Seed Industry

Structural changes in the seed industry

Jul. 5, 2019

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How do we use state-of-art technology to create high-added-value crop varieties while saving time and costs for R&D?

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Background

The seed industry creates added value by releasing new varieties. Each new variety involves a total spend of around USD 136m, and, depending on the breeding method, takes between eight and ten years to develop. Because the cost of developing a new variety is high, seed companies tend to invest in crops which are widely cultivated, and in large-scale farming systems, such as corn in the US and soybeans in Brazil. However, such a highly-concentrated product portfolio can be risky. The banning of glyphosate usage, for example, affects the sales of 145 corn varieties, 23 soybean varieties, 22 cotton varieties and 15 canola varieties. Therefore, the key to succeed in the seed industry is knowing how to deliver precisely those new varieties that meet the farmers/consumers' needs.

Future Breeding in Seed Companies: Customized Breeding

Imagine farmers ordering their seed online just like ordering a MacBook: customized color of the potato flesh, customized fatty-acid ratio of the soybean, customized pest/disease resistance, etc. Traits are adjustable according to their needs. What's more, this also allows yield to be predicted. In this scenario, the seed company makes a production plan according to the orders placed. There's no pressure on stocks, no waste on research resources. Consumers can choose their food by communicating their needs with the farmers.

A Game-Changer Technique, Gene-Editing Tool: CRISPR/Cas

How do we move from the current system to such a future scenario? It all starts with the gene-editing tool, CRISPR/Cas. Simply put, this tool allows us to edit the genome, wherever we want, using two main components: CRISPR and Cas. Cas refers to the protein that conducts the cutting of DNA. CRISPR refers to the DNA sequence that guides Cas to the desired location of the genome for cutting, which is initially used by bacteria for its immune system and was first discovered in the E. coli genome in 1987. Since 2012, the CRISPR/Cas system has shown that it can be programmed for targeted DNA cleavage and has been applied in areas such as human disease therapy, animal breeding, and also plant breeding. This system can be used to edit genes in three steps:

1. seeking a corresponding place in the genome (DNA sequence) to edit
2. cutting the DNA
3. removing/replacing the unwanted DNA by desired ones.

Gene-editing is like correcting errors in Microsoft Word: seeking a typo (finding a gene to edit), deleting the typo (cutting DNA), replacing with the correct word (paste new DNA).

Corteva is using CRISPR/Cas as breeding tool for a corn variety, which shortens the breeding cycle from eight years to five years. The pros and cons of CRISPR/Cas and conventional GMO are shown below.

Pros and cons of CRISPR/Cas and conventional GMO

	Gene-editing (CRISPR/Cas)	GMO
Required time	Short	Long
Price	Cheap	Expensive
Traceability	Can be achieved but not smart	Yes
Required knowledge level of genomics	High	Low

Different from the conventional transgenic methods, CRISPR/Cas requires a precise order for the specific location in the genome to conduct gene-editing. This requires more information about the genome, and only a few crops have accumulated enough knowledge for this (e.g. corn, soybean, and rice).

Also Some Concerns When it Comes to Gene-Editing

In the short term, seed companies can edit crops with known gene functions, but many gene functions are still lacking, for example drought tolerance.

To speed up the gene-function research in crops, plant scientists have been using state-of-art technologies. These include using drones to collect images,

crop performance. However, to extract the information from the hundreds and thousands of images, researchers in the area of (bio)informatics are needed. Such experts are hard to find, however, as salaries are often less attractive in the agricultural sector, which means there may be a lack of people available to process the huge amounts of data.

Opportunities: Data, Modeling, Gene-Editing

Taken together, the keys to achieving customized breeding are data (both phenomic and genomic), modeling, and gene-editing. Firstly, with phenomic and genomic data we establish the relationships between genes and their function. Secondly, by modeling we predict the performance of a given genotype. Lastly, with gene-editing the desired genotype can be created as soon as possible.

Conclusion

Breeding has been a long and costly task for seed companies, but this is going to change with new technologies. There are three technologies (gene-editing, phenotyping, deep learning), which can play a role in shortening the breeding cycle and reducing costs. Gene-editing allows us to precisely edit the genome of a crop without losing the high-yield background, thus saving time. Phenotyping with drones increases the efficiency of data collection, while deep learning increases the productivity of data processing. With the convergence of the ICT-driven digitalisation taking place in farm practices and with biotechnology, the seed industry will shift to a predictive and customer needs-driven breeding strategy.

Source: Rabobank

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