International Journal of Agriculture Innovations and Research
Volume 5, Issue 3, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy) :
Received : 09/12/2016 | Accepted on : 15/12/2016 | Published : 22/12/2016

Addressing Soil Health Management Issues in India

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***Abstract* – World has been observing 5th December since 2012 as the World Soil Day to ensure maintenance of soil health, This was complimented by the United Nations' General Assembly declaring 2015, as the *International Year of Soils* to create awareness among all stakeholders and promote more sustainable use of soil being the critical resource. On this occasion, UN Secretary General, Ban Ki-moon had said that without healthy soils life on Earth would be unsustainable. Indeed, soils are the foundation of agriculture. He had urged all Governments to pledge to do more to protect this important yet forgotten resource. A healthy life is not possible without healthy soils. According to the Director General of the FAO, Jose Graziano da Silva, today, world has more than 805 million people facing hunger and malnutrition. Soils are under increased pressure because population growth will require an approximately increase of 60 per cent in food outputand competing land uses.Unfortunately, 33 per cent of our global soil resources are under degradation and human pressures on soils are reaching critical limits, reducing and sometimes eliminating essential soil functions. He had emphasised the role of all stakeholders in promoting the cause of soils as it is important for paving the road towards a real sustainable development for all and by all.Against this background, this article briefly highlights the significance and aspects of soil health management in India and suggests aspects of strategic action plan to conserve this precious resource for the benefit of mankind.**

***Keywords* – Soil Health, World Soil Day, International Year of Soil, Soil Management.**

I. World Soil Day & International Year of Soil

The International Union of Soil Sciences (IUSS), in 2002, proposed to observe the 5th December as "World Soil Day" [WSD]to create awareness among all stakeholders on the importance of soil as a critical component of the natural system and as a vital contributor to human commonwealth through its contribution to food, water and energy security and as a mitigator of biodiversity loss and climate change.Under the framework of the Global Soil Partnership, the 68th session of the UNGA in December 2013 designated December 5 as the "World Soil Day" and declared 2015 as the International Year of Soil which aimed to [i] raise awareness among civil society and decision-makers about the importance of soil for human life [ii] educate the public about the role soil plays in food security, climate change adaptation and mitigation, essential ecosystem services, poverty alleviation and sustainable development [iii] support policies and programs for the sustainable management and protection of soil resources [iv] promote investment in sustainable soil management activities to develop and maintain healthy soils for different land users and population groups [v] strengthen initiatives in connection with the process of Sustainable Development Goals [vi] advocate for rapid capacity enhancement for soil information collection and monitoring at all levels (global, regional and national).

These occasions remind all stakeholders associated with agriculture all over the world to put in all efforts to promote scientific management of soil resources for soil protection, conservation and sustainable productivity. The Governments to achieve this goal can [i] seek global technical cooperation and encourage investment in R& D [ii] promote targeted soil research and development focusing on identified gaps and priorities and synergies with related productive, environmental and social development actions[iii]enhance the quantity and quality of soil data and information: data collection (generation), analysis, validation, reporting, monitoring and integration with other disciplines [iv] harmonize methods, measurements and indicators for the sustainable management and protection of soil resources. Last but not the least, initiate policy and programs to educate farmers and create awareness among them to promote regenerative landscape and integrated management of soil, water, vegetation and biodiversity to enable sustainable agricultural production that is good for the environment and farm profits.

II. Characteristic Features of Soil

Soil is the network of interacting living organisms within the earth's surface layer which support life above ground. Living organisms in soil ultimately control water infiltration, mineral density and nutrient cycling. Fungi and bacteria help break down organic matter in the soil and earthworms digest organic matter, recycle nutrients, and make the surface soil richer. In a handful of fertile soil, there are more individual organisms than the total number of human beings that have never existed.

Soil has varying amounts of organic matter [living and dead organisms], minerals and nutrients. Carbon is a master variable within the soil that controls many processes, such as development of soil structure, water storage and nutrient cycling. Soil carbon takes three distinct forms, viz. living carbon, labile carbon and fixed carbon. Living carbon takes the form of microbes, fungi, plant roots, nematodes, earth worms etc. Labile carbon in the soil comprises decomposing (dead) plant and animal material that is in a state of transition. Fixed carbon in the soil consists of stable compounds as humates and glomalins. Sequestered Carbon comprises the fixed carbon plus the total living biomass. Soil high in organic carbon content enables better rainfall infiltration & retention, providing greater resilience to drought. Every gram of soil organic carbon can hold up to eight grams of water. Soils are vulnerable to carbon loss through degradation, but regenerative land management practices can build soil and restore soil heath

Natural processes can take more than 500 years to form two centimeters of top soil. Soil erosion within conventional agricultural practices can occur at rates up to 100 times greater than the rate of natural soil formation.

