One CGIAR Global Webinar Series-Agenda

Genome Editing in Agriculture: Innovations for Sustainable Production and Food Systems

Webinar 2

Applications of Genome Editing in Agriculture: CGIAR Focus on Crop Improvement

Tuesday, September 29, 2020. 12:30 UTC

Topic[1]	Speaker	Time
Achieving Genetic Gains through Advanced Breeding Technologies	**Michael Quinn, Ph.D.** *Platform Leader, Excellence in Breeding Platform*	20’
State of the Science: Wheat and Maize	**Zhengyu Wen, Ph.D.** and **Kanwarpal S. Dhugga, Ph.D** *Applied Biotechnology Laboratory, CIMMYT*	15’
State of the Science: Rice	**Inez H Slamet-Loedin, Ph.D.** *Cluster Lead-Trait and Genome Engineering, IRRI*	15’
State of the Science: Legumes and Dryland Cereals	**Pooja Bhatnagar-Mathur, Ph.D.** *Principal Scientist and Theme Leader-Cell, Molecular Biology and Genetic Engineering, ICRISAT*	15’
State of the Science: Root, Tuber and Banana Crops	**Leena Tripathi, Ph.D.** *Principal Scientist and Deputy Director, East Africa Hub, IITA*	15’
State of the Science: Cocoa	**Paul Chavarriaga, Ph.D.** Leader Platform for Advanced Breeding, CIAT	10’
Panel Discussion Audience Q&A	**All Speakers** **Moderator: Marc Ghislain, Ph.D.** *Global Program Leader, Genomics & Biotechnology, CIP*	40’

[1] Topics are provisional, with presentation titles to be confirmed.

Alliance

Speaker Profiles and Abstracts

Michael Quinn

Michael leads EiB’s overall strategy, partnerships and operations. He has extensive experience in the commercial development of germplasm through breeding and R&D management. Prior to EiB, Quinn was principal wheat breeder and R&D manager at InterGrain, Senior Wheat Breeder at LongReach Plant Breeders, principal hybrid wheat breeder at Australian Grain Technologies, and senior durum wheat breeder at the University of Adelaide – Australia.

Achieving Genetic Gains through Advanced Breeding Technologies

The Excellence in Breeding Platform (EiB) exists to increase impact of CGIAR and NAREs breeding. EiB provides cross center, system level coordination, leadership and support to achieve the vision for CGIAR and NAREs breeding which is that “CGIAR-NAREs breeding networks generate rates of genetic gain ≥1.5% p.a. and that the average area weighted age of varieties in farmers’ fields is <10 years”. Support includes providing know-how and developing shared services and breeding tools. Gene editing provides an exciting opportunity to support the vision for CGIAR and NAREs breeding particularly when applied to the most intractable traits for which there is no native genetic variance. Gene editing itself is out of scope for EiB but as a community we must think carefully about how to best integrate outputs from gene editing laboratories with breeding pipelines to best increase rates of genetic gain and reduce the age of varieties in farmers’ fields.

Allen

Allen (Zhengyu) Wen is a plant molecular biologist. He obtained his PhD in plant physiology from the University of Adelaide and later held a postdoctoral position at the University of Sydney. During this time, he functionally characterized a pair of nitrate transporters in maize and discovered the key amino acid residue that influences nitrate/chloride specificity, which can potentially be applied to increase maize nitrogen-use-efficiency or salinity tolerance. Currently, he is trying to improve maize lethal necrosis (MLN) resistance using CRISPR-Cas9 gene editing approach. Since 2011, MLN has seriously reduced maize yields in eastern Africa. By directly editing susceptible genes in local commercial hybrid parental lines, the timeframe for developing MLN resistant maize varieties can be significantly shortened, and Allen is hoping to deliver MLN resistant seeds to African farmers as soon as possible.

Kanwarpal S. Dhugga

Kanwarpal S. Dhugga obtained his M.Sc. (Plant Breeding) at Punjab Agricultural University, Ludhiana, Ph.D. (Genetics) from the University of California, Riverside, followed by a postdoc at Stanford University. He worked in various positions at DuPont Pioneer (now Corteva Agriscience) for nearly two decades and has been leading the agricultural biotechnology program at CIMMYT for the last five years. He has published 48 papers in high profile journals, including PNAS and Science, has 42 issued US patents and more than 175 published patent applications to his credit.

State of the Science: Wheat and Maize

CIMMYT is focused on improving disease resistance in maize and wheat by editing causal genes directly in elite lines, thus eliminating the need for resource-intensive and time-consuming process of backcrossing. In maize, we have targeted maize lethal necrosis (MLN), a disease caused by a combination of two viruses that has wreaked havoc since it first appeared in Kenya in 2011 and has since spread to other eastern African countries. We identified a strong source of MLN resistance in an exotic line, KS23, and mapped the resistance QTL down to a narrow interval of ~6 kb in collaboration with Corteva Agriscience under a project funded by the Bill & Melinda Gates Foundation. Various portions of the mapped interval have been subjected to editing in an elite CIMMYT line to identify the causal locus for MLN resistance. Greenhouse screening for MLN resistance is currently underway. Once the causal locus is identified, we will edit the susceptible locus to its resistant from in other elite lines, reconstitute and introduce the popular hybrids that went out of production because of MLN in eastern Africa. At CIMMYT, we have edited several copies of a separate candidate gene for virus resistance directly in two elite lines. The edited plants are being currently outcrossed to the parental lines. In wheat, we have focused on introducing durable resistance against rusts and powdery mildew directly in elite lines. The first set of plants where a durable rust resistance gene was targeted have been generated and are undergoing screening at the present time.

