Nutrient Expert® – A Nutrient Management Decision Support Tool for Soil Health Management and Environmental Sustenance

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Connecting Frontier Science to Frontier Practice
Frontiers of Potassium – An International Conference
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Food Security – Issues and Challenges – A Global Perspective

World population is expected to increase by 40% by 2050!!

> 1 t ha\(^{-1}\) difference in 2050 with ‘business as usual’ compared to required
Temporal distribution of operational holdings

- Temporal distribution of arable land per capita (ha) from 1961 to 2009 for Bangladesh, India, Nepal, and Pakistan.
- Distribution of cultivator households (%)
  - Below 1 ha: 63.9%
  - 1 - 1.99 ha: 18.65%
  - 2 - 3.99 ha: 11.15%
  - 4 - 9.99 ha: 5.3%
  - 10 and above: 1%
- Bar chart showing the number of holdings ('000) by category from 1995-96 to 2010-11:
  - Marginal
  - Small
  - Semi-medium
  - Medium
  - Large

Source: IPNI
Challenges

• Food security
  • Additional 5-6 Mt of food grain to be added each year

• Total cultivated land either stagnant or declining
  • Increasing crop productivity is the only option

• Declining factor productivity
  • Decline in native soil fertility

• Nutrient acquisition efficient crop cultivars
  • More depletion of native soil fertility
Nutrient Management

– Frontier Science to Frontier Practice
Role of Nutrients in Improving Productivity

Rice

Wheat

Oilseeds and Pulses

Soybean
Potassium Management in India

- In general understanding, presence of mica and feldspar in soils provide an abundant *in-situ* source of K

- The issue of Nutrient Mining is most relevant for K
  - Low awareness
  - Low application rates
  - Excess removal from soils
Present Nutrient Management Practices

Farmer Fertilizer Practices

- Based on perception
- Peer influence
- Overly N-driven

Other strategies

- 4:2:1, State Recommendation
  - Nutrient mining aspects not properly integrated

Crop residue removal from farms – Major source of nutrient off-take

Low crop productivity

Low economic return

Large environmental footprint
# Nutrient balance for different cropping sequences

<table>
<thead>
<tr>
<th>Sequences</th>
<th>Nutrient addition (kg ha⁻¹)</th>
<th>Nutrient removal (kg ha⁻¹)</th>
<th>Balance (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
<td>K</td>
</tr>
<tr>
<td>Rice – Wheat</td>
<td>510</td>
<td>97</td>
<td>165</td>
</tr>
<tr>
<td>Rice – Chickpea</td>
<td>311</td>
<td>87</td>
<td>80</td>
</tr>
<tr>
<td>Rice – Wheat – Sesbania (GM)</td>
<td>621</td>
<td>148</td>
<td>249</td>
</tr>
<tr>
<td>Rice-Wheat-Maize + Cowpea (F)</td>
<td>642</td>
<td>133</td>
<td>222</td>
</tr>
<tr>
<td>Rice-Chickpea-Maize + Cowpea (F)</td>
<td>439</td>
<td>124</td>
<td>145</td>
</tr>
<tr>
<td>Pigeonpea – Wheat</td>
<td>572</td>
<td>170</td>
<td>124</td>
</tr>
<tr>
<td>Cowpea – Wheat</td>
<td>308</td>
<td>94</td>
<td>84</td>
</tr>
<tr>
<td>Rice – Wheat – Cowpea (f)</td>
<td>712</td>
<td>154</td>
<td>284</td>
</tr>
</tbody>
</table>

Source: Singh et al. (2002); Singh et al. (2005); Yadav et al. (2003); Dwivedi et al. (2003); Sanyal et al. (2014); Majumdar et al., (2016).
The K$_2$O balance (K applied as fertilizer & Manure-Crop Removal) (Dutta et al., 2013, Better Crops South Asia)

2007

2011

(a) (in ‘000 tonnes)  

(b) (in ‘000 tonnes)
4R Nutrient Stewardship

The concept defines 4Rs for fertilizer management as those producing desirable economic, social, and environmental outcomes.
Making 4R Nutrient Stewardship Available in Smallholder Farmers

Nutrient Expert® Decision Support System software provides the opportunity to integrate the 4R principles into a fertilizer recommendation.

