How AgBio scientists are seeding global change

Abstract

Not all superheroes wear capes. Some, like our agricultural biotechnology colleagues, wear lab coats. And so many possess incredible skills and talents that allow them to save the day in trying times. In moments of need, our industry has shown we can work together to tackle major problems that threaten various communities and our planet.

Below, we spotlight three innovative examples of this. These uplifting stories include:

- Applying agrigenomics and new molecular breeding tools to fortify crops in Sub-Saharan Africa, strengthening local communities and addressing malnutrition
- Generating reliable genotyping data for cocoa to improve yields and incentivise ongoing production
- Improving sustainability and knowledge within the oil palm industry by increasing genotyping efficiency with an end-to-end workflow

Along with the individuals, companies, charities, and academic institutions that play a starring role in these global agriculture solutions, one particular technology deserves a special spotlight for the role it plays.

BIOSEARCH™ TECHNOLOGIES
GENOMIC ANALYSIS BY LGC

SNP genotyping in AgBio

SNP markers have become a cornerstone of commercial crop development and an integral part of bringing favorable phenotypes, such as increased yield and nutritional content, to market. Over the past few decades, myriad SNP genotyping methodologies have been developed and commercially available SNP assays and genotyping services are streamlining plant breeders' workflows, enabling them to solve big problems with less time and money.

Agricultural biotechnology has been tasked with solving truly large, global, 21st century problems, with worldwide hunger and sustainable farming amongst them. Widespread use of KASP™ for genotyping in low-density marker assisted breeding has made it an effective and efficient part of helping molecular plant breeders find solutions. The stories below exemplify its global impact. KASP and its support team have played a foundational role in driving project success, but these cases require solutions on a greater scale than one assay, person, lab, or company. It takes unmatched teamwork to grow the seed of an idea into worldwide change.

How does KASP work?

The PCR-based competitive extension assay uses two forward primers, designed for allele-specific discrimination at the 3′ end of the SNP (including insertion/deletions) to be detected. Each forward primer has a unique 5′ tail, to which a FAM or HEX-labeled universal cassette can bind. Prior to amplification, fluorescence is quenched. Successful amplification with either forward primer, will trigger the unquenching of their respective FAM- or HEX-labeled complementary cassette. The amount of fluorescence is directly proportional to the amount of SNP in a given sample and the FAM or HEX signal can be detected through end-point fluorescence measurement on any number of plate readers or qPCR machines. A plant sample that is homozygous for a SNP will only generate a single fluorescent signal, whereas a heterozygote will generate a mixed fluorescent signal.

Learn more about how KASP works here.

Fighting malnourishment in Africa through global partnership and access to next generation genomics

The challenge

In developing countries, malnutrition and hunger are all too common and can cause an irreversible disorder, called stunting, which affects children under five and leads to decreased intellectual capacity and growth. While addressing zinc deficiency in utero has decreased the incidence of stunting globally, Sub-Saharan Africa continues to struggle with an increasing number of cases.[1] This troubling problem is multifaceted; caused in part by a lack of affordable, nutrient-rich food and a lack of infrastructure to support local farmers cultivating the crops that could help. Without an increase in the nutritional density of crops, local farmers to grow those crops, and a new distribution strategy, the long-term implications for children, families and the economic growth of this region as a whole, look grim.

The solution: The African Orphan Crops Consortium (AOCC)

This issue was brought to the attention of Howard-Yana Shapiro, Chief Agricultural Officer at Mars, Inc. and Sr. Fellow at the College of Agriculture and Environmental Sciences at the University of California, Davis (UCD), during an internal seminar by a postdoc. Struck by the jarring realisation that stunting limits the intellectual capacity and overall potential of African children, Dr. Shapiro resolved to do something about it.

His solution – to improve the cultivation and nutritional composition of locally adapted, yet under-researched African crops, called orphan crops.

Dr. Shapiro made this the primary goal of the AOCC, which he and many others helped establish in 2011.[2] The AOCC prioritised development and access to free genomic resources for 101 African orphan crops, chosen by key regional stakeholders for their potential

to be bred into nutritionally-dense, commercially viable crops. Upon setting this initial tactic and goal, the AOCC attracted a large list of partners, including life science and technology companies, non-profit organisations, African government departments, and universities. Currently, the initiative is supported by partnerships with Mars, Inc., the World Wildlife Foundation (WWF), the New Partnership for Africa's Development (NEPAD), Corteva Agriscience, Illumina, ThermoFisher Scientific, UNICEF, Oxford Nanopore, the Food and Agriculture Organization of the United Nations, Google Genomics, LGC, Biosearch Technologies™ and many others.

African Plant Breeding Academy (AfPBA)

As part of the AOCC and NEPAD, the AfPBA was established in 2013 to provide a professional development course to educate African plant breeders and scientists about advanced plant breeding theory and technologies.[3] In doing so, the AfPBA is building a scientific community with the skills to drive their own molecular breeding programs and the selection of orphan crops with improved nutritional content.

