National Conference

on

INDIGENOUS INNOVATION AND FOREIGN TECHNOLOGY TRANSFER IN FERTILIZER INDUSTRY : NEEDS, CONSTRAINTS AND DESIRED SIMPLIFICATION

SOUVENIR
AND
BOOK OF ABSTRACTS

Organized by

SOCIETY FOR FERTILIZERS AND ENVIRONMENT
and
RAMAN CENTRE FOR APPLIED AND INTERDISCIPLINARY SCIENCES

In collaboration with

ICAR-CENTRAL RESEARCH INSTITUTE FOR JUTE AND ALLIED FIBRES
FICCI (INDIA INNOVATION GROWTH PROGRAMME)

ICAR-CRIJAF, Nilgunj, Barrackpore, Kolkata,
West Bengal – 700 120

Citation:
National Conference on Indigenous Innovation and
Foreign Technology Transfer in Fertilizer Industry:
Needs, Constraints and Desired Simplification,
Souvenir and Book of Abstracts
S. Sarkar, D. Ghorai, K. Ghosh and H. S. Sen (eds.)
ICAR-Central Research Institute for Jute and Allied Fibres
Barrackpore, West Bengal – 700 120
17th January, 2015
Society for Fertilizers and Environment, Kolkata, p 1-56

Published by:
Kunal Ghosh
President
Society for Fertilizers and Environment

Organised by:
Society for Fertilizers and Environment
16 Ellora Road (Canal Road), Kolkata – 700 075
www.ferilizersenvironment.org
Raman Centre for Applied and Interdisciplinary Sciences
16A Jheel Road, Kolkata 700 075
www.rcais.res.in

In collaboration with
ICAR-Central Research Institute for Jute and Allied Fibres
FICCI (India Innovation Growth Programme)

Printed by :
Media SS
Mobile : 98306 10609, 98306 10801
E-mail : mediass60@yahoo.in
mediass60@rediffmail.com

ORGANISING COMMITTEE

President

Kunal Ghosh

Secretary

H. S. Sen

Local organising committee chiefs:

P. G. Karmakar

S. Satpathy

Accommodation and Transport Committee

Kunal Mandal

A. Bera

H. K. Sharma

Anil Kumar

Ravi Mishra

Dileep Kr. Patra

Pabitra Biswas

Reception & Registration Committee

Amit Ranjan Saha

S. Paul Mazumdar

B. S. GotyalShamna

A. Mukesh Kumar

Subrata Biswas

Rakesh Roshan

Hall Management Committee

Bijan Majumdar

S. K. Jha

K. Selvaraj

Amarpreet Singh

Ramesh Naik

Nilanjan Pal

Ashim Mukherjee

Manoj Roy

Sourav Biswas

Kamal Banik

Food & Refreshment Committee

S. K. Sarkar

Dipnarayan Saha

Ranjan Nayak

Samar Ghosh

Subrata Bhattacharya

Tridib Ghosh

Nilay Singh

Poster Session Committee

Jiban Mitra

Pratik Satya

Dhanjay Barman

P. N. Meena

Maruti T

V. Ramesh Babu

Sanjoy Shil

Publication Committee

Sitangshu Sarkar

Dipankar Ghorai

S. B. Chowdhury

A. N. Tripathi

Press / Media Committee

Hemanta Chowdhury

F. H. Rahaman

S. K. Jha

Shailesh Kumar

CONTENTS

Invited Articles

I-1

Indigenous Innovation and Foreign Technology Transfer in Fertilizer Industry : Needs, constraints and desired simplification

KUNAL GHOSH
Fellow, Senior Scientist & Council Member of the Indian National Science Academy, New Delhi
ex-Professor & HoD, University of Calcutta, Kolkata
E-mail : kghoshcu@gmail.com

The call for new products in any industry is eternal. The choice is, either indigenous innovation or import of foreign technology. The latter route, although often unjustifiably expensive, is the easier option as it provides a ready complete package. The former route is difficult but usually much cheaper. It also takes time, as one needs to plan well ahead without any immediate return; it is a continuous process with cycles of failure and success, with self-satisfaction to boot. Usually both the approaches are in practice.

Like any other industry, fertilizer industry has two sets of demands. The first is to produce the current products at a cheaper rate with more efficient and simplified clean technology. The second one is to invent new products that are desired to be cheaper, more efficient and environmentally safe. The process to produce them are expected to have simpler unit operations that are environmentally cleaner with reduced cost on material construction, power, water, high pressure, pollution and imported raw materials, if any.

There is a burning need in Indian agriculture and environment for non-polluting fertilizers, but without compromising on efficiency and more so the cost. Crops require fertilizers that will provide nutrients throughout the plant life and are not lost easily to ground water or air. The nation as a whole wishes for a reduced burden on imports pertaining to fertilizer.

Historically, we had a cutting-edge innovation base under the Fertilizer Corporation of India in the fifties, sixties and even in the seventies. The facility slowly died down owing to major shift in national policies as well as for financial reasons. Private sector was never known to contribute significantly in this regard. Days have changed. Without seminal transformation, Indian industry cannot survive in the long run in this global competitive scenario. Primarily for this reason, the Government today is calling loud for innovation. Private sector ought to develop their own support base but at the same time, they can demand Government support through a new policy or otherwise.

Unfortunately, the product and process development area, commonly called Fertilizer Technology, is shockingly poor in India particularly during the last four decades or so. This is a global concern as Universities anywhere have rarely created a base for grooming. The entire manpower in India is practically involved in the other major area, generally known as Fertilizer Application, mainly through ICAR, SAU and State Governments. Over the years there have been some accomplishments and there could be more tangible results are in the offing if we could really implement policies like customised and fortified fertilizers to produce more healthy plants and higher yields through the use of lower quantum of balanced fertilizers. Today's much publicised "Soil health card" is an essential pre-requisite in this direction.

The need of the hour for Indian fertilizer industry is to go for innovation of clean technology, on their own or through joint venture with local or foreign partners or by straightaway import of foreign technology. They can contemplate creating a joint central innovation base even in a public-private partnership mode. Under such circumstances, another critical need is to equip themselves with knowledge about patents and IPR, which is by and large weak in this sector. On the other hand, the Government could provide new incentives and make the present incentives more easily available, for innovation ventures and especially for green technology. The green technology of production and environment-friendly fertilizers for application, however, can be meaningful if and only if the network of quality control is widespread and stringent.

Subsidy is another area that needs serious re-look not just for the national exchequer but also for agriculture and environment. As long as cheap subsidised fertilizers are freely available in the market, balanced use cannot be enforced. Furthermore, subsidy stifles new innovations as such products cannot compete with the subsidised ones. Finally, it is not very easy even for the most wonderful innovation to reach the common farmer by overcoming innumerable Government barriers like FCO and many other clearances. Such checks are necessary but they should be rational, transparent and time-bound. These are only examples, the nation needs a comprehensive policy. Such policy is desired to be industry, farmer and people friendly with least red tape. This is imperative to create the right launching pad to "make (fertilizer) in India" with "zero defect and zero effect".

I-2

Smart Fertilizers

CHANDRIKA VARADACHARI
Director, Raman Centre for Applied and Interdisciplinary Sciences, Kolkata &
President & CTO, AgTec Innovations Inc, Los Altos, California
E-mail : cv@rcais.res.in

There exists an intense tug-of-war between environmentalists and the fertilizer industry with the farming community caught in between. Whereas radical environmentalists view fertilizers as a serious pollutant and demand they be replaced by 'organics', the fertilizer industry is happy to continue activities as usual because farming community doesn't have an alternative. Although no solutions have been forthcoming that can be acceptable to all concerned, it is not as if this is an insurmountable problem.

The solution lies in addressing those issues that cause inorganic fertilizers to 'pollute' and organics to be 'safe'. That issue, simply put, is the high water solubility. Easy dissolution in water causes surface run-off to water-bodies, leaching to ground water and ready chemical reactions that produce gaseous pollutants; this also results in high wastage. The obvious remedy would be to reduce water solubility and thereby simulate desirable properties of organics. This apparently simplistic solution has so far found to be unachievable. The overwhelming consideration is that any insoluble material cannot function as a fertilizer because the nutrients in them are not accessible to plants. Only some insoluble materials can function as plant nutrient sources – these are substances that can be dissolved by plant root exudates, i.e., materials that are 'root digestible'. Soils naturally contain such plant root extractable nutrients such as potassium or ammonium in exchangeable positions of clay minerals, zinc or iron in DTPA extractable forms, phosphate in dilute acid or carbonate extractable forms, etc. These soil nutrients are not in water soluble forms but are available by virtue of being extractable by root organic acids and enzymes.

Smart fertilizers, as the name suggests, are 'smart' in their nutrient release. Nutrient release is "on-demand" by the plant. It is not force fed fertilization but requires that a plant actively extract the nutrient from the compound in response to its growth requirements. Smart fertilizers simulate the chemical form of available nutrients in the soil matrix – they are, therefore, the most natural and environment-friendly materials that one can conceive of as fertilizer materials.

The design of Smart fertilizers starts with the design of a molecule with desired properties followed by reverse engineering to obtain an actual compound. This must take into consideration a few critical factors including (a) ultimate cost of product that has to be cost effective, (b) synthesis route that must be adaptable to commercial scale, (c) physical and chemical properties that will allow bulk handling and storage (such as hygroscopicity, flowability, etc). The challenge then, is to design a molecule that will be bound by the use of only low cost raw materials and technically feasible process conditions to produce a material that will have the desired properties and yet be highly efficient, effective, affordable and safe.

This is a truly daunting research. In our case, it took about thirty years of work to develop the perfect molecules for phosphate and micronutrient fertilization (Smart Phosphates and Smart Micronutrients). Based on a unique inorganic polymer matrix, these Smart fertilizers are the first of their kind in the world. Their uniqueness is twofold – (i) the compounds are novel chemicals that have never before been synthesized, (ii) their performance features are un-paralleled; at just one-tenth of the dosage, the Smart fertilizers produce yield increments that is far beyond any of the water soluble fertilizers. This incredible performance is reaffirmed by extensive field trials not just in India but also across the world. Cost benefits to the farmer are also huge as is the profit margin to the manufacturer. It is a win-win situation for all.

In the environment versus fertilizer imbroglio, Smart fertilizers offer the only viable way out. Smart fertilizers possess all desirable characteristics of organics and are completely environment friendly. On the other hand, they do not have any of the limitations of organic materials; nutrient contents are sufficiently high so that huge volumes are not required, they can be produced on large scales with affordable raw materials and they produce high yield responses. The dream of environment-friendly fertilization, therefore, can be a reality through the Smart fertilizers.

I-3

Mineral Fertilizers and Soil Health

BIJAY SINGH
Punjab Agricultural University, Ludhiana, Punjab
E-mail : bijaysingh20@hotmail.com

Over the past 40 years, mineral fertilizers accounted for an estimated 40% of the increase in food production. Total world fertilizer consumption reached 172.2 million metric tonnes (Mt) of nutrients in 2010-11, of which N, P_2O_5 and K_2O were 104.3, 40.5 and 27.4 Mt, respectively.

According to Kibblewhite *et al.* (2008), a healthy agricultural soil is one that is capable of supporting the production of food and fibre, to a level and with a quality sufficient to meet human requirements, together with continued delivery of other ecosystem services that are essential for maintenance of the quality of life for humans and the conservation of biodiversity. Soil health is an integrative property reflecting the capacity of soil to respond to agricultural intervention, so that it continues to support both the agricultural production and the provision of other ecosystem services. The major impact of inorganic fertilizers on the soil health system and ecosystem functions relates to their effect on primary productivity. The most important indirect impact of applying inorganic fertilizers to the soil is that it leads to reduction in the quantity of organic matter input.

Under-use of fertilizers leads to soil health deterioration

As soils represent a major store of reactive forms of N, P and micronutrients, their sound management is very important to address global food security challenges as well as minimize nutrient losses to the environment that can pollute air and water. Soils contain variable amounts of nutrient elements and low contents of nutrient elements in plants may lead to malnutrition of animals and humans (Sanchez and Swaminathan, 2005). As a consequence of poor soil health there occurs reduced food and nutrition security through lower agricultural production, less fodder for cattle, less fuel wood for cooking, and less crop residues and cattle manure to recycle nutrients, increased runoff and erosion losses because there is less plant cover to protect the soils, and sedimentation and siltation of reservoirs and coastal areas, and in some cases eutrophication of rivers and lakes.

Best fertilizer management practices enhance soil health

There are four management objectives associated with any practical farm level operation including management of fertilizers. These four objectives are productivity, profitability, cropping system sustainability, and a favourable biophysical and social environment. Best management practices for fertilizer are those which support the achievement of these four main objectives of cropping systems management: productivity, profitability, sustainability, and environmental health. A strong set of scientific principles guiding the development and implementation of fertilizer best management practices has evolved from a long history of agronomic and soil fertility research.

Fertilizer use best management practices or the 4R nutrient stewardship can be described as the selection of the right source for application at the right rate, time, and place. Specific scientific principles apply to these best management practices as a group and individually. The application of these scientific principles may differ widely depending on the specific cropping system, region and crop combination under consideration. Decision support guiding the adoption of fertilizer best management practices requires a dynamic process of local refinement. As soils are at the heart of several sustainability issues facing humanity, management of fertilizers in cropping systems following principles of 4R nutrient stewardship can ensure improvement in soil health due to application of fertilizers for crop production.

There are several causes of the declining or lower crop responses to applied fertilizers or efficiency of fertilizer applications in several developing countries. One major cause of this decline is the continuous nutrient mining of the soils (particularly P, K and micronutrients) resulting from unbalanced fertilization practices.

Therefore, fertilizers should be applied in sufficient quantities and in balanced proportions. Unbalanced use of N, P and K also leads to loss of soil organic matter – a key indicator of soil health. Also, site specific nutrient management, whether based on nutrient status of soil or plant in a given field, ensures that nutrients applied via fertilizers are managed as per need of the soil-plant system. Thus, as compared to blanket fertilizer recommendations for different crops, which are still prevalent in several developing countries, site specific nutrient management ensures that soil health is maintained on a long-term basis.

Nitrogen fertilizers can cause soil acidity – a negative soil health trait

Excessive application of nitrogen fertilizers, particularly as reduced N (NH_3, NH_4^+), to the soil may adversely affect soil health as it leads to soil acidification. Recently, Guo *et al.* (2010) reported that between 1980s and 2000s, soil pH was significantly reduced in China following application of heavy doses of N fertilizers. Nitrogen cycling released 20 to 221 kilomoles of hydrogen ion (H^+) per hectare per year, and base cations uptake contributed a further 15 to 20 kilomoles of H^+ per hectare per year to soil acidification. Continuing the unabated practices of large nitrogen fertilizer inputs would be disastrous in terms of reduced soil quality because soil acidification leads to reduced microbial N immobilization. Soil acidification may also affect the decomposition and mineralization of soil organic matter, and thereby soil organic matter quality.

Effect of fertilizer use on soil biota

The ecosystem services provided by soil are driven by soil biological processes. Therefore, the concept of soil health takes into account not only the soil biota and the myriad of biotic interactions that occur, but also considers that the soil provides a living space for the biota. Nutrients, applied as fertilizers or organic inputs, are a controlling input to the soil system and the processes within it. After carbon, the cycling of nitrogen and phosphorus most affects its dynamics and the delivery of ecosystem services including agricultural production. Although manipulation of nutrient supplies to increase productive outputs from the soil system is one of the keystones of agriculture, knowledge is limited about the impacts of nutrient additions on the condition of different assemblages of soil organisms and their functions. Evidence is already accumulating that soil microbes may frequently be N limited. Without additional inputs of nitrogen via fertilizers or organic manures, and particularly without due consideration of the associated carbon requirements of the biomass, soil health declines in agricultural systems. Similarly, the pool of phosphorus in soil is reduced through cropping or by erosion resulting in soil health decline in the absence of any supplemental supply via fertilizers.

The direct effects of fertilizer use on soil biota can be short- or long-term. Recently, Geiseller and Scow (2014) carried out a meta-analysis based on 107 datasets from 64 long-term trials from around the world and found that mineral fertilizer application led to a 15.1% increase in the microbial biomass above levels in unfertilized control treatments.

Fertilizer use leads to build up of soil organic matter – a key indicator of soil health

Organic matter content of the soil is a key indicator of soil health because it plays a role in a number of vital functions affecting soil fertility, productivity, and the environment. Given the fundamental coupling of microbial C and N cycling, the dominant occurrence of both elements in soil organic matter, and the close correlation between soil C and N mineralization, the practices that lead to loss of soil organic C will also have serious implications for the storage of N in soil. As a matter of fact, native soil N dictates the efficiency of applied fertilizer N as well as the quantity of N lost from the soil-plant system.

Soil organic matter changes with cultivation and fertilizer N inputs; normally, it decreases with cultivation without N fertilization and may increase with application of fertilizer N. Fertilizer application may increase soil organic matter by promoting plant growth and thereby increasing the amount of litter and root biomass added to soil compared with soil not receiving fertilizers. Although fertilizer N may accelerate loss of soil organic matter through decay of litter and indigenous organic material, Geiseller and Scow (20140, Körschens *et al.* (2013) and Ladha *et al.* (2011) have shown that in long-term experiments all over the world adequate and balanced use of mineral fertilizers has resulted in increase in soil organic matter as compared to in plots receiving no fertilizers (Fig. 1). The soil health enhancement in terms of soil organic matter build up due to fertilizer use is not observed only when their excessive use leads to soil acidification.

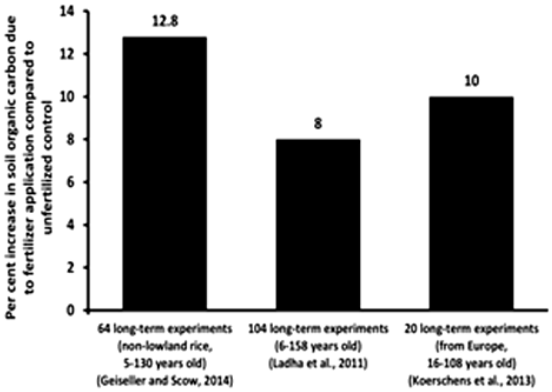


Fig. 1. Soil organic C due to fertilizer applications

Integrated management of fertilizers and organic nutrient sources - the only way forward in view of the global sustainability challenges

With increasing awareness about soil health and sustainability in agriculture, organic manures and different organic materials are gaining importance as components of integrated nutrient management strategies. As a matter of fact, a major issue in designing sustainable agricultural systems will be the management of soil organic matter and plant nutrients through integrated use of chemical fertilizers with organic inputs such as animal manures, crop residues, green manures, sewage sludge, and food industry wastes. The basic concept underlying the integrated nutrient management (INM) is the maintenance and possible improvement of fertility and health of the soil for sustained crop productivity on long-term basis and use nutrients from all sources as supplement to fertilizers to meet the nutrient requirement of the crops. In Africa, where soils are highly degraded in terms of loss of organic matter and nutrient mining, sustainable nutrient and organic matter management is emerging in the form of integrated soil fertility management (ISFM). The ISFM is defined as a set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs and improved germplasm, combined with the knowledge of how to adapt these practices to local conditions, aimed at maximizing agronomic use efficiency of the applied nutrients and improving crop productivity. All inputs need to be managed following sound agronomic principles (Vanlauwe *et al.*, 2010).

Research based on long-term experiments over more than three decades has conclusively proven that practices which support organic matter build-up in arid, semiarid and subhumid climates, also favoured sustainable productivity (Katyal *et al.*, 2001). Since sustainability is not possible without equalizing the nutrient removals and additions, productivity without fertilizers declined steadily. Under irrigated conditions regular application of recommended doses of NPK fertilizers, productivity stagnated or declined after initially increasing for 5–6 years. It was the combined application of fertilizers and farmyard manure that unfailingly sustained productivity. This conclusion is valid, irrespective of the location or the cropping system. Also, the organic manure application successfully suppressed the emergence of micro and secondary nutrient deficiencies and prevented a fertilizer-induced drop in pH of poorly buffered acid soils. Even under rainfed conditions in which fertility and productivity of soils is depleted to such an extent that fertilizer application was indispensable for getting an immediate boost in yield, the addition of organic manure was necessary to sustain the yield rise thus obtained. In long-term experiments initiated in a virgin soil, soil organic matter remained stable over the first decade if fertilizers were applied; although subsequently fell to about 40% of the initial value over a period of about 3 years. When along with fertilizer, organic manure was applied, the soil organic matter content was stable over the 25 years (Katyal *et al.*, 2001). Even in a soil already under cultivation, with application of fertilizer alone soil organic matter remained stable over the first decade, but subsequently fell to about 40% of the initial value over a period of about 3 years. With integrated management of fertilizers and organic manure, the soil organic matter content was stable over the 25 years of the study.

References

Geiseller, D. & Scow, K.M. 2014. Soil Biol. Biochem. **75**: 54-63.

Guo J.H. *et al.* 2010. Significant acidification in major Chinese croplands. Sci. **327**: 1008-1010.

Katyal, J.C. *et al.* 2001. Nutr. Cyc. Agroecosyst. **61**: 77-88.

Kibblewhite, M.G. *et al.* 2008. Phil. Trans. Royal Soc. B **363**: 685-701.

