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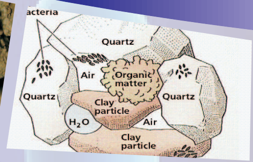
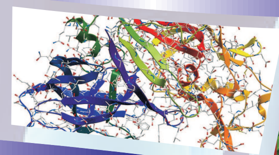




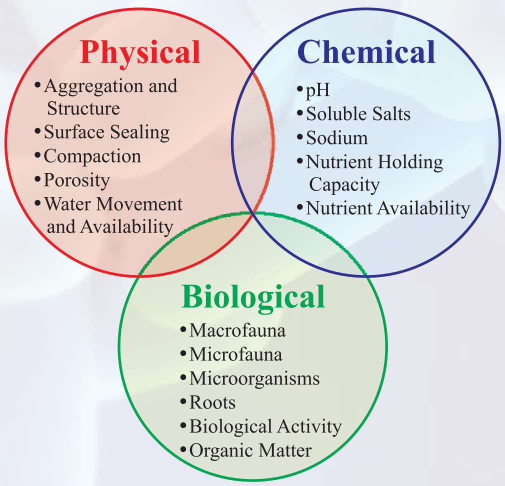
Fertilizers and Environment News

Society for Fertilizers and Environment
16 Ellora Road (Canal Road), Kolkata 700 075
West Bengal, India

From President's Desk

Focus on soil biological properties *vis-à-vis* improved soil health and production sustainability

In simplest terms, soil quality is "the capacity (of soil) to function". This definition, based on function, reflects the living and dynamic nature of soil. The soil resource must be recognized as a dynamic living system that emerges through a unique balance and interaction of its biological, chemical, and physical components. Of the three components, dynamics of chemical properties have been studied most, while the other two and their interactions were probably least studied and therefore deserve more attention for an understanding of impact of fertilizer use on soil quality or soil environment.



Soil health components (https://www.ndsu.edu/soilhealth/?page_id=37)

It is accepted that in India green revolution in sixties and the research agenda during subsequent periods resulted in high rate of mining of soil nutrients by HYVs, which might have even nearly robbed off the soil nutrient reserves to meet its supply to plants if the same was not recouped from outside. The soil organic resource, on the other hand, in conjunction with soil porosity and other physical properties is responsible to mediate and trigger major nutrient transformations and their availabilities to plants. It is not uncommon to observe under intensive application of inorganic fertilizer and plant protection chemicals downslide or at most marginal increase in productivity of lands with time, not commensurate with our expectations in spite of high technological inputs, in different soils. It is the non-return or diminished return of organic matter to soil, loss of soil organic matter by ploughing, etc. that lead to reduction in SOM and unsustainability in production. The best option for longer term biodiversity conservation and improving soil health is to use integrated farming systems (IFS) involving management practices like:

In this issue

* Organic recycling e.g., composting of residues, other biodegradable material
* Green manuring
* Agro-forestry practices involving nitrogen fixing shrub
* Conservation agricultural practice
* Organo-mineral fertilizers including fortified composts
* Biofertilizers e.g., rhizobia, mycorrhiza, PGPR, BGA, *Azolla* etc., and Bio-control agents

The missing link in research, I am particularly concerned, is complete lack of focus on soil biological properties and specifically the microbial biodiversity in our studies on soil health. Following may be the agenda: (i) relationship between genetic and functional biodiversity, (ii) modelling of data as a way to predict soil health, and (iii) statistical considerations and modelling as means of optimizing an up-to-date monitoring programme by identifying relevant indicators.

Hope this opens up interesting discussion on the theme area identified as "Influence of fertilizer application on soil biology" for this issue.

H.S. Sen
President

NEWS

Handing over – Taking over of charges of the Society for Fertilizers and Environment

A combined Executive Committee meeting of the Society was held at ICAR-ATARI on 30.03.16 where the charges of the existing EC were handed over to a newly formed EC, to be effective from 1 April, 2016.

All relevant documents of the society on day-to-day functioning including financial transactions, available audit documents, etc. were handed over. The new EC assumed the authority to deal with all administrative and financial transactions including re-designating authorized signatories to operate the bank independently.

Prof. Biswapati Mandal of BCKV assumed the charges of Secretary while Dr. H. S. Sen, Former Secretary was nominated unanimously to act as President of the Society. Dr. Dibyendu Sarkar, Asst. Prof., BCKV was entrusted for the position of Treasurer.

SOCIETY FOR FERTILIZERS AND ENVIRONMENT
16, Ellora Road (Canal Road)
Kolkata - 700 075, West Bengal, India
(Registered Society under West Bengal Societies Registration Act, 1961)

Proceedings of Handing over-Taking over charge of the Society for Fertilizers and Environment (Regn. No. 2764 of 2012-2013) w.e.f. 1 April 2016

As per bye-laws and provision in the constitution of the Society a combined EC meeting was held at the office of the ICAR-ATARI on 30 March 2016 at 3 PM wherein the charges of the existing EC were handed over and taken over by the old and new EC, respectively to be effective from 1 April 2016.

All relevant documents of the Society on day-to-day functioning including financial transactions, available audit documents, etc. were handed over. The new EC will have the authority to deal with all administrative and financial transactions including re-designating authorized signatories to operate the bank (UCO, A/C 08370110011294)independently.

Signed at ICAR-ATARI, Zone II, 30 March 2016, 3 PM:

Charges handed over

Kunal Ghosh, President
Himadri Sekhar Sen, Secretary
Amrita Lal Das, Treasurer
(Old EC up to 31 March 2016)

Charges taken over

Himadri Sekhar Sen, President
Biswapati Mandal, Secretary
Dibyendu Sarkar, Treasurer
(New EC w.e.f. 1 April 2016)

Signed in presence (EC Members) of:

1. Arabinda Kumar Jana
2. Dulal Chandra Nayak
3. D.K.Kundu
4. F.H.Rahman
5. Dipankar Ghorai
6. S.K.Roy
7. Kanu Murmu

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NEWS

Annual General Meeting of the Society held at BCKV, Kalyani on 26 Feb, 2016

The AGM was held at the Lake Hall campus of BCKV, Kalyani at 4.30 PM on 26 Feb, 2016. The Secretary welcomed all the members to the AGM. He particularly, while observing a large number of new members joining the Society, requested all to take active part and submit their suggestions. Altogether 58, out of 137 members, were present during the meeting.

