**Soil Health Management in India: Issues, Opportunities and Policy Initiatives**

**SK Chaudhari, PP Biswas and Hemlata Kapil**

Indian Council of Agricultural Research, New Delhi – 110 012

**Abstract**

Soil performs various critical functions out of which the production function is the basis for food and nutritional security to sustain human and animal life on earth. It is the soil biological, chemical and physical properties that interact to provide a soil its capacity to function. Deterioration of soil health is considered as one of the main reasons of declining nutrient use efficiencies vis-à-vis stagnation of agricultural productivity in the country. Climate change impact on soil has further aggravated the situation. Soil health is conceptualized on the ecological attributes of the soil. These attributes are chiefly those associated with the soil biota which are playing a critical role in maintaining soil health, ecosystem functions and productivity. Soil organisms act as the primary driving agents of nutrient cycling, regulating the dynamics of soil organic matter, soil carbon sequestration and greenhouse gas emission, modifying soil physical structure and water regimes, enhancing the amount and efficiency of nutrient acquisition by the vegetation and enhancing plant health. Major management options include soil test based balanced and integrated nutrient management, bio-engineering measures of soil & water conservation, crop residue recycling, soil reclamation/amelioration and conservation agriculture. Government of India is implementing several schemes for judicious use of soil resources to ensure higher agricultural productivity and profitability of farming community based on the technology backstopping provided by Indian Council of Agriculture Research (ICAR) and State/Central Agricultural Universities. Some of the notable Government initiatives are Soil health management, component of National Mission for Sustainable Agriculture (NMSA), National Mission on Soil Health Card, Bio gas and manure management schemes, Paramparagat Krishi Vikas Yojana, Watershed Management component of Pradhan Mantri Krishi Sinchayee Yojana and Nutrient Based Subsidy scheme.

**(Keywords**: Soil health, degradation, C sequestration, soil quality indicators, soil management, policy initiatives).

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**Introduction**

Caring soil is extremely important for sustaining healthy life on earth. According to Vedas ‘ upon this handful of soil our survival depends care for it, and it will care for your food, the fuel that you need, that will shelter you and surround you with beauty. Abuse it and the soil will collapse and die, taking us all with it.’ The root cause of deteriorating human/animal health actually lies on poor health of soil. Only a healthy soil can support healthy plant growth to provide nutritious produce to keep us healthy. From agricultural point of view, soil health is the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality and promote plant, animal human health. A healthy soil would ensure proper retention and release of water and nutrients, promote and sustain root growth, maintain soil biotic habitat, respond to management, resist degradation and act as a buffer for environmental pollution (Brevik and Sauer 2015).

India presently supports 17.5% of the world’s human and 15% livestock population with only 2.4% of the land mass. The country is presently home to about 175 million food-insecure population out of the world total of about 795 million(2015), who on average consume less than 2,100 calories a day. To feed the teeming millions, India has to increase foodgrain production @ of more than 6 million tonnes annually. With tremendous demographic pressure on land, the per capita availability of agriculture land in India has already decreased sharply from 0.48 ha in 1951 to 0.13 in 2011 which is likely to decrease further to 0.08 in 2035. This has resulted in intensive use of soil resource to feed the population growing @1.2% per annum. Post green revolution, concerns have been raised about sustainability arising from the deterioration of soil chemical, physical and bio-logical health through accelerated erosion, salinization (primary and secondary), depletion of soil organic matter (SOM), elemental imbalance, deficiencies of some essential nutrients, soil compaction, surface sealing, improper crop husbandry practices and scalping of top soil for brick-making.

In fact, agricultural sustainability depends to a large extent on the maintenance or enhancement of soil-quality. The terms ‘soil health’ and ‘soil quality’ are functional concepts and interchangeable, which can be viewed in two ways: (i) as inherent properties of a soil and (ii) as the dynamic nature of soils influenced by climate and human use and management (Doran et al. 1996). It is indeed a real challenge to manage soil resource for achieving food, nutritional, environmental and livelihood security, conserving this vital natural resource base for future generations without any deterioration. The United Nations Millennium Development Task Force on hunger has made Soil Health Enhancement as one of the five recommendations for increasing agricultural productivity and fight hunger.

**Soil resources of India**

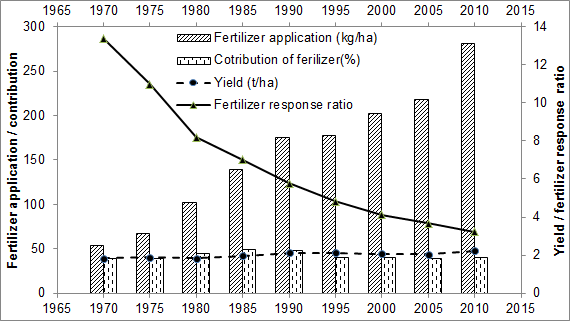
Due to extreme climatic variability, India is endowed with diverse soil types covering 7 soil Orders of the US Soil Taxonomy classification with 21 Sub-orders and 62 Great-groups. The extent and distribution of the different soil classes of India have been given in table 1.

The soils of India is represented by red and laterite soils (Alfisols, Oxisols, Ultisols, Incepitisols etc.; 117.2 M ha), black soil (Vertisols and their associations; 73.5 M ha), alluvial soil (entisols and Inceptisols; 58.4 M ha) desert soils (mostly Aridisols and Entisols; 30 M ha ) and the rest other soils types. The Major alluvial track of the country lies along the Indo-Gangetic plains and Brahmaputra and Barak valley. Alluvial soils are also located in coastal and deltaic region and along the important rivers of the country. The soils are generally deep, loamy, alluvium derived having moderate to high available water-holding capacity. The soils have low organic matter content and moderate to medium exchange capacity. The Indo-Gangetic plains of north India are the most fertile lands and are largely irrigated, contributing 65 % of the total food basket. Red and lateritic soils occur on gently sloping to undulating lands. The physical constraints to crop production in red and lateritic soils are soil erosion, hardening of soil, low water-holding capacity, reduced soil volume due to concertinos, occurrence of hard plinthite or petroplinthite, drought related stress, low cation exchange capacity, low organic matter, high acidity, iron and aluminium toxicity, high phosphorous fixations and poor fertility status. Black soils occur mostly in peninsular region on gently sloping lands at low elevations. These soils have high cation exchange capacity (CEC) with advantage of nutrient retention and swelling for moisture retention. Moisture shortage under rainfed conditions and waterlogging, salinity and alkalinity under irrigated conditions adversely affect the productivity of the soils. On saturation they become impervious, as a result they are more erodible. Since wet Vertisols are difficult to cultivate, cropping on them is concentrated more during rabi season (post-rainy season). Soils of arid regions (mostly Aridisols and Entisols) occur in Rajasthan, Haryana and Gujarat. The track is in general sandy and in many parts saline or alkaline in nature with unfavourable physical conditions and high pH value.

**Soil health issues**

*Chemical health*

Indian soils are in general, low in organic C. The continuous mining of nutrients from soil @ of 34 million tonnes per annum against the external supplement of only 26 million tonnes coupled with low addition of organic manures, secondary and micronutrients resulted in emergence of multi-nutrient deficiencies in several districts in the country (Table 3). The Nutrient deficiency in the country is in the order of : 95, 94, 48, 25, 41, 20, 14, 8 and 6% for N, P, K, S, Zn, B, Fe, Mn and Cu respectively. The limiting nutrients do not allow the full expression of other nutrients, lower the fertilizer response and crop productivity. 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 (Fig. 1). 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 being required presently to sustain the same yield level, which is a matter of concern(Chaudhari *et al* 2015).



**Fig. 1: Response and contribution of fertilizer in foodgrain production in irrigated areas over the years in India.**

The nutrient use efficiency in Indian soils are also low ranging from 30-50% (N),15-20% (P), 60-70%(K), 8-10%(S) and 1-2% (micronutrients). While the unutilized nitrogen are subjected to leaching and denitrification/volatilization loss polluting groundwater and atmosphere respectively, considerable amount of P & K nutrients are lost through the process of soil erosion. It has been estimated that over 5.3 billion tonnes of soil is lost annually through water erosion with a loss of ~8 mt of plant nutrients (NPK).

It is further reported that around 17.36 million ha of arable land of the country is affected by various kinds of chemical degradation with very low productivity (< 1 t/ha). This includes about 10.72 Mha suffering from acute soil acidity (pH < 5.5) and around 6.64 Mha are under salt affected soils comprising of 3.64 Mha under high sodicity (pH >9.5) and about 3 Mha (including 1.25 Mha coastal salinity) are under salinity. The crop production loss due to salinity and alkalinity at the national level has been estimated to be 5.66 and 11.18 million tonnes, respectively. In economic terms, this is equivalent to the annual monetary loss of Rs. 80,000 million and Rs. 1,50,000 million due to salinity and alkalinity problems, respectively, assuming 2014-15 as base year (ICAR-CSSRI, 2016a& b).

*Physical health*

Understanding and managing soil physical properties and processes are essential for sustainable management of soil and water resources. Physical environment of soil has a significant role in water and nutrient uptake and losses, pollutant transport and also emission of greenhouse gases from soil (Acharya *et al* 2016). It also influences its chemical and biological properties and processes through movement of water and gases in soil and soil thermal regime. McKenzie *et al.* (2011) defined the soil physical quality as the ability of a given soil to meet plant and ecosystem requirements for water, aeration, and strength over time and to resist and recover from processes that might diminish that ability.

It is estimated that 104 Mha of arable land is degraded in one way or the other producing less than 20% of its potential capacity (Maji et al. 2010). Out of which, around 73.27 million ha suffer from water erosion and 12.24 million ha from wind erosion. Erosion induced loss in crop production in rainfed areas under major cereal, oilseed and pulse crops has been estimated as 13.4 million tons (~16%), which in economic terms is equivalent to Rs. 162.8 billion (Sharda *et al.* 2010). Besides, nearly 89.52 Mha (Table 2) suffer from one or the other form of physical constraints like shallow depth, soil hardening, slow and high permeability, sub-surface compacted layer, surface crusting, temporary waterlogging, etc. (Painuli and Yadav 1998). In addition, around 0.9 Mha area land is affected due to permanent surface inundation. Mechanization of farm operations, frequent tillage in intensive cropping systems, unscientific and indiscriminate use of inputs and decline in soil organic matter, etc. are adding new areas with new problems to the existing degraded area.

