now to take care of the alarming scenario of increased population pressure in the future. Is there one such dimension? The dialectical approach can again help in finding it out.

The usual approach in deciding upon the policies for growth in different sectors of economy like agriculture, industry, health, environment, education etc. is to treat them separately like different compartments of the economy with minor attention to linkages between them. A dialectical view on the other hand requires taking all of them together by exploiting interactions between them along with a multidirectional causation with feed forward and feedback mechanisms. Each sector affects other sectors and is affected by them as well. For instance, a policy choice such as allocation of resources to health programs could affect the health outcomes of the people. But what would happen if health outcomes of the policies result in public action to change the policies in other sectors too in the absence of appropriate linkages? Even in a developed country like USA, they don't have an agricultural policy linked to health policy.

Recently, The Federal Government of USA developed a draft document on dietary guidelines for healthy eating (they do so every five years) in which it is suggested that Americans reduce their consumption of meat and dairy and eat more plant based foods as against previous guidelines of eating leaner meat without saying not to eat less meat altogether. This change in the dietary guidelines is because studies have shown that lower meat consumption cuts greenhouse gas emissions, lessening the contribution their eating habits make to climate change. In other words they would like to tell the American public to pay attention to how their food is grown, not just what's in it. They have given the following statistics on greenhouse gas emissions:

Kilos of carbon emissions produced per kilo of food

Lamb	39.2	Eggs	4.8
Beef	27.0	Rice	2.7
Cheese	13.5	Milk	1.9
Pork	12.1	Lentils	0.9
Turkey	10.9		

It is apparent that plant-based foods contribute much less to greenhouse gas emissions. Eating rice creates one-tenth of carbon emissions of that contributed by beef. A dietary pattern that is higher in plant-based food and lower in animal-based foods are more health-promoting and at the same time is associated with lesser environmental impacts – energy, land, and water use. This policy being environmentally friendly will lead to sustainability.

This gives us a clue to the other dimension we are looking for. Food production is linked with food consumption. Per capita availability of food is linked with per capita food consumption that we engage in ourselves. What we eat, how much we eat, whether we eat to live or live to eat etc. are no doubt our personal choices but dietary habits can be regulated by self will in times of exigencies. Instead of consumption *per se* one can stress *need-based consumption* that leads to sound health. This attitude will prevent over consumption as at present and control enormous wastages that is taking place all along post-harvest operations to the plate of food that becomes available to us for eating. This would amount to reduce consumption. It can lead to decrease in demand and, if the food production and population remain the same, to generation of surplus food grains leading to *increased* per capita availability of food. Such a policy seems to be another dimension away from the operations on the farm and can thus imply sustainability for all times to come. In a way, it echoes what Mahatma Gandhi said several years ago:

"*Earth provides enough to satisfy every man's need, but not for anybody's greed.*"

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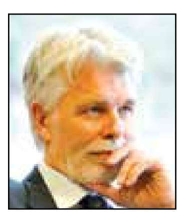
Awards and Honours

Indian institutions award to FAO Director-General for efforts to promote food security

FAO Director-General José Graziano da Silva was named Doctor Honoris Causa by the Indian Agricultural Research Institute (IARI), New Delhi and made a Fellow of National Academy of Agricultural Sciences (NAAS) during his first official mission to the country.

World Agriculture Prize 2014

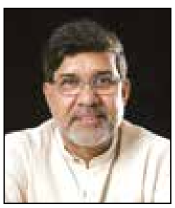


Dr. Paul Vlek, Fellow of the academy and soil scientist from Bonn University, was recently awarded the 2014 World Agriculture Prize. The prize is awarded jointly by the Global Confederation of Higher Education Associations for the Agricultural and Life Sciences and Nanjing Agriculture University. He has developed a technique to prevent nitrogen losses by deep-placement of urea in flooded rice now being utilized in more than 2 million hectares of rice fields. Dr. Vlek was appointed to the UNESCO chair of Education for Sustainable Development at Urgench State University, Uzbekistan in 2011; in West Africa he set up a climate service center to help 10 countries cope with climate change.

World Food Prize

Dr. Bram Govaerts, a native of Belgium now working from Mexico, has been awarded World Food Prize. for his work developing leading-edge, sustainable programs that are transforming subsistence agriculture and unsustainable farming systems in Mexico and other regions of the world.His research and field application in conservation and sustainable agriculture has focused on the benefits of improving long-term soil quality in both irrigated and rain-fed regions through leaving surface residues on the land and reducing tillage activities while diversifying crops.

The Nobel Peace Prize 2014



Kailash Satyarthi

Malala Yousafzai

The Nobel Peace Prize 2014 was awarded jointly to Kailash Satyarthi and Malala Yousafzai" received on December 10, 2014 for their struggle against the suppression of children and young people and for the right of all children to education. Kailash Satyarthi has dedicated his life to helping millions of children forced into slavery. Born in India in 1954, the electrical engineer founded Bachpan Bachao Andolan (BBA), or the Save the Childhood Movement, a non-profit organization aiming to eliminate child trafficking and labor, in 1980.The BBA has raided thousands of sweatshops or private homes to rescue the children forced to work there. Satyarthi also frequently takes part in street demonstrations to raise awareness on the issue and was a leader of the 1998 Global March against Child Labour, which crossed 103 countries.