Following were the activities,

1. Minutes of the last Annual General Meeting held on 26 March 2015 was confirmed.
2. Annual Report of the year 2014-2015 was presented and accepted by all.
3. Audited statement of Accounts of the year 2014-2015 was presented by the Treasurer and was duly supplemented by the President and the Secretary and was accepted. It was a general consensus that the financial strength of over Rs. 3 lakh as of now is satisfactory considering its short stint so far. The Society expressed its gratefulness to the ICAR for their support during the last Conference and the NAAS for the One-day Seminar being held on this day.
4. Appointment of Auditor for the year 2016-2017
   The following firm was appointed auditor for the year 2016-17:
   M/S K.L.Banerjee & Co.
   Chartered Accounts
   Hastings Chambers, Basements
   7C, Kiran Sankar Roy Road
   Kolkata 700 001
5. Guidelines prepared for selection of Patrons and Fellows of the Society were endorsed by the EC, and the same approved by the AGM. However, the criteria, as endorsed by the EC, will be uploaded in the website for comments/ suggestions before asking for nomination/ selection. This will take into effect w.e.f. 2016-17.
6. Formation of new Executive Committee:

   The President of the Society, as endorsed by the EC, selected the following members portfolio-wise to form the new EC as per provision in the constitution of the Society to take over wef 1 April, 2016 for the next term. Nominations were invited from all sectors and the decision was unanimous.
   - President: Dr. H.S.Sen
   - Vice-President: Dr. D.C.Nayak
   - Secretary: Prof. Biswapati Mandal
   - Joint Secretary: Dr. F.H.Rahman
   - Treasurer: Dr. Dibyendu Sarkar

   Other Council Members:

   Dr. G.C.Hazra, Dr. D.K.Kundu, Dr. S. Bhadra Roy, Dr. Amit Rastogi, Dr. Pradip Dey, Dr. Siladitya Bandyopadhyay, Dr. S.K.Roy, Dr. S. Chandra, Dr. Dipankar Ghorai, Dr. Kanu Murmu

   The Secretary presented vote of thanks on behalf of the Society to all members for cooperating in order to improve the activities of the Society, and wished the new EC a very good success in their endavour.

NEWS

One Day National Seminar on "Environmental Concerns of Fertilizer Use in Future" on 26.02.16 at BCKV, Kalyani

A One Day National Seminar on "Environmental Concerns of Fertilizer Use in Future" was organized by SFE, Kolkata in collaboration with Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur, Nadia, West Bengal and National Academy of Agricultural Sciences (NAAS), New Delhi. It was held at Farmers' Academy and Convention Centre (Lake Hall), Kalyani, Nadia, West Bengal on 26 February, 2016.

PROCEEDINGS:

Inaugural session:

Prof. Biswapati Mandal, BCKV and Organising Secretary of the event welcomed the participants and set the tone by voicing his concerns over indiscriminate and inefficient fertilizer use compromising the benignity of environment with special emphasis on phosphatic fertilizers which, according to him, should be more meticulously mended than other kinds of fertilizers. Among other issues, he expressed his qualms on sole dependency of soil test based corrective measures of soil problems, which might take a awful lot of time – 17 years on most conservative estimates – and as such, he argued, approaches like GIS based mapping of soil nutrients, private – public partnership and mass involvement of all stakeholders and players in the field, etc. should be emphasized.

Prof. G. C. Hazra, Head, Dept. of Agricultural Chemistry and Soil Science, BCKV and Organising President of the seminar went with no holds barred in voicing his disquiet over the distressing rate at which natural resources are being depleted due to inconsiderate fertilizer application and thereupon the pressing need of judicious use of fertilizers to upkeep the environmental footprints.

Prof. Kunal Ghosh, President, SFE, in his address, enunciated the need for forming 'Society for Fertilizers and Environment' to reach out to all concerned and invoke alacrity among all stakeholders about devising 'Green Technologies' from fertilizer perspective and the need for researchers and industry going hand in hand towards this end.

Dr. H. S. Sen, Secretary, SFE, briefed the audience about the initiatives taken by the society for providing a platform to industry, scientists and planners to come up with fertilizer technologies to address the issue of food security vis-à-vis environmental benignity. He advocated the need for more meaningful research to pinpoint the role of microbes, and their interaction *per se* with physical and chemical constituents of soil, to enhance the nutrient use efficiencies of applied fertilizers.

Technical session:

The technical session of the seminar was chaired by Prof. Kunal Ghosh. A total of six presentations from scientists and industry were there, three from each side.

The keynote address was delivered by Ch. Srinivasa Rao, Director, ICAR-CRIDA on 'Environmental issues of future fertilizer use in India'. The focal point of his address was food security vis-à-vis climate change. He highlighted the following points of concern in his speech:

1. Stagnation of productivity
2. Location specific nutrient deficiencies
3. Declining response ratio to fertilizers
4. Statewise wide variation in fertilizer consumption
5. Energy requirement and CO_2 emission from fertilizer production
6. High Global Warming Potential of N-fertilizers
7. Eight of the last fifteen years were drought years

In view of the decreasing use efficiencies of fertilizers, Dr. Rao pinpointed to some strategies to enhance fertilizer use efficiency as below:

1. Synchronous fertilizer application with soil moisture availability
2. Improving SOC through integration of organic with fertilizers, impose restrictions on crop residue burning, conservation agriculture through residue retention etc.

3. Recycling of lost fertile soil with nitrogen and carbon
4. Site specific nutrient management

He also presented various notable case studies/success stories of CRIDA regarding initiatives on climate resilient agriculture.