*Biological health*

Attention to soil biological health is as essential as that to chemical and physical health for sustaining higher crop productivity. Biological properties of soil also influence soil’s chemical and physical properties. Therefore, three are interactive and not mutually exclusive. This demands wider recognition of soil biological health than what it has received so far. Soil health is conceptualized on the ecological attributes of the soil, which have implications beyond its quality or capacity to produce a particular crop. These attributes are chiefly those associated with the soil biota: its diversity, its food web structure, its activity and the range of functions it performs (Sharma and Adhya 2016). By soil health we generally mean to soil physical and chemical health (forgetting biological health) both largely rely on soil biodiversity and soil biological processes. Soil and its living organisms are an integral part of agricultural ecosystems, playing a critical role in maintaining soil health, ecosystem functions and productivity. These services not only facilitate functioning of natural ecosystems but constitute an important resource for sustainable management of agricultural systems. The value of "ecosystem services" provided each year by soil biota in agricultural systems worldwide may exceed US$ 1,542 billion (FAO 2002). Nearly 40-48 million tons N per year is biologically fixed in agricultural crops compared to 83 million tons N per year fixed industrially for the production of fertiliser. Despite recognition of the fundamental role of soil biota in maintaining sustainable and efficient agricultural systems, it is still largely neglected in the majority of agricultural development initiatives. The consequences of neglecting or abusing soil life will weaken soil functions and contribute to greater loss of fertile lands and an over-reliance on chemical fertilizers for maintaining agricultural production.

Organic manures/compost is an eco-friendly source of soil organic carbon providing energy to soil biota which act as the primary driving agents of nutrient cycling, regulating the dynamics of soil organic matter, soil carbon sequestration and greenhouse gas emission, modifying soil physical structure and water regimes, enhancing the amount and efficiency of nutrient acquisition by the vegetation and enhancing plant health (Benbi 2016). Crop residues returned to the soil provide substrate to soil organisms, which help in SOM turnover. It is estimated that burning of one tone of rice straw accounts for loss of 5.5kg Nitrogen, 2.3kg phosphorus, 25kg potassium and 1.2kg sulphur besides, organic carbon. Crop residues burning is a potential source of Green House Gases (GHGs) such as CH4, CO, N2O, NOx causing global warming. Despite being aware of the beneficial effects of residue recycling on SOC and overall soil-health enhancement, farmers resort to in-situ burning of crop residues. In India, an estimated 500-550 Tg of crop residues are produces annually. After accounting for multiple competitive uses about 141 Tg are surplus most of which are burnt in situ. The crop residues on an average contain 45% C and assuming a humification rate 10% the incorporation of surplus crop residues can result in C sequestration of 6.3 Tg C annually (NAAS, 2012).

*Soil pollution*

Soil pollution is defined as the build-up of pollutants in soils like persistent toxic compounds, chemicals, salts, radioactive materials, or disease-causing agents with adverse effects on plant growth and human/animal health (Sanyal *et al* 2016). The pollutants are released into the environment, including soil, from both natural (geogenic) and anthropogenic sources.The main factors of soil pollution are the high state of soil erosion, excessive use of chemical fertilizers & pesticides, use of urban and industrial wastes, irrigation with poor quality water (sodic/saline water, arsenic, selenium and fluorude contaminated ground water, sewage water etc.). In India, about 100 million tonnes of pollutants are being added to the atmosphere annually through burning of fossil fuel and industrial emissions causing considerable air pollution. Coal combustion in thermal power plants releases 100-110 t Hg/yr, 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. More than 35 billion liters of urban waste water and 25 billion litres of industrial waste water are released every day, a significant part of which enters into agricultural land as irrigation carrying different pollutants. Some of the pollutants are constituents of extensively used agrochemicals like Cd through phosphatic fertilizer and pesticides (organic pollutants) and enter into the rhizosphere when these are used for higher production and economic return.

***Climate change impact on soil***

Climate change/variability can impact the overall soil quality through its influence on physical (porosity, maximum water holding capacity, bulk density, mean weight diameter, water stable aggregates, hydraulic conductivity), chemical (clay content, cation exchange capacity, total N, available N, P, K, Zn Fe Mn, S, P and K fixing capacities) and biological (SOC, MBC, metabolic quotient, potentially mineralizable N, soil respiration, dehydrogenase activity, phosphatase activity) attributes (Pathak *et al* 2016). It will impact soil organic matter dynamics, including soil organisms and the multiple soil properties that are tied to organic matter, soil water, and soil erosion.

**Opportunities for managing soil health**

*Soil health assessment*

Soil health/quality represents a composite of physical, chemical and biological attributes. Soil quality cannot be measured directly, but essentially needs to be inferred from measuring changes in its attributes of the ecosystem, referred to as indicators (Sharma *et al* 2016). The changes in these indicators are used to determine whether soil quality is improving, stable, or declining with changes in management, land-use or conservation practices (Brejda and Moorman, 2001). The predominant indicators for physical, chemical and biological qualities of soil at micro-and macro-farm scale have been suggested by Singer and Ewing (2000). The indicators should (i) correlate well with natural processed in the ecosystem (this also increases their utility in process-oriented modelling), (ii) integrates soil physical, chemical, and biological properties and processes, and serve as basic inputs needed for estimation of soil properties or functions, which are more difficult to measure directly, (iii) be relatively easy to use under field conditions, so that both specialists and producers can use them to assess soil quality, (iv) be sensitive to variations in management and climate and (v) be the components of the existing soil databases wherever possible (Doran et al. 1996; Doran and Parkin 1996; Chen 1998). Rapid measurements of soil quality attributes are possible using hyper-spectral remote sensing data as well as visible and near infrared diffuse reflectance spectroscopy (ISNIR DRS).

Another approach of soil quality assessment called ‘a comparative assessment technique’ is based on (i) selection of a minimum data set (MDS) of indicators that best represent the soil function, (ii) scoring of the MDS indicators based on their performance of soil functions and (iii) corroboration of the MDS indicators with functional goals set by the land manager or grower and (iv) integration of the indicator score into a comparative index of soil quality(Andrews and Carroll, 2001, Andrews et al.2002a, b). Positive effects of green manuring, INM, manure, crop residue recycling, legume based crop rotations, balanced fertilization have been observed on predominant soil quality indicator, overall soil-quality indices and SYI of crops.

*Soil testing*

Soil testing is a basic necessity to determine the quantities of nutrients to be applied to ensure balanced nutrition to plants. The country has about 700 static soil testing labs with an analysing capacity of over 7 million soil sample per annum. Given the vast cultivated area and number of farm holdings, the soil testing facilities are grossly inadequate. The ICAR has developed two portable digital quantitative soil test kits namely mini lab (*Mridaparikshak*) by Indian Institute of Soil Science, Bhopal and STFR (Soil Test and Fertilizer Recommendation) meter by Indian Agricultural Research Institute (IARI) New Delhi with GPS facilities to supplement soil testing service in the country. The kits are useful in analysing soil samples for the purpose of distributing soil health cards to farmers along with fertilizer recommendations and developing geo-referenced soil fertility maps at village level.

*Balanced and Integrated nutrient Management*

It has been amply demonstrated under Long Term Fertilizer Experiments that balanced application of nutrients along with organic manures facilitates better soil quality and yield sustainability (Fig. ) compared to chemical fertilization alone.

Source: Sharma *et al* (2002).

**Figure 2.**

(Source: Biswas and Sharma (2008), Wanjari et al.,(2004).

**Figure 3. Average fertilizer response ratios (kg grain/kg nutrient) and Sustainable Yield Index (SYI) under long-term fertilizer experiments in India**.

It has been found that soils with relatively higher organic matter content are better in performing functions that are critical for crop production and environmental conservation. Indian Council of Agricultural Research (ICAR) has developed technologies to prepare various types of organic manures such as phosphocompost, vermincompost, bio-enriched compost, municipal solid waste compost, etc. from various organic wastes. Effective biofertilizer strains of *Rhizobium* for promoting nodulation and nitrogen fixation in legumes and of plant growth promoting rhizobacteria (PGPR) consisting of *Azotobacter*, Phosphate solubilising bacteria (*Bacillus*, *Pseudomonas*) and other PGPR for cereals, legumes, millets, oilseeds, vegetables and horticultural crops were developed which resulted in increase in productivity by 10%, saving of 20-25% chemical fertilizers, improvement of nutrient use efficiency by 15-25%, produce quality and soil health. When biofertilizers are applied along with compost @ 5t/ha or vermi-compost @ 2t/ha, fertilizer saving is almost 50%. The ICAR is recommending soil test based balanced and integrated nutrient management through conjunctive use of both inorganic and organic sources (manure, biofertilizers etc.) of plant nutrients to prevent deterioration of soil health. It is concluded based on several biological, chemical, and physical indicators of soil quality that conjunctive nutrient use as well as sole organic nutrient treatments were superior to even balanced NPK application with higher crop productivity and Soil Quality Index (Chaudhury *et al.* 2005, Sharma 2009). The viable INM practices of dominant cropping systems in different agro-climatic regions of the country have been summarized (Table 4). Similarly, nutrient management packages under organic farming system for dominant crops and cropping systems have also been worked out (Table 5).

*Managing soil organic matter*

Soil organic matter (SOM*)* is an unique indicator which exerts major influence on a number of soil physical, chemical and biological attributes. The soil physical properties most commonly influenced by SOM include bulk density, aggregate stability and moisture retention. Increase in SOM lowers soil bulk density, improves aggregation and the proportion of water-stable macroaggregates and favourable impacts soil water retention and transmission properties (Benbi 2016). The increase in aggregate formation and aggregate stability is mainly due to the production of organic macromolecules by microorganisms that bind primary particles and macroaggregates to form macro-aggregates.

The chemical properties of soil that are mainly influenced by SOM include nutrient availability, exchange capacity, reaction with meals and contaminants and its capacity to act as proton buffer. It contributes 25-90% of the CEC of surface layers of mineral soils depending on the nature and content of organic matter. The soil biological properties or processes influenced by SOM include mineralization, microbial biomass and enzyme activities. A number of studies in India have shown that SOC is the most important parameter for sol quality index formulation indicating that soils with relatively higher organic matter content are better in performing functions that are critical for crop production and environmental conservation. Indeed, an increase of SOC stock by 1 Mg C ha-1in the root zone can raise the crop yield by 15-33 kg ha-1 for wheat (Benbi and Chand, 2007), 160 for kg ha-1 for rice, 170 kg ha-1 for pearl millet, 13 kg ha-1 for ha-1for groundnut, 18 kg ha-1 for lentil 90 kg ha-1 for sorghum, 101 kg ha-1 for finger millet and 145 kg ha-1 for soybean, (Srinivasarao et al. 2013). Therefore, greater SOC content can result in higher foodgrain production in the country.

