By Speed Post

भारतीय कृषि अनुसंधान परिषद
प्राकृतिक ससांधन प्रबधन प्रभाग
कृषि अनुसंधान भवन–2,
पुसा, नई दिल्ली–110012

Indian Council of Agricultural Research
Natural Resources Management Division
Krishi Anusandhan Bhawan,
Pusa, New Delhi-110012

Dr. P.P. Biswas
Principal Scientist (Soils)

Telefax No. 011-2584 3151
e-mail:parthaviswas.1957@mail.com

F.No.1-18/2014-SWDF

Dated 20th June, 2014

To

The Director
Indian Institute of Soil Science
Nabi Bagh, Berasia Road,
Bhopal-462038.

Subject: Transfer of RTI application – received from Shri Pavan Reddy R/o EWS 573, Road-2, kphb colony, Hyderbad-500085 (AP).

Sir,

Please find enclosed herewith an RTI application dated 17th June, 2014 received from Shri Pavan Reddy R/o EWS 573, Road-2, kphb colony, Hyderbad-500085 (AP). The same application is transferred to your Institute for providing the information on **Point No.2** directly to the applicant under intimation to the undersigned at the earliest.

Yours faithfully,

CPIO

(P.P. BISWAS)
Principal Scientist (Soils) &
CPIO (Scientific & Tech.)

Encl. as above

Copy to Shri Pavan Reddy R/o EWS 573, Road-2, kphb colony, Hyderbad-500085 (AP).

24/6/14

The information for point 2 may be sought from PC (STCR), PCM and PME cell on or before 28/6/14.
25/6/14

RTI REQUEST DETAILS

Registration No. :	ICARH/R/2014/60161	**Date of Receipt :**	17/06/2014
Type of Receipt :	Online Receipt	**Language of Request :**	English
Name :	Pavan Reddy	**Gender :**	Male
Address :	EWS 573,Road-2,kphb colony, Hyderabad,Andhra Pradesh, Pin:500085		
State :	Andhra Pradesh	**Country :**	India
Phone No. :	Not Provided	**Mobile No. :**	+91-7799493435
Email :	rticitizenright@gmail.com		
Status(Rural/Urban) :	Not Provided	**Education Status :**	Not Provided
Is Requester Below Poverty Line ? :	Yes	**Citizenship Status**	Indian
Amount Paid :	0	**Mode of Payment**	Payment Gateway
Mode(s) of information Supply :	Hard Copy	**Request Pertains to :**	DR. P.K. CHAKRABARTY

Provide the information available as on 17/06/2014 or the latest information available

1) Strengthening of KVKs

(a)whether India is consistently producing 250 million tonnes of foodgrains, 100 million tonnes of rice, 90 million tonnes of wheat, 35 million bales of cotton and more than 18 million tonnes of pulses at present

(b)whether the growth in production is facilitated mainly by Krishi Vigyan Kendras (KVKs) which are spread across the country

(c)if so, whether the Government is considering to expand the area of activities of KVKs as well as to open more KVKs in many parts of the country and has sought Rs.5,700 crore to strengthen KVKs during the 12th Five Year Plan and

2) Fertility of soil

(a) whether the Government has evaluated the fertility of soil/arable land across the country

(b) if so, the norms adopted for the purpose and the extent of micronutrients deficiency noticed, State/UT-wise

Dr. P/P. Biswas, Pr. Sci (soils) & CPIO
Pl discuss
SO (SW&F)

(c) the details of the schemes and projects under implementation to check the declining fertility of agricultural land and improve the fertility of soil for increasing agricultural production in the country including Chhattisgarh and

(d) the success achieved thereunder during each of the last three years and the current year

3) Missing farmers from Agriculture profession

Information Sought :

(a) whether the Government has conducted a review to assess the number of farmers who have quit agriculture during each of the last three years in each State/ UT

(b) if so, the details and the outcome thereof, State/UT-wise

(c) the main reasons identified in the review for quitting of agriculture by farmers

(d) whether the Government has suggested that the farmers shift to cash crop cultivation from traditional crops and

(e) if so, the details thereof and the other deficiencies identified during the review along with the steps taken/proposed to be taken by the Government to popularize agriculture and ensure that the farmers do not quit agriculture in the near future

4) Decline in area of agriculture

(a) the area under cultivation of major food crops in the country during each of the last three years and the current year

5) Paddy cultivation

(a) the details of the area under the cultivation of paddy in the country during each of the last three years and the current year, State-wise

(b) whether the area under the cultivation of paddy has declined in several States despite increase in consumption of fertilizers and pesticides during the said period

(c) if so, the details thereof along with the consumption of fertilizers and pesticides in the cultivation of paddy during the same period

(d) whether the per acre production of rice in the country is less than the worlds average and if so, the reasons therefor and

(e) the steps taken/proposed to be taken by the Government to increase the area and productivity of of rice in the country.

BY SPEED POST/FAX
भारतीय मृदा विज्ञान संस्थान (भा०कृ०अनु०प०)
नबीबाग बैरसिया रोड, भोपाल - 462038
Indian Institute of Soil Science
Nabibagh, Berasia Road, Bhopal–462038 (M.P.)
Tel. No. (0755) 2747375 EPABX: 2730970/2734221 (Ext. No. 252 & 256) Fax. No. (075) 2733310

Date: 02.07.2014

F. No. 73-6/IISS/RTI/2014

To

Shri Pavan Reddy
EWS 573, Road-2,
kphb colony,
Hyderabad, AP-500085

Sub: Seeking information under RTI Act, 2005 – reg.

Sir,

Please find enclosed herewith information in response to your application under RTI dated 25.05.2014. Further it is informed that the Appellate Authority is Director, IISS, Bhopal and his telephone no. is 0755-2730946.

(R. Elanchezhian)
Principal Scientist & CPIO

Copy to:

Dr. P.P. Biswas
Krishi Anusandhan Bhavan-II,
Indian Council of Agricultural Research, PUSA,
New Delhi-110012

Gmail by Google

Elanchezhian Rajamanickam <elanrc@gmail.com>

Regarding RTI by Mr Pavan Reddy, pointwise reply for serial no. 2

Dr Pradip Dey <pcstcr@gmail.com> Thu, Jun 26, 2014 at 6:08 PM
To: Elanchezhian Rajamanickam <elanrc@gmail.com>, elan@iiss.res.in, elanrc@rediffmail.com
Cc: director@iiss.res.in

Dear Dr Elanchezhian,
Please find below the reply. Attachment is not working; hence, sending in the body of mail.
Regds.

Note

-

With reference to your note dated 25.06.2014 regarding RTI by Mr Pavan Reddy, pointwise reply for serial no. 2 is provided below:

(a)

Yes. Under DAC (Division of INM) Sponsored Project on "GPS and GIS Based Soil Fertility Maps for Precise Fertilizer Recommendations for the Farmers of the Country", GPS and GIS based soil fertility maps of 171 districts (list provided below) from geo-referenced soil samples completed and the digital maps have been uploaded in the Indian Institute of Soil Science website (http://www.iiss.nic.in/districtmap.html):

State	S.No.	Dist_Name
KERALA	1	CANNURE
	2	MALLAPURUM
	3	TRISSHURE
	4	CALICUT
	5	PALAKKAD

	6	ERNAKULAM
	7	ALLAPPUZHA
	8	THIRUVANTHAPURAM
	9	WAYANAD
KARNATAKA	10	MANDYA
	11	RAMNAGARAM
	12	BANGLORE RURAL
	13	HASAN
	14	CHIKBALLAPURA
	15	CHITRADURGA
	16	MYSORE
	17	TUMKUR
	18	KOLAR
GUJRAT	19	ANAND
	20	KHEDA
	21	PANCHMAHAL
	22	PATAN
	23	VADODARA
	24	BHARUCH
	25	AHAMDABAD
	26	SABARKANTHA
	27	MEHSANA
MAHARASHTRA	28	AKOLA
	29	BHANDARA
	30	JALNA
	31	SANGALI
	32	DHULE
	33	KOLHAPUR
	34	YAVATMAL

	35	AMARAVATI
	36	BULDHANA
	37	NASIK
	38	CHANDRAPUR
	39	AURANGABAD
	40	WASHIM
TAMIL NADU	41	THANJAVUR
	42	NAGAPATTINAM
	43	CUDDALORE
	44	THIRUVARUR
	45	TRICHI
	46	ERODE
	47	VELLUPURAM
	48	COIEMBTORE
	49	TRIPPUR
	50	SALEM
ANDHRA PRADESH	51	KURNOOL
	52	KADAP
	53	ANANTPUR
	54	KRISHNA
	55	WESTGODAVARI
	56	GUNTUR
TELANGANA	57	KARIMNAGAR
	58	MEHBOOBNAGAR
	59	NIZAMABAD
	60	RANGAREDDY
WEST BENGAL	61	JALPAIGURI
	62	NORTH DINAJPUR
	63	BANKURA

	64	NORTH 24 PARAGANAS
	65	SOUTH DINAJPUR
	66	HOOGHLY
	67	MURSHIDABAD
	68	BARDHAMAN
	69	NADIA
HIMANCHAL PRADESH	70	HAMIRPUR
	71	BILASPUR
	72	UNA
	73	CHAMBA
	74	MANDI
	75	KANGRA
	76	SHIMLA
	77	SOLAN
	78	KULLU
ORISSA	79	PURI
	80	CUTTACK
	81	KHURDA
	82	DHENKANAL
	83	NAYAGARH
	84	BHADRAK
	85	BALASORE
	86	ANGUL
RAJASTHAN	87	BIKANER
	88	CHURU
	89	GANGANAGAR
	90	ALWAR
	91	BHARATPUR
	92	JODHPUR
	93	DHAULPUR

	94	KOTA
	95	JAISALMER
ASSAM	96	JORAHAT
	97	SIBSAGAR
	98	GOLAGHAT
	99	NORTH LAKHIMPUR
	100	NAGAON
	101	MERIGAON
	102	BARPETA
	103	KAMRUP
	104	KACHAR
	105	SONITPUR
HARYANA	106	HISAR
	107	BHIWANI
	108	PANIPAT
	109	FATEHABAD
	110	MAHENDRAGARH
	111	JIND
	112	KAITHAL
	113	KURUKSHETRA
	114	KARNAL
	115	SIRSA
PUNJAB	116	LUDHIANA
	117	JALANDHAR
	118	FIROZPUR
	119	NAWANSHAHAR
	120	SANGRUR
	121	ROOP NAGAR
	122	HOSHIARPUR

	123	BATHINDA
	124	AMRITSAR
BIHAR	125	SAMASTIPUR
	126	VAISHALI
	127	JEHANABAD
	128	PATNA
	129	DARBANGHA
	130	NALANDA
	131	ARWAL
	132	NAWADA
	133	MUZAFFARPUR
UTTAR PRADESH	134	KANPUR
	135	ETAWAH
	136	FARRUKHABAD
	137	CHANDAULI
	138	RAIBARELI
	139	PILIBHIT
	140	GORAKHPUR
	141	ALLAHABAD
	142	SANT RAVIDAS NAGAR
	143	VARANASI
	144	MIRZA PUR
	145	LAKHIMPUR
MADHYA PRADESH	146	JABALPUR
	147	KATNI
	148	SEONI
	149	BHOPAL
	150	NARSINGHPUR
	151	INDORE
	152	SHAHADOL

	153	MANDALA
CHATTISGARH	154	KABEERDHAM
	155	BALOD
	156	BASTAR
	157	RAIPUR
	158	RAIGARH
	159	BALODBAZAR
	160	BEMETARA
	161	KONDAGAON
	162	DURG
	163	MAHASAMUND
	164	KORIYA
	165	KORBA
UTTARAKHARND	166	UDHAM SINGH NAGAR
	167	CHAMPAWAT
	168	NAINITAL
	169	HARIDWAR
GOA	170	SOUTH GOA DISTRICT
	171	NORTH GOA DISTRICT

b)

Regarding the norms adopted for mapping is GPS based collection of samples through radom stratefied sampling process for sample collection, analysis of samples followed by standard analytical procedure and finally preparation of GIS based soil fertility maps.

Deficient areas under micronutrients has been uploaded in Institute website which may be accessed in the link: http://www.iiss.nic.in/districtmap.html. Any one may click on respective state in the map of India followed by different parameters for digital maps of respective soil fertility parameters of desired district.

C)

There are about 97 institutions of ICAR apart from 47 State Agricultural Universities and about 600 KVKs in the country. All these institutions are having the soil fertility assessment and management as one of the objectives directly or indirectly. There are four institutes listed below that are solely working on various issues related to soil management.

i) Central Soil and Water Conservation Research and Training Institute, Dehradun

ii) Central Soil Salinity Research Institute, Karnal

iii) Indian Institute of Soil Science, Bhopal

iv) National Bureau of Soil Survey and Land Use Planning, Nagpur

The Departments of Soil Science in different State Agricultural Universities are engaged in monitoring the soil fertility status of respective states, providing best nutrient management practices for different soil, crops, climatic situations and also developing technologies/ management practices for all the predominant crops / cropping sequences of the respective states. The ICAR institutes, especially the above mentioned four institutes through All India Co-ordinated research projects and in-house projects are providing solutions to national issues, which may not be tackled by individual department of the State Agricultural University. For instance, IISS Bhopal through the AICRP located at the institute is presently engaged in mapping district wise soil fertility with respect to major and micro nutrients and to give suitable nutrient recommendation through soil test crop response prescription equations.