- This has proven particularly successful where soil testing infrastructure is weak, expensive or not timely for multiple cropping systems.
The Nutrient Expert® Decision Support Tool
A scale-neutral technology for precision nutrient management

- Nutrient Expert® is a computer-based decision support tool for crop advisers
Field performance of Nutrient Expert®
## Farmers’ Field Evaluation

### Comparison of Nutrient Expert® (NE) for *Rice* with Farmers’ Practice (FP)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>FP</th>
<th>NE</th>
<th>NE – FP</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield</td>
<td>kg/ha</td>
<td>3,628</td>
<td>4,334</td>
<td>706</td>
<td>***</td>
</tr>
<tr>
<td>Fertilizer N</td>
<td>kg/ha</td>
<td>112</td>
<td>110</td>
<td>-12</td>
<td>ns</td>
</tr>
<tr>
<td>Fertilizer P(_2)O(_5)</td>
<td>kg/ha</td>
<td>40</td>
<td>31</td>
<td>-9</td>
<td>**</td>
</tr>
<tr>
<td>Fertilizer K(_2)O</td>
<td>kg/ha</td>
<td>18</td>
<td>55</td>
<td>37</td>
<td>***</td>
</tr>
<tr>
<td>Fertilizer cost</td>
<td>INR/ha</td>
<td>3,017/-</td>
<td>3,286/-</td>
<td>565</td>
<td>***</td>
</tr>
<tr>
<td>GRF(^1)</td>
<td>INR/ha</td>
<td>50,314/-</td>
<td>60,424/-</td>
<td>10,110/-</td>
<td>***</td>
</tr>
</tbody>
</table>

***, **, *: significant at <0.001, 0.01, and 0.05 level; ns = not significant

\(^1\) GRF = gross return above fertilizer cost

Prices (in INR/kg): rice = 14.70; N = 11.40; P\(_2\)O\(_5\) = 32.20; K\(_2\)O = 18.80; 1 USD = INR 65
### Farmers’ Field Evaluation

**Comparison of Nutrient Expert® (NE) for *Wheat* with Farmers’ Practice (FP)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>FP</th>
<th>NE</th>
<th>NE – FP</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield</td>
<td>kg/ha</td>
<td>4,030</td>
<td>4,400</td>
<td>370</td>
<td>***</td>
</tr>
<tr>
<td>Fertilizer N</td>
<td>kg/ha</td>
<td>112</td>
<td>117</td>
<td>5</td>
<td>**</td>
</tr>
<tr>
<td>Fertilizer P$_2$O$_5$</td>
<td>kg/ha</td>
<td>64</td>
<td>57</td>
<td>-7</td>
<td>***</td>
</tr>
<tr>
<td>Fertilizer K$_2$O</td>
<td>kg/ha</td>
<td>39</td>
<td>78</td>
<td>39</td>
<td>***</td>
</tr>
<tr>
<td>Fertilizer cost</td>
<td>INR/ha</td>
<td>4071</td>
<td>4636</td>
<td>565</td>
<td>**</td>
</tr>
<tr>
<td>GRF$^1$</td>
<td>INR/ha</td>
<td>61,458/-</td>
<td>66,864/-</td>
<td>5,406/-</td>
<td>**</td>
</tr>
</tbody>
</table>

***, **, *: significant at <0.001, 0.01, and 0.05 level; ns = not significant

$^1$ GRF = gross return above fertilizer cost

Prices (in INR/kg): wheat = 16.25; N = 11.40; P$_2$O$_5$ = 32.20; K$_2$O = 18.80; 1 USD = INR 58
## Farmers’ Field Evaluation - IGP

### Comparison of Nutrient Expert® (NE) for **Maize** with Farmers’ Practice (FP)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>FP</th>
<th>NE</th>
<th>NE – FP</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield</td>
<td>kg/ha</td>
<td>4,956</td>
<td>6,245</td>
<td>1289</td>
<td>***</td>
</tr>
<tr>
<td>Fertilizer N</td>
<td>kg/ha</td>
<td>142</td>
<td>139</td>
<td>(-) 3</td>
<td>ns</td>
</tr>
<tr>
<td>Fertilizer P$_2$O$_5$</td>
<td>kg/ha</td>
<td>53</td>
<td>48</td>
<td>(-) 5</td>
<td>*</td>
</tr>
<tr>
<td>Fertilizer K$_2$O</td>
<td>kg/ha</td>
<td>50</td>
<td>68</td>
<td>18</td>
<td>***</td>
</tr>
<tr>
<td>Fertilizer cost</td>
<td>INR/ha</td>
<td>4,327</td>
<td>4,409</td>
<td>82</td>
<td>*</td>
</tr>
<tr>
<td>GRF$^1$</td>
<td>INR/ha</td>
<td>67,534/-</td>
<td>86,144/-</td>
<td>18,610/-</td>
<td>**</td>
</tr>
</tbody>
</table>

***, **, *: significant at <0.001, 0.01, and 0.05 level; ns = not significant

$^1$ GRF = gross return above fertilizer cost

Prices (in INR/kg): wheat = 14.50; N = 11.40; P$_2$O$_5$ = 32.20; K$_2$O = 18.80; 1 USD = INR 65
# Nutrient Expert® on NUE

