The Role of Plant Nutrients in Enhancing Agricultural Productivity in a Sustainable Manner

Submission to the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) from the International Fertilizer Industry Association (IFA)

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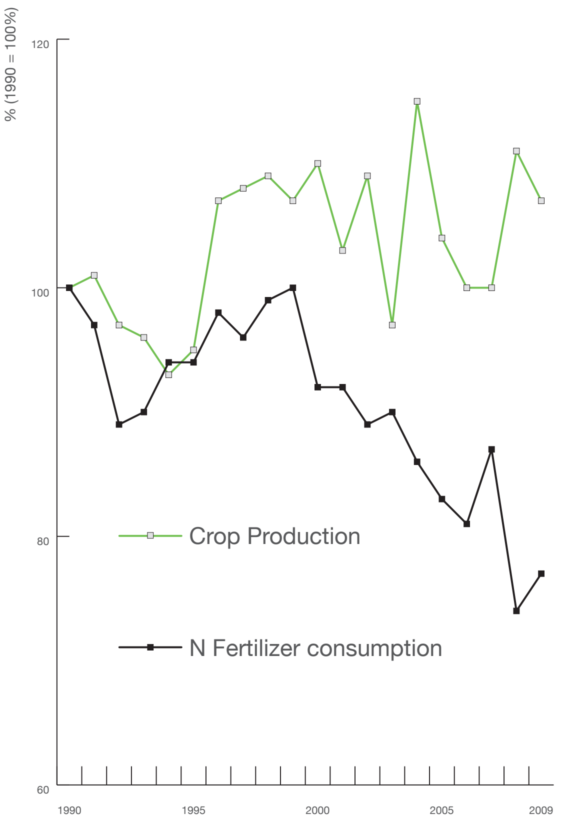
The International Fertilizer Industry hails the positive outcome of the Climate Change Conference in Paris and welcomes the upcoming examination of agricultural issues in two workshops at SBSTA44 in May 2016.



Today EU produces more crops at a lower mineral nitrogen fertilizer consumption

The paper highlights:

1. The important role of plant nutrients in **increasing agriculture productivity,** thus reducing the need for additional cultivated land and eliminating one of the most **important drivers of deforestation.**

2. The importance of site and crop specific best management practices in plant nutrient application to **maximize nutrient uptake** by plants and **minimize greenhouse gas emissions.**

Neglected soil fertility results in lost productivity

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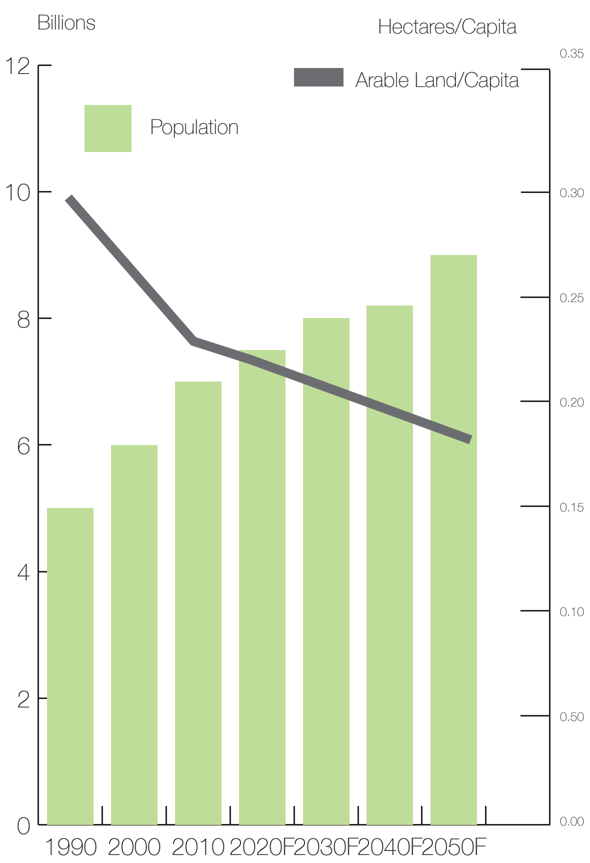
Plant nutrients play an important role in sustainably increasing agricultural productivity on arable land, taking pressure off the world's forests and peatlands, and facilitating soil carbon sequestration.

Global population and arable land per capita



Adapted from FAO, United Nations, PotashCorp. Last updated Aug 31, 2014

With the world population expected to reach 9.7 billion people by 2050 (FAO), **the agricultural sector must increase productivity by an estimated 60%** to meet the increasing global demand. This must be accomplished in the context of **shrinking availability of arable land;** as noted also by the FAO, the average amount of cropland and pasture land per capita has decreased from 0.4 and 0.8 hectares respectively in the 1970s to 0.2 and 0.5 hectares by the 2000s. (FAOSTAT, 2013).

Sustainable intensification of agricultural productivity on arable land not only promotes global food security, but also **reduces deforestation and loss of peatlands, wetlands, grassland, which, combined** make up some 5 Gt CO_2eq or **10% of global GHG emissions** (AR5, ch 11). The correct application of plant nutrients – both of an organic and mineral nature – plays an important role in **sustainable agricultural intensification,** and thus can ease pressure on the world's forests and peatlands.

