BAS-CAS Workshop on “Strategies for Innovation in Food Production”

Report

Contextualization

The Chinese Academy of Sciences (CAS) and the Brazilian Academy of Sciences (BAS) have signed a Memorandum of Understanding (MoU) to promote the development of specific scientific and technological cooperation programs, as well as activities related to the exchange of scientists, S&T information and experience. The two Academies also confirmed their mutual interest in developing and reinforcing bilateral Science and Technology cooperation to promote develop and strengthen the relationship between both countries.

Through this MoU, BAS and CAS wish to promote bilateral S&T exchange and cooperation, based on equality, reciprocity and mutual benefit. To achieve the objectives CAS and BAS shall establish specific cooperation agreements and programs, directed and not limited to the following priority areas: Mathematics; Biological Sciences and Biotech; Biodiversity; Nanotechnology; Agricultural Sciences; Earth Science and Climate Change; Space Science and Technology and Computer Science**.** The cooperation might include the exchange of scholars; joint workshops; joint calls for research projects and other forms agreed.

To initiate the bilateral S&T exchange and cooperation, CAS and BAS agreed to initially focus in a joint workshop on Agricultural Sciences. The BAS-CAS Workshop on **“Strategies for Innovation in Food Production”** was hosted by EMBRAPA, in Brasília/DF (Brazil) on November 26-27th of 2018.

The Workshop

Worldwide agriculture undergoes profound economic, cultural, social, technological, environmental and market transformations, occurring at high speeds and in different directions, impacting substantially the rural production and development.

According to global projections, consumption of water, energy and food will increase by 50%, 40% and 35%, respectively, by 2030. These are mainly reflected by the trends of population expansion, greater longevity and increase in the purchasing power of large part of the world's population, particularly in Asia and Latin America. These aspects, associated with the process of intense urbanization, changes in consumer behavior, changes in global production chains and geopolitical conflicts, pressure the agricultural

sector worldwide to reconcile the increase in food, fiber and biofuel production with the necessary sustainability[1].

In order to overcome the S&T challenges stemming from current trends and seize opportunities in increasingly complex agriculture and a demanding market in quality and sustainability, some challenges will be common and cross-cutting across all science, technology and agricultural innovation organizations.

Aiming to that, BAS and CAS focused the discussions in this first workshop in four main topics related to food production: (1) Genetically modified organisms and genome editing, (2) Innovative technologies for food production, (3) Water optimization in food production, and (4) Climate change and food production.

Participants were divided into the four working groups (WG) according to their main area of activity:

WG 1 - Genetically modified organisms and genome editing

- Aimin Zhang (Institute of Genetics and Developmental Biology-CAS)
- Alexandre Lima Nepomuceno (Embrapa)
- Daniela Matias de Carvalho Bittencourt (Embrapa)
- Elibio Rech Filho (Embrapa/Brazilian Academy of Sciences)
- Elizabeth Pacheco Batista Fontes (Federal University of Viçosa/Brazilian Academy of Sciences)
- Fan Chen (Institute of Genetics and Developmental Biology-CAS)
- Grácia Rosinha (Embrapa)
- Maria Fátima Grossi de Sá (Embrapa/Brazilian Academy of Sciences)
- Paulo Arruda (State University of Campinas/Brazilian Academy of Sciences)
- Tiago Collares (Federal University of Pelotas/Brazilian Academy of Sciences)
- Zhiyong Liu (Institute of Genetics and Developmental Biology-CAS)

WG 2 - Innovative technologies for food production

- Eliseu José Guedes Pereira (Federal University of Viçosa)
- Evaldo Vilela (Federal University of Viçosa/Brazilian Academy of Sciences)
- Francisco Murilo Zerbini Júnior (Federal University of Viçosa)
- Guilherme Lopes (Federal University of Lavras)
- Hongqing Ling (Institute of Genetics and Developmental Biology-CAS)
- Lei Qi (Institute of Genetics and Developmental Biology-CAS)
- Mario L. Chizzotti (Federal University of Viçosa)
- Paulo Henrique Duarte Cançado (Embrapa)
- Ricardo Inamasu (Embrapa)
- Rose Gomes Monnerat Solon de Pontes (Embrapa)

[1] Embrapa. Visão 2030: o futuro da agricultura brasileira. – Brasília, DF: Embrapa, 2018.

