

## ■ 30 Years of cultivar research at Westfalia technological services

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The search for superior avocado cultivars by Westfalia Fruit Estates (Pty) Ltd was initiated ca. 30 years ago, with a formal cultivar evaluation programme being introduced in the early 1990's. The aim of this programme was to find high yielding, good quality and robust cultivars to compliment the traditional cultivar spread, both on a local and a global level. Over the years Westfalia Technological Services (WTS) have sourced and tested over 150 cultivars grown either in South Africa or from other avocado producing countries where they either originated from a formal breeding program or were discovered as chance selections. Only a small percentage of these cultivars have been developed to a commercial level due to the strict quality, seasonality and production criteria imposed on them.

The evaluation programme consists of a series of rigorous screening phases that need to be completed before a cultivar will be released for commercial development. An example of the success of this programme has been the introduction and commercialisation of two new avocado cultivars in the last few years that have enabled Westfalia Fruit to offer their high-end clients (locally and internationally) superior quality fruit for twelve months of the year. The screening phases, and lessons learnt will be discussed in more detail in this paper, as well as the importance/significance of collaborating with avocado breeders from around the world.

Key words: Yield, Fruit size, Maturity, Quality.

### INTRODUCTION

The South African avocado season typically starts in March with 'Fuerte' from the earliest production regions, followed by 'Hass' from May onwards and concludes with 'Ryan' towards September/October from the late season production regions. Thus, during the four-month period of November to February, avocados are not readily available in South Africa. Westfalia Fruit Estates is mainly export orientated, but in an assessment of alternative market possibilities the supply of fruit to the domestic market in South Africa during that period was seen as an opportunity to increase profits. As a consistent availability of a high quality fruit is essential in the successful marketing of such a fruit, the limitations imposed by the relatively short South African avocado season is of concern. In order to address this issue, Westfalia Fruit Estates has been actively searching for superior avocado cultivars for ca. 30 years.

A formal cultivar evaluation programme was introduced in the early 1990's. The twofold aim of this programme was to find high yielding, good quality and robust cultivars to compliment the traditional cultivar spread and extend the traditional season with earlier or later maturing cultivars. Additionally, in recent years, niche market opportunities for "weird and wonderful" cultivars came into play.

This article aims to describe how the performance of cultivars has been evaluated at WTS and how this has led to the introduction and commercialisation of new avocado cultivars. Keep in mind that the results of these evaluations reflect the cultivar's performance under South African growing conditions.

### MATERIALS AND METHODS

The cultivar evaluation programme consists primarily of four phases which can be summarized as follows:

Phase I: Gene pool evaluation and new introductions

Phase II: Larger scale testing of promising selections and cultivars

Phase III: Pre-commercial testing of cultivars under commercial conditions

Phase IV: Commercialisation of cultivars

#### Phase I: Evaluation and consolidation of the gene pool and the newly introduced material

The aim of this long-term project is to consolidate, maintain and evaluate avocado cultivars at Westfalia Fruit Estates. A dedicated orchard of 1.5 hectare (ha) in size was established for this purpose from 1994 to 1996 using 'Duke 7' as a rootstock. Cultivars were solicited for inclusion in the screening phase from formal breeding programmes of other parties such as the University of California and the Volcani Institute in Israel. Cultivars and chance selections were also obtained from other avocado growing countries and various local South African selections were also included. As this is Phase I of the evaluation, each cultivar is designated to have two single tree replications in a completely randomised design. The commercial cultivars, 'Fuerte' and 'Hass' are included as standard controls for comparison with each batch of new introductions. For the remainder of this article, the term cultivar will be used to refer to any plant material being it an existing cultivar or a selection.

An in depth study of the following performance criteria are used to assess the potential of the various cultivars.

Flower behaviour: includes flowering period and flower type (i.e Type 'A' or 'B' flower)

Season of maturity: Fruit maturity is monitored on a regular basis by determining the moisture content of fruit and linking that to the ripening behaviour of the fruit.

Productivity: Individual tree yield (kg/tree) is recorded at harvest.

