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Future prospects with new avocado cultivars and elite rootstocks

A W Whiley[1], J S Köhne[2], M L Arpaia[3] and G S Bender[4]
[1]Maroochy Horticultural Research Station, QDPI, PO Box 5083 SCMC, Nambour Q4560, Australia.
[2]Merensky Technological Services (Pty) Ltd, Westfalia Estate, Duivelskloof 0835, Republic of South Africa.
Department of Botany and Plant Sciences, University of California, Riverside, California 92521, USA.
Cooperative Extension, San Diego County, University of California, San Diego, California 92123, USA.

ABSTRACT

Cultivation of avocado is in the early stages of domestication of this species as an orchard crop. Selection of cultivars has followed a typical evolutionary pattern for fledgling industries with the initial production of many varieties. With stringent evaluation this has subsequently diminished to two cultivars of major importance, Fuerte and Hass, in those countries growing Mexican and Guatemalan race avocados. These two have become the industry standards and form the bulk of the international trade in avocados. However, breeding programmes and field selection in California and other countries are producing a new generation of cultivars which we cannot afford to ignore. In Australia Shepard has become an important early maturing cultivar while internationally, speculation on the value of Gwen continues.

The urgent quest for Phytophthora root rot resistance in avocado rootstocks has resulted in improved tolerance to this disease, viz Duke 7, Martin Grande and Thomas. However, selection of elite rootstocks has focused on disease resistance with productivity and other horticultural characteristics of trees being largely ignored.

This article reviews our current knowledge of some new avocado cultivars and rootstocks.

INTRODUCTION

Avocados have been staple in the diets of the indigenous peoples of the central Americas for many centuries. First developed in foster countries as high priced novelty fruit, avocados are now a sought after every-day commodity in many international markets. Yet its domestication as an orchard fruit is still in its infancy with low yields and unreliability of production, major threats to market stability and development.

Improvements in post-harvest handling procedures and transportation of avocado are increasing the access of this fruit to distant markets. These changes are of significance to the South African and Australian avocado industries, the former as a traditional

supplier to Europe and the latter seeking to develop off-shore outlets. The present weak currencies, particularly of South Africa, are assisting the viability of export of this fruit to European markets. However, this situation is likely to change if inflation rates in South Africa and Australia remain higher than those countries where the fruit is marketed.

The South African and Australian avocado industries have had an excellent record of investment into research relative to the size of their industries. To survive the challenges ahead the respective industries must remain dynamic in their acceptance of improved technology, both pre and post-harvest. This must be coupled with aggressive marketing strategies.

The quality of the planting material is the basic foundation for any fruit industry. There is an unproportionally high investment at the time of orchard establishment compared to any other stage of development. Therefore, thoroughly researched decisions are needed as to the choice of rootstocks and scion cultivars most suited to the situation. There is no magic recipe for the choice of planting material, as each grower requires to make selections tailored to his/her own needs. Considerations of environmental adaptation of cultivars (Whiley & Winston, 1987) *as* well as marketing opportunities, are equally important for the success of the venture.

The evaluation of new material in experimental programmes can give some indications of performance but is often fraught with dangers. Researchers are often too closely focused to their discipline, sometimes failing to see the total implications of their technology. Critical consideration of research results by growers are often required before pursuing a course of action. This can be illustrated by the *Phytophthora* root rot research programme, which until recently focused on disease resistance in rootstocks and failed to address tree productivity issues. In the final analysis the acceptance of new plant material will be made by the industry, at production, marketing and consumer levels.

The intent of this paper is to objectively review the performance of some of the newer cultivar and rootstock lines now available as a choice for growers. We also draw attention to the current success of the cultivar Shepard in Australia and discuss the attributes of the late maturing Reed.