- Yiping Tong (Institute of Genetics and Developmental Biology-CAS)

WG 3 - Water optimization in food production

- Alisson Borges (Federal University of Viçosa)
- Eduardo Seiti Gomide Mizubuti (Federal University of Viçosa)
- José Francismar de Medeiros (Federal University of the Semi-Arid Region)
- Lineu Neiva Rodrigues (Embrapa)
- Luis Henrique Bassoi (Embrapa)
- Weicai Yang (Institute of Genetics and Developmental Biology-CAS)
- Yonghui Yang (Institute of Genetics and Developmental Biology-CAS)

WG 4 - Climate change and food production

- Flavio Barbosa Justino (Federal University of Viçosa)
- Giampaolo Queiroz Pellegrino (Embrapa)
- Jinsong Zhang (Institute of Genetics and Developmental Biology-CAS)
- Ricardo Augusto Dante (Embrapa)
- Xianzhong Feng (Northeast Institute of Geography and Agroecology-CAS)

Figure 1. Workshop participants at Embrapa's headquarters.

During the discussions, the WGs proposed the following actions and projects:

WG 1 - Genetically modified organisms and genome edition.

Project 1: Genome edition in soybean using Chinese and Brazilian technologies/know-how on Genome editing. Traits should focus on disease resistance (nematode resistance and soybean rust); drought tolerance; protein content; quality traits for animal and human health and industrial utilization. Initially the project should focus in one or two traits aiming SDN1 and/or SDN2 edition;

Project 2: Genome Editing Training in Brazil and/or China with Chinese/Brazilian instructors. The proposal is to conduct a 2-3 weeks training course on genome editing utilizing the technologies developed by Prof. Dr. Caixia Gao's group, on genome edition with Ribonucleoproteins, where there is no CRISPR introgression into the target genome. Brazilian scientists also could collaborate presenting the techniques used in Brazil for genome editing in soybean and other species.

Project 3: Screening for candidate genes in Chinese/Brazilian soybean germoplasm. Screen of Brazilian/Chinese top varieties using metabolomics, proteomics, transcriptomics. Brazil has about 30,000 accessions germplasm bank for Soybean. We already started to screen it for abiotic/biotic tolerance traits. Some accessions have been sequenced already. Soybean diversity center is China, and Chinese soybean germplasm bank is the biggest in the world. We should give mutual access to in silico/in vivo data/germplasm banks.

Additional comments: Exchange of Senior/Young Scientists and graduate students (MSc and PhD) within the programs at CAS PIFI, CAS-BAS Exchange scientist and CAPES/CNPq exchange scientist. In addition, CAS and BAS ought to concentrate efforts on searching for private sector partnerships in Brazil and China.

WG 2 - Innovations for Food Production

Major challenges and research goals are related to food quality and sustainable, long-term production, since both of countries produce enough food (ie, food quantity is no longer a problem). Regarding "Innovations for Food Production" we foresee specific topics in each of these two broad areas.

Phenotyping is a highly demanding and urgently needed area of investigation to improve research on agronomically important traits, disease resistance, and metabolites, among others. Utilization of precision tools, specifically those that can combine artificial intelligence and machine learning resources, can be explored for high-throughput phenotyping.

Considering that Brazil has a rich and large biodiversity and that only a limited fraction of microorganisms is deeply known to date, understanding the microbiome of soybeans

under different conditions will be of great interest. Additionally, it may be possible to harness or even to breed for the selection and recruiting of microbial communities of interest. These communities may contribute substantially to increase plant quality and health, as well as improve yield. The idea is to "hire" microbes to work for the plant. It would be desirable to use metagenomics for surveillance and characterization of the plant and soil microbiomes for mitigation of abiotic and biotic stresses, including soil-related problems since the notoriously nutrient-poor oxisols are the most common soil type in both Brazil and China.