*Carbon sequestration*

There are considerable opportunities to build up soil organic carbon in soils through C sequestration for enhancing the soil quality. The strategies for soil C sequestration include nutrient management, adoption of complex rotations, adoption of resource conserving technologies and soil and water conservation. Based on the results from a number of long-term fertilizer experiments conducts for 8 to 32 years across various agro-climatic zones of India, C sequestration potential of different nutrient management practices is estimated to range between 2.1 and 4.8 Mg C ha-1 with a total potential of 300 to 620 Mt (Pathak et al, 2011). In India, balanced application of fertilizers can enhance SOC concentration by 6 to 100% and C sequestration by 20-600 kg ha-1 yr-1, depending on soil, crop and climatic conditions. Judicious application of fertilizers and integrated nutrient management encompassing use of both inorganic fertilizers and organic amendments (FYM, compost and green manure, biofertilizers) can further enhance soil C sequestration. Carbon sequestration potential of integrated nutrient management practices is estimated at 100-1200 kg C ha-1 yr-1 with an enhance SOC concentration of 17-132 % under various soil, crop and climatic conditions (Benbi, 2013). Carbon-sequestration potential of rainfed production systems under different nutrient management practices ranges (Mg ha-1 yr-1) between 0.08 and 0.45 for groundnut (Arachishypogaea) on Alfisols, 0.04 and .038 for finger millet (Eleusivecoracana) on Alfisols, 0.1 and 0.2 for winter sorghum on Vertisols and up to 0.33 for soybean on black soils (Srinivasarao *et al*. 2014). C sequestration potential of agro-forestry systems very widely (1.3-173.0 Mg C ha-1) depending on tree species, climatic conditions and age of plantation (Nair *et al*. 2009). No-till agriculture can enhance soil-C sequestration by reducing the degree of soil disturbance and C turnover.

Methane is produced in soil during microbial decomposition of organic matter under strictly anaerobic continuous submergence. Improved water management such as alternate wetting and drying, direct-seeding of rice (DSR) and System of Rice Intensification (SRI) crop do not require continuous soil submergence, and therefore reduce or totally eliminate methane emission when rice is grown as an aerobic crop. The DSR and SRI have potential to reduce the global warming potential (GWP) by about 25-50% compare to the conventional puddled transplanted rice .

Incorporation of surplus crop residues improves soil health, besides leading to C sequestration, and minimizing environmental pollution, associated with residue burning. Removal or burning of crop residues can adversely impact soil quality and production-system sustainability. In north Indian state of Punjab alone, about 22Tg of rice residue is produced, out of which 80% is burnt in situ. The incorporation of rice residue in soil instead of burning can lead to C accrual of 0.80 % Tg C yr-1 over an area of 2.28 Mha in Punjab, which is equivalent to about 350 kg C ha-1. Still higher rates of C sequestration, up to 745 kg C ha-1, can be achieved if both animal manure and rice residue are applied annually in the rice-wheat cropping sequence (Benbi *et al.* 2012b). In fact, incorporation of rice residue along with FYM emerged as the most attractive C sequestering strategy for alluvial soils of north-western India as the practice could maintain SOC stocks almost at the same level as for the uncultivated soil, while imparting sustainability to the rice-wheat cropping system in the Indo-Gangetic plains.

Managing emission of other Green House Gases (GHGs)

To reduce emission of nitrous oxide from soil, enhancing the efficiency of fertilizer N with 5R approach i.e. use of right kind of fertilizer, right rate of application, right time of application, right place of application, and right method of application is the key solution. Besides, the demand-driven N use using a leaf colour chart (LCC) could reduce the nitrous oxide emission and ground water pollution by about 11-14% (Bhatia et al. 2012; Jain et al. 2014). Use of nitrification inhibitors such as coated calcium carbide and dicyandiamide can also reduce emission by 10-15%. There are some plant-derived organics such as neem oil, neem cake and karanja seed extract, which can also act as nitrification inhibitors.

*Managing soil degradation*

In order to prevent loss of top fertile soil and deterioration of soil physical conditions due to soil erosion, the Indian Institute of Soil and Water Conservation (IISWC) has developed location specific bio-engineering measures. Similarly, Central Arid Zone Research Institute, Jodhpur has developed sand dune stabilization and shelter belt technology to check wind erosion. The Council through Central Soil Salinity Research Institute, Karnal and All India Coordinated Research Project (AICRP) on Salt Affected Soils has developed reclamation technology, salt tolerant varieties of rice (CSR-30, CSR-36), wheat (KRL-210, KRL-213) and mustard ( CS-52, CS-54) and agroforestry interventions for rehabilitation of lands affected by salinity and sodicity. Also, sub-surface drainage and bio-drainage technologies have been developed to improve the productivity of saline waterlogged soils in the country. Similarly, the Council has developed cost effective amelioration techniques i.e. liming @ 3-4 q/ha for managing acid soils.

**Government’s policy initiatives**

The Government of India, based on the recommendations of Task Force on balanced and integrated use of fertilisers has taken several initiatives namely strengthening of soil testing facilities, distribution of soil health cards, promotion of integrated nutrient management, production of organic fertilizers, development of new value added fortified/customised fertilisers, fertigation, nutrient based fertiliser subsidy etc to improve soil health. The Indian Council of Agricultural Research (ICAR) through Indian Institute of Soil Science (IISS) and All India Coordinated Research Projects (AICRPs) on Soil Test Crop Response (STCR)**,** [Micro- and Secondary Nutrients and Pollutant Elements (MSNP) and Plants](http://www.nic.in/icar/nrm_soils.html#msnp), Long Term Fertilizer Experiments (LTFE) and Network Project on Soil Biodiversity-Biofertilizers are addressing researchable issues related to soil health in the country and providing requisite technology backstopping to a variety of programmes/schemes being implemented by different Ministries/Departments ranging from single component/commodity based sectoral scheme to area based integrated approach. Some of the notable schemes viz. National Mission of Sustainable Agriculture, National Mission on Soil Health Cards, Nutrient Based Subsidy scheme, P*aramparagat Krishi Vikas Yojana* have direct relevance to soil health management.

India is a country of diverse soil, crop and climatic conditions. Under such situations, the sustainability of high crop productivity can be assured through site specific nutrient management. Accordingly, a National Mission on Soil Health Card has been launched to provide soil tested based fertilizer recommendation to all the farmers in the country based on the twelve soil parameters. The Government under the component of soil health management of National Mission on Sustainable Agriculture (NMSA) is promoting soil test based balanced and integrated nutrient management in the country through setting up/strengthening of soil testing laboratories, establishment of bio-fertilizer and compost unit, use of micronutrients, trainings and demonstrations. A number of value added fertiliser materials fortified with secondary and micronutrients have been enlisted in Fertilizer Control Order (FCO) to promote balanced and efficient use of fertilisers. Also the customised fertilisers which are crop, soil and area specific show a good promise to maintain soil health by ensuring balanced fertilisation. The Govt. of India took a historical policy decision of introduction of Nutrient Based Subsidy (NBS) on N, P, K and Sulphur containing fertilizers with effect from1st April 2010. Additional subsidy for fertilizers fortified with zinc and boron was paid at the rate of ₹500 and ₹300 per tonne, respectively. It well help in soil health enhancement through balanced and efficient use of plant nutrients including secondary and micronutrients.

The Department of Fertilizers, Ministry of Chemicals & Fertilizers has declared subsidy on city compost @ ₹1500 per tonne to serve twin objectives viz i) supporting government’s Swachh Bharat Abhiyan and ii) providing manures to farmers. The **Ministry of New and Renewable Energy is implementing** National Biogas and Manure Management Programme which is a Central Sector Scheme of **Biogas Technology Development Division of the Ministry aiming at** setting-up of Family Type Biogas Plants at rural and semi-urban/households level for recycling of rural wastes linking sanitary toilets with biogas plants (<http://mnre.gov.in/schemes/decentralized-systems/schems-2/> ).

Govt. of India through various schemes like National Centre of Organic Farming, National Horticulture Mission is promoting organic farming and thereby improving soil health in the country. Cultivated area under certified organic farming has grown almost 17 fold in last one decade (42,000 ha in 2003-04 to 7.23 lakh ha in 2013-14) covering 27 states. Recently, dedicated schemes namely *Paramparagat Krishi VikasYojana* (PKVY) and Mission Organic Value Chain Development for North Eastern Region (MOVCDNER) under National Mission for Sustainable Agriculture (NMSA) have been launched. This will encourage farmers to adopt eco-friendly concept of cultivation and reduce their dependence on fertilizers and agricultural chemicals to improve yields. Under this programme, organic farming is promoted through adoption of village by Cluster Approach and Participatory Guarantee System (PGS) certification.

The Department of Land Resources, Ministry of Rural Development had been implementing an area development programme i.e. Integrated Watershed Management Programme (IWMP) w.e.f. 26.02.2009, for development of rain-fed / degraded areas. The major activities taken up under IWMP *inter-alia* include ridge area treatment, drainage line treatment, soil and moisture conservation, rain water harvesting, nursery raising, afforestation, horticulture, pasture development, livelihoods for assetless persons. In 2015-16, the IWMP has been amalgamated as the Watershed Development Component of the “Pradhan Mantri Krishi Sinchayee Yojana (WDC-PMKSY)”. The funding pattern under WDC-PMKSY is 60:40 between Centre and State Government except in the States of North Eastern Region and Hill States where the funding pattern between Centre and State Government is 90:10.

The Government implemented a Centrally Sponsored Scheme ‘Reclamation and Development of Alkali and Acid Soils (RADAS)’ through Macro Management of Agriculture (MMA) Scheme in seven states. Since inception up to March, 2013 almost 9.0 lakh ha area has been developed. This programme has been subsumed in National Mission for Sustainable Agriculture (NMSA) with effect from April 2014 as component of Reclamation of Problem soils (*viz*., saline, alkali and acid soils). The cost norms under this programme is 50% of cost to the limit of ₹ 60000 per hafor reclamation of Alkali/ Saline soils and Rs 15000 per ha for amelioration of acid soil.

Till now, nearly 1.8 million ha of sodic soils and 0.75 million ha saline soils have been reclaimed. Salt tolerant varieties of rice,wheat and mustard have been spread in more than 2 lakhs ha areas. Benefit Cost Ratio (BCR) of the technology is 1.43 with Internal Rate of Return of 25%. Besides, about 1.0 lakh ha waterlogged (water-table < 1.5 m below ground level) saline soils have been reclaimed through sub-surface drainage technology in Haryana, Rajasthan, Maharashtra, Karnataka, Gujarat, Punjab and Andhra Pradesh. The technology resulted in 40 % improvement in cropping intensity and yields of different crops leading to 2- 3 fold increase in farmer’s income at a benefit cost ratio of 1.5 and 20 % internal rate of return, besides generating 128-mandays of employment per ha annually.

Nearly 2.00 million ha in Indo-Gangetic Plains have been brought under RCTs mainly zero tillage and bed planting through National Food Security Mission (NFSM) and NMSA schemes.

