INTERNATIONAL FERTILIZER ASSOCIATION

The Role of Fertilizers in Climate-Smart Agriculture

Contribution of the International Fertilizer Association (IFA) to the UN Climate Change Conference in Marrakesh – COP22/CMP12

The Role of Fertilizers in Climate-Smart Agriculture

It is estimated that fertilizers represent 2.5% of global GHG emissions, 1.5% of which deriving from their application. Though this figure seems negligible, especially considering the agricultural sector as a whole represents 12% of all GHG emissions, the fertilizer industry is nevertheless committed to reducing its carbon footprint.

The industry and the world's farmers have to achieve this in a context of a growing world population, with an increasing demand in food, which is why IFA fully endorses Climate-Smart Agriculture (CSA), as defined by the Food and Agricultural Organisation of the United Nations (FAO) as: "Agriculture that sustainably increases productivity, enhances resilience, reduces/removes greenhouse gas emissions where possible, and enhances achievement of national food security and development goals". These three objectives are referred to as CSA's triple win.

The correct and balanced use of plant nutrients is a core component of Climate-Smart Agriculture, and IFA is dedicated to disseminating CSA practices all around the world.

KEY MESSAGES

- Global food security is not achievable without fertilizers;
- Fertilizers are crucial to sustainably enhancing food productivity;
- Fertilizers, when used following site- and crop- specific Best Management Practices in the 4 areas of nutrient management (source, rate, time and place) are important for adaptation to and mitigation against climate change.

Global food security is not achievable without fertilizers

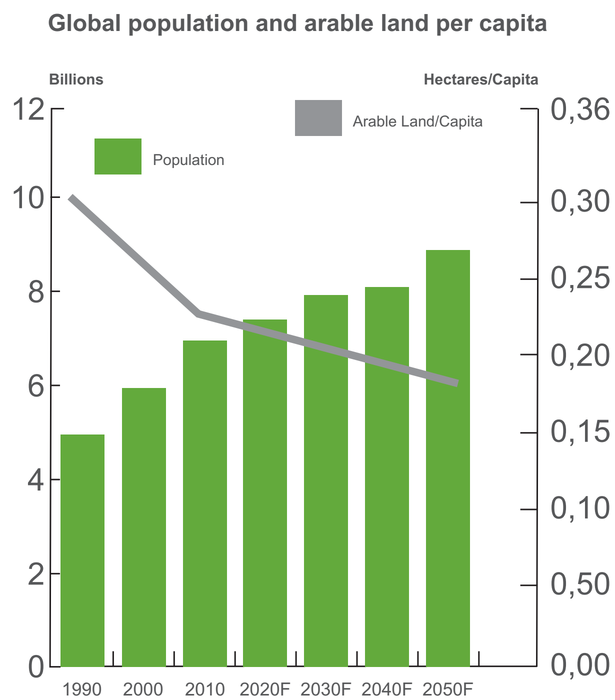
One of CSA's triple wins is "enhancing the achievement of food security and development goals", which cannot be achieved without fertilizers.

It is estimated that fertilizer use contributes to about 50% of today's food production.

Providing farmers with access to quality inputs, and the knowledge to apply them efficiently and effectively over a long period of time is the first step towards enhancing food security. However, the challenge is now to reach out to the world's 500 million farmers and sharing knowledge of the importance of site- and crop- specific plant nutrition.

Fertilizers are essential to sustainably enhancing food productivity

With the world population expected to reach 9.7 billion people by 2050 (FAO), **the agricultural sector must increase productivity by an estimated 60% compared to 2005 to meet an increasing global demand in food.** (Alexandratos and Bruinsma 2012)



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

This must be accomplished in the context of shrinking availability of arable land: according to 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_2-eq annually or 10% of global GHG emissions (AR5, chapt. 11).

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

Between 1961 and 2005, 1 billion hectares of land have been preserved from ploughing thanks to agricultural intensification, and more can be achieved through the implementation of best management practices in fertilizer use (PNAS, 2010).

Fertilizers Play an Important Role for Adaptation and Mitigation

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.

When mineral fertilizers and manures are added to soil, microbial conversion causes some loss of nitrous oxide (N_20), a GHG with a global warming potential roughly 300 times greater than that of carbon dioxide ($C0_2$). About 67 % of global N_20 emissions (around 4.5 million tonnes CO_2-eq) comes from agriculture, including 42 % of direct emissions from fertilization and livestock manure, and 25 % from runoffs and leaching (IPNI, 2015).