Dr. Amit Rastogi, Sr. Vice President, Coromandel Fertilizers Ltd. presented a paper entitled "Can nutrient use efficiency (NUE) targets promote the development of environment friendly fertilizers – an industry perspective". He pointed out to the Sustainability Development Goals (SDGs) of United Nations – Goal 2, 13 and 14, in particular - where fertilizer industries can contribute significantly. In connection with environment protection, he outlined the nine planetary boundaries propounded by Rockstorm *et al.* (2009) which define the safe operating zone for Rockstorm *et al.* (2009) humanity. He made special reference to N and P boundaries. He voiced his concern over the fact that according to Rockstorm *et al.* the N boundary has already been crossed and P boundary is very near the threshold limit. He discussed in detail International Fertilizer Association's position on NUE targets. He also briefed the house about Coromandel's initiative in developing efficient fertilizers products as below:

1. Neem coated urea ammonium phosphates
2. Complexing of phosphate with organic molecules to prevent fixation
3. Addition of elemental sulphur along with sulphate sulphur in fertilizers
4. Use of micronized zinc oxide for fortification of fertilizers
5. Use incinerated spent wash containing potassium oxide as a source of potash

The next presentation was made by Dr. T. J. Purakayastha, Pr. Scientist, IARI, New Delhi on "Can balanced fertilization enhance C-sequestration ? Opportunities for mitigating climate change". He was of the opinion that balanced fertilization can augment C-sequestration and productivity, sustainability and soil quality. Citing a paper of Dr. Biswapati Mandal, he inferred that around 3 MgC ha^{-1} $year^{-1}$ must be added to soil in order to maintain SOC.

Dr. Subhendu Bhadraray of Tata Chemicals, then, gave a lecture on "Novel formulations and approaches for sustainable crop nutrition solution". In his talk he deliberated on the myths and realities regarding fertilizers and sustainability. He argued that there is underestimated importance of product innovation in research. He also pointed out to various issues related to slow release and control release fertilizers like, agronomic efficiency, economic viability, environmental sustainability and process compatibility. The fact that developed countries relying on controlled release fertilizers like neem coated urea, polymer coated urea, sulphur and polymer coated urea and stabilized urea was highlighted by him. He opined that environmental cost of fertilizer production must be taken into consideration while talking sustainability.

Next, Dr. Pradip Dey, Pr. Scientist, IISS, Bhopal spoke on soil health management for better NUE. He informed the house that in the next 3 years a total of 140 million soil samples are going to be analysed and issued soil health cards for site specific nutrient management. He was of the view that GIS based mapping may come in handy in SSNM.

The final speaker was Mr. J. Chankraborty form Indofil Ltd. He spoke on role of agrochemical in ensuring food security.

The technical session ended with vote of thanks by Dr. F. H. Rahman, Pr. Scientist, ICAR-ATARI, Kolkata.



ARTICLE

Long-term application of fertilizers and manures on soil biological activities under intensive cropping systems

The indiscriminate and excessive use of inputs has increased the cost of production over the years and deteriorated soil health. Sustaining soil health is the most effective method for ensuring sufficient food to support living system. With the development in agricultural sciences, plant nutrients were identified as an essential component of soil health with respect to sustaining biological productivity. This resulted in a new paradigm of plant nutrition and soil health management that relied heavily on the use of chemical fertilisers and intensive tillage. Increasing concern over agriculture's impact on the environment has created renewed interest in soil health. Considering soil health, biodiversity and biogeochemical processes, soil organic carbon (SOC) storage in agricultural land is crucial not only to enhance productivity but also for maintaining and improving various soil processes, and of course, is a storehouse of all soil microorganisms.

However, total organic C estimation does not reflect the entire soil functions. Here comes the importance of the active pools that are comprised of labile or easily decomposed materials, including living biomass, most of the polysaccharides and other non-humic substances. These fractions are sensitive to subtle changes due to nutrient management. In this article we have attempted to compile the cause of poor soil health and to establish a relationship between SOC and soil biological activities under long-term application of fertiliser and manure in different soils and cropping systems of India. Our results suggest that while considering soil biological health, a minimum data set may be assessed for researchers, policy makers and end users.

Causes of poor soil health

The major reasons that have been identified responsible for poor soil health are:

1. Wide gap between nutrient demand and supply leading to negative nutrient balance
2. Imbalanced use of fertiliser
3. Intensive cultivation causing secondary and micronutrient deficiency
4. Development of acidity, salinity and alkalinity
5. Disproportionate growth of soil microbes
6. Heavy metal contamination
7. Soil erosion.

Soil organic matter and its significance in maintaining biological soil health

Soil organic matter (SOM) is the most crucial parameter contributing to soil health. It influences, directly and indirectly, soil physical, chemical and biological parameters and bio-geo-chemical processes. SOM is perceived to have influenced soil microbes by,

i) supplying metabolic energy for soil microbial and faunal activities
ii) stabilising enzyme activities
iii) acting as a source of plant nutrition through mineralization

Labile fraction of SOM (microbial biomass C and N) are more sensitive indicators for alteration in soil management practices as compared to total SOM. Furthermore, a greater range of labile soil organic matter attributes such as light fraction of organic matter, particulate organic matter (POM, <53µm), water soluble C, acid hydrolysable carbohydrates and potentially mineralizable C have also been found to be more sensitive to changes in management practices. In spite of this, little focus was given towards the labile pools of C as compared to total organic carbon (TOC) in most agricultural soils. Particulate organic C (POC) is considered as an intermediate fraction of SOC between active and slow fractions that change rapidly over time due to changes in management practices (Bayer *et al.,* 2001). It contributes to 20-45 % of TOC and 13-40 % of TN of the soil (Manna *et al*., 2015). It is the precursor for formation of soil microbial biomass C (SMBC), soluble fraction of C, humic and non-humic fraction of C in soil, and also acts as a source of cellular C and energy for the heterotrophs and endogenic soil fauna. Although the labile pool is a small fraction of SOM, its concentration is buffered by replenishment mechanisms, such as desorption from soil colloids, dissolution from litter and exudation from plant roots (Curtin and Wen, 1999). Results show that the interrelationships between SOC and active fractions of C, such as SMBC, dehydrogenase activity (DHA) and alkaline phospahatase activity are the most sensitive indicators of soil quality parameters (Fig.1). It was also observed that decline in yields was more pronounced with concomitant decrease in SOC content under imbalanced fertiliser application. Long-term application of NPK and NPK+FYM maintained or improved SOC content over initial. Therefore, application of fertiliser in combination with manure every year may contribute more labile C that acts as a source of energy for soil microbes and improves nutrient supply. Further, it was reported that POC, water-soluble C and hydrolysable carbohydrates improved significantly with the application of NPK+FYM with concomitant increase of SMBC (Manna *et al*., 2006).

