EMBRAPA SOILS AND FERTBRASIL RESEARCH CONTRIBUTION TO CoCoFe

As a contribution of EMBRAPA (Brazilian Agricultural Research Company) and of a fertilizer research network led by our company in Brazil, I present below a summary of the main aspects regarding the use and sustainable management of fertilizers on tropical soils. These contributions are being discussed in the scope of a wide research network on the Fertilizers theme, called the FertBrasil Research Network, led by Embrapa and currently coordinated by me, Dr. Vinicius de Melo Benites. I currently also holds the position of Head of Research and Development of Embrapa Soils, the reference unit of Embrapa in the research of tropical soils in Brazil.

Embrapa Soils's mission is to enable research, development and innovation solutions for the sustainability of agriculture, for the benefit of Brazilian society. Embrapa Soils coordinates and executes, throughout the national territory, actions to prognosticate and promote preventive measures of environmental risks due to the inadequate use of soil and water resources. These actions are centered on the integrated vision of the soil as patrimony of present and future generations, prioritizing the planning of sustainable land use, providing subsidies for decision making and contributing to the advancement of technical-scientific knowledge in the Soil Science area.

The FertBrazil Research Network comprises a structure for research, development and technology transfer in fertilizers in Brazil that is coordinated by the Brazilian Agricultural Research Corporation - EMBRAPA. The general objective of the Network is to consolidate a national network for research and validation of fertilizer technologies, recognized by the public and private sector as the reference research network on this theme.

We suggest that CoCoFe should be structured in a transdisciplinary way so that it has the maximum positive impact, that is, it must involve actors from all segments of the fertilizer chain, such as Research Institutions, government regulators and representatives of fertilizer companies.

We understand that CoCoFe's scope of action should involve all the essential nutrients normally applied to improve crop productivity including synthetic fertilizers as well as manures, biosolids, urease inhibitors, etc. Some current challenges are primarily to advance knowledge on a technological basis to actually discover and define new routes and fertilizer production processes using alternative mineral sources of nutrients, such as marginal phosphates and potassium silicates, for industrial application, whether by biosolubilization/bioleaching processes, comminution of particles associated or not with mechanosynthesis processes, thermal processes, and the association between them. On the other hand, several organic sources of nutrients, such as animal wastes, agricultural, agro-industrial, industrial and urban wastes have shown promise for industrial use and with their direct application in agriculture, with good agronomic efficiency.
The adoption of products with aggregate technology to control the release of nutrients was massive today occupy much of the delivery of NPK fertilizers in the world. However, little is known about the bases of operation of the aggregate technologies in the aspect of materials as polymers, enzymatic regulators, clay minerals, nanostructured materials, etc. and, therefore, there is no consensus on whether the products currently marketed in Brazil are actually more efficient compared to traditional ones. This barrier can be overcome with actions aimed at advancing knowledge about the technologies of control of the release of nutrients so that products suitable for the conditions of Brazil can really be developed, as well as a very important network of agronomic and environmental evaluation of the and other innovative products for their appropriate recommendation for agriculture. For this, studies in advance of the knowledge of the area of materials, techniques of fertilizer production as well as the development of laboratory methods of evaluation of this group of fertilizers, are essential.

Besides, it is necessary to create an integrated intelligence system so that the information and technologies generated are actually appropriated by the agricultural sector, fertilizer producers and society in general.

The entry of these products into the market represents economic impacts of different natures, either by adding value to raw materials or residues that are not currently marketed as fertilizers, or by increasing efficiency in the use of fertilizers by the aggregation of technologies in the new fertilizer formulations, by the selection of cultivars of greater efficiency in the absorption of nutrients or association of microorganisms to the rhizosphere.

Regarding environmental impacts, new technologies should be evaluated for their life cycles, greenhouse gas emissions (Ex N_2O) and heavy metal contamination, and these results

should be compared with the impacts caused by the fertilizers traditionally used. In this way, it should be possible to clearly estimate the environmental impact resulting from the adoption of the envisaged technologies. However, it is expected that with the adoption of technologies the negative impact on the use of fertilizers will be reduced, especially those related to nitrogen and organic sources.

The social impacts of the fertilizer chain should be related to the possibility of job creation in the fertilizer sector, since some of the new technologies may be related to medium and small regional companies. Some of the technologies evaluated are focused on the family agriculture segment (mycorrhizal inoculants, selection of cultivars, inoculants biosolubilizers). These technologies should promote the increase of income of this population, mainly due to the reduction of costs with the acquisition of inputs and also by the more rational use.