ZERO losses are not an achievable goal given that we are dealing with natural biological processes!

However, losses to the environment can be measurably minimized, and fertilizer-related GHG emissions can be reduced by ensuring a **maximum uptake of needed nutrients by plants:**

Therefore, the fertilizer industry and its partners:

- **have developed the 4R global framework and site- and crop- specificf fertilizer best management practices in the four areas of nutrient management**
- **are engaged in knowledge transfer to farmers**
- **develop innovative, tailored products**
- **give their support to the development of innovative technologies that contribute to reducing the impact of fertilizers on the environment, and reduce the agricultural sector's share in global GHG emissions**

FERTILIZER BEST MANAGEMENT PRACTICES: ADDRESSING CLIMATE CHANGE CHALLENGES

The fertilizer industry promotes **nutrient stewardship programmes** and **fertilizer best management practices (FBMPs)** in order to encourage farmers to use fertilizers in an effective and efficient way.

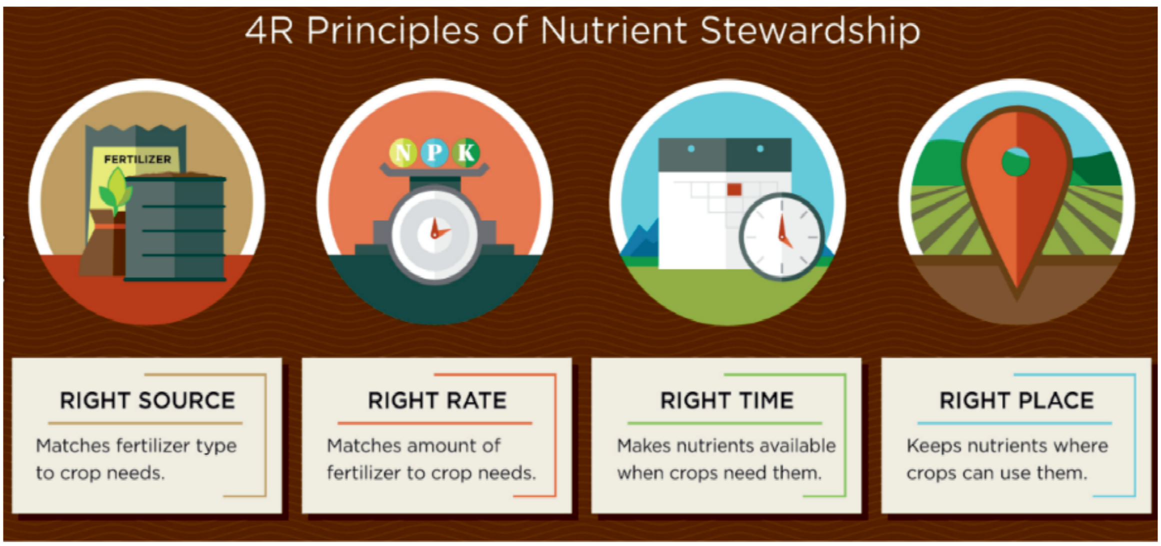
FBMPs refer to site- and crop-specific production techniques and practices developed through agronomic research, verified and continuously adapted in the fields to maximize economic, social and environmental benefits.

Through FBMPs, the benefits derived from fertilizers are maximized while the losses and negative effects of over/under or misuse of fertilizers are minimized. Correct fertilization also helps to boost the resilience of crops and therefore plays an important role in climate change adaptation.

Site-Specific Nutrient Management (SSNM), including a balanced use of all essential crop nutrients has proven an efficient way to reduce GHG emissions for farming systems using N fertilizers. Indeed, studies have shown that where SSNM had been put in place, an overuse of N fertilizer had been avoided, less reactive N had been released to the atmosphere (especially nitrous oxide, N_20), and leaching losses had also been reduced substantially (GASCA, 2015).

Global Nutrient Stewardship Principles: the 4Rs

The 4R approach entails using the Right Nutrient Source, at the Right Rate, at the Right Time, in the Right Place.



