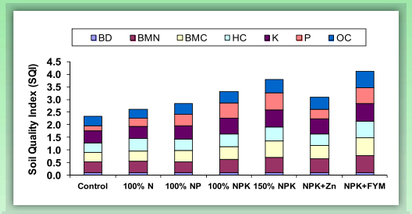
Coimbatore (Inceptisols)



The key soil quality indicators are namely biomass carbon (BMC), biomass nitrogen (BMN), hydraulic conductivity (HC), organic carbon (OC), available K, available P and bulk density in Inceptisols of Coimbatore.

Akola (Vertisols)

The key indicators for Vertisols of Akola were available Fe, available Mn, dehydrogenase activity (DHA), evolution of CO_2, soil urease activity, available S, SMBC, hydraulic conductivity and available P.

Thus, the balanced fertilizer use and integrated nutrient management sustained soil quality across major soils and cropping systems under LTFEs.

Sustainable Yield Index (SYI)

The sustainable yield index (SYI) is one of the indices to evaluate soil quality. More SYI value implies better soil quality. The estimates on SYI indicated that balanced application of nutrient resulted in higher SYI irrespective of crop and soil type. It means management of nutrients is responsible for sustainability and soil quality as well. The sustainability yield index (SYI) for crops at different AICRP LTFE Centres is as follows:

Centre	Crop	Con-trol	100% N	100% NP	100% NPK	150% NPK	100% NPK+ FYM	100% NPK + Lime
Akola	Sorghum	0.01	0.15	0.21	0.29	0.40	0.40	-
	Wheat	0.00	0.13	0.18	0.31	0.41	0.00	-
Bangalore	Finger millet	-0.26	-0.23	-0.19	0.45	0.61	0.56	0.43
	Maize	-0.20	-0.18	-0.11	0.49	0.60	0.63	0.52
Barrackpore	Rice	0.15	0.29	0.34	0.35	0.41	0.40	-
	Wheat	0.11	0.30	0.36	0.38	0.47	0.41	-
Bhubneshwar	Rice (Kharif)	0.26	0.31	0.34	0.46	0.51	0.00	-
	Rice (Rabi)	0.23	0.33	0.48	0.55	0.61	0.00	-
Coimbatore	Finger millet	0.08	0.12	0.36	0.37	0.41	0.46	-
	Maize	0.06	0.09	0.36	0.39	0.43	0.47	-
Jabalpur	Soybean	0.13	0.15	0.26	0.31	0.33	0.35	-
	Wheat	0.14	0.15	0.50	0.54	0.57	0.59	-
Jagtial	Rice (Kharif)	0.32	0.46	0.52	0.55	0.57	0.58	-
	Rice (Rabi)	0.24	0.31	0.45	0.46	0.50	0.48	-
Junagadh	Groundnut	0.22	0.20	0.21	0.27	0.30	-	-
	Wheat	0.27	0.23	0.37	0.40	0.43	-	-
Ludhiana	Maize	0.11	0.33	0.35	0.37	0.40	0.45	-
	Wheat	0.15	0.43	0.63	0.70	0.76	0.77	-
New Delhi	Maize	0.25	0.34	0.38	0.44	0.50	0.51	-
	Wheat	0.38	0.58	0.67	0.74	0.81	0.82	-
Palampur	Maize	0.01	0.07	0.15	0.35	0.36	0.53	0.47
	Wheat	0.04	0.05	0.15	0.28	0.28	0.42	0.40
Pantnagar	Rice	0.13	0.39	0.43	0.41	0.38	0.50	-
	Wheat	0.15	0.46	0.51	0.51	0.50	0.62	-
Parbhani	Soybean	0.05	0.08	0.58	0.66	0.72	0.72	-
	Safflower	0.23	0.22	0.61	0.68	0.80	0.80	-
Pattambi	Rice (Kharif)	0.26	0.36	0.38	0.41	0.42	0.52	0.40
	Rice (Rabi)	0.37	0.42	0.48	0.56	0.57	0.68	0.54
Ranchi	Soybean	0.10	0.03	0.21	0.49	0.47	0.62	0.60
	Wheat	0.02	0.03	0.40	0.47	0.51	0.61	0.56
Raipur	Rice	0.28	0.44	0.62	0.62	0.69	0.67	-
	Wheat	0.20	0.30	0.48	0.49	0.57	0.56	-
Udaipur	Maize	0.30	0.55	0.65	0.75	0.79	0.83	-
	Wheat	0.32	0.52	0.62	0.68	0.76	0.79	-