Fruit size: The fruit size distribution of the entire crop or a representative sample of 300 fruit is determined using fruit sizing equipment. Very large or very small fruit are sized manually by weighing each fruit individually.

Strip analyses at harvest: A minimum sample of 300 fruit is analysed to determine the susceptibility of the fruit to diseases, pests and other factors like sunburn, wind rub, misshapen fruit etc. A rating scale of 0-3 is used, where 0=absence and 3=severe.

Post-harvest: A sample of fruit is ripened at room temperature (20°C) to determine fruit quality. Simultaneously, another sample of fruit is stored in the WTS experimental cold-rooms for a period of 28 days at a low temperature to determine the storability of the fruit. Again, the rating scale of 0-3, is used to rate the incidence of diseases and physiological disorders.

Fruit characteristics: The overall appearance of the fruit is looked at: a) fruit shape, b) thickness and texture of the skin, as well as peel ability, c) fibre, browning potential, colour and texture of the flesh, d) size of the seed in relation to the size of the fruit, and e) taste upon ripening.

Tree characteristics: The behaviour of the tree throughout its phenological cycle is evaluated: a) density of the canopy (leaf cover) and leaf drop at flowering, b) position of the fruit within the tree canopy, c) flowering and fruit set intensities, d) out-of-season flowering and fruit set intensities, e) fruit drop when mature and f) pre-mature colour change of the fruit while still intact.

The evaluation of a cultivar according to the above mentioned criteria will typically be done for five to six years. Upon completion of this period, a cultivar can either be identified as a) having limited (or no) commercial potential and remain in the Phase I gene pool orchard to preserve the material or b) having commercial potential, and move on to Phase II.

#### **Phase II: Larger scale evaluation of promising cultivars**

Cultivars that have been identified in the Phase I screening as having commercial potential are introduced to the larger Phase II screening of the WTS cultivar evaluation programme. In Phase II the aim is to establish 24 trees per cultivar to allow for a more thorough evaluation and to confirm the results from Phase I. A range of cultivars are usually established together and 'Hass' (for black skinned cultivars) and 'Fuerte' or 'Ryan' (for green skinned cultivars) are included as a commercial control. The trial lay-out usually consists of a randomised block design with eight repetitions of three trees each. A dedicated area of 2.5ha in size is used for this evaluation phase. During Phase II, the following data is again collected: seasonality, productivity, fruit size, pre- and post-harvest fruit quality, phenotypic traits and pest and disease tolerance. In addition, multiple harvests are done to determine the earliest, optimum and latest possible harvest date for each cultivar. Sensory evaluations and market and consumer acceptance are also evaluated as more fruit are available allowing for test exports of a significant number of fruit to selected clients. A cultivar would be evaluated over five or six seasons in this phase before conclusions can be drawn on its commercial potential and recommendations for the next phase of pre-commercial testing be made.

#### **Phase III: Pre-commercial testing**

This phase of the evaluation programme involves the establishment of the successful Phase II cultivars on a larger scale of 0.5 to 1 ha (200-400 trees) on farms owned by Westfalia Fruit Estates in strategically important production regions. This allows for testing of the cultivar's adaptability to different climatic and environmental conditions. A comparator cultivar in the form of a commercial cultivar is included in the planting. All the criteria focussed on in Phase I and Phase II are repeated in Phase III. Additionally, due to a larger number of available trees and thus available fruit, trial exports to the main outlets can be performed. This allows for confirmation of market acceptability. This phase adds another five to six years to the evaluation of a cultivar.

#### **Phase IV: Commercialisation**

Only after successfully completing the first three phases of rigorous testing, will a cultivar be released commercially. Thus, it normally takes about 15 to 20 years for a cultivar to reach this phase. The commercial release of a cultivar is also depended on ownership of the cultivar, the extent and reach of the master licence agreement and the potential value of the cultivar in a specific area or country. Plant protection in the form of Plant Breeder's Rights or Plant Patents are put into place at this stage, allowing WTS to commercialise the plant material in a sensible way.

