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Development of Improved Avocado Cultivars

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ABSTRACT:

The avocado breeders at the ARC-ITSC are very aware of the need of the avocado industry for the extension of the current cultivar series. The existing breeding strategy, as was compiled in 1991, was studied closely and was rewritten with the quicker release of avocado cultivars in mind. The total time elapsing from making a cross until the release of a new cultivar, was decreased from 24 years to 18 years. It could even be as short as 13 years if a producer is prepared to take the risk. Continuity is, however, the key factor and after 13-18 years the breeding programme will theoretically be able to release new material annually.

UITTREKSEL

Die behoefte vir nuwe opsies in die huidige avokado kultivarreeks, is 'n saak wat die avokadolelers by die LNR-ITSG na aan die hart le. Die bestaande teelstrategie, opgestel in 1991, is dus deeglik ondersoek en herskryf ten einde nuwe avokado kultivars vinniger aan die bedryf beskikbaar te stel. Die totale tydperk vir die ontwikkeling van 'n kultivar, vanaf die maak van'n kruising tot die beskikbaarstelling van die nuwe seleksie aan die bedryf, kan verminder word van 24 jaar tot 18 jaar. Indien die produsent bereid is om 'n mate van risiko te neem, kan die tydperk tot selfs 13 jaar verkort word. Kontinuiteit is egter die sleutelfaktor, in die sin dat daar elke jaar kruisings gemaak en geplant word. Na afloop van die eerste 13 tot 18 jaar behoort daar teoreties dus nuwe materiaal op 'n jaarlikse basis beskikbaar te wees.

INTRODUCTION

The aim of a cultivar development programme is to ensure cost effective, low risk release of new cultivars to the industry, in the shortest possible time. Often new selections not properly investigated and mostly fresh from the juvenile phase, look promising but might display shortcomings at a later stage. The industry could suffer serious financial implications if such selections are released too early. The major risk areas are:

- *Risk of negative genotype/environment interaction:*

New material may not react the same regarding yield and fruit quality under different climatic conditions in different production areas.

- *Risk of increased sensitivity to biotic stress conditions:*

New material may prove to be more sensitive over time to certain insect pests and diseases in commercial orchards because the initial evaluation was not done under conditions of disease/pest pressure.

- *Risk of limited information on horticultural potential:*

A very short initial evaluation period may result in a biased assessment of fruit quality and yield potential due to juvenility effects.

It is thus apparent that the confidence needed to release a cultivar is directly correlated to the comprehensiveness and time span of the evaluation that the selection/cultivar has been submitted to. This was the main consideration when the new breeding programme was initiated at the Institute for Tropical and Subtropical Crops (ITSC) of the Agricultural Research Council (ARC). Following a visit by Dr. du Plooy, in 1991, to California, a breeding strategy was compiled using the available information and experience of the Californian breeding programme.

In retrospect, after seven seasons of the South African avocado cultivar breeding programme, it was decided that a balance should be found between the direct high cost associated with cultivar evaluation, the possible losses that can be suffered by the industry due to the release of poorly tested material to the industry as well as the possible losses to the industry arising from the slow release of new material.

The period needed for the development of a new cultivar in a conventional breeding programme is illustrated in figure 1. This diagramme indicates that with no unforeseen circumstances, a minimum of 24 years are needed for the development of a selection from the time of making the cross, until the release of the cultivar.