Management of agricultural soils should consider the structural, biological and mineral health of the soil [not only N, P, K] to produce nutritionally-dense food. Microbial activity controls and manipulates the chemistry of the soil, not the other way round. Soil microbes have a symbiotic relationship with plants—plants provide sugars to microbes and microbes make nutrients bio-available for plants.

III. Soil, Our Silent Ally

Soil is one of the most complicated biological materials on our planet.Soils are the bedrock for our sustainable food system for healthy lives. Soils produce 95% of our food.At the same time, soil provides living space for humans, as well as essential ecosystem services which are important for water regulation and supply, climate regulation, biodiversity conservation, carbon sequestration and cultural services.Soil stores 10% of the total carbon dioxide emitted in the world. Unfortunately,one-third of our food is wasted. Half of our household-wastes could nurture our soil, if scientifically composted.Soil supportssmall farmer's livelihood. The multiple roles of soils often go unnoticed because soils don't have a voice. Soil is an organic thin layer of earth's crust, a living media. It is a reservoir of mineral material, organic matter, water and air in varying proportions which together constitute a system for plant growth. As a source of abundant natural nutrients it supports plant growth and is one of the important factors of crop production.Healthy soils are the basis for food, feed, fuel, fibre, water and medicinal/herbal products important for human well-being.As "*silent ally'* soils are essential to our ecosystems, playing a key role in the carbon cycle, storing and filtering water, and improving resilience to floods and droughts. Soil is the largest pool of organic carbon, which is essential for mitigating and adapting to climate change. In an era of water scarcity, soils are fundamental for its appropriate storage and distribution.At least, a quarter of the world's biodiversity lives underground, wherethe earthworm is a giant alongside tiny organisms such as bacteria and fungi. Such organisms, including plant roots, act as the primary agents driving nutrient cycling and help plants by improving nutrient intake, in turn supporting above-ground biodiversity as well. FAO estimates that a third of all soils are degraded, due to erosion, compaction, soil sealing, salinization, depletion of soil organic matter and nutrients, acidification, pollution and other processes caused by unsustainable land management practices.Unless new scientific approaches are researched and adopted, the global amount of arable and productive land per person in 2050 will be only one-fourth of the level it was in 1960.Policy makers and farmers must, therefore,appreciate soil's functions and assess the risks it is running right now.

IV. Soil Governance& Soil Management

As soil has been a nonrenewable resource, soil governance needs to focuson policy, strategies and the processes regarding the use of soil. Globally, governance of the soil has been mostly confined to agricultural soil because of serious concern for food security in populated regions on earth. The FAO and its members initiated the Global Soil Partnership [GSP] to improve governance of the soil resources in order to ensure healthy and productive soils for a food-secure world, as well as support other essential ecosystem services.Governing the soil requires implementation of coherent policies, practices and methods that regulate the use of this limited resource to avoid conflict among users and promote sustainable land management. Governance of the soil differs from soil management. Soil management involves adoption of scientific techniques in agriculture to increase and maintain soil fertility, structure, and carbon sequestration, etc. viz. such as practices for tillage, fertilizer application and crop rotation.The need to monitor and avoid the negative effects of agricultural land use such as soil erosion calls for creating greater degree of awareness on soil governance and also application of science and technology for efficient soil management.

Using geographic information system [GIS], remote sensing and emerging science and technologies, a global/national soil map can be created to represent different soil types.The consortium led by the ISRIC-World Soil Information has the mandate to increase knowledge on soils through data collection and dissemination and development of technologies and methods for digital soil mapping. GIS is used to display, analyze and collate soil data and processes, and also identify different types of soils through mapping and web-based software Soil science is used in tandem with GIS to identify individual soil properties applicable to agricultural and urban soil management.

V. India's Soil Scenario

India has about 18% of world's human population and 15 % of livestock population being supported by only 2% of world's geographical area and 1.5% of forest and pasture land. Out of 328.7 million hectares [MHA] of geographical area of India, 142 MHA are net cultivated area. Of this, about 57 MHA (40%) are irrigated and 85 MHA (60%) are rain-fed. Intensive agriculture for increasing food production has caused problems of nutrient imbalance, greater mining of soil nutrients to the extent of 10 million tons annually depleting soil fertility, emerging deficiencies of secondary and micronutrients, declining water table level and its quality, decreasing organic carbon content, causing soil erosion and degradation leading to overall deterioration of soil health.
According to Indian Council of Agricultural Research (2010), out of total geographical area of 328.7 MHA in India about 120.4 MHA (37%) are affected by various kinds of land degradation. This includes water and wind erosion (94.9 MHA), water logging (0.9 MHA), soil

International Journal of Agriculture Innovations and Research
Volume 5, Issue 3, ISSN (Online) 2319-1473

alkalinity/sodicity [3.7 MHA], soil acidity (17.9 MHA), soil salinity (2.7 MHA) and mining and industrial waste (0.3 MHA). Frequent droughts, floods and climatic variability/aberrations, also, impact soil productivity and fertility and cause land degradation, thereby, affecting/threatening crop production across the country.