Scientific Personnel and Officer I/c (AICRP on LTFE)

Project Coordinating Cell (AICRP LTFE)

- **Dr Ashok K Patra,** Director & PC LTFE, ICAR- Indian Institute of Soil Science, Nabibagh, Berasia Road, Bhopal 462 038 (Madhya Pradesh). (M) +91 9811733465
- **Dr RH Wanjari,** Pr. Scientist, ICAR-IISS, Bhopal (M) +91 9893682756
- **Dr Dhiraj Kumar,** Scientist, ICAR-IISS, Bhopal (M) +91 9956598008

Coordinating Centres (AICRP LTFE)

Dr SD Jadhao, Professor, Department of Soil Science and Agricultural Chemistry, Dr PDKV, **Akola** 444 104 (Maharashtra) (M) +91 8275286876 / 9529290720

Dr GG Kadalli, Associate Professor, Department of Soil Science and Agricultural Chemistry, UAS GKVK, **Bangalore** 560 065 (Karnataka) (M) +91 9480302552

Dr AR Saha, Principal Scientist (Soil Science), ICAR-CRIJAF, **Barrackpore** 700 120 (West Bengal) (M) +91 9433921723

Dr PK Samant, Assistant Professor, Department of Soil Science and Agricultural Chemistry, OUAT **Bhubaneswar** 751 003 (Odisha) (M) +91 7008298545

Dr D Jayanthi, Associate Professor, Department of Soil Science and Agricultural Chemistry, TNAU, **Coimbatore** 641 003 (Tamil Nadu) (M) +91 9442146039

Dr P Ravi Yadav, Scientist, Regional Agricultural Research Station (RARS), PJTSAU, Polasa, **Jagtial** 500 029 (Telangana) (M) +91 8466096809 / 6305417345

Dr BK Dixit, Professor, Department of Soil Science & Agricultural Chemistry, JNKVV, **Jabalpur** 482 004 **(**Madhya Pradesh) (M) +91 9993216951 / 9425863441

Dr AV Rajani, Professor, Department of Soil Science & Agricultural Chemistry, College of Agriculture, JAU, **Junagadh** 362 001 (Gujarat) (M) +91 9429159941

Dr Gurmeet Singh Dheri, Assistant Soil Chemist, Department of Soil Science, Directorate of Research, PAU, **Ludhiana** 141 004 (Punjab) (M) +91 8146540005

Dr Mahesh C Meena, Senior Scientist, Division of Soil Science and Agricultural Chemistry, ICAR-IARI, **New Delhi** 110 012 (M) +91 9953287622

Dr RP Sharma, Principal Scientist, Department of Soil Science, CSKHPKV, **Palampur** 176 062 (Himachal Pradesh) (M) +91 9418290985

Dr Shri Ram, Professor, Department of Soil Science & Agricultural Chemistry, GBPUAT, **Pantnagar** 263 145 (Uttarakhand) (M) +91 9411324812

Dr RN Khandare, Associate Professor, Department of Soil Science & Agricultural Chemistry, VNMKV, **Parbhani** 431 402 (Maharashtra) (M) +91 9422974728

Dr PP Moossa, Assistant Professor, Regional Agricultural Research Station, KAU, **Pattambi** 679 306 (Kerala) (M) +91 9446256863