Also the Government of India through its research, education and extension institutes has been giving training to farmers to maintain the fertility of soil through judicious use of fertiliser. Also, it is mandatory for all the ICAR institutes to provide training to the farmers. The farmers are trained to make them aware of the soil health through frontline demonstrations, training on soil sampling and testing, biofertilizer use as well as soil management for efficient crop production. Also the farmers are educated during the *Kisan Mela*. The institute has conducted about 30 training programmes for farmers (20-25 no. in each programme) under various themes such as soil testing, organic farming and technology exposure to farmers. These training programmes are being conducted every year for the benefit of farmers. AICRP (STCR) has conducted on-farm trials / field demonstrations to validate STCR recommendations on different crops including cereals, oilseed, pulses and horticultural crops which have shown advantages of STCR technology over general fertilizer recommendations as given below:

Crop	No. of trials	Farmer's practice	STCR- IPNS recommended practice
Rice	120	11.4	16.8
Wheat	150	10.3	14.2
Maize	35	12.7	17.7
Mustard	45	8.0	8.2
Raya	25	4.8	7.6
Groundnut	50	5.1	6.8
Soybean	17	9.6	12.2
Chickpea	35	6.1	9.4

d)

Achievements of AICRP (STCR) for last three years is given below:

I. Development of Targeted Equations:

During the period under report, the STCR centres have developed fertilizer adjustment equations for a number of crops as given below:

a. **Hyderabad:** Rice (BPT-5204), Maize (BH 1576) and Rice (Tellahamsa).

b. **New Delhi:** Wheat (HD-2894), Wheat (HD-2851) and Aromatic hybrid rice (PRH-10).

c. **Bhubaneswar:** Sesamum (Nirmala).

d. **Rahuri:** Garlic (G-14), Okra (Arka anamika), Potato (Khupari Jyoti), Brinjal (Krishna), Rabi Sorghum (Phule Chitra), Marigold (Yellow) and Sorghum (Chitra).

e. **Coimbatore:** Rainfed Bt Cotton (Hybrid BRAHMA BG II), Rice under SRI (ADT43), Rice under SRI (CO-R-49), Maize (Hybrid NK 6240) and Tomato (Hybrid Lakshmi 5005).

f. **Ludhiana:** Bt Cotton (RCH 134) and Wheat (PBW 509).

g. **Pantnagar:** Sugarcane (Ratoon), Barley (UPB-1008) and Cowpea (Pant lobia 2).

h. **Imphal:** Upland rice (RC Maniphou 6).

i. **Karaikal:** Rice (CR. 1009).

j. **Kalyani:** Carrot (Early Nantin) and Onion (Suksagar).

k. **Vellanikkara:** Tomato (Anagha).

II. Use of Targeted Yield Equations and Development of Prediction Equations for Cropping Sequences:

The centres have developed post-harvest soil test prediction equations for recommending fertilizers to the crops in different cropping systems as given below:

a. **Hyderabad:** Rice (BPT-5204)-Rice (Tellahamsa) and Rice (BPT-5204)-Maize (BH-1576).

b. **New Delhi:** Rice (PRH-10)-Wheat (HD-2581).

c. **Jorhat:** Autumn Rice (Luit)-Winter Rice (Ranjit).

d. **Coimbatore:** Maize (Hybrid NK-6240)-Tomato (Hybrid Lakshmi-5005).

III. Fertilizer Adjustment Equations under Integrated Plant Nutrient Supply Systems:

Several centres have developed Fertilizer Adjustment Equations under Integrated Plant Nutrient Supply Systems (IPNS) to recommend nutrients through inorganic and organic sources available locally. The centres and crops for which adjustment equations have been generated are given below:

a. **Pusa:** Rice (Prabhat), Winter Maize (Deoki) and Sugarcane (BO137).

b. **New Delhi:** Wheat (HD-2894), Wheat (HD-2851) and Rice (PRH-10).

c. **Palampur:** Okra (P-8) and Potato (Kufri Jyoti 2).

d. **Coimbatore:** Bt Cotton (Hybrid BRAHMA BH II), Rice (ADT 43), Rice (CO (R) 49), Maize (Hybrid NK 6240) and Tomato (hybrid Lakshmi 5005).

e. **Bhubaneswar:** Chilli (Utkal Abha), Sesamum (Nirmala) and Cowpea (Utkal Manika).

f. **Vellanikkara:** Tomato (Anagha).

g. **Karaikal:** Rice (CR. 1009).

h. **Jorhat:** Autumn Rice (Luit) and Winter Rice (Ranjit).

i. **Raipur:** Rice (Karma masuri) and Rice (Swarna).

j. **Barrackpore:** Jute (JRO 204), Rice (NDR-97) and Garden pea (Azad P-3).

k. **Bangalore:** Sugarcane (Ratoon II) and Ragi (GPU -28).

l. **Hyderabad:** Sunflower (Sunbred), Bt Cooton (KH 112), Castor (PCH-2) and Sugarcane (2001A63).

m. **Hisar:** Bt. Cotton (MRC 6304).

n. **Varanasi:** Rice (Saryu-52).

o. **Bikaner:** Egg Plant (F1 hybrid Kanhaya), Bottle gourd (MGH-4), Onion (RMO252) and Fenugreek (RMP-1).

p. **Pantnagar:** Sugarcane (Ratoon), Barley (UPB-1008) and Cowpea (Pant Lobia2).

IV. Multilocation Feollow up Trials:

At all the centres, yield targets were achieved and higher response ratio and benefit cost ratios were obtained. The follow up trials of following centres taken are as follows:

a. **Bangalore:** Soybean (MAUS-20), Maize (Hema) and Bhindi (Arka Anamika).

b. **Barrackpore:** Jute (JRO 128), Rice (MTU-1010) and Vegetable pea (Azad P-3).

c. **Hisar:** Pearl millet (HHB 197) and Wheat (WH 711).

d. **Jabalpur:** Paddy (MR-219) and Wheat (GW-273).

e. **Palampur:** Maize (HQPM-1) and Wheat (HPW 42).

f. **Ludhiana:** Rice (PR-120) and Wheat (PBW 621).

g. **Hyderabad:** Foxtail millet (Krishnadevaraya), Muskmelon (Maduras) and Soybean (JS-335).

h. **Coimbatore:** Plains Wheat (CO(W)1), Beetroot (Ram F1), Radish (Pusa chetkishot), Hybrid Maize (NK 6240), Hybrid tomato (Lakshmi 5005) and Rainfed Bt. Cotton (BRAHMA BG II).

V. Frontline Demonstrations on Farmer's Fields:

Frontline demonstrations were organized on farmer's fields to demonstrate the value of soil test based fertilizer and manure recommendations in different states. In these demonstrations, farmers could obtain higher returns of applied nutrients through the fertilizers and manures application based on targeted yield approach. Long term demonstration trials are in progress at Coimbatore, Jabalpur and Palampur centres to demonstrate the value of soil test based recommendations in terms of yield sustainability and soil fertility maintenance.

a. **Jabalpur:** Soybean (JS-9752), Arhar (JKM-189 and Asha), Niger (PCN-8), Paddy (Kranti and MR-219) and Wheat (JW-273, JW-3211 and JG-319).

b. **Bhubaneswar:** Sesamum (Nirmala).

c. **Vellenikkara:** Amaranthus (Arun) and Cucumber (Soubhagya).

d. **Hisar:** Pearl millet (HHB 197 and HHB 223),Wheat (PBW 502 and WH 711) and Raya (Laxmi).

e. **Barrackpure:** Mustard (B-9).

f. **Hyderabad:** Groundnut (Narayani and JL-24) and Sunflower (Sunbred).

g. **New Delhi:** Mustard (Pusa Bold) and Wheat (HD 2894).

h. **Coimbatore:** Rice (APT 43), Groundnut (VRI 5, TMV 7 and VRI 2), Sunflower (Sunbred 275) and Gingelly (TMV 3).

i. **Raipur:** Soybean (JS 305) and Sunflower (Jwalamukhi).

j. **Pusa:** Rice (Hybrid, 6444, PB 73 and Parwal), Wheat (HD-2733, 2824, 711 and PBW 343), Winter Maize (Laxmi, Ganga Kaberi, Deoki, 10B10 and 31Y45), Sesame(Krishna), Mustard (Mashina gold and Karanti), Linseed (Mira), Pigeon pea (T-1), Lentil (DPL-15), Potato (Jyoti and Kufari arun) and Brinjal (Santury).

k. **Palampur:** Soybean (Bragg) and Toria (Bhawani).

l. **Bikaner:** Gram (RGC 1581).

VI. Frontline Demonstrations under Tribal Sub Plan:

Under the Tribal Sub Plan, frontline demonstrations were organized on farmers' fields of tribal areas in different states to demonstrate the value of soil test based fertilizer and manure recommendations for getting higher return of applied nutrients through the fertilizers and manures application based on targeted yield approach.

a. **Jabalur:** Gram (JG-11) and Wheat (HI-1500).

b. **Bhubaneswar:** Lady's Finger (JK OH-7315).

c. **Raipur:** Wheat (Amar, DL788-Vidisha, GW-273 and Sujata-HI1077), Maize (30V92), Chick pea (JG11-Vaibhav and Jaki) and Mustard (Pusa Bold and Pusa Jaikisan).

Achievement of AICRP (STCR) for current year is given below:

I. Development of Targeted Equations:

- **Pantnagar:** Okra (Parbhani Kranti), Chilli (Pant Jwala) and Sorghum (CSV-15).
- **Karaikal:** Rice (CR 1009) and Blackgram (Vamban 3).
- **Vellanikkara:** Chilli (Athulya).
- **Raipur:** Rice (Karma Masuri & Swarna) and Tomato (Pant-3).
- **Rahuri:** Garlic (G-14), Okra (Arka Anamika), Potato (Kufri Jyoti), Brinjal (Krishna), Bt. Cotton (Mallica), Sorghum (Phule Chitra) and Wheat (NAIW 304 & Trymbak).
- **Pusa:** Barseem (Mascavi).
- **Coimbatore:** Rice (ASD 16) and Bt. Cotton (Hybrid RCH 530 BG II).

II. Use of Targeted Yield Equations and Development of Prediction Equations for Cropping Sequences:

- **Palampur:** Maize (PG 2474)-Wheat (HPW 155).
- **New Delhi:** Rice (PRH-10)-Wheat (HD-2894).
- **Coimbatore:** Maize (CO 1)-Bt. Cotton (Hybrid RCH 530 BG II).
- **Bikaner:** Wheat (Raj-3077)-Groundnut (ICGS 5).

III. Fertilizer Adjustment Equations under Integrated Plant Nutrient Supply Systems:

- **Coimbatore:** Rice (ASD 16) and Bt. Cotton (Hybrid RCH 530 BG II).
- **Bikaner:** Onion (RO 252) and Fenugreek (RMP-1).
- **Barrackpore:** Jute (JRO 2407) and Rice (MPU 1010).
- **Hisar:** Pearl Millet (HHB 223), Wheat (DPW 621-50) and Maize (HM 5).
- **Vellanikkara:** Chilli (Athulya).
- **Palampur:** Okra (P-8) and Gobhi Sarson (HPN-1).
- **Pantnagar:** Okra (Parbhani Kranti), Chilli (Pant Jwala) and Sorghum (CSV-15).
- **Karaikal:** Rice (CR 1009) and Blackgram (Vamban 3).
- **Hyderabad:** Sunflower (Sunbred), Bt. Cotton (KH-112), Castor (PCH 222) and Sugarcane (2001 A 63).
- **New Delhi:** Wheat (HD-2894 & HD-2851) and Rice (PRH-10).
- **Jorhat:** Rice (Ranjit).
- **Bangalore:** Sugarcane (Ratoon III) and Ragi (GPU-28).
- **Kalyani:** Onion (Suksagar).
- **Varanasi:** Maize (Asha).
- **Bhubaneswar:** Sesamum (Uma).

IV. Follow up trials conducted

- **Coimbatore:** Cotton (RCH 530), Maize (NK 6240), Rice (ADT-43) and Tomato (Lakshmi 5005).
- **New Delhi:** Wheat (HD-2851).
- **Jabalpur:** PadDy (MR-219), Wheat (GW-273), Soybean (JS-9752), Chandrasur (HI-4), Garlic (G-323) and Onion (Agrifound Light Red).
- **Karaikal:** Rice (CR 1009) and Blackgram (Vamban 3).
- **Vellanikkara:** Chilli (Ujwala).
- **Palampur:** Maize (PG 2474), Wheat (HPW 155) and Potato (Kufri Jyoti 2).
- **Bikaner:** Cluster Bean (RGC 986) and Wheat (Raj-3077).
- **Barrackpore:** Jute (JRO 128), Rice (MPU 1010) and Vegetable Pea (Azad P 3).
- **Hisar:** Pearl Millet (HHB 197), Wheat (WH 711, WH 283 & PBW 550) and Bt. Cottn (MRC 6304).
- **Jorhat:** Rice (Luit & Ranjit).
- **Bangalore:** Hybrid Maize (Hema) and Ragi (GPU-28).
- **Kalyani:** Potato (Kufri Jyoti).