## **RESULTS AND DISCUSSION**

The world avocado market has become a predominately 'Hass' orientated market over the last two decades. Generally, 'Hass' sets a very high standard in terms of fruit quality, it eats well, ships well and under favourable conditions has high yields. However, it is not without a fair share of challenges. 'Hass' trees have the tendency to produce a large percentage of undersized (<170 g) fruit. This phenomenon becomes more prevalent as the trees age and during periods of physiological stress. At times up to 40% of the crop can be undersized and thus unmarketable, resulting in significant financial losses to growers. Further, a 'Hass' tree also tend to alternate in its bearing, resulting in inconsistent production. As a result the cultivar evaluation programme has focussed for many years on finding "Hass-like" (or black skinned) cultivars to replace or extend the 'Hass' season.

#### **Phase I**

The addition of new material in the gene pool orchard is facilitated through the importation of material from other countries as well as from promising local material found in household gardens on farms in South Africa. Presently, approximately 150 cultivars have been top worked in

the gene pool orchard. All material is evaluated according to the cultivar evaluation objectives set out in 2.1 (above) in order to determine the merit of passing the cultivar onto the next phase. Further, the gene pool orchard is not only maintained primarily as a source of fruiting cultivars, but also as a source of *Persea* species that collectively introduce a larger genetic diversity.

In the gene pool orchard, harvesting starts as early as February and continues into December. Thus, almost fulfilling a 12 month availability of locally grown avocados which is one of the main aims of the cultivar evaluation programme and also a strategic objective of Westfalia Fruit Estates. Unfortunately, most of the cultivars which have been found to mature earlier or later than the existing commercial cultivars have no, or little commercial potential due to various reasons. These reasons include poor productivity, poor external fruit appearance, undesirable fruit shape and size, pest and/or disease susceptibility and poor post-harvest fruit quality.

In a competitive business environment, a competitive edge is gained if a supplier can distinguish itself from competitors by offering something unique/exclusive. Westfalia Fruit Estates manages to offer such an opportunity to their suppliers by being able to supply them with extra-large fruit under the Avozilla tradename. The launch of the fruit in the United Kingdom in 2013, took social media by storm, and as a publicity stunt was so successful, that it was repeated in 2014 and has now become an annual event. The cultivar involved, has been evaluated by WTS in the programme for many years and has always impressed but, because of its size was never considered for commercial production. Due to the diligent record keeping and valuable information collected over the years, “weird and wonderful” cultivars can easily be sourced from the gene pool orchard.

As consumers are becoming more health conscious and stricter regulations surrounding agro-chemical use and maximum residue limits (MRL's) are imposed, reducing the use of agro-chemicals has been a priority for Westfalia Fruit Estates and the South African avocado industry in general. Natural plant tolerance is the most environmentally safe, reliable and cost effective means for the “control” of pests and diseases. Therefore, for the duration of the evaluations, no fungicides or insecticides are applied in the genepool orchard, thus making evaluation for natural pest and disease tolerance possible. This is important because concurrent evaluation of both horticultural and pest susceptibility allows a more objective approach for selecting new cultivars for commercial release. However, care must be taken as it is possible for the disease inoculum to build up to such an extent that fruit are subjected to unrealistic disease loads thus jeopardising accurate fruit quality evaluations. When this occurs it becomes necessary to intervene with a fungicide application, as occurred in the gene pool orchard in 2014.

In South Africa, *Cercospora* spot caused by *Pseudocercospora purpurea* is the most serious pre-harvest disease on the ‘Fuerte’ and ‘Ryan’ cultivars. From the strip analyses done on fruit from the Phase I orchard, cultivars with a natural tolerance, or even resistance against the disease, have been identified. One such mid- to late season cultivar with a high degree of tolerance against blackspot has progressed to Phase II. Incorporating this cultivar into the traditional South African cultivar spread, will allow growers to farm more cost effectively due to less agro-chemical sprays being needed to protect the fruit from infection.

To date, three cultivars with potential have been identified and are to be transferred to Phase II. These include one early, one mid- and one late season green skin (Figure 1).