Minimum dataset for biological soil health quantification

Due to the explosion of interest in alternate farming systems, like organic farming, conservation farming, etc. *minimum data* sets of physical, chemical, and biological properties that can be used as quantitative indicators of soil health have assumed crucial significance. As soil is a multitasking system, the goal of relating indicator properties to specific functions or processes is very difficult. A large, diverse and active population of soil organisms are the major drivers for maintaining soil health, as they control the decomposition of plant and animal residues, biogeochemical cycling of nutrients, formation of soil structure and fate of organics applied to soils. Despite, its tremendous significance, soil biological activity may be the most difficult indicator to satisfactorily measure and interpret.

Soil organic matter has thus been recognized as most important biochemical soil indicator attributing to its dynamic nature. More precisely, it is the fractions of soil organic C that are more instrumental behind SOC dynamics regulating soil quality. Particulate organic matter (>53µ) and microbial biomass are vital pools of SOM turnover and are sensitive indicators of management-induced changes in the fate of crop residues. In addition, soil respiration and potential N mineralization and metabolic quotient (qCO_2) are widely used as soil biological quality indicators. qCO_2 is a more sensitive indicator of soil microbial reaction to cropping systems. Lower values implying more stable and mature systems where C utilization efficiency of the microbial population is higher due to shift from zymogenous to autochthonous microflora whereas higher values indicate stress generated on soil microbial community.

Conclusion

It will be an expensive approach and needless to devote the time and effort involved in measuring dozens of soil biological parameters. Based on our studies and published literature, it is suggested that measurement of only five parameters, viz., POM, soil respiration, SMBC, DHA and SOC would be adequate to give a complete picture of soil biological health. However there is also a need to undertake systematic studies on soil microbial diversity changes in conservation farming and possible implications for soil functions, since in order to sustain the agricultural productivity maintenance of living component of soil needs a greater attention.

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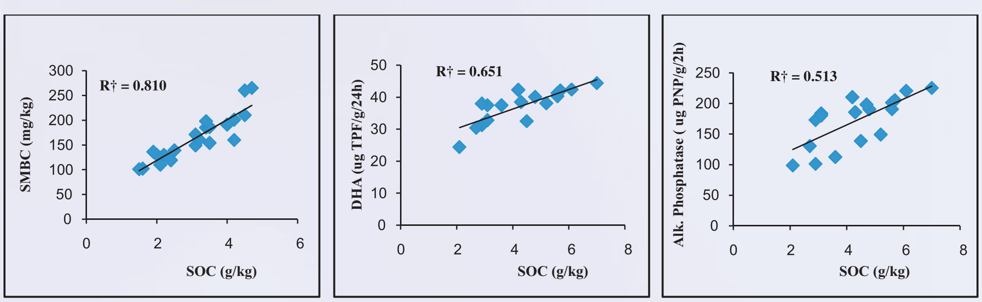

Fig. 1 Relationship between SOC and biological activities in soils

ARTICLE

Fertiliser use and soil biological health and assessment of its indices

Microorganisms perform a key role in nutrient cycling for sustaining the productivity of the soils, because they are the source and sink for mineral nutrition and can carry out biochemical transformations.

Biological indices

Different biological indicators of soil health include soil microbial biomass, soil respiration or C mineralization, potentially mineralizable N, enzyme activity, fatty acid profile or microbial biodiversity, nematode communities and earthworm populations. Soil microbial biomass is a labile source and sink of nutrients. Soil respiration indicates the oxidative capacity of soil microorganisms and therefore is influenced both by the energy sources in the soil and the number of microorganisms. It may vary with several factors, such as climate, soil management practices, amendment, contamination, etc. Another straightforward index used in the literature is the metabolic quotient (qCO_2) (respiration to microbial biomass ratio), widely used to evaluate ecosystem development, disturbance or system maturity (Bastida *et al.*, 2008). Potentially mineralizable N measures soil N supplying capacity and is also a surrogate measure of microbial biomass and a labile fraction of soil organic matter. Another widely used biological indicator is permanganate oxidizable soil C, which reacts with the most readily oxidizable (active) forms of soil C, responds more quickly to management/disturbance than total SOC. Mandal *et al.* (2011a) recorded that the permanganate oxidizable C was closely related to other soil quality parameters, such as infiltration rate, mean weight diameters of soil aggregates, bulk density, dehydrogenase activity, microbial biomass carbon and organic carbon, and can serve as a sensitive indicator for management-induced soil quality.

Soil enzyme activity is often closely related to soil organic matter, microbial activity and microbial biomass. It is sensitive to change in management practice and can readily be measured. Enzyme assays have the advantage of being relatively rapid and is low in cost. Of numerous soil enzymes, dehydrogenase is a potential indicator of active soil microbial biomass. Other potentially useful indicators measuring soil quality enzyme activities could be β-glucosidase, urease, amidase, phosphatase, and aryl-sulphatase and flu orescein diacetate hydrolyzing enzymes. Since enzyme activity is operationally defined, it requires strict protocol.

Of the soil invertebrates, earthworms and nematodes are the potential indicators of soil quality. While earthworm activity can contribute to the health of soils, its population are of little use as indicators of soil quality because it responds to large inputs of organic matter in moist soils of near neutral pH, but these conditions are not a prerequisite for good soil quality. In addition, earthworms are not ubiquitous and may be absent from soils considered to be of high quality.

Though many groups of organisms and various biological processes have been used as indicators of soil quality in research programmes, there is a lack of consensus, however, as to which are the key indicators for extensive monitoring programmes, and little information is available on threshold values to aid data interpretation. Among all the biological indicators soil microbial biomass C (MBC) is most widely used biological indicator in the assessment of soil quality around the world. Mandal *et al.* (2011b) reported that MBC contents >200 mg kg^{-1} indicated good soil biological health for semiarid tropical soils of India.