Shri Vinay Bachkaiya, Scientist, Department of Soil Science & Agricultural Chemistry, IGKV, **Raipur** 492 012 (Chhattisgarh) (M) +91 8319646878

Dr Prabhakar Mahapatra, Jr. Scientist-cum-Assistant Professor, Department of Soil Science & Agricultural Chemistry, BAU, Kanke, **Ranchi** 834 006 (Jharkhand) (M) +91 9431578997

Dr SC Meena, Associate Professor, Department of Soil Science & Agricultural Chemistry, MPUAT, **Udaipur** 313 001 (Rajasthan) (M) +91 9829210752

Dr BN Mandal, Senior Scientist, ICAR-Indian Agricultural Statistics Research Institute, **New Delhi** 110 012 (M) +91 9643696773

Prepared and Published by

Drs Ashok K Patra, RH Wanjari, Dhiraj Kumar (2022) PC-Cell,

ICAR-Indian Institute of Soil Science

Nabibagh, Berasia Road, Bhopal 462 038 (Madhya Pradesh), India

AICRP

LONG-TERM FERTILIZER EXPERIMENTS TO STUDY CHANGES IN SOIL QUALITY, CROP PRODUCTIVITY AND SUSTAINABILITY

At a Glance

Project Coordinating Cell

ICAR - Indian Institute of Soil Science

Nabibagh, Berasia Road, Bhopal – 462 038 (M.P.)

https://iiss.icar.gov.in | ISO 9001:2015 Certified

Sardar Patel Outstanding ICAR Institution

FAO King Bhumibol World Soil Day Awardee

SUSTAINING SOIL HEALTH is crucial for achieving/fulfilling food and nutritional security. In this respect, long term fertilizer experiments (LTFEs) are widely known for its importance and necessity for taking decision of soil management of any country. One such worldwide example is the '**Rothamsted Classical Experiments**' initiated by JB Lawes and JH Gilbert, in United Kingdom in 1843. These are known for their innovativeness and uniqueness in addressing researchable issues and challenges with in-built scientific inquisitiveness per se. In a similar fashion, a series of long-term fertilizer experiments were established in India at different locations at the beginning of 20th century, and some of them are still continuing. Indian Council of Agricultural Research (ICAR), New Delhi initiated All India Coordinated Research Project on Long Term Fertilizer Experiments to study changes in soil quality, crop productivity and sustainability (AICRP LTFE) in September 1970 just after the beginning of green revolution. These experiments spread across 11 agro-ecological zones covering 7 major cropping systems under 4 dominant soil types across the length and breadth of the country. These experiments spanned over five decades of existence with suitable combinations of nutrient management options in major agricultural production zones with emphasis on enhancing soil health and nutrient recommendation. The outcome from basic and strategic research emanated from these LTFEs serves as knowledge platform, fertilizer prescriptions and nutrient management.

It has been proved that balanced nutrient supply is vital for proper maintenance and improvement of carbon in soil. It is evident that soil organic carbon (SOC) content enhanced by 47% in Vertisols, 50% in Alfisols, 55% in Inceptisols and remarkably higher by 155% in Mollisols with 100% NPK + FYM compared to control (no manure and fertilizer). These experiments shed lights on nutrient pools which are adequately maintained and sustained with balanced and integrated nutrient management practices. Use of organic and inorganic fertilizers significantly improved soil physico-chemical properties and biological state of soil. In fact, LTFEs involving intensive cropping system revealed a declining trend in productivity despite the application of recommended levels of N, P and K fertilizers. This is mainly due to over mining of nutrients from soil that resulted in deficiency of micronutrients especially zinc (Zn). Moreover, continuous use of phosphatic fertilizers resulted in P build up in Inceptisols of Ludhiana and Delhi. Another important outcome is that application of N alone is unsustainable in most of the soils especially in Alfisols. Such adverse soil condition can be revived either with application of lime or combined use of organics and inorganics.