This can be implemented by:

- **Source:** Supplying the limited essential nutrients by recycling available on-farm organic nutrient sources and supplemented by mineral fertilizers suitable for site- and crop-specific conditions;
- **Rate:** Applying optimum recommended fertilizer rates based on crop needs to achieve farmers' yield goals;
- **Time:** Scheduling fertilizer applications according to regional climate and weather conditions and in accordance with crop nutrient requirements over time;
- **Place:** Ensuring the proper placement of fertilizer sources close to plant roots to optimize plant uptake.

It is important to note that all four nutrient management areas of source, rate, time and place shall be paid due attention to ensure and maximize GHG emissions reductions.

The fertilizer sector works with NGOs, governments, food companies, scientists and farmers to advance nutrient stewardship principles. 4R nutrient management projects are being implemented throughout the world, where regionally-specific FBMPs are being developed.

IFA for instance supports IPNI's[1] project in Ethiopia: 85 demonstrations and learning sites devoted to 4R nutrient management have already proven their tremendous potential in terms of yields and profits for farmers:

Ethiopia: Farmer Practice vs. 4Rs*

Crop	Farmer Practice		4R Demonstration	
	Yield, t/ha	Ave. Gross Margin, $	Yield, t/ha	Ave. Gross Margin, $
Maize	2.0 - 4.0	560	7.0	>1,000
Beans	0.5 - 1.0	240	2.3	980
Groundnuts	0.5 - 1.5	320	3.0	850

*85 demonstration and learning sites established in three regions

Source: IPNI data

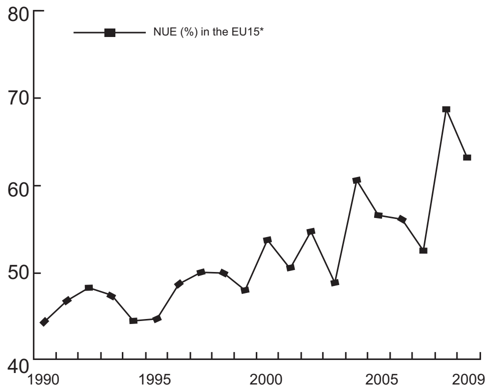
IPNI

1-The International Plant Nutrition Institute.

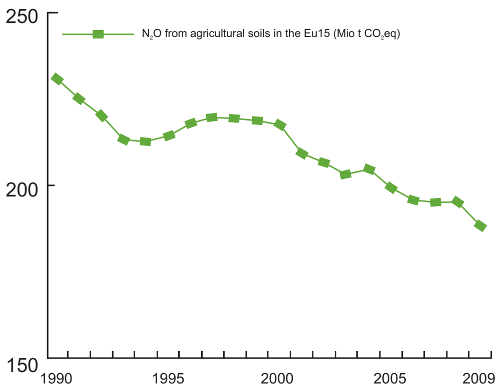
An innovative example of 4R nutrient management is being deployed in Canada's Province of Alberta: The Nitrous Oxide Emissions Reductions Protocol (NERP), initiated by Fertilizer Canada (formerly the Canadian Fertilizer Institute), aims to reduce on-farm emissions of nitrous oxide emissions in a verifiable way that allows farmers to earn carbon credits. Some 15-25 % reduction of N2O emissions in Alberta could be achieved thanks to NERP, and new science could almost double these estimates.

In Europe (EU 15), Nitrogen Use Efficiency (which refers to improved crop or cropping system recovery of the applied nitrogen) has increased, while N_2O emissions from agricultural soils have decreased, as illustrated below. Thanks to best management practices, Europe now produces more crops with stable N fertilizer consumption.

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



...while N_2O emissions from agricultural soils have decreased



MITIGATION THROUGH SOIL MANAGEMENT

Soils can store up to 50-300 tonnes of carbon per hectare, which is equivalent to 180- 1100 tonnes of carbon dioxide (CO_2), and **some 89% of agriculture's future mitigation potential is based on soil carbon sequestration** (IPCC, 2007). 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.

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 goals

In order to maximize carbon sequestration from the air in soil organic matter, the fertilizer industry promotes **Integrated Plant Nutrient Management**, which entails among others **starting with on-farm organic sources of nutrients and then supplementing them with manufactured fertilizers** to sustainably increase yields.

The integration of organic and mineral sources of nutrients should be seen in the context of overall crop production, which includes the selection of crop varieties, pest control, efficient use of water, soil management and other aspects of integrated farm management.