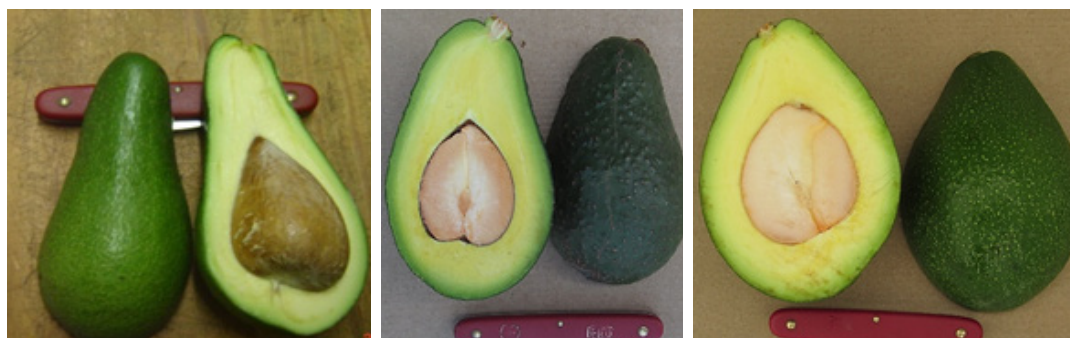


Figure 1. Green skin cultivars with potential to be transferred to Phase II in the near future: early (left), mid (middle) and late (right).

### Phase II – Larger scale evaluation

Since the inception of this formal programme in the early 1990's, some 24 cultivars have made it to Phase II of cultivar evaluation. The first cultivars to be evaluated were ‘Lamb Hass’ from California and ‘Iriet’ and ‘Gil’ from Israel, with a South African cultivar from the Western Cape, ‘1.14.2’, also being included in the evaluation (Kremer-Köhne, 1999). ‘Lamb Hass’ was identified as the most promising cultivar at that time as it had a higher cumulative yield than ‘Hass’, a favourable fruit size distribution and matured two months later than ‘Hass’. According to Kremer-Köhne and Köhne (2001), ‘Lamb Hass’ had quite different fruit characteristics to ‘Hass’ and was thus unsuitable as a replacement for ‘Hass’. It was suggested it could rather be used as a cultivar to prolong the avocado season. ‘Lamb Hass’ progressed to Phase III and was eventually commercialised to some extent in South Africa.

The cultivars ‘Sir Prize’, ‘Jewel’, ‘Nobel’ (previously BL 667), ‘8-22-5’, ‘Gem’ (3-29-5) and ‘Harvest’ (N45), from the Californian breeding programme, and ‘Bonus’, a Westfalia cultivar, were evaluated by WTS between 1996 and 2001 (Kremer-Köhne, 2001). Due to unsatisfactory performance the evaluation of ‘Sir Prize’, ‘Jewel’, ‘Nobel’, ‘8-22-5’ and ‘Bonus’ was discontinued after the 2001 season. The cultivars ‘Harvest’ and ‘Gem’ performed well and cumulative yields were 125% and 20% higher, respectively, than that of ‘Hass’ for the three year period 1999 – 2001 (Kremer-Köhne, 2002). Over the next three years, both cultivars continued to perform well with ‘Harvest’ being the best producer over the six year period out-producing ‘Gem’ by 57 ton/ha (cumulative yield) and ‘Hass’ by 72 ton/ha (Bruwer & Mokgalabone, 2005). These two cultivars

progressed to Phase III. The evaluation of a local cultivar 'Grace' from the Kiepersol area in Mpumalanga was initiated in 2003. Due to no obvious benefit over 'Hass', the evaluation of 'Grace' was discontinued after the 2007 season.

In 2002/2003, a next range of five black skinned cultivars entered Phase II. Of these 'Carmen'-Hass' (Mendez #1) impressed very early on, with its precocity and tendency to flower earlier than 'Hass' which resulted in a 2-4 week advantage over 'Hass' in terms of season of maturity. Further, the prolific flowering of the trees and the resultant out-of-season crop proved to be strategically important in terms of having a year-round supply of locally grown avocados in South Africa. These results confirmed what the cultivar does in its country of origin, Mexico, and why it was originally noticed and selected by Mr Carlos Mendez many years ago (Illsley- Granich & Brokaw, 2011). The cultivar easily moved on to Phase III and eventually Phase IV. The evaluation of the other four cultivars was discontinued due to poor performance or no real benefit in terms of seasonality, fruit size or pre- and post-harvest fruit quality.

