Policy Brief No. 3

National Academy of Agricultural Sciences

Soil Health: New Policy Initiatives for Farmers Welfare

New Delhi
May 2018

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Printed : 25 May, 2018

Citation : NAAS 2018. *Soil Health: New Policy Initiatives for Farmers Welfare. Policy Brief No. 3*, National Academy of Agricultural Sciences, New Delhi. 19 p.

Preface

Soil plays a central role for economic and social development by ensuring food, fodder, fiber, and renewable energy supplies to sustain human, animal and plant life. However, in our thrust to grow more food, soils have been particularly misused to an extent that these are now affecting the state of our health and well-being. Since there is no likely prospect of any further increase in the area under cultivation, much of the desired increase in food grain production has to be achieved by enhancing productivity per unit area. Soil health, an attribute of physical, chemical and biological processes is now showing signs of fatigue due to intensive cultivation, over mining of nutrients by crops with lesser replenishments through organic and inorganic sources of plant nutrients. The constant decline in soil health is often cited as one of the reasons for stagnating or declining yields. Not only our soils are low in soil fertility but the inadequate and imbalanced nutrient use and neglect of organic manures is causing multi-nutrient deficiencies in many areas with time. This coupled with poor field water management is the major cause of low nutrient and water use efficiency that enhances the cost of cultivation. Indian agriculture is a net negative balance of nutrients as every year there is a net deficit of about 10 million tonnes of nutrients added and extracted from the soil. The soils are now also showing the deficiency of secondary nutrients like sulphur and deficiency/toxicity of several micro-nutrients. The ICAR institutes, SAU's and All India Co-ordinated Research Projects (AICRP) have come up with several location specific and environment friendly technologies to improve and maintain physical, chemical and biological health of soils and yield sustainability.

The Government of India has also launched several programmes for the welfare of farmers like distribution of Soil Health Cards, selling of neem oil coated urea, nutrient-based subsidy policy for P and K fertilizers, organic farming, *Paramparagat Krishi Vikas Yojna*, National Mission on Sustainable Agriculture, National Action Plan for Climate Change (NAPCC), National Water Mission, National Mission for a Green India under NAPCC, Mission for Integrated Development of Horticulture, and National Mission on Oilseeds & Oil Palm etc.

In the present write-up **"Soil Health: New Policy Initiatives for Farmers Welfare"** implementable new policy initiatives/directions needed for farmer's welfare in the form of recommendations are presented. Suggestions have also been given to review, improve and strengthen the on-going programmes in order to protect, maintain and improve the soil health so as to achieve the goal of higher productivity and sustainability without any damage to the soil system and the environment.

On behalf of Academy I compliment the Resource Person Dr C.L. Acharya and other experts for their valuable efforts in developing the policy brief. My thanks are also due to Dr Anil K. Singh, Secretary for his valuable inputs as well as Dr V.K. Bhatia and Dr Kusumakar Sharma for their editorial support. I am hopeful that this document will be useful to all Fellowship and stakeholders.

Dated : 25 May, 2018

Panjab Singh
President
National Academy of Agricultural Sciences

Committee constituted for developing the Policy Brief

Dr C.L. Acharya

Dr A.K. Biswas

Dr A. Subba Rao

Dr Anupam Varma

Discussants

Dr Panjab Singh

Dr J.C. Katyal

Dr A.K. Sikka

Dr P.K. Chhonkar

Dr A.K. Shukla

Dr B.S. Dwivedi

Dr V.K. Singh

Dr S.P. Datta

Dr Abir Dey

Dr Kaushik Majumdar

Dr Surrendra Kumar

Soil Health: New Policy Initiatives for Farmers Welfare

1. Introduction

Soil ecosystems are the foundation of human life support systems. Soil erosion, loss of soil organic matter and nutrient depletion are among the leading contributors to impaired soil health, reduced crop yields and poverty. Realizing the significant role that *soils* play in food and environmental security and in abating climate change, the United Nations declared 2015 as the *Year of Soils*. Similar to this the International Union of Soil Science (IUSS) has declared 2015-2024 as International Decade of Soils. The Climate Summit in Paris during November 30 to December 11, 2015 categorically stated the importance of soil carbon sequestration to mitigate climate change and advance food security. The National Academy of Agricultural Sciences (NAAS) celebrated this important event with publication of *State of Indian Agriculture: Soil* to provide science-driven policy-relevant information for soil resource management in the country in the context of nutritional security and sustainability.

In 2015, United Nations defined 17 Sustainable Development Goals (SDGs) as a follow up to the MDGs, with 2030 as the target year. It is imperative for the country to ensure implementation of these goals and carbon sequestration addresses three of them, *viz.*, "Zero Hunger" (2), "Climate Action" (13) and "Life on Land" (15). India's Climate Pledge in which the GHG emission intensity is to be brought down by 33-35% of 2005 level by 2030, envisages creation of an additional carbon sink of 2.5 to 3 billion tonnes of carbon-di-oxide equivalent by 2030. This, in tandem with the '4 per 1000' initiative, is a formidable target for a tropical country like India. This would be possible only through concerted efforts of researchers, public and private enterprises, policy makers, administrators and general public.

2. Issues of Soil Health Management

Soil health being an attribute of physical, chemical and biological processes is constantly declining and is often cited as one of the reasons for stagnating or declining crop yields and low input use efficiency. For sustainable crop production, it is essential for all concerned, not just researchers, to understand the soil environment in which plants grow in totality, to recognize the limitations of that environment and to ameliorate wherever possible without damaging the soil quality. The degradation of soil physical, chemical and biological health along with inadequate and imbalanced nutrient use and neglect of organic manures is the cause of multi-nutrient deficiencies in many areas with time. This coupled with poor field water management is the major cause of low crop productivity and reduced nutrient and water use efficiency. As such, it poses a great threat to the soil's inherent capacity to sustain productivity for posterity. Maintaining soil health/quality, thus, is indispensable for sustaining the agricultural productivity at the desired level. The major issues related to declining soil health are discussed in subsequent section.

