Addressing Heterogeneity of Maize Yield and Nitrogen Use Efficiency in India
Farm-specific Fertilizer Recommendation from the Nutrient Expert® Tool

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Nutrient management interventions in smallholder systems must address…

**BIO-PHYSICAL**
- Topography
- Climate
- Genesis
- Management

**SOCIO-ECONOMIC**
- Resource
- Education
- Age
- Access to input
- Risk perception
- Influence
- Access to market
- Land tenure
- Farm size
- On-farm/off-farm income

*Farm-specific and Farmer-specific*
Nutrient Expert®: development process

Data collection
- Agronomic database: multiple locations, diverse conditions
  - Attainable yield
  - Yield response to N, P, K
  - Fertilizer use efficiency (AE, RE)
  - Nutrient uptake

Model development
- Data analyses
- Consultation meetings
- Algorithm development
- Programming

Field validation
- On farm field testing: NE, FP, other fertilizer practices
- Model adjustment (as needed)

Version 1 for release

Site-specific nutrient management Principles, QUEFTS model

software.ipni.net
Nutrient Expert recommendation:
• Tailored to location-specific conditions
• Consistent with 4Rs:
  - right source
  - right rate
  - right time
  - right place

Nutrient Expert® for Hybrid Maize

Recommended alternative practice for hybrid maize

Yield goal: 7.2 ton (tW), 7.0 t/ha (15.9% MC)

Planting density: 69,441 plants/ha
Distance between rows: 60 cm
Distance between plants: 24 cm

Vegetative early (VE) to V3
- Right time

Vegetative late (V6-V8)
- Right source

V10 or later
- Right rate

V14-VT
- Right source

R6
- Integration of organics

Other sources of nutrients:
Crop residue (maize): low

Organic fertilizer: 1 t

N: 0 kg

P₂O₅: 0 kg

K₂O: 0 kg

Deficient nutrient: Zinc

Recommendation to correct deficiency:
Apply 25 kg/ha zinc sulfate as basal.

Growth stage | Days after planting | Soil moisture | Fertilizer source | Weight of N (kg) | Amount (lbs)
--- | --- | --- | --- | --- | ---
Bebal | 0 | sufficient | N-P-H-P | 50 | 3.5
V6 | 25 | sufficient | Urea | 50 | 3.5
V7 | 35 | sufficient | Urea | 50 | 3.5

Fertilizer rates are adjusted to field size.
Nutrient Expert On-Station Evaluation/Research with ICAR institutes

IPNI Maize and Wheat NE on-farm trial sites (2010-till date)
(Each point represents several on-farm experiments)

Legend
- ATARI (54)
- IIFSR (14)
- IIWBR (11)
- IIMR (11)
- IIRR (17)
- Wheat (n=896)
- Maize (n=1192)
### Field Performance of Nutrient Expert® (NE) for Rice, Wheat and Maize in India (2010-14)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Wheat</th>
<th>Maize</th>
<th>Rice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 701)</td>
<td>(n = 412)</td>
<td>(n = 323)</td>
<td></td>
</tr>
<tr>
<td>Grain yield</td>
<td>t/ha</td>
<td>+0.79 ***</td>
<td>+1.27 ***</td>
<td>+1.16 ***</td>
</tr>
<tr>
<td>Fertilizer N</td>
<td>kg/ha</td>
<td>−8 ***</td>
<td>−6 ns</td>
<td>+26 ***</td>
</tr>
<tr>
<td>Fertilizer P₂O₅</td>
<td>kg/ha</td>
<td>−4 ***</td>
<td>−16 ***</td>
<td>−5 *</td>
</tr>
<tr>
<td>Fertilizer K₂O</td>
<td>kg/ha</td>
<td>+54 ***</td>
<td>+22 ***</td>
<td>+2 ns</td>
</tr>
<tr>
<td>Fertilizer cost</td>
<td>USD/ha</td>
<td>+17 ***</td>
<td>−1 ns</td>
<td>+3 ns</td>
</tr>
<tr>
<td>Gross profit</td>
<td>USD/ha</td>
<td>+163 ***</td>
<td>+256 ***</td>
<td>+235 ***</td>
</tr>
</tbody>
</table>

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

[www.software.ipni.net](http://www.software.ipni.net)
Nutrient Expert® reduced GHG emission in wheat with increased yield and profit