Preserving land from cropping from 1961 – 2005 has led to carbon emissions savings of

317-590 Gt CO_2-eq

" The correct application of plant nutrients, both of organic and mineral nature, plays an important role in sustainable agricultural intensification, and thus can ease pressure on the world's forests and peatlands. "

Soils can store up to

50-300 tonnes of carbon per hectare, which is equivalent to

180-1100 tons of carbon dioxide[2]

Global Need for Integrated Plant Nutrient Management:

Better integration of organic resources, such as animal manure and crop residues into crop nutrition programs. Farmers should use available organic sources and supplement them with mineral fertilizers to achieve their yield goal.

It has been estimated that **1 billion hectares of land has been preserved** between 1961 – 2005 because of advances in crop productivity, leading to carbon emission savings of 317 to 590 Gt CO_2-eq.[1]

There is also significant mitigation potential in soil carbon sequestration, with some estimates indicating that **soils can store up to 50-300 tonnes per hectare, which is equivalent to 180-1100 tonnes of carbon dioxide[2],** and that some 89% of agriculture's future mitigation potential is based on soil carbon sequestration.

Carbon sequestration in cultivated soil can be increased by reducing tillage, adding organic amendments, using cover crops and adding appropriate mineral nutrients for biomass production.

- Increased soil organic matter improves soil health and productivity resulting in **more CO_2 capture from the atmosphere.**

- Biomass Stimulation can be achieved through the use of organic and mineral fertilizers resulting in **greater nutrient availability** which stimulates plant growth and **higher CO_2 absorption from the atmosphere.**

- In order to **maximize carbon sequestration from the air in soil organic matter,** the fertilizer industry advocates the **integrated use of available plant nutrients (organic and inorganic) to improve crop and biomass production.** Higher yields and biomass production results in greater crop residues (above and below the ground) to build soil organic matter.

Soil carbon sequestration has a significant role to play in mitigation
We advocate for the integrated use of locally available organic sources with mineral fertilizer

Best management practices in plant nutrient application to maximize nutrient uptake by plants and minimize greenhouse gas emissions, including N_2O emissions

As indicated, the **correct use of plant nutrients plays an important role in sustainable agricultural intensification.** It is indeed important to ensure a maximum uptake of needed nutrients by plants so as to minimize losses to the environment, which can also be in the form of GHGs, while keeping in mind that **zero losses is not an achievable goal** given that we are dealing with biological processes.

When mineral fertilizers and manures are added to soil, microbial conversion causes some loss of nitrous oxide (N_20), a greenhouse gas with a global warming potential, roughly 300 times greater than that of $C0_2$. **About 67 % of nitrous oxide N_20 emissions** (about 4.5 million tonnes) **comes from agriculture,** including 42 % of direct emissions from fertilization and livestock manure, and 25 % from runoffs and leaching.[3]

"Zero losses is not an achievable goal given that we are dealing with biological processes."

The global fertilizer industry accounts for
2.5 % of global GHG,
with some
1.5% deriving from fertilizer application.

GHG emissions from fertilizer application can be significantly reduced with soil and crop-specific Fertilizer Best Management Practices.

*"The good news is that with site and crop specific application of nitrogenous fertilizers and proper manure management, combined with appropriate soil and cropping system conservation practices, these **N_2O losses can be significantly decreased.**"*

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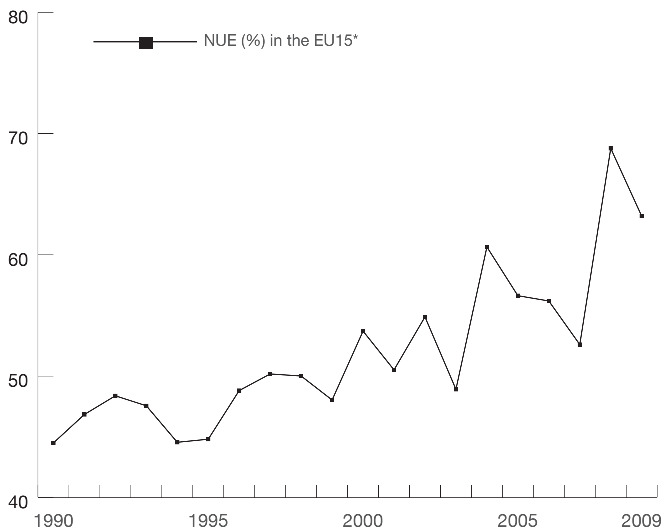
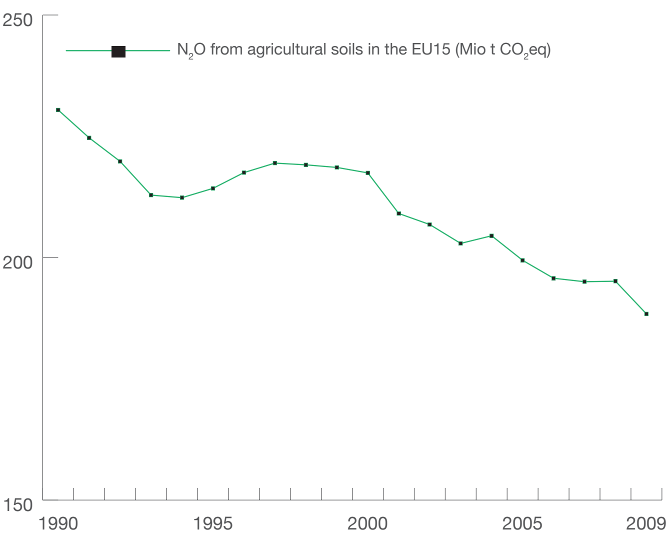
The main Management Practices for an efficient and effective fertilization are based on the “4R” principles (application of the Right Nutrient Source at the Right Rate, Right Time and in the Right Place) :