2.1. Soil erosion

Globally, about 24 billion tonnes of fertile soil is lost annually through water erosion (FAO, 2011). A recent national database on land degradation in India shows that 120.7 Million hectare (Mha) or 36.7% of the total arable and non-arable land surface of the country suffers from various forms of degradation with water erosion being its chief contributor in 83 Mha (68.4%) (NAAS, 2010a). Water erosion is the major threat to soil health/quality and runoff water quality. It results in loss of organic carbon, nutrient imbalance, soil compaction, decline in soil biodiversity, and contamination with heavy metals and pesticides.

Annual soil loss rate in our country is about 15.35 tonnes per hectare, resulting in loss of 5.37 to 8.4 Million tonnes (Mt) of nutrients, reduction in crop productivity, occurrence of floods/droughts, reduction in reservoirs capacity (1 to 2% annually), and loss of biodiversity (Sharda and Ojasvi, 2016).

Loss of crop productivity, one of many negative impacts of soil erosion by water, has serious consequences for country's food, livelihood and environmental security. Major rainfed crops in India suffer an annual production loss of 13.4 Mt due to water erosion which amounts to a loss of Rs. 205.32 billion in monetary terms (Sharda and Dogra, 2013).

2.2. Physical degradation

The physical deterioration of soil health through water logging, submergence, flooding, soil compaction, crusting, poor infiltrability and impedance to root penetration become limiting factors for crop production. The improper and untimely tillage, lack of return of crop residues to soil or inadequate availability of energy for deep tillage or for conservation agricultural practices are some of the factors responsible for these problems. They all contribute towards loss in grain productivity. Around 1.07 Mha area is under physical degradation; mostly water logging due to permanent surface inundation (0.88 Mha) and about 12.53 Mha of rainfed Vertisols remain fallow due to temporary water logging during *kharif* (NAAS, 2010a). Water logging alone results in annual loss of 1.2 to 6.0 Mt of grain in India (Bradon and Kishore, 1995).

2.2.1. Diversion of agricultural lands for other competitive uses

About 7% of the geographical area, for which land-use statistics is available, is used for non-agricultural purposes, this area is estimated to be increasing at the rate of 0.3 million ha/year. About 20,000 ha of fertile land are being converted into wasteland of poor soil health every year in different parts of the country for brick making for various kinds of construction work. This amounts to the loss of 540 million t/year of fertile soil. Most fertile soil of the Indo-Gangetic plains in Northern India produces the best quality of burnt clay bricks-hence putting tremendous pressure on the availability of fertile soil.

India is the second largest brick producer in the world after China. Traditional brick making not only involves removal of top soil but also contributes to GHGs emission. It is estimated that currently 0.7 Mha of agricultural land is being utilized by this industry alone (Nath *et al.*, 2018). The complete process contributes to 40.65 to 42.64 Tg CO^2 every year. Use of this sub soil after the topsoil removal can reduce crop yields by 60-90%. Since the Govt. of India is laying emphasis in "Housing for all" and India would have more than 50% urban population by 2050, this situation is likely to worsen and needs to be addressed on priority.

2.3. Chemical degradation

Chemical degradation of soil health is due to i) salinization/alkalinization ii) acidification iii) soil toxification through chemicals, and iv) depletion of nutrients and organic matter and other nutrient input related issues. Around 6.74 Mha are under salt affected soils comprising of 3.79 Mha under high sodicity (pH > 9.5) and about 3 Mha (including 1.25 Mha coastal salinity) are under salinity (NAAS, 2010a).

About 11 Mha of arable land suffer from acute soil acidity (pH < 5.5) with very low productivity (<1 t/ha) due to deficiencies as well as toxicities of certain nutrients. The poor soil health of acid soils is due to poor fertility owing to a combination of Al, Mn, and Fe toxicity, and deficiency of P, Ca, Mg and K and some micronutrients like B, Mo, Zn which result in loss of crop productivity (NAAS, 2010b).

Soil toxification through chemicals is increasing with greater urbanization. More and more municipal and industrial wastes are being dumped into the soil with heavy metals having carcinogenic effects. A study at the Indian Institute of Soil Science, Bhopal indicated high concentration of heavy metals (Cd, Cr, Cu, Pb, Ni and Zn) in composts manufactured in many cities of India from mixed municipal solid wastes. These heavy metals may accumulate in soil with repeated applications.

Further, excessive use of fertilizer and pesticides for crops such as vegetables, horticultural and commercial crops is also causing soil toxification. Burning of fossil fuel and industrial emissions cause considerable air pollution which finally gets precipitated on soil and water body. Polluted surface water and groundwater add several harmful chemicals into the soil body when used for irrigation. There are reports about increased levels of nitrate in some pockets. Whether this is due to fertilizer N, animal production systems or of geogenic nature, is yet to be authenticated. Animal manures constitute 5-10% of N input in Indian agriculture, but can be a significant source of nitrate pollution in some areas due to leakage to ground water during storage and handling.

