AVOCADO PRODUCTION IN 2020

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ABSTRACT

The difficult task of predicting and anticipating avocado production in 2020 has been tackled by firstly attempting a vision of the world by 2020. We have started a journey in which some aspects of technology, including I.T. but also plant biology, will show spectacular progress. The nature of agriculture will also change with globalization, the freeing of trade, greater dominance of multiples, more accountability, and seeking of competitive advantages. Value adding and processing will increase in importance. Impacts on avocado growing will be profound. Yields of quality fruit will have to improve dramatically, and the over-production bogey avoided, while keeping costs in check. Strong grower associations are vital.

INTRODUCTION

When I was asked in 1988 to review avocado technology towards 2000, I felt fairly comfortable with the 12 year timespan. Furthermore, excellent research was underway, the Whiley *et al.* (1988) phenological model had just been published, Phytophthora root rot had been brought under control by trunk injections of phosphonate, and there was a general air of optimism in agriculture and especially horticulture. Worldwide, avocado growing had passed from the launch to the growth phase, with little sign of the maturity phase, or the dreaded market saturation when growers wrestle with the consequences of being on the wrong side of the supply and demand equation. Major research priorities centred around the yield problem, and were discussed under the major headings of selection and breeding (need for new cultivars and rootstocks); manipulation of fruitfulness and vigour, especially the vegetative-reproductive balance at critical growth stages; intensive canopy management based on sunlight interception and the carbohydrate cycle; finding alternatives for controlling Phytophthora and other diseases; improved fruit quality; and tree stress alleviation (Wolstenholme, 1988). As one looks forward to 2020, a cynic may well ask what has changed, but in reality much has, and even more will.

My task in predicting changes towards 2020 is formidable. The pace of change seems to continue accelerating, and it is a brave grower who thinks more than 10 years ahead. Agriculture in the developed world is in crisis, the three issues of the day being the fallout from foot-and-mouth, mad cow disease, and genetically modified (GM) foods. A well-fed and even obese first world worries about food safety, when the variety and quality of food available is higher than ever. The developing world, in contrast, suffers from poor food distribution and often grinding poverty and malnourishment, where any food is welcome but high-priced luxury food items but a dream. The world is much more aware of the important role of fruits, nuts and vegetables in the diet, yet per capita fruit consumption in Europe is static or declining. Farmers face a cost-price squeeze, globalization, increased competition from a freezing of world trade, and a less sympathetic public and often also government. On the face of it, horticulture and orcharding should have a lot going for them, but are under pressure in many respects - not least avocado growers.

In assessing and predicting the future, it is firstly necessary to try and imagine the world in 2020. I will then look at current trends in agriculture. Finally, an attempt will be made to predict impacts on avocado growing to 2020, including technology targets (a wish list), survival guidelines, unknowns that will affect avocado growing, research priorities, and lastly thoughts on how to cost effectively increase yields of quality fruit. The 19 year time scale makes the task more than ordinarily difficult.

THE WORLD IN 2020

Unravelling the human genome

The science magazine 'Discover' brought out a special issue in 2000 entitled 'Prepare yourself for 2020'. They state that the pace of change driven by science threatens to become overwhelming. On 26 June 2000, scientists announced a working draft of the human genome. The two versions (ca 31 000 genes vs 25 588 genes) are well below the expected 100 000, and we have been humbled to learn that we have only 50% more genes than a nematode, twice as many as a fruit fly, and only 300 genes that we don't share with a mouse. We share 98.5% of our genes with chimpanzees. However, identifying and characterising all human genes will keep scientists busy for decades, even though genes comprise only 3% of the genome (the other 97% being non-coding DNA). The most obvious benefits will be in the medical field, specifically new drugs. Nevertheless, tailor-made medicines based on individual genomes is a journey that has just begun. Developing effective therapies, especially for disorders caused by multiple genes, is proving even more difficult than unravelling the genetic causes of diseases.