Under "*Land Capability Classification*" based on land use, the soils are classified into eight classes, of which four are considered suitable for agricultural purpose and remaining four are non-arable lands which need effective soil conservation measures and can be used for afforestation. This classification, among others, considersstudies of factors viz. inherent soil characteristics, external land features and environmental factors. Comprehensive soil surveys for each agro-ecological region are being attempted which records in detail the factors that promote or limit crop production viz. soil depth, topography, texture and structure, water holding capacity, drainage features followed by evaluation of soil fertility based on soil testing / soil analysis.

VI. Soil Health Management

The 11th five-year plan [2007-2012] for the first time since India's independence acknowledged the importance of proper soil management in agriculture. In their enthusiasm of increasing farm output farmers used excessive and unbalanced fertilizer which has rendered nearly two-thirds of productive farmlands as either degraded or sick.Soil health and soil quality, in general, are considered synonymous and can be used inter-changeably.Nutritional value of our food is directly related to the health of the soil which it grows.Maintenance of soil health is a *sine qua non* for sustaining agricultural production system. Soil in good health has the capacity to ensure proper physical, chemical and biological activities/processes for sustaining higher crop productivity. A healthy soil promotes sustainable root-growth, ensures adequate retention and release of water and nutrients for crop growth, maintains soil biotic habitat and responds favourably to soil management/ agronomic practices. Level of organic carbon, organic matter and microbial biomass determines the biological status of soil health. Soil health is influenced by a number of physical, chemical and biological factors and processes.

The Government of Gujarat in Indiadeveloped the Soil Health Cards Program in 2006 to significantly improve farmers' knowledge on soil and soil management practices with focus on proper and balanced use of fertilizers. Based on the analysis of soil sample, farmers get information on their soil profile including current status of soil nutrients and water content and are advised on the use of balanced fertilizers, application methods for crops most suited to their soils. In the pilot scheme, collected data were inputted into a web-based information system that included the Internet, intranet and GSWAN (Gujarat State Wide Area Network) to build up the stateand national database on soil health. Farmers' improved knowledge on soil managementincreased output, and reduced costs and contributed to Gujarat's agriculture growth rate that was three times the national growth rate in 2009.The success of the scheme has facilitated its implementation at a national level.

To assess soil health attributes soil testing is the only tool used to measure the physical, chemical and biological health of the soil. Though it aims at diagnosing total health of soil, most of the Soil Testing Laboratories [STL] deal with only nutritional aspects of soils. Soil testing provides very useful information about the changing productivity and fertility level of the soils from time to time. Though use of chemical fertilizers is indispensable in modern agriculture, their indiscriminate and excessive /unbalanced use [in terms of plant nutrients] has not only adversely affected on the soil health impacting on plant health/quality and ultimately leading to declining crop yields but also on farmer's financial/economic return in pursuing crop production programs. Besides, excessive use of chemical fertilizersleads to environmental pollution such as eutrophication and nitrate toxicity of ground water. Soil testing helps recommend judicious use of chemical fertilizers in combination with organicmanures and bio-fertilizers thereby providing balanced nutrition to crop.

Soil health management aims at promoting location and crop-specific sustainable soil management practices which include, among others[i] promoting Integrated Nutrient Management[INM][ii] balanced and judicious use of chemical fertilizers accompanied by secondary and micro nutrients in conjunction with organic manures and bio-fertilizers [iii] use of soil amendments to reclaim acidic/alkaline soils [iv] encouraging organic farming [v] establishing / strengthening soil and fertilizer testing facilities throughout the country to provide soil test-based recommendations to farmers for growing crops [vi] ensuring quality control requirements of chemical fertilizers, bio-fertilizers and organic manures under Fertilizer Control Order [vii] enhancing the skill and capacity building of the personnel of STLs and extension agency to effectively guide/help farmers [viii] organizing field demonstrations for farmers to properly understand and convince them of the economic benefits/gains of the INM &balanced use of fertilizers when excessive use of nitrogenous fertilizer [urea in particular] has done severe damage to their soils. The future of rural poor's livelihood and country's food security necessitates policy initiatives and programs to arrest deterioration of soil health and sharply focus on the conservation and efficient use of soil and water.