During the last 50 years, a large information have been generated on soil organic carbon, nutrient dynamics, microbial population and diversity, soil health and crop productivity, soil carbon modelling etc. Also, long-term experiments are the assets for assessing the impact of climate change on soil-plant system. It is essential to monitor heavy metal build up in soil and plant system as a result of continuous use of chemical fertilizer and manure application over a long period. In order to have better output from the same experiment, there is a need of involvement of multi disciplinary scientists by using their expertise to understand soil processes and concepts of long-term fertilization/ manuring experiments.

The Indian Council of Agricultural Research launched the All India Coordinated Research Project on Long term Fertilizer Experiments in September 1970 at 11 centres. They were identified in all irrigated and intensively cropped areas representing different agro climatic regions. Six of these are located at Barrackpore, Bhubaneswar, Coimbatore, Delhi, Hyderabad and Ludhiana on Inceptisols. Some of these were on rice based systems and other on maize, wheat or finger millet based systems. Three experiments were established on Alfisols at Palampur, Ranchi and Bangalore; one each on Vertisols at Jabalpur and on Mollisols, at Pantnagar. There are 10 or 12 treatments in each experiment. These are: T_1 50% optimal NPK dose; T_2 100% optimal NPK dose; T_3 150% optimal NPK dose; T_4 100% optimal NPK dose + hand weeding; T_5 100% optimal NPK dose + zinc or lime; T_6 100% optimal NP; T_7 100% optimal N; T_8 100% optimal NPK +FYM; T_9 100% optimal NPK (Sulphur free/ sulphur source); T_{10} Unmanured (Control). There is also a provision of one or two additional treatments that may be of local or regional interest. Six more centres one each at Akola, Junagadh, Parbhani, Pattambi, Raipur and Udaipur were initiated during 1995-96 to represent additional agro climatic regions.

The project is under the Natural Resource Management Division of ICAR and has 15 centres in different SAUs, two centres in ICAR Institutes with Coordination Cell at ICAR-Indian Institute of Soil Science, Bhopal. The project has a financial outlay of 574.57 lakh (ICAR share) in 2021-22. The project has position of one Project Coordinator, 17 Associate Professor/ Sr. Scientist, 18 Assistant Professor/ Scientist, 12 Technical, 2 Administrative and 18 Supporting Staff.

MISSION

Soil Fertility Management through Integrated Plant Nutrient Supply for Enhancing and Sustaining Crop Production and Maintaining Soil Quality

MANDATE

- To conduct coordinated long term fertilizer experiments in different soil types under diversified cropping systems
- To collate information on long term soil fertility trials

OBJECTIVES

- To study the effect of continuous application of plant nutrients, singly and in combination, in organic and inorganic forms including secondary and micronutrient elements (as per the need) on crop yield, nutrient composition and uptake in multiple cropping systems.
- To work out the amount of nutrient removal by the crops.
- To monitor the changes in soil properties as a result of continuous manuring and cropping with respect to the physical, chemical and microbiological characteristics of the soil in relation to its productivity.
- To investigate the effect of intensive use of biological chemicals (weedicides and pesticides) on the build up residues and soil productivity.
- To make an assessment of the incidence of soil borne diseases and changes in pests and pathogens under the proposed manuring and cropping programme.

Salient Achievements

The Long Term Fertilizer Experiments (LTFEs) conducted across the country clearly brought out following inferences:

- In Alfisols of Palampur, Ranchi and Bangalore, the yield data of crops indicated that FYM application found to be superior to lime amendment as far as soil productivity is concerned. Application of organic manure in addition to moderating soil condition also supply nutrients whereas lime increases soil pH only.
- Studies on assessment of impact of changing climate on crop productivity indicated that there will be decline in productivity of wheat at Ludhiana during next 50-60 years but at the same time increase in moisture availability due to increase in rainfall and increase in fertilizer N not only offset the decline in yield but is enhanced by 15 to 30% from baseline.
- In Vertisols of Raipur, yield can be sustained on exclusive application of fertilizer nutrients as well as integrated use of nutrients. Likewise, in Vertisols of Akola, results indicated that exclusive application of nutrients through organic manure even after 34 years could not keep the pace with 100% NPK. It is advised that there is need to increase the dose of organic manure to obtain more yield and to keep the pace with inorganic nutrient supply.
- Studies on crop response to K in Vertisols conducted at different places indicated response of crop during kharif season invariably whereas during rabi season response to applied K was random. Probably wetting of soil during kharif season resulted to cause water soluble K entrapped in 2:1 type minerals and thus available K goes below critical level.
- In Alfisols, results indicated that application of urea alone (100% N) had deleterious effect on crop productivity of maize and wheat (Palampur) and other places also. This is due to decline in soil pH which reduces the availability of P and K to a large extent.
- Application of fertilizer resulted in increase in count and enzymatic activities of soil microorganisms. Increase in application of nutrients from 100 to 150% also had positive effect on soil microorganism count and their activities.
- Irrespective of soil and crop, incorporation of farm yard manure (FYM) or green manure not only resulted in increase in productivity but also increase microbial count and their enzymatic activities.
- Application of fertilizer increased the enzymatic activity in soil which resulted in evolution of higher CO_2. Thus, the observations clearly demonstrated that application of fertilizer is essential not only to sustain the crop productivity but also to maintain or enhance population of soil microorganisms.
- Results revealed that decline in P dose to half in the plots / fields with P accumulation at Ludhiana, Bangalore and Jabalpur did not have any adverse effect on crop productivity. Thus, P accumulated over the years can be reutilized.
- At Pantnagar, combined application of S and Zn had additive effect on yield. Thus, both the nutrients are essential for sustaining crop productivity.
- Saturation and threshold carbon limits are dependent on texture (clay), rainfall, temperature and carbon sequestration are dictated by carbon added through residue biomass. Thus, more is the productivity higher will be residual biomass and carbon sequestration.
- The increase in productivity on application of fertilizer resulted increase in carbon in soil and microbial population and thus ruled out the notion that chemical fertilizer deteriorate soil carbon and adversely affect the growth of the soil microorganisms.
- Soil quality index (SQI) was derived by taking into account 25-30 soil parameters (chemical, physical and biological) and it was found that SQI was higher with balanced and integrated nutrient application. Further, SQI improved with an application of NPK along with FYM/Lime.

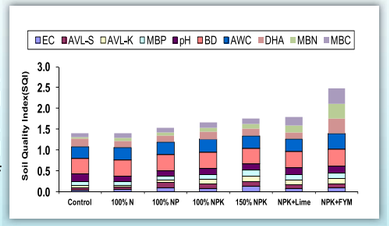
SOIL QUALITY INDICATORS

Soil Quality Index

It is essential to pinpoint the soil properties sensitive to management practices to evaluate the soil quality which are called soil indicators. In this context, studies at different LTFE locations were undertaken by analyzing chemical, physical and biological properties. Total 25-30 soil attributes were subjected to principal component analysis (PCA) to find out soil quality indicators and soil quality index. The SQI is relative numerical index which indicate the condition of soil at that point of time under a particular management and how it has affected with management practices. More is the SQI better will be the soil quality. By using this concept, soil indicators were identified through PCA by using their relative contribution in productivity. The SQI was calculated for some of the sites of long term fertilizer experiment.

Bangalore (Alfisols)

The key indicators are available K, dehydrogenase activity (DHA), microbial biomass C (MBC), N (MBN) and P (MBP), pH, EC, available S, bulk density and available water content for Alfisols of Bangalore.



Palampur (Alfisols)

The key indicators are dehydrogenase activity (DHA), microbial biomass C (MBC) and N (MBN), pH, saturated hydraulic conductivity and plant available water content for Alfisols of Palampur.