Accelerating Science and Innovation for Responsible Plant Nutrition

Achim Dobermann
Rothamsted Research, UK

1970s & 1980s
Total fertilizer production by nutrient, World
Total fertilizer production by nutrient type (nitrogen, phosphate and potash/potassium), measured in tonnes per year.

Source: UN Food and Agricultural Organization (FAO)

Global nutrient imbalance

Feast or Famine
Nearly half the people on the planet wouldn’t be alive if not for the abundant food made possible by nitrogen fertilizers. Yet its benefits have not reached everyone. In sub-Saharan Africa, where 230 million people go hungry a year, crops fail as soil is stripped of nutrients, and farmers can’t afford to buy fertilizer. Elsewhere excessive nitrate overwashes and roilses greenhouse gases.

Average annual nitrogen balance, pounds per acre:

Source:

Zero means the crop used exactly the amount of nitrogen applied. The total range varies due to local conditions.
At global scale, we will need to decouple future growth in agricultural production from growth in fertilizer consumption

Since 1990s  Towards more precise nutrient management

- Crop breeding for higher NUE (little success); biofortification
- Wide range of NM recommendations; more emphasis on crop
- Precision farming technology (VRT, sensors, models)
- SSNM, ISFM guidelines and tools for smallholder farming
- Digital soil mapping
- Numerous new soil & plant diagnostic tools
- Diverse fertilizer products offered by the industry
- Increasing investment in fertilizer use in Africa
- Nutrient regulation & stewardship (Environ. concerns)
- Digital extension tools
- More recently: disruptive technologies, new entrepreneurs

→ Overall investment in R&D has remained low and fragmented (public sector and industry)
→ Poor adoption of many innovations
Site-Specific Nutrient Management for smallholder farmers

Potential yield (climate/season)  Prices  Irrigation water quality  Diagnostic rules

Nutrient Management Decisions for Rice, Wheat, Maize…

- Rice Crop Manager Apps (Bangladesh, India, Philippines, Indonesia, Vietnam, China)
- Nutrient Expert Apps for rice, wheat, maize, soybean and cassava in 20 countries across Asia and Africa

1994-2019 (10 years research + 15 years digital application)

SSNM performance in smallholder farms in Asia and Africa (rice, wheat, maize)

At least 10-20% more yield and profit
30-50% higher agronomic NUE
Less GHG emissions
Less water and air pollution
More balanced nutrition
Less soil mining
Less insect pests and diseases

Reached hundreds of thousands farmers, not millions
Limited uptake by industry
Why so slow and often unsuccessful?

- Diverse environments - less standardization
- Supply-driven R&D
- Lack of resources, cooperation, openness
- Too difficult, not scalable
- Too risky, too expensive
- Policies

Cumulative adoption

Annual adoption rate

Basic research
Technology development
Acceptance
Release

Time (years)

IFA 2030 Scenarios

New business model:
Innovative crop nutrition companies that offer tailored solutions with massive knowledge embedded, including new production technologies and more recycling.
Industry interests and innovation drivers

- Operational efficiency (plant processes, logistics)
- Formulations and blends, including secondary and micronutrients
- Inhibitors (new molecules & formulations)
- Smart fertilizers (controlled release)
- Biodegradable polymers
- Nanofertilizers
- Biostimulants/biofertilizers
- Customer orientation & customization
- Digital technologies
- ......

→ How to connect this better with publicly funded research?

Evidence-based crop nutrition

Customized NM solutions
- Tailored & integrated
- Flexible & open
- Systems-based
- Better performing
- Easier to adopt

Genomics-, chemistry- and engineering-enabled innovations

Agroecology- and nutrition-inspired interventions

New knowledge, new targets, new modes of action, new products, nutrient recycling

Cropping systems, good management practices, more recycling, better soil health
Data- and AI-driven nutrient management decisions