CULTIVARS

Shepard is further proof of the specificity of avocado cultivars to the environment (Whiley & Winston, 1987). Selected by Mr Stan Shepard, a past director of the Californian Avocado Society, this cultivar was never considered a commercial prospect in California due to its unreliable and poor production. Having a 'B' flower pattern it belongs to the group of cultivars with the greatest sensitivity to temperature at flowering (Sedgley & Grant, 1983). This characteristic is further compounded by its earliness of flowering when temperatures are lowest. Tested in the cooler areas of Queensland and New South Wales (i.e. between latitudes 27-32°S) production proved similar to the Californian experience and once again its potential was ignored. Taken to the tropical highlands of north Queensland (ie 17°S and 390 m elevation) in the late 1970s, it found its environmental niche and has developed as an important early cultivar with

consistently high yields (Figure 1). The likely area for viable production with this cultivar in South Africa is the northern Transvaal.

The tree is a semi-dwarf suited to high density plantings. However, if allowed to crowd trees become erect and difficult to harvest (Allen & Campbell, 1987). The fruit is pear-shaped with a green pebbly skin which gives it greater resistance to post-harvest disease than Fuerte. The flesh is butter yellow, reaching 21 per cent dry matter (79 per cent moisture) about four weeks earlier than Fuerte in the same orchard. Fruit quality is superior to other early cultivars though seed size is comparatively large to the pulp content of the fruit (Figure 2). Fruit size is similar to Hass (250-300 g) and matures over an extended period. A successive harvest, removing the larger fruit each time, allows smaller fruit to grow, thereby increasing mean fruit size and yield.

Reed is a Guatemalan race cultivar, probably an Anaheim x Nabal hybrid (Platt, 1976). The cultivar was developed in California where currently there is less than 400 ha planted. In California, Reed matures towards the end of the Hass season. There is a similar situation in Australia with fruit maturing to optimum eating condition about six weeks later than Hass and overlapping the latter part of the Hass harvest. The tree will hang its crop late in cooler districts with good quality fruit harvested during December and January in Australia. However, Australian experience has shown that protracted 'on-tree-storage' of the fruit will result in severe biennial bearing. Trees with heavy crops often have a late fruit drop during early winter after a considerable investment has been made into fruit growth.

This should not be interpreted as a sign of fruit maturity, though dry matter may be approaching 21 per cent.

The fruit is round with a green and slightly pebbly skin with good resistance to post harvest fruit disease (Figure 3). Fruit size varies from 300-500 g with a relatively small seed. Although an excellent quality cultivar, fruit size is too large for the Australian market and it has not established as a popular cultivar. However, there may be an opportunity in South Africa to exploit domestic markets late in the season with this cultivar where larger fruit is acceptable. The cooler areas of Natal should be the main beneficiaries of this strategy.

Gwen is the most promising of the trio cultivars, which includes Whitsell and Esther, released by the University of California in 1984 (California Avocado Soc Yrb, 1985, 69, 62). In more recent times Bergh *et al* (1986) has recommended against further development of Esther as a commercial cultivar in California, due to inconsistent fruit quality over a number of years. Whit-sell has also fallen from favour as a potential new cultivar. However, there still remains a firm interest in Gwen with significant numbers of trees being grafted or planted to this cultivar in California (Anon, 1985; Palmer, 1986). Bergh (Pers Comm, 1990) estimates that there is currently 250 ha of Gwen growing in California.

It is a challenge to introduce any new fruit cultivar to an industry. Such introductions face resistance from major marketing groups who have not the time to sell a new

cultivar. This is further complicated by the initial absence of a critical mass of fruit

TABLE 1 Fruit yield from Hass trees grafted on ten cloned rootstock cultivars growing at the South Coast Field Station, California

Rootstocks	Yield (kg/tree)			
	Time from planting			
	2 yrs	3 yrs	4 yrs	Cumulative 2-4 yrs
G755A[1]	0,32 b	1,50 c	2,6 d	4,6 cd
G755B[1]	0,0 b	1,69 c	0,9 d	2,6 cd
G755C[1]	0,0 b	0,81 c	0,6 d	1,5 d
Duke 7	0,64 b	6,72 ab	29,7 a	37,1 a
Borchard[2]	0,44 b	3,82 bc	20,8 b	25,1 b
D9	1,05 b	1,28 c	10,3 cd	12,9 c
Toro Canyon	3,84 a	2,90 c	17,1 bc	23,8 b
Topa Topa	0,23 b	7,48 a	17,7 bc	25,4 b
Thomas	0,75 b	2,98 c	—	—
G1033	0,20 b	4,08 bc	—	—

[1]Commercial name now Martin Grande.
[2]Borchard is a speciality rootstock suited for alkaline soils. It has no resistance to Phytophthora root rot.

