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THE CRUCIAL ROLE OF PLANT NUTRITION IN THE 2030 SUSTAINABLE DEVELOPMENT AGENDA

In addition to light, carbon dioxide and water, plants need essential nutrients to grow, which can come from the soil and organic and mineral fertilizers. Mineral fertilizers contain concentrated, consistent and readily available nutrients, and enable farmers to grow more on less land. Without them, world agricultural production could fall by as much as half and it would not be possible to feed the global population.

Plant nutrients achieve more than food security: they play an important role in achieving several of the Goals of the 2030 Sustainable Development Agenda. Find out below how they contribute to SDG Goals 1 (No Poverty); 2 (No Hunger); 5 (Gender Equality); 6 (Sustainable Management of Water); 9 (Sustainable Industrialization); 13 (Climate Change); 14 (Clean Oceans) and 15 (Life on Land).

SUSTAINABLE DEVELOPMENT GOAL 1

End poverty in all its forms everywhere



Plant nutrients can lift farmers out of poverty

"Farmers are the engine of food supply in the world, yet a large proportion of them lives in poverty. Lifting them out of this poverty by increasing their access to inputs, technology, services and markets is our most important challenge for this century." Dr. Theo de Jager, Chairman, World Farmers' Organization

In developing countries around 2 billion people live and work on small farms. Most of the world's smallholder farmers are struggling to live and feed their families on less than US\$2 a day.

Fertilizers play a crucial role in overcoming this type of poverty: adequate and affordable access to fertilizers allows subsistence farmers to produce a surplus that they can sell, using the income to not only buy additional food for their families, but also send their children to school and pay for health care.

The impact of fertilizers is immediate: within a single cropping season, and with the adequate use of other crop inputs (e.g. water) farm productivity can be doubled or tripled. For every 1 kg of nutrient applied, farmers obtain 5-30 kg of additional product. (AFAP, IITA, IFDC, IPI, IPNI, One Acre Fund and IFA. The Smallholders Access to Fertilizers Campaign, 2014)

No farm in the world is too small to use fertilizers, and they can significantly increase farmers' incomes.

SUSTAINABLE DEVELOPMENT GOAL 2

End hunger, achieve food security and improved nutrition and promote sustainable agriculture



➤ Half the food we eat today is produced thanks to mineral fertilizers¹.

“Food is the moral right of all who are born into this world (...) This is a basic problem, to feed 6.6 billion people. Without fertilizers, forget it. The game is over.” - Dr. Norman Borlaug, Nobel Prize Winner and Father of the Green Revolution, 2008.

Fertilizers provide crops with the nutrients essential for their growth and health², which helps increase crop yields and food production. Fertilizers are used in every corner of the globe to support sustainable agricultural production and food security. Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food. The crucial link between fertilizers and food security is most noticeable in regions where fertilizer application rates are low: in sub-Saharan Africa, where fertilizer consumption is the lowest in the world (2% of the global average), 40% of soils are depleted of nutrients, and 243 million people suffer from hunger and malnutrition (FAO, 2017).

With the world population expected to reach around 10 billion people by 2050, the agricultural sector needs to increase its productivity by 60% compared to 2005 levels to meet the increasing demand for food. (FAO, 2012) This must be accomplished in the context of the shrinking availability of arable land. Achieving global food security today and in the future cannot be achieved without fertilizers.

➤ Fertilizers contribute to a better nutrition for all through micronutrient fertilization.

“In addition to yield, plant nutrition affects other important components of human nutritional needs, including the amounts and types of carbohydrates, proteins, oils, vitamins and minerals. Many of the healthful components of food are boosted by the application of mineral nutrients.” T. Bruulsema, P. Heffer, R.M Welch, I. Cakmak and K. Moran. Fertilizing Crops to Improve Human Health: A Scientific Review. 2013.

Currently, more than 2 billion people, mostly in developing countries, suffer from micronutrient malnutrition, sometimes referred to as “hidden hunger”. The nutrient deficiencies most commonly associated with human health problems on a global scale are iron, zinc and iodine, but selenium and fluorine deficiencies are also widespread. Micronutrient-enriched fertilization is considered one of the most promising ways to fight malnutrition, and to alleviate nutrient deficiencies worldwide, especially for zinc, selenium and iodine.