Matrix of data analytics and action

(1) Pre-emergence nutrient management

<table>
<thead>
<tr>
<th>Determinant</th>
<th>Governing factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield potential (mean, variability)</td>
<td>Genotype, climatic historical</td>
</tr>
<tr>
<td>Attractable yield (goal)</td>
<td>Soil potential (quality)</td>
</tr>
<tr>
<td>NPK input requirement</td>
<td>Indigenous nutrient supply</td>
</tr>
<tr>
<td>Fraction and form of NPK applied</td>
<td>Tillage, crop establishment method, water management, soil mineralogy, prices</td>
</tr>
</tbody>
</table>

(II) Post-emergence nutrient management

<table>
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<tr>
<th>Determinant</th>
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<tr>
<td>Crop growth; biomass and N concentration</td>
<td>Crop architecture, water management, pest incidence, prices</td>
</tr>
<tr>
<td>Fraction of N applied</td>
<td></td>
</tr>
</tbody>
</table>

Self-learning fertilizer recommendations + real-time guidance throughout the life cycle of a crop

Matthew Smith, Agrimetrics, UK

Self-learning fertilizer recommendations + real-time guidance throughout the life cycle of a crop

NeoSpectra-Scanner
Portable and handheld spectral sensing scanner.

What’s Possible

“Personalized” NM, but who will develop, share and validate application algorithms?

Above the Scanner
- Set the scanner on a flat surface
- Place samples on top

Point & Shoot
- Hold scanner in hand
- Point and shoot at samples

Below the Scanner
- Place samples on a flat surface
- Set the scanner on top

https://www.neospectra.com/
Common standards and tools for responsible NM

Imagine if all could agree on what we even mean by SUSTAINABLE. And measure what it means for small rice farmers.

So we could drive wide-scale adoption of sustainable best practices. MARS: 100% rice sourced from farmers working with SRP standards by 2020.

From grass to grass: turning abattoir waste into fertilizer

https://elementaldigest.com/

Small fertilizer factories that supplement the big supply chains and help us increase the full-chain nutrient use efficiency.
Open innovation to engage, co-develop and scale up faster

- Build a prototype to test
- Test your riskiest assumptions quickly
- Learn and design, then test again
- Fail quickly; pivot; rebuild
- Scale up

Desirability
Usefulness
Viability
Feasibility

https://agilebiofoundry.org/

Teams of biological scientists, computational scientists, chemists and engineers
DIGITAL SERVICES ALREADY EXIST – WE ENVISION A WORLD WHERE SMALLHOLDER FARMERS HAVE SEAMLESS ACCESS TO THESE SERVICES

**Planning**
- **Pre-Planting**: Use a digital service to order and schedule a walk behind tractor for plot preparation.
- **Planting**: Purchase Seeds and Fertilizer via mobile money using a bundled loan secured with transactional history and climate risk for those seeds.
- **In Season**: Adjust to the Weather Check weather forecast on a phone and delay planting to avoid loss due to lack of rainfall.
- **Management**: Receive Correct Treatment Receive advice from a mobile phone app on the proper medication for sick livestock.
- **Harvesting**: Insurance or Subsidy Receive a mobile money insurance payment for lost crop due to heavy rainfall in the latter part of the season.
- **Post Harvest & Market**: Digital Market Access Take products to a market slightly further away because of a better price secured through a digital marketplace.

**Vision & Strategy**

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DIGITAL SERVICES AND AG-TECH EXAMPLES (INDIA)

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**Vision & Strategy**

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DIGITAL PLATFORMS AND AG-DATA ECOSYSTEM POWERING DIGITAL AGRICULTURE

Humans are involved in every layer, every component of this

OPEN SOURCE PLATFORMS

- An open source digital platform for agricultural extension service
- Content management system
- Performance management
- Integration of multiple data sets
- Open, interoperable API’s
- Multiple digital channels (e.g. IVR, Video etc.)
- Starting with 2 use cases (Dairy and Wheat) but expanding to others

Integrating Farm Data
Integrating Communication Channels
Integrating Market Services
Integrating Policies
130 agronomists engaged in > 140 projects, mainly through public funding
New Excellence in Agronomy initiative

New growth model: strong innovation
Cooperate more
Data-driven but human-centric