**Conclusion**

India needs growth of about 4% annually in agriculture sector to meet our food requirements. The agriculture will not be sustainable unless soil health is managed scientifically to meet present and future needs. The real challenge before the scientists is to provide a viable farming system based on resource-efficient productive management practices that will influence soil chemical, physical and biological properties and processes in such a way as to improve and sustain land productivity. Viable farming system needs efficient crop planning based on soil characterization, climate, water availability/irrigability, vegetation, land use pattern, socio-economic conditions, infrastructure, marketing facilities etc to enable farmers to harness full potential of their land choosing the right crop/cropping system suitable for the region. Land use has to be harmonized with the soil quality and carrying capacity of the soil resources.

Farmers should be advised to adopt improved agricultural management practices like diversified crop rotation with legumes, crop residue retention, mulching, cover crop, use of, organics (FYM, green manure, biofertizers including PGPR, AM fungi, vermi compost, bio enriched compost) in conjugation with chemical fertilizers/organic farming, resource conservation technologies (minimum/zero tillage, bed planting, laser levelling, brown manuring etc), recycling residue, Bio-engineering measures of soil & water conservations, soil reclamation/amelioration and agroforestry intervention to maintain soil organic carbon vis-a-vis effective functioning of soil biota for overall improvement of soil health and quality and hence crop productivity. In this context, Conservation Agriculture (CA) practices and resource-conserving technologies, holds promise for improving soil health and sustainable intensification of crop yield and hence need to be validated and promoted in different soil, crop and agro-climate conditions. Essential principles of Conservation Agriculture are no-tillage (and direct seeding) or reduced tillage, the maintenance of a cover of live or dead vegetal material on the soil surface and the use of crop rotations. Crop sequences are planned over several seasons to minimise the build-up of pests or diseases and to optimise plant nutrient use by synergy between different crop types. Management practices that affect the placement and incorporation of residues influence the capacity of soil organisms to recycle nutrients. Tillage, for example, affects soil porosity and the placement of residues, by collapsing the pores and tunnels constructed by soil animals, affecting the water holding, gas and nutrient exchange capacities of the soil. The placement of residues influences soil surface temperature, rate of evaporation and water content and nutrient loading and rate of decay. Conservation tillage, and particularly no tillage, reduce soil disturbance, increase organic matter content, improve soil structure, buffer soil temperatures and allow soils to trap retain more rainwater besides maintaining resilience against drought and other hazards. These soils are more biologically active and biologically diverse, have higher nutrient loading capacities and release nutrients more continuously[[1]](#footnote-2).

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**Table 1. The extent and distribution of the different soil classes of India with their equivalent according to USDA nomenclature system**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Major soils**  **(traditional name)** | **Soil orders**  **US soil taxonomy** | **Extent** | | **Distribution in states** |
| **‘000 ha** | **Percentage** |
| Alluvial | Inceptisols, Entisols, Alfisols, Aridisols | 100,006 | 30.4 | J&K, HP, Punjab, Haryana, Delhi, UP, Gujarat, Goa, MP, MS, AP, Karnataka, TN, Kerala, Puducherry, Bihar, Odisha, WB, ArP, Assam, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, A&N |
| Coastal alluvial | Aridisols, Inceptisols, Entisols | 10,049 | 3.1 | AP, Karnataka, TN, Kerala, WB, Gujarat, Odisha, Puducherry, Lakshadweep, A&N |
| Red | Alfisols, Ultisols, Entisols, Inceptisols, Mollisols, Aridisols | 87,989 | 26.8 | AP, Karnataka, Kerala, TN, Puducherry, Rajasthan, MP, MS, Gujarat, Goa, ArP, Assam, Manipur, Meghalaya, Nagaland, Mizoram, Tripura, Delhi, UP, HP, A&N |
| Laterites | Alfisols, Ultisols, Inceptisols | 18,094 | 5.5 | AP, Karnataka, Kerala, TN, Puducherry, MS, Odisha, WB |
| Brown forest | Mollisols, Inceptisols | 540 | 0.2 | Karnataka, Maharashtra |
| Hill | Inceptisols, Entisols | 2,262 | 0.7 | Manipur, Odisha, WB, Tripura, Nagaland |
| Terai | Mollisols | 326 | 0.1 | UP, Sikkim |
| Mountain meadow | Mollisols | 60 | - | J&K |
| Sub-montane | Alfisols | 104 | - | J&K |
| Black | Vertisols, Mollisols, Inceptisols, Entisols, Aridisols | 54,682 | 16.6 | MP, MS, Rajasthan, Puducherry, TN, UP, Bihar, Odisha, AP, Gujarat |
| Desert | Aridisols, Inceptisols, Entisols | 26,283 | 8.0 | Rajasthan, Gujarat, Haryana, Punjab |
| Others\* |  | 28,305 | 8.6 | - |
| Total |  | 328,700 | 100 | - |

\*Includes glaciers (0.4%), sand dunes (0.01%), mangrove swamps (0.04%), salt waste (0.01%), water bodies (0.1%), rock land (0.25%) and rock outcrops (7.8%). MP, Madhya Pradesh; MS, Maharashtra; UP, Uttar Pradesh; J&K, Jammu and Kashmir; TN, Tamil Nadu; AP, Andhra Pradesh; ArP, Arunachal Pradesh; WB, West Bengal; HP, Himachal Pradesh; A&N, Andaman and Nicobar Islands. (Source: Bhattacharyya et al, 2013).

**Table 2. Extent of area affected by various soil physical constraints in India.**

|  |  |  |
| --- | --- | --- |
| **Physical constraints** | **Area (Mha)** | **Major states affected** |
| Shallow depth | 26.40 | Andhra Pradesh, Maharashtra, West Bengal, Kerala and Gujarat |
| Soil hardening | 21.57 | Andhra Pradesh, Maharashtra and Bihar |
| High permeability | 13.75 | Rajasthan, West Bengal, Gujarat, Punjab and Tamil Nadu |
| Subsurface hard pan | 11.31 | Maharashtra, Punjab, Bihar, Rajasthan, West Bengal and Tamil Nadu |
| Surface crusting | 10.25 | Haryana, Punjab, West Bengal, Odisha, Gujarat. |
| Temporary water-logging | 6.24 | Madhya Pradesh, Maharashtra, Punjab, Gujarat, Kerala and Odisha |

**Table 3.** **Districts low in soil available Nitrogen(N), Phosphorus(P), Potassium(K), Sulphur(S), Zinc(Zn), Iron(Fe), Manganese(Mn) and Boron(B) in different states**