Körschens, M. *et al.* 2013. Arch. Agron. Soil Sci. **59**:1017-1040.

Sanchez, P.A. and Swaminathan, M.S. 2005. The Lancet **365**, 442-444.

Vanlauwe, B. *et al.* 2010. Outlook on Agric. **39**, 17–24.

I-4

Fertilizer and its Management for Increased Use Efficiency

ISHAN PHUKAN[1] and Y.S. RAMAKRISHNA[2]

[1]*Senior Scientist (Soil Chemistry),* [2]*Chair, NRM*

Tocklai Tea Research Institute, TRA, Jorhat, Assam - 785 008

E-mail : ramakrishna.ys@gmail.com

Presently there is a renewed and fresh interest in fertilizer research and innovations. Scientists and fertilizer industry have recognized the need for new and innovative fertilizer technology to meet the challenges of improving soil health, productivity and sustainable food security through innovative organic/inorganic research approaches. However, many of these new product developments must pass several critical tests before commercialization by the fertilizer industry, which can take some precious time for the 'next generation' of fertilizer processes and products to be developed. The vast potential of natural and industrial by-products in India also remains to be exploited.

In recent times, climate change is an important concern to scientists. In what form, how and when the fertilizer is applied to the soil are critical concerns for addressing extreme weather conditions. One of the prime issues being addressed is also, towards reducing environmental pollutants and the release of greenhouse gases. The industry is moving forward to create more effective and efficient fertilizer products that have a controlled- or slow-release characteristics. Bio-inhibitors (e.g. urease and nitrification inhibitors) used as amendments for N fertilizers may also be regarded as providing a slow release of N, especially in soils with high cation exchange capacity.

Slow release fertilizers are mainly coated fertilizers, physically prepared by coating fertilizer granules with various materials. But success of this type of slow-release fertilizers depends on the soil moisture. Super Absorbent Polymers (SAPs) are materials that have the ability to absorb and retain large volumes of water and aqueous solutions. Thus combining superabsorbent polymers with fertilizer can enable achieving both slow release and water retention properties which provides added advantages. Developing a nano-composite superabsorbent polymer (NC-SAP) composition encapsulating fertilizer and plant nutrient products which can provide high fluid/water absorption and retention capacities and slow release of nutrients as and when needed may find efficient agricultural applications (US Patent, 2010).

The use of nanofertilizers can facilitate nutrient transport to the rhizosphere when needed, and in more suitable amounts and composition, thereby improving efficiency of use (Mura *et al.*, 2013). Nano-technology is showing promise and may help improve the nutrient efficiency of not only phosphate fertilizers, but also nitrogen and potassium, besides micro-nutrients like zinc and Boron. While nanotechnologies offer significant avenues for innovation, the use of nano-materials in food and agriculture, currently face a number of safety, environmental, ethical, policy and regulatory concerns.

Studies by agricultural scientists show that Green and microbial syntheses of nano-materials for their agricultural use would be an important approach to adopt, as they are naturally encapsulated with mother protein, therefore, more stable and safer to biological system (NAAS, 2013). Currently, research is underway in ICAR to develop nano-composites that can supply all the required essential nutrients (Tarafdar, *et al.*, 2012a). Fertilizers encapsulated in nano-particles can increase the uptake of nutrients (Tarafdar *et al.* 2012b).

Strategies for increasing FUE in agriculture

Among different strategies for increasing fertilizer use efficiency for sustainable agriculture, integrated nutrient management, balance use of fertilizer and use of bio fertilizers are most important. Long-term fertilizer experiments in different agro-ecological zones of India in different crops clearly showed that neither the organic manures nor the mineral N, P and K fertilizers can sustain higher productivity where the nutrient turnover in the soil plant system is high. Long term use of inorganic fertilizers without organic supplements has been reported to damage the soil physical properties as shown by an increase in the bulk density, a decrease in water stable aggregates (>0.25 mm) and also a decline in organic matter content leading to low nutrient retention capacity. Soil organic matter is a key attribute of soil quality.

One of the major factors for the decrease in productivity of soils has been assigned to the decreasing level of soil organic matter. To offset such a decrease and to conserve organic matter, use of inorganic fertilizers must be accompanied by periodic and regular application of organic manures. Addition of organic manure in any form helps in maintaining organic matter and fertility level of soil, and thereby improving the efficiency of applied fertilizers. However, the quality of organic manure is clearly more important as it affects its mineralization rates and thereby nutrient availability. Studies carried out in acidic tea soil indicated that combined application of organic manures with high humus content i.e., microbial (bio-fertilizers) and P enriched vermicompost with high nitrogen content organic sources (decomposed Neem Cake or decomposed tea waste) had a positive and favourable impact on the growth and yield of young tea, besides increasing labile and non-labile pool of soil organic carbon. Vermicompost either alone or in combination with decomposed neem cake or decomposed tea waste is a suitable alternative to cattle manure.

Biofertilizers enhance soil fertility as well as crop productivity by fixing atmosphere nitrogen, solubilizing fixed phosphate especially in acidic soils. Studies carried out in the recent past in acidic soil under mature tea revealed that 25-30 percent replacement of chemical fertilizer (urea) either by enriched organic manures or by consortium of biofertilizers improved the physical, chemical and microbiological conditions of soil and increased the fertilizer-N use efficiency by reducing the leaching loss of nitrate-N over 100 percent chemical fertilizers without adverse effect on yield of tea (Table 1 and 2).

Table 1. Effect of INM on soil properties

Treatments	Org C (g/kg)	Bulk density (g/cc)	Water stable aggregates (%)
100% Recommended doses of Fertilizer (RDF)	8.1	1.43	85.00
75% RDF + 2 mt vermicompost (VC)/ha	8.0	1.40	87.70
75% RDF + 4 mt VC/ha	8.2	1.40	86.90
75% RDF + 6 mt VC/ha	8.9	1.38	90.13
75% RDF + 10kg mixed BF	8.4	1.40	89.27
50% RDF + 2 mt VC/ha	8.0	1.39	88.47
50% RDF + 4 mt VC/ha	8.0	1.40	88.17
50% RDF + 6 mt VC/ha	7.9	1.40	87.03
50% RDF + 10kg mixed BF	7.7	1.40	86.67
10 kg Mixed BF	8.1	1.39	86.27
CD at 5%	1.1	0.12	3.0

Table 2. Status of NH_4-N and NO_3-N in soil under INM

Treatments	NH_4-N (mg/kg)		NO_3-N (mg/kg)	
	0-15 cm depth	30-45 cm depth	0-15 cm depth	30-45 cm depth
100% Recommended doses of Fertilizer (RDF)	13	13	10	43
75% RDF + 2 mt vermicompost (VC)/ha	18	32	9	44
75% RDF + 4 mt VC/ha	36	13	8	13
75% RDF + 6 mt VC/ha	38	12	8	12
75% RDF + 10kg mixed BF	42	20	8	14
50% RDF + 2 mt VC/ha	20	21	15	35
50% RDF + 4 mt VC/ha	22	21	14	32
50% RDF + 6 mt VC/ha	21	28	17	35
50% RDF + 10kg mixed BF	26	22	21	22
10 kg Mixed BF*	25	24	22	20

**Mixed Biofertilizer: Azospirilum, Azotobacter and PSB*

Studies carried out in acidic tea soil indicated that 50% of recommended doses of phosphatic fertilizer (Rock phosphate) can be reduced by conjoint use of rock phosphate and phosphate solubilizing bacteria or fungus (Fig 1).

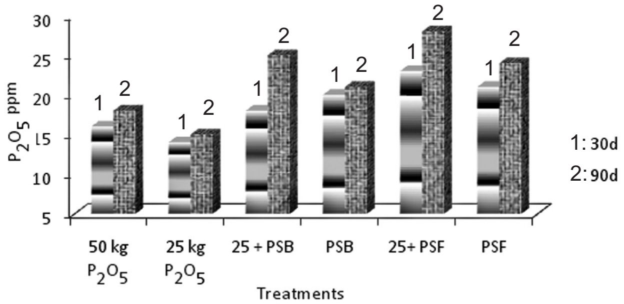


Fig. 1. Status of available phosphate in soil treated with Rock-P and phosphate solubilizing bacteria (PSB) and fungus (PSF)

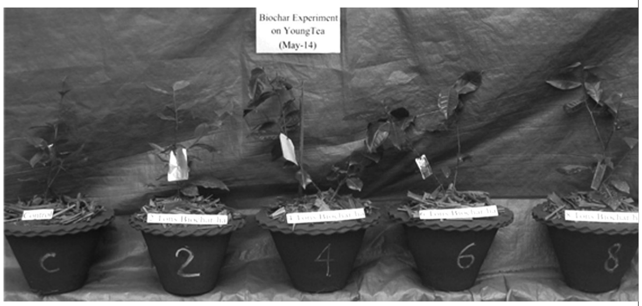


Fig. 2. Pot studies on Biochar application in Tea (0-8 t/ha) at Tocklai, Assam

Role of Biochar

Production and application of biochar (charcoal made through pyrolysis process) is receiving increasing interest as an novel approach for creating a significant, long term, (nearly permanent) locking up of atmospheric carbon through carbon negative process in terrestrial eco systems compared with other strategies, such as afforestation, organic manure addition (Glaser *et al.*, 2009; Kuzyakov *et al.*, 2009 and Schulze *et al.*, 2000). Recent study carried out indicated that biochar is a promising material for soil amendment in acidic tea soil. It can not only help in improving the soil organic status by improving SOC, but also can help in reducing leaching of nutrients and acting as a host for increased microbial colonization and improving plant growth and productivity. The quality of Biochar depends on the material from which it is made. Tea prunings prove to be a better source for biochar making for use in tea, but it can be made from any plant material including wood chips and prunings from plantation crops. However, biochar being sterile has to be blended with compost or commercially available inoculants and let it settle down for a fortnight or more, for proper microbial colonization and beneficial effects of biochar to be seen (World Bank, 2014).Current studies provide encouraging indications of improved tea plant growth from biochar application (Fig 2).

In many under developed countries the cost of fertilizer has continued to sky-rocket over the years along with transportation and application costs. This has sometimes forced growers to buy less fertilizer and thereby reduce nutrients applied per unit area. Reducing the rates of nutrient application can cause serious short and long term implications on the health and productivity of tea bushes. Weakened tea bushes would threaten the viability and sustainability of tea production. In order to counter these challenges, there is need to identify and assess other economically efficient ways of supplying nitrogen to tea plants. Application of TwinN, in combination with 75% of recommended nitrogen as urea was found to be suitable for mature tea with respect to growth and yield of tea and is cost effective (Katungwe *et al.*, 2013). TwinN (100% natural and approved by the Soil Association: Organic Farmers & Growers, 2009) is a powdery product that enhances availability of nitrogen to crop plants through the activity of endophytic micro-organisms which interact with the plant metabolic system. Twin N converts atmospheric N into nitrogenous compounds which are directly available to the plant tissues and root zone. It is thus suitable for use in a broad range of crops – both leguminous and non-leguminous. TwinN can easily be applied through fertigation, overhead irrigation or foliar spray. When sprayed onto the leaf surface, or root zone, TwinN microbes are effectively inoculated into the plant via stomata, leaf abrasions and root cracks, diluting and multiplying through the plant via the vascular system. Many such products are coming into the market and would fulfil the low cost nutrient needs of small and medium farming community.

References

Glaser, B. Parr, M., Braun, C. and G. Kopolo, (2009). Biochar is carbon negative. Nature Geoscience, **2**: 2.

Katungwe, C,. Mphangwe N.I.K, Changaya, A.G.and Nyirenda, H.E. (2013). TwinN for use in ntature tea, (Cantellia sinensis) in Malawi. TRFCA NEWSLETTER 151.

Kuzyakov, Y., Subbotina, I., Chen, H.Q., Bogomolova, I. and X.L.Xu, (2009). Black carbon decomposition and incorporation into soil microbial biomass estimated by 14C labeling. Soil Biology and Biochemistry, **41**, 210-219.

Mura S, Seddaiu G, Bacchini F, Roggero PP, and Greppi, GF (2013). Advances of nanotechnology in agro-environmental studies. Italian Journal of Agronomy 2013; volume **8**: 127-140.

NAAS (2013). Nanotechnology in Agriculture-Scope and current relevance. Policy paper 63. National Academy of Agricultural Scientists, New Delhi: 20 p.

Research L1MWADO, L.-oundation G.M. (1995). of Economic Central Africa. Quarterly evaluation of alternative Newsletter, methods **130**: 3-7of establishing clonal tea. Tea

Schulze, E.D., Wirth, C. and M. Heimann (2000). Managing forests after Kyoto, **289**: 2058-2059.

Soil Association: Organic Farmers & Growers, 2009. www.soilassociation.org

Tarafdar, J.C., Raliya, R. and Rathore, I. (2012a). Microbial synthesis of phosphorus nanoparticles from Tri-calcium phosphate using Aspergillus tubingensis TFR-5. Journal of Bionanoscience **6**, 84-89.

Tarafdar, J.C., Xiang, Y., Wang, W.N., Dong, Q. and Biswas, P. (2012b). Standardization of size, shape and concentration of nanoparticle for plant application. Applied Biological Research **14**, 138-144.

US Patent (2010). Nao-composite superabsorbent containing fertilizer nutrients used in agriculture. US 20100139347 A1.

World Bank (2014). Biochar Systems for Smallholders in Developing Countries: Leveraging Current Knowledge and Exploring Future Potential for Climate-Smart Agriculture, July 2014.

I-5

New fertilizer materials : Regulatory mechanisms of establishing quality control

ASHOK K. PATRA[1] **and SURESH KUMAR CHAUDHARI**[2]

[1]*ICAR-Indian Institute of Soil Science, Nabibagh, Berasia Road, Bhopal*

[2]*Assistant Director General (SWM), ICAR, New Delhi*

Most of our soil based production systems are showing the signs of fatigue. As a result, the partial factor productivity of fertilizers has declined in intensive cropping systems. An assessment found that about 40 to 60% of crop yields are attributable to commercial fertilizer use (Stewart *et al.*, 2005). They are essential for high-yield harvest. It has been estimated that almost half the people on the Earth are currently fed as a result of synthetic nitrogen fertilizer use (Erisman *et al.*, 2008). But, the current status of nutrient use efficiency is quite low in case of N (30-50%), P (15-20%), S (8-12%), Zn (2-5%), Fe (1-2%) and Cu (1-2%) as brought about by the deterioration in physical, chemical and biological health of soils. Obviously, there is an urgent need to develop new indigenous fertilizer materials that are efficient, effective, and economical. At the same time, the regulatory mechanisms is very important for establishing quality control.

Fertilizers: A key to agricultural production

India has achieved a remarkable growth in agriculture, increasing food grain production from 83 mt in 1960-61 to about 264.8 mt (fourth estimate) in 2013-14. Fertilizer consumption likewise has been showing a continuous upward trend, with consumption from less than 1 million tons of total nutrients in the mid-sixties to almost 24.7 million tons in 2013-14. About 50% increase in agricultural production in the post Green Revolution era is attributed to the use of fertilizers. The country will require about 300 MT of food grains by 2025 to feed its teeming millions. This would necessitate use of about 45 MT of nutrients. While about 6-8 MT of nutrients could be supplied through existing organic sources, the rest has to come from chemical fertilizers. Therefore, the fertilizer industry has to keep pace with the growth of population and increasing food demands in the country.

Restructuring fertilizer pricing and subsidy

The Government is committed to supply fertilizers to the farmers at affordable prices and, accordingly, provides subsidy on certain fertilizers. At the same time, the Government is also concerned over the large fiscally unsustainable subsidy bill. The pricing pattern of fertilizers, hitherto, has also contributed to imbalanced fertilizer use and deterioration of soil health. Therefore, restructuring of fertilizer pricing and subsidy, providing for reduction in subsidy and promotion of balanced fertilizer use, became quite relevant. The Govt. of India has, accordingly, taken historical policy decision of introduction of Nutrient Based Subsidy (NBS) w.e.f. 1.4.2010. The move would broaden the basket of fertilizers and enable fertilizer use as per soil and crop requirements. Primary nutrients, viz., N, P and K and nutrient Sulphur 'S' contained in the fertilizers are eligible for NBS. The NBS to be paid on each nutrient, viz. N, P, K and S, will be decided annually by the Govt. and will be converted into subsidy per tonne for each subsidized fertilizer. Additional subsidy for fertilizers fortified with zinc and boron will be paid at the rate of Rs. 500 and Rs. 300 per tonne, respectively. The Govt. of India has also included SSP under NBS w.e.f. 1.5.2010 to promote its use. The Government is also promoting customized fertilizers based on area and crop specificities. Permission for manufacture and sale of customized fertilizers shall be granted to the manufacturing companies whose annual turnover is Rs. 500 crore or above, have soil testing facility with annual capacity of 10,000 samples per annum and have analyzing capacity for NPK, micro and secondary nutrients .

In spite of these measures, the major objectives of NBS policy of balanced fertilization is yet to be achieved. Exclusion of urea from NBS and decontrol of P & K fertilizers has also led to imbalanced application of nitrogen vis-à-vis phosphatic and potassic fertilizers (NPK consumption ratio: 8.2:3.2:1 and 6.9:2.4:1 in 2012-13 and 2013-14, respectively).

Specialty fertilizers

While there is need to increase the use of plant nutrients, there is an urgent need to increase fertilizer use efficiency which is about 40-50 per cent in upland crops, 30-35 % in rice for N, l6-20 % for P_2O_5 and 60 % for K_2O. The use efficiency of secondary and micronutrients is still lower. This also calls for innovative fertilizer products, which meet the specific requirement of crop. Generic products like Urea, DAP, SSP. etc. will continue to play the major role in nutrient supply to the soil. However, there is need to design new products to provide the customized solutions and enhance the overall use efficiency of all the plant nutrients.

Specialty fertilizers were first introduced in 1993 in Maharashtra. Today the demand for specialty fertilizers is prevalent in most of the horticultural and floricultural segments in the states of Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat, UP and Haryana.

Specialty fertilizers (l00% water-soluble, fortified and customized fertilizers) can give immense benefit to enhance crop response to fertilizers. These fertilizer products are developed after experimentation to suit matrix of soil fertility status, type of crop, availability of water and climatic conditions. There are products available which include l00% water soluble fertilizers having combination of various nutrients, e. g. NPK. NP, NK, PK, NCa, KMgS, etc. These water-soluble grades of fertilizers leave no residue and are best suited for fertigation and foliar application. Twelve grades of 100% water-soluble fertilizers have been included in the Fertilizer Control Order (FCO). These fertilizers can also be enriched with micronutrients in chelated (Zn, Fe, Cu. Mn) or unchelated form. To get the maximum yields, crops should be provided nutrients at optimal rate throughout the growth cycle in the most efficient manner. This can be achieved to a large extent by use of 100% water-soluble fertilizer. These fertilizers are applied to crop plants through micro irrigation system (fertigation) or foliar application on the canopy of the leaves. Fertigation and foliar nutrition enable efficient use of nutrients, leading to better yields and quality. Specialty fertilizers can be put into following categories.

- **Foliar fertilizers:** These are soluble-fertilizers specially formulated for foliar application and easy absorption through plant foliage.
- **Organic Fertilizers:** These are processed organic based fertilizers suitable for organic farming and for improvement of soil texture.
- **Chlorine-free Fertilizers:** These are sulphate of potash based complex fertilizers, suitable for all type of crops especially chloride sensitive plants.
- **Slow-release Fertilizers:** These are either chemical slow-release fertilizers or special coated controlled release fertilizers for a longer lasting supply and availability of nutrients.
- **Fertigation Fertilizers:** These are fertilizers salt specially formulated for fertigation, suitable to use in systems where nutrients are directly supply to the roots.
- **Organic Plant Growth Enhancers:** These are seaweed based liquid organic fertilizers suitable for all type of crops and organic planting.

Specialty Fertilizers (SF) are fully water-soluble solid fertilizers having high content of primary nutrients with low salt index. They may or may not have secondary/micro-nutrients. These water-soluble fertilizers can be advantageously utilized for foliar feeding and Nutrigation/Fertigation, thus helping in precision agriculture. The simultaneous delivery of water and fertilizers to the crop through the irrigation system ensures that plant nutrients are directed to the active root zone. Nutrigation/Fertigation amplifies the nutritional and environmental benefits of this technique by using pure plant nutrients exclusively. A well-balanced Nutrigation program will satisfy the exact needs of the plant as they change along the season.

Customized Fertilizers

The fertilizers, which are catering to regional soil-crop-stage specific fertilizer requirements, can be classified under a new category called "Customized Fertilizers". All the grades, whether coming through complex or otherwise, should be termed as "Customized Fertilizers". Customised fertilizers facilitate the application of the complete range of plant nutrients in the right proportion and to suit the specific requirements of a crop at different stages of growth, and are more relevant under site specific nutrient management practices. The Central Fertilizer Committee has included customised fertilizers in the Fertilizer (Control) Order 1985, as a new category of fertilizers that are area/soil/crop specific. Fortified fertilizers are generally common fertilizers to which one or more specific nutrients have been added in order to increase their nutrient content and make them more versatile. At present there are 3 fortified products (Zincated urea -2% Zn, Boronated SSP – 0.18% B; and 10:26:26 fortified with 0.5% Zn and 0.3% Boron) included in the FCO. Depending on the soil test report, climate, water requirement, crop and seed chosen, a particular type of grade of fertilizer (customised fertilizer) is prescribed along with the recommended doses and time and method of application to get the best yield and maintain soil health. Customized formulated fertilizer, designed specifically to provide the level to nutrients for optimum plant growth and soil nutrient balance, completes the package.