The trees were planted in April, 1986 with the exception of Thomas and G1033 which were planted in May 1987,

Means with different letters in columns are significantly different at P> 0,01 using Duncan's Multiple Range test (data provided by Arpaia and Bender, unpublished).

TABLE 2 Number of fruit per tree and average fruit size from Hass trees grafted on ten cloned roostock cultivars growing at the South Coast Field Station, California

Rootstock	No. of fruit per tree			Mean fruit size (g)		
	Time from planting					
	2 yrs	3 yrs	4 yrs	2 yrs	3 yrs	4 yrs
G755A[1]	1,3 b	5,9 c	11,9 d	254	253	218
G755B[1]	0,0 b	7,3 c	4,2 d	—	232	214
G755C[1]	0,0 b	3,3 c	2,5 d	—	249	240
Duke 7	2,3 b	24,5 ab	112,8 a	276	275	263
Borchard[2]	1,8 b	14,1 bc	72,2 b	250	271	288
D9	4,0 b	4,4 c	36,6 cd	267	288	281
Toro Canyon	15,1 a	10,5 c	64,6 bc	293	276	265
Topa Topa	0,6 b	28,5 a	67,3 bc	263	262	263
Thomas	0,3 b	10,6 bc	—	250	252	—
G1033	0,8 b	15,4 bc	—	250	290	—

[1]Commercial name now Martin Grande.
[2]Borchard is a speciality rootstock suited for alkaline soils. It has no resistance to Phytophthora root rot.

The trees were planted in April 1986 with the exception of Thomas and G1033 which were planted in May 1987. Means with different letters in columns are significantly different at P > 0,01 using Duncan's Multiple Range test (data provided by Arpaia and Bender, unpublished). necessary to develop a market profile for the new cultivar. With avocado this Is aptly demonstrated by the case history of Pinkerton (Brokaw, 1989)

which in recent years has become a significant cultivar in California. This is largely due to the efforts of a support group of growers (Pinkerton Growers' Assoc) who fostered the packaging, marketing and promotional developments necessary for success. Currently in California Gwen is being piloted down the same pathway that Pinkerton followed, yet it faces a greater challenge in that it will compete more directly in the market with the mighty Hass. Certainly, many of its attributes, documented in California, should make it more attractive for growers. For instance, it is a comparatively low vigour tree allowing higher density plantings than those considered before, with greater ease for management. Bergh & Martin (1988) suggest that this leads to yields about eight times greater than Hass (computed from standard spaced trees rearranged on closer planting densities) during the early years of fruiting (Figure 4). However, crop records of Gwen across several sites in California show that yield performance is inconsistent and the discrepancies are currently unaccounted for (Bergh *et al,* 1986; Bergh & Martin, 1988). Arpaia & Eaks (1989) report that for the most part post-harvest storage characteristics of Gwen are similar to Hass. However, with Gwen there was greater low temperature scalding and discolouration of the rind than with Hass handled under the same conditions of storage. Bergh & Martin (1988) similarly report on rind discolouration of Gwen after cool temperature storage. While this gives cause for alarm, further research has the potential to solve these post-harvest problems as it has in the case of Pinkerton.

Fig 1 Cv Shepard fruiting in a tropical highland environment in north Queensland, Australia. Harvesting begins in the first wek of February.

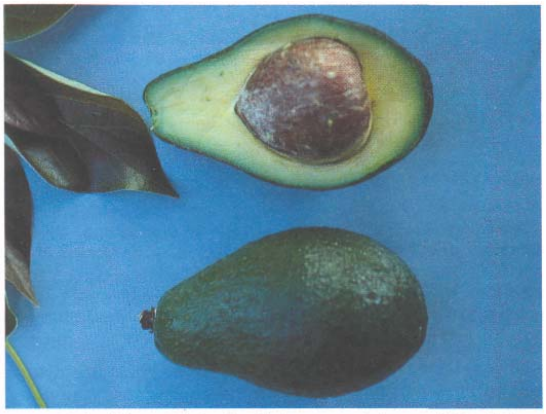

Fig 2 Fruit of Shepard showing the large seed characteristic of this cultivar.