In addition, macro and micronutrient fertilization can extend the lifecycle of food, improve the post-harvest integrity of crops and thus reduce food waste: this is the case for calcium-based and boron-supplemented fertilizers, which help strengthen plant cells and make them more resistant post-harvest.

¹ Erisman et al., 2008

² Seventeen elements are essential for plant growth and can be divided in three groups: primary macronutrients (N, P, K), secondary macronutrients (sulphur (S), magnesium (Mg) and calcium (Ca)) and micronutrients: iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), chlorine (Cl) and nickel (Ni). Plant growth is limited by the essential element that is the furthest below its optimum. N, P and K are generally the most widely deficient elements, but mineral fertilizers also supply secondary and micronutrients as well, as they are gradually becoming new limiting factors throughout the world.

➤ Best Fertilizer Management Practices help to increase the proportion of agricultural area under productive and sustainable agriculture:

“A key shift is to accept that growth alone is not enough: we must grow food in the right way, for the health of consumers and the planet” Liam Condon, President of the Crop Science Division, Bayer

When applied according to Best Management Practices, fertilizers (both mineral and organic) can fulfil their primary function of providing plants with consistent and easily available nutrients more efficiently; while the risks of losses, and the negative effects of their over, under or misuse are minimized.

The “**4R**” **Principles** of nutrient management, that refer to applying the **right source of nutrients** (including organic and mineral fertilizers); at the **right rate** needed to optimize yields to a specific crop; at **the right place** in the field; and at **the right time** they are needed by the crop; are applicable to each country and region worldwide.

Applying the 4Rs has allowed farmers in various regions of the world to sustainably increase their yields, incomes and livelihoods.

Conservation practices such as crop rotation, reduced tillage, mulching and cover cropping can increase soil resilience by reducing soil erosion and water evaporation. Combining them with 4R nutrient stewardship (“4R Plus”) is starting to show very good results in reducing nutrient losses to the environment while boosting productivity.

SUSTAINABLE DEVELOPMENT GOAL 5

Achieve gender equality and empower all women and girls



➤ Fertilizers can increase gender equality in agriculture

“It is critical that governments commit to addressing the gender gap if we are to have a food secure Africa. Closing the gender gap should be viewed as a business priority and an economic imperative” Dr. Lindiwe Majele Sibanda, Vice- President of the Alliance for a Green Revolution in Africa (AGRA)

Fertilizers have an important role to play in terms of bringing female farmers to the same level as their male counterparts. The FAO has recorded women’s use of fertilizer as being significantly lower than men’s, mainly due to lack of access to this vital input.

This is a major factor that contributes to their yields being around 20-30% lower than men’s. This gap could be bridged sizably by improving women’s access to fertilizers: such an intervention could feed a further 150 million people, according to the FAO.

SUSTAINABLE DEVELOPMENT GOAL 6

Ensure availability and sustainable management of water and sanitation for all

6 CLEAN WATER AND SANITATION



➤ Nutrient losses to water can be significantly reduced with Fertilizer Best Management Practices

“Site-specific nutrient management (SSNM) practices have been developed as alternatives to blanket fertilizer recommendations for large areas. These practices achieve a more efficient use of fertilizers, that results in higher yields per unit applied, and protects the environment by preventing their excessive use. SSNM strategies have shown success in a wide range of farmers' fields.” Achim Dobermann, Director and Chief Executive of Rothamsted Research

Plant nutrients – in the form of both organic and mineral fertilizers – applied by farmers to their fields play a crucial role in enhancing agricultural yields, but some of these nutrients can make their way into nearby streams, and end up in rivers, lakes and coastal areas through agricultural runoff of soils caused by heavy rainfall or can leach into groundwater. These losses can be minimized with proper soil and crop nutrient management practices.

Eutrophication, the excess growth of algae and phytoplankton in water bodies due to their enrichment with plant nutrients, and aquatic hypoxia (oxygen deficiency in water) have been identified in recent years as a significant source of marine pollution, in particular in coastal areas.