VII. Soil Testing

Soil testing is important to diagnose status of the physical, chemical and biological properties of the soil and to assess the quantum of available nutrients and productivity/fertility of the soils. Soil testing enables farmers to assess the suitability of land for agriculture, identify and quantify the constraining factors of crop-productivity viz. soilerosion, surface crusting, compaction, poor aeration, high bulk density, acidity, salinity, alkalinity, toxic chemicals, nutrients' deficiencies and chemical fixation of nutrients, low activity of microbes and biocatalyst, reduced biochemical process such as transformation, mineralization and fixation of biological nitrogen etc. Soil testing provides sound information for making recommendations on the use of specific types and amount of chemical fertilizers, organic manures and soil amendments for improving the soil health.

As high-yielding varieties of field crops under irrigated farming system requires significant use of crop nutrients in the form of chemical fertilizers soil testing is a must to assess the level of salinity or alkalinity.Soil testing helps taking nutrient management decisions related to manure and sludge applications with the objective of maximizing economic benefits while minimizing the potential for negative impact of water quality. Soil testing identifies factors responsible for poor performance of crop productivity and suggests appropriate measures to improve the performance. While soil testing results can reveal the status of plant nutrients, nutrient-holding capacity, organic matter content, and soil alkalinity or acidity, the reliability and the value of this information significantly depends upon the method of soil sampling, as *analysis is no better than sampling*. If soil testing is done scientifically and consistently over several years, soil test data can be used to determine the application of chemical fertilizer, compost, manure, lime, or other soil amendments in terms of their timing, quantity and method aimed at improving crop response. Soil testing can be used as a good guide to evaluate quality of soils and adopt appropriate cropping pattern, crop rotations and fertilizers. Soil testing includes sampling and sample preparation, sample analysis, preparation of fertility maps and indices, interpretation of analytical data and recommendation of fertilizers. Despite accurate and precise analysis in laboratory, results may not be meaningful if sampling and sample preparation is not of technical specifications. Soil sampling must be scientific and true representative of the field under investigation.

VIII. Soil Testing Laboratories

It was in late 1940s that soil testing became an importanttool to determine the need for lime and fertilizer use in United States. With mechanization and increased farm size, the large-scale application of synthetic nitrogenous fertilizers led to increased crop output. As crop nutrient removal increased with high yields, soil reserves of plant nutrients, particularly P and K, began to be depleted, resulting in nutrient deficiencies and lower yields. To resolve the problem, a need was felt to develop soil-testing methods that could assess nutrient deficiencies in different regions of United States. These initial efforts were later expanded to include soil tests involving other crop nutrients, such as calcium, magnesium, boron, sulfur, copper, iron, manganese, molybdenum, and zinc. Soil testing has now been universally accepted as a useful scientific tool to determine the economically optimum rates of nutrients required by most crops.

In India, soil testing commenced in1955-56 when 16 STLs were established under the Indo-US operational Agreement for "Determination of Soil Fertility and Fertilizer Use."In 1965, five of the existing STLs were strengthened and nine new STLs were established to meet the needs of the Intensive Agricultural District Programme (IADP) in selected districts. By 1970, to meet the increasing requirement of soil testing facilities, 25 new STLs were added. Besides, 34 mobile soil testing vans were put in place under the joint auspices of the Technical Cooperation Mission of USA, IARI and Government of India to serve the farmers in remote areas and educate them on the benefits of the use of balanced fertilizers through holding group discussions, demonstrations, film shows etc.

In the IADP districts, initially the annual capacity of each STL was to analyse 30,000 soil samples. The installed capacity of STLs varied from 1000 samples/year/lab in UP to 30,000-70,000 samples/year in Tamil Nadu. In 1980-81, Out of 354 STLs functioning with total annual capacity of analysing about four million soil samples, each of 90 STLs had annual capacity less than 5000, followed by 142 [6000-10,000], 65 [11,000-20,000],47[21,000-30,000] and 10 more than 30,000. Till 1980, STLs used to analyse soil samples for pH, texture, electrical conductivity, and available N, P & K but not for analysis of micronutrients. The process of setting up of STLs has continued with the financial support from Central Government and State Governments. Fertilizer companies are also establishing STLs.Presentlythe thinking is to set-up smaller laboratories with analysing capacity of 10000-12,000 samples/year.

The State Governments are preparing district-wise and block-wise soil fertility maps. Some States have even ventured to prepare village level soil fertility maps. Some States have commenced computerization of soil test data on soil fertility status which the resourceful farmers can access them online and receive advisory services through mobile phones.