2.3.1. Depletion of nutrients, organic matter and other nutrient input related issues vis-a-vis soil health degradation

2.3.1.1. Poor soil fertility and low and imbalanced nutrient use

Our soils are very low in organic matter content and thus have poor soil fertility. In view of poor soil fertility and shrinking land and water resources, the singular option for India is through increase in productivity. Soils of about 59, 36 and 5% area are low, medium, high in available N, respectively. Similarly, soils of about 49, 45 and 6 percent area are low, medium and high in available P, respectively; and soils of around 9, 39 and 52% area are low, medium and high in available K, respectively (Chaudhari *et al.*, 2015). Not only the inherent soil fertility is poor and the nutrient input is low but also there is growing evidence of increasing deficiency of P and K, aggravated by the disproportionate/imbalance application of higher doses of N in relation to P and K (Tewatia *et al.*, 2017). The N based fertilizers constitute a major fraction, nearly 70 per cent, of the total fertilizer material. There is a growing evidence of increasing responses to S for oilseeds, pulses and legumes and high-yielding cereals. Sulphur status of Indian soils is going down with each passing year. Soil analysis and crop response data generated by the TSI-FAI-IFA project (1997-2006) re-enforced the finding of the AICRP data of ICAR system based on reported results. Out of over 49,000 soil samples analyzed across 18 states, 46% of samples were deficient in sulphur and another 30% were medium in available sulphur which could be considered as potentially sulphur deficient (Source: https://www.sulphurinstitute.org/india/status.cfm).

The micronutrient deficiency, as shown in Figure 1, in crops is growing rapidly both in extent and intensity and as per assessment made under All India Coordinated Research Project on 'Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants' nearly 49, 15, 6, 8, 11 and 33% samples were found to be deficient in zinc, iron, manganese, copper, molybdenum and boron, respectively, across the country and hence all contribute towards poor soil health (Shukla *et al.*, 2012).

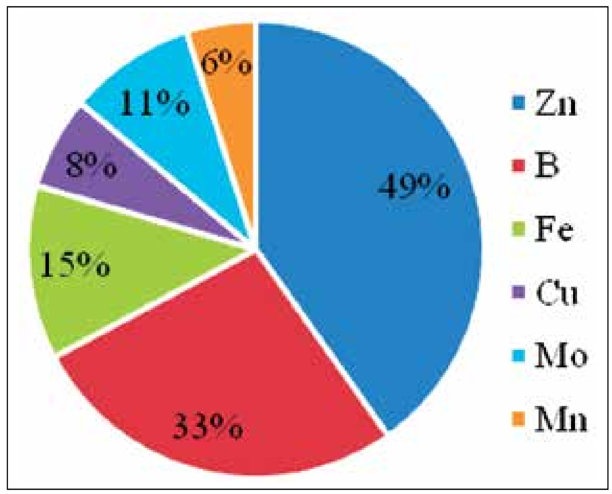


Fig. 1. Micronutrient deficiency in Indian Soils

It is anticipated that with higher yields and more intensive agriculture the micronutrient deficiency will increase both in amount and extent. The limiting nutrients do not allow the full expression of other nutrients, lower the fertilizer response and crop productivity.

The current gap between annual drain of nutrients from the soil and inputs from external sources is 10 million tonnes, which is likely to grow further. This is one of the major causes of soil chemical degradation resulting in poor soil health. However, on the input side there is large disparity in fertilizer consumption across Indian states. In the west zones of the country, the fertilizer input of NPK, being 95.9 kg/ha is much lower than the national average (141.9 kg/ha). These figures for east, north and south zones are 140.9, 182.4 and 186.2 kg/ha, respectively (Fertilizer Statistics FAI, 2015-16). Further, out of 565 districts surveyed for fertilizer consumption 93 districts consume <50 kg/ha and another 124 districts fall in the category of 50-100 kg/ha NPK consumption (Fertilizer Statistics, FAI 2015-16). Lack of assured water supply for irrigation is one of the major reasons for low fertilizer input. Only 109 districts in the country consume fertilizer NPK > 200 kg/ha. In Punjab, where more than 98% of the area is irrigated, 19 out of 20 districts surveyed consume fertilizer NPK > 200 kg/ha. Thus, Indian agriculture is operating as a net negative balance of plant nutrients resulting in chemical degradation and poor soil health.

2.3.1.2. Low use of organic manures

Organic carbon is an index of good soil health and application of organic manures helps in maintaining high organic carbon content of the soil. Our soils have very low organic matter content. Therefore, without regular application of organic manures and recycling of crop residues, we cannot hope to maintain good soil health to sustain productivity and ensure high responses to NPK fertilizers. With rapid urbanisation the bulky organic wastes are increasing and their disposal and profitable use in agriculture in rural areas is hampered because of transportability and cost constraints. The green manuring practice is almost forgotten.

Soil organic carbon (SOC) is the key constituent which dictates soil physical condition, chemical properties including nutrient status and biological health of a soil. Long-term Fertilizer Experiments (LTFE) proved beyond doubt (Table 1) that balanced fertilization and more so with FYM maintained and/or improved SOC status (Singh and Wanjari, 2017).

Table 1: Soil organic carbon (SOC) status (g kg^{-1}) in long-term fertilizer experiments

Location	Control	N	NP	NPK	NPK + FYM
Akola	3.1	4.3	4.9	5.4	7.9
Bangalore	4.8	5.1	5.2	5.5	5.8
Barrackpore	5.5	6.8	7.2	7.2	9.0
Jabalpur	4.2	5.2	4.2	6.8	8.9
Ludhiana	2.8	3.9	3.9	4.2	5.3
New Delhi	3.4	4.3	4.6	4.6	5.2
Palampur	7.9	8.8	9.3	10.2	13.7
Pantnagar	6.1	9.1	9.9	9.8	15.6
Parbhani	5.7	5.4	5.9	6.2	6.8
Ranchi	3.5	4.2	4.2	4.0	4.9

2.3.1.3 Skewed N: P: K ratio

Degradation of soil health has also been reported due to long-term imbalanced use of fertilizer nutrients. The N: P: K use ratio has gone skewed from considered ideal nutrient use (N: P_2O_5 : K_2O) of 4:2:1. This has happened more so in high urea consuming states, indicating urgent need for restoring soil nutrient balance. This imbalance in nutrient use has resulted in wide gap between crop removal and fertilizer application. Long-term coordinated fertilizer response experiments in India have in general showed that P and K status in soils at all centres has gone down when only N was applied and thereby soils have become highly degraded showing very poor soil health (Table 2). The years have been specifically chosen to indicate the effect on NPK use whenever there has been any policy change in fertilizer prices as has been highlighted in the Table i.e. 1991-92, 1992-93, as well as the impact of Nutrient Based Subsidy (NBS) scheme in 2010-11 and 2011-12.