<table>
<thead>
<tr>
<th>Year</th>
<th>Treatment</th>
<th>REN (%)</th>
<th>AEN (kg/kg)</th>
<th>PFPN (kg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>NE</td>
<td>30.8a</td>
<td>13.3a</td>
<td>52.8a</td>
</tr>
<tr>
<td></td>
<td>FP</td>
<td>23.5a</td>
<td>11.4a</td>
<td>47.8a</td>
</tr>
<tr>
<td></td>
<td>OPTS</td>
<td>28.1a</td>
<td>12.3a</td>
<td>51.3a</td>
</tr>
<tr>
<td>2014</td>
<td>NE</td>
<td>36.7a</td>
<td>16.2a</td>
<td>52.4a</td>
</tr>
<tr>
<td></td>
<td>FP</td>
<td>26.1b</td>
<td>12.8b</td>
<td>47.7b</td>
</tr>
<tr>
<td></td>
<td>OPTS</td>
<td>28.0b</td>
<td>13.8ab</td>
<td>48.2b</td>
</tr>
<tr>
<td>All</td>
<td>NE</td>
<td>34.2a</td>
<td>15.0a</td>
<td>52.6a</td>
</tr>
<tr>
<td></td>
<td>FP</td>
<td>25.0b</td>
<td>12.2b</td>
<td>47.7b</td>
</tr>
<tr>
<td></td>
<td>OPTS</td>
<td>28.0b</td>
<td>13.2ab</td>
<td>49.5b</td>
</tr>
</tbody>
</table>

Chatterjee et al., 2015
**Effect of Nutrient Expert® based nutrient Management on microbial properties**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>MBC (µg C/g soil)</th>
<th>FDA (µg Florescein/g soil /hr)</th>
<th>Dehydrogenase (µg TPF Rel/g soil /day)</th>
<th>β Glucosidase (µg p-NP Rel/g soil /24 hr)</th>
<th>Alkaline Phosphatase (µg p-NP Rel/g soil /24 hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfertilized</td>
<td>326.1&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.451&lt;sup&gt;c&lt;/sup&gt;</td>
<td>27.9&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.717&lt;sup&gt;c&lt;/sup&gt;</td>
<td>39.2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>FFP (110:13:0)</td>
<td>382.5&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.497&lt;sup&gt;b&lt;/sup&gt;</td>
<td>30.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.967&lt;sup&gt;b&lt;/sup&gt;</td>
<td>40.5&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Adhoc (150:26:33)</td>
<td>427.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.582&lt;sup&gt;a&lt;/sup&gt;</td>
<td>33.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.185&lt;sup&gt;a&lt;/sup&gt;</td>
<td>42.6&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SSNM (Nutrient Expert)</td>
<td>449.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.603&lt;sup&gt;a&lt;/sup&gt;</td>
<td>34.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.204&lt;sup&gt;a&lt;/sup&gt;</td>
<td>43.0&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Dr. C. M. Parihar, IIMR, Personal Communication, 2015
IPNI Collaborators for Rice, Wheat and Maize Nutrient Expert® Development, Validation and Dissemination in South Asia

International Center for Maize and Wheat Improvement (CIMMYT)
Cereal System Initiative for South Asia (CSISA)
Central Research Institute for Dryland Agriculture (CRIDA)

Acharya N G Ranga Agricultural University
Bidhan Chandra Krishi Viswavidyalaya (BCKV)
Bihar Agricultural University, Sabour
Birsa Agricultural University, Ranchi, Jharkhand
Dr. B. R. Ambedker University, Agra
Dr. Rajendra Prasad Central Agricultural University
Orissa University of Agriculture & Technology (OUAT)
Ramakrishna Mission Vivekananda University, West Bengal
Tamil Nadu Agricultural University (TNAU)
University of Agricultural Sciences, (UAS), Dharwar, Karnataka
University of Agricultural Sciences, (UAS), Raichur, Karnataka
Visva Bharati University, West Bengal

Seed and Fertilizer Industries
Bayer
Mosaic

ICAR – IIMR, New Delhi
ICAR – IIWBR, Karnal
ICAR – IIFSR, Modipuram
ICAR – Indian Agricultural Research Institute (IARI), New Delhi
ICAR – ATARI, Zone II, Kolkata
Department of Agriculture, Govt. of Bihar
Department of Agriculture, Govt. of West Bengal
Department of Agriculture, Govt. of Rajasthan
Available Resources

- \texttt{http://software.ipni.net}
Future Outlook

• Tool enhancement
  – recommendation options based on farmers’ resources
  – local languages, data management, etc.

• Wide scale dissemination of the field-validated versions
  – Web-based applications
  – Compatibility with smart phones
  – Link to online databases/services

• New business models for partnerships in tool development and dissemination
  – new crops and new geography with new partners
Thank you

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Better Crops, Better Environment … through Science