The outcome

It takes a global community to solve global problems. The unification of private companies, non-profit organisations, and the African government has, to date, enabled the publication of 6 orphan plant reference genomes. In addition, 60 other orphan genomes have been partially sequenced, 6 are near completion, and 19 are in progress.[4] With the guidance and expertise of veteran scientists, mentors, and teachers from consortium members, the AfPBA has successfully trained hundreds of breeders and scientists from dozens of countries across Africa 80 local scientists in advanced agrigenomics and molecular breeding. This supportive community network of Africans is armed with the technical expertise and resources to improve the long-term agricultural potential of their country and their people. Biosearch Technologies continues to nurture and serve this community by providing affordable KASP genotyping services and scientific support. The continued efforts of the AOCC and AfPBA exemplify how powerful genomic data and advanced breeding technologies can be when put in the right hands.

How KASP and Biosearch Technologies fits in

To support the training and development To support the training and development of these African scientists, Biosearch Technologies offers scientists at the AfPBA their all-inclusive KASP genotyping service at a discounted price based on the economic capabilities of the region. In addition, Plant Genetics Specialist at Biosearch Technologies Darshna 'Dusty' Vyas helps train students at the AfPBA, giving them access to top technical experts and gold standard SNP genotyping techniques used broadly across agrigenomics.

Making cocoa genotyping a little sweeter

The challenge

The cultivation and genetic improvement of cocoa has lagged behind many other major crops and productivity has largely plateaued in Africa, where approximately 70% of the crop is produced.[5] Improving yields could unlock new economic potential for local farmers and would make cocoa farmers more efficient and prosperous. This could also encourage continued investment in sustainable cocoa farming practices and help limit the numbers of farmers who abandon cocoa farming in favor of more lucrative, but environmentally-damaging crops.

However, improving cocoa productivity has been challenging. For years genotyping in cocoa relied on expensive and low-throughput gel-based methods such as amplified fragment length polymorphism (AFLP) and simple sequence repeat (SSR) analysis, or mass spectrometry-based techniques. Extracting DNA from cocoa leaf material is also notoriously difficult. The end result was often low quality and low quantity DNA that produces unreliable, inaccurate results from downstream genotyping assays. Lastly, 15 to 44% of the cultivated cocoa strains used for commercial production have been mislabeled and their genetic profiles weren't what would be expected based on their labeled identity.[6] This confounded any marker-based selection or molecular breeding strategy.

The solution: The Generation Challenge Programme

The Generation Challenge Programme (GCP), funded by the Bill and Melinda Gates Foundation, used genomics and molecular breeding techniques to improve the yield and genetic diversity of a number of crops in the developing world, including cocoa. Through the creation of a genetics and genomics platform that made all data freely available to the global agricultural community, they hoped to enable farmers with limited resources to grow and improve cocoa yields with greater efficiency. The challenges above were a major roadblock in working towards this goal. In principle, efficient DNA extraction and reliable SNP genotyping assays could help generate the reliable, high-quality data required to drive this project forward.

How KASP and Biosearch Technologies fits in

At the start of the project, initial analysis of DNA samples, which had been extracted by five separate labs in Africa, showed highly variable quality and quantity of genomic DNA. This resulted in extremely poor call rates, with nearly 35% data loss. Samples were unable to be assigned to a specific genotype, which prevented the breeding program from moving forward.

Biosearch Technologies helped the GCP standardise their leaf collection, DNA extraction and SNP genotyping protocols across their five labs. Leaf collection was done using BioArk Leaf Sample Collection, which helps provide consistency in the quality of DNA extracted. In combination with sbeadex bead-based extraction and purification chemistry, and KASP assays, this creates a scalable, reliable, and reproducible end-to-end workflow, resulting in high-quality data and more accurate call rates. Biosearch Technologies' standardised approach was used to genotype over 130,000 samples across 12 distinct crops, including cocoa. Other key partners, like Mars Incorporated, have used KASP genotyping services to genotype plantations in South American and Southeast Asia. Biosearch Technologies' has helped Mars to collect high-quality data for over 35,000 cocoa samples.

The outcome

Ultimately, the use of Biosearch Technologies and KASP genotyping services helped implement a standardised end-to-end workflow that resulted in high-quality, reliable data. This data helped to form the foundation for parentage analysis of mislabeled, ancestral cocoa plants, and resulted in development of solid molecular breeding strategies aimed at improving the yield of chocolate globally, especially for the local farmers and rural workers involved in cocoa production.