In view of the critical role of soil-testing and analysis in facilitating farmers to make balanced and efficient use of fertilizer, the Union Government has been since fourth March, 2010 advising State Governments to increase physical facilities and improve the soil testing capacity with specific emphasis on soil testing for major and micronutrients and furnish Action Plan including progress report of soil testing facilities and issuance of soil health cards to farmers. The Union Government showed keen interest particularly in States, which accounted for 100 districts that consume 50 per cent of the total fertilizers in the country, the need to issue soil health cards to the farmers in these districts on priority basis and for making serious efforts to issue soil health cards to all farmers by July, 2013.To ensure availability of fertilizers of standard quality to farmers, fertilizer has been declared as an Essential Commodity under Fertilizer Control Order, 1985. Up to March 2013, 75 Fertilizer Quality Control Laboratories [FQCL] with annual analysing capacity of 1,42,621 samples had analysed 1,33,872 samples. As on 31.3.2013, there are 1,206 STLs in the country, with annual analysing capacity of 128.31 lakh samples.

IX. Current Program

Soil Health Management [SHM] is one of the important interventions under National Mission for Sustainable Agriculture [NMSA]. During the year 2014-15, Government approved establishing five STLs, one FQCL, strengthening three existing FQCLs, provision of 224 Portable Soil Testing Kits, organizing 358 training programs and demonstrations, one Liquid Carrier based Bio-fertilizer production unit, four Bio-fertilizer and Organic FQCLs , promotion of organic inputs & green manuring to bring 30,000 hectares under organic farming, distribution of micronutrients for 25,700 hectares. Government approved the “Soil Health Card [SHC]” scheme for providing 14 crore SHCs to farmers by 2016-17. SHCs would provide useful information to farmers on soil nutrient status of their farms and crop-specific recommendation on the amount of nutrients to be applied. SHCs will be issued every three years to all farmers for all their land holdings in order to promote balanced use of fertilizers and integrated nutrient management. To facilitate issuance of SHCs 100 mobile STLs are to be established..

X. Use of Fertilizers

India is the second largest producer and consumer of nitrogenous fertilizers and the second largest consumer of phosphatic fertilizers in the world. China and USA compete with India in terms of production and consumption of these fertilizers. However, consumption of 144.14 kg of NPK per hectare in 2010-11 was far less than China (289 kg) and Bangladesh (197 kg) in particular. It is estimated that 10 million tons of plant nutrients are removed by various crops in excess to what is being applied in the form of fertilizers in India. India has attained a level of consumption of 24.482 million tons of nutrients comprising 16.75 million tons of nitrogen, 5.633 million tons of phosphorus and 2.099 million tons of potash[2013-14]. The Task Force on Balanced Use of Fertilizers (2005) had estimated that 36 million tons of fertilizers in nutrient terms would be required to produce the requirement of 300 million tons of foodgrains by 2025, since there is limited possibility of further increase in totalarea under cultivation. National Academy of Agricultural Sciences has estimated (2009) that for meeting country’s food requirement by 2025, India would need to increase supply of nutrient to over 45 million tons. Out of this, 35 million tons should come from chemical fertilizer sources and 10 million tons from organic sources.

The concerted efforts to increase the consumption of fertilizers in 1970s and 1980s to support *Green Revolution*substantially increased food grain production from 74.0 million tonnes in 1966-67 to 209.8 million tons in 1999-2000. The rate of growth of food production, however, has shown a declining trend, in spite of increase in fertilizer consumption during recent times, due to the adverse impact of imbalanced use of fertilizers on food grain production and productivity. Fertilizer consumption in India is highly skewed, with wide inter-state, inter-district and inter-crop variations, leavealone by individual farm holdings and cropping pattern. The ICAR studies indicate that partial factor productivity of fertilizers (i.e. additional kg of food grain production per kg of nutrient applied) has been continuously declining.

XI. NPK Ratio

The NPK ratio, which is a measure of balanced use of fertilizer, shows wide inter-regional and inter-state disparity.Generally, NPK consumption ratio of 4:2:1 in India is considered desirable based on recommendation of 120:60:30 NPK kg/ha for wheat/rice. There is, however, a widevariation in the NPK use ratio in different geographical regions of the country. As for example, the Northern region exhibits the ratio as wide as 13.5: 4.3:1, whereas it is narrower in Southern region (2.9: 1.6: 1) and it is 5.6: 3.3: 1 in Western region and 5.0: 2.4: 1 in the Eastern region. indeed, specific requirements of N, P and K nutrients have to be assessed through scientific soil testing and analysis of individual farmer’s field in order to determine (i) available nutrient status of the soils and (ii) the crop-specific requirement of the nutrients; the difference between the two (ii – i) is the required nutrients to be replenished through application of the recommended quantity and specific chemical fertilizers [along with the time, instalments and method of application] best suited to the soil conditions for the proposed crop. It is, also, necessary to determine the deficiencies of secondary and micronutrients which should be corrected on time. Following Tables indicate consumption of chemical fertilizers in terms of nutrients, N,P& K and the NPK ratio from 2001-02 to 2013-14.

