Analysis of crop productivity, partial factor productivity, and soil fertility in relation to nutrient management in the Indo-gangetic plains

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Structure

- About Indo-gangetic plains (IGP)
- Agriculture development in IGP – history, current status, & issues
- Trends in crop productivity in IGP
- Trends in partial factor productivity in IGP
- Trends in soil fertility status in IGP
- Use of efficient nutrient management approaches in IGP
- Summary

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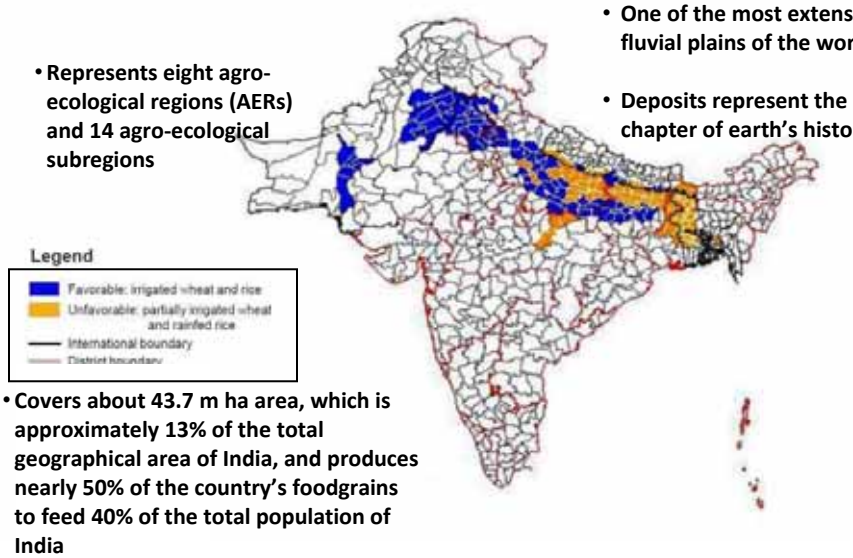
Indo-gangetic plains

- Represents eight agro-ecological regions (AERs) and 14 agro-ecological subregions



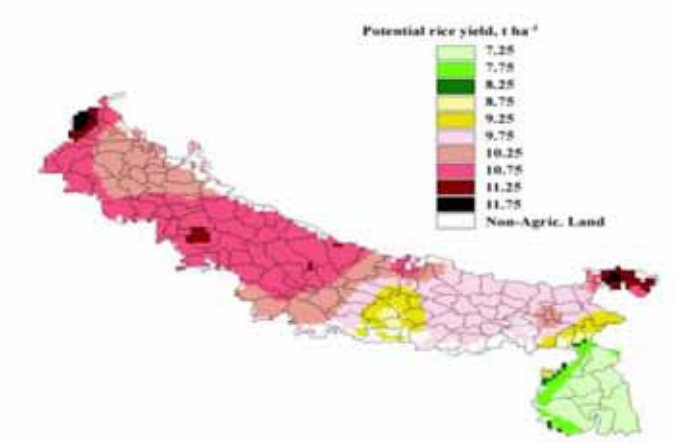
- One of the most extensive fluvial plains of the world
- Deposits represent the last chapter of earth's history
- Covers about 43.7 m ha area, which is approximately 13% of the total geographical area of India, and produces nearly 50% of the country's foodgrains to feed 40% of the total population of India

Source: Ladha et al. (2000)

