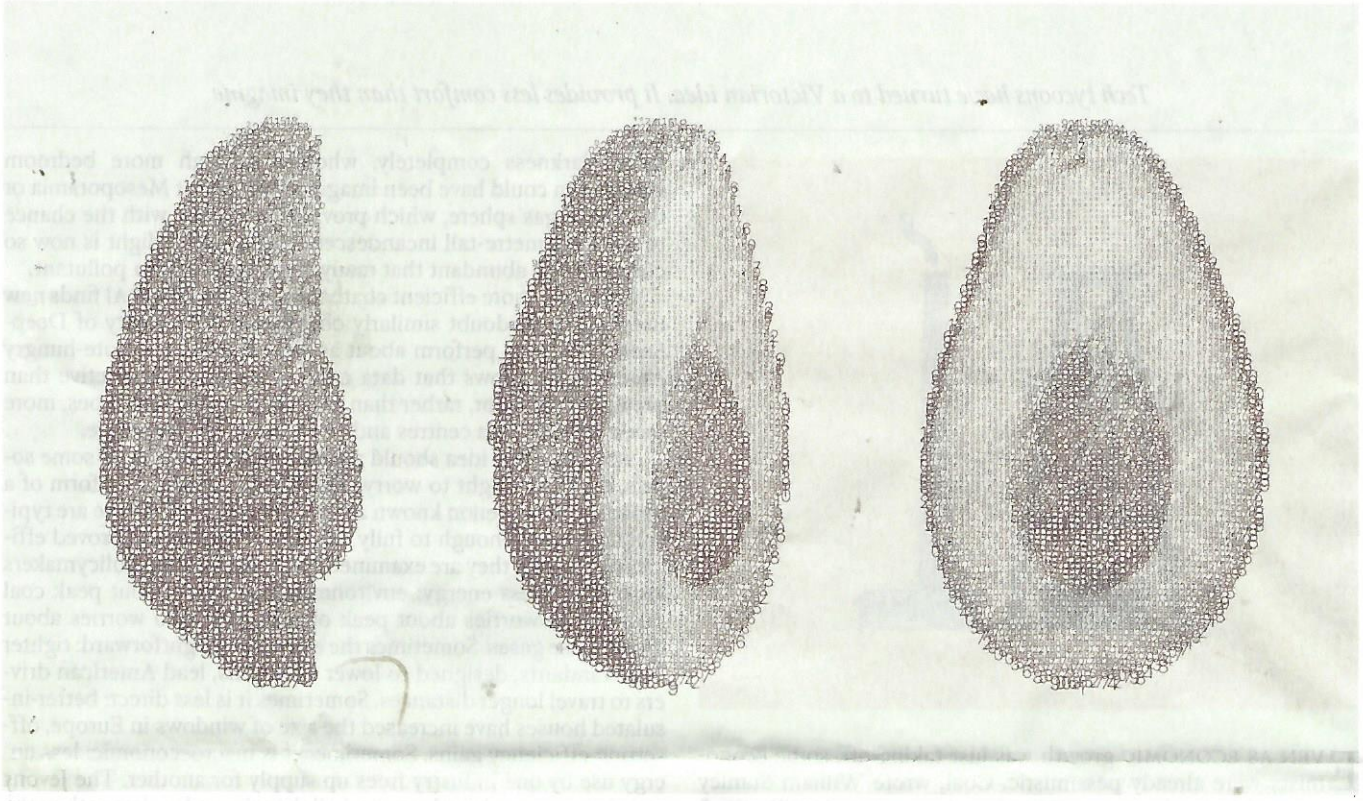

AI for crops

Borlaug-in-a-box

Heritable Agriculture is using artificial intelligence to breed better crops

WHEN NORMAN BORLAUG moved to Mexico in 1944, 60% of the wheat consumed in the country was imported. The government wanted to produce enough of the staple domestically to meet demand, so with money from the Rockefeller Foundation it had started the Cooperative Wheat Research and Production Programme, and asked Borlaug to lead it.

Borlaug and his team ran breeding programmes for the next 20 years, at first to improve Mexican wheat's resistance to disease, and then to increase its yield—largely by breeding shorter plants that did not collapse under the weight of a heavily fertilised wheat ear. By 1963 some 95% of wheat sown in Mexico was Borlaugian, yields had sextupled and Mexico was self-sufficient. American governments and philanthropists exported this "green revolution" around the world in the hope of helping places like India and Pakistan feed fast-growing populations. Borlaug was awarded the Nobel peace prize in 1970.