Effect of fertilisers on soil biological health

The direct effects of fertiliser use on soil biota can be positive or negative and vary in duration depending on time-frame considered, the type and amount of fertiliser used and its manner of application. As a whole the short term effects of fertiliser applications on soil microbial communities have been found to be minimal. Several long term studies found that fertilization led to changes in soil microbial community composition. Recently, Geiseller and Scow (2014) published a meta-analysis based on 107 datasets from 64 long-term experiments from around the world and revealed that mineral fertiliser application led to a significant increase (15.1%) in the microbial biomass above levels in the unfertilized control treatments. Mycorrhizal fungi have been consistently reported as being decreased by P fertiliser application but the extent to which this occurs depends on species of fungus involved and level of plant available P. It is considered that the availability of C substrate is the primary limiting factor on microbial activity in soils. Additions of organic manures through FYM and crop residue (Fig. 1) and the use of mineral fertilisers can counter losses of N, P, and other nutrients – and help to restore and sustain soil biological health (Singh and Ryan, 2015). Our observation in semiarid tropical soils of India showed that most of the dominant rainfed cropping systems i.e., castor, redgram and intercropping systems under subsistence agricultural practices had poor biological soil health whereas rice, maize cotton under balanced nutrients of chemical fertiliser and organic manures have good soil biological health (Table 1).

Fig. 1 Farm waste to be used as organic source in soil

Table 1 Soil biological health in semiarid tropical soils of India

Land use system and soil type	Organic carbon (%)	Dehydrogenase activity (mg $kg^{-1}h^{-1}$)	Microbial biomass C (mg kg^{-1})	C-mineralization (mg C-CO_2 kg $soil^{-1}day^{-1}$)	N-mineralization (mg kg $soil^{-1}$)
Castor	0.34	3.13	95.0	4.33	18.43
Cotton	0.59	3.28	223.4	8.52	41.80
Fallow	0.69	3.49	277.9	11.75	40.86
Intercrop	0.50	2.65	176.5	6.36	46.22
Maize	0.62	3.69	221.2	8.50	34.28
Rice	0.76	4.56	289.5	9.85	41.85
Redgram	0.55	2.99	192.8	7.34	47.66
Alfisols	0.61	3.12	218.7	8.26	42.90
Inceptisols	0.62	3.92	257.9	9.25	44.52
Vertisols and Vertic Inceptisols	0.69	3.77	258.5	10.60	35.85
Irrigated system	0.67	3.87	251.2	9.12	38.24
Rainfed system	0.53	2.78	189.2	7.15	47.16

The effect of fertiliser in microbial community composition still cannot be fully captured with methods that discriminate, at best, major microbial groups, such as bacteria, fungi and actinomycetes. Genomics approaches that can differentiate changes within specific groups need to be used to identify and interpret phylogenetic and functional changes of microbial communities with long-term fertiliser induced changes. More studies investigating the long term effects of different fertilisers across different soil types and environmental conditions are needed to better understand these complex interactions.

Conclusion

Variations in soil properties and environmental factors, such as temperature, water availability, aeration and nutrient supply have a large effect on the population dynamics of soil microorganisms so that care must be taken to standardise sampling procedures as much as possible. The primary aims of soil quality monitoring, however, are (i) to establish benchmark values (or ranges) for key indicators, and (ii) to monitor changes over time. The availability and standardisation of methods for the measurement of biological indicators and its threshold values by soil laboratories is a challenge. While the absolute values of many biological indicators are of little value without the benchmarks, the change in indicator values, either over time or when compared to a nearby reference site, can measure changes in soil quality, provided that the indicators are relevant to critical soil functions.

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ARTICLE

Effect of chemical fertilisers on the beneficial soil microorganisms

The early green revolution in India introduced intensive application of chemical fertilisers as inputs for increasing the per unit productivity of the crop production to meet the food requirement for the growing population (Damodaran *et al.*, 2014). Since the 1950's these mineral fertilisers, especially nitrogen (N) inputs have been the major contributor in crop yield increase (Robertson and Vijtousek, 2009) and simultaneously is the limiting nutrient for many terrestrial ecosystem like soil bacteria and fungi (LeBauer and Tresder, 2008). These tiny below ground communities are greatly affected by the chemical inputs in the form of fertilisers, in other words, about 84% of the studies in this regard reported that microbial community composition is sensitive to nitrogen (N), phosphorus (P), and potassium (K) fertilisation. The chemical fertilisers are although one of the prime factors contributing to increase in agricultural production, are however known to exhibit deleterious effect on soil and environment, if used injudiciously (Olajire-Ajayi *et al.*, 2015).

Effect of nitrogen fertilisers

Addition of N through mineral fertilisers has been found to influence the aboveground biological processes both directly and indirectly. The SMB is one of the most sensitive indicators of ecosystem function though they form a small part of the soil. High N application reduced the SMB significantly and also the functional diversity of the microflora. Studies have indicated a taxon shift in response to N addition with climate. In summer, there was an increase in relative abundance of actinobacteria and acidobacteria with N addition while in winter there was a decrease. High level of N application in the form of ammonia fertilisers like urea, di-ammonium phosphate increased the toxicity of ammonia to the bacterial population. Increasing levels of N significantly suppressing the population of *Azotobacter* in soil is well documented (Bagyaraj and Patil, 1975). Application of calcium nitrate did not alter the microbial biomass N while repeated application of ammonium sulphate reduced the microbial biomass N (Wessén *et al.*, 2010).

Long-term fertiliser applications significantly affect soil microbial communities throughout the soil profile; in fact the relative abundance of ammonia-oxidizing archaea at 0-40 cm depth was noticed (Li *et al.*, 2014). Application of ammonium nitrate resulted in relatively lower proportion of Gram negative bacteria while there was an abundance of Gram positive bacteria (Peacock *et al.*, 2001). Long-term continuous application of ammoniacal fertilisers without any supplementation of the organic fertilisers leads to acidification of soils.