Agriculture Development

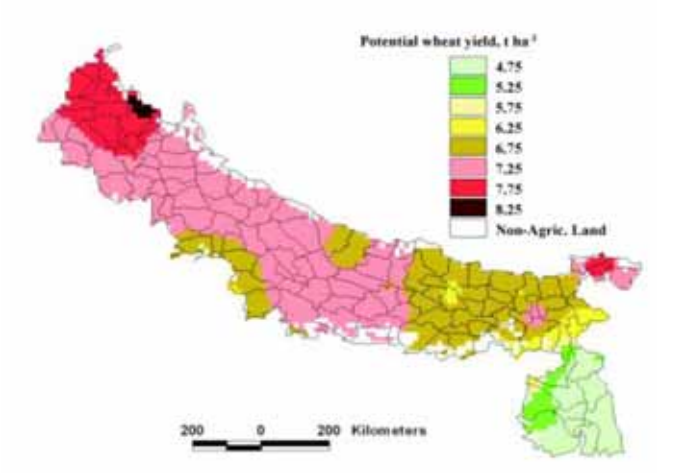
- Mughal statistics confirm that much of the land in the IGP was under cultivation. This involved traditional mixed cropping methods
- Over the last three–four decades the states of the IGP have been successful in increasing their foodgrain production, chiefly rice and wheat, by introducing high-input technologies to meet the demands of the exponentially growing population
- Strategies and measures adopted to achieve this success included, among others, (i) the spread of high-yielding varieties, (ii) expansion of irrigated area, (iii) increased use of fertilizers, (iv) plant protection chemicals, (v) strengthening of marketing infrastructure, and (vi) introduction of subsidies
- These management interventions for 'money economy' have resulted in (i) depletion of natural resources, (ii) declining water level, (iii) loss in soil fertility, (iv) nutrient imbalance/deficiency, (v) drainage congestion, and (vi) loss in soil carbon. Secondly, production of grains is, however, not uniform across the IGP regions because of the spatial variation in land-resource characteristics and socio-economy in the region.

Variation in Potential Rice Yields



Source: Aggarwal et al. (2000)

Variation in Potential Wheat Yields



Source: Aggarwal et al. (2000)

Variation in Actual R-W Yields

Table 1. Wheat and rice yields under favorable and less favorable rice-wheat systems in India.

State	Wheat yields (t ha^{-1})			% of wheat area under irrigation[b] 1994-95	Rice yields (t ha^{-1})			% of rice area under irrigation
	1990-93[a]		1996-97[b] (overall)		1990-93[c]		1996-97 (overall)	
	W-R (fav)[d]	W-R (unfav)			W-R (fav)	W-R (unfav)		
Punjab	3.69		4.24	96.7	4.84		5.10	99.1
Haryana	3.57		3.88	98.4	4.29		4.45	99.6
Uttar Pradesh	2.28	2.03	2.66	92.2	3.04	2.45	3.18	60.4
Bihar	1.79	1.71	2.17	87.8	2.29	1.58	2.14	39.8
West Bengal		2.00	2.39	72.5		2.68	3.27	24.6
Madhya Pradesh		1.04	1.76	67.3		1.20	1.75	23.1

Data sources are
[a]Center for Monitoring Indian Economy. India's Agricultural Sector, July 1996.
[b]Department of Economics and Statistics, Ministry of Agriculture, India. 1998. Agricultural statistics at a glance.
[c]Huke and Huke (1997) adjusted to an unhusked rice basis.
[d]Fav = favorable, unfav = unfavorable.

Source: Ladha et al. (2003)

Trends in Partial Factor Productivity

Period	Increase in fertilizer Nutrients Consumption m t	Increase in food grain production m t	Response ratio , kg grain/ kg applied nutrients ($N+P_2O_5+K_2O$)
1960-1970	1.47	26.40	17.9
1971-1980	2.44	31.09	12.7
1981-1990	5.28	46.80	8.9
1991-2000	3.18	19.53	6.3

Source: FAO (2004)

Trends in Partial Factor Productivity

- Partial Factor Productivity (PFP) is the average productivity, measured by grain output divided by quantities of fertilizer
- PFP has shown sharply declining trends in various studies, and they are cited as a cause for concern. But this can be highly misleading as an indicator of sustainability
- Total Factor Productivity (TFP) can be a better choice to assess system sustainability. The data, however, with which to measure TFP at the farm level are difficult to collect
- Ali and Byerlee (2000) in Pakistan's Punjab and Murgai (2000) in Indian Punjab found positive growth in the wheat-cotton and wheat-mungbean systems, but a negative in the rice-wheat system during early GR period. Later on, however, the trend reversed
- Another problem with TFP is that it still does not directly measure environmental degradation
- If TFP growth is positive in the presence of environmental degradation, this indicates that technological progress and improved infrastructure have more than compensated for the environmental degradation