Table 1. Consumption of Fertilizers in Terms of N,P,K in lakh tons [2001-2014]

Year	N	P	K	Total	Year	N	P	K	Total
2001-02	113.10	43.82	16.67	173.60	2008-09	150.90	65.06	33.13	249.09
2002-03	104.74	40.19	16.01	160.94	2009-10	155.80	72.74	36.32	264.86
2003-04	110.77	41.24	15.98	167.99	2010-11	165.58	80.50	35.14	281.22
2004-05	117.73	46.24	20.61	183.98	2011-12	173.00	79.14	25.75	277.90
2005-06	127.23	52.04	24.13	203.40	2001213	168.21	66.53	20.62	255.36
2006-07	137.73	55.43	23.35	216.51	2013-14	167.50	56.33	20.99	244.82
2007-08	144.19	55.15	26.36	225.70					

Table 2. Year-wise N,P,K Ratio from 2001-02 to 2013-14

Year	N:P:K Ratio	Year	N:P:K Ratio	Year	N:P:K Ratio
2001-02	6.78: 2.63:1	2006-07	5.90: 2.37:1	2011-12	6.72: 3.07:1
2002-03	6.50: 2.51:1	2007-08	5.47:2.09:1	2012-13	8.15:3.23:1
2003-04	6.93: 2.58:1	2008-09	4.55:1.96:1	2013-14	7.98:2.68:1
2004-05	5.71: 2.24:1	2009-10	4.29:2.00:1		
2005-06	5.22:2.16:1	2010-11	4.71:2.29:1		

XII. Micro-nutrient Deficiencies

Indian soils in general are observed to be deficient in major/primary nutrients (Nitrogen, Phosphorous and Potassium) as well as in minor/ secondary nutrients (Sulphur, Calcium andMagnesium) and in micro nutrients (Boron, Zinc, Copper and Iron etc.) in most parts of the country. The deficiency of three major nutrients (N, P, K), and deficiency of Sulphur and micro nutrients [Zinc and Boron] in many States, and that of Iron, Manganese and Molybdenum in some States has proved to be a limiting factor in country's efforts to increase crop productivity.A comprehensive study by ICAR on Micronutrients, Toxic and Heavy Metals, involving analysis of 2,51,547 soil samples across the country revealed deficiency of zinc in as many as 48 per cent of soil samples followed by boron [33%], molybdenum [13%], iron [12%], manganese [5%] and copper [3%]. While a large number of farmers in India are aware of using chemical fertilizers involving major nutrients [N,P,K] but they are unaware of deficiencies of micronutrients in their individual farms. Also, large scale experiments by ICAR to study the crop response to application of micronutrients confirmed that additionalyield ranging from 300 kg to600 kg/hectare was obtained in cereals, showing pronounced response of food crops and vegetables to application of micronutrients. Under micronutrient-deficient situations, the application of major nutrients alone does not give expected results.Therefore, individual farmers should get their farm-soil scientifically tested and analysed in order to correct the deficiencies of specific micronutrients on time, through the application of chemical fertilizers and organic manure carrying these micronutrients.

XIII. Use of Organic Manures

Though, chemical fertilizers are a major source of nutrients to crops, use of chemical fertilizers alone for a long period of time produces adverse/unfavourable effects on physical, chemical and biological properties of the soil and environment. To avoid this, it is always desirable to use specified chemical fertilizers along with organic manures in the prescribed proportion. This approach improves fertilizer use efficiency and enhances cost-benefit ratio. Organic manures though carry low nutrient contents produce favourable effects on soil properties. ICAR studies on cereal- based cropping systems revealed that 25-50 per cent fertiliser requirement in terms of NPK for *Kharif* crops can be curtailed with the use of adequate Farm Yard Manure, *Sesbania* green manure and crop residues under different situations. Experiments conducted on cultivators' fields by the ICAR, further, revealed beneficial effects of integration of chemical fertilisers with green-manuring or FYM, as the total productivity of the cropping systems involving cereals, oil seeds and cotton increased by 7 to 45 per cent over farmers' practices in different agro-ecological regions. In sugarcane-based cropping system, integrated use of sulphitation press mud, cane trash and bio-fertilisers each with inorganic fertilisers and green-leaf manuring brought 20-50 per cent savings in nitrogenous fertilisers applied to sugarcane by improving the efficiency use of N, P and other nutrients. Indian Institute of Soil Science, Bhopal and many State Agricultural Universities have, also, reported similar results.