Inez Slamet-Loedin

Inez Slamet-Loedin is a Cluster Leader of the Trait and Genome Engineering at The International Rice Research Institute. She is an elected fellow of The World Academy of Sciences for the advancement of science in developing countries (TWAS), and UPLB adjunct professor. She obtained her PhD from Nottingham University and was a postdoctoral fellow at the Institute Molecular Plant Science-Leiden University. She has over 25 years of experience working on genetic engineering, and currently also on genome editing with the focus on biofortification and disease resistance. She has published articles as co-author or lead author in Nature, Nature Biotechnology, PNAS, JEB, Scientific report, Plant Biotechnology, Frontiers and others.

State of the Science: Rice

Genome editing as a novel-breeding tool is highly potential to accelerate breeding in rice. CGIAR embarked on rice genome-editing activities for trait improvement and gene function validation. Targeting agronomic and quality traits important to farmers and consumers is our primary objective. Concurrently, revealing gene function is important for gene based-marker assisted breeding. A versatile plasmid DNA for knockout editing as a tool to study gene function, was developed at IRRI. Gene knockout approaches are currently being used by CIAT and IRRI to study genes related to the resistance mechanism of the rice hoja blanca virus, rice quality traits and other traits which contribute to the development of hybrid rice and understanding the mechanism of the incompatibility barrier between rice and its wild relatives.

IRRI and CIAT have successfully evaluated the agronomic performance of edited rice lines with SWEET gene promoter variants showing resistance to bacterial leaf blight, one of the devastating rice diseases in South Asia, Southeast Asia and Africa. These lines were developed at IRRI together with Healthy Rice project collaborators. Furthermore, regulators in both Colombia and the US have recently declared them as conventional breeding cultivars. In addition, rice lines edited for water-use-efficiency and improved yield, are being evaluated. Another major objective is to produce healthier rice by tweaking expression of metal homeostasis genes. The concept of this product is to combine micronutrient-dense rice, to benefit consumers, with agronomic traits, to improve farming productivity in rural areas. This novel technology is widely used in rice globally.

Pooja Bhatnagar-Mathur

Pooja Bhatnagar-Mathur holds a Ph.D. in Biotechnology and leads the Research Theme on Cell, Molecular biology and Genetic engineering at ICRISAT. She has over 15 years of experience in developing tools towards candidate gene discovery and validations, genetic and genome engineering as well as translational research activities in grain legumes and dry land cereals of SAT. Her team combines multiple platforms to develop and test new research interventions specifically targeting constraints for which no genetic traits are available in conventional plant breeding applications. Combining forward and reverse biological engineering tools and technologies and more recently integrate cutting edge CRISPR-Cas based gene editing technologies, strong global collaborations back her efforts on deploying for trait and genome engineering in grain legumes, sorghum and millets.

Pooja has to her credit, several advanced certifications on several components of Intellectual property management for commercialization of biotech products. She has published over 100 research communications in various international peer reviewed journals and books besides several popular articles in various newsletters.

State of the Science: Legumes and Dryland Cereals

Continual reliance on older varieties that were developed for an environment that no longer exists is economically and environmentally unsustainable for todays' agricultural needs. With an objective to accelerate the rate of genetic gains, ICRISAT is deploying transformative breeding strategies in its mandate grain legumes and dryland cereal crops (GLDC) that are critical to meet the food, feed, and forage needs throughout Asia and African regions where the most poor and under-nourished live.

This talk details on how cutting-edge tools and technologies are being utilized to translate the foundational sciences into product innovations to support food security, safety, health and nutrition. Following the massive genomic and phenotyping data sets available in most of our crops, integrating precise and efficient gene editing tools with breeding offers tremendous opportunities to precisely and efficiently bring changes in the genetic makeup. Specific examples on state of science and technology in GLDC crops will be discussed for traits such as protein quality and seed size, plant architecture, Striga resistance and other quality traits. Advancing research and delivery of these genome edited crops varieties, will not only level the playing field for innovations in the crop breeding pipelines but will also enable "disruptive reduction" in the input costs to the farmer–and "exponential gains" in the nutrition and quality traits for the consumers

Leena Tripathi

Leena Tripathi is a Plant Biotechnologist with over 21 years of experience in genetic improvement of important staple food crops for control of diseases and pests. After obtaining Ph.D., she began her career as a Research Scientist at the University of North Carolina, USA. Dr. Tripathi is currently a Principal Scientist leading the transgenic and genome editing research at the International Institute of Tropical Agriculture (IITA)-Kenya. She is also the Deputy Director of the Eastern Africa Hub and Country Representative of IITA in Kenya. She provides science leadership as a faculty member of various institutions such as Adjunct Professor at the University of Queensland, Australia, and Support Leader for CGIAR Research Program for Root, Tubers and Banana (CRP-RTB).