Crop breeding remains a fiddly business. Plant geneticists must decide which traits they are looking for, cross plants which appear to possess them, run a series of field trials and wait to see if their new plants are an improvement. The interplay between a plant's genes and the weather, the soil condition and scores of other environmental variables in which it grows, are complex. Working out which genetics suit which conditions can take decades, as it did Borlaug in Mexico.

Heritable Agriculture, which spun out of X, Alphabet's moonshot lab, in December, aims to speed things up. The idea is to use artificial intelligence (AI) to predict, for a given environment, which genetic changes will improve a crop's yield, as well as other properties like taste, nutritional content and photosynthetic capacity. The software which does this has been trained on a database that Heritable's staff has spent the past six years compiling.

The data describe how different combinations of plant genes fare in particular soil and weather conditions, which genes are being expressed and which concentrations of various metabolites are present as a given plant grows. Heritable has processed data from some 14,000 samples taken from field trials it or its customers have run in Nebraska, Wisconsin and California with seven different crops. Once the desired genetics for a given environment have been determined, a different model determines the quickest breeding path to take to get there, based on the plants available to a given breeder. For now, Heritable does not edit the genomes of plants its customers plan to sell. The company's use of editing is, instead, restricted to checking the accuracy of its models.

Brad Zamft, Heritable's co-founder, says the firm's system can breed a crop with the right genetics to achieve a desired trait in just one year. He presented data validating Heritable's approach at the Plant and Animal Genome Conference in San Diego on January 13th. They showed that the firm's software can be used to ▸▸

→ ALSO IN THIS SECTION

69 The civilisations of the Amazon basin

70 Doping with carbon monoxide

71 Well informed: Microplastics

quickly breed corn with fine-grained control over the time it takes to flower. Heritable says it has already used its software to breed plants with specific properties for undisclosed customers, including tastier leafy green vegetables. "Traditional crop breeding is much too slow and expensive to enable all the beautiful things that synthetic biologists have said we'll do: nitrogen fixation, sustainable forestry, food-as-medicine, carbon capture," says Dr Zamft.

Other biotechnology companies like Inari, based in Cambridge, Massachusetts, focus on editing genomes to help breeders tweak their crops towards higher yields. They mainly focus on crops grown on the largest, most industrial of scales like maize and soya. Pivot, based in Berkeley, California, sells tinctures that are meant to improve soil microbiomes, designed based on sequences of the genomes of the microbes in a given field. In the past ten years agricultural biotechnology firms have raised some $40bn in venture capital.

The big difference between these kinds of approaches and Heritable's appears to be their lack of a map of the incredibly complex links between genetics, biology and environment that they are trying to distil. Heritable, in contrast, with its reams of field-trial data, represents a sort of Googlification of the breeding process, making it possible for breeders to search and explore the large number of possible genetic combinations for a given crop, to an extent and at a cost that was not possible before.

The other difference is the crops that Heritable is focusing on. Dr Zamft and his colleagues are coy about the crops to which they are applying their computational breeding programme at first, and which traits they will attempt to improve. But a priority will be less industrialised crops such as berries and avocados, which have not experienced yield gains comparable to industrially grown maize and soya over recent decades. "Oats, barley, rye, chickpea, bok choi, avocados and grapes: imagine if they all had the kind of gains that we've seen in corn over the past 100 years," says Dr Zamft.

If technology can drive down the cost of breeding, then a larger number of plants could be adapted to a larger number of environments. Relatively poor farmers in developing countries, for example, could then breed and use plants which are designed for their needs. This will be particularly useful as staple crops face the pressures of climate change, which is happening too fast for traditional breeding to adapt. Heritable also hopes to apply its computational powers to the breeding of trees, and thereby the management of forests. Native trees might be bred so that their yield of timber became competitive with industrial pine, thereby increasing biodiversity. The firm is already working with ArborGen, a seedling provider, to improve its loblolly pines.

Heritable also represents Alphabet's new approach to growing companies that gestate within its X division. Some of these have been absorbed into Google, like Google Brain, an AI company started in 2011. Others have become "other bets", independent companies operating under Alphabet's corporate umbrella, like Waymo, a self-driving car company. A few businesses, like Heritable, are a less natural fit. For some years now, X has been spinning these companies out, raising money from venture capitalists outside Alphabet, and freeing them to operate independently.

Fields in the Nebraskan countryside are not the Googler's natural home. It seems a good thing that software engineers are there now, collecting data and automating some of the processes which help feed the world. Borlaug would be proud. ■