Customized N-P-K water soluble fertilizers fortified with micronutrients

With the increase in food grain production, micronutrients elements in soils are getting depleted. Individual micronutrient fertilizer as simple inorganic salt or chelated compound capable of supplying each of these micronutrients are notified under FCO and are available in market. However, farmers find it rather inconvenient to procure and use several micronutrient fertilizers to provide their crops with balanced fertilization. In fact, one of the important reasons of imbalanced fertilization is unavailability of tailor-made soil-crop-stage specific customized fertilizer products.

Adoption of micro-irrigation systems has led to use of 100% water soluble N-P-K fertilizer. A variety of grades of these fertilizers have been notified under FCO. These are primarily imported, however, of late, few Indian fertilizer manufacturers have commenced its manufacturing, particularly 19+19+19 indigenously. These are basically "blends" of highly pure, 100% water soluble finished N, NP, NK and K fertilizers or compounds designed to provide crop-stage specific N-P-K ratios. As such the various water soluble grades can be used at different crop growth stages either alone or in appropriate combination to optimize the plant nutrient use for improved crop productivity.

Primarily being "blends" offer an opportunity for fortification with adequate amounts of micronutrients based on soil-crop need. In fact most of the N-P-K water soluble fertilizers of foreign origin are fortified with micronutrients. However, in India since these are notified only for its N-P-K contents under FCO, are normally not recognized as N-P-K water soluble fertilizers fortified with micro-nutrients. Besides fertigation, being 100% water soluble, these fertilizers are commonly used by farmers as foliar sprays.

Regulatory mechanisms of establishing quality control in the use of customized and specialty fertilizers

Fertilizer Control Order which was enacted by the Central Govt. in March, 1957 and was later revised in 1985, to regulate trade, price, quality and distribution of fertilizers in the country. Accordingly, the Ministry of Agriculture had set up a *Task Force on Balanced Use of Fertilizers*. One of the main recommendation of the Task Force was to encourage the development of alternative products with better efficiency, fortification of major fertilizers with appropriate grade of secondary and micro-nutrients, customized and value added fertilizer.

The DAC has already amended the FCO provisions and incorporated a new clause 20A, which permits commercial trial of any new fertilizer including customized fertilizer, which has not yet been approved under FCO. There is also a proposal for relaxing the procedure for approval of the fertilizers in FCO in the ensuing CFC meeting during October, 2006. This may enable the manufacturers to produce and sell any new product based on their label claim. As per the provision of Fertilizer Control Order, no person shall carry on the business of preparing any mixture of fertilizer including customized fertilizers except under and in accordance with the terms and conditions of Certificate of Manufacture granted to him under clause 15 & 16.

Under clause 13 of FCO, no person shall manufacture any mixture of fertilizers including customized fertilizers unless such mixtures confirms to the standards set out in the notification, issued by the State Govt. Therefore, no Certificate of Manufacture of mixture shall be granted by the Competent Authority in respect of any fertilizer which does not confirm to the standards set out in the notification of the State Govt. However, for obtaining Certificate of Mixtures of Customized Fertilizers, every person has to apply under clause 14 to the Registering Authority. On receipt of application, the Registering Authority shall by order in written, either grant or refuse to grant the Certificate of Manufacture in respect of any mixture of fertilizers including customized fertilizers within 45 days from the date of receipt of application under clause 15 (1). The conditions for grant of Certificate of Manufacture are prescribed under clause 16 of FCO.

Future Requirements

It should be emphasized that production of customised and water-soluble fertilizers needs to be encouraged. At present much of water-soluble fertilisers are imported. Similarly, only small quantity of customised fertilizers are produced and used. Companies are to be encouraged by bringing these products within the ambit of the Nutrient Based Subsidy (NBS) scheme.

The growth of micro irrigation system has helped use of l00% water-soluble fertilizers in agriculture. The use of 100% water-soluble fertilizers started with modest quantity of l200 tonnes in 1995 which has reached almost 40,000 tonnes now.

In the country like India having diverse soil, crop and climatic conditions, the sustainability of high crop production can be ensured through site-specific nutrient management that utilises specialty fertilizers, customized fertilizers, fortified and value added fertilizers with micro nutrients.

- The relevance of fortified fertilizers is more specific to the clearly delineated soil problems/nutrient deficiencies and their application can be extrapolated through GIS, GPS and satellite imageries in similar soil series.
- Extensive evaluation of new products both in short term and long term with regard to higher agronomic efficiency, economics and environmental consequences especially accumulation of some elements in toxic proportions before their commercial recommendation for any crop/cropping system.
- Establishment of quality standards for the fortified fertilizers and monitoring their use should go hand in hand with promotion of fortified fertilizer.
- Identification/development of alternative cheaper sources and processes is essential to make fortified fertilizers a reality for crop production.
- Extension workers should sensitize farmers in promoting the use of customized fertilizers since these are knowledge and technology based.
- Awareness creation and sensitization of farmers about the ground realities based on site-specific management is required that sets the demand for fortified fertilizer.

Acknowledgement

We acknowledge the input from Dr. Sanjay Srivastava, Principal Scientist and Dr. Pradip Dey, Principal Scientist and Project Coordinator, AICRP on STCR in the preparation of this manuscript.

References

Erisman, Jan Willem; MA Sutton, J Galloway, Z Klimont, W Winiwarter (October 2008). "How a century of ammonia synthesis changed the world". *Nature Geoscience* **1**(10): 636.

Stewart, W.M.; Dibb, D.W.; Johnston, A.E.; Smyth, T. J. (2005). "The Contribution of Commercial Fertilizer Nutrients to Food Production". *Agronomy Journal* **97**: 1.

I-6

Few Innovations at National Fertilizers Limited (NFL) Vijaipur Unit – A Bird's Eye View

A.K. LAHIRI

General Manager (In-Charge), National Fertilizers Limited, Vijaipur- 473 111,
Dist: Guna, Madhya Pradesh, India
E-mail : aklahiri@nfl.co.in

Vijaipur Unit of M/S National Fertilizers Limited, the second largest producer of Urea in the country, operates two Ammonia Plants –I &II @1750 & 1864 MTPD respectively and two Urea Plants-I & II @ 3030 & 3231 MTPD respectively. Over the last three decades, number of innovations have been successfully executed by the Unit. Glimpses of few such innovations are being brought out in this "Bird's Eye View".

Pioneer in manufacture of Neem Coated Urea (NCU), the Unit developed the Process and implemented the same totally In-house and with all Indian components. The Unit is capable of producing and produce, as per demand, 100% NCU.

The Unit, in association with IARI and MFL, developed three types of Bio-fertilizers and is in commercial production with an annual capacity of 700 MTPA.

The Sludge from Sewage Treatment Plant is used as manure for Floriculture and Horticulture. Afforestation is one of the prime objectives of the Unit and as per census, there are about 3.6 lakhs trees. The Township and the vacant area in the Plant has extensive forest area and abode of a variety of flora and fauna.

In the Urea Plant, the High Pressure Loop at 165 Kg/sq.cm (g) pressure, consists of Urea Reactor; Stripper (E-1); Carbamate Condenser (E-5); Carbamate Separator. In case of any Break down in E-5 or E-1, a shutdown of seven days used to be required to resume Urea Production. With experience gained, the procedures were reviewed In-house and modified. The shutdown period has been reduced to three to three & half days. This improved the On Stream Days and also reduced loss of Unproductive energy.

In the CO_2 export line from Ammonia Plant to Urea Plant, the pressure drop across the NRV at Ammonia Plant. Battery Limit was identified to be high leading to lower suction pressure at CO_2 Compressor at Urea Plant. The effect was load restriction and higher energy consumption. The NRV was removed as there is already one NRV at the CO_2 Blower discharge.

A reduction in power consumption to the tune of about 20% has been achieved by replacing the Glass Reinforced Plastic Blades of Cooling Tower Fans with Fibre Reinforced Plastic blades of Indian Make.

The Unit implemented a major energy savings scheme by recovering low grade heat from treated Process Condensate (coming out of Process Condensate Stripper installed in Ammonia Plant) in DM Water being used after polishing as Boiler Feed Water in Boilers. An energy saving of about 0.07 G Cals/MT of urea has been achieved. The Plate Type Heat Exchanger is of Indian Make.

In the post Capacity Enhanced scenario, the dew point of Instrument Air became a point of concern. Detailed In-house study revealed that additional Heat Sink is required to offer relief to the Driers. Accordingly one Heat Exchanger, that got redundant after implementation of Capacity Enhancement Revamp Project, was suitably modified and Installed with allied piping, etc. The total job was carried out In-house and the problem has been resolved.

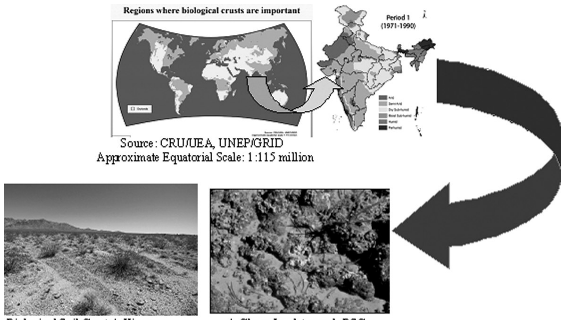
With a view to improve the vacuum of Surface Condenser of Process Air Compressor, so as to increase the capacity of the Steam Turbine and thereby that of the Air Compressor, additional Cooling Water lines were connected to the Surface Condenser to supply more Cooling Water. This has improved the vacuum by about 0.13 Kg/sq.cm (g) and increased the Air flow. The problem was analysed and executed In-house.

I-7

Biological Soil Crust Research and Restoration-Envisaging New Vistas of Basic and Applied Ecology for Arid and Semi-arid Regions of India

DIPANKAR SAHA, SHARMILA ROY, MAHESH KUMAR, N.R. PANWAR, C.B. PANDEY and M M ROY
ICAR-Central Arid Zone Research Institute, Jodhpur - 342 003, Rajasthan
E-mail : dipankar_icar@yahoo.com

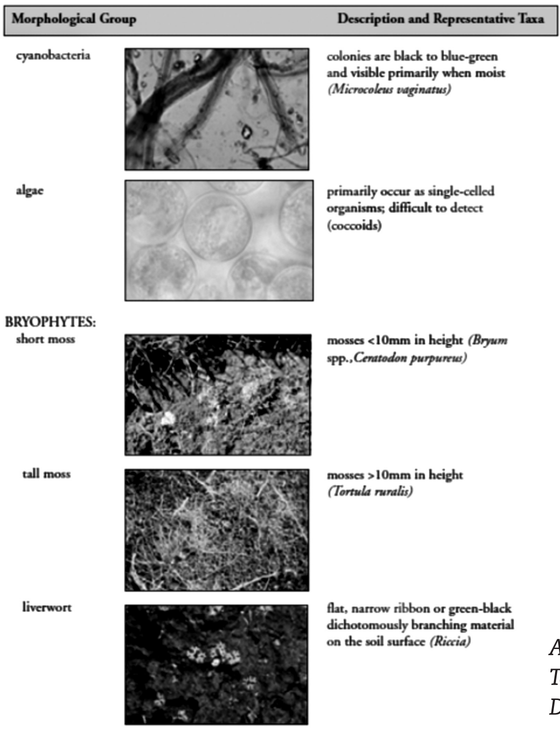
In arid and semi-arid regions throughout the world, vegetation cover is often sparse and these open spaces are usually covered by a highly specialized community of cyanobacteria, mosses, and lichens termed as Biological soil crusts (BSCs). The benefits of BSCs in the landscape include: soil building, erosion reduction, greater water capture and retention by soils, lessening of severity of dust storms, control of invasive plants through inhibition of germination, soil temperature amelioration, help in soil microbial growth, moderation of fire events through reduction of fine fuels, and improving perennial plant growth.



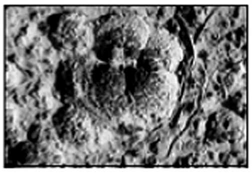
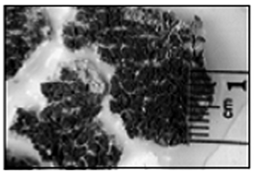
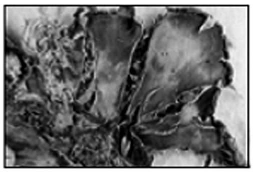
Biological Soil Crust-A View   A Closer Look towards BSCs

Composition

Crusts are predominantly composed of cyanobacteria (formerly called blue-green algae), green and brown algae, mosses, and lichens. Liverworts, fungi, and bacteria can also be important components. The various morphological groups for biological soil crust components with examples of common taxa or groups are depicted below.

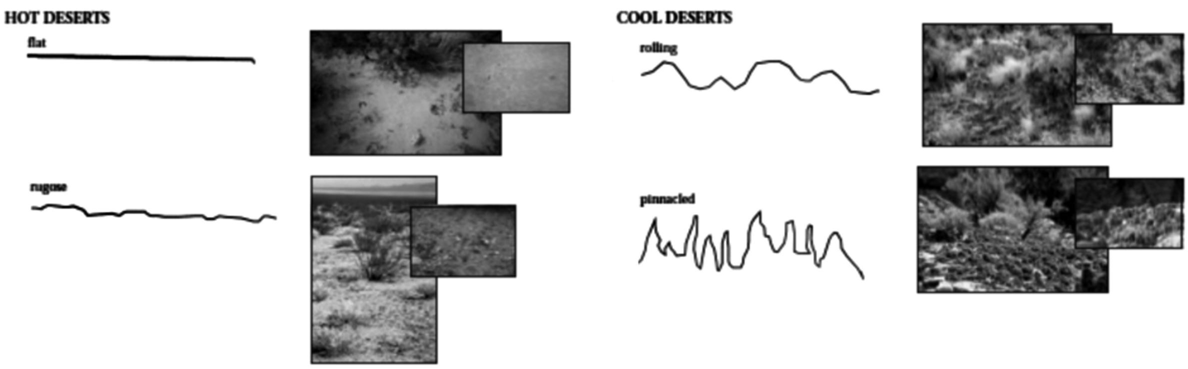


Adapted from Belnap et al., 2001. Technical Reference 1730-2 of the U.S. Department of the Interior

Morphological Group		Description and Representative Taxa
LICHENS:		
crustose lichen		crust-like growth tightly attached to the substrate *(Lecanora muralis)*
gelatinous lichen		blackish, jelly-like when moistened *(Collema coccophorum)*
squamulose lichen		discrete flakes that are round or ear-shaped, convex or concave, and often have lobed margins *(Psora decipiens)*
foliose lichen		"leafy," tending to be flattened with definite upper and lower surfaces *(Peltigera occidentalis)*
fruticose lichen		three-dimensional, ropey or branching, without definite upper and lower surfaces *(Aspicilia hispida)*

Adapted from Belnap et al., 2001. Technical Reference 1730-2 of the U.S. Department of the Interior

Crusts are formed by living organisms and their by-products, creating a surface crust of soil particles bound together by organic materials. Aboveground crust thickness can reach up to 10 cm. The general appearance of the crusts in terms of color, surface topography, and surficial coverage varies. These crusts are characterized by their marked increase in surface topography, often referred to as pinnacles or pedicles. The process of creating surface topography, or pinnacling, is due largely to the presence of filamentous cyanobacteria and green algae. These organisms swell when wet, migrating out of their sheaths. After each migration new sheath material is exuded, thus extending sheath length. Repeated swelling leaves a complex network of empty sheath material that maintains soil structure after the organisms have dehydrated and decreased in size. Frost heaving, subsequent uneven erosion, and lack of surface plant roots results in high pedicles. Biological soil crust forms based on temperature characteristics of the environment which is depicted below.



BSCs given their extraordinary abilities to survive desiccation and extreme temperatures (up to 70 1C), high pH, and high salinity, have been found in desert areas all over the world and may constitute as high as 70% of the living covers in some plant communities.

Ecosystem function and services

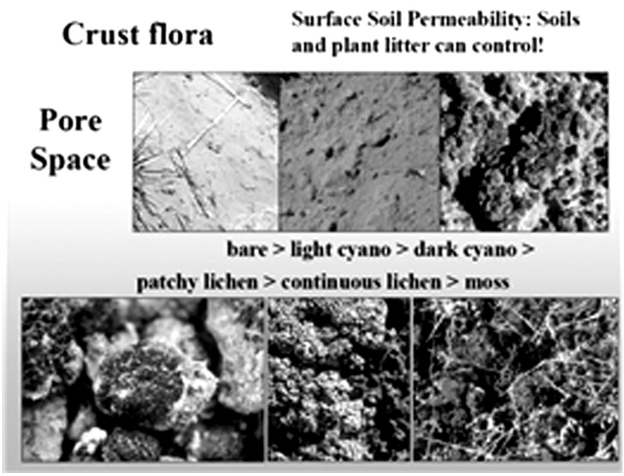
Crusts play an important role in the environment.

(i) Contributing to Fertility : BSC can increase weathering of parent materials. Soil surface biota retain dust having nutrients like N, P, K, Mg, Na, Mn, Cu and Fe

(ii) Soil Stability : Crust-forming cyanobacteria have filamentous growth forms that bind soil particles.

(iii) Water Infiltration : Crusts can alter water infiltration.

(iv) Effects on Plant Germination and Growth : Studies investigating the role of crusts in plant germination have had varied results. Soil crusts reduce soil movement, and this may limit passive burial and germination of large-seeded exotic plants like *Bromus tectorum* (cheatgrass). Many studies have shown increases in survival and/or nutrient content in crust-covered environments as opposed to bare soil.



Response to disturbance

Crusts are well adapted to severe growing conditions, but poorly adapted to compressional disturbances. Direct damage to crusts usually comes in the form of trampling by humans and livestock or vehicles driving off of roads. Disturbance to soil surfaces in arid regions can lead to large soil losses.Several native rangeland shrubs (*Artemisia tridentata*, *Atriplex confertifolia*, and *Ceratoides lanata*) may have allelopathic effects on the nitrogen-fixing capabilities of crusts, potentially lowering nitrogen fixation by 80 percent. Fire is a common damaging occurrence in many regions where microbiotic crusts grow. Full recovery of crust from disturbance is a slow process, particularly for mosses and lichens. However, there are means to facilitate recovery.

Restoration and Recovery

Much of the conceptual backbone of restoration ecology derives from ecological succession theory. Collectively, BSCs have several life history traits that enhance their ability to colonize severe environments: (1) wind dispersal of small propagules; (2) desiccation tolerance; (3) several photoprotective pigments; (4) N fixation; and (5) C fixation. BSCs are potentially important in secondary succession, though this hypothesis has not been extensively studied.

Envisaging New Vistas of Research

- The species composition and general distribution of soil crusts in different habitats and also looking towards the spatial distribution pattern of biological soil crusts is of utmost importance of basic and applied ecological research for the time to come in Indian arid and semi-arid regions.
- We intend this article to stimulate further research and discussion on the critical topic of biological soil crusts.

- Most studies world wide up to now have focused on single roles (e.g., carbon fixation) or single types of biological crust communities.
- The challenging next step will be investigating the integral roles of biological soil crusts within ecosystems and documenting and quantifying their ecosystem services.
- This will require concerted and coordinated efforts among different scientific sub-disciplines such as collections, conservation, taxonomy, biodiversity informatics, physiology, carbon and nutrient cycling, and hydrology.
- Of critical importance is gaining an understanding of how the ecological roles of biological soil crusts respond and how the ecosystem services they provide are altered as land use and climate changes around them.
- To accomplish this vision, we need greater and continued collaboration and networking among scientists, as well as sharing of information with the public and managers.
- We look forward to similar efforts in the future, as research continues on this fascinating and critical component of arid and semi-arid ecosystems.

Suggested Readings:

Ahti, T., and J. Oksanen. 1990. Epigeic lichen communities of the taiga and tundra regions. Vegetatio **86**: 39–70.

Belnap, J. 1994 Cryptobiotic soil crusts: basis for arid land restoration (Utah). Restor Manage Notes **12**: 85–86

Belnap, J. Eldridge, D.J., 2001. Disturbance and recovery of biological soil crusts. In: Belnap, J., Lange, O.L. (Eds.), Biological Soil Crusts: Structure, Function, and Management. Springer, Berlin, pp. 363–384.

Belnap, J. Kaltenecker JH, Rosentreter R, Williams J, Leonard S, Eldridge D (2001) Biological soil crusts: ecology and management. USDI Bureau of Land Management National Science and Technology Center, Tech. Ref. 1730–2.

Belnap J 2003 Biological soil crusts and wind erosion. In: Belnap J, Lange OL (eds) Biological soil crusts: structure, function, and management, ecological studies. Series 150. Berlin, Springer, pp 339–347.

Belnap, J. 2003. The world at your feet: desert biological soil crusts. Frontiers in Ecology and the Environment **1**, 181–189.

Booth, W. E. 1941. Algae as pioneers in plant succession and their importance in erosion control. American Journal of Botany **22**: 38–46.

