CHAPTER SIX

Outlook for World Horticulture

The choice of whether to plant a crop or not to plant, and what to plant, has faced farmers ever since crops were first planted.

In our present world, the task of feeding a hungry world stretches out far beyond the responsibilities of growers, but in the face of increasing demand and in spite of natural disasters of all kinds, farmers have risen to the challenge and enhanced the supply of food.

There are many parts of the world where production is below what could be achieved given the soils and the climatic conditions prevailing. Movement from this underperforming level to a 'normal' level of production in these regions will be an exciting part of the future of horticulture.

The adaptation of growers, supply chain operators, transporters and scientists in raising the levels of quality and production in the last three decades has been huge. Production has been prodigious. Products are improving in quality and freshness.

Growers are providing many new cultivars to both northern and southern hemisphere markets to provide year-round supply and to be closer to major markets. Product diversity in world markets continues to increase with crops such as blueberries, mangoes, rocket lettuce, bok choi, and dragonfruit being readily available.

Biotic stresses such as pest and disease damage account for 10-30% of yield losses while abiotic stresses, such as nutrient and poor water management, account for 70-90% of yield reductions. Scientific knowledge is helping to provide answers to the difficult dilemmas facing all areas of the horticultural industry.

The rich diversity of horticulture provides opportunities to improve human health and wellbeing for all.

Elsewhere in this publication reference is made to the significant value that lifestyle and amenity horticulture adds to peoples' lives. The understanding and appreciation of this value is expected to increase as people recognise the importance of achieving a healthy lifestyle and a healthy environment. There remain many parts of the world's cities and landscapes that can be transformed by the planting of amenity and lifestyle plants and flowers.

Whilst the foreseeable future has a number of challenges and opportunities, the future of horticulture is full of growth, potential and promise.

Consumer behaviour and profiles

Many opportunities for horticulture arise from a number of the current challenges.

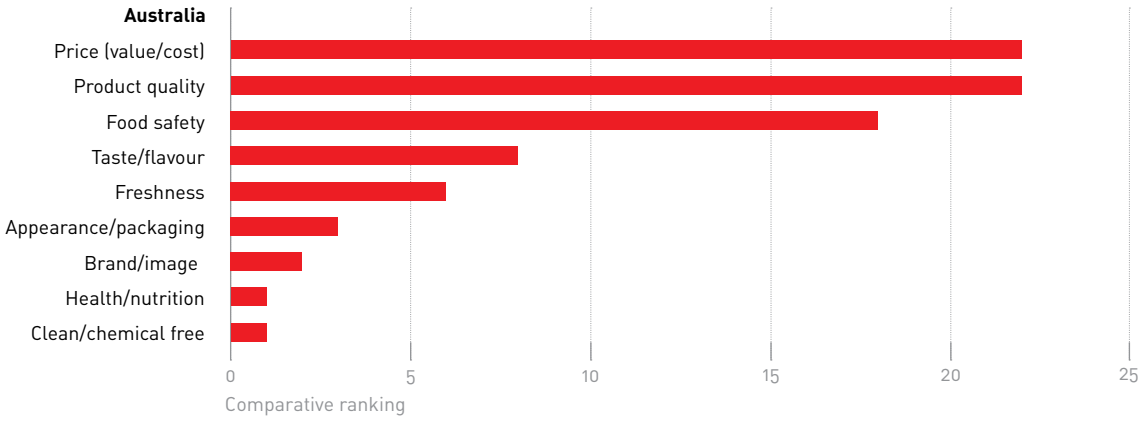
It is important that producers and marketers understand the basis upon which consumers buy food, as availability and price are not the only criteria as is demonstrated in the following two graphs from different markets.

It is also important to realise that consumer behaviour changes over time as their knowledge and incomes increase and social influences change.