Trends in Soil Fertility

Centers	Nutrient deficit							
	P	K	S	Zn	Fe	Mn	Cu	B
PDCSR, Modipuram	-	√	√	√	-	√	√	√
GBPUA&T, Pantnagar	√	√	-	√	-	√	-	√
CSAUA&T, Kanpur	√	√	√	√	-	-	-	-
NDUA&T, Faizabad	√	√	√	√	-	√	-	√
BHU, Varanasi	√	√	√	√	-	√	√	√
RAU, Sabour	√	√	√	-	-	-	-	-
BAU, Ranchi	√	√	√	√	-	-	-	√
HPKV, Palampur	√	√	√	√	-	-	-	√
PAU, Ludhiana	√	√	√	√	√	√	√	√
R S Pura	√	√	√	√	-	√	√	-

Source: IPNI data

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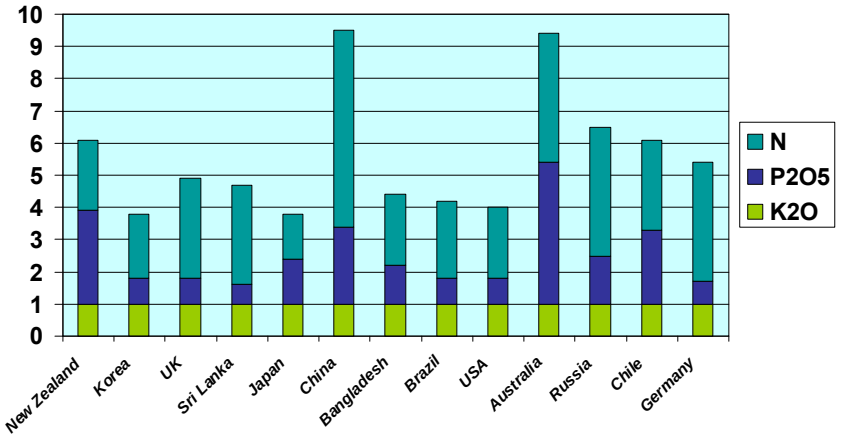
Fertilizer Ratios in Murshidabad

Year	$N:P_2O_5:K_2O$
1997-98	3.5:1.7:1.0
1998-99	3.0:1.7:1.0
1999-2000	2.7:1.5:1.0
2000-01	1.9:1.1:1.0
2001-02	1.7:1.0:1.0
2002-03	1.6:1.0:1.0
2003-04	1.9:1.1:1.0
2004-05	2.2:1.1:1.0

Source: IPNI data

4:2:1 is NOT a Magic Ratio



Source: Banga (2005)

Efficient NM Approaches

- Soil Test and Target Yield-based
- Plant-based
- GIS-based
- Integrated

Soil Test & Target Yield-based Fertilizer Application

Site	S	Zn	B	Mn	Cu
Ranchi	√	√	-	-	-
Modipuram	√	√	√	√	-
Kanpur	√	√	-	-	-
R.S. Pura	√	√	-	√	√
Pantnagar	√	-	√	-	-
Ludhiana	√	√	√	√	√

Source: IPNI research

Soil Test & Target Yield-based Fertilizer Application

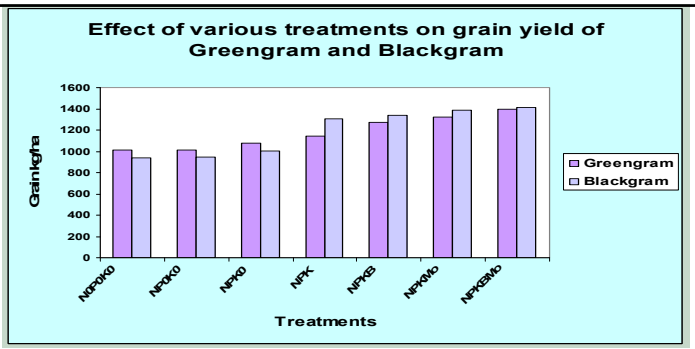
Site	Rice (Mg/ha)	Wheat (Mg/ha)	Total
Modipuram	10.03 (10)	6.43 (7)	16.46
Palampur	5.89 (7.5)	6.39 (7)	12.28
Kanpur	8.35 (10)	6.00 (7)	14.35
Ludhiana	10.04 (10)	6.55 (7)	16.59
Sabour	8.36 (10)	6.55 (7)	14.91
R.S. Pura	8.56 (10)	5.82 (7)	14.38