In an experiment on microbial dynamics in alfisol of Western Himalayas (Mahajan *et al.*, 2007) significant reduction in bacterial colony forming units (CFU) was witnessed with an increase in the dose of NPK from 50% of recommended level to 150%. However, supplementation of the inorganic N application with the organic sources like FYM and biofertilisers neutralized the negative effect of the fertilisers and had a stimulatory growth effect on the Genus *Bacillus* (*B. megaterium*, *B. aureus*). The application of biofertilisers and bioformulations along with N fertilisers induced an increase in the count of soil bacteria, oligonitrophilic bacteria and *Azotobacter*. In addition the formulations lead to higher phytohormone production and detoxification of the soil contaminated with heavy metals, high salt levels, etc. A bio-product CSR-BIO containing a consortium of microbes like phosphate solubulisers, growth promoters and bioprotectants when applied with NPK fertilisers increased the CFU of bacteria and fungi in the salt affected soil and also alleviated the salt stress in the plant rhizosphere (Damodaran *et al.*, 2014). Higher levels of the nitrogenous fertilisers increased the fungal population due to the acidification of the soil.

Application of heavy doses of N fertilisers can have a large negative effect on AM population and nitrate as a source of N has been shown to be more inhibitory to AM development than ammonium salts (Lakshmipathy *et al.*, 2007). Levels greater than 80 ppm N significantly decreased the number of infective propagules of *G. fasciculatum*. These results indicate that N content in soil could greatly influence the distribution and abundance of AM fungi.

Effect of phosphorus & potash fertilisers

Repeated applications of P fertilisers from chemical source leads to disturbance in the microbial diversity. In long-term, continuous use of chemical fertilisers through different sources of phosphate fertilisers inhibits substrate-induced respiration and microbial biomass C production ability of the microbes (Bolan *et al.*, 1996). Phosphate solubilising microorganisms (PSM) of the soil/rhizosphere aids in reducing the effect of P deficiency in soils. PSM solubilise tri-calcium phosphate by binding free P in the medium and also by release of organic acids. Application of microbial inoculants possessing P-solubilising activities in agricultural soils is considered as an environmental friendly alternative to further applications of chemical based P fertilisers.

The role of arbuscular mycorrhizal (AM) fungi in P mobilization and improving crop growth is well documented (Bagyaraj *et al.*, 2015). High P availability is reported to be negatively correlated with AM fungal activity (Krishna and Bagyaraj, 1982). Apparently, the internal P content of plants regulates AM fungal infection and reproduction. The percentage of P in plants at the time of AM colonization is the best indicator to identify a soil, which provides good AM colonization. The rock phosphate applied at 100 ppm P level resulted in more infective propagules of *Glomus fasciculatum* (Sreenivasa and Bagyaraj, 1989). It has also been observed that rock phosphate encourages better proliferation of AM fungi, compared to bone meal and super phosphate.

K content of tropical acidic soils is generally low, and sustainable crop yields depend on K application. Cassava has a very high K demand. About 5.8 kg has to be applied for each tonne of cassava yield (Lakshmipathy *et al.*, 2007). It was found that increasing K application levels up to 200 kg K ha^{-1} increased mycorrhizal root colonization as well as tuber yield in Columbia.

In conclusion it may be said that heavy doses of chemical fertilisers, in general, have a deleterious effect on beneficial soil microorganisms like N fixing bacteria and P solubilising and mobilizing organisms.

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HONOURS

Prof. Kunal Ghosh appointed Director of the Board, Projects & Development India Limited (PDIL)

Professor Kunal Ghosh, Founder President of the Society for Fertilizers and Environment, has been appointed as a Director of the Board, Projects & Development India Limited (PDIL), a Government of India Undertaking, Department of Fertilizers, Ministry of Chemicals & Fertilizers, Government of India."

ARTICLE

Managing fertilizers for improving mycorrhizal activities in the rhizospheric soils

Arbuscular mycorrhizal fungi (AMF) is the most common type of association forming symbiotic relationship with more than 80% of higher plants. These obligate symbionts rely wholly on plants for carbon and in exchange provide nutrients to plants. AMF have been widely recognized and used as fungal biofertilizers due to their beneficial effect on plants such as increased supply of nutrients especially P, by their extra-radical mycelium from soil, and provide it to the plants (Smith and Read, 2008). Growth promotion factors associated with AMF are chiefly uptake of nutrients such as P, Zn and Fe. Indian soils are deficient in P and its availability gets affected due to high P-fixation and the poor mobility of P to the growing roots. AM fungi through their extensive hyphal network of growing plant roots mobilize the P and enhance its availability to the plants. The potential of resident native AMF can be harnessed through adoption of crop sequences practices by substantiating the plant's nutrient requirement through enhanced availability of native nutrients from the pool. Hence the application of AMF in the P-limited soils and with appropriate crop sequences not only saves fertilizer inputs but also sustains crop and soil productivity on long run.

AMF mediated nutrient acquisition

The colonization of AMF is stimulated by low levels of P and prohibited by higher or even enough concentration of phosphorus (Smith and Read, 2008). The rate of P acquisition by root being higher than the diffusion of P in soil (as seen in case of soil solution) creates a phosphorous depletion zone in the rhizosphere (Bagyaraj *et al*., 2015). As observed in case of soil solution a negative correlation has been found to exist between amount P contained in solution and AMF colonization and dependency (Habte and Manjunath, 1987). Therefore nutrient profiling for P in soil before or after fertilization is necessary to get higher AMF response.

Impact of fertilizers and AMF on plant productivity

Keeping in view the chemical fertilizer induced damages future aim may be to reduce the fertilizer application doses suitable for obtaining beneficial AMF symbiosis of a low input sustainable agriculture. There is an optimum P level beyond which the response of native AMF colonization starts declining. For example, accelerated AMF growth and better soil health have been observed when P is applied in the form of rock phosphate. However, keeping in view of their external P requirements of a particular crop, the incremental response might vary. AMF infection has been found to decrease when soil P availability is higher. A remarkable increase in AMF colonization can be obtained if no P fertilization application is performed. Zn fertilization has also been found to have different effects on AMF functioning.

Fertilization does play an important role in shaping AMF communities. AMF species have been found to differ from each other in terms of P acquisition with *Glomus mosseae* and *Glomus intraradices* being able to acquire higher P as compared to *G. claroideum,* but *Glomus intraradices* and *G.claroideum* were found to be better when P acquisition by maize plant was concerned (Jansa *et al*., 2005). In general AMF are site specific i.e., its functionality depends on nutrient profile of the soil. Besides chemical fertilizers, the addition of compost and adoption of organic farming practices promoted AMF colonization which consequently enhanced plant nutrient uptake (P and Zn). Besides increasing AM colonization in organic farming practices the practice enhances AMF species richness. A list on integrated response of AMF along with fertilizer on major crop and horticultural species has been given below (Table 1).