Modern consumers have a wide choice in what is available to them but are discerning in what they purchase. PHOTO: UNIVERSITY OF CALIFORNIA, DAVIS

Food attributes influencing consumer purchase decisions (as nominated by market)

SOURCE: BEYOND PRICE AND QUALITY, DEPT OF RURAL AFFAIRS, VICTORIA, 2004



Thought Challenge #11

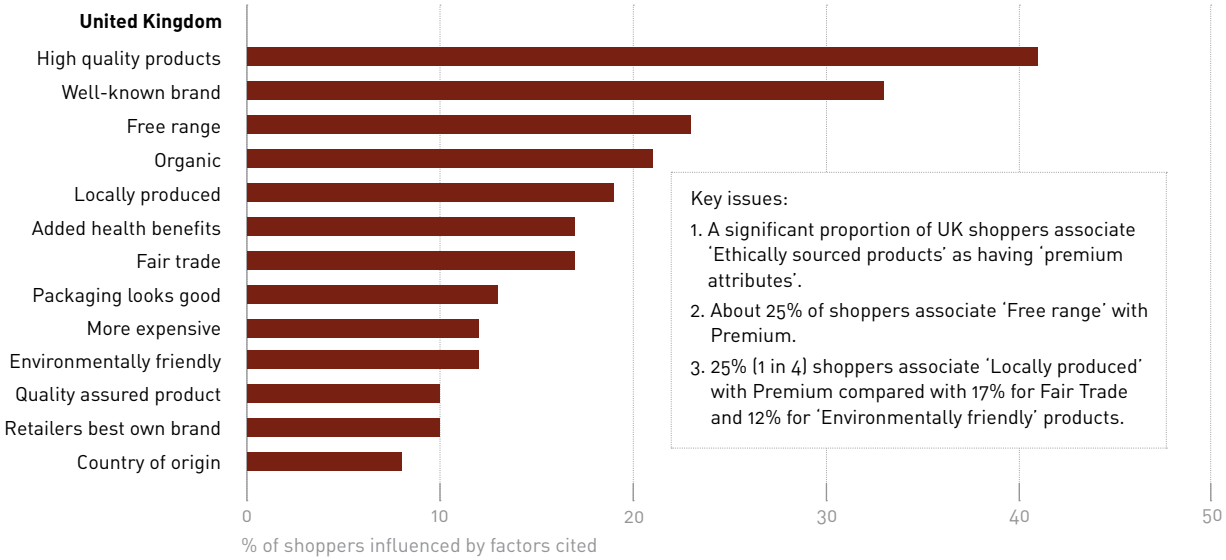
Much is made of the 'carbon footprints' that are generated as a consequence of shipping fresh produce from distant producers.

The reality is that sea freight is highly efficient and carbon footprints for many products can be predominantly from inefficient production practices, road transport through distribution chains and inefficient consumer behaviour. Fruit and vegetables shipped from the Southern Hemisphere to Europe often have smaller carbon footprints than similar produce grown and then carried by road transport within the EU. In some instances the consumer makes a larger carbon footprint after purchase, for example by driving to a supermarket to purchase a single product.

Q. Are consumers aware of where carbon footprints occur – or do they solely think in terms of freight from another continent?

Food attributes influencing UK consumer purchasing

SOURCE: ADAPTED FROM IGD GROCERY AND SHOPPER SURVEY 2007:
"WHAT NEXT FOR PREMIUM?" (N=1,017 UK SHOPPERS)



Psychographics: consumer profiles

Psychographics, the study of shopper identification in relation to attitude to food, is a key part of the purchase equation. An IGD, Shopper Trends in Product and Store Choice, 2007 study offered the following profile:

Foodies – those who enjoy cooking, trying new things and cook meals from scratch (40%)

- Younger people, women, higher incomes.

Traditionalists – always eat the same thing, not adventurous with food choices (29%)

- Older shoppers, lower incomes.

Economists – shop to budget, interested in value for money (18%)

- More than 65 years young, limited incomes.

Fuelies – not interested in food, eat because they have to (13%)

- Males, low incomes.

Consumers vary widely in their purchasing behaviours. Above: apples and green beans.
PHOTOS: UNIVERSITY OF CALIFORNIA, DAVIS.
Left: Nuts & ginger, Borough Market, London, UK.

Consumer trends

A consolidation of consumer trends identified from several sources leads to the following conclusions:

- Consumers will continue to seek products that are healthy, convenient, providing good value for money
- As incomes rise, consumers will look for excitement and difference in food experiences and will allow themselves to indulge in the tastes and flavours of new foods from different countries and regions of the world
- Consumers seek products that will aid them in disease prevention, self-treatment for health, appearance and general wellbeing, and risk prevention
- Purchasing decisions will be influenced by labels such as 'SuperFoods', 'nutrient dense food' or 'high density foods' all of which have a connotation of specific high concentration health-conferring beneficial attributes.

