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Picking Microbial Teams for Superior Plant Health and Crop Protection

Holly Meadows-Smith of BioConsortia introduces the breakthrough Advanced Microbial Selection process that combines disciplines of plant breeding, directed selection and microbiology for the development of effective microbial consortia.

In 2012, Prabhu Pingali, then Deputy Director of Agricultural Development at the Bill & Melinda Gates Foundation, framed the concept of 'Green Revolution (GR) 2.0'. This included challenges associated with the sustainability of agricultural systems and their impact on climate change.[1] Pingali's thoughts on GR 2.0 have since started to be reflected within the industry. Most large seed treatment and crop protection companies now have research programs focused on naturally sourced solutions, while synthetic and chemical inputs are facing tougher regulations worldwide. The move toward agricultural biologicals – natural products, plant extracts, and agents derived from beneficial bacteria and fungi – is now common.

BioConsortia is a unique biological company developing microbial consortia products – combinations of bacteria and fungi with distinct or complementary functions. The complexity of biological interactions in natural soil environments underlies the idea that combinations of beneficial microbes may produce more effective biological treatments.

Conventional methods for discovering active bacteria and fungi involve *in vitro* screening of individual isolates obtained from microbial libraries and *in planta* assays to determine if on-plate bioactivity translates into actual plant response. When this is approach is applied to the development of multi-microbe treatments, natural or artificial 'stacking' of individual microbes is complicated by the magnitude of potential combinations and the innate competition of certain microbes.

Unlike other microbial research teams, BioConsortia utilizes a patented (US9150851B2) discovery process called Advanced Microbial Selection (AMS). The system uses the plant as a 'magnet' for beneficial microbes, as crops are put through various stresses that represent specific crop challenges. The foundation of the AMS process is based on the equation: Genotype x Environment x Microbiome = Phenotype. By manipulating the microbiome variable and identifying phenotypic changes in plants growing in those microbiomes, AMS helps to collect organisms providing benefit.

Discovery begins with rhizosphere selection from the plant root areas of diverse soil samples to capture a variety of organisms that are capable of plant colonization. From there, multiple rounds of selection are performed in controlled systems (Figure 1). Microbiomes from phenotypically superior plants (identified by yield-relevant indicators, such as the plant's ability to withstand an applied disease pressure) are moved forward. As the microbiomes are advanced, Directed Selection shifts the community composition toward one enriched with beneficial microbes (Figure 2).

Figure 1 – Corn plants during an AMS plant-microbe selection round in BioConsortia growth chambers

Figure 2 – Directed Selection of the microbiome drives improvement in trait performance
A normal curve depicting plant health in one selection round is shifted to improved plant health in the next

In contrast to conventional strategies, microbes are not isolated until the end of the AMS process. The selection rounds work as a filter, screening the trillions of microbes in initial starting soils and delivering a few hundred plant-associated strains for isolation. Standard 16S rRNA gene sequencing is used most commonly, although as technologies improve and newer services come to market, other genomic targets and techniques are being added for higher resolution and more efficient processing.

This information is coupled with data collected throughout the selection rounds, which visualize changes in the frequencies of specific microbes as the microbiome moved through selection rounds (Figure 3). These data are used to reconstruct consortia that replicate or improve on the performance seen in the final selection round.

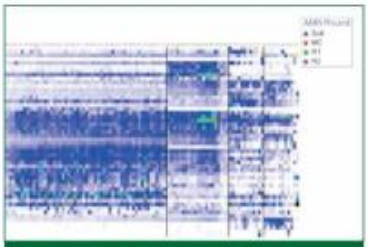

Figure 3 – Analysis of samples through an AMS process. Each row represents a different microbe and each column a different sample; shifts in community structure are visualized at different stages of AMS

The initial emphasis of discovery is on effective microbial teams rather than individual entities. This results in a group of compatible microbes that colonize and confer benefits onto a plant. The AMS process can also be amended to select for microbes that specifically enhance the activity of many inputs, from fertilizers to seed treatments.

BioConsortia has focused on major US crops, such as corn, soybean, wheat, tomatoes and lettuce. Targeted traits include water use efficiency and drought resistance; pest and disease protection; and fertilizer and nutrient use efficiency. The company established headquarters in the US in 2014 and is already working with several major players in the agricultural field. The AMS process provides a highly efficient way to solve the discovery challenges of microbial research, to bring effective multi-microbe products to farmers and the agricultural industry.

REFERENCE

1. P Pingali. PNAS 2012;109: 12302-8.

CONTACT

Holly Meadows-Smith
Manager, Business Development
BioConsortia
Davis, CA, USA
T: +1 530 564 5570
E: hmeadowssmith@bioconsortia.com