Source: IPNI research

Soil Test & Target Yield-based Fertilizer Application in West Bengal

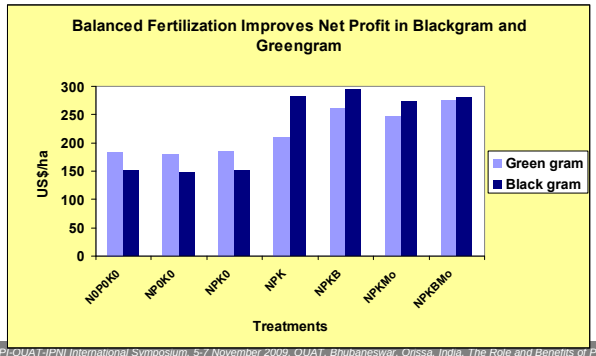
Treatments	Sugarcane (q/ha) (Average of 5 trials)	Brinjal (q/ha) (Average of 5 trials)	Potato (q/ha) (Average of 10 trials)
State Recommendation	630.70a	164.20a	214.97a
STTY-based NPK	700.00b	206.80b	216.27a
STTY-based NPKS	705.00b	213.35bc	236.92b
STTY-based NPKSMg	720.00b	225.60c	252.07c

Source: IPNI research



Farmers' field trial on pulses in Jharkhand shows yield was maximum with the application of N, P, K, B & Mo

However, economics was best at NPKB



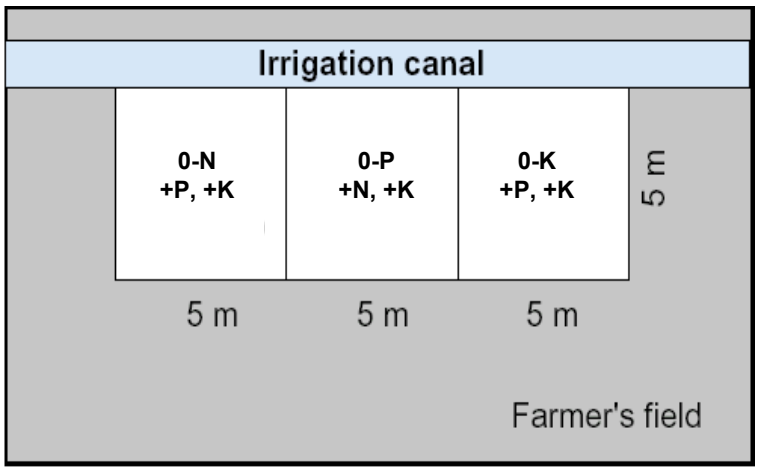
Source: IPNI research

Profit with STTY-based Approach

Crops	Additional income with STTY-based approach (Rs/ha)	
	Over RDF	Over FP
Rice	3417	7950
Maize	2219	4057
Cotton	4274	7419
Chilli	4892	8724
Wheat	3765	6778
Chickpea	5208	6838
Sunflower	2613	4322
Jowar	1929	3441