Fig 3 Cv Reed , a late maturing fruit with adaptation to a wide range of environments.

Fig 4 Cv Gwen showing precocity and high yielding characteristics. Photograph courtesy of Dr Bergh.

Fig 5 Three-year-old Hass grafted on Martin Grande and growing at Westfalia Estate, Duivelskloof, South Africa.

TABLE 3 Mean yield, fruit size and trunk girth from cv Hass trees grafted on Phytophthora root rot tolerant rootstocks and grown at Westfalia Estate, Duivelskloof, South Africa

Site A

Rootstock	Yield (kg/tree)	Mean fruit size (g)	Trunk girth (cm)
Duke 7[1]	2,02	291	33,9
Martin Grande[2]	1,04	239	37,5
G6[3]	0,51	264	34,4

[1]data are mean values from 55 trees.
[2]data are mean values from 51 trees.
[3]data are mean values from 36 trees.

Site B

Rootstock	Yield (kg/tree)	Number of trees providing data
Duke 7	1,85	393
Martin Grande	0,5	760
G6	0,2	885

The trees were planted in *Phytophthora* free soil in 1987 and data is the first year of fruiting 1989.

To date the South African and Australian avocado industries have not had exposure to Gwen and the evaluation of this cultivar in the respective countries is still in its infancy. However, there are indications of precocity, the semi-dwarf, upright nature of the tree

and excessive leaf loss during late winter (Palmer, 1988) from the earliest plantings in Australia. The yield benefits with respect to Hass, reported from California, may not reach the same magnitude in the kinder subtropical environments of South Africa and Australia, where production under good management with all cultivars is already comparatively high. However, lower tree vigour would be a welcomed characteristic in both countries where benevolent subtropical climates encourage vegetative growth.

It is obviously too early to predict the future of Gwen in South Africa and Australia. Recent observations in California confirmed Hass and Pinkerton as the two most popular cultivars currently being planted (Atkins, Brokaw, personal communication). So despite its exposure to Gwen from the mid-80s this industry is still waiting for further evidence relating to productivity, post-harvest handling and market acceptance.

ROOTSTOCKS

Bergh (personal communication, 1990) estimates that there is currently 250 ha of Gwen growing in California. Cloned elite rootstocks have revolutionised many fruit industries providing precocity, control of vegetative vigour, salt tolerance, lime tolerance and disease resistance. The devastation caused by *Phytophthora* root rot in avocado orchards in many countries, has served to focus research resources on the development of resistant rootstocks to combat this problem. The success of the Zentmyer avocado root rot resistance programme, begun in California in the 1950s (Coffey & Guillemet, 1987), is reflected in the number of 'tolerant' rootstocks which have recently become available to industry. These include Duke 7, G1033, G6, Martin Grande (collectively G775A, G775B, and G775C), Toro Canyon, Barr Duke and Thomas. These rootstocks have been drawn from the Mexican or Guatemalan race germplasm while the West Indian race has been ignored. However, current work by Ms Luisa Gallo Llobet, on West Indian seedling populations is yielding rootstocks with potentially high *Phytophthora* root rot resistance. This programme is still in its infancy, but it is encouraging that high resistance to *Phytophthora* (glasshouse tested) is being found in this gene pool which may provide further options in the future.

While considerable advances have been made with the development of disease tolerant rootstocks none of the material to date gives absolute protection against Phytophthora root rot. The tolerance mechanism works on either the capacity of the rootstock to replace diseased roots, eg Duke 7, or physiological resistance retarding lesion development on roots as occurs with Martin Grande (Coffey, 1987a). It should be noted that trees grafted to cloned rootstocks are generally more difficult and slower to establish in the field than those on conventional seedling rootstocks. The selection of a cloned tolerant rootstock is not a guarantee of success and in California the use of fungicides is necessary when planting back into diseased soil (Coffey, 1986). Other management inputs including the maintenance of a bio-dynamic soil and sound nutrition and irrigation practices, all assist with an integrated package of root rot control (Piccone *et al,* 1987; Pegg *et al,* 1988).