- **Varanasi:** Rice (Super Moti).

V. FLDs conducted

- **Hisar:** Pearl Milet (HHB 197 & HHB 223), Wheat (PBW 502 & WH 711) and Raya (Laxmi).
- **Bangalore:** Sunflower (KBHS-53).
- **Palampur:** Soybean (Brag) and Toria (Bhawani).
- **New Delhi:** Mustard (Pusa Bold) and Wheat (HD-2894).
- **Jabalpur:** Soybean (JS-9752), Pady (Sahbhagi, Kranti & MR-219), Pea (Azad Pea-1), Wheat (JW-273) and Gram (JG-319 & JG-311).
- **Coimbatore:** Groundnut (JL-24, VRI-2 & CO-6), Sunflower (Sunbred 275) and Gingelly (TMV 3 & TMV 7).
- **Pusa:** Rice (6444 & PT 71), Wheat (PBW 348, HD 2733 & PBW 502), Maize (10 B 10), Sesame (Krishna), Mustard (45521, 66157 & Voruna), Linseed (Subhra), Potato (Jyoti) and Turmeric (Rajendra Soniya).

VI. FLDs conducted under Tribal Sub Plan

- **Coimbatore:** Maize (CO 6), Groundnut (CO 6), Onion (CO 4), Carrot (Tokito) and Tomato (PKM 1).
- **Manipur:** Garden Pea (Arkel), Field Pea (Rachna) and Rape Seed (M-27).
- **Bhubaneswar:** Chilli (Bamra Local), Brinjal (BV-45 C) and Tomato (BT-20).
- **Barrackpore:** Mustard (B-9) and Lentil (B 256).
- **Jabalpur:** Gram (Jaki 9218, JG 14, JG 16, JG 130 & JG 315), Wheat (JW 273, JW 321, JW 3269, Lok 1 & Sujata) and Lentil (JL 3).
- **Raipur:** Wheat (Amar, DL788-Vidisha, GW-273 and Sujata-HI1077), Maize (30V92) and Chick pea (JG11-Vaibhav and Jaki).

Regarding Chattisgarh, AICRP on STCR at Raipur centre has developed soil test based balanced fertilizer prescription equations for rice (hybrid, scented, Swarna, Mahamaya, MTU 1010, Karma Mahsuri), oilseed crop (sunflower and safflower), wheat (Sujata, HI-1077, GW-273), vegetable crops (Brinjal, cauliflower, tomato), cash crop (like sugarcane and potato) and chickpea as pulse crop in various crop suitable soil types. These crops have been successfully tested on farmer's fields through follow-up trials, fronline demonstrations with the help of directorate of oilseeds, AICRP on STCR, DAC, TSP and NFL for their validity and suitability of balanced fertilization based on soil test results of the farmer's farm. There is 30 to 50 % increase in the yield of the tested crops that resulted higher crop resonse as kg/kg fertilizer use, net profit and net return as Rs/Re spent on fertilizers. The equations were also developed using IPNS approach (FYM as organic source), cropping system like rice-vegetable, rice-chickpea, maize-potato covering CG plains, Sarguja Hills and Bastar plateau region of the state. More than 500 FLD's were conducted on farmer's fields covering the whole state with major crops like soybean, rice, mustard, sunflower, safflower, chickpea and wheat with more than 85 % success rate. The project scientists have organized more than 100 Kisan Mela, farmer's day, farmer's Training program on soil test technology, balanced fertilization, Integrated Nutrient Management based on soil testing, efficient plant nutrient management covering the whole state.

(Pradip Dey)

PC (STCR)

To

Dr R Elanchezhian
PS & CPIO

Gmail by Google

RTI Reply from PCM Unit

Arvind Shukla <arvindshukla2k3@yahoo.co.in> Tue, Jul 1, 2014 at 4:38 PM
Reply-To: Arvind Shukla <arvindshukla2k3@yahoo.co.in>
To: "elanrc@gmail.com" <elanrc@gmail.com>

Dear Dr. Elanchezhian,
Please find attached herewith inpiuts from PCM Unit reagrding RTI reply .

Dr Arvind Kumar Shukla
Project Coordinator Micronutrients
Indian Institute of Soil Science
Nabibagh, Berasia Road, Bhopal- 462 038
Madhya Pradesh, India
Telephone: 0755-2734487
Fax: 0755-2733310, 2734487
Email: akshukla@iiss.ernet.in, arvindshukla2k3@yahoo.co.in

RTI question.docx
16K

AICRP on Micro- and Secondary Nutrients and Pollutant Elements in Soils and Plants

A) Whether the Government has evaluated the fertility of soil/arable land across the country.

Yes, the soil fertility status is being evaluated time to time though different schemes/ projects funded by DAC, ICAR and other agencies. AICRP on Micro- and Secondary Nutrients and Pollutant Elements in Soils and Plants, running in 15 states of the country is engaged in delineation of Micro- and Secondary Nutrients and amelioration/ management of their deficiencies as per the local need.

B) If so, the norms adopted for the purpose and the extent of deficiency notice, state/UT-wise

Geo-reference based soil and plant samples are collected from different districts and analyzed for micro- and secondary nutrients. Secondary and Micronutrients deficiencies are extensive in soils of intensively cultivated areas of the country and on average 32, 40, 13, 6, 4 and 20% soil are deficient on S, Zn, Fe, Mn, Cu and B, respectively. In addition, large no. of crop response trials has been conducted for Zn, Fe, B and S to verify the deficiency of these nutrients. Crop response trials are also conducted to verify the deficiency status of various nutrients.

C) The details of the scheme and projects under implementation to check the decline fertility of agriculture land and improve the fertility of soil for increasing agricultural production in the country including Chhattisgarh.

AICRP on micro and secondary nutrients is working on evaluation of micro and secondary nutrients status of soil in 15 states of the country *viz.* Assam, Bihar, Jharkhand, Odisha, Maharashtra, Andhra Pradesh, Tamil Nadu, West Bengal, Madhya Pradesh, Gujarat, Uttar Pradesh, Uttarakhand, Himachal Pradesh, Punjab and Haryana. The scheme works are executed through its centers working in State Agricultural Universities in respective state. Depending upon size of the district, about 100-500 geo-reference based soil samples are collected from each district. About 35-50 districts are covered in a year. In addition, crop response trials are also conducted to verify the status of different nutrient analyzed in soils collected from different districts. One centre under the AICRP on Micro- and Secondary Nutrients scheme is in operation at JNKVV, Jabalpur in Madhya Pradesh which earlier used to cover the area under undivided Madhya Pradesh. However, after division of states there is no centre operating in the state of Chhattisgarh.

D) The success achieved there under each of the last three years and the current year.

In last three years, soil samples from 111 districts have been collected and analyzed for available micro and secondary nutrients status. The details of deficiencies are given in table below.

Table: Deficiencies of micro- and secondary nutrient in various districts

S. No.	year	No. of districts covered	Average micro and secondary nutrient deficiency					
			Zn	Cu	Fe	Mn	B	S
1	2010-11	32	43.8	8.0	14.0	18.1	12.6	21.5
2	2011-12	23	24.8	1.6	15.7	7.2	13.4	26.8
3	2012-13	56	38.1	5.0	9.8	4.4	17.0	30.5

- During the current year 2013-14, soil samples have been collected from 45 districts of the country and analysis is in progress.
- The response to application of deficient micro- and secondary nutrients varies from crop to crop and soil. However, based on the response trials conducted on Farmers' field the response to Zinc application varies from 8 to 30% while same for Boron varied from 10 to 40%.

File No. 47/PME Cell/RTI/2014/1

Note

This is to response to the RTI application received from Shri Pavan Reddy, Hyderabad. The information on Point No. 02 is attached herewith in the form of research highlights/achievement of the institute for the desired period.

I/C PME Cell 30/06/14

Dr. R. Elanchezhian, PS & CPIO

2. EXECUTIVE SUMMARY

Soil Fertility Evaluation and Database

- District-wise nutrient database was developed. The nutrient availability per hectare of cultivated area was computed from different sources viz., farmyard manure, compost, green manure, and chemical fertilizers. The animal census data of 2003 was used in computing the manure availability from cattle and buffalo. The total availability of manure N, crop residue N, and Green manure N is 1.42, 0.216, and 0.112 mt, respectively. The total consumption of fertilizer N is 14.47 mt. This means around 10% of total N consumption is presently met by organic manures. Around 15% of P need is met by organic sources, whereas the values for K are more encouraging. Around 60% of K consumption is met by organic sources. The district-wise consumption of N, P and K, as well as the losses of N, and K were also computed. Some districts mainly in central India are spotted where nutrient budget need to be looked into and more nutrient input need to be given. The district-wise maps representing above information were prepared using GIS. A databse in MS Access has been created from where the required information for a particular district can be retrieved.

Improving Input Use Efficiency

- The efficiency of urea coated with urease inhibitor (UI) and nitrification inhibitor (NI) was evaluated in comparison to plain urea in wheat. At 100% recommended rate of N, UI-NI coated urea produced 12% higher wheat grain yield compared to plain urea, whereas, UI coated urea produced 7% higher grain yield as compared to plain urea. Nitrogen use efficiency in wheat was measured in terms of Apparent Recovery of applied N. When applied at 100% rate, the apparent recovery of applied N was 64% with UI-NI coated urea, 53% with UI coated urea against only 42% recovery of applied N as plain urea. The apparent recovery of applied N as UI-NI coated urea was 20% higher than the recovery of N from plain urea.

- Zeolites are porous crystals with the ability to exchange ions and catalyze reactions. They can be used as carriers and/or medium of nutrients. The N release kinetics was studied in a Vertisol inoculated with a natural zeolite over a period of 28 days in an incubation study. Addition of zeolite delayed the N release from the soil-zeolite system. Addition of zeolite to soil also reduced soil urease activity.

- Allwin wonder and Allwin top (patented products) are under the specialty fertilizer mixtures. A study conducted to study their efficacy on Maize indicated that application of Allwin wonder and Allwin top as separate doses along with 100% of recommended fertilizer dose increased yield of maize only to a marginal extent. However, the combination of Allwin wonder and Allwin top half of the dose used for their individual application along with 100% of recommended fertilizer dose increased maize yield up to 10% compared to the application of chemical fertilizers alone.

- Amongst the different nano rock phosphate particles, SRP II (110 nm) recorded the highest dry matter yield of soybean crop. The other plant parameters like, plant height, root length, root volume, root dry matter weight were all improved due to application of rock phosphate nano particle. By Double Stage Froth Flotation Process heavy metal concentration in the rock phosphate can be minimized up to certain level. Complete removal of heavy metals from rock phosphate is not possible by this method. The biomass yield of soybean crop harvested after 60 days of sowing was higher in nano rock phosphate applied soil in comparison to micron sized rock phosphate.

Monitoring Long Term Productivity, Soil Quality and Resilience

- Soil quality studies in on-going 37 year old long-term experiment indicated that microbial biomass nitrogen, plant-available water content, microbial biomass carbon, saturated hydraulic conductivity and dehydrogenase activity were found very important indicators in Alfisols at Palampur. In Alfisols of Ranchi, higher values of SQI and sustainability index were obtained with balanced and integrated nutrient supply system.
- In Vertisols of Akola, sustainability yield index (SYI) for sorghum and wheat was very high in 150% NPK (sorghum 0.384; wheat 0.417) and NPK + FYM (sorghum 0.378; wheat 0.397). Integration of NPK with FYM application maintained higher SQI and SYI reflecting better physical, chemical and biological health of soil. The role of microbial biomass C and N found to be overall important in making the soil quality functional.
- A field experiment was carried out to screen the indicators of soil quality of the districts Vidisha and Sehore. The master indicators explained 43.7% and 52.3% of the yield in Vidisha and Sehore, respectively. The SQI value of Sehore district ranged from 1.31 to 3.92 (with mean value of 2.57) whereas the SQI value in Vidisha varied from 1-4 (with mean value 2.19). The optimum and threshold level of oxidizable C were 9.72 and 5.14 g/kg soil in Sehore district and 13.07 and 3.23 g/kg were the values for the same in Vidisha district.
- An investigation on "Microbial Resilience of Degraded Soils under Copper Stress" was undertaken to understand the microbial resilience capacity of degraded soils under copper stress. The incubation studies revealed that Cu stress showed significant reduction in acid phosphatase, alkaline phosphatase, DHA and MBC over the control (without Cu stress). Among the various treatments, application of Charcoal + FYM showed greater recovery in DHA and MBC at the end of 12 weeks after Cu stress application, followed by FYM, Charcoal and control in Nagda soil (Saline) and Pithampur soil (Sodic).