Bringing increased yield, sustainability and efficiency to oil palm

The challenges

Palm oil, extracted from the fruits of the oil palm plant, is used globally in a broad range of markets including food, personal care, cosmetics, biofuel, and pharmaceuticals. Ingredients derived from the oil palm are found in approximately 50% of products on supermarket shelves.[7] With the world's growing population, there is increasing demand for oil palm and finding seedlings with increased yield at maturity. At the same time, increasing productivity must be done without increasing the total size of plantations or increasing the industry's contribution to global warming. In addition to these important environmental challenges, improving harvestability through stalk lengthening and palm dwarfing would help reduce the safety hazards, time and cost associated with harvest for local farmers and plantations

The solution: The Sime Darby Plantation

The Sime Darby Plantation, one of the world's largest palm oil producers, has been committed to addressing these problems and developing higher yield, more sustainable, and easy to harvest oil palm plants. The company was a founding member of the Roundtable on Sustainable Palm Oil, a non-profit organisation that has developed a sustainability certification for palm oil, based on environmental and social criteria. The Sime Darby Plantation was also the first to sequence, assemble, and annotate the oil palm genome in 2009.[8] However, using marker-assisted selection and molecular breeding strategies has been difficult as genotyping the vast array of oil palm progeny across a huge number of markers is laborious, costly, and not in line with planting timelines.

Developing a high-throughput genotyping workflow and reducing the number of genomic markers that needed to be assayed to predict advantageous phenotypes would help the Sime Darby Plantation develop new clones for planting. Doing so required high-throughput, reliable SNP genotyping methods for marker-assisted selection so that mutations could be linked to desirable traits in a timely manner.

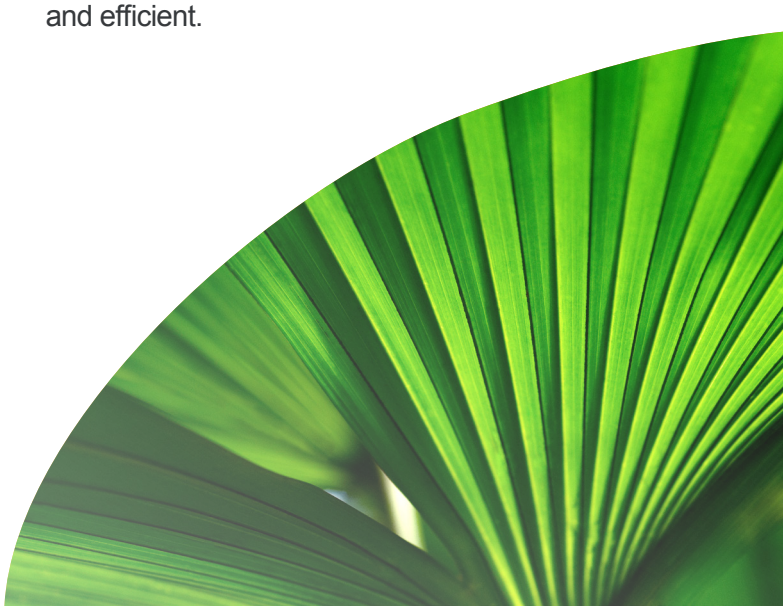
How KASP and Biosearch Technologies stepped up

SNP genotyping using the KASP assay provides a high-quality and reliable method for genotyping oil palm. Sime Darby was able to access Biosearch Technologies scientific support to develop a set of KASP assays to analyse a wide range of markers related to oil yield traits, including shell-to-fruit ratio, fruit-per-bunch, and oil-per-bunch phenotypes. Together with Sime Darby Plantation researchers, Biosearch Technologies was able to help reduce the number of markers that needed to be assayed to accurately predict the heritability of advantageous traits, cutting down on the time and cost associated with their breeding program.

To meet Sime Darby Plantation's high-throughput needs, the organisation installed Biosearch Technologies' SNPline system, an automated instrument that provides an end-to-end solution for SNP genotyping, from DNA extraction to data analysis. This workflow was used as the framework for Sime Darby to build the GenomeSelect programme, a multidisciplinary team of breeders, wet lab scientists, bioinformaticians, agronomists, IT specialists, and operations managers. Together, the SNPline enabled this team to analyse 132 genome sequences and 200,000 SNPs.[9]

The outcome

This supportive, streamlined partnership achieved 30,000 DNA extractions and 5 million data points per month, making it one of the largest SNP genotyping facilities in Asia. Analysis of the resulting 80 million genotyping data points enabled development of the first GenomeSelect palms, which were planted in 2016. Implementation of the KASP and SNPline workflow helped Sime Darby Plantation to win the prestigious bronze Edison Award for Sustainability as well as the Best Product Innovation at the Malaysia Dutch Business Council Innovation and Sustainability Awards.[8] In addition, these exceptional and innovative studies resulted in multiple peer-reviewed scientific publications.[9,10] The SNPline instruments and the KASP genotyping assay are now the cornerstones of the internal Molecular Breeding Laboratory within the Sime Darby Plantation. This lab is a critical internal service for Sime Darby scientists to continually collect accurate and timely genomic data, allowing breeders to make innovations that will make the palm oil industry more sustainable, safe and efficient.



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CONTACT INFO

Want to learn more about KASP? Go to
www.biosearchtech.com/support/education/kasp-genotyping-reagents/how-does-kasp-work

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