The range and diversity of fruit and vegetables available to consumers continues to increase. (Left) cherimoya (custard apple) and (right) jalapeno peppers. PHOTO: D. KARP (RIGHT)

Consumer knowledge and demands – the future

Consumers of the future will be better informed and no less choosy than today. The internet will give them the opportunity to see what is available. Buyers of the future may survey a range of horticultural products on three dimensional screens and from those images decide to order produce to be delivered directly from wholesalers or growers.

The ability of enterprising growers to use technology and improved transport and presentation methods to access changing and faster channels to markets may change consumer preferences and lead to whole new industries.

More effective production methods in developing countries and the migration of peoples to the developed world may give growers new opportunities to produce horticultural products, first to ex-patriots and then to the wider public. What was once exotic to some is becoming commonplace to many consumers.

The onward progress of information and communication technologies will also lead to changes and new opportunities. Telephony, especially in the form of mobile phones and tablet computers, will deliver timely and effective science, education and knowledge to a wider range of growers (and indeed consumers) than at present.

The imperative for better information management, monitoring of produce volumes, prices and timely placement, and the opportunities for extension education will doubtless multiply.

Borough Market, London, UK.

Food loss and food waste

Food loss and food waste amount to a major squandering of resources, including water, land, energy, labour, capital and infrastructure.

Developing countries will come to recognise that, given the limited availability of natural resources, it is more effective to reduce food losses than increase food production to feed a growing world. This realisation will inevitably lead to a stronger commitment to improving food quality at the production point, improving grading methods and standards, and improving cool-chain distribution facilities. The net gain of available food will be huge.

In developed countries where food waste is a high proportion of all food that progresses past retail, needlessly throwing food away will become increasingly unacceptable as resources in all forms become more valued.

Technology and infrastructure

Much of the fruit and vegetables produced globally and sold locally is not sorted or graded. If more investment in technology was made in postharvest production many growers could achieve better prices, make better use of resources and be more profitable.

Increased emphasis and investment in complying with food safety standards, technology and knowledge would open wider market opportunities for smallholders especially. The gathering of small unit holders into cooperatives and/or the growth of independent, well financed contractors who could service a number of growers would also improve profitability for many growers.

Improving fruit and vegetable grading and storage in many markets will reduce wasteage and enhance returns. Photos (left) Delhi fresh market, (right) Morocco fruit and vegetable market.

Energy costs

The fuel component of production and transport costs is rising. It may pose an issue in relation to year-round provision of some crops. There could be an increased need to grow some products nearer to sites of consumption.

Rising fuel prices will be challenging. Whilst an estimated 93% of horticulture is consumed locally there is nevertheless a large volume that is exported to other countries. Where intensive horticulture is practised in protected environments such as greenhouses, management of input costs such as energy, nutrients and fertilisers, is critical to maintaining viable quality outputs and viable enterprises.

In developing countries, energy for horticulture has traditionally come from labour, but there too the cost is rising and becoming an issue.

A diverse range of fruit (left) and vegetables (right) is available to consumers.
PHOTOS: NZ INSTITUTE FOR PLANT & FOOD RESEARCH LTD

Climate variability

The current focus on climate variability will give horticultural scientists the opportunity to develop new cultivars and innovative growing systems through research and development. Climate changes will place more emphasis on the development of knowledge systems and technology to monitor water, nutrient, pest and disease factors and so lower plant stresses. New cultivars will have to be developed that adapt to changing temperature conditions. The opportunity will be available to evaluate plant genetic material stored in gene banks and with future climate variability in mind, to seek new varieties from the wild.

It is therefore essential to collect the seeds of wild relatives of fruit, vegetable, root and tuber crops and ornamental plants before they disappear. Some invaluable collections do exist and it is increasingly possible that these collections could make a contribution to maintaining sustainable and viable production in the face of climate variability.

It is also possible that changes in climate will reduce food production in some zones where temperature and radiant energy levels change and lead to an increase in food production in other zones where viable production becomes possible.