During the period under report, field investigation was carried out on 10 farmers' fields (5 each from Sehore and Vidisha) from Kharif season of 2010, to study the soil resilience after imposing treatments with graded levels of hardwood charcoal (0, 5.4, 10.8 and 16.2 t/ha). There was marked improvement in Soybean yield due to charcoal application and the yield improvement was more pronounced in soil having low SQI value. In Sehore district, the mean yield of Soybean increased from 1621 kg/ha to 1818, 2005 and 2143 kg/ha due to 5.4, 10.8 and 16.2 t/ha charcoal addition where as in Vidisha district, the mean yield increased from 1636 kg/ha to 1724, 2000 and 2169 kg/ha due to 5.4, 10.8 and 16.2 t/ha charcoal addition, respectively. Thus the results showed that application of graded levels of bio-char resulted in yield improvement by 13.76, 25.25 and 35.54% over the treatment receiving no charcoal in Sehore district and by 5.82, 25.84 and 38.20%, respectively in Vidisha district. The results further suggested that soils with low SQI values were more resilient to external application of charcoal. The possible reasons attributed to this effect could be i) the N availability in soil is decreased due to high C:N ratio of the charcoal, ii) the availability of nutrients is higher due to increase in cation and anion retention capacity of the soil and iii) enhanced mycorrhizal infection.

Managing Soil Physical Environment

- No-tillage (NT) significantly reduced the bypass loss of water by 40% compared to conventional tillage (CT) beyond 60 cm soil depth due to lesser crack width and intensity. Soil resistance to penetration was more in CT compared to NT. Per cent water stable aggregates significantly improved in NT at 0-5 and 5-15 cm soil depth compared to CT. The profile distribution of SOC showed that maximum SOC was found at 15-30 cm soil depth in CT and 5-15 cm in NT. It was observed that the microbial activities were increased with increasing level of organic matter application. The soil microbial biomass carbon was relatively greater in NT plots (556.8 mg/kg) as compared to CT (369 mg/kg). Whereas the other parameters such as soil respiration, FDA and Dehydrogenase (DHA) were at par between conventional tillage and No-tillage plots.

- In a long-term tillage experiment, after ten cropping cycles of soybean, variations in N levels significantly influenced the bulk density (BD) of the top 15 cm soil, while below 15 cm depth the BD difference among the treatments were not significant. The BD at 0-7.5 cm depth was minimal in reduced tillage (1.20 Mg/m^3) while the maximum value was recorded (BD 1.30 Mg/m^3) under conventional tillage. The cumulative infiltration up to 300 minutes was significantly higher in no tillage, mould board tillage treatments compared with the reduced and conventional tillage treatments. Cumulative infiltration recorded at 100%N and 150%N level was also significantly higher than that at 50%N level.

- Broadband vegetation indices viz. normalized difference vegetation index (NDVI), green-NDVI, and narrow-band vegetation indices viz. normalized difference red edge (NDRE) calculated from the spectral reflectance of maize crop (cv. Kanchan101) recorded at important growth stages was used for prediction of leaf area index and biomass of the crop at different growth stages. The results showed that the NDVI is a good predictor for the leaf area index (LAI) and biomass of maize at the initial stages. GNDVI was found to be a better predictor for LAI and biomass than NDVI during full vegetation stages. However, hyper-spectral vegetative indices NDRE was found to predict LAI more accurately (R2 = 0.65) than both the NDVI and G-NDVI.

- In a long-term tillage experiment, weed density (monocot as well as dicot weeds) were the least in the mould board (MB) plough treatments and the highest in the conventional tillage (CT) treatments. The reduced tillage (RT) and no-till (NT) treatments had fewer monocot weeds than the CT because of the use of pre-emergence herbicides. The dicot weed density in the RT and NT plots was greater than the CT during 30 days after sowing whereas the differences were not significant in the later stages of crop growth. Weed seed stratification in the 20-30 cm soil depth followed the trend as: MB > CT = RT > NT. Type of tillage implement and cultivation techniques significantly impact weed seed stratification in soil as soil disturbance regimes are related to seed distribution, burial, viability and seed emergence. No-tillage systems retain sizeable quantity of weed seeds in the surface soil, whereas with soil inversion caused by mould board ploughing, weed seeds tend to distribute uniformly over the soil depth.

Monitoring Soil Chemical Parameters

- The concentration of total and extractable copper in acid soils of India varied widely. Extracted soil Cu by different extractants was well correlated with each other. Contribution of soil organic carbon towards total and extractable Cu was significant.

- Application of 1 kg Zn/ha either through Micromac (a new formulation of zinc fertilizer in the form of zinc polyphosphate) or zinc sulphate monohydrate were found statistically at par with respect to grain yield of maize in a Vertisol.

- The concentration of hot water soluble boron of 0.51 mg/kg soil was recorded as critical value of boron in neutral to alkaline soils of Punjab whereas, critical value of 29.2 mg B kg^{-1} dry matter at 45 days growth of toria in those soils was recorded.

Improving Soil Biological Condition

- The higher concentrations of active C pools such as soil microbial biomass carbon (SMBC), water soluble carbon (WSC) and acid hydrolysable carbohydrates (AHC) were observed in NPK+ FYM treated plots in Vertisol under soybean–wheat rotation at Jabalpur.

- The (POM-C) particulate organic matter fraction (% of TOC) decreased substantially from 20 -36.9 % at 60% WHC, and 2-8.6% under submerged condition. Similar trend was observed for acid hydrolysable carbohydrates indicating that active and slow pool of carbon are the sensitive pool to change with moisture and temperature.
- C-mineralization rate increased with increase in temperature from 25 to 45°C with soil moisture of 60% WHC as compared to submerged condition in all fertilizer and manure treatments during 90 days period of incubation. C-efflux was greater during April-May and July-August. However at day time it was relatively lower than evening.

Microbial Diversity and Biofertilizers

- Studies on genetic diversity of *rhizobia* of 20 major legumes initiated. 830 *rhizobial* strains isolated and tested for nodulation. Groundnut and Soybean *rhizobia* authenticated by *nif* and nod gene detection.
- Soil genomics analysis of organically farmed and pesticide polluted soils initiated. 50 clonal libraries of 16s r DNA and *nif* H genes for each soil sequenced and analyzed phylogenetically.
- *Azotobacter, Azospirillum* and PSB tolerant to high temperature and matric stress and performing well under drought stress identified.
- Biofertilizers (*Azospirillum, PSB*) improved yield of aerobic rice by 20-40% in Tamilnadu.
- Enriched mycostraw along with PGPR and cyanobacteria inoculation in farmers' field saved nitrogen and phosphorus significantly and improved rice yields by 15-32% in Bihar.
- A single medium formulated for *Rhizobium*, PSB and *Pseudomonas fluorescens* for preparation of liquid inoculants. Liquid inoculants gave highly promising results (+15% yield increase) with maize and pigeonpea in Alfisols reducing fertilizer requirement by 25-50%.
- PGPR- *Bacillus licheniformis* application improved plant health and yield of apple. PGPR *Bacillus sp.* was highly promising for Capsicum and Chrysanthemum.
- Transfer of Biofertilizer Technology to tribal districts of Orissa gave significant improvement in yield of pulses. In the North-East, biofertilizer enriched compost technology transferred through KVK's gave highly promising results in sali rice, boro rice, toria and jute.
- A complete database of the most promising PGPR (50) and rhizobia (58) for growth promotion of soybean, chickpea and wheat in Vertisols was prepared. 15 elite PGPR strains increased the soybean yield by 18% and 10 elite rhizobial strains increased the grain yield of soybean by 15% in Vertisol field.
- Based on 16s r DNA analysis, 23 PGPR identified and gene sequences deposited with NCBI. Early report of *Lysinibacillus fusiformis* as PGPR. New report of *Dyella marens* is as PGPR. First isolation of *Staphylococcus succinus* from soil.
- 5 PGPR were antagonistic to all three pathogenic fungi studied viz., *Fusarium oxysporium, Sclerotium rolfsii* and *Rhizoctonia bataticola*. Based on 16s r DNA homology these were identified as *Bacillus amyloliquefaciens, B. subtilis (3 no.)* and *B. licheniformis*. They showed early promise for checking Fusarium wilt in `sick plots' in Vertisol field.

- 10 oligotrophic bacteria from rhizosphere soils and composts identified that could survive in double distilled water for one year. They belonged mostly to Bacillus sp. were as effective as other PGPR for soybean, chickpea and wheat in Vertisols.

- Diversity analysis of chickpea rhizobia in Vertisols showed that they fell into 3 clusters at 54 % level of similarity. Diversity analysis based on utilization of carbohydrate sources was more discriminatory as compared to intrinsic antibiotic resistance (IAR). The most effective strains (83%) fell in the major cluster.

- The chickpea growing soils of M.P. had sufficient population of native rhizobia (MPN 1600- 4100 cells/g soil) showing the need for identifying competitive strains from among the local isolates.

- Three effective rhizobial strains identified for chickpea in Vertisols that can increase yields by 25-40% and fix 32-52 kg/ha of additional N over native rhizobia.

- Inoculation of Rhizobium and PGPR resulted in significant increase in nodulation and yield of chickpea along with improved soil health as evident from increased population of free living, heterotrophic N fixers and acid phosphatase activity in soil.

- Microbial mediated bioreduction of terminal electron acceptors in tropical soils of long term agroecosystem are affected by the type and dose of fertilizer application. Inorganic fertilizers applied alone and/or with organic amendments regulate the microbial metabolic processes differentially under anaerobiosis.

Biofortification

- An experiment was conducted for Zn biofortification of 15 varieties each of sorghum and finger millet crops. Overall, the Zn foliar application found to be superior in terms of plant height, photosynthetic pigments, nitrate reductase activities, and root volume. Further, the pre-flowering stages are more responsive than the post-flowering stages in both the crops. Among the two crops, the finger millet seems to be more sensitive than the sorghum.

Amelioration of Contaminated Soils

- Long term application of NPK+FYM moderated the soil reaction (pH) of Jabalpur LTFE centre and pH was maintained at 7.44. The recorded EC value in the soil of LTFE did not show any significant change irrespective of treatment and depth. All the enzymatic activities like acid phosphatase, alkaline phosphatase, FDA etc. showed the highest activity in surface horizon of the soil treated with 100% NPK + FYM.

- Among different varieties of tuberose, Prajwal tolerates up to the highest level of Cr i.e., 200 mg kg^{-1} soil while the varieties like Shringar and Mexican single tolerate up to 50 mg kg^{-1} soil.

- Cr affected tuberose plant by delaying the seedling emergence. Cr up to 10 mg kg^{-1} soil didn't affect but at 25, 50, 100 and 200 mg kg^{-1} soil delayed emergence significantly resulting in stunted growth. Among the three varieties, the variety Prajwal recorded the highest total dry weight and the highest photosynthesis rate than Shringar and Mexican single varieties. The data on the partitioning of Cr in different plant parts revealed that the highest concentration of Cr was found in roots followed by shoot and flower.

- A study was conducted to investigate the effect of treated and/or untreated effluents coming from textile industries in up-stream and down-stream of Bandi River, Pali (Rajasthan) on soil and groundwater bodies. Groundwater from downstream villages was highly saline and had high Na as compared to upstream villages.

Copper, Pb, Cr and As concentrations in groundwater of several downstream villages were above the permissible level for drinking water. The soils cultivated by using contaminated well waters developed high salinity.

- A study was conducted to investigate the effect of acidic industrial effluent generated by industries of Korba city (Chhattisgarh) on soil quality of agricultural land in nearby Kharmora village. Water samples from several locations had high Cd and Cr content, beyond the permissible level for drinking water. Soils irrigated with effluent were highly acidic, saline and contained high amount of heavy metals Cr and Cu.

Recycling and Rational Usage of Different Waste in Agricultural Soils

- A study was conducted to determine screening levels of Cd, Cr, Cu, Ni, Pb, and Zn for a susceptible soil amended with municipal solid waste compost following a widely recommended soil test procedure involving the extraction of these heavy metals with a dilute calcium chloride solution. Soil test screening levels were determined through three different approaches, namely, 'phytotoxicity', 'food contamination,' and 'soil microbial activity diminution'. The lowest values of these soil test screening levels of the heavy metals determined by three different approaches were considered to be protective for all target organisms and were found to be: 0.003 mg kg^{-1} Cd, 0.052 mg kg^{-1} Cr, 0.637 mg kg^{-1} Cu, 0.022 mg kg^{-1} Ni, 0.008 mg kg^{-1} Pb, and 3.800 mg kg^{-1} Zn.

- Study was carried out to quantify the limits of Cd, Cr, Cu, Ni, Pb, and Zn levels permissible in soil, which would help in protecting animals, plants, and microorganisms. Maximal protective concentration limits of these metals were determined in the soil through three different approaches, namely, 'phytotoxicity', 'food contamination,' and 'soil microbial activity diminution'. Considering the lowest values of these maximal permissible soil concentrations of the heavy metals determined by three different approaches to be protective for all target organisms, these levels were found to be: 392 mg kg^{-1} Zn, 179 mg kg^{-1} Cu, 0.34 mg kg^{-1} Cd, 81 mg kg^{-1} Pb, 30.7 mg kg^{-1} Ni, and 31 mg kg^{-1} Cr.

Organic Farming

- Application of 100 % NPK along with FYM not only resulted in improvement in the nutritional quality such as protein, tryptophan (amino-acid) and nutritionally important microelements in wheat grains but also improved the 100-grain weight of wheat in both the LTFE wheat grain samples.

- Organic farming practices recorded the highest soybean seed yield which was 22.4% higher than the inorganic management practices. The incessant rains and cloudy weather aggravated the insect problem and there was a drastic reduction in over all soybean yield in the year 2010.

- Nutritional quality constituents' viz. protein and oil contents were better in the organic farming practices than inorganic management practices but was at par with integrated nutrient management. However, total ash, methionine and tryptophan contents in seeds were not affected significantly among the nutrient management practices.