A knowledge of agricultural nutrient cycles and their loss pathways is essential to avoid losses to water that can occur through soil erosion and runoff of particulate matter: Nitrogen (N) and Phosphorus (P) cycles are complex biological cycles and, by definition “leaky” systems, largely due to microbiological activity. They are also affected by weather conditions. As such, N and P losses to the environment in various forms cannot be completely avoided but can be minimized through the application of best management practices and the “4R” Principles (management of the nutrient source, rate, time and place).

For instance, ensuring the proper placement of the fertilizer source close to the plants' roots to optimize its uptake (right place) and scheduling fertilizer application according to regional climate and weather conditions (right time) have proven to be very efficient methods to reduce nutrient losses to water beds. (IFA, 2018)

➤ Sound water management at fertilizer production sites

“The sustainability of a business depends on its capacity to anticipate, analyze, understand and address an issue or a crisis, such as the increasingly limited availability of water. Fertilizer producers are tackling this challenge head-on and have implemented measures on their production sites that have already resulted in substantial water savings worldwide.” Philippe Fonta

The sustainable management of water has become a priority on most fertilizer production sites: manufacturers work hard to monitor and adjust their water use to ensure that losses are minimized while recycling and reuse are maximized.

These efforts are showing tangible results: for example, significant progress has been achieved in recycling water. In North America, the fertilizer industry has achieved the reclaiming of around 1.4 billion gallons of water. Many plants have set water efficiency goals, and the amount of water needed to produce a ton of Nitrogen has decreased by 38% since 2013, and by 9% for potash and phosphate production. (TFI, 2018).

SUSTAINABLE DEVELOPMENT GOAL 9

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation



➤ The manufacture of fertilizers is becoming ever more efficient thanks to Best Available Technology (BAT) and innovation on plant sites

“The Haber-Bosch process has been of greater fundamental importance to the modern world than the airplane, nuclear energy, spaceflight or television.” Vaclav Smil, Faculty of Environment at the University of Manitoba in Canada.

The first half of the 20th century witnessed major breakthroughs in fertilizer product development, such as the invention of processes to produce Ammonia in 1909, Urea in 1922, and DAP (the most widely used phosphorus-based fertilizer) in 1959. These advances have enabled to feed a fast-growing world population until today, and they still contribute to about 50% of the world's food production.³

Large gains have already been achieved in the last 30 years thanks to the adoption of Best Available Technologies (BATs): Plants built today with the most advanced technologies use 30% less energy per tonne of ammonia produced compared to older plants; but older plants have also shown tremendous progress in cutting their energy requirements through revamping improvements. The capture and re-use of CO₂ emitted on plants, called Carbon Capture and Storage (CCS), has enabled production sites over the past years to reduce their GHG emissions significantly and consistently: in 2016 in North America, fertilizer producers captured 8 million metric tons of CO₂. (TFI, 2018).

Phosphate and potash companies have put into place various, locally adapted recycling measures of water or electricity: Potash facilities are increasingly converting the waste heat generated during potash production into steam, which is then converted through “cogeneration” to produce electricity for their internal consumption; and several phosphate producers have developed programs to reuse 95% of the water previously used in transporting and processing phosphate ore by removing heavy metals and other impurities. (IFA, 2015).

➤ Innovations in agriculture have made the application of fertilizers more efficient and effective

“Digitalization will drive transformation, sustainability will shape it”- Peter Bakker WBSDC

Technological advances in agricultural production, nutrient and water management have enabled significant gains in fertilizer application efficiency and reduction of nutrient losses to the environment.

³ Erisman et al., 2008

Thanks to advances in soil testing and soil mapping technologies⁴, farmers can quickly identify nutrient deficiencies at crucial crop growing stages; collect data on planting records, fertilizer application, crop yields and nutrient removals; and even work in low visibility conditions. It is also possible to combine these technologies with decision support tools that generate crop and soil recommendations to the farmers based on the real-time information collected on the field, market information and crop simulation models. Handheld tools also provide useful information of a plant's nutrient status in real time.⁵

The use of these emerging new technologies in agriculture, referred to as "Precision Agriculture", helps steer the sector towards a high-efficiency, sustainable, energy-friendly and input optimized model. While it has become a widespread practice in developed countries, the high-tech nature of these tools can make adoption in developing countries challenging - although the IT revolution and tremendous spread of smartphones also allows for significant "leapfrogging."

