Automation, Mechanisation and Robotics in Horticulture

Errol W. Hewett
Institute of Food, Nutrition and Human Health
Massey University
Albany, Auckland
New Zealand

Email: ewmrhewett@xtra.co.nz


Decreasing proportion income spent on food 1930-2010

- Less political influence for agriculture.
- Fewer students hence reduction and amalgamation of departments
- Less funds for education and horticultural research

Are fruit and vegetables too cheap!

Labour a major cost for horticulture

- Nearly 50% of production costs for fruit are for hired labour
- Intensive horticultural crops require much more skilled labour than broad scale agriculture

Reasons for automation

- Labor problems - a major driver for increased automation and mechanization.
- Reduce crop losses by harvesting at proper time.
- Skill and availability when it is needed
- Cost of labor – is it really too high? Minimum wage is $7.25 – 9.00/hour? USA has lowest minimum federal wage in OECD countries. NZ is $13.75/hr.
- Skill level and experience of labor often not available.
- Machines with sensors are objective and product throughput can be consistently monitored
- Uniform quality of output
- Competition in production from low cost labor
Harvesting is labor intensive

- Availability – crop must be harvested at optimum maturity
- Skilled harvest hands understand fragility of product
- Humans harvest faster than machines for many crops
- Potential to reduce labor costs with machines
- Will proposed changes in immigration law affect labor market?

Many types of robots

Communication robots; no hands so no use in horticulture

Personal health aides

Robots in Horticulture

- Nurseries and greenhouses
- Parks and golf courses
- In the field; monitoring
- Mechanical aids
- Mechanization and machines
- Postharvest
  * Picking/harvesting
  * Grading and sorting
  * Packing
  * Accumulation

Robot machines in the field

Massey Ferguson Robot harvester; can be designed for weeding and spraying

Robotrtac by Valtra. Remote controlled

Microbots for pathogen control?

- Microbots for disease control
- Systemic distribution of selective natural biocides through vascular system
- Targeting viruses, fungi or bacteria
- Nanotechnology has to be developed for plants
Automatic vegetable grafting machines

- Cucurbit automatic grafting machine, 800 plants/hr at 95% success rate
- Tomato automatic grafting machine, 1000 plants/hr at >95% rate

Nursery robot machines

- Automatic pot filler, Demeter
- Transplanter by Demeter: 3-32 fingers, 1000 plants/finger/hr

Greenhouse robot sprayers
Worker safety and precision application

- Robotic sprayer for greenhouses, Holland Green machine
- Robot sprayer for greenhouses, Holland Green machine

Crop monitoring

- Octocopter
- Carries sensors and cameras for aerial surveillance
- Crop loads, stress conditions – including water, nutrient, harvest maturity, pest and disease load

Lettuce harvesting and field packing

- Lettuce harvester
  - Mainly for large growers >1,000 acres
  - Can provide return on investment in 1 year
  - Reduced labor costs by 50%
  - Many processes automated increasing operator efficiency

Lettuce harvester

Tomato harvesters

CTM self propelled tomato harvester

Johnston self propelled tomato harvester

Machines for harvesting fruit and vegetables

Pea viner

Apple and cherry harvester

Instrumented glove for fruit quality

• Developed as harvesting aid by French scientists
• Equipped with non-destructive miniature sensors and artificial intelligence
• Measures color, sugars, firmness,
• Programme to specific attributes and enables picker to make objective decisions.
• Not commercialised

Harvesting aids

• Pneumatic branch shaker
• Used for cherries and apples
• Fruit falls onto collecting surface
• Physical damage an issue – fruit hits branches, other fruit or surface of catching frame

Strawberry robotic harvesting

• Fruit very perishable
• Physical damage and slow speed are problems with mechanical harvesting
• Damage leads to ethylene production, to infection sites for fungi and rapid deterioration
• Selectivity – challenge to find all berries on plant
• Cost an ongoing issue
• Not commercial yet