Co-inoculation of AMF with PGPRs

AMF has highly compatible synergistic effect with both plant growth promoting and nitrogen fixing bacteria. Recently Thilagar *et al*. (2016) showed that co-inoculation of *Funneliformis mosseae* and *Bacillus sonorensis* together with 50% decrement in recommended dose of fertilizer (NPK) in chilli plants could yield better results in terms of soil health parameters, plant growth, nutrient uptake and productivity as well as AMF biomass. The dual inoculation of native AMF species with DAPG (diacetyl-phloroglucinol) producing *Pseudomonas or Bacillus* strains increased iron, phosphorus and protein concentration of the grains. Enormous reports are available endorsing the co-inoculation effect of two *Pseudomonas* strains with multispecies of AMF in horticultural crops to enhance yield at lower doses of fertilizers. This suggests that the combined application of AMF with beneficial bacteria as AMF-bacterial consortia yield better at the reduced doses of fertilizer inputs.

Recommendations

- The nutrient management practice being followed with AMF needs prior testing under microcosm and field trials (including rotations to test effects on succeeding crops) to successfully establish threshold limits of doses to be applied that not only maintain abundant AMF but also deliver AMF derived benefits to the crop.
- Co-inoculation of AMF with other beneficial microbes needs to be implemented as the extracellular enzymes

released by these microbes play significant role in organic matter and C cycling thus enabling efficient nutrient uptake by plants.

- AMF species specific to a particular site in the rhizosphere need to be investigated as a site might choose a particular AMF species.
- The appropriate crop and soil management practices (tillage and rotations) with fertilizers need to be followed for harnessing the maximum benefit of resident AMF inhabiting in a particular rhizosphere.

Table 1 Some examples of fertilizer savings through application of AMF in different plants

AMF	Fertilizer	Crop/Plant
Glomus fasciculatum Glomus intraradices	Zn and P fertilization	Apricot
Native AMF	P-fertilization	Spring wheat
Glomus manihotis	P fertilisation	Legume grasses
Native AMF species (mixed culture)	P fertilisation	Strawberry, Onion
Native AMF	NPK fertilisation	Soybean
Funneliformis mosseae and Bacillus sonorensis	NPK fertilizers	Chilli

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HIGHLIGHT

Getting down to biology – SoilOne Report

SoilOne Report comes from the Soil Health Lab, a concept developed by Alpha-Agri in collaboration with SGS Lab. The SoilOne Report adds a biological component to the final results, providing key indicators that create a more complex, multi-layered profile of a grower's soil. Carbon dioxide respiration, potentially mineralizable nitrogen, root health, and organic matter are all included under the biological heading. Additional tests for mychorrizal infection rates, presence of nematodes and pathogenic fungi are also available.

Initial SoilOne test provides a baseline or benchmark on a farm's soil health. Subsequent tests every two to three years will add data on changes in soil quality.

- Ralph Pearce
(Source: http://www.country-guide.ca/contributor/ralph-pearce/)

ARTICLE

Influence of fertilizer application on soil biology

Soil is a habitat an estimated 2.6×10^{29} for prokaryotic cells alone, and harbours much of earth's genetic diversity. A single gram of soil contains kilometres of fungal hyphae, more than 10^9 bacterial and archael cells and organisms belonging to tens of thousands of different species. Soil performs many vital functions like nutrient cycling, physical stability, etc. which are driven by soil organisms. The macroorganisms which we call as soil animals e.g., Collembola, Enchrytacidae, Isoptera, Isopoda, Earthworm, Termites, Centipedes, Millipedes, Nematodes, Protozoa, etc. also perform various soil functions e.g., decomposition of organic residues in soil by mixing, churning and fragmentation, improving the soil physical properties by enhancing aeration and drainage, improving soil fertility through enriching the soil with casts.

Importance of fertilizer on crop productivity and soil biological health

The widespread use of commercial mineral fertilisers has been one of the major factors in ensuring global food security so far. Among the Asian countries, the increase of demand for nitrogen is expected in India (30 percent) and China (7 percent), followed by Pakistan (6 percent), Indonesia (5 percent), Bangladesh (3 per cent), Vietnam (2 per cent) and Malaysia (1 percent). Balanced fertilization or integrated nutrient management (INM) is the key to maintain or enhance soil biological activities and sustainable agricultural production (Fig. 1). The chemical fertiliser has direct as well as indirect impact on soil biology – direct impact through readymade source of nutrients for soil organisms proliferation and indirect impact by enriching soil with C responsible for driving various important soil functions. Balanced fertilization/INM induces enhance productivity, higher root biomass and rhizodeposition, and thus are the prime factors for enriching soil with C and accelerated humification.

Impact of fertilization on soil flora

Recently, Geisseler *et al.* (2014) performed meta-analysis of microbial parameters under 64 long-term fertility trials spread in Europe, North America, Latin America, Australia, Asia and Africa. In all the trials, the addition of mineral fertilisation significantly increased organic C content compared to the unfertilised control by an average of 12.8%. Fertilisation significantly increased microbial biomass C (MBC) across all datasets by 15.1%. The effect of fertilization on MBC was pH dependent. While fertilisation tended to reduce MBC in soils with a pH below 5 in the fertilised treatment, it had a significant positive effect at higher soil pH values. In trials where soil pH in the fertilised treatment was at least 7, the fertilisation related increase in MBC averaged 48%. In a long-term fertilizer experiment continued for 33 years it was found that except for the mineral nitrogen fertilizer N treatment, long-term fertilization greatly increased soil MBC and dehydrogenase activity (Luo *et al.*, 2015). Organic manure had a significantly greater impact on SMBC and dehydrogenase activity, compared with mineral fertilizers. The duration of the experiment also may affect the response of MBC to fertilisation. The increase in MBC was highest in studies that had been continuing at least for 20 years or more. Type of nitrogenous fertiliser also significantly affects the MBC and at any N level anhydrous ammonia decreased the MBC indicating its detrimental effect on microorganisms. Ammonium is preferred N source for most bacteria and fungi (Merrick and Edwards, 1995). Despite the development of localized conditions, hostile to soil biology, following application of urea and ammonium fertilisers, short-term effects of fertiliser applications on soil microbial communities as a whole have been found to be minimal. Application of approximately 100 kg Nha^{-1} as urea caused changes in microbial community composition on a short-term basis. It was demonstrated that the type of fertilisation could significantly change the structure of soil microbial communities most likely by changing the soil chemical properties and its fertility status. In the N trial, the functional diversity of soil microbes was higher in the unfertilised than fertilised treatments (Sarathchandra *et al.*, 2001). There were no significant differences in these values in the P trial. The long-term fertiliser experiment in India started since 1970s showed that balanced fertilisation significantly increased MBC, mineralizable C (Purakayastha *et al.*, 2008), and number of bacteria, fungi, actinomycetes and azotobacter. However, the effect was dramatic in treatment combined 100%NPK with FYM. In acid soils the effect was more pronounced in 100%NPK+lime than in 100%NPK fertilisation. Long-term organic and inorganic fertilisation can increase the temperature sensitivity of potential N_2O emissions and associated microbes (Cui *et al.*, 2016). At the higher rate, nitrate decreased the specific growth rate of microbial community, increased the ratio of fungal to bacterial PLFA markers and decreased the ratio of Gram-positive and Gram-negative bacterial PLFA markers (Yevdokimov *et al.*, 2012).