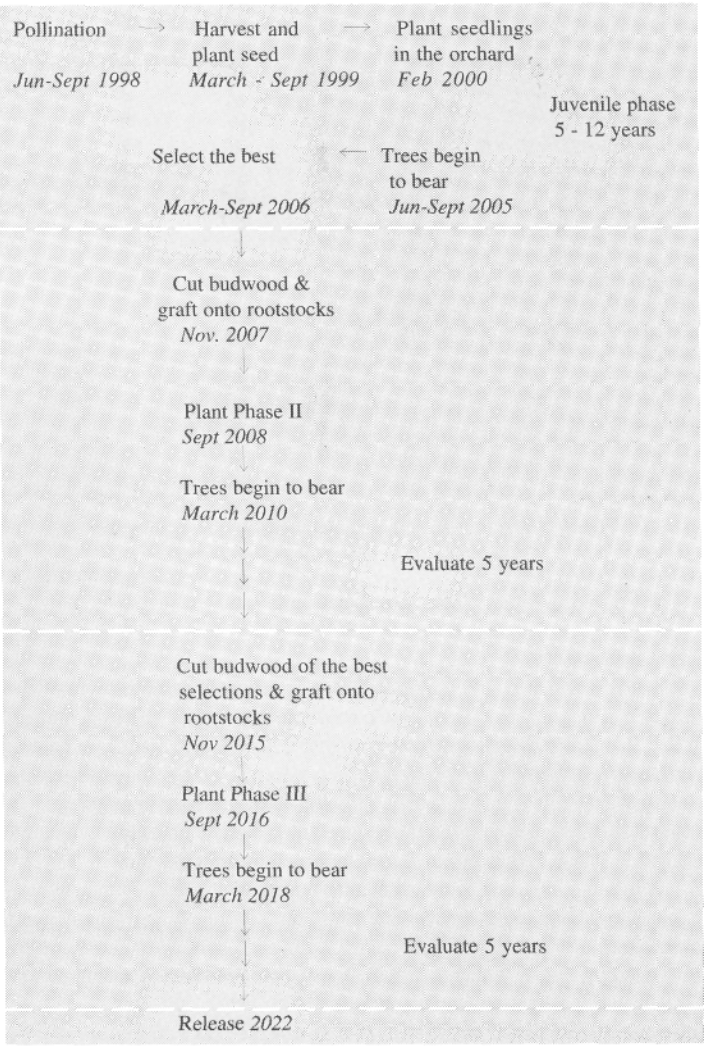

Figure 1. A schematic presentation of a conventional avocado breeding programme drafted in 1991 in accordance with the Californian breeding programme

The need for the expansion of the current cultivar series, is a matter that the breeders at the ITSC are very aware of and the strategy in figure 1 has been adapted to shorten the breeding period with as much as eight years (figure 2).