In 2008, a mid- to late season green skin cultivar identified for its tolerance against the fungal infection *Cercospora* spot was introduced into Phase II. The cultivar proved to be highly productive, producing large sized fruit of excellent eating quality (unpublished data). Unfortunately, post-harvest quality was compromised when fruit were subjected to long term storage (28 days) at low temperatures as required for export by sea. However, the cultivar is thought to hold local promise as a mid- to late season addition to the cultivar spread in South Africa. The cultivar has been recommended for inclusion in some Phase III plantings in future.

A promising black skinned cultivar from California was introduced into Phase II in 2009. To date this cultivar has out-performed 'Hass' in terms of cumulative yield, has fruit that are generally 2 count sizes larger than 'Hass' and seems to produce much less smaller, unmarketable fruit counts (unpublished data). Even though the cultivar does not offer any benefit over 'Hass' in terms of seasonality, the higher yield and better fruit size distribution alone warrants moving this cultivar to Phase III.

In 2010, yet another range of new cultivars were established. Unlike before when trees were top worked on existing stumps, a new evaluation orchard of approximately 1ha was developed and the new range was established as young trees obtained from the Westfalia Fruit Estates nursery. They comprised two early season green skin cultivars, one early season black skin and one mid-season black skin cultivar. However, due to poor performance, low productivity and poor fruit quality the evaluation of the two green skin cultivars was discontinued after the 2015 harvest. The evaluation of the two promising black skin cultivars continues and an additional two new black skinned selections have been top worked in 2015.

#### **Phase III: Pre-commercial**

The first cultivar from Phase II to enter Phase III was 'Lamb Hass'. The cultivar was established in different geographical regions and continued to perform well, even though its alternate bearing pattern was of some concern. Next into Phase III was 'Harvest' and 'Gem' in 2004. Both cultivars continued to impress with their productivity, but 'Gem' excelled in terms of excellent fruit quality, consistent production (low alternate bearing) and ability of fruit to be stored on the tree for late season harvesting. 'Carmen'-Hass' entered Phase III a few years later due to the unique opportunities offered by the cultivar and has since progressed to Phase IV.

The only cultivar currently in Phase III is the black skinned cultivar from California. Limited data is available and it will probably be another three years before a conclusion can be drawn about its potential for commercialisation.

#### **Phase IV: Commercial**

The cultivar 'Lamb Hass' was the first cultivar from evaluations done by WTS, to be commercially released in South Africa. 'Gem' and 'Carmen'-Hass' followed and were commercially released to the South African industry in 2009 and are managed by WTS. In Southern Africa, approximately 100 000 (300 ha) 'Carmen'-Hass' trees have been planted up to date and approximately 75 000 (200ha) 'Gem' trees. Both these cultivars play an important role in the extension of the South African season. Further, WTS is licenced to manage the cultivars 'Gem' (including 'Harvest') and 'Carmen'-Hass' internationally according to a cultivar specific licence for other avocado growing countries.

#### **CONCLUSIONS**

The cultivar evaluation programme at WTS will continue to search for cultivars that are superior in terms of eating quality, fruit-size distribution, disease resistance, and seasonality (ideally earlier or later than current commercial cultivars). The long term nature and low success rate of  $\leq 2\%$  over 25 years of this type of research, makes it an expensive effort and requires financial dedication and commitment from all involved parties. Sadly many avocado breeding programmes show a decline in research efforts due either to financial constraints or the cannibalisation of 'Hass' as the preferred cultivar, and WTS has thus identified an urgent need to start a cultivar breeding programme to limit the current dependency on external parties for new genetic material. Further, with the world market being dominated by 'Hass', the natural genetic variation is becoming less by the day. Therefore, the systematic evaluation of cultivars remains essential in order to utilize the collected genetic resources with the objective of identifying cultivars suitable for commercial release.

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# ACTAS • PROCEEDINGS

## VIII CONGRESO MUNDIAL DE LA PALTA 2015

del 13 al 18 de Septiembre. Lima, Perú 2015

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