ADAPTING TO A WATER-SCARCE ENVIRONMENT

Water is fast becoming a scarce resource in certain regions of the world, and farmers need to be very careful in managing inputs (water and nutrients) to ensure high yields while reducing adverse effects on the environment.

Fertigation is an innovative fertilizer application method that entails applying fertilizers to crops with irrigation water.

Fertigation makes it possible to synchronize the crop's nutrient demand with fertilizer supply throughout its growth cycle, simultaneously addressing the rate, time and place dimensions of 4R nutrient stewardship.

Fertigation has tremendous potential in maximising yields while minimizing environmental pollution, that could help turn vast areas of arid and semi-arid land in many parts of the world into farmland, as well as preventing water from being wasted in conventional irrigation systems.

FINDING SOLUTIONS THROUGH INNOVATION

There are many tools and technologies available to assist farmers to **correctly apply plant nutrients,** for instance:

- Soil testing (using wet chemistry or sensors);
- Field mapping, data management and Global Positioning System (GPS), useful for precision farming;
- Tools for monitoring crops' nutrient status, ranging from a simple leaf colour chart to sophisticated remote sensing technologies;
- Decision support tools;
- **Slow- and controlled- release** or **stabilized fertilizers** with polymer coatings or additives, such as nitrification inhibitors, have shown significant results in successfully delaying **nutrient release** or microbial conversions to forms subject to losses, **thereby reducing the amount transferred to the atmosphere or to water;**
- Foliar fertilization allows to apply small amounts of nutrients (typically micronutrients) when and where needed without being influenced by soil-nutrient interactions;
- Precision farming techniques like "micro-dosing" of small quantities of fertilizer to improve productivity on depleted soils – a method that has shown significant results in Africa.

Box 1- Monitoring technologies

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 technologies are available to measure Soil Organic Carbon, such as rapid spectroscopy; remote sensing; inelastic neutron scattering; micrometeorological techniques; computer models (e.g. CENTURY)

Box 2- Enhanced-efficiency fertilizers

In New Zealand pastures, adding both urease and nitrification inhibitors to urea increased total N update by

> 20 %

Reduced nitrate leaching by

> 20 %

Reduced N_2O emissions by

< 30 %

Enhanced-efficiency fertilizers have shown significant environmental results, such as an increase of N uptake by plants, reduced nitrate leaching and a reduction of N_2O emissions.

Box 3- Minimizing nutrient pollution by maximizing nitrogen use efficiency

Case study in a rice field in North-east Japan on NUE (Shoji, 2005).

Case	NUE %	N rate kg N/ha	N rate reduction %	N uptake by rice kg N/ha	Max. potential fert. pollution kg N/ha
1	30	100	0	30	70
2	80	40	60	32	8

Notes:
30% NUE: average data of conventional fertilizer basal application
80% NUE: highest data of Meister application

With intensive agriculture in Japan, N fertilizer commonly makes the greatest contribution to crop production while it has the highest potential for environmental degradation. Shoji and Mae (1984) considered that to minimize nitrate pollution but optimise yield in a given farming system, it is necessary to maximize NUE as shown in Box 3. Maximizing NUE requires FBMPs programmed fertilization using controlled-release fertilizers.

NUE can also be successfully improved by adopting balanced fertilization, taking into account all essential plant nutrients (macro- and micronutrients) that have the potential to limit crop yield. For instance, field trials have shown that a balanced supply of N and K fertilizers can improve NUE by 20% on average (IPI, 2014).

KEY TAKEAWAYS:

- **Climate-Smart Agriculture (CSA) is a must** for ensuring food security in the midst of climate change.
- **CSA cannot happen without fertilizers-** they help achieve all of CSA's "**triple wins**"- increasing agricultural productivity; adapting and mitigating agriculture to climate change realities; and achieving global food security.
- **Local FBMPs are vital** for ensuring that plant nutrients are applied in the correct way and that losses to the environment are minimized.
- **The 4Rs provide a framework for applying FBMPs to the four nutrient management areas to achieve improved economic, social and environmental performance**: they are inclusive and can be applied anywhere, even with limited access to new technologies.
- **Correct fertilizer use helps with climate change adaptation and mitigation** in several important ways:
    - By contributing to plant growth
    - By increasing soil carbon sequestration
    - By enhancing crop resilience
    - By enhancing water use efficiency
    - By reducing nutrient losses to the environment
    - By stalling deforestation