Source: IPNI research

Plant-based Fertilizer Application



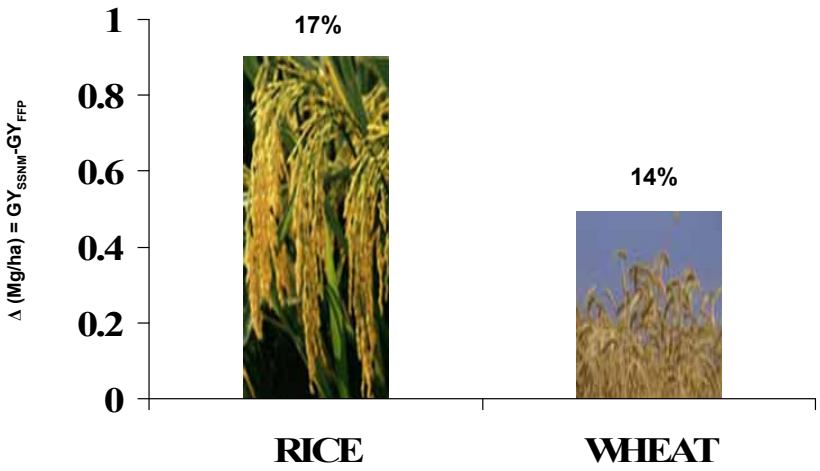
Fertilizer N requirements for maize

based on yield response to fertilizer N and agronomic efficiencies

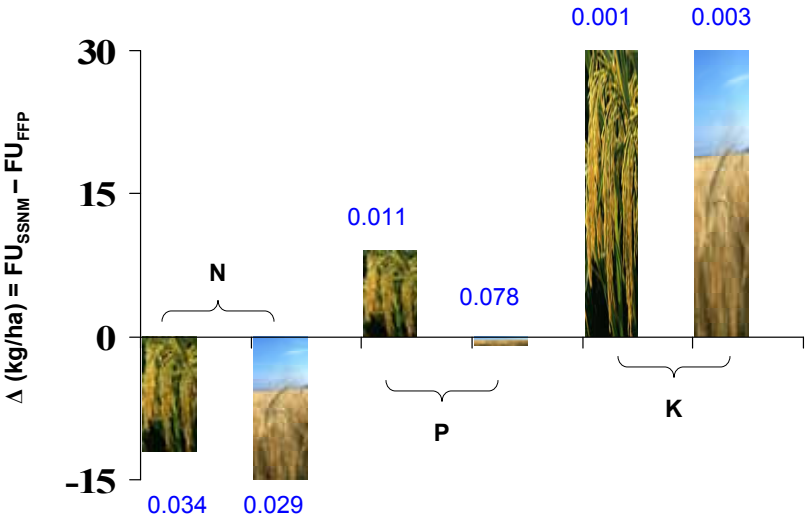
Yield response to N	V – L	L	L – M	M	M – H	H	V – H
Expected yield increase (t/ha) to fertilizer N application over 0N →	≤ 2	2-3	3-4	4-5	5-6	6-7	7-8
Expected agronomic efficiency (kg grain increase/kg applied N) →	15-17	17-25	21-29	25-31	28-33	30-35	32-36
Fertilizer N rate (kg/ha)	**100**	**120**	**140**	**160**	**180**	**200**	**220**

The agronomic efficiency of fertilizer N is most likely linked to the yield response to fertilizer N application depending on climatic conditions and yield level in an average season.

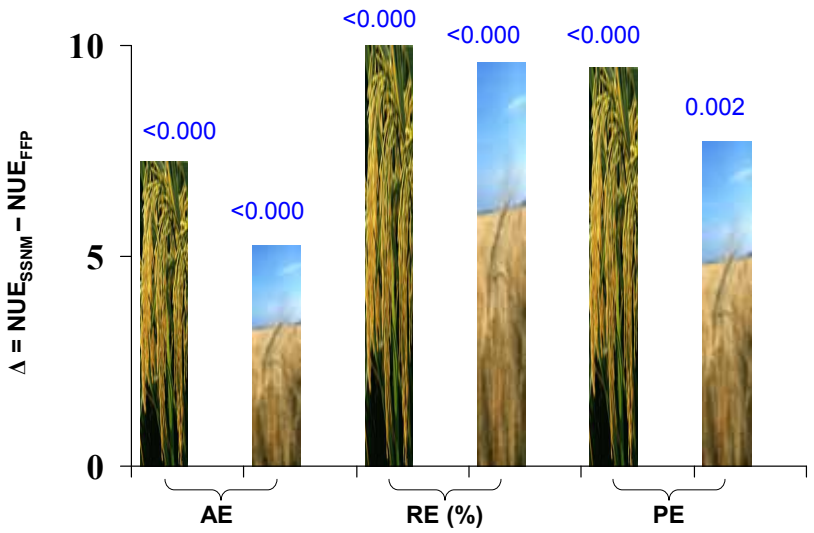
Plant-based Fertilizer Application & Grain Yield