Farmers can also turn to innovative fertilizer products to match precisely the crops' needs in nutrients. These include slow- and controlled- release fertilizers which better match crop nutrient needs; stabilized fertilizers, which contain inhibitors to reduce nitrogen losses to the environment, and water-soluble fertilizers which can be applied through fertigation (with irrigation water) or foliar application.

SUSTAINABLE DEVELOPMENT GOAL 13

Take urgent action to combat climate change and its impacts*



➤ Fertilizers contribute to climate change mitigation through preventing deforestation and increasing soil carbon sequestration

"There are clear opportunities for Fertilizer Best Management Practices projects to complement national climate change mitigation strategies. They can help policy makers understand fertilizer -related emission trends, and associated mitigation options that can deliver on targets such as those of the Paris Agreement."
Dr. Clare Stirling, Senior Scientist with the Global Conservation Agriculture Program, CIMMYT (International Maize and Wheat Improvement Centre).

As fertilizers increase productivity on arable land, they also forestall deforestation. They help maintain the integrity of the globe's forests, which are important carbon sinks. In the context of climate change, this is crucial, as deforestation, and loss of peatland, wetlands and grasslands combined, represent about 10% of global GHG emissions, not to mention cause considerable damage to the ecosystem. **One billion hectares have been preserved from conversion to cropping** between 1961 and 2005, leading to carbon emission savings of **317 to 350 Gt CO₂-eq** (Burney et al. 2010).

Optimized fertilizer management helps to build up soil organic matter (SOM) since it increases biomass production, allowing the increased non-harvested carbon rich biomass (e.g. roots and stems) to return to the ground. Improved agricultural practices, such as Integrated Plant Nutrient Management (IPNM) (which entails using on-farm organic sources of nutrients and supplementing them with manufactured fertilizers) lead to higher Soil Organic Matter (SOM) which improves not only soil health and productivity but results in more CO₂ sequestration. **This is very important as soils represent 89% of agriculture's mitigation potential.** Indeed, they are the largest terrestrial pool of carbon and can store up to 50-300 tons of carbon per hectare (IPCC, 2007).

⁴ These include: vehicle – mounted sampling systems allow to take soil samples on large areas; and Global Positioning Systems (GPS), Geographic Information Systems (GIS) and remote sensors in airplanes, satellites and drone that provide multispectral imagery of fields from above the ground.

⁵ For instance, a device that measures the chlorophyll content of plant leaves (which gives an indication of the crops' nitrogen content) will help to target better nitrogen application for minimal losses to air and water while maximizing crop quality and yield.

➤ Fertilizers can help farmers adapt against climate change

"I'm very optimistic [about] fertilizer-based interventions that can provide food security and make sure that agriculture is as climate-smart as it can be". Dr. Bernard Vanlauwe, International Institute of Tropical Agriculture

Healthy soils and plants can better withstand climate stress than those with nutrient deficiencies. Fertilizers can considerably increase crops' resilience to climate change when applied following best management practices. This is vital for farmers that need to maximize their yields in good seasons to make up for more severe weather events in bad seasons.

Certain soluble fertilizer products can also be combined to irrigation water to provide plants with nutrients and water in the most efficient way possible, which is an asset in water-scarce areas. This method, called fertigation, can be carried out in every arid or semi-arid region with extremely simplified irrigation systems, like drips from water bottles.

SUSTAINABLE DEVELOPMENT GOAL 14

Conserve and sustainably use the oceans, seas and marine resources for sustainable development



➤ Fertilizer Best Management Practices can help preserve the health of seas and oceans

"Few industries have the ability to address not only one but a variety of environmental problems. The fertilizer industry (...) has a unique capacity not only to support food security but cleaner oceans, human health and the fight against climate change." Ibrahim Thiaw, Deputy Head of UN Environment

Nutrients can make their way to seas and oceans through the same loss pathways that carry them to streams, lakes and rivers: for instance, heavy rainfall or improper soil and crop nutrient management practices. In addition, losses to the atmosphere are often followed by deposition onto oceans.

