How to improve diversity in potato plantings

By Dirk Uys, Potatoes SA

The saying goes, variety is the spice of life. In fact, diversity is critical to the success of any population. This is particularly relevant to commercial crop production as growers prefer specific varieties that meet their standards for quality, yield, taste, or pest tolerance.

Unfortunately, the lack of diversity in a population can be detrimental to its future survival. This happened in both the banana and potato industries in the past, which led to some dramatic changes taking place within these industries.

Panama disease in bananas

Bananas are the cash cow of many retailers. This fruit faced a massive crisis in the 1950s with Panama disease. The dominating banana variety, Gross Michel, also known as Big Mike, was rapidly wiped out by this disease, which is caused by the fungus *Fusarium oxysporum* f. sp. *cubense*. This led to the introduction of the Cavendish variety, which was tolerant to the Panama disease.

Half a century later, this pathogen had mutated into Tropical Race 4, which began to attack the tolerant Cavendish variety and once again put the banana industry under pressure.

The Irish Potato Famine

A similar example, which ruined the Irish potato industry, was the well-known potato famine. Ireland's potato industry boomed between 1841 and 1851 and Irish farmers preferred to exclusively plant the highly popular Lumper variety. This variety was known for its great yields and was highly recommended by agronomists. Unfortunately, it was also susceptible to late blight, caused by *Phytophthora infestans*.

This ultimately led to the Irish Potato Famine, which is well documented in history as an example of how plant pathogens can influence food security around the world. According to the Agriculture and Food Development Authority of Ireland, 332 000 ha of potatoes were planted in 1850. This number has been reduced to around 9 200 ha today (*PotatoPro*). The famine is estimated to have impacted more than one million Irish citizens.

Tools at our disposal

Nature has the ability to continually stay one step ahead of us. Fortunately, diverse potato populations with different traits have the ability to decrease this risk. The potato has its origin in South America. These farmers were known to cultivate a wide range of varieties, which ensured that they remain significant potato producers to this day.

Potatoes are one of the more diverse plant crops, with 169 species of wild potatoes listed in *The Potato: Evolution, Biodiversity and Genetic Resources* (JG Hawkes, 1990). Hawkes also reminds us that potatoes have lost their ability to survive nature's challenges as they have been nurtured for so long. Fortunately, these diverse pools of genetic resources are available to enable potatoes' adaptability to varying climates, temperatures, altitudes and agronomic conditions. Modern potato breeding companies have been including wild types through diploid breeding, but this technique has its complications due to incompatibility between species. It is also time-consuming.

What does 'diploid' mean?

The ploidy of a potato indicates how many copies of each chromosome are available. A haploid type has one chromosome (or gene) copy, while a diploid has two and a tetraploid has four copies. Commercial potatoes are usually tetraploids.

True potato seed is currently under evaluation in countries such as the Netherlands as well as closer to home in Kenya, Malawi and Zimbabwe, where it has been planted in experimental sites. (Photo: www.solynta.com)

When multiple chromosome copies are present, different variants of these genes occur. These are known as alleles. When alleles are the same, they are known as homozygous types, and heterozygous types if they differ.

When heterozygous plants are crossed, the result is a wide genetic variation which is not ideal for commercial production. The ideal is to enable a homozygous cross to ensure a uniform offspring, which is the basis of inbred hybrid breeding.

Current practices

The accepted practice of potato production is to propagate potatoes by planting vegetative tubers (seed potatoes), which enables growers to produce a perfect and uniform crop. In South Africa, this is supported by the Potato Certification Service (PCS), which ensures that the genetic material is uniform and that disease-incidence risks are well managed.

This does, however, require four to six generations to produce sufficient planting material to provide enough seed potatoes for multiplying the potato crop. In South Africa, 51 000 ha

Figure 1: Varying offspring from two heterozygous potato varieties with Aa alleles crossed.