Climate change impacts – grape wine production

A study in New Zealand considered the impacts that climate change might have on the growing of grapes for wine:

- Drier growing seasons – increased water demands
- Drier seasons – fewer fungicide sprays required
- Warmer growing seasons – earlier bud break and exposure to frost damage
- Warmer growing seasons – shift to new varieties
- Shorter vintages (the time between budbreak and harvest) and maybe lower yields
- Lower fruit acid concentration due to higher (night) temperatures
- Shift of production to growing areas that are currently marginal.

Competition for water

With a growing world population and rising standards of living, water usage by urban populations will increase. This will include demands for recreation and concerns to protect water reserves for wild-life and conservation. Industries will also need more water. These and other segments of future societies will be competing with horticulture (ie. food production) for available water.

The intensive nature of horticultural crops requires reliable and consistent water supplies to optimise productivity and quality. Globally 70% of all water used is in the many forms of agriculture.

In some regions of the world, water has been mined indiscriminately for many years by tapping into underground reservoirs formed during previous ice ages. In some places, the water being used is said to be 1,000 years old and is clearly not a renewable or sustainable resource.

It is indeed possible that shortages of water could limit production of fruit and vegetables if priority is not given to the use of this resource for food production.

Crop mulching can help to conserve water in the soil and efficient irrigation systems can enhance water use efficiency.

Automated irrigation and nutrient management

The water needs of plants change day-by-day and season-by-season as plant needs for water depend on a number of environmental and plant development factors.

Wireless sensor networks have been developed enabling real time capture and collation of the information within the root zone of crops. This allows irrigation and nutrient application to be more precisely scheduled by accurately monitoring the real-time water use of plants with substrate moisture and temperature sensors.

Such methods assist to reduce water use, leaching of nutrients and overall runoff from intensive plant growing operations.

Other sensors that simultaneously measure air temperature, canopy relative humidity, leaf wetness, and photosynthetically active radiation will allow modelling to better predict plant stress and disease pressure.

These systems can all be monitored and managed via the internet.

Thought Challenge #12

The global area of irrigated land doubled in the 30 years between 1950 and 1980 because of the construction of dams. Aside from construction in China, few dams have been developed since.

Q. In the years ahead, where is irrigation water for increased crop production going to come from?

Water measurement

To ensure production remains viable and sustainable, measurement and management of water is crucial in all areas of horticultural activity including those associated with food production and also amenity and ornamental horticulture.

One key area requiring attention is improving the ability of countries to implement effective systems for 'water accounting' – the thorough measurement of water supplies, transfers, and transactions as the basis for informed decisions about how water resources can be managed and used.

Water accounting in most developing countries is very limited, and allocation procedures are non-existent, ad hoc, or poorly developed. Helping developing countries acquire good water accounting practices and developing robust and flexible water allocation systems is a major priority.

Horticultural scientists can provide underpinning information on a wide range of plants to help inform these important decisions

Virtual water

The concepts of 'water footprints' and 'virtual water' can be helpful to understanding and optimising the use of water.

'Virtual water' is the volume of water used to make a product and is the sum of the water used in the various steps of the production chain. Virtual water consists of three components:

(i) Green water being rainwater stored in soil and transpired by the plant

(ii) Blue water which is water drawn from surface and groundwater reservoirs and irrigated onto soil

(iii) Grey water which is water used during production and is of a lesser quality than Green or Blue water.

A virtual water calculation has been applied to the gross volume of water from all sources (average global virtual water content) that is needed to produce a single cup or glass of end-product. Such calculations gave the following results: 200 litres for milk, 140 litres for coffee and 120 litres for wine.

Virtual water required varies with growing environments

A virtual water calculation was applied to a typical tonne of apples produced in three southern hemisphere production areas: if grown in Australia 735 cubic metres (m^3) of water was required, if grown in Chile 245 m^3 was required and if grown in New Zealand, 141 m^3 was required. Virtual water calculations for kiwifruit were similar; it takes five times as much water to produce kiwifruit in Australia as compared to producing the same or similar crop in New Zealand.

This result is largely because of the more arid growing environment in Australia as compared to New Zealand.