Plant biology

In the plant sciences, a worldwide consortium of botanists, after 10 years of study, published the full genome of *Arabidopsis thaliana* - a small cress plant - in 2000. They hope, by 2010, to have worked out what every gene does. Even though only ca 3000 of its 26 000 genes have yet been studied, discoveries have led to improvements in crop plants. These include genes to protect wheat against disease, ripen tomatoes and double the yield of rapeseed oil. We are launched on the road to understanding all plant biology. However, finding roles for each gene will be difficult, since many genes are duplicated and many functions are multigenic (Coghlan, 2000). But without doubt, 2000 saw the start of the new era, in which humans start to take control of their biological destiny. If they are allowed to, scientists will be able to pack vaccines into vegetables, bananas etc. (Langridge, 2000) and develop more drought tolerance, stress tolerance etc. through genetic modification.

Worries about GM crops (called a disaster in the making by activists) include concerns that innocent creatures will be hurt by insecticides built into GM crops; that superweeds will arise as genes find their way into weeds; and that GM crops will suddenly fail. Currently, agronomic crops have been the main beneficiaries of GM, e.g. 36% of soybean, 7%of maize, 16% of cotton and 11% of canola hectareage is based on GM cultivars (Brown, 2001). European countries are especially wary of GM foods, and companies in the forefront of development, e.g. Monsanto, have been targeted by activists. Nevertheless, more than half the foods in US supermarkets contain GM ingredients (Hopkin, 2001). The debate will continue to rage, and the outcome will determine to what extent GM technology will extend to perennial crops such as avocados by 2020.

The developing world

Our fortunes as growers will not only depend on the affluent world, where the average annual income of the richest countries is 727 times that of the poorest (e.g. Switzerland $U.S. 40080 vs Ethiopia $100). There are 800 million undernourished people. About 20% of all people who ever lived are alive today. In 2020 you'll live in a world with 2 billion more people than today - equivalent to two India's of extra people - over 90% in already poor countries. The chances are that you'll watch 1 billion people starve, with resulting anarchy and terrorism. Yet if only 10 or 20% of current third world people could have middle class lifestyles by 2020, you'd have a huge market for fruits. But the prognosis for most third world peoples is poor, and by and large their children will be lost in the next techno-revolution. It is also highly likely that these countries will see their salvation in the growing and exporting of cash crops including avocados (e.g. Kenya at present), especially if affluent people make it too difficult for their own growers to compete (D'Agnese, 2000).

Communications and the information revolution

Without doubt, we are in the midst of a communications and information revolution, with computers, TV's and telecommunications converging wirelessly. By 2020 we'll need to know things hardly credible today, with gains in convenience but loss of the familiar world of today. The home PC or advanced equivalent will run our daily lives, perhaps even giving us a daily report on blood, saliva and body wastes. This could determine daily eating patterns. Of concern to us avocado growers is whether, for example, if we find we are short on vitamin A and potassium when we wake up, we remedy the situation with a pill, or a fresh or processed fruit. Currently, the actual fruit is better than the pill, but in 2020?

At present, the speed of computers is almost doubling every 18 months. Moore's law predicts that the Pentium chip in 2020 will have ca.10 000 times its current power. RAM chips double in capacity every 18 months, and magnetic disk drives every 9-12 months. Gene-based therapies will by common by 2020. Declining oil reserves will necessitate energy-efficient innovations. Many things will become obsolete, including much mechano-electrical technology; also storage media and push buttons (replaced by digital imaging and voice-activated controls). Many analogue devices will disappear, as will video, record and software stores. Cars, trucks and tractors will be powered by battery-driven electric motors, hybrid gas/electric engines, or gas/fuelcell engines. Plastic wraps will be replaced by more environment friendly biopolymers from cornstarch (Haseltime, 2000). All of this assumes that we don't experience doomsday. Powell (2000), among 20 ways in which the world as we know it could end, includes a runaway green-house effect, ecosystem collapse, a biotech disaster, environmental toxins, and global war. Human activity is accelerating extinctions and biodiversity loss 10 000 times faster than in the fossil record - we are actually in the midst of the sixth great extinction.

Climate change

Today, the scientific consensus is that our atmosphere near the ground is warming; that greenhouse gases such as CO_2 (mainly), methane, nitrous oxide and CFC's all play a role; and that at least half of the 0.6°C temperature rise in the past 120 years (during which atmospheric CO_2 levels increased 30% from 270 to 365 mg l^{-1}) is from our activities. We have been

especially culpable in burning fossil fuels, and in deforestation, but methane emissions from ruminant animals and rice paddies, *inter alia* have not helped. The 1990's were the warmest decade on record. Warming would have been greater but for cloud changes, trophospheric aerosols, volcanic eruptions and alterations in land cover. Manifestations of warming are everywhere.