- There was higher available N and K under soybean-wheat cropping system when Panchagavya, Biodynamic preparations and organic manures were applied together, while under maize + cowpea-gram system, application of panchagavya preparations with organic manures registered higher post harvest soil N content.

Crop Adaptability to Climate Change

- Land use largely determines the potential for soil organic carbon storage and ultimately C sequestration in soil. The forest land use system having the maximum amount of soil organic carbon mineralized significantly more of native soil organic carbon in comparison to other land use systems. Soil carbon mineralization followed direct relationship with initial soil carbon content. Residue carbon mineralization in soil was observed to be the function of soil initial carbon content, microbial biomass, carbon in labile pool and prevalence of substrate specific soil heterotrophs.

- Among the 10 soybean varieties, most of them are very much sensitive to the sudden change in soil moisture and atmospheric temperature. But all the varieties in the first sowing plots thrived well compared to the second sowing plots. It was found that those short duration varieties surviving better by utilizing the soil moisture and giving good yield. As the time of sowing extended the available moisture in the soil will be less to support the proper plant growth under non-irrigated condition and this may lead to drastic decrease in the yield.

On-farm Research and Impact Assessment

- The assessment of qualitative parameters for categorizing different degrees of soil quality to enhance the soil health and productivity based on soil physical, biological and chemical properties involving simple, low cost, farmer-friendly methods, in participatory way was conducted. Total 12 parameters of soil quality assessment comprising of soil physical, biological and chemical parameters were determined in selected farmer's fields using low cost farmer friendly tools. The weighted average values of three parameters as assessed in the field, organic manure based farming was in 'Good' category of soil health followed by integrated farming system that recorded 'Fair' category overall.

2. EXECUTIVE SUMMARY

Soil Fertility Evaluation

- Application of either NPK+ farm yard manure (FYM) or FYM alone increased the carbon content of resistant pool (bio-chemically stabilized carbon) of soil organic matter (SOM) in both Vertisol and Alfisol. Long-term application of chemical fertilizer (NPK) alone did not influence the carbon content of resistant pool of SOM in Alfisol whereas it was significantly increased in Vertisol. Chemical fertilization significantly increased the carbon content of slow pool of SOM in Alfisol.
- Availability of N in soil was well correlated with the amount of carbon in the acid-hydrolyzable pool ($R^2=0.64, p=0.01$) rather than total soil organic carbon content ($R^2=0.12, p=0.01$).
- A universal relationship between Walkley Black carbon (WBC) and total organic carbon (TOC) was established, thereby eliminating the use of TOC/CHNS analyzer for soil TOC determination. A user friendly visual basic model was also developed for predicting soil carbon and nitrogen pools with simple measurable parameters (WBC, silt + clay and mean annual rainfall). The model was calibrated and validated by samples collected from different agro-ecological regions of the country.
- Soil carbon mineralization from different aggregates had a significant ($r=0.60$, $p=0.05$) positive relationship with their oxidizable soil carbon content. Residue carbon mineralization in different aggregate size classes was inversely related to aggregate oxidizable soil carbon content ($r=-0.95$, $p=0.01$), cumulative soil carbon mineralization (r=-0.89, p=0.01) and resistant soil carbon pool ($r=-0.80, p=0.01$). Residue carbon mineralization in different aggregate size classes was also inversely ($r=-0.61, p=0.05$) related to the active carbon content ($KMnO_4$ oxidizable carbon) of the aggregates.
- Among different INM interventions evaluated at different locations in Nagaland, revealed mean paddy yield between 4.63t $ha^{-1}$and 6.02 t ha^{-1}. Application 50%NPK+5 t FYM + Green manuring/PSB/Azolla resulted in highest yield at most of locations.
- The Nagaland state registered a very limited use of fertilizers (2.5 kg ha^{-1}) but at the same time availability of nutrients such as N, P and K from all possible organic sources was 1.72, 0.39 and 1.49 thousand tonnes only against the crop removal of 13.5, 2.78 and 8.85 thousand tonnes, respectively.

Improving Input Use Efficiency

- The morphology and elemental composition of zeolite samples were studied through scanning electron microscope equipped with EDAX. Natural zeolite sample had a tubular assembly while synthetic one had cube assembly. Composition of zeolites was ascertained through EDAX. Natural zeolites had a Si/Al ratio of 3-5, (acidic zeolites) while synthetic had a value lesser than one.
- The combination of Allwin wonder and Allwin top as half of the dose used for individual application along with 100% of recommended fertilizer dose increased maize yield up to 10% higher than the application of chemical fertilizers alone.
- Application of nano rock phosphate particles SRP II (110 nm) increased the dry matter yield of rice and soybean and also enhanced the enzyme activity like nitrate reductase, and phosphatase.

- The Zn nano particle can be loaded up to 1000 ppm in seed through Zn_{Metal} (<50 nm) and 1330 ppm through ZnO (<100 nm) without any toxic effect on plant growth. \
- The supply of K, Mg and S through either of the sources, i.e. Patentkali and standard sources could not make any difference in yield response. The economic response was less when K, Mg and S were supplied through Patentkali in potato-garlic, rice-cowpea and maize-wheat cropping systems as compared to standard sources.

Monitoring Long Term Productivity

- The long term fertilizer studies at different LTFE locations indicated higher microbial count, biomass and enzymatic activities under NPK either alone or along with FYM or lime. The N balance calculations made in soybean-wheat system at Jabalpur clearly demonstrated that soybean fixed 98 to 238 kg N. Out of this, added 24 to 66 kg biologically fixed N per hectare to soil subsequently met the N requirement of wheat to some extent.
- Biological studies conducted under LTFE at different locations indicated that irrespective of soil, application of fertilizer resulted in increase in soil microbial population (bacteria, actinomycetes and fungi). Incorporation of FYM along with fertilizer, further enhanced microbiological activities in soil which resulted more turnover of nitrogen, phosphorus and other nutrients and ultimately resulted in improvement of soil quality and productivity.
- A field experiment carried out to study the resilience capacity of Vertisol of AESR 10.1 showed that the loss of soil quality as compared to respective pristine soil is different in different sites. After imposition of interventions, SQI values were improved in each site. The mean resilience index increased gradually from 39.28% to 68.78%. It was further observed that in of the ten sites the value of resilience index ranged from 28.12 to 68.78 % which resulted in gain in soybean yield ranging from 264 to 442 kg ha^{-1} and gain in succeeding wheat yield ranging from 103 to 815 kg ha^{-1}.

Managing Soil Physical Environment

- The LAI, biomass values of maize crop showed distinct variations among the different N levels. LAI reached the highest value at 55 days after sowing and was significantly higher in 100% and 150% than that in 0% and 50% doses of nitrogen.
- The NDVI was found to be a good predictor for the LAI and biomass yield of maize at the initial stages compared to the other vegetation indices like GNDVI but during the full vegetation stage (when LAI value exceeded the value 1.7), GNDVI was found to be a better predictor for LAI and biomass than NDVI.
- In a long term tillage experiment, imposition of different tillage treatments significantly influenced the bulk density of the soil during the soybean growing season, but nitrogen level had no effect on it.
- Different tillage treatments like mould board plough (MB), conventional tillage (CT), reduced tillage (RT) and no tillage (NT) did not show any significant effect on soybean yield in Vertisol.
- Cultivated fallow resulted in maximum runoff and soil loss. Among the sole crops, pigeon pea resulted in the highest runoff and soil loss while soybean recorded the lowest. In case of intercrops, the highest run off and soil loss was in maize and pigeon pea (1:1) and the lowest in soybean + pigeon pea (2:1).

- Amongst the soybean based cropping systems, soybean+ cotton (2:1) recorded significantly higher weed biomass as compared to other systems. However, maize–gram recorded higher weed biomass than soybean based cropping system. Although, population of broad leaved weeds were less under reduced tillage (RT) due to herbicide spray, grassy weeds were found to be more.
- Different cropping systems had clear effect on leaf litter addition to the soil and also on crack volume. Among cropping systems compared, soybean + pigeon pea (2:1) recorded the highest leaf litter addition followed by soybean + cotton (2:1) and soybean-wheat systems. Maize–gram system recorded the highest crack volume among the six cropping systems. Reduced tillage (RT) recorded higher leaf fall/crop residue addition than conventional tillage system.
- Maximum root length density (RLD) was observed at flowering stage (R1) for soybean cultivars. Long duration cultivar (JS335) was having higher RLD compare to shorter duration cultivar (JS 9305) because that RLD is the function of vegetative growth, hence a variety having longer vegetation period will have higher RLD.

Monitoring Soil Chemical Parameters

- In Ranchi and Bhubaneswar soils, addition of FYM and Zn significantly increased DTPA extractable Zn. Concentration of zinc in plant increased with increased levels of FYM and Zn and decreased with increased levels of lime application.

Improving Soil Biological Condition

- The CO_2 emission was relatively greater in macroaggregates (250-2000 μm) followed by micro aggregates (53-250 μm) and mineral associates (<53 μm) at 25, 35 and 45°C. Temperature affected C mineralization rate and it depended upon source and amount of substrate applied.
- Balanced fertilization (100% NPK + FYM) under LTFE improved the nutritional parameters such as protein, amino-acids, micro nutrient content of soybean seeds and 100-seed weight of soybean samples.

Microbial Diversity and Biofertilizers

- Genetic diversity of soybean and groundnut rhizobia was characterized. Salt tolerant (10% NaCl) rhizobial isolates made for groundnut in Kutch.
- In Vertisols of Guntur, usage of chemical fertilizers and pesticides at twice the recommended dose in blackgram- rice had no adverse effect on microbial counts, nutritional and functional groups, soil enzymes, 16s rDNA and *nifH* diversity.
- In an alfisol, the abundance and relative ratio of eubacterial communities remained unchanged due to long term chemical fertilization. Proportions of Actinobacteria and Acidobacteria increased due to long term organic manuring.
- Soybean rhizobia (R 33) and chickpea rhizobia (R 40) showed nodule occupancy of 52-56%. Soybean was nodulated by both soybean and chickpea strains. But chickpea was nodulated by only its own strains. Inoculation of the best combination of rhizobia and PGPR increased soybean seed yield (28%) in Vertisols.

- Majority of actinomycetes from arid and semi-arid regions were *Streptomyces* (61%) and *Nocardia* (29%). About 2/3rd of the isolates were effective in promoting growth of maize while 1/3rd were ineffective.
- Microbial based bionutrient package for rice improved grain and straw yield by 11-23% and fertilizer use efficiency by 5 -10% in small and marginal farmers fields in Bihar.
- Biocontrol agent *Bacillus lichiniformis* application in root rot infested apple orchards led to rejuvenation of plant health and vigour and improved fruit yield by 43 to 70%.
- FLD's with biofertilizers as integral component of INM practice in tribal areas of Odisha brought highly significant improvement in yields of local potato, cowpea, maize, greengram, arhar and garden pea over farmer's practice.
- Relative abundance of soil biota was greater in Bt- cotton than non-Bt cotton cropping system. Glomalin content in Bt- cotton-soybean was higher (123 ppm) than Bt-cotton-wheat cropping system (56 ppm). Soil biological population was significantly correlated with water soluble carbon, acid hydrolysable carbohydrates and total organic carbon content of soil indicating that higher soluble phase of carbon enhanced rhizospheric microbial population.

Biofortification

- The highest zinc content in grain was observed in CSV 21 F and Pant chari 3 of sorghum cultivars, and Paiyur 1, MR 1 and MR 6 of millet cultivars.

Amelioration of Contaminated Soils

- A study was carried out to assess the impact of continuous fertilization on heavy metals, and microbial diversity in soils under long term fertilizer experiment. Application of NPK+FYM moderated the soil reaction (pH) at barrackpore centre. The highest value of acid phosphatase, alkaline phosphatase, FDA and DHA activity was recorded in surface horizon with 100% NPK + FYM, application.
- Higher microbial biomass carbon was observed in treatments where balanced fertilization/FYM was practiced.
- Fertilizers contain heavy metals in varying quantity. Amongst the fertilizers, SSP and DAP supply higher quantity of Pb, Cr, Ni and Cd. FYM also contains higher quantity of Cr (14.25 ppm) and Ni (51.75 ppm).
- The potential of three varieties of tuberose (Prajwal, Shringar and Mexican single) for phytoremediation of soil contaminated with cadmium to a level of 100 mg kg^{-1} soil revealed that Cd did not exhibit any toxic symptom in all the three varieties of tuberose. Tuberose possessed the typical ability of Cd hyper accumulation as (1) 100 μg Cd g^{-1} DW accumulated in the shoots that exceeeds the critical judging standard, and (2) the ratio of Cd in the shoots to roots was > 1. Cultivation of tuberose may be advocated for phytoremediation of cadmium in polluted soils.

- Mean concentration of all heavy metals was minimum in the biggest size fraction (i.e., > 500 μm) and maximum in smallest size fraction (i.e., 10 - 75 μm) of MSW compost.
- Heavy metals contents in the smallest size fraction of compost prepared from BWC were lower as compared to those prepared from partially segregated wastes or mixed wastes.
- The proportions of the total heavy metals (except Cd) extracted by HCl were more where MSW composts were prepared from either mixed wastes or partially segregated wastes as compared to those prepared from segregated biodegradable wastes.