Kiwifruit blossom

With better measurement of the water profile and footprint, consumers and growers may be able to make better choices in consumption which could lead to optimising water use. It is, for instance, possible to use a dwarf rootstock and improved canopy management to halve the water use per tonne of apples produced.

At the farm level, growers can change their cropping patterns to allow earlier or later planting, reducing their water use and optimising irrigation. Yields and productivity can be improved by shifting to soil moisture conservation practices, including zero- and minimum tillage. Planting deep-rooted crops would allow farmers to better exploit available soil moisture.

Nanotechnology

Nanotechnology is the scientific term for the engineering and technology of the very, very small.

And the world of the very small is going to make a very big contribution to horticulture in the years ahead. Nanoscale science involves the understanding of the physical, chemical, and biological properties of matter at the length of scale of approximately 1 to 100 nanometres.

And a nanometre is really small. A sheet of paper is about 100,000 nanometres thick. A pin head is one million nanometres across. A human hair is approximately 50,000 to 100,000 nanometres in diameter.

In horticulture, nanotechnology has the potential to enhance the quality and value of food and non-food crops. It has a contribution to make in pest, disease and weed control and improvement of soil processes.

Preharvest nanotechnology could provide bio-sensors and diagnostic instruments for monitoring plant disease and environmental stresses enabling sustainable and precise production methods.

Other examples are micro sieves for separation and fractionation which can also improve emulsification processes in food processing. This would allow the use of drug delivery concepts for nutrient delivery and the enhancement of the nutritional quality of food products.

Postharvest technology improvements from nanotechnology could include better waste management and improved permeability characteristics in packaging materials. Such packaging could combine printable electronics and low cost sensors to inform the customer about the product and its quality.

These new instruments will enable much faster measurements in or near production lines by non-expert personnel. Nanotechnology will also result in new concepts for food production processes. It could even give rise to totally new products that at present we can only imagine.

Automation and robotics in horticulture

Robots and automation processes are finding many uses in horticulture.

Automation and robotics reduce overall labour costs and increase the consistency of quality and safety during production and postharvest cycles. Mechanical harvesting is currently largely restricted to products destined for processing such as grapes for wine, olives, sour cherries, tomatoes and citrus. This is because of the physical damage that can occur during harvest.

Robots in horticulture are widely used in some nursery industries for producing transplants, especially with vegetable plants for grafting, and for planting vegetable seeds and plantlets in both greenhouses and open fields.

Labour costs

Use of robots in the developed world is driven by the cost of labour and its availability. These two factors threaten to make many crops uneconomic. In the USA, labour costs have increased in the past decade from 38% of the net value of the farm economy to 58% currently. If the trends continue some farms will become uneconomic.

Many of the tasks associated with horticulture, such as picking, pruning, pest, disease and weed control, are repetitive and arduous. Such tasks seem ideally suited to robots.

The fruit industry in the USA is recognising that if it is to survive economically, it is fundamental that their costs are lowered significantly. Robotics and automation seem the only options to achieve this reduction in costs.

What robots can do

Robots can contribute to the early detection of pests and diseases through the application of remote sensing technologies, in the monitoring of plant health, assessing crop value, reducing the amount (and cost) of sprays and nutrients (through the imaging of micro stresses caused by localised infections), increase in the efficiency of labour (by providing mechanical aids to humans) and to the reduction of damage to crops at harvest.

Challenges of using robotics in horticulture

Designers of robots for fields and orchards face a daunting task. Robots have to 'see' the paths between the produce and they need to 'know' which areas have already been harvested. They need eyes to see the trunk of a tree and to separately identify fruit, flowers and leaves. Their arms need to be able to pluck, prune, spray and pollinate.

They have to be strong enough to handle rough terrain, sloping ground and mud. They must also be able to handle fragile fruits and berries which bruise easily. After avoiding all the people, poles, wires, stumps and rocks, robots need to be able to work near other robots without getting in their way.

Their economic use poses a number of problems. Some horticultural tasks such as fruit picking last for only a few months of the year. It simply is not profitable to use a robot for such a short period. Robots may have to be multifunctional and be able to pick, count buds, prune, and pollinate to ensure a reasonable return on their cost.

Fruit picking robots

Examples of fruit picking robots in development and/or in early stages of use:

Oranges

Italy: System that uses GPS way points to navigate in the orchard; 8.7 second picking cycle, fills bin.