Bowker, M. A., S. C. Reed, J. Belnap, and S. L. Phillips. 2002. Temporal variation in community composition, pigmentation, and Fv/Fm of desert cyanobacterial soil crusts. Microbial Ecology **43**: 13–25.

Bowker, A. Matthew. 2007. Biological Soil Crust Rehabilitation in Theory and Practice: An Underexploited Opportunity. Restoration Ecology Vol. 15, No. 1, pp. 13–23.

Campbell, S. E. 1979. Soil stabilization by a prokaryotic desert crust: implications for Pre-Cambrian land biota. Origins of Life **9**: 335–348.

Chapin, F. S. III, L. R. Walker, C. L. Fastie, and L. C. Sharman. 1994. Mechanisms of primary succession following deglaciation at Glacier Bay, Alaska. Ecological Monographs **64**:149–175.

Clements, F. E. 1916. Plant succession: analysis of the development of vegetation. Carnegie Institute, Washington, D. C.

Connell, J. H., and R. O. Slatyer. 1977. Mechanisms of succession in natural communities and their roles in community stability and organization. The American Naturalist **111**: 1119–1144.

Danin, A., and M. G. Barbour. 1982. Microsuccession of cryptogams and phanerogams in the Dead Sea area, Israel. Flora **172**: 173–179.

DeFalco, L. A., J. K. Detling, C. R. Tracy, and S. D. Warren. 2001. Physiological variation among native and exotic winter annual plants associated with microbiotic crusts in the Mojave Desert. Plant and Soil **234**: 1–14.

Eisele, K. A., D. S. Schimel, L. A. Kapustka, and W. J. Parton. 1989. Effects of available P and N:P ratios on non-symbiotic dinitrogen fixation in tallgrass prairie soils. Oecologia **79**: 471–474.

Eldridge, D.J., Greene, R.S.B., 1994. Microbiotic soil crusts: a view of their roles in soil and ecological processes in the rangelands of Australia. Australia Journal of Soil Research **32**, 389–415.

Elmarsdottir, A., A. L. Arado´ ttir, and M. J. Trlica. 2003. Microsite availability and establishment of native species on degraded and reclaimed sites. Journal of Applied Ecology **40**: 815–823.

Evans, R. D., and J. R. Ehleringer. 1993. A break in the nitrogen cycle of aridlands? Evidence from *d*15 N of soils. Oecologia **94**: 314–317.

Friedmann, E.I., Galun, M., 1974. Desert algae, lichens and fungi. In: Brown, G.W. (Ed.), Desert Biology II. Academic Press, New York, pp. 165–212.

Harper K T, Marbel G R. 1988. A role for nonvascular plants in management of arid and semi-arid rangeland. In: Tueller P T. Vegetation Science Applications for Rangeland Analysis and Management. Dordrecht: Kluwer Academic Publishers, 135-169.

Hawkes, C. V. 2004. Effects of biological soil crusts on seed germination of four endangered herbs in a xeric Florida shrubland during drought. Plant Ecology 170:121–134.

Hunt, M. E., G. L. Floyd, and B. B. Stout. 1979. Soil algae in field and forest environments. Ecology **60**: 362–375.

Kapustka, L. A., and E. L. Rice. 1976. Acetylene reduction (N2-fixation) in soil and old field succession in central Oklahoma. Soil Biology and Biochemistry **8**: 497–503.

Karnieli, A., Kokaly, R., West, N.E., Clark, R.N., 2001. Remote sensing of biological soil crusts. In: Belnap, J., Lange, O.L. (Eds.), Biological Soil Crusts: Structure, Function, and Management. Springer, Berlin, pp. 431–455.

Kurina, L. M., and P. M. Vitousek. 1999. Controls over the accumulation and decline of a nitrogen-fixing lichen, Stereocaulon vulcani, on young Hawaiin lava flows. Journal of Ecology **87**: 784–799.

Lewis Smith, R. I. 1993. The role of bryophyte propagule banks in primary succession: case-study of an Antarctic fellfield soil. Pages 55–78 in J. Miles, and D. W. H. Walton, editors. Primary succession on land. Blackwell Scientific Publishers, Oxford, United Kingdom.

Lange, O. L., A. Meyer, H. Zellner, and U. Heber. 1994. Photosynthesis and water relationships of lichen soil crusts: field measurements in the coastal fog zone of the Namib desert. Functional Ecology **8**: 253–264.

LukesÇova, A. 2001. Soil algae in brown coal and lignite post-mining areas in central Europe (Czech Republic and Germany). Restoration Ecology **9**: 341–350.

Mitchell, D. J., M. A. Fullen, I. C. Trueman, and W. Fearnhough. 1998. Sustainability of reclaimed desertified land in Ningxia, China. Journal of Arid Environments **39**: 239–251.

Oliver, M. J., B. D. Mishler, and J. E. Quisenberry. 1993. Comparative measures of desiccation-tolerance in the Tortula ruralis complex. I. Variation in damage control and repair. American Journal of Botany **80**: 127–136.

Prave, A. R. 2002. Life on land in the Proterozoic: evidence from the Torridonian rocks of northwest Scotland. Geology **30**: 811–814.

Rayburn, W. R., R. N. Mack, and B. Metting. 1982. Conspicuous algal colonization of the ash from Mount St. Helens. Journal of Phycology 18:537–543.

Tateno, R., S. Katagiri, H. Kawaguchi, Y. Nagayama, C. Li, A. Sugimoto, and K. Koba. 2003. Use of foliar 15N and 13C abundance to evaluate effects of microbiotic crust on nitrogen and water utilization in Pinus massoniana in deteriorated pine stands of south China. Ecological Research **18**: 279–286.

Uchida, T., N. Ohte, A. Kimoto, T. Mizuyama, and L. Chnaghua. 2000. Sediment yield on a devastated hill in southern China: effects of microbiotic crust on surface erosion process. Geomorphology **32**: 129–145.

Watanabe, Y., J. E. J. Martini, and H. Ohmoto. 2000. Geochemical evidence for terrestrial ecosystems 2.6 billion years ago. Nature **408**: 574–578.

West N E. Structure and function of microphytic soil crusts in wildland ecosystems of arid to semi-arid regions. Advances in Ecological Research, 1990, **20**: 179-223.

Worley, I. A. 1973. The ‘‘black crust’’ phenomenon in upper Glacier Bay, Alaska. Northwest Science **47**: 20–29.

Wynn-Williams, D. D. 1993. Microbial processes and initial stabilization of fellfield soil. Pages 17–32 in J. Miles, and D. W. H. Walton, editors. Primary succession on land. Blackwell Scientific Publishers, Oxford, United Kingdom.

I-8

Constraints and Strategies for Enhancing Soil Quality in Arid Western Rajasthan

MAHESH KUMAR, SHARMILA ROY, N. R. PANWAR, P. SANTRA and DIPANKAR SAHA

ICAR-Central Arid Zone Research Institute, Jodhpur

E-mail : mahesh.veer523@gmail.com

Introduction

Soil quality, though realized synonymous to soil health, is fitness of soil for specific purpose (Carter *et al.* 1997) adjudged by the factors chosen for soil classification, soil suitability and land capability (Singer & Eving, 1999). It examines spatial and temporal variations induced by land use, policy, or management, based on soil physical, chemical and biological indicators. Soil organic carbon (SOC) is most reliable, versatile and easily assessable indicator, encompassing interactive effect of several indices.

Plateuing or decreasing trends of crop yield at current level of management indicates declining soil quality in arid and rainfed ecosystem of India, covering more than 65% (92 mha) of cultivable land, spread over in 18 states and 12 agro ecological regions. Wind and water erosion, drought and desertification, salinity and sodicity, paradigm shift in land use, nutrient depletion and adoption of intensive cultivation practices aimed at maximizing crop productivity are cause of soil quality decline. Erratic rainfall and exploitation of land, water and vegetation resources by ever increasing human and livestock population further intensifies the problems of deteriorating soil quality. These are the emerging issues which call for comprehensive strategies of land management including erosion control, alternate land use plan, residue management, minimum tillage, intercropping, nutrient and water management through organic, inorganic and biofertilizers and diversification of agriculture for enhancing soil quality in a system approach.

Arid Western Rajasthan

Arid region of India is spread over 38.7 million hectare, comprising of 31.7 million in hot and 7 million hectares in cold arid region. About 82% of hot arid region lies between $22^0$30' to $32^0$05' N latitude and $68^0$05' to $70^0$45' E longitude, in western Rajasthan and the adjoining northern and southern part of Gujarat, Haryana and Punjab. These together account for 99.3% of arid region (Entisol and Aridisols are the dominant soil orders) with very low available water capacity, inadequate nitrogen and low available phosphorus.

Extensive fallowing undulating topography and severe windstorm are the major reasons of nutrition depletion. Ground water is deep and is usually brackish, declining at alarming rate due to excessive withdrawal for irrigation. The region is mostly mono cropped and double cropping is being practiced extensively in canal and tubes well command area. Pearl millet, moth, guar and *Kharif* pulses are the major crops. Animal husbandry offers a dependable source of livelihood and the fodder requirements are met by native grazing lands.

Soil Quality Scenario

Soil organic carbon, phosphorus and potassium stock for a meter soil profile in the year 2002 on 22860 km^2 areas was compared with the baseline data of 1975 under pearl millet based production system of arid Rajasthan. Soil organic carbon, phosphorus and potassium stock depletion were 9.7, 17.2and 9.0%, respectively in a span of 27 years. Equivalent CO_2 emission was 11.49Tg, while CO_2 sequestration was 0.37Tg (as inorganic carbon) during the period. SOC loss was 19.7% and 17.7% in sandy and gravelly soils, while sandy loam deep soils it was 0.9%. Sandy and sandy loam soils together emitted around 91% of CO_2, while latter could contain the highest (91%) of sequestered CO_2 as inorganic carbon. In arid western Rajasthan However, salinity and pH level were also increased with corresponding decrease in bulk density (Mahesh Kumar *et al.* 2009; Singh *et al.* 2007).

Causes of soil quality deterioration

Drought and desertification

The immediate effect of drought is the reduction of organic residues while it indirectly accentuates the soil erosion and enhances inorganic carbon sequestration. The inorganic carbon sequestration cause SOC degradation and decomposition (Pal *et al.*, 1999). In arid western Rajasthan drought occurs once in 2.5 years may be one of the reasons for soil health deterioration as evident from SOC loss by 9.7% from 1975 to 2002.

Soil erosion

Erosion was one of the dominating factors, prompting soil organic carbon depletion in the arid region (Singh *et al.*, 2006). SOC loss was reported about 50% from wind-eroded and cultural able wasteland as compared to their non-eroded counterpart (Narain, 2001).

Cropping with imbalanced fertilization

Application of nutrient lower than the recommended doses decreased the soil fertility, which resulted in sparse plant cover and low vegetative inputs to soils. The consumption of plant nutrients (NPK) per hectare in India during 2012-13 has 128 kg/ha though there is wide variation from state to state varying from 250 kg/ha in Punjab, 212 kg/ha in Bihar, 208 kg/ha in Haryana and 58 kg/ha in Rajasthan (37 kg/ha in arid Rajasthan). In arid and semi-arid areas removal by crop was far more than the added through fertilizers. Improper balance of fertilizer induces depletion of phosphorus and potassium by 7.7 and 13.4 %, respectively in arid soils of Jodhpur from 1975 to 2002 (Singh & Narain, 2005).

Shifting cropping patterns

A paradigm shift of cropping pattern has taken place in rainfed areas, replacing low water requiring crops by commercial crops in search of high productivity. Intensive agriculture appears to be non-sustainable in the absence of holistic land management and triggers soil health deterioration through initiation of wind and water erosion. Perpetual explosive view of this kind is a serious threat to soil health deterioration, which continues to spread at the rate of 6 mha per annum (FAO/UNEP, 1984).

Poor quality ground water

Ground water in general sodic/saline is in the entire arid region (safe limit for irrigation is < 2me/l, Richards 1954). In the situation of high sodicity, sandy soils release silica on drying that seals the soil pores on precipitation with iron oxides. Under the situation soils acquire unusual hardness; water infiltration reduces to greater extent and workability of soils becomes very difficult. The emergence of seedling, growth of crop and yield of harvest were severely affected (Joshi *et al.* 1992). Even RSC water of 5 me/l has induced high sodicity in the rainfall zone of 200 to 300 mm (Joshi and Dhir 1989). However, Manchanda *et al.* (1982) demonstrated the suitability of irrigation water of RSC, 4.5 to 13.8 me/l in loamy sand soils for the rainfall zone of 400 mm and above. The water (RSC, 10-20 me/l and SAR 20-35) used for the irrigation raised soil pH and exchangeable sodium percentage. Large areas irrigated with high RSC water have gone out of cultivation. These situations are also not congenial for enhancing soil organic carbon.

Industrial effluents

Urbanization and industrialization are detrimental to soil health. Inappropriate management of city garbage, sewage sludge, sewage water, industrial effluents etc. contaminated soils. Discharge from textile industry increased ECe, SAR and ESP of treated soils from 2.5 to 193.6 dS/m, 24 to 485 and 25 to 87, respectively. Chloride and sulphate increased from 14.5 to 28.30 and 3.0 to 107 me/l, respectively. The quality of soil water was also found deteriorated due to increasing in total dissolve salts (TDS), SAR and chlorides by 50, 10 and 40 times in the same sequence (CAZRI, 1975).

Strategies for improving soil quality

Erosion control

Soil conservation methods like windbreaks, shelterbelts and sand dune fixation. An increase of SOC density from 850 to 1400 $kgha^{-1}$ during 1994 to 1999 was noted beneath the shelterbelts by Solanki *et al.*, 1999. Increased level of nitrogen, phosphorus and potassium has also been reported in the area protected under these shelterbelts.

Alternate land use system

Forestry, horticulture, agri-horticulture, silvipostoral, agri-silvipostoral and intercropping improve soil health compared to annual cropping system. A higher soil organic carbon density (32 $Mgha^{-1}$) has been reported under forestry and horticulture (31 $Mgha^{-1}$) followed by cotton+legume (30 $Mgha^{-1}$) and cotton (28 $Mgha^{-1}$) based cropping system, respectively in Vertisols (IISS, 2002-03). Agri-horticulture system increased SOC from 600 to 1600 $kgha^{-1}$ during 1989 to 95 at Jhansi, while sivipostoral and agri-silvipostoral system increased SOC by 400 and 150% over the control in a span of 5 years. Nitrogen, phosphorus and potassium in latter were also increased by 175,125 and 165% (Solanki *et al.*, 1999).

Afforestation

Afforestation on degraded land considerably improved soil health. The *Prosopis juliflora* and *Tecomella arjuna* plantation on a highly degraded soil, lowered pH to 8.03 and 8.15, from 10.3 and increased SOC from 0.12% to 0.46% and 0.35%, respectively (Singh and Singh, 1993). While, *E. Tereticornis* and *Acacia nilotica* reduced pH to 9.18 and 9.03 respectively and SOC was reported to increase 0.21% and 0.32% respectively.

Legume based crop rotation

Incorporation of legume in the cropping system is beneficial for maintaining/enhancing of soil health. Pearl-millet- moth bean rotation of four years in arid Rajasthan maintains initial SOC of 0.22 and 0.14% in surface and subsurface horizons, while a rotation involving three years of moth or cluster bean with a year of pearl millet increased SOC. A rotation of fallow with two years of legume and a year of pearl millet also brought about the similar effects (Kumar *et al.*, 1997).

Reclamation of saline and sodic soils

Saline and sodic soils and improvement in soil drainage enhance soil health. A combined application of FYM (20 tons/ha) with gypsum in highly saline sandy loam soils (ECe 25 to 80 dS/m in 0-15 cm), having high salty ground water (EC 10-40ds/m) at Sampala in Haryana significantly removed the salt (decreased ESP from 89 to 50) and increased crop yields (Yadav, 2003). Use of salt-tolerant crops, low-volume irrigation, and various management techniques are other options for minimizing the effects of salts. Alternatively biodrainage may also be used.

Tillage and residue management

Residue management and minimum tillage are also important techniques for raising SOC (Yadav *et al.* 2003). A higher pearl millet yield and increased SOC by incorporating cluster bean and moong bean residue along with nitrogenous fertilizers was reported in arid Rajasthan (Aggrawal *et al.*, 1997). An Increase in SOC and hydrolysable nitrogen was also reported by practicing no tillage (Singh *et al.*, 1998)

Integrated use of organic and inorganic fertilizers

Organic and inorganic fertilizers applications together have been found beneficial for enhancing soil health at various locations. An increase of soil organic carbon by 1.10, 0.88, 5.54, 0.16 and 0.16 Mg/ha has been observed under rice-wheat, soybean-wheat, sorghum-wheat, and finger millet-wheat and rice-wheat system in 5 to 30 years of duration (CRIDA, 2003-04). However, sorghum-wheat cropping sequence sequestered the highest SOC than any other land use system with adequate fertilization, indicating the suitability of sorghum-wheat sequence for Vertisols of Maharastra. Suitability of pearl millet in sandy soils of arid agro ecosystem of Rajasthan (Kumar *et al.*, 2004) was also investigated with adequate fertilizer application increased soil organic carbon.

Diversification of agriculture

Diversification of crops integrating crops and livestock in the farming system acts as buffer in farm against deterioration of soil health and also reduces economic risk. Pasture and forage crops included in rotation enhance soil quality and reduce erosion; livestock manure, in turn contributes to soil fertility.

Conclusion

Organic carbon has been considered as the most crucial factor for maintaining and monitoring soil health. The factors, such as wind and water erosion, inappropriate land use pattern, extensive fallowing, drought and desertification responsible for declining soil health. The efficiency of various technological options, including erosion control measures, conservation tillage, irrigation management, alternate land use and diversification of agriculture, for enhancing soil health is described in length. Alternate land use plan for a window area, consisting of crops, tress and grasses are suggested. Application of FYM, biofertilizers along with proper dose of macro and micronutrients are stressed. There is a need of adoption of integrated approach including gypsum and locally available organic materials for ameliorating sodicity. Biodrainage should be preferred for minimizing the effect of salinity.

Suggested Readings :

Aggrawal, R.K. Parveen-Kumar and Power, J.F., 1997, Use of crop residue and manure to conserve water and enhance nutrient availability and pearl millet yields in arid tropical region. *Soil Tillage Research* **41**: 43-51.

Carter, M.R., Gregorich, E.G., Anderson, D.W., Doran, J.W., Janzen, H.H. and Pierce, F.J., 1997, Concept of soil Quality and their significance. In Soil Quality for Crop Production and Ecosystem Health (Gregorich, E.G and Cater, M.R eds.), Elsevier, Amsterdam, 448P.

Carter, M.R., Andrew, S.S. and Drink water, 2004, Systems approaches for improving soil quality. In *Managing Soil Quality; Challenges in Modern Agriculture* (Schjønning.P. Elmholt, S. and Christensen, B.T. eds.), CAB International, pp. 261-280.

CAZRI, 1997, Report on impact Assessment of Industrial Effluents along the Jojari, the Bandi and the Luni rivers in Pali District of Rajasthan. Central arid Zone Research Institute Jodhpur.

CRIDA, 2004, Annual Report, *NATP for Rainfed Agro ecosystem*. Central Research Institute of Dry land Agriculture, Hyderabad India.

FAO/ UNEP (1984) Map of Desertification Hazards, UNEP, Nairobi, Kenya.

Joshi, D. C. and Dhir, R. P. 1991. Rehabilitation of degraded sodic soils in an arid environment by using residual na-carbonate water for irrigation, Arid Soil Research and Rehabilitation, **5**: 3, 175-185

Joshi, D.C., and Dhir, R. P. 1994. Amelioration and management of soils irrigated with sodic water in the arid region of India. *Soil Use and Management* **10**: 30-34.

Joshi, D. C., Tibor, Toth and Diana Sari. 2002. Spectral reflectance characteristics of Na-carbonate irrigated arid secondary sodic soils. *Arid Land Research and Management* **16**: 161-176.

Kumar, P., Aggrawal, R.K and Power, J.F., 1997, Cropping System: Effects on soil quality indicators and yield of pearl millet in arid region. *American Journal of Alternate Agriculture* **14**: 178-184.

Kumar, P., Joshi, N.L., Singh, D.V and Saxena, Anurag, 2004, Evaluation of pearl millet production systems for high yields and net carbon accumulation in soils and crop. *Journal of the Indian Society of Soil Science* **52**: 95-99.

Lal, R. and Kimble, J.M., 2000, Conservation tillage; prospect for the future. Proceedings of International Conference on Managing Natural Resources for Sustainable Agricultural Production in the 21st Century, New Delhi, India, pp. 116-125.

Mahesh Kumar, Praveen-Kumar, Bohra, P.C., 2009a. Effect of land use systems on soil properties and relationship organic carbon and available nutrients. Ann. Arid Zone. **48**, 25-38.

Manchanda, H. R., Sharma, S. K., Malik, H. R. and Suneja, B. K. 1985. Sodic water for wheat. *Indian Farming* **35**: 11-16.

Narain, P., 2001, Strategies of carbon sequestration on degraded soils. *Journal of the Indian Society of Soil Science* **49**: 634-644.