|  |  |  |
| --- | --- | --- |
| **State / UTs** | **Nutrient** | **Districts** |
| **Andhra Pradesh including Telengana** | N | Adilabad, Chittoor, Cuddapah, East Godavari, Guntur, Karimnagar, Khammam, Krishna, Kurnool, Mahbubnagar, Nizamabad, Visakhapatnam, Vizianagaram, Warangal, West Godavari |
| P | Adilabad, Anantapur, Chittoor, Cuddapah, Guntur, Hyderabad, Karimnagar, Khammam, Krishna, Kurnool, Mahbubnagar, Medak, Nalgonda, Nellore, Nizamabad, Rangareddi, Srikakulam, Warangal |
| K | Nil |
| S | Kurnool, Mehboobnagar, Karimnagar, Kadappa, Guntur, Anantpur, Nizamabad  Nalgonda |
| Zn | Kurnool, Mehboobnagar, Karimnagar, Guntur, Anantpur, Rangareddy, Krishna  West Godavari, Adilabad, Parakasham, Srikakulam |
| Fe | Kurnool, Anantpur, Nizamabad, Adilabad, Parakasham, Vishakhapatnam |
| Mn | Rangareddy, West Godavari, Nizamabad, Medak |
| B | Mehboobnagar, Karimnagar, Rangareddy, Krishna, West Godavari, Nalgonda, Adilabad, Vishakhapatnam, Srikakulam, Medak |
| **Assam** | N | Bongaigaon, Bopeta, Chirang, Darrang, Kokrajhar, Morigaon, NC Hills, Nalbari |
| P | Jorhat, Karbi angling, Udalguri |
| K | Bongaigaon, Cachar, Chirang, Golaghat, Hailakandi, Jorhat, Karimganj, Kokrajhar, N C Hills, Nagaon, Sivsagar, Udalguri |
| S | Jorhat, Sibsagar, Kamrup |
| Zn | Jorhat, Golaghat, Barpeta, Kamrup , Sonitpur , Dibrugarh, Darang, Tinsukia |
| Fe | Nil |
| Mn | Nil |
| B | Jorhat, N Lakhimpur, Dibrugarh |
| **Chhattisgarh** | N | Bastar, Dantewara, Dhamtari, Durg, Kanker, Kawardha, Mahasmund, Raipur, Rajnandgaon |
| P | Bastar, Dantewara, Dhamtari, Kanker, Korba, Mahasmund, Raipur |
| K | Bastar, Dantewara, Kanker |
| Gujarat | N | Amreli, Banaskantha, Bharuch, Gandhinagar, Jamnagar, Kutch, Mahesana, Narmada, Patan, Sabarkantha, Surat, Surendranagar, Vadodara |
| P | Banaskantha, Bharuch, Bhawnagar, Dahod, Mahesana, Narmada, Navsari, Panchmahal, Patan, Porbandar, Surendranagar, Valsad |
| K | Nil |
| S | Banaskantha, Anand, Kheda, Panchmahal, Vadodara, Ahmedabad, Dahod |
| Zn | Patan, Bharuch, Ahmedabad, Sabarkantha, Mehsana, Banaskantha, Kutch |
| Fe | Anand, Kheda, Patan, Vadodara, Mehsana, Banaskantha, Gandhinagar  Kutch |
| Mn | Nil |
| B | Panchmahal, Patan, Sabarkantha, Mehsana, Gandhinagar |
| **Haryana** | N | Bhiwani, Faridabad, Fatehbad, Gurgaon, Hisar, Jhajjar, Jind, Kaithal, Karnal, Kurukshetra, Mahendragarh, Panchkula, Panipat, Rewari, Sirsa, Sonipat, Yamuna Nagar |
| P | Bhiwani, Faridabad, Fatehbad, Gurgoan, Hisar, Jhajjar, Jind, Kaithal, Karnal, Kurukshetra, Panchkula, Panipat, Rewari, Sirsa, Sonipat, Yamuna Nagar |
| K | Nil |
| S | Kurukshetra, Mohindergarh , Jhajjar, Rewari, Ambala, Palwal, Bhiwani, Rohtak, Fatehabad |
| Zn | Mohindergarh, Bhiwani |
| Fe | Sirsa, Hisar, Mohindergarh, Fatehabad, Bhiwani, Rohtak |
| Mn | Hisar, Karnal, Fatehabad |
| B | Nil |
| Himachal Pradesh | N | Nil |
| P | Hamirpur, Kangra, Mandi, Simla, Una |
| K | Chamba, Hamirpur, Kangra, Kinnaur, Lahaul spiti, Una |
| S | Nil |
| Zn | Hamirpur, Una, Chamba, Mandi |
| Fe | Nil |
| Mn | Nil |
| B | Bilaspur, Una, Kangra, Shimla, Solan |
| **Karnataka** | N | Kolar |
| P | Bellari, Bijapur, Hassan, Norht Kannada, South Kannada, Udupi |
| K | South Kannada, Udupi |
| **Kerala** | N | Kasaragod, Kollam, Thiruvananthapuram |
| P | Nil |
| K | Nil |
| **Madhya** **Pradesh** | N | Bhind, Chhattarpur, Daria, Gwalior, Indore, Jabalpur, Mandsaur, Neemuch, Morena, Panna, Ratlam, Sheopu, Shivpuri, Sidhi |
| P | Ashok Nagar, Betul, Bhind, Chhattarpur, Damoh, Daria, Dewas, Gwalior, Japlpur, Jhabua, Katni, Panna, Shivpuri, Ujjain, Umaria |
| K | Dhar, Anuppur, Betul, Gwalior, Morena, Sagar, Sidhi |
| S | Chattarpur, Satna, Chindwara,Narsinghpur, Reewa, Dewas, Panna, Morena |
| Zn | Balaghat, Seoni, Shahadol, Mandala, Bhopal, Raisen, Tikamgarh, Chattarpur, Satna, Chindwara, Jabalpur, Narsinghpur, Reewa, Dewas, Panna, Morena |
| Fe | Bhopal, Panna, Narsinghpur |
| Mn | Nil |
| B | Nil |
| **Maharashtra** | N | Akola, Amaravati, Aurangabad, Beed, Bhandara, Buldhana, Gondiya, Hingoli, Jalgaon, Jalna, Latur, Nagpur, Nanded, Nashik, Parbhani, Pune, Raigad, Ratnagiri, Sangali, Satara, Solapur, Usmanabad, Wardha, Washim, Yeotmal |
| P | Akola, Amaravati, Aurangabad, Bhandara, Bhuldhana, Dhule, Gondiya, Hingoli, Jalgaon, Jalna, Kolhapur, Latur, Nagpur, Nanded, Nandurbar, Nashik, Parbhani, Pune, Raigad, Ratnagiri, Sangali, Satara, Sindhudurg, Solapur, Usmanabad, Wardha, Washim, Yeotmal |
| K | Raigad, Sindhudurg |
| S | Akola, Aurangabad, Washim, Nanded, Gondia, Nagpur, Parbhani, Latur |
| Zn | Akola, Bhandara, Jalna, Yavatmal, Amravati, Buldhana, Chandrapur, Aurangabad, Wardha, Hingoli, Nanded, Nagpur, Parbhani, Latur |
| Fe | Akola, Jalna, Amravati, Aurangabad, Washim, Wardha, Beed, Parbhani |
| Mn | Nil |
| B | Nil |
| **Orissa** | N | Bhadrak, Boudh, Cuttuck, Dhenkanal, Gajapati, Ganjam, Jagatsinghpur, Kalahandi, Kendrapada, Khurda, Mayurbhanj, Naupada, Nayagarh, Bhulbani, Puri, Sundargarh |
| P | Balasore, Bhadrak, Cuttack, Gajapati, Ganjam, Jharsuguda, Keonjhar, Mayurbhanj, Nawrangpur, Phulbani, Sambalpur |
| K | Cuttack, Ganjam, Nayagarh |
| S | Bargarh, Bhadrak, Dhenkanal, Kalahandi, Nayagarh, Nuapada, Sambalpur, Sonepur |
| Zn | Angul, Bhadrak, Boudh, Puri, Sonepur |
| Fe | Nil |
| Mn | Nil |
| B | Angul, Bargarh, Bhadrak, Boudh, Dhenkanal, Kandhmal, Kendrapada, Nayagarh, Nuapada, Puri, Sambalpur, Sonepur |
| **Punjab** | N | Bhatinda, Faridkot, Ferozepur, Gurdaspur, Hoshiarpur, Jalandhar, Kapurthala, Ludhiana, Mansa, Moga, Muktsar |
| P | Nil |
| K | Nil |
| S | Nil |
| Zn | Gurdaspur |
| Fe | Bhatinda |
| Mn | Bhatinda, Faridkot, Gurdaspur, Tarantaran |
| B | Nil |
| **Rajasthan** | N | Alwar, Banswara, Baran, Bharatpur, Barmer, Bundi, Churu, Dausa, Dholpur, Durgapur, Hanumangarh, Jaisalmer, Jalore, Jhunjhun, Jodhpur, Karauli, Kota, Nagpur, Pali, Rajsamand, Sawai Madhopur, Sikar, Sirhi, Sriganganagar, Tonk |
| P | Bharatpur, Barmer, Churu, Dausa, Dholpur, Durgapur, Hanumangarh, Jaisalmer, Jalore, Karauli, Sawai Madhopur, Sikar, Sirohi, Sirhi, Sriganganagar |
| K | Nil |
| **Tamil Nadu** | N | Coimbatore, Cuddalore, Dharmapuri, Dindigul, Erode, Fudukkottai, Kanchipuram, Kanyakumari, Karur, Madurai, Nagapattinam, Namakkal, Peerambalur, Ramanathapuram, Salem, Sivagangai, Thanjavur, Theni, Thiruallur, Thiruvarur, Thoothukudi, Tiruvannamalai, Tiruvarur, Trichiraplli, Vellore, Villupuram, Virudhunagar |
| P | Kanchipuram, Sivagangai, Thoothukudi, Trichirapalli |
| K | Ariyalur |
| S | Nagapattinam, Coimbatore, Virudhunagar, Theni, Krishnagiri, Pudukkotai |
| Zn | Thanjavur, Cuddalore, Villupuram, Virudhunagar, Theni, Krishnagiri  Kanyakumari, Toothukudi, Pudukkotai |
| Fe | Trichy, Erode, Villupuram , Virudhunagar, Krishnagiri |
| Mn | Villupuram |
| B | Erode, Salem, Krishnagiri, Kanyakumari, Toothukudi, Pudukkotai |
| **Uttar Pradesh** | N | Aazamgarh, Agra, Aligarh, Allahabad, Ambedkarnagar, Auraiya, Badanyu, Baghpat, Baharaich, Baliya, Balrampur, Banda, Barabanki, Bareli, Basti, Bijnaur, Buland Shahar, Chandouli, Chitrkut, Devariya, Eta, Etahwa, Faizabad, Farukkhabad, Fatehabad, Firozabad, Gautambudh nagar, Gazipur, Ghaziabad, Gorakhapur, Hameerpur, Hardoi, Hathras, Jalaun, Jaunpur, Jhansi, Jyotishaphool nagar, Kannauj, Kanpur Dehat, Kanpur Nagar, Kashiram Nagar, Kaushambee, Kushinagar, Lalitpur, Lucknow, Lukhimpur, Maharajganj, Mahowa, Mainpuri, Mathura, Mau, Meerut, Muradabad, Muzzafar Nagar, Peelibhit, Pratapgarh, Rampur, Raybareli, Saharanpur, Santkabeer Nagar, Shahjahapur, Sidhrth Nagar, Sitapur, Sonebhadra, Sribasti, Sultanpur, Unnav, Varanasi. |
| P | Aazamgarh, Agra, Aligarh, Allahabad, Ambedkarnagar, Auraiya, Badanyu, Baghpat, Baharaich, Baliya, Balrampur, Banda, Barabanki, Bareli, Basti, Bijnour, Buland Shahar, Chandouli, Chitrakut, Devariya, Eta, Etawa, Faizabad, Farukhabad, Fatehabad, Firozabad, Gautambudh nagar, Gazipur, Ghaziabad, Gorakhpur, Hameerpur, Hathras, Jalaun, Jaunpur, Jhansi, Jyotishaphool nagar, Kannauj, Kanpur Dehat, Kanpur Nagar, Kashiram Nagar, Kaushambee, Kushinagar, Lalitpur, Lucknow, Lukhimpur, Maharajganj, Mahowa, Mainpuri, Mathura, Mau, Meerut, Mirzapur, Muradabad, Muzzafarnagar, Peelibhit, Pratapgarh, Rampur, Raybareli, Saharanpur, Santkabeer nagar, Santravidasnagar, Shahjahapur, Sidhrath Nagar, Sitapur, Sonebhadra, Sribasti, Sultanpur, Unnav, Varanasi |
| K | Nil |
| S | Allahabad, Etawah, Farrukhabad, Lakhimpur, Pilibhit, Raibareli, Ramabai nagar, Unnao |
| Zn | Agra, Allahabad, Farrukhabad, Gorakhpur, Kannauj, Kanpur, Lakhimpur, Pilibhit, Raibareli, Ramabai nagar, Sitapur |
| Fe | Nil |
| Mn | Etawah, Farrukhabad, Kannauj, Kanpur, Sitapur, Varanasi |
| B | Nil |
| **Uttarakhand** | N | Dehradun, Tehari Gadwal, Udhamsingh Nagar, Uttarkashi |
| P | Bageswar, Chamoli, Champawat, Dehradun, Haridwar, Paudi, Rudraprayag, Udhamsingh Nagar, Uttarkashi |
| K | Nil |
| S | Champawat, Dehradun |
| Zn | Udham Singh Nagar |
| Fe | Nil |
| Mn | Rudraprayag |
| B | Pithoragarh, Uttarkashi, Tehri |
| **West Bengal** | N | Midnapore E, Midnapore W, North 24- Parganas, South 24- Parganas |
| P | Midanpore E, Prakama, Purulia |
| K | Jalpaiguri |
| S | Nil |
| Zn | Jalpaiguri, North Dinajpur, N 24 Pargana, Bardhaman, Coochbehar |
| Fe | Nil |
| Mn | Nil |
| B | Hooghly, Murshidabad, Bardhaman, Nadia, Coochbehar, S 24 Pargana |