Source: Sapkota et al. 2014, Field Crops Res. 155: 233-244
Fertilizer recommendations addressing variability in regional growing environment

**Eastern India**
- Alluvial heavy to light textured soils
- Traditional maize growers
- Small farms
- Resource poor farmers
- Low fertilizer input
- Low yields except for some areas growing winter maize

**Southern India**
- Red, Lateritic, Black and Alluvial soils
- Market–driven non-traditional maize growers
- Larger farms
- Resource rich farmer
- High fertilizer input
- High maize yields

<table>
<thead>
<tr>
<th>Region</th>
<th>Difference in Nutrient Expert-based fertilizer recommendation and Farmers’ Practice</th>
<th>N (kg/ha)</th>
<th>P$_2$O$_5$ (kg/ha)</th>
<th>K$_2$O (kg/ha)</th>
<th>Yield (kg/ha)</th>
<th>PFP$_N$ (kg N/kg N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South India</td>
<td></td>
<td>- 33.8***</td>
<td>- 40.8***</td>
<td>8.7**</td>
<td>677***</td>
<td>4.3*</td>
</tr>
<tr>
<td>East India</td>
<td></td>
<td>6.5*</td>
<td>-15.0**</td>
<td>28.0**</td>
<td>1482***</td>
<td>6.0***</td>
</tr>
</tbody>
</table>
Fertilizer recommendations need to match temporal variations within locations

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<tr>
<td></td>
<td>N (kg/ha)</td>
<td>P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt; (kg/ha)</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainy Season</td>
<td>-43***</td>
<td>-6&lt;sup&gt;NS&lt;/sup&gt;</td>
</tr>
<tr>
<td>Winter Season</td>
<td>-49**</td>
<td>-66***</td>
</tr>
<tr>
<td>Bihar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainy Season</td>
<td>25***</td>
<td>15***</td>
</tr>
<tr>
<td>Winter Season</td>
<td>-1.6***</td>
<td>-6.3***</td>
</tr>
</tbody>
</table>
Conceptual Framework for Technology Targeting in Smallholder Systems

Farm typology  Flexible recommendations
<table>
<thead>
<tr>
<th>Farm Typologies</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Farm Type 1 (16)</td>
<td>Moderate-resourced commercial maize grower</td>
</tr>
<tr>
<td>Farm Type 2 (9)</td>
<td>Exclusive cultivators with large holding and large family</td>
</tr>
<tr>
<td>Farm Type 3 (37)</td>
<td>Low-yielding new maize growers</td>
</tr>
<tr>
<td>Farm Type 4 (16)</td>
<td>Moderately resourced family farms</td>
</tr>
<tr>
<td>Farm Type 5 (28)</td>
<td>Traditional maize grower</td>
</tr>
<tr>
<td>Farm Type 6 (21)</td>
<td>Resource-rich commercial maize growers</td>
</tr>
</tbody>
</table>
Fertilizer Recommendation based on Farmer Resources

Farm Type 1 [Moderate-resourced commercial maize grower]
Farm Type 2 ['Exclusive cultivators' with large holding and large family]
Farm Type 3 [Low-yielding new maize growers]
Farm Type 4 [Moderately resourced family farms]
Farm Type 5 [Traditional maize grower]
Farm type 6 [Resource-rich commercial ‘seed producers’]
Matching Fertilizer Recommendations to farmers’ resource endowment can produce large gains in N use Efficiency

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<tbody>
<tr>
<td></td>
<td>N (kg/ha)</td>
</tr>
<tr>
<td>Type 1</td>
<td>-11.5$^{NS}$</td>
</tr>
<tr>
<td>Type 2</td>
<td>-71.3$^{NS}$</td>
</tr>
<tr>
<td>Type 3</td>
<td>39.7$^{***}$</td>
</tr>
<tr>
<td>Type 4</td>
<td>21.3$^{***}$</td>
</tr>
<tr>
<td>Type 5</td>
<td>-38.4$^{***}$</td>
</tr>
<tr>
<td>Type 6</td>
<td>-78.0$^{***}$</td>
</tr>
</tbody>
</table>
Summary

• NE recommendations significantly improved yield and profitability in on-farm validation trials over existing farmers’ practices.

• NE-based recommendations adequately addressed the regional and temporal variation in maize growing environments in India.

• Besides improving yield and profitability, matching fertilizer recommendations to regional, seasonal and farmers’ resource endowment can produce significant gains in N use efficiency.
Thank you