Pal, D.K., Dasog, S., Vadivelu, S., Ahuja, R.L., Bhattacharyya, T., 1999,Secondary calcium, carbonate in soils of arid and semi-arid regions of India. In *Climate Change and Pedogenic Carbonates* (Lal, R., Kimble, J.M., Stewart, B.A. eds.). CRC Press, Boca Raton, FL

Singh, S.K., Kumar, M., Sharma, B.K., Tarfadar, J.C., 2007b. Depletion of organic carbon, phosphorus and potassium stock under pearl millet based cropping sequence in arid environment of India. *Arid Land Research and Management* **21**: 119-131.

Singh, S.K., Singh, A.K., Sharma, B.K., Tarafdar, J.C., 2007a. Carbon stock and organic carbon dynamics in soils of Rajasthan. *Journal of Arid Environment* **68**: 408-421.

Singh, G. and Singh, N.T 1993. Mesquite for Vegetation of Salt Affected Soils (Research Bulletin,No. 18). Central Soil Salinity Research Institute, Karnal, India.

Singh, S.K., Singh, R.S., Shyampura, R.L. and Pratap Narain, 2005, Organic and inorganic carbon stock in soils of Rajasthan. *Journal of Indian Society of Soil Science* **53**: 281-287.

Singh, Y.V., Parveen Kumar, Lodha, S and Agrawal, R.K. 1998. Consolidated Work Report on Indo US Project. Central Arid Zone Research Institute Jodhpur, India.

Solanki, K.R., Bisaria, A.K and Handa, A.K., 1999, Sustainable Rehabilitation of Degraded land through Agro forestry. National Research Center for Agro forestry, Jhansi, India.

Yadav, J.S.P., 2003, Managing soil health for sustained high productivity. *Journal of the Indian Society of Soil Science* **51**: 448-465.

I-9

Soil Fertility Management Strategies for Maximizing Jute Production

S.P. MAZUMDAR, A.R. SAHA, D.K. KUNDU, B. MAJUMDAR, D. GHOSH and P. G. KARMAKAR
ICAR-Central Research Institute for Jute and Allied Fibres, Barrackpore
E-mail : sonalimazumdar110@gmail.com

Jute, a natural fibre, is considered as the golden fibre of India. Jute is eco-friendly, biodegradable and has much higher CO_2 assimilation rate which is creating an opportunity for the survival and growth of jute industry in the era of environmental concern. Global production of jute and allied fibres is around 3.0 million tonnes, 92.5% of which comes from India and Bangladesh alone. India ranks first in area and production of jute followed by Bangladesh and earns approximately Rs. 1400 crores/annum through export of jute goods mainly Jute diversified products (JDPs). India has produced approximately 108 lakh bales of jute in the last fiscal. In our country, jute growing tracts have been classified in to nine agro-climatic zones comprising the states of West Bengal, Assam, Odisha, Bihar, Uttar Pradesh, Meghalaya and Tripura. The potential yield of jute is up to 40 q/ha in Indian climatic condition. There is a yield gap between potential yield and national average yield. Therefore, there is a scope to bridge the yield gap through proper nutrient management and other agronomic practices. Apart from all the factors responsible for increased production, fertilizer is known to be a powerful productivity-enhancing input. India has witnessed rapid growth in fertilizer consumption and country is now the second largest use of fertilizers in the world next to China. Fertilizer use increased by about 432 times from 1951-52 to touch a level of 28.1 mt of $N+P_2O_5+K_2O$ in 2011. No doubt, consumption of fertilizer in the country over the years has increased considerably, there still exists an inter crop, inter district, inter area and inter state (kg/ha) disparity in the use of fertilizer pattern. Fertilizer consumption (per ha) is still inadequate and mining of nutrients from the soil continues to take place at an alarming rate. The mining of nutrients from the soil on continuous basis coupled with inadequate and imbalanced use of fertilizers has resulted in increasingly deficiencies of secondary and micronutrients resulted depletion of soil fertility, deterioration in soil health and decline in factor productivity which are seriously affecting the economic growth of the country as a whole. The product pattern of fertilizer use has undergone a sea change from low analysis fertilizers to high analysis fertilizers. Due to increasing prices of fertilizers, particularly those of phosphate and potassic fertilizers, nowadays farmers are more inclined towards the use of urea only. As a result, jute crop is not getting balanced fertilisation which finally is leading to lower productivity of jute crop. The response of jute to applied N, P and K varies with soil type, fertilizer dose, time of application, location, crop combinations, etc. which indicates that blanket fertilizer recommendation will affect the soil fertility as well as the cost of production of fibre.

Soil fertility constraints in jute production

The jute growing soils are low to medium in N, low to very high in P with P fixation capacity ranges between 41-86% and medium in K content. It was reported that deficiency of S in different jute growing soils is one among several constraints in jute production. In a study conducted at south Dinajpur to analyse the production constraints of West Bengal, it was observed that the status of secondary (S) and micronutrients (B and Zn) were deficient and application of S and micronutrients increased fibre yield of jute in North Bengal. Conduction of long term fertilizer experiment at CRIJAF, Barrackpore for 43 years with jute rice-wheat cropping system pointed out that yield decline were more in sulphur free treatment.

Nutrient requirements of Jute

Studies showed that a crop of *olitorious* jute (cv. JRO 632) producing 3.1 t /ha fibre removed 65 kg N, 23 kg P, 136 kg K, 91.4 kg Ca and 20 Kg Mg /ha while *capsularis* jute (cv. JRC 212) producing 2.0 t /ha fibre removed 84 kg N, 16.2 kg P, 97.5 kg K, 85.7 kg Ca and 29.6 kg Mg /ha respectively. Further studies revealed that *olitorious* jute removed 60 kg N, 24 kg P and 142 kg K/ha in acid soils of Coochbehar. In general, removal of sulphur by *capsularis* jute is higher than *olitorious* jute. Results also revealed that micronutrient uptake by *capsularis* varieties was almost double than that of the *olitorius* varieties and maximum uptake was observed with white jute cultivar.

Nutrient management effects on jute production

Major nutrients

Nitrogen is the major yield determining nutrient for jute crop. Ammonium sulphate was found to be the better source of nitrogen for jute. It was also ascertained that coated urea was better than uncoated urea. Both urea and ammonium sulphate top dressing was more effective than basal application. Urea @ 20 kg N ha^{-1} + Gliricidia compost @ 2.5 tonnes ha^{-1} (~20 kg N ha^{-1}) yielded on par with 40 kg N ha^{-1} applied as urea. On an average, about 15 tonnes of green jute leaves per hectare are added in to the field during growing period from the shedded leaves addition of nutrients. The uptake of phosphorus by jute crop was observed to be more than what was present in the soil solution. Jute does not generally respond to potassium fertilization, to the same extent as N or P. Split (two) application of potassium may be advocated to prevent loss of potassium fertilizer, improve fibre yield, K uptake, K utilization and K use efficiency. Recommended dose of NPK for *olitorious* jute is 40:20:20 and that for *capsularis* jute is 60:30:30. But from LTFE experiment at CRIJAF, Barrackpore with jute rice wheat cropping system it was observed that recommended dose of NPK fertilizer could not produce potential jute fibre yield. Hence, it was necessitated to relook into the fertilizer schedule for jute. Accordingly STCR experiment conducted at CRIJAF provide new fertilizer schedule for different soil fertility type.

Table 1. Fertilizer recommendation based on soil test for jute

Topography	N- kg/ha	P_2O_5- kg/ha	K_2O- kg/ha	Remarks
***Olitorius* jute**				Based on STCR, NATP and Agronomic Experiments
Upland				
Low Fertility	70-80	40	40	<u>Method</u>
Medium Fertility	40-60	25-30	25-30	N to be applied, ½ dose at 21-30 DAE and ½ dose
High Fertility	40	20	20	at two weeks after 1st[t] top dressing P & K are
Mid land				to be applied as basal.
Low Fertility	60-80	40	40	FYM - 5-8t/ha for both capsularis and *olitorious*
Medium Fertility	40-60	25-30	25-30	
High Fertility	40	20	20	
Low Land				
Low Fertility	60-80	40	40	
Medium Fertility	60	30	30	
High Fertility	40	20	20	
***Capsularis* jute**	60-80	30-40	30-40	Method of application same as *Olitorius*

Secondary nutrients

Sulphur stimulates root growth, seed formation and helps in various enzymes synthesis. It also improves the fibre quality of fibre crops. Nearly 18kg extra jute fibre was obtained by the application of one kg of S in the sulphur deficient soils of Bangladesh and 21 kg extra jute fibre yield was reported from the soils of Barrackpore by application of 1 kg sulphur. Saha *et al.* (2002) in an experiment using ammonium sulphate as the source of S nutrition reported that in Gangetic alluvial soil, dry matter and fibre yield of *olitorius* jute increased significantly upto 40 kg S/ha application. In another experiment on gangetic alluvial soils of West Bengal, maximum jute yield was observed at 45 kg S/ha of elemental sulphur application. It was also observed that in alluvial as well as lateritic soils of West Bengal, increased doses of N and S in combination increased fibre yield of *olitorius* jute and maximum fibre yield was observed with 60 kg N/ha and 30 kg S/ha which was found to be optimum for higher productivity and improvement in quality. In an interaction study, it was observed that K (@ 40 kg K_2O ha^{-1} and Mg (@ 10 kg $MgSO_4.7H_2O$ ha^{-1} favourably influenced growth and yield of both the jute varieties (JRO 632 and JRC 212). Hence, inclusion of Mg (@ 10 Kg ha^{-1} as secondary nutrient along with prescribed doses of NPK is suggested.

Response of micronutrients

Apart from the primary and secondary nutrients, deficiencies of micronutrients such as zinc and boron are now becoming widespread in jute growing areas. Detailed study on effect of different micronutrients on the yield performance of both *capsularis* and *olitorius* jute showed that Fe and Mn had some positive effects on fibre yield of *capsularis* jute while positive effect of B and Mn was observed in *olitorius* jute. It was found that Cu, B and Cobalt (Co) positively influence the seed yield of jute.

Lime application

Liming is necessary if jute is grown in acid soil. Application of lime affects phosphate and micronutrients availability, nitrification and nitrogen fixation of soil. In a study on the acid soil of Sorbhog, Assam, it was observed that application of lime improved the soil pH and subsequently increased jute fibre yield by 24% compared to no lime treatment.

Integrated nutrient management

It was observed that integrated use of 75% N through urea and 25% N through organics (water hyacinth compost or FYM) increased fibre yield, reduced the use of chemical fertilizers and enriched soil fertility. Dependence on inorganic fertilizers could be reduced up to 75 percent with the application of organic nutrient like neem cake. Seed treatment with the fungal culture of *Trichoderma viridi* (local strain) exhibited a beneficial effect in jute fibre production. Soil health has become a cause of concern for sustainable agricultural production in the new millennium, so balanced nutrition of crops with fertilizers are needed. Balanced nutrition is a key component to increase yield and quality of fibre, maintenance of soil productivity, soil health and protection of environment. Fertilizer application based on integrated soil test and targeted yield is advantageous for good jute crop yield.

Long term effect of jute cultivation on soil fertility

The results of a forty three years old jute–rice wheat cropping system showed that significant increase in yield was obtained at 100% NPK+FYM as compared to 100% NPK in all the three crops. This may be attributed to the fact that the response of FYM is perhaps related to the build up of SOM in the soil due to FYM application over the years. It is clear from the soil data that SOC increased from 0.42 to 0.89%. With the advancement of years of cultivation, the beneficial effect of integrated use of NPK and FYM was more pronounced and effective in enhancing the productivity as compared to 100% NPK. The continuous application NPK in jute-rice-wheat system has resulted in significantly higher soil organic carbon (SOC) over control and also over the initial level. Irrespective of treatments, the SOC content has increased over the years due to continuous cultivation of jute. Application of fertilizer and manure resulted in significantly improvement in the build up of the available N in soil, which may be attributed to mineralization of N from native sources during decomposition. Similarly the available P status of the soil also continued to increase with addition of fertilizer alone and their combined use with FYM, except the plots where no phosphatic fertilizer was added i. e., 100%N and control. Similarly there was increase in available potassium in the balanced treatments with reduction in 100%NP, 100%N and control. DTPA extractable micronutients decreased over the period of 43 years. After 43 years of continuous cropping and manuring, depletion of Mn was maximum, and Cu was the least affected with degree of reduction less in FYM added soils.

Conclusion

The aspects that need much attention as far as soil fertility management strategies in jute are concerned are planning of jute cultivation in relation to soil suitability, nutrient requirement of jute at different stages, crop quality in relation to soil fertility and regional specific nutrient recommendation package integrating organic sources available as nutrient supplements and soil health management for yield maximization.

Of late, country is experiencing the second generation problems of green revolution which are seriously affecting the crop yield, economics and in turn the economic growth of the country. Continuous R&D efforts would be needed for popularizing speciality fertilizers like 100% water soluble, customized fertilizers, fortified and value added fertilizers with secondary and or micronutrients to increase agricultural productivity and farmer's profitability on sustained basis. Conducive policy should be developed to encourage the production and use of speciality fertilizers. Customised fertilizers re developed based on soil-crop-climate to supply the macro and micro-nutrients in a right proportion. Besides yield, customised fertilizer also increases fertilizer response by optimising fertilizer dose. Increase in jute yield should be studied with use of customised fertilizers developed by different companies as compared to farmers input.

Fertilizer subsidy accounts for a significant share of total support to agriculture that the Government provides and it plays an important role in promoting use of fertilizers. Though subsidy has contributed to an increase in use of fertilizers that has helped in achieving higher production but in some cases it has resulted in overuse, which has adverse effect in productivity, soil health. Sharp increase in both domestic and imported fertilizer prices as well as raw material/ feedstocks, rising imports and reduction in subsidy of phosphatic and potassic fertilizers have made markets more volatile and, to the extent that higher prices have led to a decrease in consumption of phosphatic and potassic fertilizers and deterioration in N:P:K ratio.

I-10

Fertilizer Use for Sustainable Agricultural Development in India

S. K. ROY[1], F. H. RAHMAN[2] and A. K. SINGH[3]
[1]Principal Scientist; [2]Senior Scientist; [3]Zonal Project Director
ICAR-Zonal Project Directorate Zone-II, Bhumi Vihar Complex,
Salt Lake City, Kolkata – 700 097
E-mail : zpdkolkata@gmail.com

Food grain production and Nutrient management

India is the second highest user of fertilizers after China (50.5 Mt) in the world. The food grain production was as low as 78.01 Mt when fertilizer use was only 69.8 thousand ton in 1950-51. The food grain production reached to 257.1 Mt in 2012-13 compared to 151.2 Mt in 1981-91. The estimated production in 2013-14 is 264.4 Mt (Fig. 1). There was progressive increase in production of all the major crops over the years since 1950. Even in last 10 years the crop production and productivity also increased steadily. The production of rice was 81 Mt in 1994-95 and reached to 106.5 Mt in 2013-14. Similarly, production increased in wheat from 29.9 to 43.1 Mt., in pulse from 14.1 to 19.3 Mt, in oil seeds from 11.9 to 36.6 Mt, in sugarcane from 275.5 to 350.0 million bales and that of jute and mesta increased from 9.1 to 11.6 million bales for the same period i.e. in last 10 years.

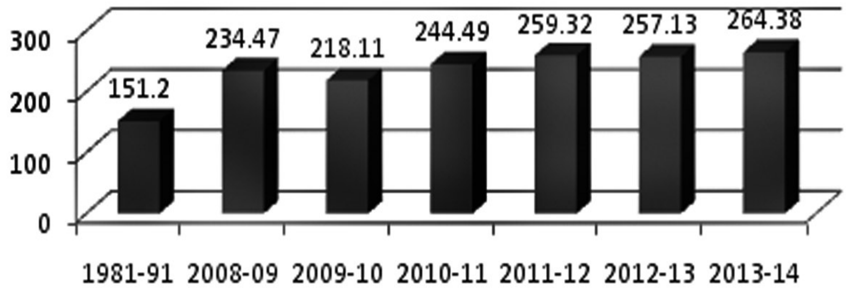


Fig. 1. Food grain production in India (Mt)

Productivity of rice was 2078 kg/ha in 2003-04 which increased to 2462 kg/ha in 2012-13. Productivity of wheat increased from 2713 to 3119 kg/ha while maize 2041 to 2553 kg/ha, coarse cereals 1221 to 1626 kg/ha, Pulses 635 to 786 kg/ha, food grains 1727 to 2125 kg/ha, oilseeds 1064 to 1169 kg/ha, sugarcane 59380 to 66988 kg/ha, Jute & mesta 2008 to 2338 kg/ha and in cotton 307 kg/ha to 482 kg/ha. Thus, these was an productivity gain in 403 kg/ha in wheat, 512 kg/ha in maize, 405 kg/ha in coarse cereals, 151 kg/ha in pulses, 398 kg/ha in food grains, 105 kg/ha in oilseeds, 7608 kg/ha in sugarcane, 330 kg/ha in jute and mesta and 175 kg/ha in cotton in last 10 years.

The gain in production and productivity is attributed to fertilizers use, use of HYVs and hybrids, apart from irrigation and nutrient management strategies adopted by the farmers. The productivity enhancement was further strengthened by the Country's extension system, for example, an ongoing centrally sponsored scheme "Support to State Extension Programme for Extension Rerforms" popularly known as ATMA scheme is under implementation in 614 districts of 28 states of 3 UTS of the country. The scheme include capacity building and extension functionaries and farmers. Through these activities latest agricultural technologies are disseminated to the farmers of the country. Over 239.97 lakh farmers have been benefited since 2005-06 through these programmes.

The training were also imparted through Krishi Vigyan Kendras (KVKs) in the country through latest technologies including fertilizer management. About 16 lakh farmers are trained annually by the KVKs which has major impact in production and productivity improvement.

Fertilizer remain the key input in the production and productivity jump in India. About 20-30 kg N, 8-20 kg P_2O_5 and 25-50 kg k_2O/ha are removed by the major cereals and pulses per kg of grain production (Rajendra Prasad, 2012). To meet up the requirement India needs 45 Mt ($N + P_2O_5 + k_2O$) by the year 2015.

Basic strategies of nutrient management in India

Fertilizer consumptions are increasing consistently while total area under food grain is decreasing. More than half (72%) of the total consumption of fertilizers is attributed to only two crops i.e. rice and wheat. Pulses, oilseeds, vegetables, other food grains, cotton, sugarcane, fruits etc. consumed 2-9% of the total fertilizer consumption (Fig. 2).

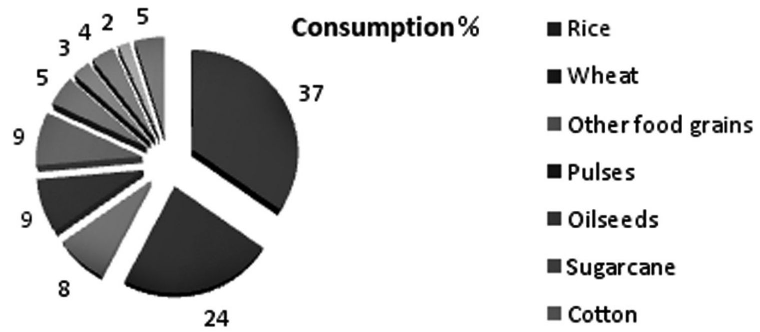


Fig. 2. Crops wise consumption of Chemical Fertilizer in India
(Source: Food and Agriculture Organization 2011)

In view to maintain soil fertility and protection of environmental concerns, Integrated Plant Nutrient Management System (IPNM) has been widely introduced through research system. IPNM aims at maintaining soil fertility and plant nutrient supply for sustainable crop productivity by adjusting chemical fertilizers, organic manures, bio fertilizers, and crop residues. Different proportion of these components are used based on crop requirements and availability of materials.

The nutrient component by crop is analyzed, it may be seen that wheat consume most of the N (18.9 Mt) followed by maize (17.55 Mt) and rice (16.03 Mt) worldwide. Maximum K_20 is consumed by maize (4.08 Mt) followed by wheat (3.47 Mt). Phosphorus consumption is more of less equal in all the three major crops (Fig.3).

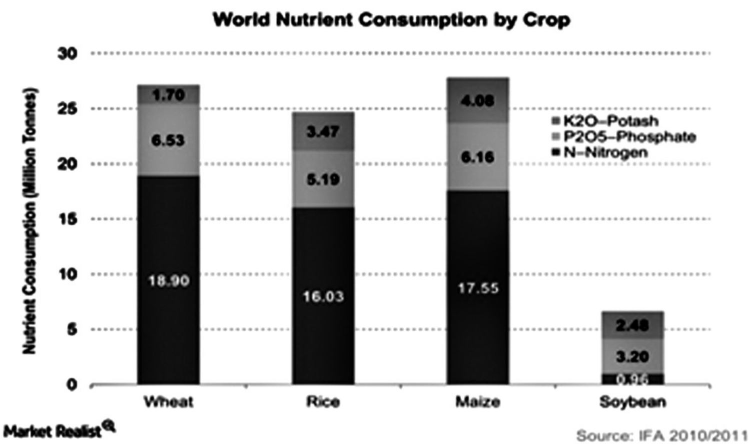


Fig. 3. World Nutrient Consumption by crops

Integration of management practices is necessary to take care of multiple nutrient deficiencies, to utilize scares organic sources of fertilizers, higher cropping intensity and to avoid the loss of crop due to cultivation of green manure crops.