The UN sponsored Intergovernmental Panel on Climate Change (IPCC) reported in January 2001 that the trend towards a warmer world has unquestionally started. By 2100, mean temperatures will be 1.4-5.8°C higher - especially at high latitudes - some 50% higher than 1995 predictions. Temperature change is not new, but we must remember that it took only a 5°C rise to end the last ice age. The speed of the present rise (the fastest in 100 mill. years) is worrying, and a runaway effect could perversely trigger a new little ice age if ocean currents are radically changed.

A recent special report in Time magazine (Kluger & Leminick, 2001) notes that the U.S., with 4% of the world's population, produces 25% of the world's greenhouse gases (China produces 11%). Table 1 shows $C0_2$ emissions. Since 1950 for selected countries; Table 2 per capita emissions; Australians will note that in the latter category they are in the big league.

Table 1 Total $C0_2$ emissions (bill. tons) since 1950

Very high	USA	186.1; EU 127.8
High	Russia	68.4; Japan 31.2
Moderate	India	15.5; Canada 14.9
Fairly low	South Africa 8.5; Australia 7.6	

Table 2 Per capita $C0_2$ emissions (tons/an./person)

Highest (19-36)	USA, Australia, UAR
High (7-16)	South Africa, New Zealand, Japan, China
Moderate (2.5-7)	Mexico, Argentina
Low (0.8-2.5)	Brazil, India

The consequences of a warmer world (coupled with higher CO_2 concentration, perhaps 385 mg l^{-1} by 2020) are shifting agricultural and vegetation belts (poleward and upward), (Wilkinson, 1999) faster extinctions and loss of biodiversity, rising seas, more frequent and intense storms (including cyclones) longer and worse droughts; crops more vulnerable to pests, diseases and weeds; probably less water for irrigation; people migrations and refugees; and a devastating effect on wildlife. Epstein (2000) discusses probable surges in human diseases such as malaria, dengue, encephalitis, cholera and Rift Valley fever. We could pay for changing climate with our health (Lee, 1998).

On the plus side, increased $C0_2$ will favour plant growth, provided there are not other limiting factors. Yields of crops are expected to increase by an average of 30% with a doubling of $C0_2$, and stomatal conductances reduced, with increased water use efficiency (Wand, 2000). In avocado, studies of potted plants under controlled environment conditions have shown that increased $C0_2$ levels certainly enhance carbon assimilation, provided there are no 'sink' restrictions (such as severe root restriction in pots). Productivity should increase as a result of increased global $C0_2$ concentration. Other studies have also shown increased allocation of assimilates to roots, which should also benefit productivity by reducing the sink limitation of root restriction (Whiley *et al.*, 1999). However, plants may adapt to slowly rising $C0_2$ levels (e.g. fewer stomata), and long-term field studies are needed. Furthermore, higher temperatures will

increase respiratory losses in the tree's carbon budget, thereby negating some of the benefits of increased atmospheric $C0_2$ concentration.

Australasians are very familiar with the El Nino-Southern Oscillation (ENSO) phenomenon, and its reversed La Nina pattern. Recurrent droughts and flooding rains are familiar to Australians. The problem is that the recent trend is towards more frequent and prolonged El Nino's, with accompanying droughts and wildfires, possibly associated with global warming. By 2005 scientists should be able to accurately predict El Nino's a year in advance for more than 70% of occurrences (Couper-Johnston, 2001).

TRENDS IN AGRICULTURE

Commodities vs products

For some time, commodities such as steel, wool, and fresh fruit, have been caught in a classic cost-price squeeze. The real price, because of the ever-present threat of over-production, has remained static or declined. To remain in business, one must avoid the treadmill of every-increasing production for every-decreasing prices. Efficiency and reduction of costs become crucial to survival, and often also growth by acquisitions, mergers and partnerships for economies of scale or specialization of tasks.