The degree of Phytophthora root rot resistance of these rootstocks has been frequently documented (Coffey, 1986; Coffey, 1987a; Coffey, 1987b; Coffey & Guillemet, 1987). However, the lack of information on the production characteristics of these root-stocks,

when grafted to commercial cultivars and grown in clean soil, has lead to recommendations not always in the best interests of growers. Fruit production data recently available (Tables 1, 2 and 3) is providing a more balanced appraisal of the benefits from using the elite *Phytophthora* tolerant rootstocks. Indeed, our perception on the usefulness of some rootstocks is changing considerably now that comprehensive fruit yields are being reported.

Martin Grande Fruit production from two experimental sites, where cv Hass were grafted on Martin Grande rootstocks, has been most disappointing. Poor yields on this rootstock in the first years of production have been independently recorded in California and South Africa (Tables 1 & 3). Indeed, in a subtropical climate (Westfalia Estate) trees grafted to Martin Grande have shown strong vegetative bias growing vigorously at the expense of fruit production (Figure 5). At this point in time we would urge extreme caution with further commercial planting using Martin Grande as a rootstock.

Duke 7 This rootstock is currently the most productive clone evaluated when grafted to Hass (Tables 1 & 3). Despite higher fruit yields it maintains fruit size on young trees (Table 2). Furthermore, it has been tested on an industry scale for 13 years in California and found superior to most of the seedling rootstocks used (Brokaw, 1987). In South Africa precocity and high yields have been recorded in orchards planted on this rootstock (Whiley *et al,* 1988). Duke 7 has been shown to have mild tolerance to Phytophthora root rot but not the elusive resistance being sought. It is sensitive to water logging conditions and generally fails if used as a replacement tree in low lying, wet areas in the orchard. South African experience has shown that it is susceptible to *Phytophthora* trunk canker (Lonsdale *et al,* 1988). However, due to its root regenerative capacity, trees planted on this rootstock are highly responsive to phosphonate injections for *Phytophthora* control (Brokaw, personal communication).

Of the cloned rootstocks currently available to industry Duke 7 still remains a priority contender for consideration in the orchard. It has a reliable track record and if managed correctly will give uniform trees of good performance.

Toro Canyon is a Mexican race rootstock recovered from an escape tree in a diseased orchard (Coffey, 1987b). It has *Phytophthora* resistance and its early productivity at the California experimental site is reasonable (Table 1). Little else is known of this rootstock which should be more intensely tested in the future.

Thomas is also a Mexican race rootstock recovered from an escape tree in a diseased orchard (Coffey, 1987b). Resistance to Phytophthora root rot is as high as Martin Grande (Coffey *et al,* 1988) which makes it one of the most resistant root-stocks recovered. Currently little is known about its potential effect on scion productivity. However, preliminary data from California suggests that it may not perform as well as

Duke 7 (Table 1). Observations with this rootstock suggest that tree vigour will be much less than with Martin Grande. Further testing is required in the subtropical environments of South Africa and Australia before recommendations can be made.

CONCLUSIONS

Plant improvement in tree crops is a long term process. Orchard establishment costs are high and there is some time from planting before a significant cash flow is generated. There will be a continuation of new rootstocks and cultivars being made available. However, it is unlikely that structured research programmes can handle the effective evaluation of this material due to limitations on the soil types and environments that they can cover. Therefore it becomes the responsibility of growers within the industry to share some of this burden. However, the testing of material should be approached with caution and all options and information considered before planting a new block.

It is risky to commit large plantings to new rootstocks or cultivars without a sound data base to support their performance. Like-wise it is dangerous to transfer performance data from one country to another, particularly if environmental differences are significant. We face exciting times ahead with avocado crop improvement yet our enthusiasm for advancement must be tempered by the collection of useful information for sound decisions.

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