While implementing the IPNM, it is to keep in mind that the availability of the organic resources. The potential availability of the rural compost is 600 Mt and urban compost is 16 Mt out of these only 2 t/ha/year is available for use in agriculture. Less than 50% of the manural potential of livestock population is utilized in crop production. Indian agriculture produce about 500-550 million ton of crop residues annually. These crop residues are utilized for animal feed, soil mulch, manure etc. while 90-140 Mt is burnt annually. Burning of crop residues results in number of problems like emission of green-house gases, global warming, loss of nutrients (NPKS) and adverse effect on soil properties. Therefore, it is better to utilize these resources as much as possible in IPNM system. The crop residues could meet about 5 Mt. of nutrient requirement in India. The estimated crop residue utilized in India is about 84-141 Mt/year. Surface retention of crop residues increases N uptake and yield and improve the soil physical properties in rice-wheat system. Though residue incorporation leads to immobilization of inorganic N but addition of 15-20 kg N into straw increase yield of rice and wheat.

Biofertilizers are another source of organic nutrients. Total availability of bio-fertilizers in India (2011-12) is 69 thousand ton (Fig 4) (NCOF data, Govt. of India 2012). Vermicompost is the most important source of organic fertilizer. Total availability of the vermicompost in India is about 269 lakh tones (2011-12) while availability of compost is about 1081 lakh tones and FYM is 1861 lakh tones (Fig 5). The area under green manure is about 242 lakh ha (NCOF data, Govt. of India 2012).

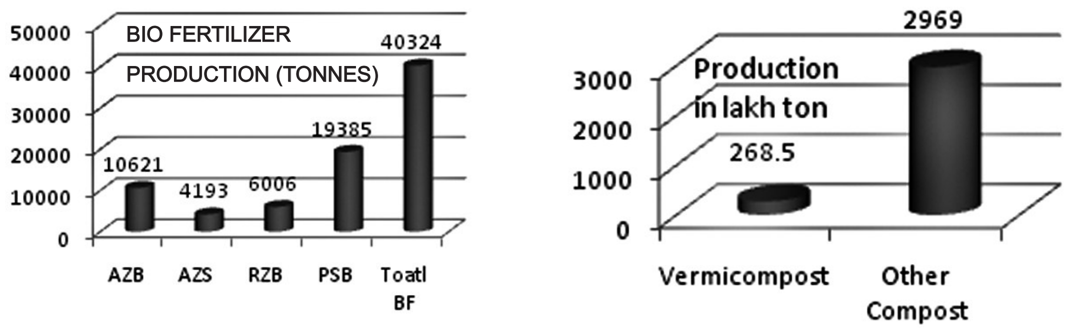


Fig. 4 and 5. Status of Bio fertilizer, vermin composts and composts availability in India 2011-12

Food production policy issues

Considering the trend in food grain production and fertilizer consumption in India, it may be assumed that fertilizer requirement will go on increasing over the coming years. The projected food grain requirement of 300 Mt by 2025 could be achieved only when we meet the demand of fertilizers of about 45 Mt. Since India have potential of producing 298 Mt of organic manure, Vermicompost, green manure etc. and 141 Mt of crop residues, it may provide upto 15-20 Mt of nutrients. Rest of the requirement should be met from the chemical sources. Therefore adoption of integrated nutrient management strategies and training of farmers on the INM techniques will be very much useful to maintain sustainable in production and protection of environment.

References

Prasad Rajendra (2012) Fertilizers and Manures. Current Science, Vol. 102 (6) pp. 894-898

http://ncof.dacnet.nic.in

www.fao.org/statistics

I-11

Importance of Forest Floor Litter in Maintaining Soil Fertility and Carbon Stock in IGNP Command Area, Rajasthan

N. BALA

Scientist E & Head, Forest Ecology Division, Arid Forest Research Institute,
Indian Council of Forestry Research and Education, New Pali Road, Jodhpur – 342 005
E-mail :

Indira Gandhi Nahar Pariyojana (IGNP) is one of the gigantic canal projects in the world aiming to check desertification and to transform desert wastelands of western Rajasthan into agriculturally productive area. Afforestation on large scale was taken up in the project area to reduce wind velocity and check drifting of sand during dust storms, to protect the canal systems from drifting sand and to improve microclimate of the area. As envisaged, these plantations have brought about a radical change in the landscape and microclimate of the area affecting soil nutrients and organic carbon as well, through addition of litter.

Plantations of different species were studied across different age class to find out impact of forest floor litter on soil nutrients and soil organic carbon. Six species and four age categories were selected for the study (Table 1). Soil samples were collected from within the sample plots (cleared of litter periodically) as well as from outside the sample plots (undisturbed forest floor) and from two depths (0-25 cm and 25-50 cm). Soil pH, electrical conductivity (EC), organic carbon, ammonium nitrogen, nitrate nitrogen and phosphorus content in soils were estimated.

Plantation along the IGNP

Forest floor litter in *E. camaldulensis* plantation

Species	Age category
Acacia nilotica	1-5, 6-10 and > 15 year
Acacia tortilis	6-10, 11-15 and > 15 year
Dalbergia siooss	6-10 and > 15 year
Eucalyptus camaldulensis	0-5, 6-10, 11-15 and > 15 year
Prosopis cineraria	0-5, 6-10, 11-15 and > 15 year
Tecomella undulata	0-5, 11-15 and > 15 year

It was observed that soil pH and electrical conductivity was comparatively high in old plantations (Y17). There was an increase in soil organic carbon (SOC), NH_4-N, NO_3-N and PO_4-P in the plantation area with increase in age. Increase in availability of these nutrients may be due to accumulation of more soil organic matter through higher litter-fall which regulate organic matter decomposition and formation of stable and labile soil organic matter pool. Soil organic carbon varied significantly in different depths and between inside the sample plot and outside the sample plot. Inside the plot from where, regular litter collection was made for two years, organic carbon was found to be lower than outside the plot where forest floor was undisturbed and contained litter mass. Relatively high soil organic matter was found in the top soil layer (0-25 cm) than the sub-surface soil layer (25-50 cm). Carbon stock in top 25 cm soil layer was high in P. cineraria and *A. nilotica* (7.87 Mg ha^{-1}), followed by *A. tortilis* (7.75 Mg ha^{-1}), *E. camaldulensis* (6.75 Mg ha^{-1}), *D. sissoo* (6.37 Mg ha^{-1}) and *T. undulata* (5.25 Mg ha^{-1}). Significant amount of carbon was added to the soil through litter-fall in the plantations. Highest amount of carbon was added in E. camaldulensis (2620 kg ha^{-1}) plantation and lowest in T. undulata (375 kg ha^{-1}).

Ammonium nitrogen, nitrate nitrogen and phosphorus status in soils were found to vary significantly depending on these two factors. High ammonium nitrogen, nitrate nitrogen and phosphorus were observed in soils of undisturbed forest floor (outside the plot) in comparison to soils inside the plot. Though ammonium nitrogen and phosphorus content was also high in top soil layers (0-25 cm) compared to the sub-surface soil layers (25-50 cm) nitrate nitrogen was found to be low in top soil layers. In terms of nutrient addition to the soil, highest amount of nitrogen (8.75 kg ha^{-1}) was added through litter-fall in E. camaldulensis plantation. This was followed by *A. nilotica* (8.63 kg ha^{-1}), *A. tortilis* (8.60 kg ha^{-1}), *D. sissoo* (6.73 kg ha^{-1}), *P. cineraria* (4.80 kg ha^{-1}) and T. undulata (2.03 kg ha^{-1}). Amount of phosphorus added to the soil through litter-fall was also highest in E. camaldulensis (3.83 kg ha^{-1}) which was followed by *A. nilotica* (2.85 kg ha^{-1}), *A. tortilis* (2.83 kg ha^{-1}), *D. sissoo* (2.02 kg ha^{-1}), *P. cineraria* (1.62 kg ha^{-1}) and *T. undulata* (0.69 kg ha^{-1}).

All these data signify the importance of forest floor litter mass in maintaining fertility status of the soils in a plantation. In absence of litter cover on forest floor rapid decrease in organic carbon, NH_4-N, NO_3-N and phosphorus was observed. All these parameters were found to be high in the top soil layers except NO_3-N which was high in the sub-surface soil layer (25-50 cm). This may be because of leaching out of NO_3-N from the top soil layer.

Book of Abstracts

P-1

Long term effect of soil test and target yield equation based integrated nutrient management on soil quality under jute-rice-lentil sequence

A.R. SAHA, B. MAJUMDAR, S.P. MAZUMDAR and D. GHOSH

Crop Production Division,

ICAR-Central Research Institute for Jute and Allied Fibres, Barrackpore, Kolkata

It is being increasingly realized that when crops are grown in system the fertilizer requirements of the cropping system as a whole is important than that of the individual crop. The soil fertility status and their availability to plants are strongly affected by nutrient management practices and cropping system. The loss of soil fertility in many developing countries, due to continuous nutrient depletion by crops without adequate replenishment poses an immediate threat to food and environmental securities. The fertilizer recommendations based on targeted yield equations have been well established in India. However, information on long-term effect of these recommendations used with or without FYM and biofertilizers in a jute-rice-lentil cropping system on soil quality is limited. Keeping this in view, an experiment was initiated at CRIJAF in 2010-11 to study the long term effect of ST-TY equation based integrated nutrient management on soil quality under jute-rice-lentil sequence. The treatments were T_1 - control, T_2 - ST-TY (target yield 1), T_3 - ST-TY (target yield 2), T_4 – T_3 + FYM (5 t/ha), T_5 –T_3 + Azotobacter + PSB, T_6 –T_4 + Azotobacter + PSB, T_7 -FYM @ 5 t/ha, T_8 –T7 + Azotobacter + PSB, T_9 - recommended dose of fertilizer (RDF) and T_{10}-farmers practice (FP). The treatments were replicated thrice and laid in randomized block design. In case of jute and rice, Azotobacter was used as biofertilizer but in case of lentil Rhizobium was used instead of Azotobacter. Application of fertilizer as per ST-TY with INM significantly increased the yield of jute fibre, rice and lentil. Application of fertilizers as per ST-TY with FYM significantly increased the available nutrient status over RDF. Application of fertilizer as per ST-TY along with FYM and biofertilizer significantly increased enzymatic activities over only ST-TY. The results conclude that for sustainable crop production and maintaining soil quality, input of organic manure like FYM, biofertilizers along with NPK fertilizer using STCR-based targeted yield approach should be advocated in the nutrient management of intensive cropping system.

P-2

Nutrient management for higher growth and seed yield of jute under late transplanted condition

AMARPREET SINGH, MUKESH KUMAR, S. P. MAJUMDAR, D. K. KUNDU, M. RAMESH NAIK, A. BERA and M. S. BEHERA

ICAR-Central Research Institute for Jute and Allied Fibres, Barrackpore, Kolkata, West Bengal 700 120

Creation of a sustainable bio-industry producing biofuels and bio-products on a significant scale is critically dependent on having a large, sustainable supply of biomass with appropriate characteristics at a reasonable cost. It is anticipated that the biomass will remain as an important global energy source in the next century. It is therefore crucial to explore the potential bio-resources for production of paper, bio-fuel and allied materials. Jute (*Corchorus olitorius* L.) has high biomass production potential. Jute can be highly economical, renewable natural resource for bio-energy and important crop for environmental cleaning. Seed is the basic input for crop production. The conservative estimate of annual requirement of jute seed in the country is around 5000 t. To ensure higher seed yield in any crop, effective nutrient management strategy is imperative. A field experiment was therefore conducted in Barrackpore, West Bengal on a Gangatic alluvial soil (typic Ustochrept) during kharif season of 2012-13 under late transplanted conditions. Twenty five days old seedlings of olitorius jute (cv. JRO

128) were transplanted in September, 2012. The field experiment was conducted with 6 treatment combinations in randomized block design. The treatments were: T_1 = Control (no fertilizer application); T_2 = N only (40 kg N/ha); T_3 = NP only (40:60 kg/ha N: P_2O_5); T_4 = NPK (40:60:60 kg/ha N: P_2O_5:K_2O); T_5 = NPK +S (40:60:60 kg/ha N: P_2O_5:K_2O + 20 kg/ha S); T_6 = NPK +S + Zn (40:60:60 kg/ha N: P_2O_5: K_2O + 20 kg/ha S + 20 kg/ha $ZnSO_4.7H_2O$). Other standard packages of practices were followed to raise the crop and the same was harvested in January, 2013. Results of the study revealed that the application of treatment T_6 resulted in significantly higher plant height, yield attributes and seed yield (1.18 t/ha) compared with all other treatments. Sulphur @ 20 kg/ha application alone along with NPK (40:60:60 kg/ha N: P_2O_5: K_2O) i.e., T_5 also recorded significantly higher plant height, yield attributes and seed yield compared with all other treatments except treatment T_6. It may be concluded that the application of S and Zn is also required along with recommended NPK doses for higher jute seed productivity in soils having low available S and Zn status in Gangatic alluvial soils.

P-3

Response of different form of zinc on seed yield of paddy in red and lateritic soils of Paschim Medinipur, West Bengal

ASIM KUMAR MAITI and N. K. BEJ

Seva Bharati Krishi Vigyan Kendra, Kapgari, Paschim Medinipur, West Bengal

In eastern India, red and red lateritic soil is dominated as main growing media of rice Crop. Most of the area comes under rain fed. High acidic soil having pH range from 5-5.5 causes problem of normal vegetative growth, less no of tillers, less no of grains per panicle and brings khaira disease in paddy. Symptoms generally appears in nursery but may appears in patches after 10-15 days of transplanting. High yielding varieties show chlorosis between the veins of new leaves. On lower leaves, a large number of small brown to bronze spots appear which coalesce to form bigger spots and ultimately the entire leaf turn into bronze coloured and dries up. Ultimately the yield losses due to such causes. The Trial was laid out in different villages under the jurisdiction of the Krishi Vigyan Kendra with 4 treatments viz. T_1: FYM @ 5 t/ha; T_2: FYM @ 5 t/ha + foliar spray of Zinc Sulphate @ 3 g/litre water; T_3: FYM @ 5 t/ha + foliar spray of liquid micronutrient mixture@ 1 ml/litre water; T_4: FYM @ 5 t/ha + foliar spray of chelated zinc @ 1 g/litre water. The average plant height, no. of tillers/m², panicle length and no. of grains per panicle of T_4 were higher than the other treatments. The application of different forms of Zn in different doses at different time intervals to the plants attributed higher seed yields over control. The treatment T_4: i.e. FYM @ 5 t/ha + foliar spray of chelated Zn @ 1 g/litre water at the time of 21 and 42 days after transplanting showed higher seed yield (46.4 q/ha) and other treatment T_2 and T_3 had produced 42.8 and 40.5 q/ha, respectively.

P-4

Effect of nitrogenous fertilizer on yellow mite (*Polyphagotarsonemus latus*) infestation in jute crop

B S. GOTYAL, R. K. DE, K. SELVARAJ and S. SATPATHY

Crop Protection Division, ICAR-Central Research Institute for Jute and Allied Fibres, Barrackpore, Kolkata

Fertilizers are applied to increase productivity through improved crop growth and yield potential. The no-optimal application of fertilizers may adversely affect the biochemical, physiological and morphological characteristics of crop plants, which in turn can adversely influence their resistance and/ or increase their susceptibility to pests. The levels of nitrogenous fertilizers play an important role in the infestation,

multiplication and distribution of yellow mite i.e, Polyphagotarsonemus latus (Banks). The recommended dose of fertilizer (N: P_2O_5: K_2O) for olitorius jute is 80:40:40 kg/ ha. The impact of different doses of nitrogenous fertilization (40, 60, 80, 100 and 120 kg/ha) in jute (cv. JRO 8432) on population of yellow mite was studied at ICAR-Central Research Institute for Jute and Allied Fibres research farm during 2012 and 2013 cropping seasons. The infestation of P. latus in different fertilizer regimes showed that significant variations among nitrogen treatments in both the years. Moderate infestation during peak period (55 DAS) of yellow mite infestation (97 mites/cm^2 leaf) was recorded in the recommended dose (80:40:40 kg/ha) as compared to the higher doses i.e., 120: 40: 40 kg/ha (139 mites/cm^2 leaf). The effect of K_2O was prominent in reducing the yellow mite infestation (68 mites/cm^2 leaf) in the fixed dose of N which indicates the role of K_2O in suppressing the mite infestation. There was a high correlation between mite population and fibre yield at various doses of nitrogen levels at 55 DAS (R^2= 0.91), 70 DAS (R^2=0.93) and 85 DAS (R^2=0.95). The study concludes that an excessive use of nitrogen is a key factor in producing chlorophyll; this pigment absorbs sunlight for basic photosynthesis needs which in turn will attract mite infestation. Moreover, higher doses of fertilizer also affect the crop maturity and heavy attack of yellow mite. Therefore, optimum dose of fertilizer should be applied at appropriate time. Although more research is needed, preliminary evidence suggests that fertilization practices can influence the relative resistance of agricultural crops to mite pests.

P-5

Nutrient Expert based fertilizer application for higher yield of wheat in Terai zone of West Bengal

BIPLAB DAS and JYOTIRMAY KARFORMA

Jalpaiguri Krishi Vigyan Kendra, West Bengal University of Animal and Fishery Sciences, Ramshai, Jalpaiguri, West Bengal- 735219

Wheat (*Triticum aestivum* L.) is the second most important food crop in India after rice, both in terms of area and production. India is the second largest wheat producer (12%) of the world. The yield in the Terai areas is below the average attainable yield of the zone as well as of state. The reasons for this gap in productivity are improper nutrient management and lack of knowledge of improved agronomical practices. Hence, a study was undertaken to demonstrate the yield response of fertilizer application of wheat crop by using of nutrient expert recommendation in Jalpaiguri district of Terai region, West Bengal. During the year 2013-14, nine demonstrations were conducted in 3 villages with 3 treatments; Farmers' practice (FP) 100: 48: 48, State recommendation (SR) 120: 60: 60 and Nutrient expert (NE) based recommendation 175: 78: 65 kg NPK/ha. The variety of the crop was PBW 343. Phosphate and potash were applied as basal in all the demonstration and nitrogen were applied in 3 splits (½ +¼ +¼) in case of farmers practice and state recommendation and three equal split at basal, CRI and late tillering stage in case of nutrient expert based recommendation. The average fertilizer N rate was highest with NE and lowest with FP, while average fertilizer K rate was highest with NE (65 kg/ha) and lowest with FP (48 kg/ha). The average yield obtained under nutrient expert based recommendation was 37.11 q/ha which was 33 % and 23 % higher than yield achieved under farmers practice (24.76 q/ha) and state recommendation (28.58 q/ha) respectively. The net profit under demonstration of nutrient expert based recommendation was Rs. 27,876 and the B: C ratio was 1.88 while under farmers' practice net profit was Rs. 25,125 and the B: C ratio was 1.58. On the basis of results obtained, it can be concluded that the nutrient expert based fertilizer recommendation could improve yield and economics of wheat crop production in the district.

P-6

Field study on production of Azolla in different temperature regimes in Burdwan district

C. JANA, D. GHORAI, S. SARKAR, G. ZIAUDDIN and SITANGSHU SARKAR[1]

Krishi Vigyan Kendra Burdwan, ICAR- Central Research Institute for Jute and Allied Fibres, Bud Bud, Burdwan - 713 403

[1]Principal Scientist (Agronomy), ICAR-CRIJAF, Barrackpore

In India, Azolla has gained attention in this decade due to its multipurpose use in agriculture as biofertilizer, green manure especially in rice cultivation. Now it is also used as animal feed and fish feed. Among the 6 species, two species namely Azolla pinnata and Azolla microphylla were introduced widely in India. Farmers are often facing difficulty of mortality of such species due to variable temperature regimes. Standardization of the growth and most importantly time of initiation of inoculation in relation to temperature is an utmost need for successful production and continuation of Azolla cultivation. The objective of the study was to assess the growth and yield of 2 popular Azolla species viz., Azolla pinnata and Azolla microphylla in different temperature range in the district. The study was conducted in three dominating seasons of West Bengal (summer, rainy and winter) in 10 different locations of the district with similar management practices. The production was conducted in 2 m^2 area having 10 cm depth of water, where 8 kg soil, 2 kg decomposed cow dung and 50 g single super phosphate (SSP) were applied initially and subsequently 500 g decomposed cow dung along with 15 g SSP were applied after each harvest. Bio-mass production of 2 species were recorded at weekly intervals. Study revealed that the optimum temperature range for growing both these species of Azolla was 20-29°C i.e., in the rainy season with the average productivity of 1.78 kg/m^2/week and 1.62 kg/m^2/week for A. microphylla and A. pinnata, respectively. Both the species were able to survive to the lowest temperatures range of 5-9°C during winter season of the district, though growth rate was significantly reduced. In this temperature range, A. pinnata was performed better. Result indicated that A. microphylla was able to tolerate even higher temperatures in the range of 30-39°C with the productivity of 1.59 kg/ m^2/week, whereas the growth of A. pinnata was reduced, showing reddish brown discolouration in the fronds. It can be concluded that mass production of A. pinnata during winter and A. microphylla in the summer months will be economical in the district of Burdwan. Initiation of production or inoculation of any one of the species should be done during the rainy season.