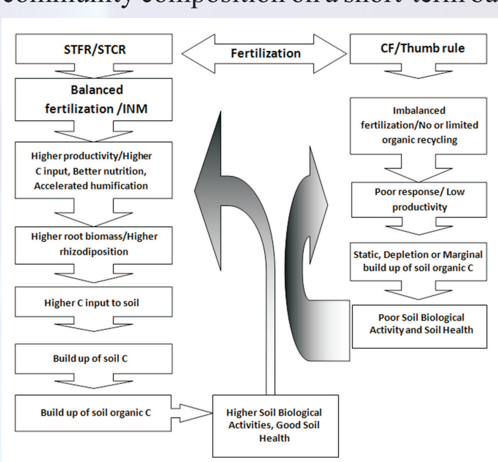

Fig. 1 Role of balanced fertilisation on soil biological health (Source: Purakayastha, T.J., unpublished)

Impact of fertilisation on soil fauna

The inorganic fertilisers may also contribute indirectly to an increase in earthworm populations by increasing the quantity of crop residues returned to the soils, although the long-term use of inorganic nitrogen fertilisers may sometimes cause a decrease in earthworm abundance and biomass, particularly if it is ammonia-based (Ma *et al.*, 1990). The acute toxicity of urea on earthworm, *Eisenia foetida* was noticed at the rate of 175 kg urea ha^{-1} (Rai *et al.*, 2014). Contrarily, Edwards and Lofty (1982) reported a strong positive correlation between amounts of inorganic N applied and populations of earthworms especially in arable crops. In long-term continuous cereal production, earthworm abundance and biomass was reported to be higher in treatment receiving a combination of manure and inorganic fertiliser. The effects of organic manure were greater on populations of *Lumbricus terrestris* than those of *Allolobophora longa*, *A. caliginosa* or *A. chorotica*. Easily accessible fertiliser nutrients encourage the development of opportunistic bacteria and coloniser nematodes, thereby reducing the proportion of K-strategist bacteria and nematodes in the soil community (Bongers *et al.*, 1997). Populations of the plant feeding nematodes *Pratylenchus* and *Paratylenchus* were greater; whereas those of *Meloidogyne* were lower in soils fertilised with N than in unfertilised soils (Sarathchandra *et al.*, 2001). Nematode Maturity Index was not affected by the application of P, however, but all values in the P trial were greater than those in the N trial. However, the consistent decrease in functional diversity of nematode populations with the application of N, but not P, indicates that the N application can impact on community structure.

Fertilization and soil enzyme activities

Despite the fact that the number of studies that reported change in enzyme activities was relatively small due to fertilization, it is interesting to note that protease activity was not reduced in soils receiving mineral fertiliser in spite of evidence that protease production is generally repressed by ammonium (Allison and Macfarlane, 1992). In contrast, a number of studies found an increased availability of mineral N promoting extracellular enzymes involved in the C cycle (Geisseler and Horwath, 2009). This is in line with the results which showed a strong increase in β-glucosidase activity in fertilised soils. The results emanated from LTFEs in India showed that activities of dehydrogeanase, phosphatase and urease increased significantly in treatments either receiving balanced application of NPK or integrated application of NPK with FYM. However, the sole application of nitrogenous fertiliser decreased the enzyme activities which were even lower than the control.

Conclusion

The misconception about deterioration of soil biological health due to use of chemical fertiliser has been proven wrong from the long-term fertiliser and manuring trials. If the fertilisers are applied in right quantity from right source and in right proportion based on soil test values, biological health of soil would improve. Thus balanced and or integrated uses of chemical fertiliser (NPK) along with organic resources (crop residues, FYM, green manure, vermicompost, etc.) are keys to maintain or enhance biological health of soil and sustainability in agricultural productivity. As majority of the studies has been primarily focusing on the impact of fertiliser on soil flora, more information is required in the field of soil fauna which are also important. Soil biotechnology is emerging as a new promising area which should also be explored in light of the long-term fertilisation and manuring.

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Upcoming events of the Society

1. Students' orientation programme during end of September, 2016.
2. Farmers orientation and interface meeting at Gosaba, Sunderbans with KVK, Narendrapur on 5th October, 2016.
3. Farmers orientation and interface meeting at Burdwan with KVK, CRIJAF on 5th November, 2016.
4. Farmers' meet on biofertilizer use & environment in collaboration with Vivekananda Women Welfare Society at Potashpur in December, 2016.
5. Two day National Seminar in collaboration with Bihar Agricultural University, Sabour during January - February, 2017. Details (1st announcement) of the seminar will be uploaded in the website shortly.

"Essentially, all life depends upon the soil ...
There can be no life without soil and no soil without life;
they have evolved together."

- Charles E. Kellogg, USDA Yearbook of Agriculture, 1938

Editors: H. S. Sen, Biswapati Mandal, Dipankar Ghorai, F. H. Rahman and Dibyandu Sarkar

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