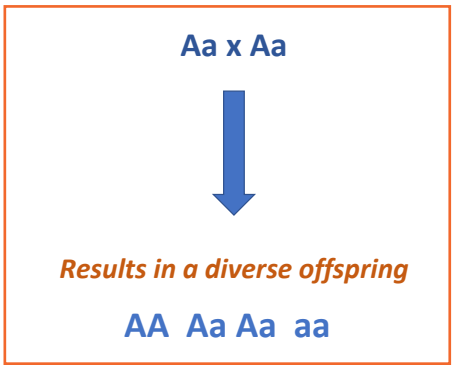
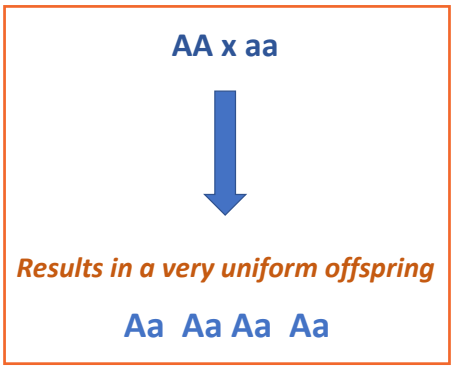


Figure 2: Very uniform offspring from crossing single homozygous variants with different alleles.



of potatoes are planted, of which 10 000 to 11 000 ha are registered for seed potato production.

True potato seed

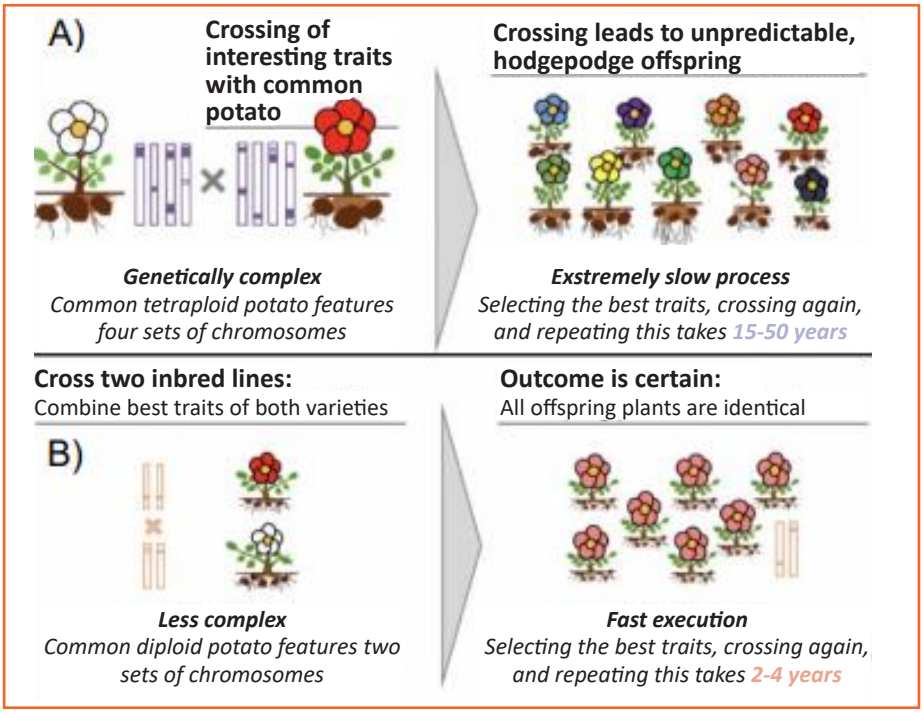
Like its sister crop, tomatoes, potatoes have the ability to produce fruit and seed. Peruvian farmers often harvested the potato fruit and planted its seed. The challenge with potato seed was that it resulted in an extremely diverse population with different characteristics.

Under normal conditions, potatoes are heterozygous, which means they have two alleles which can be depicted as Aa. When these varieties are crossed, a diverse offspring is produced that is often not suitable for commercial potato farming due to the variety in its progeny. This is depicted in *Figure 1*, symbolising the example of two potato varieties containing the Aa alleles which are crossed. This results in varying offspring.

It is no wonder the *Rennie's Seed Annual and Garden Guide* punted this as "innumerable new kinds, colours, shapes and quantities".