Develop entire system for sweet cherry production

• The next generation sweet cherry orchard must be precocious, consistently productive, bear excellent-quality fruit, and be designed to be labor efficient.
• Precocious productive system – fruit in 3 years
• Systematic approach to pruning and training - UFO
• Facilitates precision canopy and crop management
• Compact fruiting walls that facilitate incorporation of new technology for improving labor efficiency and fruit quality
• A system that minimizes environmental footprint
• Space between trees filled at planting
• Partner fully with industry in system development
• Develop market for no-stem cherries
Cherry harvester
- Programme to develop holistic system for sweet cherries Matthew Whiting by WSU, Prosser.
- Rootstocks, varieties, tree training, fruit quality, picking aids, mechanical harvesting
- Developing Upright Fruiting Offset (UFO) training system

Change the tree structure
- Use long (1m) rods at planting
- Bend 45-90° from vertical
- Allow vigorous lateral growth
- Can be trained to one dimension or ‘V’ shaped
- Yield increases
- Harvest efficiency improvement

The Future growing system?
Illustration of 3-year-old sweet cherry trees trained to the UFO system creating an angled, single-plane fruiting wall that is ideally suited for mechanized harvest. Dr. Matthew Whiting, WSU Prosser

Stemless cherries
- Consequence of mechanical harvesting
- Sensory quality attributes same as cherries with stems
- Major marketing effort required to overcome consumer perception
- Increasing number of growers using the UFO system

A modern packhouse

Automatic sorting of multiple quality attributes
- High tech sensors with very fast response times
- Fast, accurate segregation based on preset quality parameters.
- Measures 14 fruit per second per lane
- 10,080,000 individual fruit per 20 hour day for 10 lanes.
- No labor problems
Robots in the packhouse

Automated fruit sorting

- Mechanisation will progress for fruit harvesting and handling
- Sensors will become more sophisticated and faster.
- Robots will become more sophisticated and accurate for repetitive tasks
- Robots will become increasingly self-learning – adapting to changing conditions

Supply chain monitoring and traceability

- XSENSE® system by Stepac [Now BT9 intelligent supply chain solutions]
- Records temperature and relative humidity automatically at short intervals for precise monitoring.
- Purfresh Transport
- Ozone technology for in transit preservation
- Constant storage remote environment monitoring and management

Conclusions

- Pressure will continue for producers to reduce costs of production, harvesting and packing fruit and vegetables.
- Supermarkets will continue to manipulate prices received for their benefit and not the producers. Are growers forced to sell produce too cheap?
- Labour costs will continue to increase and drive further mechanisation, automation and robotics. Is $7.25 or even $9.00/hour a living wage today?
- Costs of technology reducing; more sophisticated, accurate and faster sensors and machines are being developed.
- Functional robots are just around the corner for fruit and vegetable systems.

Conclusions

- Crucial that multidisciplinary research, involving plant scientists, engineers, food scientists, economists and marketing expertise is focused on creating new production systems.
- Innovation will come through intimate understanding of all parts of the system.
- Growing systems will be designed for specific crops and then dedicated machines will fit.
- Mechanization and robotics for fruit harvesting, grading and packing remains more of a problem than for vegetables.
The End
Thanks to Carlos Crisosto and UC Davis for assistance

A scary statistic for fruit and vegetables growers.
Low intake of dietary fibre found in fruit and vegetables is a major public health concern

Consumers underspend on fruit and vegetables except for potatoes.
Overspend on refined grains, fats and sugars/sweets.

UFO – Upright Fruiting Offshoots

Year 1: dormant
Dormant year 2:
Do not head uprights
Remove lateral growth with thinning cuts to leave unbranched uprights
Renew excessively vigorous uprights with dormant stub cuts
High Yields 3rd year – 6 to 11 t/ha
Precision canopy management
No extensive decision making in pruning

Robot farmers?

Harvesting machines

Pik Rite 190 Tomato harvester
Cherry harvester with branch shaker
WSU M. Whiting
Increased automation

Up to 10 lanes in large packhouses

Robotic pallet wrapper