***Source****: agricoop.nic.in/dacdivision/Comsoilhealth28612.pdf and IISS, Bhopal*

**Table 4 : INM packages for dominant cropping system in different agro-climatic regions of the country.**

|  |  |
| --- | --- |
| **Cropping System** | **IPNS package** |
| **Western Himalayan Region** | |
| Rice - Wheat | **Rice :** 40 kg N + FYM/Green Manure @ 15 t/ha + 20 kg Zinc sulphate (in Zn deficient soils)  **Wheat :** 120 kg N + 80 kg P2O5 (through SSP) + 40 kg K2O |
| Maize - Wheat | **Maize :** 60 kg N + 30 kg P2O5(through SSP) + 20 kg K2O + 10 t FYM + fresh Eupatorium/ Lantana Mulch @ 10t/ha **Wheat** : 80 kg N + 30 kg P2O5 ( through SSP) + 15 kg K2O |
| **Eastern Himalayan Region** | |
| Rice – Rice | **Rice** : 20 kg N + 20 kg P2O5 + 15 kg K2O +FYM/GM @ 10t/ha + Azolla @ 10t/ha + 20 kg Zinc Sulphate once in 3 years + 5 kg borax + 1 kg ammonium molybdate + 5 kg copper sulphate  Rice : 60 kg N + 40 kg P2O5 25 kg K2O + Azolla @ 10t/ha |
| Rice- wheat | **Rice** : 40 kg N + 20 kg P2O5 + 40 kg K2O + FYM@5t/ha/GM + Azolla @ 10t/ha + 20 kg Zinc Sulphate once in 3 years + 5 kg borax + 1 kg ammonium molybdate + 5 kg copper sulphate.  **Rice** : 50 kg N + 20 kg P2O5 + FYM @ 5t/ha |
| Rice – Mustard | **Rice** : 40 kg N + 30 kg P2O5 ( through SSP) + 40 kg K2O + FYM/GM @ 10t/ha + Azolla @ 10t/ha + 20 kg Zinc Sulphate once in 3 years + 5 kg borax + 1 kg ammonium molybdate + 5 kg copper Sulphate  **Mustard** : 20 kg N + 10 kg P2O5 ( through SSP) + 25 kg K2O |
| Rice - Potato | **Rice** : 40 kg N + 20 kg P2O5 + 15 kg K2O + Azolla/GM @ 10t/ha + 20 kg Zinc Sulphate once in 3 years + 5 kg borax + 1 kg ammonium molybdate + 5 kg copper sulphate  **Potato** : 50 kg N + 50 kg P2O5 + 30 kg K2O + FYM@ 10t/ha + seed treatment with Azotobacter and PSB |
| **Lower Gangetic plain** | |
| Rice - Rice | **Rice** : 60 kg N + 40 kg P2O5 + 30 kg K2O + FYM/GM @ 10t/ha + 20 kg Zinc Sulphate  **Rice :** 90 kg N + 80 kg P2O5 + 60 kg K2O + Azolla @ 10t/ ha |
| Rice – Wheat | **Rice :** 40 kg N + 45 kg P2O5 + 30 kg K2O + FYM/GM @ 10t/ha + Azolla @ 10t/ha/BGA @ 10 kg/ha + kg Zinc Sulphate **Wheat:** 90 kg N + 45 P2O5 + 45 kg K2O |
| Jute – Rice - Potato | **Jute :** 30 kg N + FYM @ 5t/ha  **Rice :** 30 kg N + 30 kg P2O5 + 30 kg K2O + Azolla @ 10t/ha/BGA@ 10 kg/ha + 20 kg Zinc Sulphate.  **Potato :** 150 kg N + 40 kg P2O5 + 100 kg K2O + FYM@ 5t/ha + seed treatment with Azotobacter and PSB |
| **Middle Gangetic plain** | |
| Rice – Wheat | **Rice :** 50 kg N + 30 kg P2O5 + 20 kg K2O + Green Manure ( greengram/stover) 20 kg Zinc Sulphat ( in calcareous soils) **Wheat:** 90 kg N + 60 P2O5 + 30 kg K2O + FYM@ 10t/ha OR  **Rice :** 75 kg N + 45 kg P2O5 + 30 kg K2O + BGA @ 15 kg/ha + FYM @ 10 t/ha + 20kg Zinc Sulphate (in calcareous soils) **Wheat** : 100 kg N + 65 kg P2O5 + 30 kg K2O |
| Maize - Wheat | **Maize :** 90 kg N + 60 P2O5 ( through SSP) + 30 kg K2O + GM + 16 kg borax ( in calcareous soil)  **Wheat :** 90 kg N + 60 kg P2O5 + 30 kg K2O + FYM@ 10t/ha |
| Groundnut-Pigeonpea intercropping | 100% RDF + lime @2 t/ha + FYM@2 t/ha + Soil water conservation measure (furrows between groundnut and pigeonpea rows) |
| **Upper Gangetic plain** | |
| Rice – Wheat | **Rice :** 90 kg N + 30 kg K2O + FYM/GM (Sesbania/ Leucaena Lopping ) @ 10t/ha  **Wheat :** 90 kg N + 60 kg P2O5 ( through SSP ) + 30 kg K2O |
| Maize – Wheat/ Mustard | **Maize :** 50 kg N + 20 kg K2O + FYM @ 10t/ha  **Wheat :** 120 kg N + 60 kg P2O5 ( through SSP) + 40 kg K2O  **Mustard :** 60 kg N + 40 kg P2O5  ( through SSP ) + 30 kg K2O |
| Sugarcane – Potato | **Sugarcane ( Autumn planting) :** 100 kg N + 45 kg P2O5 + 30 + Sulphitationpressmud/ GM + Incorporation of Potato foliage.  **Potato ( Intercropping):** 135 kg N + 20 kg P2O5 + 60 kg K2O + FYM 2 10 t/ha + seed treatment with Azotabacter and PSB \* (In case of ratoon crop, incorporate sugarcane frash along with only 75 kg N) |
| Sugarcane - Wheat | **Sugarcane(Autumn planting) :** 135 kg N + 45 kg P2O5 + 30 t ( FYM/ Sulphitationpressmud ) /GM ( Sesbania /Sunhemp/cowpea @ 10 t/ha  **Wheat (Intercropping) :** 80 kg N + 40 kg P2O5 + 40 kg K2O  \*(In case of ratoon crop, incorporates sugarcane frash along with only 75 kg N) |
| **Trans Gangetic plain** | |
| Rice/Cotton/Maize/Bajra – wheat | **Rice :** 60 kg N + 30 kg K2O + FYM/poultry manure/GM @ 10t/ha  **Maize :** 70 kg N + FYM/GM ( sesbania/ cowpea) @ 10t/ha  **Cotton :** 120 kg N  **Bajra :** 60 kg N + 30 kg P2O5 FYM @ 10 t/ha  **Wheat:** 150 kg N + 30 kg P2O5 ( through SSP) + 30 kg K2O + Azotobactor/Azospirillium + PSB |
| **Eastern Plateau & Hills** | |
| Rice –Winter Maize/Wheat/Pulses | Rice : 30 kg N + 15 kg P2O5 ( through SSP ) + 15 kg K2O + FYM/GM @ 10t/ha + 15 kg BGA  Winter Maize : 100 kg N + 45 kg P2O5 (through SSP) + 20 kg K2O  Wheat : 90 kg N + 45 kg P2O5 ( through SSP) + 30 kg K2O  Pulses : 10 kg N + 20 kg P2O5 ( through SSP) + FYM @ 2.5t/ha + Rhizobium + 500 g PSB |
| Rice-Wheat/Mustard | **Rice** : 75 kg N + FYM/Green Manure @ 5t/ha  **Wheat :** 90 kg N + 45 kg P2O5 + 30 kg K2O  Mustard : 30 kg N + 15 kg P2O5 + 10 kg K2O FYM @ 10 t/ha. |
| Soybean - Wheat | **Soybean :** 10 kg N+ 25 kg P2O5 ( through Boronated SSP) + 4t FYM+ Rhizobium + 25 kg Zinc Sulphate in alternate years **Wheat** : 90 kg N + 45 kg P2O5 ( through SSP) |
| Rice – Gram | **Rice :** 25 kg N+ 15 kg P2O5 + pulse crop residue Incorporation + BGA @ 10 kg/ha/Azolla @ 10t/ha  **Gram :** 10 kg N+ 20 kg P2O5 + Rhizobium + 5t FYM + 500 PSB |
| Soybean-Chickpea | **Soybean-Chickpea** (Rainfed system): 100% RDF + 2 t/ha FYM to soybean and 50% RDF to chickpea |
| **Western Plateau & Hills** | |
| Soybean - wheat | **Soybean :** 10 kg N + 25 kg P2O5 ( through SSP)+ 4 t FYM + Rhizobium + 25 kg Zinc Sulphate in alternate year **Wheat:** 90 kg N + 45 kg P2O5 ( through SSP) |
| Cotton – Fallow/Pigeon pea/wheat | **Cotton :**50 kg N + 25 kg P2O5 + 25 kg K2O + seed treatment with Azotobacter + 4 t FYM / in situ Green manuring ( cowpea) followed by mulching with subabulloppings .  **Pigeon pea :** 10 kg N + 20 kg P2O5 ( through SSP) + 10 kg K2O + FYM @ 2.5 t/ha + Rhizobium + 500 g PSB **Wheat :** : 90 kg N + 30 kg P2O5 ( through SSP ) + 30 kg K2O + Azotobactor / Azospirillium + PSB |
| Green gram-Safflower | **Safflower** (Rainfed): Incorporation of green gram stalk before sowing of safflower along with 75% RDF of safflower + Soil moisture conservation measure (Summer ploughing and inter-culture with blade hoe) |
| Fallow-Sunflower | **Sunflower** (Rainfed): 100% RDF+FYM @ 2 t/ha +SMC measure (Opening furrow after every 6 rows) |
| **Southern plateau and Hills , East Coast Plains &Ghats and West Coast Plains Regions** | |
| Rice-Rice | **Rice :** 75 kg N +15 kg. P2O5 + 15 kg. K2O+ FYM/Green Manure @ 5t/ha  **Rice :** 90 kg N + 60 kg P2O5 + 40 kg K2O + 40 kg. K2O+Azolla @ 10 t /ha BGA @ 10 kg / ha + 20 kg Zinc Sulphates |
| Rice – Pulses | **Rice :** 25 kg N+ 15 kg K2O + pulse crop residue incorporation + BGA @ 10 kg /ha/Azolla @ 10 t/ha  **Pulses :** 10 kg N + 20 kg P2O5  + 10 kg K2O + Rhizobium + 2.5 T FYM + 500 g PSB |
| Fallow-Sunflower | **Sunflower** (Rainfed) **:** 100% RDF+FYM @ 2 t/ha +SMC measure (Opening furrow after every 2 rows) |
| Castor | **Castor monocropping (Rainfed) :** Cowpea incorporation after first picking and 75% RDF of castor |
| **Gujarat plains & Hills Regions** | |
| Groundnut/ wheat/ Mustard | **Groundnut :** 15 kg N + 30 kg P2O5 (through SSP) +45 kg K2O + Gypsum @ 250 kg / ha in furrow + 25 kg Zinc Sulphate + 1 kg Boron  **Wheat:** 70 kg N + 30 kg P2O5 ( through SSP) + 20 kg K2O + Azotobactor/Azospirillium + PSB  **Mustard** : 30 kg N + 15 kg P2O5 ( through SSP) + 10 kg K2O + FYM @ 10 t/ ha |
| Cotton – Castor | **Cotton :** 50 kg N + 25 kg P2O5 + 25 kg K2O + seed treatment with Azotobacter + 4 t FYM  **Castor (irrigated ) :** 25 kg N + 50 kg P2O5 ( through SSP )+ 1 t castor seed cake/FYM @ 5t/ha + seed treatment with Azospirillium and PSB @ 5 kg/ha |
| **Western Dry Regions** | |
| Kharif Pulses | **Pulses - fallow :** 10 kg N + 20 kg P2O5 +10 kg K2O + Rhizobium + 2.5 t FYM |
| Pearmri millet – mustard | **Pearl mrimillet :** 25 kg N + 20 kg P2O5 (through SSP )+ 10 kg K2O + Azotobacter/ Azospirillium  **Mustard :** 45 kg N + 20 kg P2O5 ( through SSP)+ 15 kg K2O + FYM @ 5 t/ha |
| Fallow-Mustard | **Mustard (Rainfed)** Green manuring with Sesbania and FYM @ 2 t/ha + 75% RDF (80 kg N + 40 kg P2O5 + 20 kg S) |
| Maize-Raya (Rainfed) | Maize-Raya (Rainfed) : 100% RDF + S @ 20 Kg/ha + SMC Measures (summer ploughing + maize residue application on surface) |

\*Liming @3-4 q/ ha in furrows at the time of sowing for soils having pH<5.5 may be practiced except for submerged rice.