USA: A scout robot forms a 3-dimensional map of the location of fruit and an eight-arm picker robot gathers the fruit.

Apples

Belgium: Robots that pick 85% of crop at a 9 second cycle.

USA: Developing and testing technologies including navigation and augmented harvesting of fruit.

Strawberries

Japan: Operates in a greenhouse; 10 second cycle – provided fruit is trained to grow over the edge of the container.

Kiwifruit

New Zealand: autonomous visual navigation of orchard rows; pick rate 0.25 seconds (1 fruit per second for each of four 'hands'), gentle fruit handling and bin filling; automated bin replacement.

Top: Mechanical harvesting of cherries; experimental unit in Michigan, USA.
Above: Automated tray transfer in greenhouses.PHOTO: WAGENINGEN UR GREENHOUSE HORTICULTURE, THE NETHERLANDS

Superfoods

Although the term has no official definition, the term 'superfoods' has been widely promoted in marketing circles and applies to nutrient dense foods that are believed to have more significant health benefits than any other type of food because of their specific phytonutrient content.

There are five key criteria considered necessary for superfruit success namely novelty, health benefits, convenience, controlled supply and promotion.

From Goji berries to broccoli the amount of fresh produce claiming superfood status seems to be growing all the time. Trends in selected countries have seen a boom in superfoods and numerous superfood status products are enjoying buoyant sales, especially in the USA where the concept is more widely promoted.

In the United Kingdom the media have laid emphasis on the message that common diseases, such as heart failure, diabetes and cancer, can be prevented largely by eating a well-balanced diet. As a consequence the concept of superfruits and supervegetables – foods that contain high levels of disease-fighting nutritional compounds is having a huge impact on the United Kingdom fresh produce sector.

Superfoods span a vast array of foods, usually encompassing those with high antioxidant contents, including fruits and vegetables such as pomegranate, broccoli, blueberries, spinach, pumpkin (and even red wine and dark chocolate).

These intensely coloured, highly flavoured and attractive fruit and vegetables contain high concentrations of functional chemicals (bioactive compounds) including polyphenols, anthocyanins, carotenoids, vitamins (especially B, C and K), minerals, folic acid, fibre and a range of other components that are known to positively affect human health. Berries in particular have been the centre of increased research attention over the past few years because of their high antioxidant activity.

Red, orange, yellow and purple fleshed fruits and vegetables have greatest antioxidant activity plus an increasing number of health conferring attributes. For example, blueberries are considered a super-food because they contain significant amounts of antioxidants, phytoflavonoids, vitamin C, and potassium, all of which provide important health benefits.

Some consider the 'flagship' superfoods to be blueberries, spinach and salmon because of their particular nutrient attributes. Fruit and vegetables dominate listed 'superfoods'.

Note: the EU has banned use of the term 'superfruit' on labels unless specific nutritive and health attributes have been scientifically demonstrated; this is a consequence of there being too many spurious claims.

Many fruit and vegetables are very high in antioxidants. (Left) blueberries and (right) spinach.
PHOTOS: NZ INSTITUTE FOR PLANT & FOOD RESEARCH LTD

A diet that is rich in fruit and vegetables can enhance human health. (Left) fresh peas and (right) blackberries.
PHOTO (RIGHT): D. KARP

What horticulture can expect

Some predictions for horticulture include:

- State-provided farm advisory services will decline further with time. An example comes from the Chilean horticultural sector where since 2000 there has been a marked increase in non-governmental extension services and industry-supported research programmes. Similar trends have occurred in New Zealand.
- Farmers will organise into groups or associations to achieve collective power, and to advocate for the importance of their sector to urban populations and urban-based politicians.
- 'Champions' will emerge who can provide local and/or regional leadership in key areas that will be essential to achieve much needed improvement in:
  - technical and marketing networks
  - information on postharvest technology
  - supply chain management concepts
  - marketing systems and channels.
- Having too few advisory agents relative to the number of farmers needs to be addressed to optimize production, the use of scarce resources and to feed populations.
- The creation of discussion groups and workshops to interact with advisors to provide the vital linkages between knowledge and practice.
- The establishment of demonstration farms and postharvest facilities for development work and technical training that are vital for countries committed to developing their horticultural sectors – even without expanding farm resources.
- Increased utilisation of modern information transfer tools for information gathering and knowledge sharing and dissemination. The basic tools exist right now in the form of mobile phones, and increasingly cheaper internet-connected smartphones and computers. Access to these facilities and the infrastructure to populate, train and maintain systems need to be a funding commitment for many countries.
- Governments will continue to provide vital infrastructure such as roads (to give access for cultivation, crop maintenance and harvested produce), plus the enabling resources of electricity, cool chains and port and quarantine standards that are beyond the scope of individual farmers.