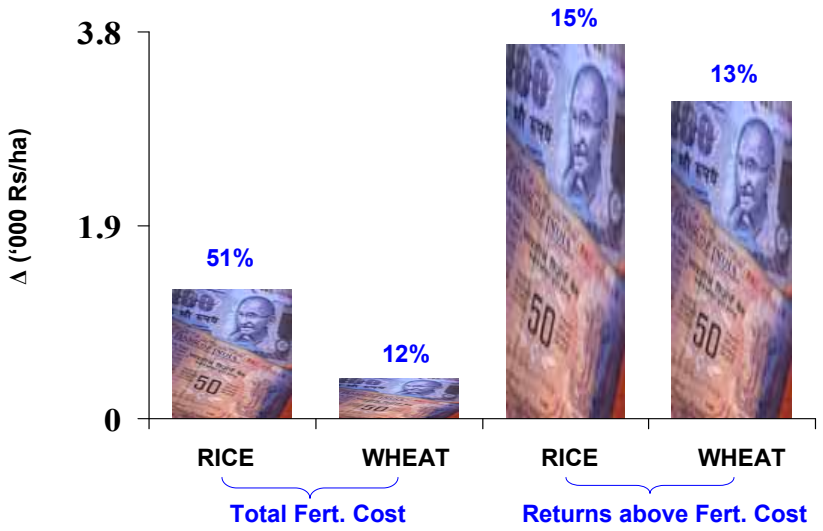
Plant-based Fert. Application & Fert. Use



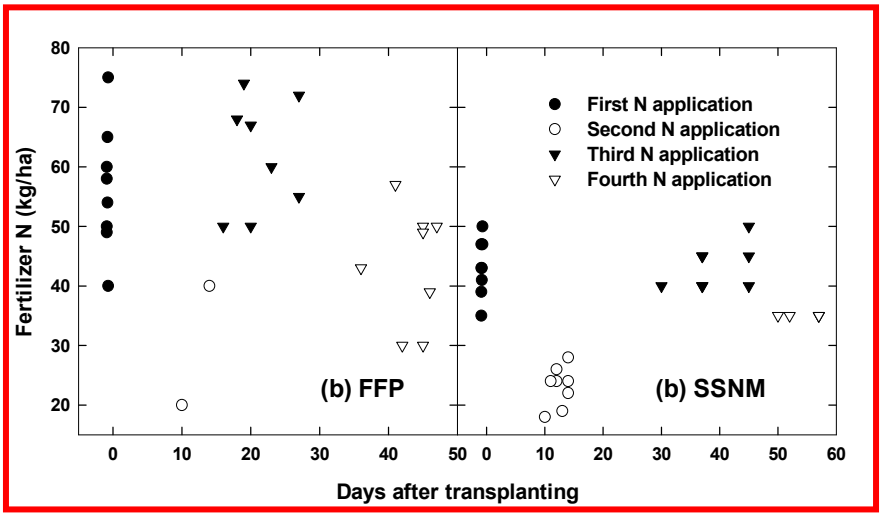
Plant-based Fertilizer Application & NUE