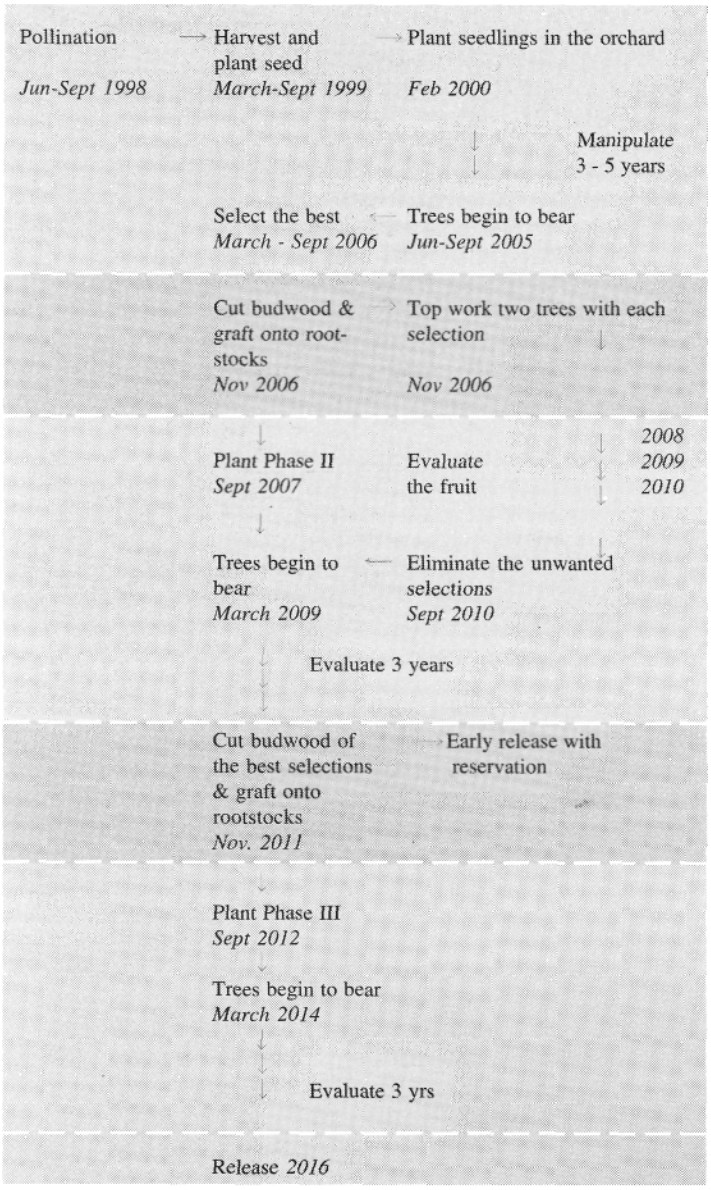

Figure 2. The revised conventional breeding strategy for the earlier release of new avocado cultivars

The following factors influence the success rate:

- **The genesource**

A well established and expanded gene source with a high level of diversity is necessary for use as basic breeding material. The incorporation of new material to the gene source is an essential exercise in order to ensure availability of more advanced breeding parents. It includes imported material and individual selections discovered on farms and in gardens in South Africa. Genetic material obtained from these sources are evaluated alongside Phase I trees produced in the breeding programme.

The relative breeding value of a cultivar or tree cannot be judged from its phenotype due to heterozygosity for many loci resulting in many gene interactions, including epistatic and dominance effects. The point is illustrated by Fuerte which is a fine avocado but fails as a breeding parent both in self pollination and in crossing with other cultivars (Bergh & Whitsell, 1975 and Bergh, 1987). It is envisaged that a minimum of 100 an open pollinated progeny of each parent will be evaluated. Sound record keeping enables the breeder to identify the best parents in a planned crossing programme.

- **Pollination:**

The pollen of the avocado is sticky and tends to clump together in a mass at the opened valve until it is removed by insects, or falls with the flower. Despite the fact that some cultivars bear flowers estimated to be close to a million per tree, the number of fruit that persist to maturity is in the order of several hundred (Bergh, 1987). Although hand pollination can be used in order to obtain controlled pollination, avocado hybrids from such controlled pollinations are extremely difficult to obtain. The pollen is sparse, sticky and difficult to collect in any quantity. Several methods of pollen collection, which are successful with other fruit crops, give poor results with the avocado and the use of large insects, like bees, is the most practical procedure to achieve controlled pollination (Vithanage, 1990).

Controlled crosses contribute a greater degree of sophistication to the breeding programme. Bergh (1987) is of the opinion that self pollination of the better cultivars is a worthwhile option as selfed progeny will identify superior breeding parents. He also stated that every cultivar tested, carries the genetic potential to produce the ideal fruit without the need for hybridisation. Excessive vegetative vigour is reduced by self pollination, with the probable result of greater fruitfulness. Another advantage of selfing is that it is a means of removing unwanted recessive genes from breeding populations. Once the breeding values of parents are known, hybridizing on the other hand becomes more valuable in exercises such as corrective mating, repeated back crossing, utilizing the cumulative effect of favourable genes, and in exploiting specific combining abilities.

Bearing in mind the impracticalities associated with hand pollinating avocado trees, hybridising will be encouraged by top working two cultivars onto one tree. Once the top worked tree starts flowering it is enclosed in a cage in order to promote cross pollination, the pollinating agents being either bees or flies. Phase I trees are produced with seed from such trees. Their pollen parents can usually be identified with isozyme techniques.

The Juvenile Phase

Similar to most fruit tree crops the avocado has a relatively long juvenile phase of between five and twelve years, which makes evaluation of seedlings expensive and time consuming (Lahav, Zamet, Gazit & Lavi, 1986). To speed up the breeding programme the seedlings can be forced into flowering by means of various methods:

- *Grafting or budding onto mature trees: (Bergh, 1969)*

It was, however, not mentioned how much the juvenile period will be shortened using this method but the idea was discarded due to the labour intensiveness of the original and follow-up operations. Other problems experienced were confusion concerning identity and the danger of hidden carriers of the "sunblotch' virus disease. It was also not very cost effective.