Two South African examples illustrate the worst bogey of fruit growers - overproduction or supply exceeding demand. The Cape apple industry is in a crisis of confidence - it has exceeded its market niche's requirements in Europe. A shake-out is in progress and the inefficient will go to the wall- as will those who borrowed at high interest rates. Secondly, our export avocado industry has learnt by hard experience that the traditional European markets are saturated by ca. 650 000 cartons per week in the March through September time-slot. Supplies exceeding this figure, especially early on, result in a price crash from which it takes weeks to recover. In spite of attempts to co-ordinate and regulate supplies, this happened in 2000, due to adverse rainy weather and competition between export agents.

On the other hand, those who can differentiate from the crowd, with specific products, face less competition. The contempory buzzword is value-adding, which usually means processing of some sort, and niche brands and patents. Agricultural economists believe that this trend will continue, due to the difficulties of competing in the fresh fruit market increasingly dominated by the major supermarket chains. The latter, dealing with commodities, are increasingly dictatorial in regard to cultivars, counts, quality, packaging, food safety, ethical farming practices (including 'organic' produce), protocols, paperwork, traceability, regular supplies, and transparency. They can play brands and suppliers off against each other, with price under constant downward pressure. The multiples such as Tesco, Safeway, Sainsburys, Mack etc. are making life very difficult for the fruit growers.

Changes in land ownership and operation

Another trend is the separation of land ownership and land operation. A large operating company will contract out the growing of the crop to 'landlords' for a specific period. They will select optimal sites, supply the technology, and supplement/complement their own production, but doing the processing and marketing themselves, and retaining the brand. Variations around these

themes are seen in the operations of Dole, Chiquita and other well known brands. Seasons can be extended, supplies better regulated, risks reduced, and the cost: price squeeze better controlled or shifted to others.

The trend towards larger farm sizes seems set to continue. The cost: price squeeze is most severe on growers 'in the middle'. Large growers can achieve economies of scale, while the hobby farmer with 50-100 trees and a roadside stall, and prepared to work for pittance, will survive.

Globalization, free trade, fickle consumers

Agriculture faces troubled times. In the U.K. it has been shrinking rapidly in recent times, and is now down to 0.9% of GDP and employs only 1.5% of the workforce. Australia and especially New Zealand are better off as primary producers, but even here governments are less sympathetic than in the past, and urbanized people even less so. Free market philosophies and 'row your own boat' dogma prevail, as governments gradually withdraw subsidies and support programmes (the EU being a conspicuous exception), and see agriculture as a sacrificial cow at budget time.

Globalization and freeing up of trade have been conspicuous trends, although trading blocks are still important. Australia and New Zealand have rightly used their island status for phytosanitary controls. But if trends continue and technology reduces or eliminates the risks, you will increasingly have to cope with competitive imports. Much of this will be from countries with cheaper cost structures.

Marketing 'windows of opportunity' become increasingly fewer and smaller as the seasonal advantages are eroded by trade between countries and hemispheres; as technology enhances post-harvest longevity; and new cultivars stretch traditional harvest times. The cold country markets have never had it so good, groaning under the volume and variety of fresh produce on offer - yet many countries continue to increase production. Old cultivars come under the whip as fickle restauranteurs and customers try out the new 'flavour of the month'. Shoppers are confronted by a huge array of old and new exotic fresh fruits and vegetables, available year-round in their favourite malls and supermarkets. Buyers have the upper hand. Growers must be ever more resilient, resourceful and responsive to challenges (Cordes, 2000). Australian and New Zealand growers have an excellent record in these aspects.

Dietary value and healthy lifestyles

The overwhelming evidence of the importance of fruits, nuts and vegetables in the diet and in healthy lifestyles has undoubtedly benefitted horticulture. Vitamins, minerals, other phyto-chemicals, and desirable mono-unsaturated fats have proven benefits in protecting against coronary heart disease, certain cancers, and cateracts. The evidence also favours consumption of the products themselves, rather than popping pills. And yet, in spite of general awareness of the '5-a-day' concept, consumption of fruits and vegetables in the U.K. is actually declining. A recent survey of the eating habits of British school children found that 20% had not eaten a single fruit in the past week (Gregory & Lowe, 2000).

Belsten (2001) blames the myth that 'fresh is best' (not always true), and social factors. Meals are less structured and at different times, and with more snacking of convenience foods. Perhaps fruits need to be marketed as such.