Table 2. Trends in NPK use and its ratio in Indian agriculture

Year	N	P_2O_5	K_2O	Total	NPK use ratio
	kg ha^{-1}				
1965-66	3.70	0.85	0.50	5.05	7.4:1.7:1
1980-81	21.31	7.03	3.61	31.95	5.9:1.9:1
1990-91	43.06	17.34	7.15	67.55	6.0:2.4:1
1991-92	**44.15**	**18.22**	**7.47**	**68.84**	**5.9:2.4:1**
1992-93	**45.40**	**15.32**	**4.76**	**65.48**	**9.5:3.2:1**
2000-01	58.92	22.74	8.46	90.12	7.0:2.7:1
2010-11	**83.76**	**40.72**	**17.78**	**142.26**	**4.7:2.3:1**
2011-12	**88.36**	**40.42**	**13.15**	**141.93**	**6.7:3.1:1**
2012-13	86.60	34.25	10.61	131.46	8.2:3.2:1
2013-14	83.35	28.03	10.44	121.83	8.0:2.7:1
2014-15	85.45	30.75	12.77	128.96	6.7:2.4:1
2015-16	87.58	35.18	12.11	134.87	7.2:2.9:1
2016-17	84.37	33.80	12.65	130.82	6.7:2.7:1

Source: FAI (2017)

Improper and imbalanced use of chemical fertilizer as is evident from wide fertilizer NPK consumption ratios coupled with less addition of organic manures, has resulted in deterioration of soil health with widespread multi-nutrient deficiencies, particularly secondary and micronutrients, namely sulphur (46%), Zinc (49%) and boron (33%). The limiting nutrients, not allowing full expression of other nutrients, have lowered the fertilizer responses markedly and stagnated crop production in the country. The fertilizer response ratio (kg grain per kg nutrient) decreased nearly by four times (from 13.4 in 1970 to around 3.2 in 2010) in irrigated areas of the country. The yield in irrigated areas remained about 2.0 t/ha over the years with contribution of fertilizers to total food grain production increasing from 39 (1970) to around 50 (1990) and thereafter it is almost stagnant at 40 per cent. While only 54 kg fertilizer nutrients were required per ha during 1970 to maintain the yield level around 2.0 t ha, over five times fertilizer nutrients (280 kg) is required presently to sustain the same yield level (Sharma, 2008), indicating soil sickness and hence poor soil health owing to improper and imbalanced use of chemical fertilizer which is a matter of great concern.

Poor soil health is resulting in low nutrient use efficiency. There have been genuine concerns over fertilizer use efficiency, in general, and N use efficiency (NUE) in particular, for economic as well as environmental reasons. Worldwide, NUE for cereal production (wheat, rice, maize, barley, sorghum, millet, oat and rye) is as low as 33%. The unaccounted 67% represents an annual loss of N fertilizer worth upto Rs. 72,000 crores in monetary terms (NAAS, 2005).

Many N recovery experiments conducted in the country on different crops have reported unaccounted losses of fertilizer N from 20 to 50% depending on soil health status and local conditions. In India though about 70 per cent of fertilizer used consists of nitrogenous fertilizers and 80 per cent of it is urea, its use efficiency is hardly 30-50 per cent. The use efficiency in case of other nutrient elements is 15-20% (P), 60-70% (K), 8-10% (S) and 1-5% (micronutrients) which is a major cause of concern. Low N use efficiency due to improper and imbalanced N use ultimately resulting in poor soil health has its global implications. Whereas the global C cycle is being perturbed by less than 10% due to anthropogenic activities, the global reactive N cycle is being perturbed by over 90%. Increasing agricultural N use to meet the perpetual demand for food production, combined with the increasing release of N from dairies and industrial exhausts/effluents makes it inevitable that perturbation of N cycle will continue to be much faster than that of carbon.

It is worthwhile to mention that nitrous oxide as a potential green house gas is having global warming potential 298 times that of CO_2. Besides, there is burning of cow-dung cakes and crop residues causing greenhouse gases emission, losses of plant nutrients and organic carbon. Similarly, nitrogenous fertilizers due to low use efficiency are contributing around 77% of the total direct nitrous oxide emissions from agricultural soils through the process of denitrification linked with soil health, being more from a soil with poor soil health.

Thus, the challenge now facing India is to find ways to further our agricultural and industrial development in a sustainable manner without adversely impacting soil health, the environment and ecology, with respect to nitrogen.

2.4. Biological degradation

Biological degradation of soil health occurs due to soil erosion by water resulting in loss of fauna and flora, loss of organic carbon, extremes of acidity and alkalinity, addition of toxic substances, excessive use of chemicals, intensive tillage, extremes of climate etc. Management practices that reduce organic matter in soils, or bypass biologically-mediated nutrient cycling also tend to reduce the size and complexity of soil communities. Soil organisms, both animals (fauna/micro-fauna) and plants (flora/micro-flora), are important for maintaining the overall soil quality, fertility and stability of soil. They are intimately associated with biological and biochemical transformations occurring in soil. The biological state of soil health furnishes early indication of soil degradation to help take timely additional prudent sustainable soil-crop management practices. However, information about the desirable level of activity, numbers and diversity of soil organisms to maintain a fertile and productive soil has yet to be established.