Our perception is that CoCoFe should act in promoting the responsible and efficient use of fertilizers in the different countries. Each country should have its own laws regarding legislation, production and use of fertilizers. However, we suggest that following the final definition of the CoCoFe's focus, actions should be set similar to the established and widely publicized follow-up system for the UN's "Sustainable Development Goals", which could act as guiding principles for international public policies aimed on sustainable use of fertilizers. These goals can then serve as a benchmark for national executive and legislative powers and serve as a basis for national and international funding for research, innovation and technology transfer in the area.

Some suggested strategies for sustainable fertilizer management

NITROGEN

Together with the scenario of expansion of fertilizer production capacity, technologies can be developed to increase the efficiency of nitrogen utilization by plants. The main actors in this trend will be the public research research companies in partnership with the private sector. Technologies under development by the research in this area have the potential of having a direct impact on the fertilizer and bioinoculars market, both by increasing the efficiency of nitrogen utilization by plants and by reducing losses to soil and air through the volatilization and leaching processes.

The development of new nitrogen fertilizer formulations that present high efficiency with reduction of losses can represent a great contribution to the sector, through technologies added to conventional fertilizers based on the development of new formulations for the production of fertilizers slow release / controlled of nutrients; or of granulation technologies and biological processes for the production of fertilizers.

An important field of action is the selection and use of bacterial inoculants in crops to optimize nitrogen nutrition, such as the success of inoculation of soybeans in Brazil, which guarantees savings of about R$ 10.3 billion of annual dollars, through the process of biological nitrogen fixation. If this crop depended on nitrogen fertilization, it would make the Brazilian dependence even greater and financially impact the production, reducing the competitiveness of the Brazilian soybean. Such technological success is now expanding in the country through the development and use of new bacterial inoculants in crops such as corn, beans, wheat and sugarcane. These microorganisms promote root growth and improve the use of applied nitrogen fertilizer. Such technology became a reality in the country in 2013, primarily for maize culture inoculated with strains of *Azospirilum*. In 2014, the technical feasibility of soybean co-inoculation with *Azopirillum* was indicated. There is an indication of the launch of the sugarcane inoculant in commercial scale in 2018. Recently, research has demonstrated the high potential of inoculation to improve the efficiency of nitrogen fertilization in pastures, which in 2014 occupied a total of 1.6 million km².

PHOSPHORUS

Concerning mineral fertilizers, the main concern is the depletion of phosphate rock stocks, the raw material of phosphate fertilizers. There are several reserves of phosphate rock distributed throughout the globe, however, only 37 countries produce industrial phosphate rock, 90% of which is concentrated in 10 countries.

From the point of view of the consumption of phosphate fertilizers, in the last decade a continuous and linear growth of demand has been observed, especially for the soy, maize and sugarcane crops, which together represent more than 60% of the Brazilian demand for phosphates. The incorporation of new agricultural areas into the productive system has leveraged this demand, especially in agricultural frontiers and in the conversion of degraded pasture areas to agriculture. On the other hand, in the already consolidated agricultural areas where intensive agriculture has

been practiced for several years, it can be observed that there was an accumulation of P in the soil, which represents a natural capital gain, which can be managed to reduce the doses of fertilizers to be applied in the following harvests.
It is necessary to direct the efforts of the research to new forms of management of the systems of production that increase the efficiency of use of these nutrients. Management systems that promote the sustainable intensification of agriculture, prioritizing crop rotation, soil cover aiming at the conservation or increase of organic matter levels in the soil, and the reduction of soil phosphorus losses by the fixation process, a common phenomenon in tropical soils. There is also the possibility of recycling agro-industrial waste for agriculture, mainly residues originating from animal production, which contain appreciable amounts of nutrients such as phosphorus and potassium.

POTASSIUM
In the field, the management practices currently used have been very efficient in the use of potassium fertilizer. Among the macronutrients, it is estimated that potassium is the element that presents the highest average use efficiency index. In the case of soybean crop, this index is close to 100%, which means that the addition of potassium in the Brazilian agricultural areas is basically for the replacement of the potassium extracted by the crops. Therefore, the demand for this nutrient is directly proportional to the increase in Brazilian grain production.
The reuse of recycled potassium obtained from agricultural, agro-industrial and urban wastes is still one of the best alternatives for reducing international dependence on this input. Segments such as the sugar and alcohol industry, where practically all the potassium extracted by sugarcane cutting is disposed in the residue form of the process (vinasse), there is the possibility of recovery and recycling of this nutrient in the planting of new areas or in the maintenance of existing areas. It is estimated that if all the residues from the sugarcane crop were recycled, it would represent more than one million tons of KCl equivalents per year. However, nutrient recycling within the production system represents logistical costs that can sometimes exceed the cost of purchasing and distributing potassium fertilizers, depending on the international market situation.
The development of modern industrial plants for the provision of essential nutrients, new formulations that allow the reduction of soil losses, better utilization of crops, recycling and local use of agricultural residues, and innumerable other areas of research with potential for innovation and technological development can be glimpsed.

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