Trends towards safer food and sustainable farming

Affluent people, with assured food supplies and often obesity problems, can afford to be choosey. Environmental concerns are forcing global multiples to lay down production procedures and accounting to suppliers. Intensive or industrialized agriculture is under fire for food safety, waste generation, and pollution of soil and water by some fertilizers and chemicals. A small but expanding market has developed for so-called 'organically' grown produce, for which affluent consumers are prepared to pay a premium.

How does horticulture and especially orcharding fare in the sustainability stakes? By any objective definition of sustainability, not too badly, but with room for improvement. The relatively small scale of orchards reduces overall impact, even with intensive pesticide and herbicide use. Trees protect the soil, with greater biodiversity than annual cropping, especially with cover cropping, mulching and minimum or zero tillage. Sustainability is more likely to be under threat from urbanization, as in southern California. Fruit farms are often part of the national cultural heritage. Excessive zeal in regarding all man-made chemicals as inherently unsafe will only succeed in shifting fruit growing into drier areas or other countries, pressurizing scarce water supplies. It will also accelerate the market dominance of large and corporate-owned farms (Merwin & Pritts, 1993).

Organic farming is legitimate choice for some, but far from cost-free. The product is more expensive to produce, and likely to remain so. Yields are usually lower. Even Germany's 'green' farms minister concedes that her country is unlikely to exceed the target of 20% organic produce (up from 2.5% today) by 2010. Most modern consumers like cheap, varied, year-round food items, produced by intensive conventional methods. It is not possible to have the best of both worlds - food cannot be cheap, local, 'green', utterly safe, and varied, all at the same time (The Economist, 3 March, 2001). Organic farming will expand, but it is not a panacea.

The agricultural food value chain (Anon., 1999)

A typical value chain for a fruit commodity, marketed fresh, would be:-

Research, technology	➔	Input suppliers	➔	Co-op. or Association	➔	Grower	➔	Marketing agent, transport	➔	Retailer	➔	Buyer

This chain has the grower in the centre, with both upstream and downstream linkages. Today, more than ever, the grower cannot afford to limit activities to production. For a sustainable competitive advantage in the global market, all linkages are interdependent. The key is the consumer's needs and wants; key words for success are now strategic alliances, acquisitions mergers, partnerships, value adding (processing), and increasing differentiation of products. The golden thread binding the chain together is information. To prevent under- or over-supply, with their profound financial implications, co-ordination of supply is even more critical, as the South African export industry has learnt to its cost. This trend is expected to become more pronounced towards 2020.

Food accountability

About 25 000 new products were introduced to supermarket shelves in 1998, compared to 4400

in 1980. In the average supermarket, some 350 000 food products vie for about 50 000 slots. In the past, taste and marketing determined the winners. In future, this may also depend on the right horticultural pedigree - and the data trail to prove it.

Multiples today and in future will increasingly demand tracking and certifying every link in the chain of supply, from farm to table. Growers are being forced to collect and manage huge amounts of information - by database programming. Companies with names such as Crop Verifye.com are springing up to help them. This is helping to decommoditise commodities. Technology helps growers to differentiate crops from their neighbours - to stand out from the herd. E-commerce buyers will log onto, for e.g. Identify Preserved.com, and shop around for what they want, knowing where it came from and how it was grown. Computer aids such as AVOMAN and AVOIMFO are an outstanding start, but they are just the beginning.

AVOCADOS TOWARDS 2020 : A VISION

This topic will now be summarized in point form under various headings. In doing so I have been strongly influenced by Strydom (2000), discussing options for the Cape deciduous fruit industry.