3. Recommended technologies

3.1. Arresting water/wind erosion

For arresting soil loss due to water and wind erosion and conservation of runoff water several location-sustainable specific technologies have been developed and are being implemented in different parts of the country.

3.2. Minimizing soil physical degradation

The raised and sunken bed technology in waterlogged Vertisols; multiple usage of water through integrated farming systems approach for waterlogged alluviums of eastern India; soil compaction for light textured fluffy soils having high permeability; "seed line mulch" for crusting soils; construction of 10 cm high ridge on shallow soils etc. are some of the technologies which have been developed and found useful to mitigate the problems of soil physical health degradation. The conservation tillage (minimum tillage with crop residue retention on the soil surface) protects soil structure, conserves moisture, allows more entry of rain water in to the soil profile, reduces soil erosion, moderates thermal regime and improves soil chemical and biological health (Acharya *et al*., 2015).

3.3. Containing soil chemical health degradation

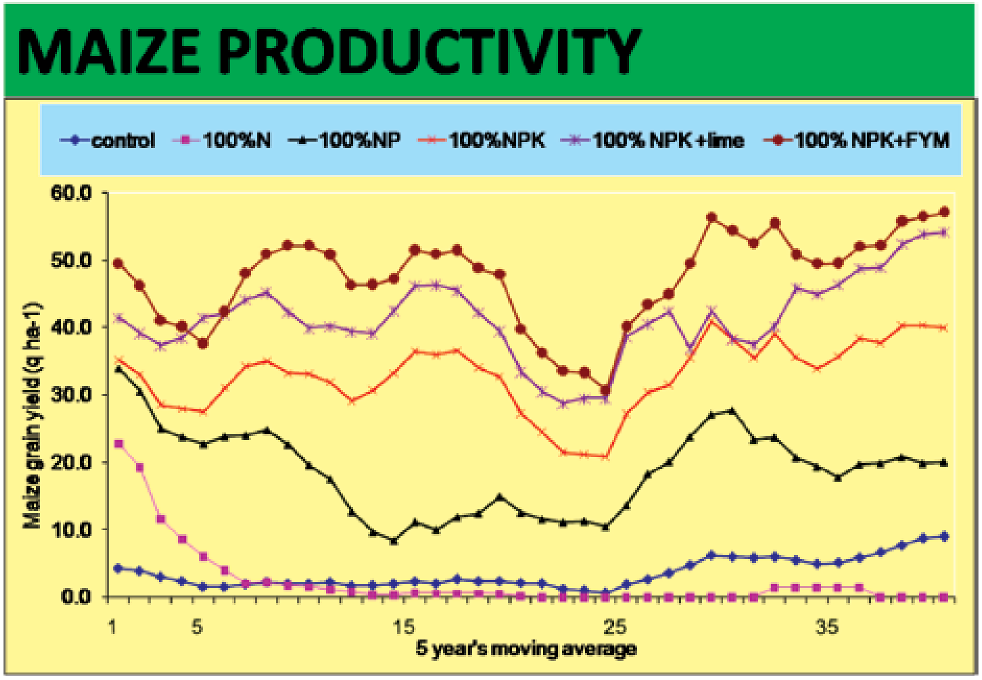
i) To improve productivity of saline, sodic, acid and waterlogged soils, appropriate reclamation technologies have been developed in the country and are being adopted by the farmers.

ii) Soil-test based fertilizer prescriptions is recommended to correct the skewed N:P:K ratio and imbalanced nutrient status of soil.

iii) Soil-test based Integrated Nutrient Management (INM) envisaging conjunctive use of both inorganic and organic sources (FYM, vermi/bio-enriched compost, green manuring, biofertilizers) of nutrients is recommended to meet out the demand of macronutrients and for correcting deficiency of micronutrients which facilitates better soil quality, produces higher crop yield and enhances response of fertilizers besides ensuring yield sustainability.

