

25 YEARS OF AVOCADO ROOTSTOCK DEVELOPMENT IN SOUTH AFRICA

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The production potential of fruit tree crops depends on the choice of rootstock, whether it be either their ability to resist diseases or to impart greater productivity to the scion. In the late 1970s, avocado root rot caused by *Phytophthora cinnamomi* severely impaired the South African avocado industry which was based on seedling rootstocks. This necessitated the importation of root rot tolerant rootstocks from California for vegetative propagation to establish genetically uniform and productive avocado orchards. Out of the range of imported avocado rootstocks evaluated under South African growing conditions, only the 'Duke 7' rootstock provided uniform, productive and reasonably healthy trees, and therefore became the industry standard rootstock for many years. In the 1980s, several survivor trees on seedling rootstock were identified in diseased South African avocado orchards. Rootstock shoots were induced on these trees, the material propagated and evaluated in field trials in comparison with the 'Duke 7' rootstock. At various test sites the Westfalia rootstock selection 'Dusa'TM out-performed 'Duke 7' with regard to tree health and yield. Based on these results the superior rootstock 'Dusa'TM has recently been released in several countries. Further, the Westfalia rootstock breeding program generated new plant material which was then screened for its root rot tolerance. Seedling selections with healthy roots were included in field trials to confirm their root rot tolerance and evaluate their production potential.

Key words *Phytophthora cinnamomi*, root rot, tolerance, Hass, production, Dusa[®] ('Merensky 2')

25 AÑOS DEL DESARROLLO DEL PORTAINJERTO DE AGUACATE EN SUDÁFRICA

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La producción potencial de cultivos de árboles frutales depende de la elección del portainjerto, ya sea por su capacidad para resistir enfermedades o para lograr una mayor productividad del vástago. A fines de la década de los setenta, la podredumbre de la raíz del aguacate, causada por *Phytophthora cinnamomi*, deterioró gravemente la industria del aguacate de Sudáfrica, que tenía como base portainjertos de semilla. Esto hizo necesaria la importación desde California de portainjertos tolerantes a la podredumbre de la raíz para la propagación vegetativa

con el objeto de establecer huertos de aguacates productivos y genéticamente uniformes. Además de la variedad de portainjertos de aguacate importados, evaluados bajo las condiciones de crecimiento existentes en Sudáfrica, sólo el portainjerto 'Duke 7' proporcionó árboles razonablemente sanos, productivos y uniformes y, por ello, se convirtió en el portainjerto estándar de la industria durante muchos años. En la década de los ochenta, se identificaron varios árboles sobrevivientes de portainjerto de semilla en huertos de aguacate enfermos de Sudáfrica. Los vástagos de los portainjertos fueron injertados en estos árboles, el material se propagó y se evaluó en pruebas de campo y fue comparado con el portainjerto de 'Duke 7'. En los distintos lugares de prueba de la selección de portainjerto de Westfalia 'Dusa'TM superó a 'Duke 7', en cuanto a salud y rendimiento del árbol. A partir de estos resultados el portainjerto superior 'Dusa'TM recientemente se ha aplicado en varios países. Además, el programa de cultivo del portainjerto de Westfalia produjo nuevo material vegetal que luego fue seleccionado por su tolerancia a la podredumbre de la raíz. Las selecciones de árboles de semilla con raíces sanas se incluyeron en las pruebas de campo para confirmar la tolerancia a la podredumbre de la raíz y evaluar su producción potencial.

1. Introduction

Avocado seeds of the West Indian and Mexican races were introduced to South Africa in the last decade of the nineteenth century. By the late 1920's mainly Mexican seedlings were used as rootstocks as these were more hardy and slightly less vigorous than the West Indian seedling trees. Later, most of the Mexican mother trees were found to be infected with the sun-blotch viroid, and seeds of the Guatemalan cultivar Edranol became the main source for rootstocks in the 1950's. The Guatemalan seedling rootstocks were, however, highly susceptible to root rot caused by *Phytophthora cinnamomi*, which resulted in poor yields and an average orchard life span of only 12 years. Despite the use of more root rot tolerant Mexican Duke seedling rootstocks in the 1960's, avocado root rot severely impaired the South African avocado industry in the late 1970s.

2. Imported clonal rootstocks

Vegetatively propagated rootstocks are used successfully in many woody, perennial fruit crops to overcome certain problems related to productivity, soil factors, disease, growth habit as well as fruit quality, and avocado is no exception. In South Africa, the propagation and use of clonal avocado rootstocks goes back to the late 1970s when first vegetatively propagated rootstocks were produced at Westfalia Estate (W.E. Maddison¹, personal communication, 2005). The devastation caused by *P. cinnamomi* necessitated the importation of root rot tolerant rootstocks from California for vegetative propagation to establish genetically uniform and productive avocado orchards. The avocado rootstocks 'Duke 6', 'Duke 7', 'G6', 'G755', 'Thomas', 'D9'

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and 'Barr Duke' were subsequently evaluated under South African growing conditions. During the early 1980s 'Duke 6' was planted on commercial scale at Westfalia Estate, but after a few years the trees started dying due to an unidentified disease associated with stem pitting. Subsequently, all the 'Duke 6' plant material was destroyed in an attempt to eradicate the disease and therefore this rootstock no longer exists in South African orchards (Roe *et al.*, 1995). 'G6' and 'G755' were out-performed by 'Duke 7', with 'G755' imparting excessive vigour to the scion, particularly when grafted with 'Hass' (Köhne, 1991). 'Thomas' did not perform up to expectations producing lower 'Hass' yields than 'Duke 7', while 'D9' and 'Barr Duke' imparted lower vigour to 'Hass' but did not out-perform 'Duke 7' in terms of yield (Roe *et al.*, 1995 and 1997). In conclusion, 'Duke 7' generally out-performed the other imported avocado rootstocks evaluated in South Africa, and similar results were obtained in California (Arpaia *et al.*, 1993). The 'Duke 7' rootstock provided uniform, productive and reasonably healthy trees, and therefore became the industry standard rootstock in South Africa for many years.