By improving the management of plant nutrients from all sources on land, losses to seas and oceans can be considerably reduced, and negative phenomena like eutrophication or hypoxia can also be reduced in coastal areas.

The 4Rs can substantially improve the uptake of nutrient by plants, and thus reduce losses to water streams, and by extension, seas and oceans. This has been shown recently in Australia, where nutrient runoff to the Great Barrier Reef diminished by 18% per year between 2009 and 2015 thanks to best management practices and incentives to farmers. (Fertilizer Australia, 2015).

SUSTAINABLE DEVELOPMENT GOAL 15

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss



➤ Fertilizers help prevent soil degradation and desertification

“Soil is important; soil is threatened; it is time to take soil seriously. In the same way that food plays a role in human nutrition, fertilizers and soil fertility play such an important role in soil health. The two go completely hand in hand.” Chris Lambe, Director Strategic Initiatives, Agriculture and Food Security Center, The Earth Institute at Columbia University.

Desertification refers to the extreme degradation of land in arid, semi-arid and dry sub-humid areas, primarily caused by human activities and climatic variations. Although several regions are concerned by this phenomenon the most dramatic examples of desertification are found in Africa, where declining soil fertility is linked to declining agricultural productivity.

Traditionally, methods for restoring soil fertility entailed long fallow periods and shifting agriculture to new areas. However, these practices no longer suffice to meet the needs of the current and future population levels, and have raised serious environmental concerns, such as deforestation, as people tried to expand arable land.

Fertilizers have an important role to play in combatting desertification, as they restore and maintain soil health and fertility. **Integrated Soil Fertility Management (ISFM)**, a holistic approach to enhancing plant nutrient uptake (from the selection of crop variety to the biological and physical dimensions of soil health, and adapting practices to local conditions), is key to achieve this. ISFM incorporates **Integrated Plant Nutrient Management (IPNM)**, which also plays a central role in maintaining soil health: it entails using on-farm organic sources of nutrients and supplementing them with manufactured fertilizers to achieve the farmer's yield goal. IPNM allows for the best use of both organic and mineral fertilizers. Organic sources provide nutrients, and soil organic matter that improves soils' health and ability to retain water, and mineral fertilizer complement them with more concentrated, consistent and readily-available nutrients to plants.

IPNM has also proven to be the best method to sustainably increase yields on available arable land⁶, and thus also has the potential to prevent further deforestation.

➤ Fertilizer best management practices help adapting to a water-scarce environment

“The introduction of well-tested and efficient fertigation techniques into the world will help turn vast areas of desert soils into productive agricultural areas as well as saving precious water from being wasted in conventional agricultural systems”- Uzi Kafkafi, International Potash Institute, and Jorge Tarchitzky, the Hebrew University of Jerusalem

Often, water and nutrient management are addressed separately, although they are intimately linked. Improvements in nutrient use efficiency should not only be seen as a fertilizer issue: plant nutrients and water are complementary inputs, and the most limiting will constrain plant growth response to water and nutrients. The soil

⁶ A meta-analysis of research in sub-Saharan Africa comparing the effects of organic fertilizers, mineral and IPNM on maize found that on average IPNM produced the highest yield responses at 114% over the control plot (i.e. the plot with no management serving as a baseline).

water content is the single most important factor controlling the rate of various processes in soils that influence nutrient cycling, flows and availability to plants. Similarly, poor soil fertility limits the ability of plants to efficiently use water.

Fertilizers added to irrigation water through a method called “fertigation” can make it possible to synchronize crops’ nutrient requirements with fertilizer through their growth cycle, and address the rate, time and place dimensions of nutrient stewardship, while reducing overall water consumption due to precise placement and timing when using micro-irrigation systems.

Fertigation has tremendous potential in maximizing yields while minimizing environmental pollution, that could help turn 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.

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