XIV. Balanced Use of Fertilizers

Use of fertilizer has to be according to the types of soils and needs of nutrients of the proposed crops. Fertilizer use efficiency should increase crop production while rationalizing input cost and minimizing environmental degradation. Different types of fertilizers are required to be used in acid and alkali soils. Fertigation involving the use of water soluble fertilizers through sprinklers and drips imparts better use efficiency for water and fertilizers. Location-specific nutrient management involving application of fertilizers based on soil tests is critical to efficient utilization of fertilizers. Use of required sources of plant nutrients has to be promoted, accompanied by the use of appropriate soil amendments in acidic/ alkaline soils to moderate acidity/alkalinity by bringing the soil pH level to near neutrality so as to enhance soil nutrient availability and efficiency.

Nutrient-management based on soil test is the key to increase crop productivity. The optimum use of nutrients based on soil analysis can improve crop productivity and minimize wastage of costly nutrients thereby it can enhance profitability of crop cultivation and minimize the impact on environment. Balanced use of fertilizers is, in general terms, defined as the timely application of all essential plant nutrients (primary, secondary and micronutrients) in readily available form, in optimum quantities and in the right proportion, through the correct method, suitable for specific soil/crop conditions. Balanced fertilizationincludes application of chemical fertilizersin conjunction with organic manures and bio-fertilizers. Appropriate soil amendments for acidic/alkaline soils need to be timely applied to improve soil health thereby ensuring adequate availability of nutrients to plants at critical stages of growth.

Integrated Nutrient Management focuses on promotion and use of micronutrients, organic manure, soil amendments (lime/basic slag) in acidic soils, and strengthening Fertilizer Quality Control Laboratories [FQCL].

XV. Government's Initiatives

Government has a policy and program to promote soil test based balanced and judicious use of chemical fertilisers, bio-fertilisers and organic manures [Farm Yard Manure, vermi-compost and green manure] to maintain/improve soil health and its productivity. For this, Union Government is providing financial assistance/grant to States for establishing and strengthening STLs throughout the country, organizing farmers' trainings and field demonstrations involving balanced use of fertilisers and micro-nutrients.

Government launched during 1991-92 a "Balanced and Integrated Use of Fertilizers" aimed at disseminating information on the balanced and judicious use of chemical fertilizers involving N,P,Kand secondary nutrient (Sulphur, Calcium, Magnesium) and micro nutrient (Zinc, Iron, Copper, Boron, Molybdenum, Manganese), in conjunction with organic sources of nutrients [green manures, organic manures /compost, vermi-compost] and bio-fertilizers based on a scientific soil test. Important components of the scheme included [i] establishing compost plants to process biodegradable city solid waste into compost [ii] increasing soil testing facilities [iii] conducting training programs for up-gradation of skills of staff of STLs [iv] organizing seminars and workshops on the use of fertilizers recommendations based on soil test. The scheme was continued during subsequent plan periods and since 2000 it has been merged with the Macro Management of Agriculture Scheme.

Major constraints in promoting balanced use of fertilizers, *inter alia*, include [i] lack of awareness among farmers about benefits of balanced fertilization [ii] inadequate awareness as also neglect of use of organic manure [iii] inadequate extension support system [iv] wide gap in dissemination of knowledge between research institutions, STL and the extension machinery, and [v] inadequate and ill equipped soil testing facilities to match country's needs. Government-appointed Task Force on Balanced Use of Fertilizers has, *inter alia*, recommended strengthening/revamping of soil testing facilities, encouraging production and promotion of the use of organic manures and bio-fertilizers; and fortification of major fertilizers with appropriate grade of secondary and micro-nutrients.

Under the National Mission for Sustainable Agriculture, the program on [A] soil health management, among others,include[i] creation of databank on location specific balanced use of fertilisers [ii] creation of district-wise digital soil fertility maps[iii[distribution of portable soil testing kits to field functionaries and [iv] promotion and distribution of micronutrients [B] Integrated Nutrient Management & Organic Farming, among others, includes provision of financial assistance for setting up of [i] mechanized Fruit/ Vegetable market waste/Agro waste compost production units [ii] State of art liquid/carrier based bio-fertiliser/ bio-pesticide production units [iii] Bio-fertiliser and Organic fertiliser testing laboratories and strengthening of existing ones under the Fertilizer Control Order [iv] adoption of organic farming through cluster approach under Participatory Guarantee System certification [v] support to PGS system for on-line data management and residue analysis [vi] adoption of villages under organic farming for manure- management and biological nitrogen harvesting [vii] organizing training programs and demonstration on organic farming [viii] support to research for development of package of practices on organic farming best suited to cropping system in the concerned States [ix] establishing separate Organic Agriculture Research and Teaching Institute.