**Table 5** : **Recommended nutrient management packages for dominant crops and cropping systems in different states of India under organic farming system**

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| **Chhattisgarh** |
| **Cropping System**s : Soybean-chickpea, Soybean-onion, Rice-chickpea  **Soyabean:** Seed treatment with Rhizobium culture (0.5 kg/ha), PSB (0.5 kg/ha). Basal application of FYM (2 t/ha), VC (0.8 t/ha), NC(0.2 t/ha), RP(0.27 t/ha).  **Rice:** EC(6.6 t/ha), CDM(4.4 t/ha), NEOC (0.88 t/ha), Rock phosphate (0.05 t/ha)  **Chickpea:** Seed treatment with Rhizobium culture (0.5 kg/ha), PSB (0.5 kg/ha). Apply FYM (1.33 t/ha), VC(0.53 t/ha), NC (0.13 t/ha), RP(0.27 t/ha).  **Onion:** Basal application of FYM (5 t/ha), VC (2 t/ha), NC(0.5 t/ha), RP(0.27 t/ha). |
| **Himachal Pradesh** |
| **Cropping System**s : Maize – Garlic, Cauliflower - Pea –Tomato, Coriander - Pea –Tomato  **Maize**: Basal application of FYM (16 t/ha), VC (12 t/ha), RP (60 kg/ha). Top dressing with CU60 L/600 L water/ha (30, 45, 60,90 DAS), Panchagavaya 18 L/600 L water/ha (60,90 DAS), VW 60 L/600 L water/ha (60,90 DAS).  **Garlic:** Basal application of FYM (22 t/ha), VC (16 t/ha), RP (100kg/ha). Top dressing with CU 60 L/600 L water/ha (30, 45, 60,90, 120 DAS), Panchagavaya 18 L/600 L water/ha (60,90, 120 DAS), VW 60 L/600 L water/ha(60,90, 120 DAS).  **Pea:** Basal application of FYM (4.34t/ha), VC (3.2 t/ha) and RP (87 kg/ha).Top dressing with Cow urine 60 L/ha (15, 30, 45, 60 DAT), Panchagavya 18L/ha (30, 45, 60 DAT) VW-10% 60 L/600 L water/ha 3(0, 45, 60 DAT).  **Tomato:** Basal application of FYM (17.4 t/ha), VC (12.8 t/ha), RP (100 t/ha).Top dressing with Cow urine 60 L/ha (15, 30, 45, 60 DAT), Panchagavya 18L/ha (15,30, 45, 60 DAT) VW- 60 L/600 L water/ha (15, 30, 45, 60 DAT).  **Coriander:**Basal application of FYM (13 t/ha), VC (8 t/ha) and RP (65 kg/ha). Top dressing with CU 60 L/ha ( 30, 45, 60 DAS), Bio dynamic (501) 2.5 g/40 L/ha (45 and 60 DAS), Panchagavya 18L/ha (30, 45, 60 DAT)**.** |
| **Jharkhand** |
| **Cropping Systems:** Rice (Basmati type)-wheat, Rice (Basmati type)-lentil, Rice (Basmati type)-linseed, Rice (Basmati type)-potato.  **Rice:** Basal application of FYM (53.28 t/ha), Karanjcake(6.66 t/ha) and Azolla (1 kg/ha). Top dressing with VC (26.66 q /ha), Panchagavya (10-12 lit/ha mixed in 500-600 litre of water) 15 DAT.  **Wheat:** Basal application of PSB &Azotobacter (250gm/10 kg seeds each)VC (33.33 q/ha), Panchagavya (10-12 lit/ha mixed in 500-600 lit of water).  **Lentil:** Seed treatment with PSB & Azotobacter (250gm/10 kg seeds each) FYM (14 q/ha), Karanj cake(2 q/ha), VC (7 q/ha) (25-30 DAS)  **Potato:** PSB &Azotobacter (250gm/10 kg seeds each) with the application of FYM (80.0 t/ha), Karanj cake(10.0 t/ha), VC (40 q/ha) (25-30 DAS). |
| **Kerala** |
| **Yams:** Basal application of Azospirillum (3 kg/ha) Mycorrhiza(5 kg/ha) Phosphobacteria (3 kg/ha) and application of FYM (15 t/ha) and NC(1.0 t/ha). Top dressing with cowpea green manuring (15-20 t/ha) and Ash (1.5 t/ha) at 45-60 DAP. |
| **Karnataka** |
| **Groundnut:** Seed treatment with Rhizobium (1kg/ ha), PSB (1kg/ ha). Basal application of EC (3 t/ha), NC (250 kg/ha), VC (2.40t/ha). GLM (5t/ha). Foliar application of cow urine @ 10 % and Panchagavvya spray @ 3% as a source of nutrient and growth promoter at 45 and 60 DAS.  **Soybean:** Seed treatment with Rhizobium (1kg/ ha), PSB (1kg/ ha). Basal application of EC (3.3 t/ha), NC (250 kg/ha), VC (2.7t/ha). GLM (5.3t/ha). Foliar application of cow urine @ 10 % and Panchagavvya spray @ 3% as a source of nutrient and growth promoter at 45 and 60 DAS. Foliar application of cow urine @ 10 % and panchagavya @ 3% at 30 and 45 days after sowing.  **Sorghum**: Seed treatment with Azospirillum (500g/ ha), PSB (500g/ ha). Basal application of EC (2.0 t/ha), NC (250 kg/ha), VC (1.7t/ha). GLM (3.7t/ha). Foliar spray of cow urine @ 10% and Panchgavyya @ 3% spray at 30 and 45 DAS.  **Rainfed wheat :** Seed treatment with Azospirillum (500g/ ha), PSB (500g/ ha). Basal application of EC (2.0 t/ha), NC (250 kg/ha), VC (1.7t/ha). GLM (3.7t/ha). Foliar application of Panchgavya @ 3% spray and 10% cow urine at 30 DAS and at boot leaf stage**.**  **Cotton :** Seed treatment with Azospirillum (500g/ ha), PSB (500g/ ha). Basal application of EC (3.3 t/ha), NC (250 kg/ha), VC (2.7t/ha). GLM (5.3t/ha). Foliar application of Panchgavya @ 3% spray and 10% cow urine at 60 and 75 DAS.  **Chilli:** Seed treatment with Azospirillum (250g/ ha), PSB (250g/ ha). Basal application of EC (4.2 t/ha), NC (250 kg/ha), VC (3.3t/ha). GLM (6.7t/ha). Foliar application of Panchgavya @ 3% spray and 10% cow urine at 45 , 60 and 75 DAS.  **Potato:** Seed treatment with Azospirillum (1kg/ ha), PSB (1kg/ ha). Basal application of EC (4.2 t/ha), NC (250 kg/ha), VC (3.3t/ha). GLM (6.7t/ha). Foliar application of Panchgavya @ 3% spray and 10% cow urine at 30 and 45 DAS.  **Chickpea:** Seed treatment with Rhizobium (1kg/ ha), PSB (1kg/ ha). Basal application of EC (1.0 t/ha), NC (250 kg/ha), VC (0.8t/ha). GLM (1.7t/ha). Foliar application of Panchgavya @ 3% spray and 10% cow urine at 30 and 45 DAS.  **Maize :** Seed treatment with Azospirillum (1kg/ ha), PSB (1kg/ ha). Basal application of EC (4.2 t/ha), NC (2250 kg/ha), VC (3.3t/ha). GLM (6.7t/ha). Foliar application of Panchgavya @ 3% spray and 10% cow urine at 30 and 45 DAS. |
| **Madhya Pradesh** |
| **Cropping Systems:** Soybean-Wheat, Soybean-Mustard, Soybean-Chickpea, Soybean-Isabgol/Linseed.  **Soybean:** Basal application of Rhizobium culture (5g/kg), PSB (5g/kg seed), basal application of CDM (0.95% Nitrogen) 5 t/ha  **Wheat:** CDM (4.5 t/ha ), VC (3.5 t/ha), PM (1.5 t/ha).  **Mustard:** Basal application of CDM (1.5 t/ha), VC (1.7 t/ha), PM (1 t/ha)  **Chickpea:** Seed treatment with Rhizobium culture (5g/kg) & PSB (5g/kg seed), Basal application ofCDM(1.7 t/ha ), VC(1.3 t/ha), PM (0.5 t/ha).  **Isabgol:** Basal application of CDM(1.2 t/ha ), VC(0.6 t/ha), PM(0.3 t/ha).  **Linseed:** Basal application of CDM(3.4 t/ha ), VC (1.7 t/ha), PM(1.0 t/ha) |
| **Maharashtra** |
| **Cropping Systems:** Rice-groundnut, Rice-Dolichos bean, Rice-cucumber, Rice-red pumpkin.  **Rice:** PSB 2.5 kg + Azospirillum 2.5 kg + 100 lit of water/ha (Seedling root dip for 20 to 30 minutes in the slurry). Basal application of FYM (5t /ha before puddling), NC (0.5t /ha before puddling), Glyricidia Green leaves (4.5t /ha soil incorporation before transplanting), Rice straw (4.2t /ha soil incorporation before transplanting). Top dressing with Cow urine (50 lit/ha)& VW (50 lit/ha) (30, 60 DAS).  **Groundnut:** Seed treatment with Rhizobium strain 96 (25g/ kg), PSB (25g/ kg) of seed. Basal application of FYM (1.5tg/ha), NC (160 kg/ha), VC (0.56t/ha). Top dressing with CU (50 lit/ha)&VW(50 lit/ha) (30, 60 DAS).  **Dolichos bean:** Seed treatment with Rhizobium strain (25g/ kg), PSB (25g/ kg).Basal application of FYM (4t/ha), Neem cake (390 kg/ha), VC (1.3t/ha). Top dressing with Cow urine (50 lit/ha)&VW (50 lit/ha) (30, 60 DAS).  **Cucumber: S**eed treatment with PSB (25g/ kg).Basal application of FYM (9t/ha), NC (0.87t/ha), VC (3t/ha).  **Pumpkin:** Basal application of FYM (6.7t/ha before puddling), Glyricidia Green leaves (1.2t /ha before puddling, Rice straw (5.5t /ha) soil incorporation. |
| **Meghalaya** |