Large-scale monitoring for management purposes (*sensu lato*) is crucial to enhance the efficiency of cropping systems. Information technology for smart mechanization, such as the use of satellites, drones, and remote sensing to precise and simplified cultivation techniques can be useful to improve food production. At the opposite end of the scale, nanotechnology tools can be valuable resources to improve plant nutrition and pest control, particularly under the current and future scenarios of climate change and limiting plant-growing conditions.

Another important issue is to enhance the nutritional value of soybean, such as increasing the content of amino acid, lipids and minerals that can benefit human and animal nutrition and health. Such approach is currently known as functional agriculture, where the aim is to produce not only high amounts of food, but also functional foods.

WG 3 - Water optimization

Project Title: Land-Water-Food Nexus in Brazil and China through food trade

Common interests for collaboration: (a) China is the biggest food demander of the world as more poor people are becoming richer; (b) Brazil is the second biggest seller of soybean and still wishes to play an important role in China’s soybean supply; (c) Brazil has the potential to be a good partner to China, due to its large territory and capacity of increasing the food trade percentage.

Why Nexus is important: Delivering food in a sustainable way is one of the major challenges both for China and Brazil. Transdisciplinary systematic approaches are necessary to solve the multifold interactions among land, water, and food and to break down the silo-thinking in land, water, and food. Regarding soybean, there are no differences. Nexus of land-water-food is becoming a very practical method to optimize the complex tradeoffs among two of the 3 factors.

Content of the study

Project 1: Land-Water-Food Nexus in Brazil:
The tradeoffs between water-food, land-food and water-land will be studied to clarify the trend of soybean production influenced by multifold tradeoff of land-water-food nexus in Brazil. The tradeoffs can be described as follows:

Tradeoffs between water and food. Climatic extremes and inter-annual variation of weather are strongly influencing food production. Improvement in water use efficiency through soil-water management is increasing soybean production. Food demand drives the application of new technology (precision agriculture, waste water use and irrigation systems) in water management.

Tradeoffs between land and food. Drivers of food demand for food itself and for other uses can potentially change the land use for soybean. Change in land management could also change yield potential and soybean production.

Tradeoffs between land and water. More water will be needed if land for soybean production will be increased. Aquifer water quality can be affected by soybean production.

Project 2: Virtual flow of Land and Water through soybean trade from Brazil to China:
Considering the fact that importing soybean will influence China´s food supply and land use for different crops, land-water-food nexus influenced by soybean will be evaluated. Meanwhile the virtual flow of water and key environmental inputs like nitrogen will be evaluated in time and space.

Project 3: Land-Water-Food Nexus in China:
Similar to the research in Sub-Project 1, tradeoff approach of Land-Water-Food Nexus will be used to study the impact of soybean importation on China´s Land-Water-Food.

WG 4 - Climate change and food production

Climate change consolidates a trend of great relevance at global and national levels, due to the potential impacts it has on food production. The relationship between agriculture and climate change, as with other sectors of the economy, involves an active component - the contribution of the agricultural sector, as an economic activity, related to greenhouse gas emissions and a passive component - represented by the set of effects that climate change imposes on this economic activity. (…) These scenarios indicate the increasing vulnerability of agricultural systems, which, coupled with increased world demand for food, water and energy, represents a huge challenge for the sustainability of production, terrestrial and aquatic ecosystems and services to society[1].

Having this in mind, this WG focused its discussion on the influence of climate conditions on crops including temperature, water, technology, carbon dioxide & ozone. It was agreed that the main focus on research collaboration will be on the development of field experiments aiming to modelling crop yields and phenological stages as support for breeding strategies.

General conclusion:

Intensification of production of soybean and derivatives were highlighted as the core of future collaborative projects. In this context, it was decided that China and Brazil will create a Soybean Consortium Initiative aiming to contribute for intensification of food production and security, sustainable resource management, innovation and value creation, through research and knowledge production within the four themes discussed. The strategy to accelerate evolution on soybean production matrix should be based on sustainable use of science and technology, renewable resources and social inclusion, thus helping to maximize the contribution towards the implementation of the 2030 Agenda and the Sustainable Development Goals (SDGs), as well as the Paris Agreement.