• *Girdling: (Hodgson & Cameron, 1937 and Lahav, Zamet, Gazit & Lavi, 1986)*

A single cut, in the period shortly before bloom starts to halfway through, has been effective if done two to three years after planting of the seedlings. However, results have been inconsistent.

• *Grafting breeding progeny onto ordinary rootstocks (Bergh, 1969)*

No appreciable gain in precocity was achieved with this method. It was not mentioned whether clonal or seedling rootstocks were used. It was also found not to be cost effective.

• *Chemicals (Bergh, 1969)*

According to Prof B.O. Berg some precocity was induced by the use of maleic hydrazide but no details were given. Many other chemicals have emerged recently that could be of value.

Clonal propagation for further evaluation programmes

Phase I seedlings are evaluated as soon as they come into production. The most promising selections are grafted onto the best commercial rootstock available, for further evaluation. Currently the rootstock in use is a *Phytophthora* tolerant rootstock, Duke 7. The original programme however, made provision for three rootstocks to be used. The commercial period for producing a clonal rootstock is at least 18 months, after which the scions still have to be grafted onto them. The normal time to produce a grafted tree on a clonal rootstock is about two years.

With the decision to use only the best commercial rootstock available, a number of rootstocks can be produced every year, as a permanent order, for grafting new selections for evaluation purposes. Trees for evaluation can then be multiplied in the same season as it was decided to promote a particular selection to the next phase. Rootstocks that were not used can be grafted to commercial scions and be sold, making the programme less costly.

Evaluation period of every phase

Previously it was recommended that the Phase II and Phase III evaluation periods should be at least eight years, seeing that most cultivars take eight years to reach maximum production before reaching a plateau. It can be seen in figure 2 that a preliminary recommendation for the promotion of selections to Phase III and to release, are already done after three years although data will still be accumulated in each phase for at least eight years. This implies a further shortening of the breeding process and release could now take place 18 years after making the original cross.

Prompt release with reservation

If the phase II evaluation is done with precision and a selection already excels to a great extent in phase II, the particular selection can be released at this early stage as a cultivar to be planted by producers willing to take the risk. This could shorten the breeding process to as little as 13 years instead of 24 years.

Phase I extension

It is also indicated in figure 2 that simultaneously with the grafting of trees for the phase II evaluation; at least two trees are also top worked with each selection. The advantage of this is that by the time the phase II trees come into production, which normally takes between one and two years, fruit from the top worked trees could already have been evaluated for two years. This would not necessarily shorten the process but could contribute to the effectiveness of the programme. Data from these trees, for instance on the cold storage of fruit, might indicate a selection included in Phase II, that can be omitted. It could even be eliminated from the Phase II programme saving space and fertilizer. With the release of the cultivar producers may wish to top work some of their old cultivars with the new release. Then data would be available on the performance of the particular genotype with regard to being top worked.

Continuity

Breeding programmes for annual crops are very often measured in decades; in that respect fruit tree breeding must surely be planned in terms of centuries. The only way to do so is to make sure that breeding material is planted and evaluated annually at as many localities as possible. After 13-18 years, the breeding programme will theoretically be able to release new material annually

CONCLUSION

On first impression it appears as though a conventional breeding programme is academic and not worth the consequently high costs involved. If this is true, the South African industry must be content to build their future on Californian cultivars that are not very well adapted to the South African climate. The current intricacies surrounding new Californian cultivars, make them less accessible to the South African avocado industry. With the Californian breeding programme experiencing substantial losses of seedlings due to freezes and also no longer hybridizing scion material after 1994, new cultivars from this source will probably become less. With regard to the local breeding programme, continuity and sound management of the programme are however the key factors. The anticipated acceleration of the breeding programme illustrates that the ITSC considers the needs of the producers as high priority.

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