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COMMENTS

Comments on "Adaptation of Chinese and German maize-based food-feed-energy systems to limited phosphate resources—a new Sino-German international research training group"

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Of all nutritional elements essential for plants, phosphorus is one of the most limited elements worldwide. Recent estimates that consider a continued high consumption level and compare this with the available phosphate rock reserves for the production of fertilizer and feed phosphates suggest that the available phosphorous reserves have a life expectancy of less than 300 years. In addition, the world phosphate resources are unevenly distributed with more than 70% located in Morocco and the Western Sahara where access might be at risk in the long term. In China, reserves are estimated to run out in less than 25 years, based on the current consumption, and Germany does not have any phosphate resources of its own at all. Taking these limitations into account it seems to be a paradox that overfertilization with phosphate continues, even though it causes environmental problems in water bodies, particularly in areas with high life stock densities and intensive cropping. Furthermore, phosphate is lost through the pathways of human waste and waste water, leading to additional environmental risks. Another problem is that phosphate resources may be contaminated with heavy metals such as cadmium and uranium. To extend the life of the existing phosphate reserves, the situation calls for closing of the phosphate cycles and increasing the phosphate fertilizer and feed additive utilization efficiencies.

The paper by Müller and Zhang (https://doi.org/10.15302/J-FASE-2019282) thoroughly reviews the state of the art of science and current shortcomings within this context and highlight the fields of research where additional work is needed. As the authors argue, "it is virtually unknown how the steps within the phosphate cycle will react and interact if phosphate input is increasingly reduced or even limited and demand pressure can be expected to rapidly impact on prices". The complexity of this issue calls for an interdisciplinary, if not holistic, approach to achieve solutions towards sustainability.

The second part of the paper introduces the new International Research Training Group (IRTG) "Adaptation of Chinese and German maize-based food-feed-energy systems to limited phosphate resources (AMAIZE-P)", jointly carried out by China Agricultural University (CAU, Beijing, China) and the University of Hohenheim (UHOH, Stuttgart, Germany). Maize-based cropping systems were chosen because maize is one of the most important crops world-wide, with a high phosphate demand, particularly in the early stages of growth. In addition, maize is a multi-purpose crop, providing different elements in human nutrition, animal feeding and bio-energy/biomass production. China and Germany together cover most aspects of the multi-purpose crop maize under a wide range of different climate conditions.

In this uniquely interdisciplinary and international research and training program for early career scientists, the vision of a closed phosphate cycle is the driving force for science tackled by four consecutive research areas that address genetic potential, management at field and farm level, nutrition and recovery as well as economic evaluation and synthesis. Each subject area is further subdivided into two to four research subjects each, with a total of 13

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individual research subjects. These research subjects focus on key issues that have to be understood if the goal of a closed phosphate cycle is to be reached. Research focus is on different aspects of primary maize production, including breeding and physiological aspects, soil phosphate turnover and fertilization, human and animal nutrition and biomass conversion. All research subjects are progressing with an integration of the results and an economic evaluation. The participating Chinese and German research groups are strongly complementary, both with respect to the addressed issues and to the methodologies applied.

The qualification program for early career scientists is based on six specific educational instruments for cohorts of doctoral researchers comprising three years of research and training each. The core element of the qualification program, where participants and supervisors from China and Germany come together, are block seminars (two in Germany, three in China), followed by thematic fieldtrips further deepening the issues addressed during block seminars. In combination with two of the thematic field trips, two case studies are being carried out in the first and second year. One international scientific doctoral researchers' conference is jointly organized in the third year of each doctoral researchers' cohort. In addition, doctoral researchers work for three months each year in the respective partner country as a prolongation of the block seminars. Moreover, a comprehensive intercultural training is provided to doctoral researchers.

A particular highlight in the context of this paper is the already 40-year-long lasting cooperation between CAU and UHOH. This provided generations of Chinese and German doctoral researchers with the chance to carry out their research within an international environment. The IRTG AMAIZE-P therefore represents another milestone in the successful Sino-German cooperation between CAU and UHOH in the field of agro-ecological research and joint training of young scientists. Together with the two other Sino-German IRTGs "Geoecosystems in Transition on the Tibetan Plateau (TransTiP)" and "Tree Diversity Interactions (TreeDi)" that also started in 2018, AMAIZE-P sets a new benchmark for further promotion of Sino-German collaboration in general. Highly topical Sino-German ecosystem research, characterized by joint field work combined with joint training within an international, interdisciplinary research environment provides early career scientists with the necessary expertise and intercultural competence for a transformation towards sustainable environmental management in a global context.