Organic Farming

- Cultural diversity of different group of microbes (bacteria, fungi, actinomycetes, aerobic nitrogen fixer, solubilizers and Pseudomonas) were estimated from panchagavya, BD500 and cow dung manure treated soil revealed that population of plant growth promoting bacteria like aerobic nitrogen fixer, P solubilizers and pseudomonas were found to be the highest in panchagavya.

On-farm Research and Impact Assessment

- Seed yield of soybean at different farmers' fields varied significantly among various treatments. The highest seed yield of soybean was recorded with vermicompost treatment followed by enriched compost, farmer's practice and the lowest with 100% NPK. However, seed yield of wheat did not vary significantly between vermicompost and enriched compost treatments but it varied significantly between farmer's practice and 100% NPK treatment.
- The fertilizer prescription equations developed by different centres for profitable use of fertilizers based on soil test values demonstrated through various multi-location / verification follow up trials as well as front line demonstrations revealed that jute targeted yield (35 and 40 q ha^{-1}) was achieved within (+) 2.10 to 4.17 per cent yield deviation without FYM and 7.62 and 7.50% with FYM (@ 5 t ha^{-1}.
- Targeted yield (40 and 50 q ha^{-1}) of rice without FYM application was achieved within (+) 2.10 to (-) 1.11 per cent yield deviation while with FYM @ 5 t ha^{-1} it was (+) 11.1 and 4.3%. In case of wheat, the targeted yield of 55 q ha^{-1} was achieved within ± 5% variations.
- Test verification trials conducted with pigeon pea, paddy, field pea, gram and wheat in montmorillonitic hypothermic *Typic Hapulustert* deep black fine soil showed greater benefit of STCR technology over fertilizer application as general recommended dose or farmers' practice.
- Under long term STCR-IPNS demonstration, jute-rice-lentil sequence on alluvial soil at Barrackpore showed an average response ratio of 21.0, 19.6 and 19.1 kg kg^{-1} over blanket (17.6 kg kg^{-1}) and FP (15.3 kg kg^{-1}).
- Pearlmillet - wheat sequence on a *Typic Haplustept* soil at Delhi showed depletion of available N, P and K after pearlmillet in organic alone as well as control treatment.
- In maize-wheat cropping sequence, wheat yield under IPNS and non-IPNS situations were 25 and 35 q ha^{-1}, respectively which was within $\pm$10% of target yield. The highest net benefits over control under prescription based fertilizer applications using IPNS equations was Rs 34344 ha^{-1}.

- Front line demonstrations conducted with oilseed crops (gingelly, groundnut, linseed, mustard, niger, soybean, sunflower, toria) showed distinct superiority of STCR-IPNS recommendations over blanket and farmer's practice in respect of yield, net returns and B : C ratio.

2. EXECUTIVE SUMMARY

Theme I: Soil Health and Input Use Efficiency

Soil Fertility Evaluation

- GPS and GIS based soil fertility maps of 152 districts of India showed that almost all soils of the districts of North, South, East and West zones are deficient in available N. In **North Zone**, majority of the soils are medium to high in available P and available K status. In **West Zone**, majority of the soils are low to medium in available P. In **East Zone**, most of the area is low in available P. Micronutrient fertility maps showed that almost all soils of Punjab, Haryana, and Himachal Pradesh in North Zone are high in available Zn.
- The 24698 surface soils and 840 plant samples covering 62 districts of various states, showed wide spread micronutrients deficiency by an average of 37.7, 2.57, 8.50 and 7.50 % soil samples deficient in Zn, Cu, Fe and Mn, respectively.
- A new soil carbon and nitrogen prediction model has been developed by using the soil and crop dataset of long term fertilizer experiments of India. Soil carbon and nitrogen prediction model is controlled primarily by net primary production (yield), mean annual rainfall and temperature, texture (sand, silt, clay content), bulk density and soil initial carbon content. Soil carbon and nitrogen prediction model uses a yearly time step and the users have to define only initial soil carbon content The model itself determines the relative allocation of carbon in different pools. Model assumes soil carbon sequestration rate is the function of soil carbon content, net primary productivity, soil texture, rainfall, temperature and C: N ratio of residue. The model automatically computes the carbon and nitrogen turnover based upon these parameters and model outputs are displayed in excel sheet.
- A three years field study showed that the biophysical parameters like, leaf area index and biomass growth in maize could be predicted through broadband vegetation indices viz. normalized difference vegetation index (NDVI), green-NDVI, and narrow-band vegetation indices viz. normalized difference red edge (NDRE). However the prediction could be improved by using the soil reflectance line developed for Vertisols. Double-peak canopy nitrogen index calculated from the spectral reflectance in maize could predict 71% variability of nitrogen content in maize leaf.
- Spectral reflectance from the bare soil at different moisture contents ranging from 15 to 32% was measured during the winter season. Analysis of data clearly showed that with increase in moisture content spectral reflectance from the soil decreased monotonically at all wavebands.
- Pyrolysis conditions were standardized for preparation of biochar from different feedstocks viz. subabool (*Leucenea leucocephala*) and mustard (*Brassica campestris*). Preparation of biochar was done at 1, 2 and 3 hr duration at temperature ranging between 250 and 400°C for subabool. Biochar recovery for three different size classes did not vary much at similar temperatures. However there was a sharp decline in the recovery of biochar from subabool feedstock with increase in temperature up to 400°C. Therefore, keeping other issues aside the higher proportion of total carbon that may be converted into resistant fraction through biochar could be obtained at lower temperature. Almost

similar trend has been observed with respect to total N, P and K.

- The soil from Trivandrum was used for P sorption studies and was equilibrated with different levels of P. After equilibration, the soil solution P increased with increase in P concentration from 0 to 39.34 μg/mL and the adsorbed P ranged between 0 and 606.63 μg/g.

Improving Input Use Efficiency

- An incubation study was conducted to understand the sorption of zinc on zeolite with zeolite concentrations of 0, 0.1, 0.25, 0.5 and 1% weight of soil for 15 days at room temperature. The zinc sorption studies have shown that the sorption of zinc would continue beyond 15 days due to the complex soil system. Whatever be the dose of zeolites used in the soil system, it was found that the zinc retention increased up to 15 days although not linearly after 5 days. However, a zig-zag pattern of retention was found during the study period which might be due to the presence of various other competing ions in either soil or zeolites system.
- Field experiment was conducted to evaluate the efficacy of different nano rock phosphates, taking maize as a test crop. Results showed that crop utilization of P from nano rock phosphate was at par with that of P from SSP while yield response to P from nano rock phosphate was marginally lower than the P from SSP.
- A protocol was developed to coat the seeds of maize (*Zea mays L.*), soybean (*Glycine max L.*), pigeon pea (*Cajanus cajan L.*) and ladies finger (*Abelmoschus esculentus L.*) with micron scale (<3 μm) and nano scale (<100 nm) ZnO powder @ 25 mg Zn/g seed and @ 50 mg Zn/g seed. The most important advantage of seed coating with ZnO (both micron/nano scale) is that it did not exert any osmotic potential at the time of germination of the seed, thus, the total requirement of Zn of the crop can be loaded with the seed effectively through nano scale ZnO particle.
- The greater effect of Mo stress was observed on seed number and seed weight plant^{-1}, which was reduced by 24 and 22%, respectively. Nitrate assimilation, studied using nitrate reductase indicator decreased by 23% under no Mo supply as compared to adequate Mo supply through Hoagland solution.

Monitoring Long Term Productivity

- In general, the carbon content in aggregates decreased with the decrease in the size of the aggregates. The results suggest that higher carbon input to soil increases carbon content of mineralizable pool and resistant pool in light and heavy textured soil, respectively.

With intensive and continuous cultivation of crops gradually micronutrients are gaining importance in terms of their supply. In long term experiments it is observed that amongst the micronutrients, Zn cation was found highly deficient in different pockets of country. To be specific Zn level has gone below critical limit at Pantnagar (Mollisols), Jabalpur (Vertisols) and Akola (Vertisols). Available status of Cu, Fe and Mn is in sufficient range in soils and crops are not expected to suffer in near future. Application of organic manure (NPK+FYM) irrespective of quantity and location improved available status of Zn, Cu, Fe and Mn. As fertilizer could be one of the sources of heavy metal contamination, data indicated that there is no alarming level of heavy metal contamination in soil.

- Balanced application of nutrients (100% NPK + FYM) improved the nutritional quality constituents such as protein, amino acids and nutritionally important protein fractions in wheat grains and protein, S-containing amino acids and chemical score value of amino acids in soybean seeds, besides improving the 100-grain weight of both the wheat and soybean samples.

Soil Quality and Resilience

- The index properties viz., plasticity, maximum dry density, optimum moisture content and strength characteristics like reduction in Californian Bearing Ratio (CBR) may be attributed to the water holding capacity of the soil subjected to load. Maximum dry density of all the soils increased while optimum moisture content reduced under heavy compaction as compared to light compaction. The soil is having better physical resilience in Alfisol than Vertisol and Inceptisol.
- Utilizing the database generated on different physical, chemical and biological attributes of soils of eight targeted districts, a software program (stand alone) for "Site Specific Soil Information System" has been made in which there is a facility where the user or decision maker is able to derive all information of the geo-referenced field (Latitude and Longitude) with respect to different physical, chemical and biological attributes within the domain of eight studied districts. Generation of soil related information for a geo-referenced specific site using this software within the domain of a specified district is very rapid, less expensive and helps the user or decision maker to design/adopt suitable soil management techniques for higher productivity of the crops.

Biofortification

- Efficient cultivars were capable to translocate more Zn to the grain from vegetative parts of the plant than that of direct translocation from the soil. Under nutrient stress conditions the rhizospheric activities were more in inefficient cultivars than that of nutrient sufficient conditions. Efficient varieties were able to absorb/ translocate adequate amount of nutrients as per their need in both nutrient stress and nutrient adequate situations. The carbonic anhydrase activity decreased from pre anthesis to post anthesis stage in case of inefficient cultivars while there was no change in efficient cultivars.
- The foliar application was found to enhance the Zn content in grain in finger millet, while soil and foliar combined application enhances in the sorghum by over 10%. By analyzing the Zn content, the varieties were divided into low, medium and high Zn content. For finding the mechanism the higher zinc content varieties have shown the positive correlation with thiol group (-SH), higher amino acids secretion, but not with phenolic content in phytosiderophores exudates, implying the binding capability of these compounds for zinc. Further the phytate content and phytase activity of the harvested grain did not show any change in phytase activities or phytate content. However, genotype difference was observed among low, medium and high zinc efficient varieties. There was increasing trend among phytate/phytase activitiés from low to high zinc varieties.

Theme II: Conservation Agriculture and Carbon Sequestration *vis a vis* Climate Change

Conservation Agriculture and Climate Change

- After 20 years of cultivation with rice-wheat cropping system the active pools of carbon viz., microbial biomass carbon, water soluble carbohydrates and acid hydrolysable carbohydrates were substantially improved with regular application of 50%NPK + 50% N through crop residues.
- The particulate organic matter carbon (>53-μm) in the cultivated soil comprised 10 to 20% of total organic carbon (TOC) and particulate organic nitrogen PON-N comprised 3.2 to 4.6% of TN. Twenty years of continuous cultivation with NPK+CR improved the POM-C and POM-N by 18.4% and 23.4% over 100% NPK treatment.
- The humus is most recalcitrant fraction of TOC and it was substantially lowered in inorganic fertilized plot as compared to organic in combination with inorganic treatment.
- After 32 weeks of laboratory incubation at 25°C temperature and 60 % MHC the particulate organic matter carbon was reduced by 12- 34 % over initial value.
- Further it was observed that soil biological activities were relatively greater under 60 % MHC as compared to submerged condition.
- The APSIM model predicted LAI, total biomass and grain yield of soybean and wheat very well. The error in prediction of days to flowering and date to physiological maturity for rain fed soybean were in the range of +1 to -1 days, of observed dates. Similarly, the error in model prediction of days to 50% flowering and date to physiological maturity for irrigated wheat were in the range of +1 and -1 days, of observed dates. Hence it was established that the APSIM soybean and wheat modules were able to simulate the observed days to 50% flowering, physiological maturity, total biomass produced and grain yield reasonably well for central Indian conditions in this parameterization study.
- The organic carbon content showed a trend of decreasing content with increasing depth. The available nitrogen, phosphorus, potassium, microbial biomass carbon (SMBC) and DHA also followed the similar trend. Reduced tillage recorded the highest number of weeds and total weed biomass (g/m2) than other tillage treatments. From the available data, it is inferred that CO_2 emissions were higher under conventional tillage (CT) followed by no-tillage (NT) and reduced tillage (RT) during end of Kharif crop harvest. Similar trend was observed under CT for N_2O.
- To screen the nutrient use efficient varieties of soybean, 10 high yielding varieties were screened in the field, of which four were identified to perform in optimum and adverse condtions (JS 335, JS 9560, JS 9305 and JS 9752) were selected to study their phosphorus use efficiency under two conditions (optimum and adverse) in the field. It was found that JS 9752 was performing well under STCR+ 2% KNO_3 spray in both sowing conditions where as JS 335 performed better under organic farming treatment. However, JS 9305 and JS 9560 performed well under INM.
- Under Gram, it was found that the treatment INM (50:50) recorded the highest yield in all varieties except one (JG 16). This indicated that the best nutrient management practice for JG 11, JG 315 and JG 218 could be INM (50:50) for high yield target. The variety JG 16 recorded the highest yield for organic farming treatment and other best management practices for this variety recorded lower yields

than organic treatment. Under late sowing conditions organic farming treatment recorded the highest yield in all varieties.