| **Cropping Systems:** Rice-Carrot (Raised beds in lowland), Rice-Tomato (Raised beds in lowland), Maize + soybean- French bean (Upland).  **Rice**-Azospirillium (100 ml in 10 Litres of water) Root dip treatment for 30 minutes before planting. Basal application FYM (15 t/ha), neem cake (100 kg/ha) and RP (150 kg/ha). Top dressing with VW (100 ml/litre of water) 40-45 DAT, Panchagavya (3 litres/ 100 litres of water) flowering stage.  **Carrot**: Basal application of PSB(1.5 kg/ha). Top dressing with VW (50 l/ha)  **Tomato:** Basal application of Trichoderma harzianum (100 ml in 10 Litres of water)  FYM (20 t/ha), NC (200 kg/ha) and RP (150 kg/ha). Top dressing with Panchagavya (3 litres per 100 litres of water) (25-30 DAT).  **Maize + soybean**: Basal application of FYM (15 t/ha), neem cake (150 kg/ha) and Rock phosphate (200 kg/ha). Top dressing withVermiwash (100 ml/litre of water) 40-45 DAT, Panchagavya (3 litres/ 100 litres of water) Tesseling (60-65 DAS).  **French bean (Upland):** Basal application of FYM (15 t/ha), neem cake (150 kg/ha) and Rock phosphate (200 kg/ha). Top dressing with Panchagavya (25 litre/ha) 20-25 DAS. |
| **Punjab** |
| **Cropping Systems:** Maize-potato-summer greengram, Turmeric-onion, Basmati rice-wheat-green manure *(Sesbania,* Maize-durum wheat-cowpea (fodder), Maize-berseem-bajra (fodder system), Maize-berseem-maize+cowpea (fodder system).  **Maize- Potato:** Basal application of FYM (1% N) (12.5 t/ha), VC (1.5% N) (4.25 t/ha).  **Summer greengram:** Rhizobium (0.5 kg/ha). Basal application of FYM (1% N) (0.75 t/ha), VC (1.5% N) (0.25 t/ha).  **Turmeric:** Basal application of FYM (1% N) (10.0 t/ha), VC (1.5% N) (3.25 t/ha).  **Onion:** Basal application of FYM (1% N) (6.75 t/ha), VC (1.5% N) (2.25 t/ha).  **Rice:** Basal application of FYM (1% N) 4.25 t/ha, VC (1.5% N) 2.75 t/ha, NEC( 2.5%  N) 1.65 t/ha.  **Maize:** Basal application of FYM (1% N) 4.25 t/ha, VC (1.5% N) 2.75 t/ha, NEC( 2.5%  N) 1.65 t/ha.  **Durum wheat**- Basal application of FYM (1% N) 4.25 t/ha, VC (1.5% N) 2.75 t/ha, NEC( 2.5% N) 1.65 t/ha.  **Cowpea(fodder):**18.75 kg N, 55 Kg P2O5 Recommended NPK and micro nutrient dose for the crop (kg/ha)  **Maize:** Basal application ofFYM (1% N) 8.75 t/ha  **Berseem:** Basal application ofFYM (1% N) 2.5 t/ha  **Bajra (fodder system):** Basal application ofFYM (1% N) 5 t/ha |
| **Tamil Nadu** |
| **Cropping systems:** Cotton-maize-green manure (*sesbania*), Chillies-Sunflower-green manure (*sesbania*), Beetroot-maize- green manure (*sesbania*).  **Cotton:** Basal application of Azospirillum (600 g/ha), Phosphobacteria (600 g/ha), Pseudomonas (10 g/kg), Trichoderma (4 g/kg) of seed treatment. FYM (7.05 t/ha), VC (4.49 t/ha), Azospirillum (2kg/ha), PB (2kg/ha), Pseudomonas (2.5 kg/ha), Trichoderma (2.5 kg/ha). Top dressing with VC (1 t/ha) 45 DAS, Panchagavya (3% spray) 30, 60 and 90 DAS.  **Maize:** Azospirillum (600 g/ha), Phosphobacteria (600 g/ha) Seed treatment. Basal application of FYM (11.88 t/ha), VC (7.57 t/ha), Azospirillum (2kg/ha), Phosphobacteria (2kg/ha). Top dressing with VC (1 t/ha) 30 DAS.  **Green manure (*sesbania*):** Azospirillum (400 g/ha), PB (400 g/ha) Seedling root dip. Basal application of FYM (7.50 t/ha), VC (3.09 t/ha), Azospirillum (2kg/ha), Phosphobacteria (2kg/ha), Pseudomonas (2.5 kg/ha), Trichoderma (2.5 kg/ha). Top dressing with VC (1 t/ha) 30 DAS, Panchagavya (3% spray) 30, 60, 90 and 120 DAS.  **Chillies :**Azospirillum (400 g/ha), PB (400 g/ha) Seedling root dip. Basal application of FYM (7.50 t/ha), VC (3.09 t/ha), Azospirillum (2kg/ha), PB (2kg/ha), Pseudomonas (2.5 kg/ha), Trichoderma (2.5 kg/ha). Top dressing with VC (1 t/ha) 30 DAS, Panchagavya (3% spray) 30, 60, 90 and 120 DAS.  **Sunflower :**Azospirillum (600 g/ha), PB (600 g/ha), Trichoderma (4g/kg) Seedling root dip. Basal application of FYM (5.30 t/ha), VC (3.37 t/ha), Azospirillum (2kg/ha), Phosphobacteria (2kg/ha). Top dressing with VC (500 kg/ha) 30 DAS, Panchagavya (3% spray) 30, 45 and 60 DAS.  **Beetroot-** FYM (5.30 t/ha), VC (1.55 t/ha). Top dressing with VC (500 kg/ha) 45 DAS, Panchagavya (3% spray) 30, 45, and 60 DAS.  **Maize** :Azospirillum (600 g/ha), PSB (600 g/ha) Seed treatment. Basal application of FYM (11.88 t/ha), VC (7.57 t/ha), Azospirillum (2kg/ha), Phosphobacteria (2kg/ha), Top dressing with VC (1 t/ha) 30 DAS  **Sunhemp**: Rhizobium (1 kg/ha) seed treatment. |
| **Uttarakhand** |
| **Cropping systems:** Basmati rice- wheat-*Sesbania,* Basmati rice- Lentil-*Sesbania,* Basmati rice- Vegetable pea-*Sesbania,* Basmati rice- *Brassica napus* –*Sesbania,* Basmati rice- Chickpea –*Sesbania* (under biodynamic practices), Basmati rice – wheat - *Sesbania* green manure.  **Basmati Rice**: Green manure (15-20 t/ha) green biomass as basal application. V.C. (if FYM has not been applied) (2.5 t/ha) 20 DAT .  **Wheat**: Basal application of FYM (10 t/ha), VC (5 t/ha).  **Lentil**: Basal application of FYM (5t/ha ), VC (2.5t/ha)  **Vegetable Pea:** Basal application of FYM (5t/ha ), VC (2.5t/ha).  ***Brassica napus* –*Sesbania :*** Basal application of FYM (5t/ha ), VC (2.5t/ha).  **Chickpea:** Basal application of EC (2 t/ha), NC (200 g/ha), VC (1.0 t/ha), FYM (2.0t/ha). Top dressing with BD-501 (2.5g/ha) and CPP (2.5kg/ha) during flowering and fruiting stage and Panchgavya @ 3% spray at Flowering & 15 days after flowering and Two sprays of 10% cow urine at 30 and 60 days after sowing . |
| **Uttar Pradesh** |
| **Cropping systems:** Basmati rice – wheat - *Sesbania* green manure  **Basmati rice:** Sesbania Green manuring followed by basal application of Azotobactor (10kg/ ha), PSB (10kg/ ha), FYM (12 t/ha), NC (200 kg/ha). Top dressing with VC (4.8t/ha) and foliar application of Panchgavya @ 15 liter/ha at 45 and 60 DAP.  **Wheat:** Basal application of Azotobactor (10kg/ ha), PSB (10kg/ ha), FYM (12 t/ha), NC (200 kg/ha). Top dressing with VC (4.8t/ha) and foliar application of Panchgavya @ 15 liter/ha at 45 and 60 DAP.  **Green gram (Summer):** Seed treatment with Rhizobium (25g/ kg seed). Basal application of FYM (4t/ha) and PSB (10kg/ ha). Top dressing with VC (1.6 t/ha) at 30 and 60 days after sowing.  **Kharif Maize:** Seed treatment with Azotobactor (10kg/ ha), PSB (10kg/ ha). Basal application of FYM (10 t/ha) and NC (200 kg/ha). Top dressing with VC (4.0t/ha) and foliar application of Panchgavya @ 15 liter/ha at 45 and 60 DAS.  **Potato:** Seed treatment with Azotobactor (10kg/ ha), PSB (10kg/ ha). Basal application of FYM (15 t/ha) and NC (200 kg/ha). Top dressing with VC (6.0t/ha) and foliar application of Panchgavya @ 15 liter/ha at 45 and 60 DAS.  **Mustard + radish (1:2):** Seed treatment with Azotobactor (10kg/ ha), PSB (10kg/ ha). Basal application of FYM (12 t/ha) and NC (200 kg/ha). Top dressing with VC (4.8t/ha) and foliar application of Panchgavya @ 15 liter/ha at 45 and 60 DAS.  **Barley + mustard (4:1):** Seed treatment with Azotobactor (10kg/ ha), PSB (10kg/ ha). Basal application of FYM (8 t/ha) and NC (200 kg/ha). Top dressing with VC (3.2t/ha) and foliar application of Panchgavya @ 15 liter/ha at 45 and 60 DAS. |
| \*RNMP- Recommended Nutrient Management Practices, FYM- Farm Yard Manure, CDM-Cow Dung Manure, NC- Neem Cake, VC- Vermi Compost, EC- Enriched Compost, GLM-GLC-Green Leaf Manure, NEOC- Non edible oil cake CDM- RP-Rock Phosphate, NEC- Nitrogen Enriched Compost, VW-Vermi Wash, PSB- Phosphate Solubilising Bacteria, DAS- Days After Sowing, DAP- Days After Planting. |

Source: <http://www.iifsr.res.in/npof/data/uploads/files/package_of_practices.pdf>

1. [↑](#footnote-ref-2)