Her focus is on "Science to Practice" and linking scientific innovations to practical applications to solve food production. Her team has successfully established a robust genetic transformation and genome-editing platform at IITA —the only one of its kind in Africa— to develop genetically modified and genome-edited products and to transfer these technologies to national agricultural research systems in sub-Saharan Africa and beyond. The research outputs of her group have been published in over 90 articles in refereed internationally reputed journals and book chapters. Her research has been featured in more than 200 national and international news articles and documentary films. Her scientific contributions have been recognized internationally through several awards and honors such as excellence awards for outstanding scientist and publications. Recently, she has been honored as the fellow of the American Association for the Advancement of Science (AAAS) for her contributions to Agriculture and food security.

State of the Science: Root, Tuber and Banana Crops

Root tuber and banana (RTB) crops, including banana, cassava, potato, sweet potato, and yam are staple crops playing a major role in food security, providing more than 15% of the daily per capita calorie intake for the 763 million people in developing countries. Besides, they generate income as cash crops, particularly in tropical and sub-tropical countries. RTB crops present several common challenges, such as pathogens, pests, non-diverse starch quality and slow breeding methods. As they are clonally propagated rather than with seeds, yield-reducing pathogens and pests build up over time. Using disease-resistant varieties mitigates the negative impacts of pathogens on their production. Similarly, searching for starch diversification and speeding up breeding adds value to RTB crops.

Recent advances in new breeding techniques have the potential to accelerate the breeding of RTB crops. The CRISPR/Cas based genome editing has emerged as the most powerful tool for crop improvement to create precise targeted changes in plant genomes. This targeted mutagenesis is now possible for RTB crops with a final product free of foreign DNA. Recently, the robust CRISPR/Cas-based genome editing of RTB crops has been established, which can be applied for developing disease-resistant and improved-quality varieties. We will present a synopsis of recent advancements and perspectives on the application of genome editing for generating genetically-improved RTB varieties.

Paul Chavarriaga

Paul Chavarriaga-Aguirre graduated as a Biologist (Genetics Major) from Universidad del Valle in Cali, Colombia, in 1986. He got a Master of Arts degree from Washington University (St Louis, MO, USA), an MSc in Botany from the University of Georgia (Athens, GA, USA), and a PhD in Biology from Universidad del Valle. He joined CIAT in 1998 and currently leads the Platform for Advanced Breeding in the same institution, a laboratory dedicated to the genetic transformation and genome edition of tropical crops such as cocoa, cassava, rice and beans. He was also a professor of Molecular Biotechnology at the Pontificia Universidad Javeriana in Cali, Colombia, between 2012 and 2017. Paul has over 45 publications among indexed journals and book chapters and has been the director/co-director of over 20 theses for undergraduate and graduate students. .

State of the Science: Cocoa

Cadmium (Cd) is a heavy metal non-required for normal biological functions and can contaminate cocoa beans when plants grow on Cd-rich soils. Watering of Cd rich sedimentary rocks raises Cd concentration in soils, but the main source of Cd in soils comes from heavy metal-laden pesticides and fertilizers. Cd cannot degrade and remains in soils for years. Contamination with Cd severely affects the quality of cocoa beans in LAC countries. The EU established limits for the concentration of Cd in cocoa (0.8 mg/Kg), and the Codex Alimentarius set a higher standard (2.0 mg/Kg). However, Colombian cocoa is above both levels. Conventional breeding for low-Cd containing cultivars should be supported by genome editing to knock out genes responsible for Cd uptake and translocation.

Such genes were characterized in rice and at least one was mutated to produce cadmium-free rice grains. The **Alliance BIOVERSITY-CIAT**, with the support of USDA and the cocoa industry in Colombia, uses gene editing to switch off Cd-absorbing genes in the roots of the most relevant Colombian cocoa varieties. This approach, together with soil-remediation and chemical treatment to remove Cd in, i.e., chocolate products, offer alternatives to reduce Cd-contamination risks in human and animal food chains.

Photos: Inez Slamet- Loedin- IRRI & Michael Selvaraj (CIAT)

Left: Edited rice lines for Bacterial Leaf Blight (BLB) Resistance in confined field testing at IRRI .
Right: Aerial view of BLB Rice lines in the confined field Palmira, Colombia.

CGIAR

ICRISAT International Crops Research Institute for the Semi-Arid Tropics

Alliance Bioversity International CIAT International Center for Tropical Agriculture Since 1967 Science to cultivate change

CIMMYT International Maize and Wheat Improvement Center

CIP International Potato Center

ICARDA

IITA Transforming African Agriculture

ILRI International Livestock Research Institute

IRRI

CGIAR Research Program on Rice

CGIAR Research Program on Roots, Tubers and Bananas

CGIAR Research Program on Grain Legumes and Dryland Cereals

CGIAR Research Program on Livestock

CGIAR Research Program on Maize

CGIAR Research Program on Wheat