- Effect of tillage and manure on soybean productivity and soil properties was studied after five years of soybean-wheat cropping. In general, relatively higher grain and biomass yield were measured in Reduced Tillage (RT) than No Tillage (NT) treatments. The tillage methods and FYM rate had a significant effect on soil penetration resistance (MPa), which decreased from 0.87 to 0.05 and 0.09 to 0.07 under NT and RT respectively, with increase in FYM rate from 0 to 6 Mg ha^{-1} at 5 cm soil depth. Effect of FYM was more pronounced in no tillage compared to reduced tillage on soil physical properties such as infiltration, penetration resistance and soil aggregation.
- Amongst commonly observed weeds *Digitaria sanguinalis* was highly competitive with soybean. Studies on weed seed bank indicated that most weed seeds remain in top 0 to 5 cm of the soil in no till and reduced tillage systems. These weed seeds germinate and emerge more readily than those buried deeper by mould board (MB). Average yield of soybean was in ascending order as NT (no tillage) < CT (conventional tillage) < MB < RT (reduced tillage) across the weed controlled treatments. Thus, NT system recorded the lowest soybean yield probably due to more perennial weeds which competed for space, light and moisture.
- The study of plant roots is one of the most promising, but least explored areas of research related to plant growth. The root length density (RLD) was progressively increased from sowing to flowering in both cultivar and both the tillage systems (CT and NT) and the maximum/highest RLD was observed at the flowering stage (R1) followed by the pod-setting/filling (R3). It has been also observed that conventional tillage enhances the root development of chickpea. These differences are attributed to higher soil temperature and water availability during the flowering and grain-filling stages under conventional tillage compared with No-Tillage. Any cultivar which invests more dry matter to root would be more drought resistant. Analysis of root: shoot biomass ratio indicates that JG 130 is more drought resistant than the JG 11.
- The present study was carried out to assess the impact of crop covers on soil and nutrient losses through run off in vertisol. The trend of runoff and soil loss was in the order of cultivated fallow > pigeon pea > maize > maize+pigeonpea > soybean + maize > soybean + pigeon pea > soybean. Among the sole crops, the reduction of runoff and soil loss was the highest under soybean and the lowest was under pigeonpea crop but in case of intercrops, soybean + pigeon pea (2:1) recorded the highest reduction of runoff and soil loss and the lowest was in maize +pigeon pea. Among the crop covers treatments, the maximum nutrient losses were recorded under sole crops namely maize and pigeon pea and the lowest was in soybean crop and intercrops.

Theme III Micrbial Diversity and Genomics

Microbial Diversity and Biofertilizers

- Microbial diversity varied significantly among the treatments - Control, NPK % and NPK 100% +FYM were represented with 16, 12, and 30 unique ribotypes (fragments). FYM treatments were dominated by *Bacillus cellulyticus, Geobacillus, Rhizobium and clostridium*. Treatment comprising NPK 100% was dominated by *Methylobacter, Ralstonia, Chloroflexi,* and *Nitrospira* sp. While the unamended control soil was predominated by *Arthrospira, Paenibacillus, Clostridium* sp, and many uncultured soil bacterium.

- Microbial diversity and their response to ecological attributes were emphasized through series of lab and field experiments. CH_4 oxidation activity and CH_4 driven redox metabolism during sequential reduction of soil was characterized in vertisol. CH_4 oxidation was stimulated during NO_3, Fe^{3+} reduction but was inhibited during SO_4 reduction stage. Process of cycling of electron acceptors and their role in CH_4 oxidation in vertisol was elucidated with series of experiments. This finding has potential application in bioremediation of toxic pollutants as well as to enhance nutrient use efficiency in select crops grown under higher soil moisture regime. Another experiment was carried out to define microbial diversity in long term fertilizer experiment. It revealed that FYM amendment exhibited higher microbial diversity than inorganic treatments amended soil concluding the relevance of soil fertilizer management towards regulating microbial diversity.
- Green house gas (CH_4 and N_2O) emission from different compost systems comprising vermicompost, phosphocompost, poultry manure and farm yard manure were quantified using static chamber method. Microbial populations involved in greenhouse gas (GHG) cycling processes were quantified by enrichment techniques. Result confirmed that composts vary in the GHG emission activity due to chemical composition and microbial activities. We have identified the composts emitting high and low GHG emission, and defined the linkage of compost properties and microbial population change to elucidate the GHG emission potential of composts.
- The relative abundance, biological and biochemical activities were higher under bt-cotton based cropping systems than non bt- based cotton system. The beneficial microbes were found higher in case of bt than non Bt rhizosphere soil indicating no adverse effect of transgenic Bt cotton based cropping system on soil microbial activities. The restriction profile showed no difference in diversity between Bt and non Bt soil using this techniques.
- Work on diversity of 600 rhizobia of groundnut, soybean, chickpea, methi, berseem, blackgram etc. is in progress.177 isolates have been characterised for nif and nod functions so far out of 206 isolates. 341 rhizobia of clusterbean, pigeonpea, moongbean, mothbean and cowpea isolated and characterised from arid areas. All the clusterbean and pigeonpea rhizobial isolates were able to grow upto 40°C although growth of some was slightly suppressed at 40°C. However, few isolates were able to grow at even 45°C.
- Long-term (100 years) organically managed soil had higher organic and microbial biomass carbon, total culturable bacteria and Azotobacter than chemical fertilized soils but genetic diversity of Azotobacter was unaffected. The results showed the importance of continuous addition of organic manures and also the optimal use of inorganic chemical fertilizers.
- In the present scenario a number of mixed biofertilizers are being produced commercially. The quality standards for such mixed biofertilizers are under development and notification. It was concluded that King's B agar, CRYEMA and N-free malic acid medium can be used to enumerate Pseudomonas, Rhizobium and Azospirillum respectively from consortia. Jensen's agar can be used

when the consortium contains not more than one nitrogen fixer. None of the media proved to be useful for differentially counting all the members of a given consortium.

- Forty one isolates of actinomycetes were short-listed from the isolates (100 no.) made earlier on four different media and were characterized for morphological and biochemical characteristics. Among the beneficial traits; all were positive for ammonia production and 40 % were positive for urease production. All were negative for HCN production and nitrogen fixation. 50 % of the isolates showed biocontrol potential.

Recycling and Rational Usage of Different Wastes in Agricultural Soils

- Isolation and screening of lignocellulolytic thermophilic microorganisms was done from different rural and city wastes where 7 bacteria, 7 actinomycetes and 6 fungi were found positive for lignocellulolytic ability, capable of growing in thermophilic range.
- Comparative microbiological analysis showed that except panchagavya, other liquid organic preparations contain less number and groups of culturable microbes compared to cow dung manure, BD compost, BD500 or cow pat pit (CPP).

Theme IV Soil Pollution, Remediation and Environmental Security

Amelioration of Contaminated Soils

- The potential of an ornamental shrub 'Crown of thorns' (*Euphorbia milli*) was evaluated for remediation of soil contaminated with Cr. The plant could tolerate well up to 75 mg /kg of applied Cr and beyond that there was mortality of plants. Though the plant could not be classified as a hyperaccumulator, the plant was still very efficient in translocating Cr from roots to shoots as evident from the data on uptake and translocation efficiency values.
- Soil and effluent samples from the tannery industrial area of Kanpur were collected. Effluent water was more saline (2.35 to 13.15 dS/m) and high in heavy metals concentration. Effluent which is use for irrigation purpose contains Cd, Cr, Ni and As concentration more than the permissible limit o irrigation water of WHO. Soil samples were collected from industrial areas also contain higher heav metal concentration specially Cr. The soil organic carbon ranged 0.72 to 1.52 %, which is due t significant contributions from tannery effluent. The heavy metal concentration was more in groun water of industrial area specially Zn, Pb and Cr. The effluent is used for crop production i contributing a significant amount of salt as well as heavy metals in the agricultural field.
- The results indicated that the total P in the lake water collected at pre and post monsoon sample varie from 0.23 to 0.59 mg/L with a mean value of 0.41mg/L, which is higher than limit for eutrophicatio (0.2 mg/L). The mean total dissolved P (TDP), total reactive P (TRP), dissolved reactive P (DRP dissolved organic P (DOP) and particulate P (PP) were 35.42%, 24.49%, 13.12%, 10.18% ar 72.51% of TP, respectively. The total P in the sediment of post monsoon stage samples ranged fro 0.02% to 0.08% with a mean value of 0.038%. The mean sediment inorganic phosphorus (SIP) ar the sediment organic phosphorus (SOP) was 72.47 % and 27.53% of total phosphorus (TI respectively. In general total P and other P fractions in post monsoon water samples were found to

higher than pre monsoon stage. The source of water from the city and at idol immersion location contained relatively higher TP and dissolved reactive phosphorus (DRP).

On-Farm Research and Impact Assessment

- In order to backstop the soil health categories assessed by field tools, the laboratory analysis for selected quality parameters and the inference drawn tallied with that from the field methods. The weighted average values of thee parameters as assessed in the field, placed organic manure based farming in 'Good' category of soil health followed by integrated farming system that recorded 'Fair' category overall.
- Among the selected sites at Nagaland, the highest yield has been recorded in Jaluki and Kohima. Paddy grain yield among different INM interventions varied between 2.52 and 4.97 t ha^{-1} with significant improvement over the farmers practice. Variations among the INM interventions were the minimum owing to about similar amount of nutrient inputs. The influence of INM treatments on availability of major nutrients and soil organic carbon was found to be significant.
- Among the three types of compost prepared, the highest N content was recorded in vermicompost followed by enriched compost and the lowest in the ordinary compost whereas the highest phosphate content was recorded in the enriched compost followed by vermicompost and the lowest in the ordinary compost. The highest seed yield of soybean and wheat were recorded with vermicompost treatment followed by enriched compost, farmer's practice and the lowest with 100% NPK treatments at all the farmers' fields.

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

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

EXECUTIVE SUMMARY

Theme I: Soil Health and Input Use Efficiency

Soil Fertility Evaluation

- Analysis results of 63,243 geo-referenced samples from 12 states of the country Collected under AICRP-MSN revealed that 27.8% of Indian soils are deficient in available S. Among the states, 46.5% soils of delineated districts of West Bengal were low in available S, marginally followed by Bihar (46.4%), Gujarat (43.3%), Haryana (35.8%) and Uttar Pradesh (32.5%). Overall, 39.9% of 70,759 samples collected from 174 districts of 13 states across the country were deficient in available Zn. The Fe deficiency in India stayed close to 13% and that of Mn was 6.0% while Cu deficiency (4.3%) was little less than Mn.

- To determine the degree of phosphorus saturation (DPS) threshold values for crop yield and environmental pollution for the Vertisols, Inceptisols, Alfisols and Ultisols, Mehlich 3 and Ammonium oxalate extractants can be preferred along with routine soil test procedures like Bray and Olsen. The results obtained with the extractant Mehlich 3 revealed that the Inceptisol are most vulnerable for P leaching because they have the minimum environmental threshold. This is followed by Alfisol, Ultisol and Vertisol which are less susceptible to P leaching.

Improving Input Use Efficiency

- Field experiment was conducted to evaluate the dose of nano rock phosphates, taking maize as a test crop. Results showed that crop utilization of P from nano rock phosphate was at par with that of P from DAP while yield response to P from nano rock phosphate was marginally lower than P from DAP but much more economical. Experimental result of the field trial also revealed that application of nano rock phosphate @45 kgha^{-1} for maize crop was effective as @60 kgha^{-1}.

- A protocol was developed to coat the nano rock phosphate (~48.8 nm, 34% P_2O_5) with POR coated urea and experimental results showed that the coated materials are useful to coat the naked NRP and the products are promising alternatives of conventional phosphatic fertilizer for crops like wheat, maize *etc.*

- To understand the pore volume distribution patterns of fractions of Clinoptilolite, collected from St. Cloud Mining Co, New Mexico, USA, was divided into three physical fractions using mechanical sieves (fraction 1, <125 μ (Z8); fraction 2, 125-250 μ (Z9) and fraction 3, >250 μ (Z10)). The adsorption/desorption isotherms of the samples showed inverted-S-shaped curves. The micropore region of the fractions, differential pore volume distribution patterns for the three fractions have shown sharp minima/parallel to the X axis between 1.6 nm and 6 nm. There was no peak point for adsorption for the 1-2 nm region, which might be due to the artificial layering steps inherent to the theoretical isotherms causing artificial gaps on the calculated pore size distributions around 1 and 2 nm. It was found that Z9 and Z10 exhibited a sigmoid curve with peaks at 230 and 280 nm respectively.

- Long-term application of integrated plant nutrient supply modules influenced the grain and stover yield of maize. Grain yield and total dry matter yield of maize was the highest for STCR based recommended dose of fertilizers which was at par with GRD and FYM based INM modules. Maize yield of 6.85 t ha^{-1} and chickpea yield of 1.87 t ha^{-1} were achieved against the targets of 5 and 1.5 t ha^{-1}, respectively, and hence there was a need to enhance the yield target levels.