P-7

Effect of application of different doses of fertilizers and organic manures on production of *boro* paddy

F. H. RAHMAN, N. J. MAITRA[1] S. K. MONDAL, K. S. DAS, H. K. DE and A. K. SINGH

ICAR-Zonal Project Directorate, Zone-II, Bhumi Vihar Complex, Salt Lake City, Kolkata;

[1]South 24 Parganas Krishi Vigyan Kendra, Nimpith, South 24 Parganas

A multi-locational trial was conducted to evaluate the effect of applying different sources of organic manures on the boro paddy production. The trial was carried out in South 24 Parganas district of West Bengal at 32 different locations with 8 farmers in each of 4 groups applying various sources of fertilizers, viz., (i) Application of N : P_2O_5 : K_2O @ 80 : 40 : 40 through comical sources (Control: T_1); (ii) Application of N : P_2O_5 : K_2O as per soil test based recommendation (70% N through chemical fertilizers and 30% N through cow dung @ 9.0 t/ha) (Treatment 1: T_2); (iii) Application of N : P_2O_5 : K_2O as per soil test based recommendation (70% N through chemical fertilizers and 30% N through poultry manures @ 3.0 t/ha) (Treatment 2: T_3); and (iv) Application of N :

P_2O_5 : K_2O as per soil test based recommendation (70% N through chemical fertilizers and 30% N through vermicompost @ 3 t/ha) (Treatment 3: T_4). The results showed that the yield of boro paddy in T_3 was significantly ($P<0.05$) higher than in T_1 (63.4 vs. 54.2 q/ha); the corresponding values for T_2 and T_4 were 60.9 q/ha and 61.5 q/ha, respectively. The sheath blight disease incidence score was significantly ($P<0.05$) less in T_3 than in T_1 (1.00 vs. 3.50) and net return was also the highest in case of T_3. Therefore, it can be concluded from the present study that transplantation of 25 days old seedlings of paddy cv. WGL-20471 with a spacing of 20 cm x 15 cm under T_3 and two times manual weeding yielded the highest (63.4 q/ha) and recorded a net return of ₹22,812/ha and a B:C ratio of 1.52:1 was found for this group.

P-8

Effect of application of soil test based fertilizer along with micronutrients on paddy productivity

F. H. RAHMAN, SANJIB KUMAR[1], K. S. DAS, S. K. MONDAL and H. K. DE

ICAR-Zonal Project Directorate, Zone-II, Bhumi Vihar Complex, Salt Lake City, Kolkata;

[1]Nalanda Krishi Vigyan Kendra, Nalanda, Bihar

An experiment was conducted at 27 different locations of Nalanda district of Bihar to assess the effect of application of soil test based fertilizer on the productivity of paddy. Six farmers were included in each of 4 treatment groups – i) Application of N : P : K :: 80 : 30 : 10 (Control: T_1), ii) Application of N : P : K :: 80 : 30 : 10 + 25 kg $ZnSO_4$/ha (Treatment 1: T_2), iii) Application of N : P : K :: 80 : 30 : 10 + 10 q vermicompost + 12.5 kg $ZnSO_4$/ha (Treatment 2: T_3), and iv) Application of soil test based fertilizer + 10 q vermicompost + 12.5 kg $ZnSO_4$/ha (Treatment 3: T_4). The T_3 group i.e. application of soil test based fertilizer combined with vermicompost @ 10q/ha and $ZnSO_4$ @ 12.5 kg/ha resulted highest paddy yield (52.3 q/ha) followed by T_2 and T_1 group. With such fertilizer application, organic carbon content of the soil (0.52%) was also improved along with the status of nutrient availability in terms of N:P:K (kg/ha) and Zn availability (0.724 mg/kg). The net return was also highest (₹36,460/- per ha) with the highest BC ratio of 2.80 in this treatment compared to other experimental groups. It was concluded from the experiment that application of soil tested fertilizer along with the use of vermicompost and micronutrients had beneficial effect on the productivity of paddy.

P-9

Novel zeolite based nutrient products in agriculture

K. RAMESH, A.K. BISWAS and A.K. PATRA

ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh

Nanoporous zeolites are one of the greatest cationic interchangers and their cationic interchange capacity is 2 to 3 times greater than other types of minerals found in soils. The zeolitic channels (or pores) are microscopically small, and in fact, have molecular size dimensions such that they are often termed "molecular sieves". Zeolites are becoming the subject of interesting investigation in dozens of agricultural issues of which increasing the input use efficiency assumes greater significance in the soil science sector. The reason zeolites are now attracting so much interest lies in the honeycomb structure of cavities and minute channels in different directions which work at the cellular level. The internal surface area of these channels are reported to reach as much as several hundred square meters per gram of zeolite, making zeolites extremely effective ion exchangers. Understanding the nutrient retention processes in zeolites is necessary for effective utilization for these minerals as nutrient adsorbent and consequently as controlled release of plant nutrients. Losses of the applied nitrogenous fertilizers can be reduced through fertilizer management practices. Indian Institute of Soil Science (ICAR), Bhopal has initiated studies to characterize the commercial zeolites available in the country for their possible utilization in farming. When urea fertilizers are applied to the soil, an enzyme called urease begins their conversion to ammonia gas. The capacity of zeolites to adsorb the soil urease enzyme was studied in an experiment with different ratios of soil to zeolite and it was found that addition of zeolite to soil reduced soil urease activity. The same way mixing organic manures with zeolites delayed release of nutrients in the solution. Another study on zinc retention in a commercial synthetic zeolite has shown zig-zag retention pattern for a 15 day period.

P-10

Effect of nutrients and crop residue incorporation on system productivity, resource use efficiency and nutrient status of soil in different jute based cropping system

MUKESH KUMAR, A.K. GHORAI, S. MITRA, and B. MAJUMDAR
ICAR- Central Research Institute for Jute and Allied Fibre, Barrackpore, Kolkata

A field experiment was conducted to study the effect of nutrient and crop residue incorporation on productivity, resource use efficiency and their effects on nutrient status of soil under different jute based cropping sequence in split plot design during 2012-14. The main plot comprised of five cropping sequences viz., rice-rice, jute-rice-wheat, jute-rice-baby corn-jute (for leafy vegetable), jute-rice-garden pea, jute-rice-mustard-mung bean and four nutrient management practices viz. 75% recommended doses of fertilizers (RDF) with and without crop residue (rice, wheat, corn, garden pea and mung bean with their respective cropping sequence) and 100 % RDF with and without crop residue in sub plot. The highest system productivity (200.2 q/ha) was recorded in jute-rice-baby corn-jute (for leafy vegetable) cropping system followed by jute-rice-garden pea (91.34 q/ha) with 100 % RDF with crops residue. Water use efficiency (36.2 kg/ha-mm), energy use efficiency (6.86) and economic efficiency (Rs. 770/ha/day) were also higher in jute-rice-baby corn-jute (for leafy vegetable) cropping system. Although, organic carbon, N, P and K status in soil did not vary significantly, higher value of N and OC was recorded in 100 % RDF with crops residue treatments.

P-11

Standardization of fertilizer dose for seed production of onion in farmers' field of Hooghly district

N. GAYEN, S. H. ANSARY, N. MUDI, K. BARUI, A.K. CHOWDHURY and A. MANNA
Hooghly Krishi Vigyan Kendra, Bidhan Chandra Krishi Viswavidyalaya
Chinsurah- 712102, Hooghly, West Bengal, India

Low productivity of onion seed crop is a major problem in Hooghly district due to application of inorganic fertilizer at doses higher than the recommended one having no sources of Sulphur and micronutrients like Zn and B. An on-Farm trial was conducted for 2 years during 2010-11 and 2011-12 at farmers' field of Hooghly district of West Bengal during rabi season to standardize the fertilizer dose for increasing seed production of onion. The experiment was laid out in randomized block design with 4 treatments replicated 7 times. The treatments comprised of farmers practice (FP) i.e. N: P_2O_5: K_2O:: 250:210:210 (through compound fertilizer 10-26-26 and urea), Technology Option I (TO-I) i.e., Soil test based N: P_2O_5: K_2O through straight fertilizer, Technology Option II (TO-II) i.e., Soil test based N: P_2O_5: K_2O through straight fertilizer + 2 foliar spray of 0.25% $ZnSO_4$ at 30

and 45 DAP, Technology Option III (TO-III) i.e. Soil test based N: P_2O_5: K_2O through straight fertilizer + 2 foliar spray of 0.25% $ZnSO_4$ at 30 and 45 DAP + 2 foliar spray of 0.25% borax at 55 and 70 DAP). From the results of both year, it has been observed that TO III was recorded highest average yield (6.91 q/ha) resulting highest net return (563300/ha) and B:C ratio (3.42).

P-12

Eco-friendly management of *Spodopteralitura* in cabbage through application of *Metarhizium anisopliae* under coastal saline belt of South 24 Parganas

P. K. GARAIN, C. K. MONDAL and N. J. MAITRA
Ramkrishna Ashram Krishi Vigyan Kendra, Nimpith, Nimpith Ashram, South 24 Parganas, West Bengal

Field tests were conducted to evaluate the effect of Metarhizium anisopliae (Metsch.) an entomopathogenic fungus for the management of Spodoptera litura (Fab.) in cabbage under upland situation of coastal saline zone of Sundarban. Metarhizium anisopliae is a ubiquitous natural inhabitant of soil and biological control agent for several soil-dwelling insect pests. Spodoptera litura is a serious polyphagous pest that creates nuisance in Cabbage by boring and feeding on the cabbage head and making it unsuitable for marketing, resulting in 30-40% crop loss. Widespread development of resistance to chemical insecticides including the widely used pyrethroids has been reported in S. litura. Talc formulation of M. anisopliae was incorporated in soil in combination with cow dung manure, neem cake and vermicompost at the time of land preparation. Three foliar sprays were followed in each treatment. In control plot cabbage was planted without any soil treatment and followed by 6 sprays of conventional pesticide (chlorpyriphos 50 EC + cypermethrin 5 EC). From the Metarhizium treated plots, Spodoptera larvae and pupa were collected from the soil. They were found to be colonized by the Metarhizium mycelia and spores. The plots treated with Metarhizium in combination with neem cake gave better control against pest incidence (6.31%) as against the control plots (21.44 %) at 50 days after planting. Also considering the long term residual action of neem cake in association with Metarhizium against pupation of Spodoptera in soil and less chance of pesticide residue, the (Metarhizium - neem cake) combination is considered as the best option.

P-13

Imbalances in fertilizer application in India and the role to be played by the Indian Agricultural Extension Agencies

PRABUDDHA RAY, SUBRATA MANDAL and DULAL CHANDRA MANNA
Rathindra Krishi Vigyan Kendra, Institute of Agriculture, Visva-Bharati,
Sriniketan, Birbhuum, West Bengal, 731236
E-mail: rathindrakvk@gmail.com

The imbalanced use of chemical fertilizers and neglect of organic manure caused many problems, like stagnation in productivity, soil sickness, widespread deficiency of secondary and micro nutrients, spread in salinity and alkalinity etc. On an All-India basis, the deficiency of sulphur has been found to be 41%, zinc 48%, boron 33%, iron 12% and manganese 5%. Declining response on fertilizer use particularly on food grains has been noticed in the decade of 2000. The average response to fertilizer application used to be around 10:1 during 1960s and 1970s. The response ratio obtained by research scientists who had been adopted by Department of Agriculture and Cooperation, GOI, for calculating demand projections was 1:7.5 for the 8th Plan, 1:7 for 9th Plan, 1:6.5 for 10th Plan and 1:6 for 11th Plan. However, IASRI, ICAR has made a study in the recent years to work out

the response ratio of fertilizers for food grains based on the farmers field data and has concluded the response ratio of NPK as 1:7.8, but the response ratio varied for different crops from 1:4.9 for oilseeds to 1:7.1 for pulses and 1:8.6 for cereals. Keeping these in mind, it must be noted that imbalanced nutrition produces low yields, low fertilizer use efficiency and low farmer profit. It also results in further depletion of the most deficient nutrients in the soil. Once the critical level of a nutrient is reached, yield fall dramatically even through large aggregate amounts of other nutrients may have been applied. Hence, the importance of balanced fertilization in increasing crop yield must be realized. At present, the country is having vast agricultural extension system to educate the farmers on improved farm technologies. Central/State Governments, State Agriculture Universities, ICAR, NGOs etc. are engaged for this purpose. However, Farmers' knowledge regarding the right product, dosage, time and method of application of fertilizers based on soil condition is very limited, leading to inefficient use of fertilizers. Extension services are required to be rejuvenated and reoriented with focus on the poor farmers and low fertilizer consumption areas for increasing farm profitability. Under National Project on Management of Soil Health and Fertility (NPMSH&F) of Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India the knowledge of farmers on fertilizer usage is enhanced continuously through farmer's training, field demonstrations etc. Financial assistance is provided to State Governments/ICAR/SAUs/Fertilizer Industry for farmer's training @ Rs. 10,000 per training programme for two days duration on balanced use of fertilizers. Similarly, field demonstrations on balanced use of fertilizer @ Rs. 10,000 per demonstration is provided. Finance assistance is also provided for adoption of villages by Soil Testing Laboratories (10 villages each) through Frontline Field Demonstrations (FFDs) @ Rs. 20,000 per FFD. Field day-cum-farmer's fair are organized under field demonstrations and FFDs.

P-14

Effect of different organic and inorganic sources of nutrients on growth and yield of cauliflower (*Brassica oleracea* var. botrytis)

RAJ NARAYAN, N. AHMED, B. L. ATTRI, SOVAN DEVNATH, ANIL KUMAR and MUKESH S. MER
ICAR-Central Institute of Temperate Horticulture Regional Station, Mukteshwar, Nainital, Uttarakhand

Cauliflower (*Brassica oleracea* var. botrytis) is an important vegetable crop of Uttarakhand state which fetches higher remuneration to the growers. Like other vegetable crops of Brassicaceae family, it removes large quantity of major nutrients from the soil. The soil health, environment and eco balance is hampering day by day due to application of huge amount of chemical fertilizers. The conjunctive use of chemical fertilizers and organic manures is probably the only way to sustain crop production as well as maintain and eco-balance of soil health. An integrated approach for nutrient application in cauliflower cultivation was undertaken with 9 treatments consisting of sole as well as integrated use of farm yard manure (FYM), vermicompost and chemical fertilizers to ascertain the effect of various treatment combinations on growth and yield of cauliflower hybrid (cv. Snow Crown) during kharif 2014 at Mukteshwar, Nainital. The treatments viz., control (without application of nutrients), application of 100% recommended fertilizer dose of NPK through Urea, DAP and MOP, 100% FYM on the basis of nitrogen requirement, 100% vermicompost on the basis of nitrogen requirements, 50% FYM+ 50% NPK, 75% FYM+ 25% NPK, 50% vermicompost + 50% NPK, 75% vermicompost + 25% NPK and 25% FYM + 25% vermicompost + 25% NPK were tested following randomized block design (RBD) with 3 replications. Among the treatments, application of recommended dose of NPK in chemical form exhibited highest values for most of the traits viz., plant height (57.8 cm), plant spread (4199.7 cm^2), number of leaves/ plant (18), total leaf weight (77.2 g/plant), stalk weight (228.9 g), and curd size (339.9 cm^2) and curd weight (760 g). The treatment combination of 75% FYM + 25 % NPK proved second best treatment for most of the growth and yield parameters.

P-15

Increase of stem rot of jute (*Corchorus olitorius* L.) caused by *Macrophomina phaseolina* (Tassi) Goid with more nitrogenous and reduction with phosphatic and potassic fertilizers

RAJIB KUMAR DE

Crop Protection Division, ICAR-Central Research Institute for Jute and Allied Fibres, Barrackpore, Kolkata

Jute (*Corchorus olitorius* L. and *C. capsularis* L.), the 'golden fibre' crop, is grown mainly in eastern and north-eastern (NE) region of India as pre-kharif crop in West Bengal, Bihar, Assam, Odisha and other NE States. Among biotic constraint of raw jute production, stem rot caused by Macrophomina phaseolina (Tassi) Goid. is economically the most important disease affecting both yield and quality of fibre in both the cultivated species. Although stem rot is the common name but the pathogen attacks any part of the plant at any stage of growth right from germination to harvest producing various symptoms. The disease is seed, soil as well as air borne. Present investigation response of nitrogen, phosphate and potash fertilizer schedules was studied on the incidence of stem rot caused by Macrophomina phaseolina on jute (cv. JRO 8432) at ICAR-CRIJAF, Barrackpore during 2012-13. Application of more nitrogenous fertilizer enhanced stem rot of jute. But increased application of P and K fertilizers reduced stem rot incidence. Among the different NPK fertilizer schedules considered in the study, 120:30:30 kg/ha attracted more stem rot of jute with 47.9 %disease at 120 DAS, followed by 120:40:40 kg/ha with 40.5 %, 100:30:30 kg/ha with 36.1% and 80:40:40 kg/ha with 35.2 % of stem rot. With similar dosage of nitrogen, when phosphate and potash were increased, lower stem rot was recorded. Phosphate and potash fertilizer moderated the effect of deleterious effect of nitrogen by reducing the stem rot incidence. In control (no fertilizer), stem rot increased from initial 0.3% to 2.2% in 45 days and finally to 21.6% during the maturity of the crop. But in different NPK fertilizer treated plots, dynamics of stem rot was different showing varied interaction. The progress of disease over time was typically slowest in case of NPK 40:30:30 kg/ha. Higher level of nitrogen with phosphorus and potash not only increased susceptibility of jute plants and killed more plants due to high prevalence of stem rot disease but also increased dry fibre yield.

P-16

Assessment of balanced fertilizer application in production of jute at farmers' field of West Bengal

SHAILESH KUMAR, S.K. JHA, SHAMNA A. and SITANGSHU SARKAR

Agricultural Extension Section, ICAR-Central Research Institute for Jute and Allied Fibres, Barrackpore

Jute is an important cash crop grown by majority of small and marginal farmers of West Bengal. In spite of improved production technologies available, the main concern in jute fibre production system is the irregular or non-uniform productivity in jute growing districts of the state. It has been observed that most of the farmers use imbalanced fertilizers skewed especially towards nitrogen with meagre amount of P and K fertilizer use. This might be due to recent exorbitant price escalation of K-containing fertilizers and dwindled availability of P fertilizer in the open market. Further, lack of mass awareness about importance of balanced fertilizer application has resulted in adverse effect on jute (and even other crops in rotation) as well as soil health of the jute growing districts. The present study was carried out in farmers' participatory mode for a span of 3 years during 2010-13 covering 33 acres in the intensively jute growing districts of West Bengal viz., Nadia, Hooghly, Murshidabad and North 24 Parganas. The objective of the study was to demonstrate the advantages of soil test based fertilizer application on jute productivity and maintenance of soil health. Soils of the demonstration field

were near neutral in reaction pH 6.6-7.5 (1:2.5 w/v), low to medium in organic carbon (4.0 to 9.3 g/kg) and medium level of available N (274-334 kg/ha), P (26-34 kg/ha) and K (128-149 kg/ha). Based on the soil test data, doses of NPK were decided and applied to the soils of jute crop. The result showed that maximum gain in fibre and stick yield was achieved with balanced use of NPK fertilizers (i.e., 60:30:30 to 80:40:40 kg/ha) in Hooghly followed by Nadia> Murshidabad > and North 24 Parganas. Farmers were reasonably satisfied with the results of the demonstration as the intervention of use of balanced fertilizer increased fibre (and stick) yield, reduced disease incidence (especially stem rot) and also helped them in reducing the cost of production of jute fibre.

P-17

A few steps for the production of quality jute seeds

SUBRATA BISWAS, MONU KUMAR, A. BERA and C. S. KAR

ICAR-Central Seed Research Station for Jute and allied Fibres, Bud Bud, Burdwan, West Bengal

In production of breeder seeds, maintenance breeding of all the released varieties of jute in Nucleus plots is one of the most important steps in quality jute seed production. In this programme, nucleus seeds were harvested from selected individual true to type plants of a variety were used to raise progeny rows. Progeny rows found to be true to the type of varieties of jute. Off type plants, if any, found in any progeny row of nucleus seed plots, entire progeny row was eliminated to obtain purest seeds. In all, 27 released Jute varieties were used for nucleus seed production. The seeds from nucleus plots were used for breeder seed production. In 20013-14, 18.54 q of breeder seed was produced and supplied to various seed producing agencies against DAC indent of 17.4q (11 *olitorius* and 4 *capsularis* varieties). In 2014-15, about 13.0 q breeder seeds of 12 varieties of jute were produced as per the DAC indent 11.87q. For quality jute seed production application of balanced fertilizers at appropriate time is essentially required. At the field level, it was observed that N, P and K up to 60 kg/ha and splitting the dose of N judiciously (50% at 28 DAS following final weeding-cum-thinning plus 50% at 45-55 DAS coinciding the time of topping) could sustain higher seed yield with better seed quality. The another important step in quality seed production as followed was grow out test (GOT) of produced breeder seeds to check the genetic purity of the breeder seeds of all the indented varieties of jute. Percentage off types present in the varieties was recorded by making critical observations on the important morphological parameters related to leaf shape, pigmentation on leaf, stem, flowering, capsule/pod, seed coat etc. GOT was performed during March-May, 2014, before supplying breeder seed. Percentage off type present in each of the jute and allied fibres varieties were within the permissible limit.