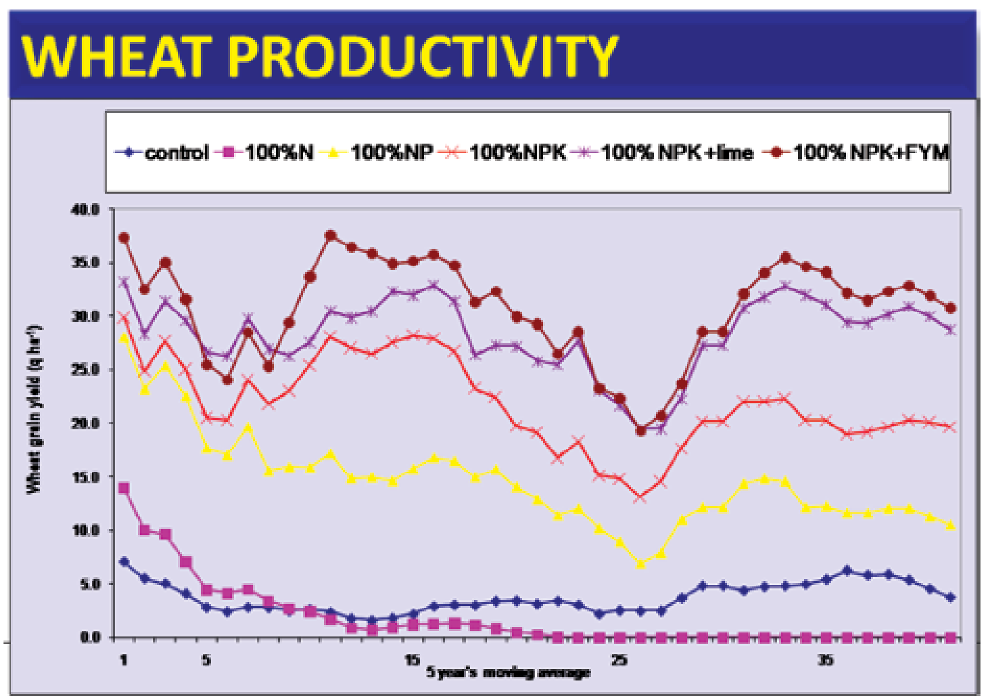
Long Term Fertilizer Experiments (LTFE) continuing for the last 40-50 years in different agro-ecoregions of the country have proved beyond doubt that application of organics like FYM to the extent of 10-15 t/ha to a single crop (preferably *kharif* crop) in the cropping sequence along with recommended dose of NPK not only produced but also maintained the highest grain yields over the years in both crops at all centers in the country. Application of N alone over the years degraded soil health to the extent that it produced grain yields even lower than the control having no addition of NPK. Inclusion of P and K showed incremental increase in crop yields and improvement in different attributes of soil health thereby highlights the significance of balanced fertilization. Further, the treatment having addition of FYM with recommended dose of NPK not only showed built-up of soil organic carbon (Table 1) but also improvement in all parameters of soil physical, chemical and biological attributes of soil health. Results of one of the centers of AICRP of LTFE at Palampur are shown in Figure 2a and Figure 2b. This clearly demonstrates that inclusion of FYM along with recommended NPK has provided yield stability in both maize and wheat crops grown in an acidic Alfisol and signifies the importance of addition of organics to improve and maintain the soil organic carbon content and thereby the soil health (Source: Annual Report 2014-15, AICRP, LTFE, Department of Soil Science, CSK HPKV, Palampur).

iv) For increasing N use efficiency and thereby reducing environmental pollution, split application of nitrogen, use of slow releasing N-fertilizers and nitrification inhibitors based on neem products, inclusion of legumes in cropping system, adoption of Resource Conservation Technologies (RCTs), foliar spray and fertigation are recommended.



Annual Report of Department of Soil Science 2014-15

Fig. 2a. **5 years moving averages of maize yield over a period of more than 4 decades at Palampur centre of Long Term Fertilizer Experiments (LTFE) of AICRP (ICAR)**



Annual Report of Department of Soil Science 2014-15

Fig. 2b. **5 years moving averages of wheat yield over a period of more than 4 decades at Palampur centre of Long Term Fertilizer Experiments (LTFE) of AICRP (ICAR)**

v) The concept of Site-Specific Nutrient Management (SSNM) is recommended as most soils in India have deficiencies of S and one or more micronutrients in addition to NPK deficiencies i.e. they have multi-nutrient deficiencies. The farmer's general practice (FP) even though contains higher levels of N or P than SSNM gives lower yields advocating the superiority of SSNM.

3.4. Preventing biological health degradation

A variety of endophytic nitrogen fixing bacteria colonizing roots of legumes and several other plants species of economic importance have been identified as most plants are host to one or more endophytes. Endophytic microorganisms have been shown to aid N and P nutrition and protect plants from diseases, pests and abiotic stresses. The use of bio-fertilizers is recommended in soils of low fertility and for those areas and systems which use low amount of fertilizers as responses to bio-fertilizers are environment, crop and management specific. Rhizobium cultures are most relevant to legumes and their greater benefit can be realised in environments where such crops and their varieties are newly introduced, e.g. soybean and berseem, and N status is low. The blue green algae and Azolla to rice-based system, VAM-micorrhizae fungi for tree-based system and phosphorus solubilizers for high phosphorus fixing soils are recommended.

4. On-going Government Policies for Sustainable Soil and Nutrient Management

1. The Government of India is implementing nutrient-based subsidy (NBS) policy for P and K fertilizers with effect from April 2010. Under the NBS Policy, a fixed rate of subsidy (in Rs. per kg basis) is announced on nutrients on annual basis. However, urea is kept out of the policy due to various reasons.

2. Entire urea is now being sold as neem oil coated urea with an objective to enhance the N use efficiency and to prevent diversion to non-agriculture usage. The Govt's policy of making only neem-coated urea to be marketed in India has certainly led to a decrease in consumption by 10% and enhanced yield of various crops by 6-17%. The actual benefits need to be quantified both in terms of actual reduction in use, yield enhancement, leaching nitrate, and reduction in GHGs. Urea is the only fertilizer that remains under statutory price control and its maximum retail price is fixed by the government. The difference between production cost and the administered concessional price is allowed as subsidy.

3. The Government of India through National Mission on Sustainable Agriculture (NMSA) and 'National Action Plan for Climate Change (NAPCC) for India' is promoting sustainable use of natural resources. Besides, the National Water Mission and National Mission for a Green India under NAPCC have direct relevance to management of natural resources and rainfed areas. The Government under NMSA has also included a component of Reclamation of Problem Soils *viz.*, saline, alkali and acid soils.

4. Under the component of Soil Health Management (SHM) of NMSA the government is promoting soil test-based balanced and integrated nutrient management through setting-up/strengthening of soil testing laboratories, establishment of bio-fertilizer and compost units, use of micronutrients, trainings and demonstrations on balanced use of fertilizers.

5. A National Mission on Soil Health Card has been launched under which a Soil Health Card is being issued to each farmer by the soil testing laboratory located in each district of the state. This has been done with an objective to provide soil test-based fertilizer recommendations to all the farmers in the country.