Private-public cooperation may provide:

- Establishment of post-harvest facilities including packhouse, coolstores and processing factories.
- Specialised workshops covering topics such as: postharvest and supply chain management including product physiology (maturity, ethylene, temperature), coolstore design and operation, precooling, temperature and inventory management and food safety.
- Specific R&D projects are increasingly being enabled by the private sector participating in initiatives that also receive public funding.

Commentary – Advocacy

By harvesting the sun in combination with the use of quality seeds, water, growing media and ingenuity, fruit, flowers, vegetables and ornamentals make horticulture a critical and vibrant part of our growing world.

International trade in fruit and vegetables is massive, but few people have an appreciation of the extent and complexity of horticulture. For many people horticulture is gardening, but the span of horticulture is very broad and its outputs are vital to the health and quality of life for virtually all people.

The value of fruit and vegetables in export trade is calculated to be US$180 billion annually – but an estimated 93% of these crops are grown and consumed locally. Worldwide production of fruit and vegetables exceeds 2.4 billion tonnes. Amenity horticulture worldwide produces parks, gardens, sports fields, and many ornamental applications (such as indoor and office plants), and is calculated to add close to US$290 billion in economic value to peoples' lives.

Education and training

The capacity of horticulture to provide nutrition, health and wealth, will not be sustained without recognition of the complex factors that underpin the current production of fruit, vegetables, flowers, and ornamental plants.

New products and processes will require the continuing application of advanced scientific and technical knowledge, and skilled management by producers and others in the supply chain. Support for the sustainable growth of horticulture in all of its dimensions – physical, economic, environmental, and social – will require investment in education and training if vital information is to be available at the appropriate levels.

Educational resources in horticulture are being progressively reduced in developed countries where food supply is increasingly being taken for granted. These resources are increasing in developing countries where their value is being increasingly recognised.

A shift in fruit and vegetable production focus

Horticultural crop production is increasingly shifting from countries with high land, labour and energy costs (as in the developed world), to other countries with lower input costs (such as Thailand, Vietnam, Kenya, Morocco and Mexico). This shift is markedly changing the patterns of world trade and in some places raising concerns about food safety and the environmental impact of 'fuel miles'.

New jobs and economic opportunities

Horticultural crop production creates jobs – about twice the amount of employment per hectare compared to cereal production, and further jobs from horticulture's more complex and technically challenging supply chain. In developing countries, the move from animal grazing and staple crop production towards high-value horticulture crops is an important contributor to employment opportunities and income enhancement.

Improved food security and nutrition

Fruit and vegetables are the most sustainable and affordable sources of micronutrients in diets, providing essential nutrition to those on marginal diets in developing countries and helping to combat the 'rich diseases' (heart disease, obesity) in developed countries.

Increasing demand – but fewer additional resources

Consumer expectations for high quality, low cost and safe horticultural products are key factors in driving the horticultural industry. Challenging these ideals are access to suitable productive land, limited water supplies, the high costs of land and labour, and the increasing scarcity of fertilisers.

The need for commitment

If increasing demand for horticultural products is to be met, substantial investment increases will be required in education and research with parallel investment in production, postharvest, processing, and other supply chain facilities and services.

More so than at any previous time in history, disruptions in food supply, crop failures, plant disease and pest outbreaks, and incidents of food contamination will increase. To ignore the increasing needs for training to reduce these hazards is to prejudice food security and the wellbeing of communities.

Maintaining and expanding the worldwide knowledge base in horticulture is critical for horticultural crops to continue to enhance human health, help sustain rural communities, generate wealth along complex supply chains, and enhance peoples' quality of life.

Fresh fruit display, Brazil.