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JKI and CAS – Bilateral Departmental Research in Agronomy since 1998

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Introduction

After almost 25 years of bilateral co-operation, this synopsis summarizes the major achievements made in the Sino-German departmental research in plant nutrition and soil science. It was in the year 1998 when the scientific co-operation between the Institute for Plant Nutrition and Soil Science at the Federal Agricultural Research Center (FAL) – since 2008 the Institute for Crop and Soil Science of Julius Kühn Institute (JKI-PB) – and the Institute of Botany in Beijing and the Institute of Applied Ecology of the Chinese Academy of Sciences (CAS) in Shenyang started. Since then researchers from the College of Resources and Environment at the University of the Chinese Academy of Sciences (UCAS) in Beijing and the Institute of Karst Geology of the Chinese Academy of Geological Sciences (CAGS) joined the collaboration. At FAL/JKI-PB 32 visiting scientists from China conducted research on various topics, the majority of them spending 1-2 years to complete their studies.

Issues of sulfur nutrition of crop plants

Severe sulfur deficiency on production fields in the main cash crops sugar beet, winter wheat and oilseed rape dominated the last decade of the 1990s in Europe. At the same time, high atmospheric sulfur depositions jeopardized air and crop quality in the industrialized areas in East Asia while little attention was paid to rural regions where sulfur is a limiting growth factor. Research at JKI focused on the impact of sulfur deficiency on crop production, crop quality and environmental impact such as increased losses of nitrogen under limited sulfur supply. JKI and CAS scientists extended sulfur research to grassland in the Inner Mongolia steppe and the impact of fertilizer type and production systems on losses of climate relevant trace gases by in Liaoning province. In 2001, the scientists of both institutions organized the 12th World Fertilizer Congress in Beijing and presented first results of their work. The joint research provided first evidence that a sufficient sulfur supply is essential for high yielding, high quality grassland and insufficiency will negatively affect wool quality (Wang et al., 2002). The Model for the Prognosis of Sulfur deficiency (MOPS) was successfully applied to the Inner Mongolia steppe showing that sulfur is a major nutrient disorder in grassland farming and sheep housing (Wang et al., 2001). Common research on sulfur speciation in soils delivered significant insight into the turnover dynamics of sulfur in soils (Hu et al., 2002). Novel studies on the *in situ* digestion of rock phosphates by elemental sulfur primed with Thiobacillus ssp. showed that the plant availability of this otherwise more or less insoluble sulfur source can be increased significantly (Fan et al., 2012).

The role of sulfur to activate and stimulate natural resistance mechanisms against fungal pathogens was another field of mutual research interest. Sulfur-Induced Resistance (SIR) is meanwhile an acknowledged concept in plant protection (Yang et al., 2006).

In 2001, the Sino-German Symposium on *Greenhouse gas N_2O emissions from farmland ecosystems* took place in Shenyang and in 2004 the Sino-German Sulfur Workshop on *Aspects of Sulfur Nutrition of Plants* in Shenyang. In 2018, the 18th World Fertilizer Congress was hold in Shenyang under the auspices of both organizations.

Issues of Precision Agriculture

With the start of the new Millennium CAS and JKI intensified their research in the field of Precision Agriculture (PA) (Haneklaus & Schnug, 2006; Haneklaus et al., 2016; Ma et al., 2000). Here, the small-scale spatial variability of soil characteristics was of prime interest comparing small farms rural in China with big farms in Germany (Hu et al., 2003). At the end of the day, research stressed the need for a purely demand-driven input of nutrients such as phosphorus and potassium in order to save resources and to minimize negative impacts of agricultural production on neighboring ecosystems and waterbodies.

Issues of beneficiation of phosphate rock

In the early 2000s, the JKI/CAS team presented a novel and intriguing concept for the extraction of uranium from phosphate rock thus delivering clean fertilizers and a finite resource for energy production, which has been recognized meanwhile as a cornerstone for the beneficiation of rock phosphates (Hu et al., 2008). The studies implied the collection and analysis of phosphate rock samples on a global scale. JKI holds presumably the biggest fertilizer core collection worldwide. Data are available to the science community about not only the uranium content in various mineral and organic fertilizer specimen, but also other trace elements such as rare earth elements (REEs). Long-term research and a meta data analysis of – in particular Chinese – literature on the impact of REEs on crop productivity finally revealed that the range of positive effects by graded REE fertilizer applica-

tions is extremely small and only to be quantified on basis of a model. In review papers and book chapters, the German/Chinese team summarized and interpreted their data to the topic (Haneklaus et al., 2015). Meanwhile REEs are highly precious resources required in the non-food sector so that use of REEs for fertilizer purposes is no longer a valid option. Latest research covered aspects of uranium in the food chain with special view to health effects (Haneklaus et al., 2021). Here, research showed that dietary habits unfold a significant impact on the intake of phosphorus and uranium. An over-proportionally high phosphorus intake by the consumption of processed food multiplies the risk of health damages by uranium toxicity in humans in the course of combinatory effects.

Outlook

On a global scale, numerous future challenges lay ahead for agricultural production, which future generations need to tackle. Microplastic is ubiquitously abundant and a persistent challenge in agricultural production. Recently, JKI/CAS scientists evaluated the significance of microplastic for soil productivity in the future (Schnug et al., 2022). Throughout the decades, bilateral research between JKI and CAS was versatile and innovative, always relying on the ambitious research work of meanwhile three generations of scientists. This commitment was noticed and honored in 2020, when the Chinese Academy of Sciences (CAS) conferred the "2019 Award for International Scientific Cooperation of the Chinese Academy of Sciences" to Ewald Schnug (head of the Institute of Crop and Soil Science, JKI until 2020) for his basic research for more efficient fertilization practices and the promotion of young scientists. In 2022, CAS bestowed Ewald Schnug the accolade "Distinguished Scientist" under the CAS President's International Fellowship Initiative (PIFI) for 2021.

With hindsight, it can be noted that it is the personal exchange of experience, anticipatory problem identification and outlining of visions for future developments, which motivates and enables bilateral research on the fast track. JKI and CAS warmly welcome graduated and post-doc students to work in Germany and China as visiting scientists. Has your interest been incited, just get in touch! Whatever your ideas are, with JKI and CAS you work together in a team that strives for an ecologically and economically sound agricultural production.

Friends and colleagues – Prof. Dr. Yanfen Wang and Dr. Silvia Haneklaus at one of their numerous working meetings on the campus of the Chinese Academy of Sciences in Beijing in January 2020 (photo: Ewald Schnug).

Conflicts of interest

The author(s) declare that they do not have any conflicts of interest.

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