Unknowns that will affect avocado growing

- Climate change
  - ± 1°C warmer?
  - More stressful
- Atmospheric $C0_2$ increase to 385 mg l^{-1}
  - Faster growth
  - Higher yield
- World overproduction?
  - Mexican exports
  - Developing countries
- Globalization and freezing of world trade
- Promotion to increase per capita consumption
- Changes in farming
  - Increased role for computers/I.T
  - Information overload
  - Cost: price squeeze
  - Commodities vs products
  - Loss of essential chemicals
  - Sustainability issues
  - Organic threat/opportunity
- Changes in marketing
  - Need for partnerships, strategic alliances
  - Increased competition
  - Supermarket/multiples tyranny
  - Value adding/processing
  - Food safety
  - Accountability

Innovation
Niche markets

- Availability of research funds
  - Pro-active, focussed research
  - Multidisciplinary research
  - International collaboration
  - Rapid technology transfer
- Responsibility
  - Co-operation
  - Intellectual property
  - Plant cultivar rights
  - Alliances, clubs, franchises

Survival guidelines for beleaguered growers

- Manage the farm as a business
- Be consumer driven
- Select cv/rootstock adapted to your farm
- Cut costs and improve outputs
- Improve quality
- Identify uneconimal blocks
- Ensure traceability and transparency
  - Environment friendly
  - People friendly
- Maintain growth by adding value, and planting or topworking to elite cvs/rootstocks
- Manage change
- Be informed - know your competitors
- Differentiate your product for a premium price
  - Add value
  - Consider going organic
  - Form upstream & downstream alliances
- Innovate - be a step ahead of the herd.

How to increase yield/ha of quality fruit

- Do the basics right - first time, on time, every time (Strydom, 2000)
- Match site and cultivar/rootstock
- Spacing, tree size and shape
  - * Maximum canopy sunlight interception
  - * Management friendly
  - * Hedgerows?
- Canopy containment
  - * Training and pruning
  - * Bioregulants?
  - * Girdling/cincturing?
- Manipulation of veg./reprod. balance

    - N nutrition - control vigour
    - Growth retardants
- Awareness of critical periods/phenology
- Reduce environmental stress
    - Mulching for root health
    - More efficient irrigation (Postel, 2001)
    - Balanced nutrition
    - Windbreaks
    - Site & soil selection
- Pest, disease and weed management
    - Monitoring systems
    - Less reliance on chemicals
- Sustainability issues
    - Soil structure
    - Organic matter
    - Environment & human friendly
- Management for fruit quality
    - Reduce tree vigour (soil, nutrition)
    - Sufficient fruit Ca, B
    - Low fruit N
    - Moderate crop load
    - Pest & disease control
- Join the information age

Avocado technology targets

- Increase best grower yield from 20-30 t ha^{-1}
    - 2-3 elite semi-dwarfing cvs
    - 2-3 elite semi-dwarfing, P.c. resistant rootstocks
    - Semi-high density plantings (500-1000/ha)
    - Proven pruning & manipulation technology
- More sustainable technology
    - Improved soil structure
        - Higher O.M.
        - Minimum or zero tillage
    - Better nutrition
        - Slow release fertilizers
        - Greater reliance on organics
        - Tighter recycling of nutrients
    - Improved water use efficiency
    - Safer pesticides & herbicides
- Improved fruit quality and postharvest behaviour
    - Consumer driven
    - Greater postharvest “legs”
- More value-adding/processed products

Research priorities

- High/moderate density planting
- Canopy light management
    - * Training & pruning
    - * Bioregulants
- New elite cultivars & rootstocks
- Friendlier management chemicals
- Better fruit quality
- Better postharvest performance
- Innovative processed products
- Sustainability issues

IMPLICATIONS FOR AVOCADO GROWERS : CONCLUSIONS

The above rather sketchy and selective notes and discussion hopefully provide some vision of what the next two decades will be like. Technology advances in IT are likely to be spectacular. Those in plant biology and horticultural technology will depend on the resolution of conflict in the GM controversy, and satisfactory compromise in the organic vs inorganic debate. Sustainability issues must not lose sight of the grower's need to make a profit, and food safety issues must allow production to be competitive in developed countries. Climate change may cause mean temperatures to be up to 1°C higher in 2020, effectively turning a Brisbane climate into a Bundaberg climate. Plants will grow faster and yield more, but water supply will be more erratic, and weather more variable. Plants will be more stressed. Growers will have to be far more business and marketing oriented in the food supply chain, and more accountable to multiples. Processing is likely to become far more important. Strong grower associations will be vital for information gathering, co-ordination and not least research. Perhaps it is time to start on an industry 'Vision 2020' document to help anticipate and mange change. Survival will depend on many factors, not all of which can be anticipated. That we face critical times is obvious.

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