Malala, 17, was shot in the head by a Taliban gunman two years ago in Pakistan after coming to prominence for her campaigning for education for girls. After being shot she was airlifted to Queen Elizabeth hospital in Birmingham, where she was treated for life-threatening injuries. She has since continued to campaign for girls' education. She won for what the Nobel committee called her "heroic struggle" for girls' right to an education. She is the youngest ever winner of the prize

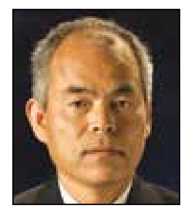
Nobel Prize in Chemistry 2014

Nobel Prize in chemistry was awarded to U.S. researchers Eric Betzig and William Moerner and German scientist Stefan Hell for finding ways to make microscopes more powerful than previously thought

possible, allowing scientists to see how diseases develop inside the tiniest cells. Their breakthroughs have enabled scientists to study diseases such as Parkinson's, Alzheimer's and Huntington's at a molecular level. "Due to their achievements the optical microscope can now peer into the nanoworld,"

The Nobel Prize in Physics 2014

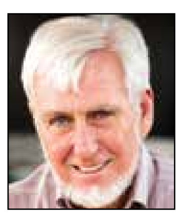
Isamu Akasaki and Hiroshi Amano of Japan and US scientist Shuji Nakamura won physics award for the invention of blue light-emitting diodes _ a breakthrough



that spurred the development of LED technology that can be used to light up homes and offices and the screens of mobile phones, computers and TVs.

Nobel Prize medicine in 2014

Anglo-American John O'Keefe and Norwegian couple May-Britt and Edvard Moser won the 2014 Nobel Prize for medicine on Monday for discovering the brain's



John O'Keefe

May-Britt

Mose

internal positioning system, helping humans find their way and giving clues to how strokes and Alzheimer's affect the brain

National Silver Jubilee Symposia held in 2014

- **Small Farm Mechanization – A Review and Roadmap,** held on July 18, 2014 at Bhopal (Convener: Prof. Anwar Alam).
- **Nutritionally Sensitive and Environmentally Sustainable Agriculture for India's Food and Nutrition Security: Challenges and Opportunities**, held on August 23, 2014 at Hyderabad (Convener: Dr. Mahtab S. Bamji).
- **Indian Fisheries and Aquaculture: 25 Years of Achievements & Way Forward,** held on October 21-22, 2014 at Mumbai (Convener: Dr. W.S. Lakra).
- **Enhancing and Sustaining Agriculture Productivity for Food and Nutrition Security,** held on November 22, 2014 at Chennai (Convener: Dr. Ajay Parida).
- **Strategic Approaches for Horticultural Research, Education and Development – Way Forward,** held on December 26-27, 2014 at New Delhi (Convener: Dr. H.P. Singh and Co-convener: Dr. Pritam Kalia).
- **Managing Natural Resources for Posterity: 25 Years of Achievements and Way Forward,** held on December 30, 2014 at Kolkata (Convener: Dr. Biswapati Mandal).

XII Agricultural Science Congress at ICAR-NDRI Karnal from 3-6 Feb 2015

The XII Agricultural Science Congress (12th ASC) is going to be organized at ICAR-NDRI, Karnal from 3rd to 6th February 2015 on the theme "Sustainable Livelihood Security for Small Holder Farmers". The four days event include 11 technical sessions on Crop/ Animal/ Engineering and Social Science issues apart from plenary lectures, poster sessions, round table meetings for policy formulation, farmers exhibition, inter-university students elocution contest and a grand all India Agri-Expo. A large number of participants cutting across the diaspora of researchers, policy makers, farmers, entrepreneurs and students shall be attending the congress. Preparations for the event are in full swing at NDRI for hosting this mega event in most befitting manner to commemorate the Silver Jubilee of National Academy of Agricultural Sciences (NAAS). An outstanding line-up of speakers across the globe has already confirmed their participation in the Congress. The organizing committee, through this circular, is requesting everybody to join this mega event. Your participation will be very important for discussing most burning issues in Indian Agriculture and creating opinion for technological innovations & policy reforms to the benefits of small farmers. The 12th ASC team at NDRI remains committed to make your participation in the congress, intellectually the most rewarding one.

Please register for 12th ASC, send abstracts and find all details about the event at www.agricongress2015.in

ANNOUNCEMENT

Nominations are invited for election of Fellows and selection of Associates of the Academy for 2016. The last date of receipt of Nomination is March 31, 2015.

The Nomination Forms are available on Academy's website: http://www.naasindia.org

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