New rootstocks are imported continuously from various countries and evaluated under South African growing conditions. However, only preliminary results have been obtained to date.

3. Survivor trees

In the 1980s, several survivor trees on seedling rootstock were identified in diseased South African avocado orchards. Rootstock shoots were induced on these trees, the material propagated and evaluated in field trials in comparison with the 'Duke 7' rootstock. At the ARC Institute for Tropical and Subtropical Crops in Nelspruit, a rootstock selection originating from a survivor tree named PvT was evaluated. PvT showed potential, being tolerant to waterlogged conditions and *P. cinnamomi* (Bijzet, 1999).

At various test sites, the Westfalia rootstock selection Dusa[®] ('Merensky 2') out-performed 'Duke 7' with regard to tree health and yield. Many years of South African and Californian data show that the rootstock Dusa[®] is significantly more root rot tolerant and more productive than 'Duke 7' (Roe *et al.*, 1997; Roe *et al.*, 1999; Menge, 2002; Kremer-Köhne and Mukhumo, 2003; Rose, 2003). Dusa[®] is of Guatemalan / Mexican origin (T. Chao², personal communication, 2002), and shows a good measure of tolerance to cold winters (D. Smith³, personal communication, 2005) as well as high salinity conditions (Menge, 2002; Crowley and Arpaia, 2002). In recent years, the situation in terms of the preferred clonal rootstock has changed considerably in South Africa and some other countries such as California. There has been a rapid increase in the popularity of the Westfalia rootstock selection Dusa[®],

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and a strong decline in the popularity of 'Duke 7'. Since 2002, the newly released rootstock Dusa[®] has been made available to avocado growers in several countries.

4. Super trees

Based on a recommendation by Dr. A. Ben-Ya'acov, a large scale selection program focusing on avocado productivity was undertaken at Westfalia Estate in the 1980s. In this selection program, individual tree yield data for all avocado trees on the Estate grafted on seedling rootstocks were recorded for several consecutive years. The productivity survey revealed huge differences in yield between trees. The best trees were found to bear approximately 500 kg of fruit year after year, with very little alternate bearing. Under the assumption that the specific seedling rootstock supporting the most outstanding trees would continue to produce these tree yields if clonally propagated trees were adequately spaced over an orchard, sustainable yields of 50 t per hectare per annum should be obtainable under suitable climatic conditions (Smith and Köhne, 1992, Smith *et al.*, 1993). Therefore, rootstock shoots were induced and eventually obtained on twelve high yielding trees. Subsequently, the rootstocks were propagated and screened in the mistbed for their tolerance to *P. cinnamomi* as described below. The three best selections were then grafted with 'Hass' and planted in a field trial in 2003, from which only preliminary results have been obtained to date.

5. Avocado rootstock breeding

The requirements for superior new rootstocks can be defined clearly as tolerance to *Phytophthora* root rot and potential to produce high yields. When breeding and selecting avocado rootstocks, over 99% of the initial plant material can be culled within the first year in a screening system for seedlings.

The ARC Institute for Tropical and Subtropical Crops in Nelspruit undertook a rootstock breeding project in the 1990s (Bijzet, 1999), which did not yield any rootstock selection with potential, and was therefore abandoned.

Concurrently with the large scale selection program focusing on avocado productivity, the avocado rootstock breeding program at Westfalia (previously Merensky) Technological Services was initiated in the early 1990's (Kremer-Köhne *et al.*, 2001). The avocado rootstock breeding block contained 20 different rootstocks which have shown superior performance under *P. cinnamomi* pressure (e.g. 'Duke 7', 'Merensky 1' and Dusa[®], 'G755'). These trees were used as parent trees for breeding, and underwent open pollination. Pollen from commercial avocado cultivars was excluded from the breeding block by the remoteness of the breeding block from commercial orchards. Seedlings from the breeding block were screened for their tolerance to root rot by exposure to a virulent strain of *P. cinnamomi* in a mistbed. The seedlings were planted in *Phytophthora* infested vermiculite and evaluated for

their root health after six weeks. Selected seedlings were then cloned and re-tested (10 of each) in the mistbed in comparison to 'Duke 7' (2000-2002) and Dusa[®] (from 2003 onwards) clonal commercial rootstocks as described above. Rootstocks with better root health than 'Duke 7' and Dusa[®] respectively were selected in the second mistbed screening, vegetatively propagated and grafted with 'Hass' for field trials to confirm their root rot tolerance and evaluate their yield potential as described by Kremer-Köhne and Duvenhage (2000). The rootstocks were evaluated in orchards heavily infested with *P. cinnamomi*, and no root rot control treatments were applied. The vegetatively propagated rootstock selections were compared to the commercial standard clonal rootstocks 'Duke 7' and Dusa[®] (from 2003 onwards). Individual tree yields were recorded, tree condition was rated annually and tree size determined by measuring the trunk circumference. First promising rootstock selections are presently being evaluated in larger scale field trials in which a high potential selection is heralding a new level of rootstock performance not achieved previously.

6. Outlook

The Westfalia rootstock breeding program continues to generate and evaluate new selections of rootstocks with the ultimate aim of increasing the profitability of avocado farming. While promising new Westfalia rootstock selections with the potential to out-perform Dusa[®] are presently undergoing stringent field tests, the good news to avocado farmers around the world is that there is at long last a clonal rootstock better than 'Duke 7'.

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