In Europe (EU 15) NUE (Nitrogen Use Efficiency) has increased



...while N_2O emissions from agricultural soils have decreased



SOURCE: Supplementing the deficient essential nutrients by using organic nutrient sources and the best available mineral fertilizers for the specific crop and soil

RATE: Applying optimum recommended nitrogen rates based on crop needs

TIME: Scheduling nitrogen applications according to regional climate and weather conditions and in accordance with crop nutrient requirements over time

PLACE: Ensure the proper placement of nitrogen sources close to plant roots to optimize plant nutrient uptake

As estimated through the Nitrous Oxide Emissions Reduction Program/NERP[6], a voluntary offset scheme run by the Province of Alberta, Canada, some 15-25 % reduction of N_2O emissions could be achieved, and new science could almost double these estimates.

It is important to note that all four performance areas of source, rate, time and place are needed to ensure and maximize N_20 reductions. Therefore, Best Management Practices have to be regionally specific.

The fertilizer sector works with NGOs, governments, food companies, scientists and farmers to advance nutrient stewardship principles.

There is a need to maximise nutrient uptake by plants to minimize N_2O emissions

In response we are promoting the 4R approach – the Right NUTRIENT source, at the Right RATE, Right TIME and Right PLACE

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Innovations & Technologies for improved fertilizer use

In New Zealand pastures, adding both urease and nitrification inhibitors to urea

Increased total N uptake by

> 20%

Reduced nitrate leaching by

< 20%

Reduced N_2O emissions by

< 30%[4]

1 Burney J.A.,S.J. Davis, and D.B. Lobell, 2010, Greenhouse gas mitigation by agricultural intensification, Proc.National Academy of Sci. 107(26): 12052-12057
2 Watson, RT, Noble, IR, Bolin, B, Ravindranath, NH, Verado, DJ & Dokken, DJ (eds) 2000, 'Land use, land-use change, and forestry: a special report of the Intergovernmental Panel on Climate Change', Cambridge, Cambridge University Press, pp. 23–51
3 IPNI, 2015, Nitrous Oxide: Reducing emissions from fertilizer and manure nitrogen. Available online:http://www.ipni.net/publication/stewardship.nsf/0/B77659016F88E9A885257D150065 6A87/FILE/StewSpec-EN-19.pdf
4 IPCC Fourth Assessment Report Climate Change 2007 sustainable crop and animal production to help mitigate Nitrous Oxide emissions. Current Opinion in Environmetal Sustainability 9-10:46-54
5 W. van Groeningen, O. Oenema, K. van Groeningen, G. Velthof, C. van Kessel, Best Nitrogen Management Practices to decrease Greenhouse Gas Emissions, 2011 Better Crop 95(2); 16-17
6 Alberta Environment, 2010, Quantification protocol for agricultural Nitrous Oxide emissions reductions. Available online: http///environment gov.ab.ca/info/library/89294.pdf

There are many tools and technologies available to assist farmers **correctly apply plant nutrients,** but the challenge of reaching out to the world's more than 500 million farmers remains significant:

- Soil testing
- Field mapping, data management and Global Positioning System (GPS) for precision farming
- Tools for monitoring crops' nutrient status, ranging from simple leaf colour chart to sophisticated remote sensing technologies
- Precision farming techniques like "microdosing" of small quantities of fertilizer to improve productivity on depleted soils – a method that has shown significant results in Africa
- Decision support tools
- Outreach and knowledge transfer to the over 500 million farms around the world on site and crop specific plant nutrition is of vital importance

Enhanced Efficiency Fertilizers

Moreover, slow and controlled release and stabilized fertilizers with polymer coatings or additives, such as nitrification inhibitors, have shown to **contribute successfully to delay nutrient release** or microbial conversions to forms subject to losses, **thereby reducing the amount transferred to the atmosphere or to water.** Measurement technologies are being developed and need to be implemented broadly to assess mitigation tactics in relation to yield increase and food security goals.

New non invasive technologies to measure Soil Organic Carbon

- Rapid spectroscopy
- Remote sensing
- Inelastic neutron scattering
- Micrometeorological techniques – eddy covariance
- Computer models (e.g. CENTURY)