- Yield performance of wheat, mustard, chickpea and linseed under organic management practice (soybean based cropping system), performed better followed by integrated nutrient management. In organic management, the yield of all *rabi* season crops were found to be higher in 100% organic nutrient management practices than 75% organic + 25% innovative practices. In integrated nutrient management, 75% organic + 25% inorganic treatment was better than 50% organic +50% inorganic nutrient management. Among soybean varieties, RVS-2002-4 was found to produce higher yield followed by JS-97-52 and JS-20-41. In maize, variety Arawali recorded a maximum seed yield of 21 qha^{-1} while popcorn variety produced poor yield. The yield of chickpea variety JG-130 was higher followed by RVS-203 and JG-16. The yield of wheat variety GW-366 recorded maximum seed yield of 29 qha^{-1} while C-306 produced poor yield. Among the HI varieties, HI-1531 was found to give higher grain yield.
- Significant response to multinutrient application was recorded in several crops at Akola, Ludhiana, Hisar, Palampur, Jabalpur, Pusa, Hyderabad, Pantnagar and Anand. Although per cent response varied significantly with crops and nutrients. Besides Zn being the most crucial nutrient for crops, increased responses were recorded when it was applied along with S, B and Mo. Different soil specific amelioration techniques for micro- and secondary nutrients deficiency were developed successfully at all the centres of AICRP-MSN catering to the specific conditions of the corresponding state.

Monitoring Long Term Productivity

Soil Quality and Resilience

- The physical indicators of resilience *viz.* Californian Bearing Ratio (CBR) and resilient modulus values were the highest in the treatments with FYM + fly ash (2.79% and 28.88 MPa, respectively) followed by poultry manure + fly ash (2.25% and 23.28 MPa, respectively) depicting their higher strength due to addition of fly ash.
- Application of Cu stress significantly reduced the soil microbial biomass carbon and dehydrogenase enzyme activity from 0 to 6 week in un-amended soil and from 0 to 4 week in soil amended with various amendments such as FYM, biochar, poultry manure and fly ash. The maximum soil resilience index was found under FYM + fly ash (0.74). The resistance capacity of the soil studied under Cu stress is found better in either biochar (0.66) or biochar + fly ash (0.67) treatment.
- To investigate the effect of soil C depletion on the soil plasticity parameters, soil samples of the clay loam texture were collected after four crop seasons and the test was carried out for plastic limit, liquid limit and plasticity index estimation. The data showed that the plastic limit and liquid limit reduced with depletion in soil C level, though the depletion was drastic from no depletion (C1) to 33% depletion (C2). Averaged over management treatments, the plastic limit reduced from 29% (g/g) under C1 to 18% (g/g) under both C2 and C3 (54% depletion) treatments.
- To study the factors affecting potential carbon mineralization (PMC) in soil, 14 samples having

different soil and climatic conditions were used for long term incubation studies (247 days) and PMC and decay constant for different soil types and land use systems were computed. Subsequently 12 variables including soil and climatic conditions were subjected to principal component analysis (PCA) technique for determining the factors responsible for PMC in soil. It was observed that silt, clay and C: N ratio are the main factors which affect potential carbon mineralization in Indian soils. Subsequently, a model for computation of PMC in soil was developed.

- To study the soil carbon dynamics, soils samples were obtained from permanent manurial trial of Ranchi and analysed for soil carbon sequestration rate and carbon pool dynamics. It was observed that application of FYM invariably increased total organic C and carbon in mineralizable and passive pool in all the treatments wherever FYM was applied.

Theme II Conservation Agriculture and Carbon sequestration *vis-a-vis*

Conservation Agriculture and Climate Change

- An increase in temperature by 1.5°C will reduce the grain yield of soybean by 20%. Similarly reduction in rainfall does not favours soybean yield. Decrease in temperature from the current climate by 1°C and increase in rainfall by more than 10% would favour the soybean yield the most. On the other hand. Increase in temperature by 1.5°C along with increase in rainfall up to 50% during soybean growth reduces the soybean yield to the tune of 5 to 10% which can be considered as tolerable limit. Beyond 1.5°C increase in temperature, the increase in rainfall doesn't show any positive impact on soybean yield.

- Increase in CO_2 concentration favours soybean growth when the temperature is reduced by 1°C from the current climate. With increase in CO_2 concentration the yield is masked by the adverse impact of rise in temperature on crop growth. Even by increasing the temperature by 1°C and CO_2 concentration to double from the current stage, the yield decline in soybean is as high as 15%.

- Rooting parameters such as root length, root diameter, root surface area, root volume and root architectural parameters such as number of nodes, number of primary and secondary roots were found to be significantly higher in JS-9560 than JS-335. It was observed that primary as well as secondary root insertion angles were higher in JG-9560 compared to JG-335 indicating higher lateral spread making the cultivar more tolerant towards stress conditions.

- The of runoff and soil loss varied from 336 to 479 mm and 3431 to 5557 kg ha^{-1}, respectively. The maximum runoff (479 mm) and soil loss (5557 kg ha^{-1})) was recorded under cultivated fallow over sole as well as intercrops. Among the sole crops, the highest runoff and soil loss was recorded under pigeon pea and the lowest was in soybean crop.

- In case of intercrops, the highest runoff and soil loss was in maize and pigeon pea (1:1) and the lowest in soybean + pigeon pea (2:1).The trend of runoff and soil loss was in the order of, cultivated fallow > pigeon pea > maize > maize + pigeon pea > soybean + maize > soybean + pigeon pea > soybean.

- The SOC and total NPK losses were recorded the highest in cultivated fallow over crop treatments. Among the sole crops treatments, higher nutrients losses were recorded in sole pigeon pea followed by maize and the lowest in sole soybean but in case of intercrops, the maximum nutrient losses were recorded in maize + pigeon pea (1:1) followed by soybean + maize (1:1) and the lowest in soybean + pigeon pea (2:1).

Different tillage practices such as conventional tillage (CT) and reduced tillage (RT) had no effect on soybean grain equivalent yield after three years of crop cycle. Among the cropping systems studied, maize-gram recorded higher yield followed by soybean + pigeon pea (2:1) and soybean-wheat cropping system. No-tillage (NT)/ reduced tillage (RT) recorded the highest number of weeds and total weed biomass (g/m^{-2}). Surface soil moisture was measured under different tillage systems. The temporal data revealed that no-tillage recorded higher soil moisture compared to reduced tillage and conventional tillage. Carbon stocks data revealed that about 6.1-10.9% increase of carbon stocks under RT and NT over CT in 0-5 cm. However, tillage system did not have significant effect on carbon stock. Among the tillage systems, no-tillage (383 mg kg^{-1}) and reduced tillage (360 mg kg-1) recorded higher active carbon compared to conventional tillage (335 mg kg^{-1}) in 0-5 cm, similar trend was observed for 5-15 cm soil depth.

Theme III: Microbial Diversity and Genomics

Microbial Diversity and Biofertilizers

- Differences in eubacterial diversity and species richness were higher under organic management in soybean and maize compared to inorganic but the differences were subtle rather than dramatic. Arthropods in soil reduced under chemical farming in paddy soils as compared to INM paddy, organic vegetable soils and forest soils in NEH.
- Promising actinomycetes strains for maize and chickpea identified. Actinomycetes A10 performed well in dry land conditions and saved 25% NP for maize.
- Microbial consortium (Cyanobacteria, Azospirillum, Bacillus subtilis, enriched mycostraw) was found effective on upland rice in eastern India.
- P and Zn mobilizing cultures improved yields of Bt cotton
- Biofertilizers for jute found effective in NEH and coastal soils. Biofertilizers improved yield and capsicain and Vitamin C content in hot chilli.
- Molecular characterization of arid zone rhizobia of cluster bean, pigeon pea was done and temperature tolerance and PGPR characteristics quantified. Arid zone rhizobia were also highly salt tolerant. Five rhizobial isolates antagonistic to chickpea fungal pathogens identified.
- Diversity of ammonium oxidizing bacteria (AOB) and archaea (AOA) associated with soybean assessed to define community dynamics during crop growth stages. Potential nitrification rate revealed differential nitrification by AOB and AOA in response to crop growth stages and fertilizer management. Nitrification by AOB and AOA during terminal electron accepting process (TEAPs) indicated that Fe^{3+} reduction stimulated NH_4 oxidation through Fe^{2+} coupled NH_4 oxidation.
- Biofertilizer production at 3 centres of the SB-BF project was to the tune of 114.5 lakhs during 2013-14 (project budget 190 lakhs) (76.3% ROI).

- Medium for cultivation of PGPR-Bacillus was modified to obtain high counts which improve the quality. Consortia of PGPR, Rhizobium and Actinomycetes performed extremely well on chickpea in Vertisol.

Theme IV: Soil Pollution, Remediation and Environmental Security

Amelioration of Contaminated Soils

- Compost prepared from unsegregated municipal solid wastes contains high amount of heavy metals restricting its use in agricultural land as amendment material. A laboratory experiment showed that removal of finer size fraction and extraction of metals through wet sieving method using acidic distillery effluent containing dilute EDTA may lesson hazardousness of such composts.

- The total phosphorus in the water sample that enters to the Upper Lake Bhopal from different source ranges from 0.30 to 0.73 mgL^{-1} with a mean value of 0.47 mgL^{-1} with lowest and highest value from Kholukhedi (Agriculture source) and Bhadbada (domestic waste water), respectively. Among the P fractions, the bioavailable P fraction (TDP) was the highest in the domestic waste water, where the dominant P fraction in water samples from agriculture source was particulate Phosphorus (PP).

- Municipal solid waste carry heavy metals, as a consequence, these metals degrade soil health, affects plant growth, livestock and human health if they enter the food chain or drinking water supply. A study was carried out to develop bio-filtration method for removal of heavy metals from poor quality of municipal solid waste compost using isolated mesophilic fungi. Six mesophilic fungi were *isolated and identified such as Trichoderma viride; Aspergillus heteromorphus; Rhizomucor pusillus; Aspergillus flavus; Aspergillus terrus* and *Aspergillus awamori*. All the fungal growth were not affected up to 400 ppm of Pb and Zn. However, except *T. viridi*, other mesophilic fungal growths were confined at 10 ppm of Cd followed by Cu. Further, it was observed that the growth tolerant of these fungi was up to 150 ppm of Ni.

- To control the weed, and pest use of pesticide is one of the important inputs in agriculture. A laboratory study was conducted at some of the LTFE centres in soil, from long term fertilizer plots were subjected to graded doses of herbicide with differential incubation period. The results indicated that the enzyme activities (dehydrogenase, urease, fluorescein diacetate hydrolyzing activity and acid and alkaline phosphatase) in soil declined significantly after 7 days of herbicide and fungicide application, while treatments having un-weeded control and hand weeding maintained the same status as compared to initial status. Addition of lime along with 100% NPK enhanced the rate of degradation which was almost similar to treatment receiving 100% NPK+ FYM. The half-life of isoproturon in field ranged from 9.9 to 20.8 days.

- Accumulation and translocation behavior of heavy metals in crops irrigated with contaminated water was studied. Characterization of heavy metals in peri-urban areas of Nagpur and Aurangabad districts of Maharashtra continuously irrigated with sewage water along with profile distribution of these metals was also studied. Threshold toxic limits for heavy metals in different crops like buckwheat were established and effect of organic amendments in minimizing the toxicity was investigated successfully.

On-Farm Research and Impact Assessment

- Follow up/Verification trials were conducted on jute, rice, vegetable pea, garlic, chandrasur, soybean, onion and chilli by the Barrackpore, Jabalpur and Vellanikkara centres, respectively. In all the trials, the targeted yield was achieved with the adoption of IPNS-STCR fertiliser prescription eqation within permissible yield deviation limit (±10%) with higher nutrient response ratio, greater B: C ratio and better net return.
- Long-term IPNS-STCR demonstrations have been conducted on pearlmillet-wheat and rice-rice cropping sequence at New Delhi and Coimbatore STCR centre, respectively. The results showed significant improvement of soil health as indicated by physical, chemical and biological parameters with STCR-IPNS treatment.
- Under frontline demonstrations (FLDs) on oilseeds, the Coimbatore centre has conducted 10 FLDs on groundnut, sunflower and gingelly. In all the demonstrations, the targeted yield was achieved with the adoption of IPNS-STCR fertiliser prescription equation within permissible yield deviation limit (±10%) with the highest nutrient response ratio, B: C ratio and maximum net return.
- A farmers' field demonstration project was conducted with five technologies (IPNS, STCR, Phospho-Sulpho-Nitro Compost, Broad Bed and Furrow technique (developed by ICRISAT) with Reduced Tillage, and application of Bio-fertilizers developed by the institute). It was found that in soybean yield increased by 14.3% with IPNS, 25.9% with Phospho-Sulpho-Nitro Compost, and 15.2% with STCR based fertilizer recommendations over farmers' practices in the selected Agro-ecosystem. However, in the following wheat crop the percentage yield increases with the IPNS, Phospho-Sulpho-Nitro Compost, and STCR over farmers' practice were 12.0, 16.3, and 12.8 respectively.