Plant-based Fertilizer Application & Profits



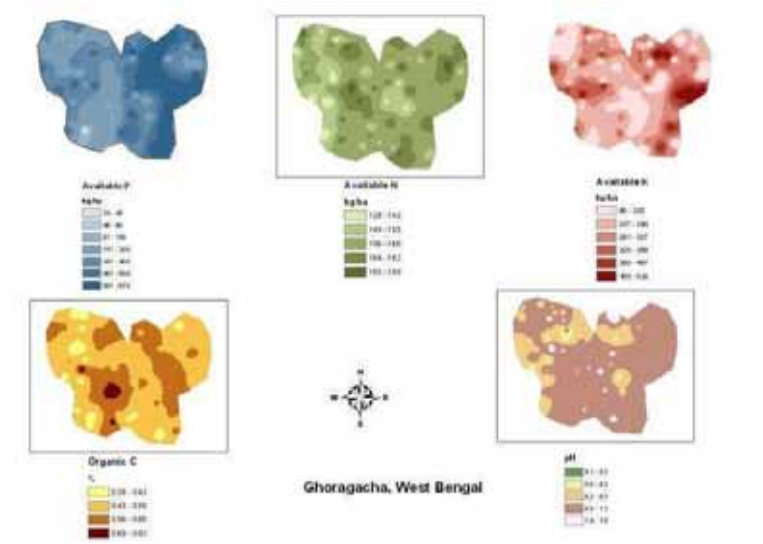
Plant-based Fertilizer N Application



GIS-based Fertilizer Application

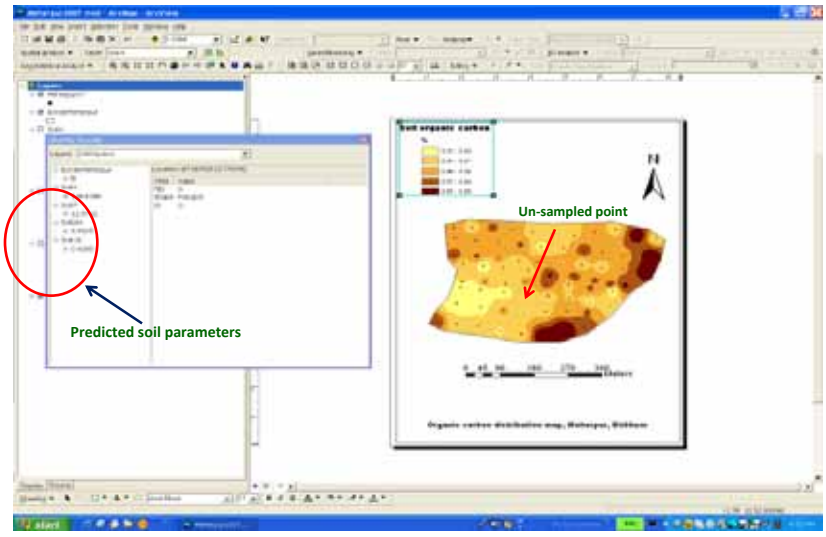
- Soil samples from 0-15 cm depth collected at 100m x 100m grid.
- GPS coordinates of the sampling points recorded by a GARMIN GPS Map 60 instrument.
- Physico-chemical properties and available nutrient status measured by standard procedures.
- Spatial variability maps of nutrients and soil properties for the study area were developed by ArcView Geographical Information System

Interpolated Maps of a Village from New Alluvial Zone of West Bengal



IPNI Research with BCKV, 2007

Variability Maps for Fertilizer Decision Support



IPNI Research with BCKV, 2007

Rice Yield Improvement

Name	Farmers' Practice	Fertility Map-based Recommendation
Kharif (Summer rice) kg/ha		
Manoranjan Mandal	3105a	3750b
Niren Mandal	3270a	4200b
Abul Hassan Mallick	3600a	3900a
Nasir Seikh	-	2700
Madhusudan Mandal	3467a	3852b
Boro (Winter Rice) kg/ha		
Benu Mondal	5520a	6900b
Sukumar Biswas	6000a	7200b
Manik Sarkar	5400a	7080b
Ruptan Mandal	5850a	6750b

IPNI research with BCKV, 2007

Integrated Approach to Nut. Mgt.

- **Integrated Plant Nutrient System (IPNS) encompassing adequate and balanced nutrient use in an integrated manner employing chemical, organic, and biofertilizers is the most ideal system of nutrient management . Extensive research has shown that such a system has improved crop productivity, fertilizer use efficiency, and farmer profits (Sharma 2008)**

- **Nutrient management in isolation will have lesser impact in addressing issues in IGP than when it will be done in collaboration with other crop and resource conserving technologies (Saharawat 2009). A lot of work needs to be done in this regard still**

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Summary

- Crop productivity, factor productivity, and soil fertility are not uniform across the IGP regions because of the spatial variation in land-resource characteristics and socio-economy in the region

- The imbalanced fertilizer application in the IGP has resulted in stagnating or declining yields, nutrient use efficiencies, and soil health

- New and more efficient, knowledge-intensive, and site-specific strategies of nutrient management need to be explored, adapted, extended, and applied in tandem with other crop and resource conserving technologies to adequately address nutrient management issues in IGP

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