Precision plant breeding and genetic biofortification

By Claudi Nortjé

Several distinguished speakers contributed to the 13th Southern African Plant Breeding Symposium hosted by the Southern African Plant Breeders' Association (SAPBA) at the University of Pretoria's Future Africa Campus earlier this year.

The event looked at how the Fourth Industrial Revolution is driving digital transformation throughout the agricultural industry, changing the way agriculturalists live and work within the multidisciplinary nature of plant breeding.

Precision breeding

Richard Fly, head of breeding at Bayer South Africa, discussed precision breeding for the modern farm. "We are going to have an extra 2,2 billion people on earth by 2050, which means we need 50% more food than we currently consume. There is a massive amount of pressure on our ecosystems and resources, which means we have to start thinking differently about how we do things."

He says the science of plant breeding has improved by leaps and bounds over the last 100 years. "If you look at the area it took to cultivate ten bushels of maize in 1940 compared to what we are cultivating now, we have really made impressive advances. However, we need to focus on doing the small things really well and setting new standards in terms of sustainability to make sure we pioneer digital transformation and improve our overall productivity."

According to Richard, enhanced precision translates into better resource allocation, which will improve any breeding programme. "By considering which type of traits or alleles are interacting best in a particular climate and environment, we can gain insight into which type of alleles would be best suited to each country. This will enable us to leverage our global germplasm library effectively."

Genetic biofortification in Africa

Prof Maryke Labuschagne of the University of the Free State discussed genetic biofortification of crops in Africa. According to her, approximately 792,5 million people across the world are malnourished, of which 780 million live in developing countries. In addition, around two billion people suffer from hidden hunger caused by inadequate daily intake of essential micronutrients. One of the possible solutions to this global concern is genetic biofortification of crops.

"Biofortification is the process during which the nutrient density of food crops is increased through conventional plant breeding, improved agronomic practices, biotechnology or a combination of all of these factors, without sacrificing plant characteristics preferred by farmers and consumers," she explains.

Fighting hidden hunger

The biofortification approach involves fixed one-time costs in developing breeding methodologies, breeding nutritional quality traits into current crop varieties, and adapting these varieties to diverse environments. This approach will require minimum recurrent investments and the benefits can be made available globally, especially to all developing countries. Most importantly, breeding for higher trace mineral density in the consumed plant parts will not incur a yield penalty.

"Biofortification through conventional breeding offers a cost-effective, long-term and sustainable approach for fighting hidden hunger. About 300 biofortified crop varieties have been released for commercial production, with most of these produced through conventional breeding. At this stage, the crops have mostly been biofortified with minerals such as zinc and iron, or provitamin A.

"The agronomic approach focuses on optimising the application of mineral fertiliser and improving the solubilisation and mobilisation of the mineral elements in the soil. This is the simplest method among all the biofortification methods, but the success rate is highly irregular due to differences in mineral mobility, mineral accumulation among crops, soil composition and the location of each crop."

According to Prof Labuschagne, biofortification through conventional breeding is the most accepted method of biofortification. Nevertheless, there must be sufficient variation in the traits of interest for it to be feasible.

Conventional breeding limitations

Since the uptake and accumulation of micronutrients are controlled by polygenes and are dependent on genetic diversity for their traits, the conventional breeding-based biofortification approaches have not always been successful in all crops.

Transgenic approaches are an alternative to conventional breeding. "Transgenic technologies improve the genotypes by changing focused metabolic pathways. These technologies pave the way for modified proteins, vitamins, carbohydrates, minerals and other metabolites," says Prof Labuschagne.

"Ample research has been done on transgenics, but relatively few cultivars have been released so far. In contrast, research on conventional breeding has been limited with a higher number of cultivars available. When looking at the biofortification approaches of agronomics, transgenics and conventional breeding, you can see that cereals have benefitted the most, followed by legumes, vegetables, fruit and oilseeds."

Addressing concerns

The biggest problem is consumer acceptability, seeing as modified crops may differ physically from normal varieties. Marketing therefore plays an important role prior to commercial release. Regulatory processes are also very expensive and time consuming, especially in an African context. Many countries do not yet have supporting legislation in place, causing delays.

For more information or references, contact the author at claudi@plaasmedia.co.za.