In 1950, Dr Srinivasa Ramanujam of the ICAR-Central Potato Research Institute in Shimla, India, managed to find a method to produce true potato seed (TPS) by crossing single heterozygous (e.g., AA and aa) variants containing different alleles (Gupta, 2004), as shown in *Figure 2*. The result was a uniform potato crop. This technique can ideally be used to speed up the production of seed from four to six generations, to 18 months.

Figure 3A and B: An illustration of conventional versus hybrid breeding of potatoes. (Source: Solynta)



Breeding techniques

Figures 3A and *3B* explain the differences between two potato breeding techniques, namely conventional breeding (*A*) and hybrid breeding (*B*).

With conventional breeding, two heterogenous tetraploids are crossed. Due to genetic complexity, the outcome of the crossing is unpredictable. This leads to slow genetic progress, and it is impossible to stack the desired traits.

With hybrid breeding, homozygous parent lines are produced through several generations of self-pollination. As the genetics are less complex than in tetraploids, it is much easier to select traits and combine them. By crossing two inbred lines, the best traits of the two parents are combined. Because of the use of homozygous parent lines, the hybrid is predictable, and all offspring plants are identical.

What lies ahead

TPS is currently under evaluation in countries such as the Netherlands as well as closer to home in Kenya, Malawi and Zimbabwe, where it has been tested in experimental sites. The benefit of TPS is that it offers the opportunity to introduce genetic diversity faster by creating crosses with wild *Solanum* species such as *Solanum tuberosum* x *Solanum andigena*.

This will enable the introduction of new traits such as disease tolerance, for example late blight tolerance, as well as improvements to crop architecture to equip potatoes to mitigate environmental challenges such as drought more efficiently.

TPS will have its limitations, which include the finalisation of legislation to regulate this. This technology is, however, already in place in other vegetables such as tomatoes. Farmers are currently equipped to plant only potato seed tubers (seed potatoes) and will need to adapt their

Table 1: The benefits and disadvantages of seed potatoes versus those of TPS.

	Benefits	Disadvantages
Seed potatoes	• Vegetative plant material results in consistent and uniform offspring. • Farmers are geared to plant tubers. • South Africa has a well-managed certification scheme.	• Large volumes are required (2.5 to 3 t/ha). • Three to six generations are needed to provide enough seed (three to six seasons). • May contain low incidences of diseases e.g., viruses.
True potato seed	• Small amounts of seed are required (25 g/ha). • Disease incidence is reduced. • Easy to introduce new traits (e.g., disease resistance) from wild types. • Shorter lead time (18 months) to supply sufficient amounts of seed.	• Legislation needs to be finalised. • Planting with transplant can be labour-intensive. • Currently, this may result in a yield lag. • Not yet commercialised.

planting practices. TPS will require planting of seedlings with unique logistical challenges, such as the acquisition of new equipment. The pros and cons of seed potatoes versus TPS are listed in *Table 1*.

This innovation does, however, provide us with the opportunity to ensure greater diversity in potato farming, which will enable greater choice of relevant traits as it provides the opportunity to introduce traits from wild types. This will mitigate potential threats, such as what happened with the Irish Potato Famine and the Panama disease crisis threatening the banana industry.

In conclusion

Cultivar diversity is always beneficial as cultivars differ in how they react to different pests, diseases and environmental conditions. Consumers are also diverse in their buying behaviours and have different requirements for potatoes. This provides a good reason to diversify potato varieties just as the Peruvian farmers do in producing up to 14 different varieties on their farms.

The innovation needed to provide diversity in potato choices to mitigate our reliance on single varieties must be supported. We are excited to follow the innovations behind TPS. This has the potential of boosting the potato industry very similarly to what was seen in the South African maize industry with the introduction of new breeding technologies.

For more information, visit *https://www.youtube.com/watch?v=lVwjZ2SH8bw*.
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Mondstuk van die Suid-Afrikaanse aartappelbedryf • Mouthpiece of the South African potato industry

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