P-18

Simplification of balanced fertilization in summer paddy cultivation under lateritic soil

SUBRATA MANDAL, PRABUDDHA RAY and DULAL CHANDRA MANNA

Rathindra Krishi Vigyan Kendra, Institute of Agriculture,

Visva-Bharati, Sriniketan, Birbhuum, West Bengal-731 236

E-mail: rathindrakvk@gmail.com

Three plot demonstration was conducted on simplification of balanced fertilization on summer paddy cultivation under lateritic soil of Birbhum under FAI-APP Soil Health Enhancement Programme during the year 2013-14 with each plot size of 0.5 acres. The programme was conducted in the farmer's field at village Durgapur of Birbhum district in the soils having pH 6.67, organic carbon 0.59 %, available N 292 kg/ha, available P_2O_5 18 kg/ha, available K_2O 390.21 kg/ha, available S 18.53 ppm, available Zn 0.87 ppm and available B 0.35 ppm. The

Soil of the demonstration plots were sandy loam in texture and the paddy (cv. IR-64) was transplanted on 22nd Feb., 2014 with a seed rate of 60 kg/ha. In the Plot-I, the fertilizers were applied as per farmers' practice in the form of 10-26-26, Urea and MOP @ 90 kg, 75 kg and 9 kg/acre respectively. In the Plot-II, the fertilizers were applied through optimization of fertilizer ratio with same expenditure as in Plot-I (Rs.18,529/- per Plot) in the form of Urea, SSP, MOP, Zinc-EDTA and vermicompost @ 87.2 kg, 125.4 kg, 32.8 kg/acre, 300 g and 30 kg/acre respectively. In the Plot - III, fertilizers were applied on the basis of soil testing with a minimal increase in expenditure for fertilization (Rs. 20,840/- per plot) in the form of Urea, SSP, MOP, Chelated-Zinc (foliar spray) and Boron-20 (foliar spray) @ 105.4 kg, 187.5 kg, 40.4 kg, 490.8 g and 981.6 g/acre respectively. From the study, it was found that grain yield of 41.46 q/acre was achieved from Plot - III whereas 34.90 q/acre and 31.10 q/acre yield were achieved in the Plot - II and Plot – I, respectively. At the same time, it was also noted that variations in yield components followed the same trend of result. Furthermore, it may be mentioned that benefit: cost ratio was higher in Plot - III (0.31) than that of the Plot - II (0.24) and Plot - I (0.11). Thus the results of the study showed that soil testing based fertilization in summer paddy cultivation could be beneficial in the lateritic soil of Birbhum district of West Bengal.

P-19

Effect of bio-fertilizer on growth and yield of wheat in major nutrient deficient soils of Jamui

SUDHIR K. SINGH, BRAJESH KUMAR, F. H. RAHMAN[1] and P.K.SINGH

Jamui Krishi Vigyan Kendra, Shrama Bharati, Khadigram – 811 313, Jamui, Bihar;

[1]ICAR - Zonal Project Directorate, Zone II, Salt Lake, Kolkata-700 097

In order to evaluate the effect of bio-fertilizer on growth and yield attributes of wheat (*Triticum aestivum* L.) in very low N and P_2O_5 levels situations of Jamui, a field experiment was conducted in two consecutive *rabi* seasons of 2012-13 and 2013-14. The nutrient status of the study area were available N and P as 135-212 kg/ ha and 5.6-9.8 kg/ha, respectively, with medium K_2O 122-226 kg/ha. Three technology options were replicated 10 times in Completely Randomized Block Design. The details of the treatment were as follows: T_1: Farmers Practice (FP): 132:55:0 kg/ ha NPK as control, T_2: FP with *Azatobactor* + PSB @ 3 kg/ha each with 100 kg vermicompost (Soil application), T_3 : 75% NPK of FP + *Azatobactor* + PSB @ 3 kg/ha each with 100 kg vermicompost (Soil application). It was revealed that the highest grain yield 39.2 q/ha (37 % more over control) was recorded in technology option 2 followed by technology option 3 which is 33.8 q/ ha (18 % more over control). Higher net return per ha (Rs. 29,080) and benefit: cost ratio (2.12) were recorded with technology option 2 and followed by technology option 3 (i.e. Rs. 24,120 and 2.04, respectively). It reflects the importance of bio-fertilizers in reduction of requirement of chemical fertilizer by their effective utilization and dissolution of bound form of phosphate to available form but also for getting better yield in sustainable agriculture.

P-20

Response of wheat under different tillages and nitrogen levels in south eastern Bihar

SUDHIR K. SINGH, P. K. SINGH, CHANCHAL SINGH and F. H. RAHMAN[1]
Jamui Krishi Vigyan Kendra, Shrama Bharati, Khadigram-811313, Jamui, Bihar;
[1]*ICAR - Zonal Project Directorate, Zone II, Salt Lake, Kolkata-700 097*

Establishment method of tillage practices and level of nitrogen play an important role in wheat productivity. In the present investigation it was tried to find out the suitable combination of establishment method and nitrogen levels in medium land under irrigated condition at Jamui district of Bihar. A field experiment was conducted to study the response of wheat under different tillage practices such as Furrow Irrigated Raised Bed (FIRB), Zero Tillage (ZT) and Conventional Tillage (CT) with different nitrogen levels of 100, 120 and 150 kg/ha on farmer's field during 2013-14. The experiment was laid out in Split Plot Design with 3 replications. Establishment methods were allocated in main plots, while nitrogen levels were in subplots. The statistical analysis revealed that, all the treatment combinations were recorded significantly superior over the conventional practices, whereas FIRB system produced the highest number of ear head/m^2 (292) and grain yield (5081 kg/ha) with nitrogen level of 150 kg/ha, which was found significantly superior over all the treatment combinations, whereas number of ear head/m^2 (197) and grain yield (2830 kg/ha) were observed lowest in conventional tillage with nitrogen level of 100 kg/ha.

P-21

Influence of mode and time of N application at different level through urea on N use efficiency in winter rice

SUJAN BISWAS and F. H. RAHMAN[1]
Coochbehar Krishi Vigyan Kendra, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar;
[1]*Senior Scientist, ICAR-Zonal Project Directorate, Zone - II, Salt Lake, Kolkata*

A field experiment was conducted for 2 consecutive years during 2011-12 and 2012-13 to study the influence of different mode and time of N application at different level through urea on yield of winter rice, N use efficiency in winter rice as well as changes in available N status in coarse textured soil of terai region of West Bengal. The experiment consisted of 8 treatments with varying levels of inorganic N applied in 2 different modes viz. soil application and spray at different time interval. Wheat was grown after rice in all the treatment applying NPK @ 80:40:40. Grain and straw yield as well as N uptake by rice, noted higher value with increase in level of fertilizer irrespective of mode and time of application, being highest (5.07 & 6.23 t/ha, 74.15 kg/ha) with treatment wherein N was applied on the basis of soil test value @ 80 kg N ha^{-1} as ½ basal in soil + spray of 10 kg at 15 & 30 DAT in equal proportion + rest by top dressing at 21 & 42 DAT in equal split. Balance of available N status after 2 years of experiment registered highest changes (9 kg/ha) with soil test based N application @ 80 kg/ha N in soil as ½ basal + ½ top dressing at 21 & 42 DAT in equal split. Different indicators of N use efficiency viz. agronomic efficiency (AE), internal efficiency (IE), recovery efficiency (RE), physiological efficiency (PE) and partial factor productivity (PFP) ranged from 26.50-32.50 kg additional grain per kg N applied, 66.20 - 68.54 kg grain per kg N uptake, 0.412 - 0.468 kg additional N uptake per kg N applied, 64.22 - 69.42 kg additional grain per kg additional N uptake and 64.80 - 97.75 kg grain per kg N applied, respectively being highest for recommended application of N @ 60 kg/ha – $^1/_3$ basal + ½ top dress at 21 and 42 DAT in equal split + 10 kg N spray at 15 and 30 DAT in equal proportion except PFP which accorded highest value when N was applied @ 40 kg/ha through $^1/_3$ as

basal and $^{2}/_{3}$ top dressing at 21 and 42 DAT in equal split, followed by farmers' practice i.e. application of 40 kg ha^{-1} through ½ as basal, ½ as top dress at 30 DAT. It was observed that for a specific mode and time of application magnitude of all indicators of N-use efficiency decreased with increased level of applied N. On the other hand, level of applied N being constant, different indicators of N-use efficiency increased with split application of N and more so when split application was coupled with spraying of applied N.

P-22

Effect of potash on potato production and productivity

VINAY KUMAR SINGH, MANISH KUMAR, CHANCHILA KUMARI and BHOOPENDRA SINGH

Krishi Vigyan Kendra, Koderma, Jharkhand – 825 109

Potato (*Solanum tuberosum* L.) is the fourth most important world crop, after rice, wheat, and maize. India ranks fifth in area as well as production in the world. The potato is grown in almost all the states in India under diverse agro-climatic condition. India occupies 1.28 million ha producing 22.5 million tonnes of potato, but the average yield (19 t/ha) is very low. Apart from other factors the main cause for poor yield is inadequate and imbalanced use of fertilisers. Potato crop has strict requirement for a balanced fertilization management, without which growth and development of the crop are poor and both yield and quality of tubers are affected. Among the major nutrients, potassium not only improves yields but also benefits various aspects of tuber quality. Some of the tuber quality parameters affected by potassium nutrition are tuber size, percentage of dry matter, starch content, internal blackening, storability and resistance to mechanical damage. Potassium also provides resistance against pest and diseases and drought & frost stresses. Field studies were conducted in the farmers' field by Krishi Vigyan Kendra Jainagar, Koderma, Jharkhand during 2 seasons (2011–12 and 2012–13), with cultivar (cv. Kufri Ashoka) and 4 fertilizer doses viz., i) NPK 100:60:30, ii) NPK 100:60:50, iii) NPK 100:60:60, iv) Farmer's practice (control) NPK 60:30:00 . The time of K application basal dressing, split application to investigate their effect on tuber yield and qualitative attributes (tuber length, no. of tubers/m^2, average weight of tubers). The highest potato yield was obtained with fertilizer doses NPK 100:60:60 (285.9 q/ha). The lowest potato yield was recorded in farmer's practice NPK 60:30:00 (165 q/ha). The highest no. of tubers (44/m^2) and tuber length (6.7 cm) were observed in NPK 100:60:60 and lowest in control treatment (NPK 60:30:00) 18 and 4.44 cm, respectively. The cost and return analysis showed that the highest benefit cost ratio (1:7.6) was recorded with fertilizer doses NPK 100:60:60. It was concluded that high yield and enhanced tuber quality can be achieved through the application of optimal nutrient doses in balanced proportion with potash.

P-23

Effects of bio-manipulation with fishes on eutrophic ponds in West Bengal

G. ZIAUDDIN, C. JANA, D. GHORAI, and SITANGSHU SARKAR[1]

Krishi Vigyan Kendra Burdwan, ICAR- CRIJAF, Bud Bud, Burdwan - 713 403

[1]Incharge, Agricultural Extension Section, ICAR-CRIJAF, Barrackpore

Pond fertilization through inorganic sources can cause eutrophication leading to negative health impacts in human and livestock, besides adversely affecting fish production in ponds. A biological method known as bio manipulation has been reported to be effective for treating ponds undergoing eutrophication in India and elsewhere. The objectives were to study the different combination of fishes, known to be heavy feeder like Grass carp and Silver carp, to control eutrophication and convert the excess nutrients into fish flesh. The effects of eutrophication leading to the concentrations of algal biomass, nitrates and turbidity were studied over a period

of 6 months on fishes such as Rohu, Grass Carp and Silver Carp on in eutrophic village ponds in Burdwan, West Bengal. Measurements of these water quality parameters were taken fortnightly in four experimental ponds where three ponds consisted of different combinations of fish (T_1- SC & Rohu, T_2- GC & SC, T_3- Rohu & GC) and the control pond (T_0) contained no fish. Results from this study suggested that introduction of fish in ponds as bio-manipulation did not reduce the concentrations of algal biomass or nitrate. This could be attributable to nutrient loading from fish excreta. The amount of turbidity, however, was lower in the control pond compared to the bio manipulated ponds probably because fish were not available to disturb the sediment in this pond. The results also revealed best fish productivity in case of T_3 (3.3 t/ha/yr), followed by T_2 (3.0 t/ha/yr) and T_1 (2.5 t/ha/yr). From this study it can be said that, though GC and SC are heavy feeders, bio-manipulation through these species are ineffective to control eutrophication in ponds.

P-24

Mind map in fertilizer purchase decision: A study in Birbhum district of West Bengal

KAUSHIK CHOUDHURY[1] and DEBDULAL DUTTA ROY

Psychology Research Unit, Indian Statistical Institute, Kolkata;

[1]School of Management Studies, Narula Institute of Technology

The aim of fertilizer industry is to expand market of existing fertilizer and to create new market with innovation. Fulfilment of both objectives depends upon fertilizer purchase decision of the farmers. This study examines what are the factors farmers consider to purchase fertilizer and how their socio-economic conditions affect purchase decisions. A study was conducted at few agricultural dominated blocks of Birbhum district, West Bengal. Two hundred farmers having more than 20 years of farming experiences voluntarily participated into the study. Farmers were interviewed with 30-item questionnaire. Results revealed that during purchase of fertilizers, they were thinking of 7 issues as Price, Landscape, Land size, Type of crops, Brand, Quality, Advertisement, Source of information. Out of them, more than 70% of farmers gave priority on fertilizer quality (89%), landscape (78%), crop types (73%) and brand (71%) than others as advertisement (64%), information (55%) and price (45%). Purchase decision varied with landholding capacity and economic conditions of the farmers. The findings are useful for fertilizer marketing.

P-25

Fertilizer prescriptions based on targeted yield concept for potato (*Solanum tuberosum*) in New Alluvial zone of West Bengal

NIHARENDU SAHA, SUDESHNA MONDAL, SHUBHADIP DASGUPTA, BISWAPATI MANDAL, and PRADIP DEY[1]

AICRP on Soil Test Crop Response Correlation, Directorate of Research,

Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal;

[1]Project Coordinator, ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh

Soil-test based fertilizer application to achieve potato (*Solanum tuberosum* L.) yield fixed and its response to fertilizer applied was studied in New Alluvial soil (Aeric Haplaquept) during rabi season to develop fertilizer prescription equations. Three levels of fertilizer N, P, K were randomly distributed in 16 plots and 4 fertility gradient strips with a total of 64 plots. Soil and plant analysis data were exploited to formulate fertilizer adjustment equations at varying yield targets at different fertility levels. Co-efficient of determination (R^2) was found significant between yield and soil test values. Agronomic, physiological and recovery efficiencies were

computed for different fertility gradient strips. Based on the experiment, the nutrient requirement for producing 100 kg of potato tuber was 0.33 kg of N, 0.05 kg of P and 0.40 kg of K. The per cent contribution from soil was 20.01, 8.02 and 19.84 and that of fertilizer was 15.41, 5.43 and 26.21 for N, P and K, respectively. Verification of the equations was done in the next rabi season on 4 farmers' field in 2 districts viz. Hooghly and Burdwan. The deviation in yield obtained from the targeted yield ranged from +8.5 to 12.5%. Response ratio varied from 25 to 35 kg/kg under different farmers' field. The farmers' practice of fertilizer application was least efficient in producing desired tuber yield of potato. Both the highest benefit: cost and response ratio was found with farmyard manure 5 t/ha + yield target 2500 kg/ha indicating the best management practice for potato cultivation.

P-26

Green technology for sustainable agriculture

SANJAY KUMAR[1] and F. H. RAHMAN[2]

[1]*Programme Coordinator, Gumla Krishi Vigyan Kendra, Vikas Bharti Bishunpur, Gumla, Jharkhand;*
[2]*Senior Scientist, ICAR-Zonal Project Directorate, Zone - II, Salt Lake, Kolkata*

Green Technology (GT) is an environmental healing technology that reduces environmental damages, which contributes to both poverty reduction and sustainable agricultural development. The study heavily focuses on environmental concerns and increasing demand for green production technology for raising income and achieving sustainable agricultural development through Identifying appropriate technology suitable for income generation through sustainable agriculture; Examining the impact and implications of national policies on GT; Diagnosing policy-level impact of GT on rural income generation under the sustainable agricultural development framework; Reviewing the challenges and available policy options for the adoption of GT. Sustainable Green Technology for tribal areas of Jharkhand is green manuring which is an important option to maintain or improve soil fertility for sustainable crop production. Importance of the soil ameliorating practice is increasing in recent years due to high cost of chemical fertilizers, increased risk of environmental pollution and need of sustainable cropping system. Green manuring could be an alternative option in place of costly chemical fertilizers for improving soil physical, chemical and biological properties and consequently crop yields. At present only 6.7 mha is under green manure which account for 4.5% of net sown area of the country. Integrated crop management is the best traditional method with appropriate modern technologies which includes economic production of crops with positive environment management as example high yielding variety adapted, use of high quality seed, whole seedling produced in a modified mat nursery, transplant one seedling per hill, mechanical weeder used at proper time and fertilizer application as and when needed, harvest when 95% of grain is yellow, thresh immediately after harvest dry grain evenly, mill grain at 14% moisture. Water management must be integrated like check dam, Jalkund, renovation of existing ponds/wells, field bunding, mulching, micro irrigation system, rain water harvesting structure etc. Conservation agriculture are recommended for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production level while concurrently conserving the environment. Organic waste production are constantly increasing. Waste water or sludge from waste water treatment is often spread on agricultural land on the outskirts of cities. These organic waste productions are source of organic matter. Biogas is product of anaerobic digestion of organic matter by bacteria. Biogas can serve to meet energy requirements for cooking, lighting, refrigeration, electricity generation and internal combustion engines. Environmentally responsible and economically rewarding use of complex technologies demands knowledge and foresight. The technologies should satisfactory facilitate the growth of green farming business. The enabling environment should be created to inform potential rewards, challenges and consequences of green technologies to all stakeholders. Only then the fruits of Green Technologies could be enjoyed by farmers as well as the consumers.

P-27

Changes in physico-chemical properties of soil with fertiliser gradient, soil depth and soil moisture content in wheat

A. KRISHNA CHAITANYA, ARUP DEY, SHUBHADIP DASGUPTA, and S.K. PATRA
Department of Agricultural Chemistry and Soil Science,
Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal – 741 252

A field experiment was conducted on wheat at the Central Research Farm, Gayeshpur, encompassing the new alluvial zone of West Bengal, laid out in factorial RBD with 3 treatments [T_1: 100:50:50, T_2: 120:60:60, T_3: 150:75:75:: N:P:K kg ha^{-1}], 8 sampling dates and 3 depth of sampling with 3 replications. Soil pH was reduced significantly with increase in dosage of fertilizer, to increase significantly with depth of sampling, increase significantly with increasing soil moisture and can govern 32.2 - 42.4% of total variations. The Soil organic carbon (OC) increased significantly with increase in fertilizer doses and to reduce significantly with depth of sampling, recoveries increased significantly and progressively with advancement of crop period and the changes in moisture can govern 86.7% of total variations in soil OC. The recoveries of plant available N, P and K were observed to increase significantly with increasing doses of fertilizers and reduce with increasing depth of sampling. The recoveries of available macronutrients in the soil were within the range of 111.40-178.53 for N, 38.91-86.74 for P and 120.74-178.40 for K. The changes in recoveries of available macronutrients (63% for soil N, 83 % for soil P and 77% for soil K variations) under different simulated situations were largely dictated by variations in soil moisture.

P-28

Use of water hyacinth through a new composting method as an effective tool for bio-resource utilization in farmers' level – A case study

K. MUKHOPADHYAY[1], S. MUKHERJEE[1], AJIT KUMAR DOLUI[2], ANIRBAN SOM[2], R. BERA[3] and A. SEAL[3]
[1]*Howrah Krishi Vigyan Kendra, BCKV, Jagatballavpur, Howrah-711 408, West Bengal;*
[2]*Institute of Agricultural Science, Calcutta University, 35 Ballygunge Circular Road, Kolkata-700 019;*
[3]*Inhana Organic Research Foundation (IORF), 168 Jodhpur Park, Kolkata-700 068, West Bengal*

Water hyacinth is a major threat for water bodies and at the same time it could be an excellent tool for organic soil resources if suitable composting technique can be adopted. The vast water masses in Howrah district of West Bengal have ample resources of water hyacinth which was not used till date as an organic resource in agricultural fields and thus remain as waste material. Novcom composting method was tried out for effective biodegradation of water hyacinth in Krishi Vigyan Kendra, Howrah, West Bengal during January to February, 2014 and the results showed a good quality mature compost can be obtained only within 21 days. The analytical results showed qualitative aspects of Novcom compost in terms of total NPK content (4.18 %), total microbial count (in the order of 10^{14} to 10^{16} c.f.u.) and germination index (>1.0 which it confirmed that the compost enhanced rather than impaired germination and radical growth) as also substantiated by the high compost quality index. Absence of any infrastructural requirement for composting, speedy biodegradation period (21 days), high end product quality indicated the potential of Novcom Composting Method towards large scale adoption among farmer's level.

Author Index