6. Organic farming is being promoted through various schemes/programmes, namely Rashtriya Krishi Vikas Yojana (RKVY), Mission for Integrated Development of Horticulture (MIDH), National Mission on Oilseeds & Oil Palm (NMOOP), National Programme on Organic Production (NPOP) of Agricultural & Processed Food Products Export Development Authority (APEDA).

   Paramparagat Krishi Vikas Yojna (PKVY) was launched by the Govt. of India in 2015 as a component of Soil Health Management (SHM) as an initiative to promote organic farming in the country. Cluster approach is being followed to implement this scheme with every cluster consisting of 50 farmers each having one acre for conversion to organic farming. The target was to have 10,000 such clusters in the country over a three-year period.

7. National guidelines have been issued to prevent burning of crop residues, thereby ensuring their proper recycling for improving soil health.

8. The '4 per 1,000' initiative was launched by the French Government at COP21 Paris Climate in 2015 (Rumpel *et al*., 2018). The emphasis of this initiative is on enhancing carbon storage in soils by 0.4% annually as a mitigation measure and ensures food security (www.4p1000.org). It is important to bring this issue of soil carbon sequestration on the political agenda as it was not discussed at the Bonn COP23 meeting in November 2017. Sustainable intensification of food production is possible if this initiative is implemented on ground (Chabbi *et al*., 2017).

5. Recommendations (New Policy Initiatives/Directions Needed for Farmers Welfare-Implementable)

1. Implementation of technologies to arrest water and wind erosion developed by the ICAR Institutes and State Agricultural Universities may be reviewed and strengthened. Focused attention has to be given to the Himalayan region where loss of soil, water, property, human and animal wealth is now taking place at an alarming and accelerated rate.

2. It is high time that land use policy in the country is framed to save productive lands being transferred for purposes other than agriculture. The farmers then will have the option to decide crops and cropping patterns keeping in mind the safe water availability, land capability, resources available with him, socio-economic conditions and demand driven market to avoid gluts and sudden fall in prices. This may also eliminate the practice of fixing minimum support price (MSP) of the commodity by the government.

3. Soil Health Mission introduced by Govt. of India to provide soil health card to each and every farmer is a timely and welcome step. The Govt. of India has invested heavily in its Soil Health Mission and it is estimated that 120 million Soil Health Cards have been distributed. The most important aspect is that it would be a continued exercise repeated every two years.

In order to maintain the quality and authenticity of soil test values, there has to be a strong monitoring mechanism for cross- checking or referencing of soil testing data so as to make the programme viable. For this some reference laboratories need to be identified and strengthened. All soil testing laboratories (STL's) especially district and regional laboratories in the country should be well equipped for the analysis of available macro and micronutrients and quality of irrigation water. Soil testing should include plant tissue testing also to provide advisory service for general as well as for specialized farming including horticulture, floriculture and plantation crops. Qualified and trained staff should be appointed in STL's with some incentives. Training and updating of the staff of STL's should be a regular feature. It is vital to ensure that the information contained in Soil Health Card is not only conveyed to the farmers appropriately but also put into practice.

4. Biofertilizers (BF) along with organics has to be an integral part of nutrient management. Deployment of new microorganism or consortia of microorganisms and quality control of biofertilizer packets supplied at farmer's doorstep should be of paramount importance. Newer formulations of mixed biofertilizers and devising effective delivery systems are crucial for making further progress in taking the BF technology to farmers' fields. Efficient utilization of organic manures, integration of crop and livestock-production systems, promotion of biogas plants and improving their efficiency; training and incentives for better manure management; improved and enriched compost preparation is desired/to be ensured. Washing of cow dung and urine to nallas, canals and streams from the dairy farms established in the peri-urban areas should be strictly banned.

5. The Nutrient Based Subsidy (NBS) policy encourages use of more urea which has highly skewed the N: P: K use ratio in some states. Reforms in NBS policy are required to correct this aberration. The subsidies on fertilizer should be rationalized so that there is parity in nutrient pricing to promote balanced fertilizer use. A research cess on fertilizers can be levied which can thus be utilized to funding research for developing efficient use of nitrogenous fertilizers. Blending or coating of N fertilizers with nitrification inhibitors to increase N use efficiency is one of many options for developing more efficient N-fertilizers. Incentives may be provided to the fertilizer manufacturers opting for the manufacture of value-added fertilizers such as neem-coated urea, sulphur coated urea, etc.

6. There is need to develop new products and popularize more efficient methods of nutrient application. Fertigation is one means which can effectively enhance the nutrient use efficiency considerably. The Hon'ble Prime Minister has made a call to halve the use of urea by 2022. Serious R&D efforts are needed to meet the target in time, through appropriate substitutes as well as novel products.

7. The deficiency of secondary and micronutrients can be overcome to a great extent by fortification of the presently manufactured N/P/NP/NPK fertilisers ensuring supply of micro-and secondary nutrients. Since deficiencies of micro- and secondary nutrients are affecting the quality and productivity in all commodities of soil – plant – animal - human chain, promotion of use of micronutrients at recommended rates and quality maintenance of micronutrient fertilizers through regulation has to be ensured.

8. Safe disposal of municipal wastes and industrial effluents should strictly be followed. A simple policy change may be urgently introduced in government campaign in areas having high nitrates in potable waters and phosphates in surface waters. Policies designed to promote greater N-use efficiency in agriculture should emphasize incentives to farmers rather than punitive regulations, so as to avoid export of crop and livestock production to areas with less stringent environmental guidelines.

9. The process of approving, pricing and incorporation in Fertilizer Control Order by Govt. of India for Value Added Fertilizers (VAF) needs to be accelerated. A special committee consisting of senior representatives of the Ministry of Agriculture & Farmer Welfare, Ministry of Fertilizers & Chemicals, ICAR and the fertilizer industry be constituted to examine various issues pertaining to VAF and make appropriate recommendations to the Government of India.