XVI. National Project

India has 120 million farm holdings which need soil analysing capacity of 40 million samples annually since each holding will require soil testing once in three years. This necessitates a massive expansion of soil testing programme throughout the country. As recommended by the Task Force on Balanced use of Fertilizers "National Project on Management of Soil Health and Fertility [NPMSF] was launched in 2008-09. For this national project the State Governments can, also, avail resources from the "Rashtriya Krishi Vikas Yojana" and "Macro Management of Agriculture".The NPMSFprimarily aims at facilitating and promoting the implementation of the Integrated Nutrient Management through judicious use of chemical fertilizers including secondary and micro nutrientsin conjunction with organic manures and bio-fertilizers. The NPMSF envisaged [i]strengthening 315 existing State STLs, establishing 500 new STLs and 250 mobile STLs during 2007-12 for assessing micronutrients deficiency [ii] ensuring quality of fertilizers through strengthening FQCLs and training officers of State Governments for effective enforcement of "Fertilizer Control Order"[iii] creating site-specific data-bank for balanced use of fertilizers[iv] adoption of 10 village by each STL through Frontline Field Demonstrations [v] preparing digital district soil maps (using Global Positioning System) and soil fertility monitoring system by ICAR/State Agriculture Universities. Under the NPMSF, 134 new STLs, 123 mobile STLs and 16 new FQCLs were established and existing 173 STLs and 46 FQCLs were strengthened. .

In 2010-11 STLs increased to 1049 with annual capacity of 1.07 crore from 715 STLs with capacity of 78 lakhs in 2009-10. Based on soil analysis,74 lakh soil health cards were issued to farmers during 2010-11 compared to about 57 lakh in 2009-10 taking the aggregate number of 408 lakh soil health cards now. States viz. Andhra Pradesh, Gujarat, Haryana, Karnataka and Uttar Pradesh reported comparatively better progress in respect of [i] expansion of soil testing facilities [ii] launching campaign to popularize the programme [iii] development of soil fertility maps [iv] use of information technology in delivering soil nutrient status and appropriate recommendation to farmers.

XVII. Strategic Action Plan

As the NPMSF has been under implementation since 2008-09, beginning from this 5th December 2016 [WSD] India can thoroughly evaluate its performance and identify factors responsible to inhibit the performance and formulate the Strategic Action Plan focusing sharply on following aspects to yield expected results by 31st March 2019.

- Often, soils are treated as just dumping grounds for fertilisers to extract more and more yields. Besides, India's fertiliser policy is skewed against soil health. Farmers today use so much urea carrying only nitrogen, because it has a price advantage as compared to phosphorus and potassium. Their perception is what they lose on phosphorus and potassium [because of higher open market price] can be more than compensated by the unbridled use of urea [because of substantial amount of subsidy]. In this process, they distort the healthy nutrient balance in soil severely affecting the carbon balance, leading to all the subsequent soil-related problems. This calls for an immediate policy intervention.
- Creating awareness among all farmers to get soil tested and analysed; training them to use balanced fertilizers& Integrated Nutrient Managementthrough field demonstrations;providing soil health cards to all those who do not have yet;following-up with those who have already been issued to assess the outcome or whether they have any problems.
- Monitoring-cum-Concurrent Evaluation studies need to be conducted through systematically drawing plans village-wise to ensure that farmers are using the soil health cards for the purpose for which they are issued and assess the economic benefits of the NPMSF. Robust Management Information System must be put in place to ensure effective implementation, assess the economic benefits realised and initiating remedial measure if there are any problems.
- Make effective use of print and electronic media to create awareness for Soil Health Management in each village during the years 2016-18 and ensure that targeted number of STLs, mobile STLs and FQCLs are established/strengthened, staff trained for capacity building,
- Conduct Action Research Project in each district to understand ground realities of the implementation of the NPMSF and prepare case studies on the success or failure of the NPMSF at farmer's level which can be shared with farmers in other districts

XVIII. Conclusion

The success of the NPMSF calls for effective institutional coordination [horizontal & vertical] at all levels right from the grass roots villages to the Union Ministries, concern & commitment of elected legislators, good governance & accountability of implementers and effective participation of media to launch aggressive campaign during the winter, summer and monsoon crop seasons to carry the message to farmers.

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