10. Conservation agriculture has emerged as an alternative to residue burning, where residue is managed *in-situ* thereby improving soil organic carbon for sustainable soil health. Availability of appropriate machinery that does no-till, fertilizer placement, seeding, chopping and spreading of standing crop residues in one-go should be ensured. Heavy machinery for land shaping, construction of raised and sunken beds, ponds etc. may be ensured through rural cooperative societies by custom hiring. Technical help should be provided to achieve such special tasks.

11. Use of alternate energy sources such as solar and wind energy in on-farm agricultural operations should be encouraged.

12. Introducing and providing carbon-credit or incentives to the farmers practicing conservation agriculture for carbon sequestration and greenhouse gas mitigation may be a good option.

13. In view of the 3 related SDGs (2, 13, 15), "4 per 1000" as well as India's Climate Pledge stated earlier, extra emphasis has to be laid on carbon sequestration in soils. Since Organic Carbon Content is an easily measurable parameter, monitoring and incentivizing the farmers through payment of ecosystem services, would go a long way in achieving these targets.

References

1. Acharya, C.L., Bandyopadhyay, K.K. and Chaudhary, R.S. (2015) Management of soil physical quality. ***In***: *State of Indian Agriculture–Soil* (Eds.) H. Pathak, S.K. Sanyal and P.N. Takkar. *National Academy of Agricultural Sciences*, New Delhi, India, pp. 65-84.

2. Bradon, H. and Kishore, N.M. (1995) The cost of inaction valuing the economy wide cost of environmental degradation in India. ***In***: *Fifty Years of Natural Resource Management Research* (Eds.) G.B. Singh and B.R. Sharma, *Indian Council of Agricultural Research*, New Delhi.

3. Chabbi, A., Lehmann, J., Ciais, P., Loescher, H.W., Cotrufo, M.F., Don, A., SanClements, M., Schipper, L., Six, J., Smith, P. and Rumpel, C. (2017) Aligning agriculture and climate policy, *Nature Climate Change*, **7**: 307-309.

4. Chaudhari, S.K., Biswas, P.P., Abrol, I.P. and Acharya, C.L. (2015) Soil and nutrient management policies. ***In***: *State of Indian Agriculture–Soil* (Eds.) H. Pathak, S.K. Sanyal and P.N. Takkar. *National Academy of Agricultural Sciences*, New Delhi, India, pp. 332-342.

5. FAI (2017) Fertiliser Statistics 2016-17, *The Fertiliser Association of India*, New Delhi.

6. FAO (Food and Agriculture Organization) (2011). The state of the world's land and water resources for food and agriculture (SOLAW): Managing systems at risk. *Food and Agriculture Organization of the United Nations*, Rome, 50 p.

7. NAAS (2005) Policy options for efficient nitrogen use. Policy paper No. 33, *National Academy of Agricultural Sciences*, New Delhi. pp. 12.

8. NAAS (2010a) Degraded and wastelands of India, status and spatial distribution, *Indian Council of Agricultural Research*, New Delhi and *National Academy of Agricultural Sciences*, New Delhi. 150 p.

9. NAAS (2010b) Exploring untapped potential of acid soils of India. Policy paper No. 48, *National Academy of Agricultural Sciences*, New Delhi. pp. 8.

10. Nath, A.J., Lal, R. and Das, A.K. (2018) Fired bricks: CO_2 Emission and Food Security. *Global Challenge.* DOI:10.1002/gch2.20170015.

11. Rumpel, C., Lehmann, J. and Chabbi, A. 2018. ´4 per 1,000´ initiative will boost soil carbon for climate and food security. *Nature*, **553**: 29. DOI: 10.1038/d41586-017-09010-w.

12. Sharda, V.N. and Dogra, P. (2013). Assessment of productivity and monetary losses due to water erosion in rainfed crops across different states of India for prioritization and conservation planning. *Agricultural Research*, **2(4)**: 382-392. DOI 10.1007/s40003-013-0087-1.

13. Sharda, V.N. and Ojasvi, P.R. (2016). A revised soil erosion budget for India: role of reservoir sedimentation and land-use protection measures. *Earth Surf. Process. Landforms*, **41**: 2007-2023.

14. Sharma, P.D. (2008) Nutrient management-challenges and options. *Journal of the Indian Society of Soil Science,* **55**: 395-403.

15. Shukla, A.K. and Behera, S.K., Shivay, Y.S., Singh, Pooja and Singh, A.K. (2012). Micronutrient and field crop production in India: A review, *Indian Journal of Agronomy,* **57** (3rd IAC Special Issue): 123-130.

16. Singh, Muneshwar and Wanjari, R.H. (2017) Annual Report 2016-17. All India Coordinated Research Project on Long-Term Fertilizer Experiments to Study Changes in Soil Quality, Crop Productivity and Sustainability. AICRP (LTFE), *ICAR-Indian Institute of Soil Science*, Bhopal. pp. 1-118.

17. Tewatia, R.K., Rattan, R.K., Bhende, Shital and Kumar, Lalit (2017). Nutrient use and balance in India with special reference to phosphorus and potassium. *Indian Journal of Fertilizer*, **13(4)**: 20-31.

Executive Council 2018

Published by Dr Anil K. Bawa, Executive Director on behalf of
NATIONAL ACADEMY OF AGRICULTURAL SCIENCES
NASC, Dev Prakash Shastry Marg, New Delhi - 110 012
Tel: (011) 25846051-52; Fax: (011) 25846054
Email: naas@vsnl.com; Web site: http://www.naasindia.org