Development and Incorporation of Mechanisation into Intensely Managed Grape Vineyards

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Development and Incorporation of Mechanisation into Intensely Managed

Grape Vineyards

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Abstract

Economic considerations have caused grape growers to look toward mechanisation of vineyard operations to remain competitive. The first operation mechanised successfully on a commercial basis was harvesting. Many grape growers recognised, however, that commercial prosperity of the grape industry would rely on the concept of complete systems of vineyard mechanisation, that is, mechanisation of every cultural operation throughout the season, including shoot and fruit thinning, summer and winter pruning, shoot positioning, cordon and trunk scrubbing, leaf removal, centre breaking, and harvesting. The Oenology and Viticulture Program at the University of Arkansas developed and patented the Morris-Oldridge (M-O) Vineyard Mechanisation System that offers a complete systems approach to the 12 major trellising systems used throughout the grape-growing industry. The System uses specific pieces of equipment for different operations, but they work together to accomplish “balanced cropping” and optimise yield and quality in a vineyard. The patent includes the sequence of steps and timing of operations for this equipment. OXBO International Corporation has acquired the licence for the M-O System patent and is manufacturing and marketing the system under their name, vMech® Total Vineyard Mechanization System. Large-scale research studies and commercial operation of the system are underway in a large Region III vineyard in California. In this work, yields obtained using mechanisation were near target yields required by contracting wineries. Fruit quality parameters of hand and machine treatments were almost identical for the cultivars studied (Chardonnay, Sauvignon blanc, Merlot, Sangiovese, Syrah, and Zinfandel).

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Taking Mechanisation Research into the Vineyard

Leader:
J.R. Morris, Institute of Food Science and Engineering, University of Arkansas

Panellists:
C. Intrieri, Dipartimento di Colture Arboree Cattedra di Viticoltura, University of Bologna, Italy
T. Bates, Cornell University Vineyard Laboratory, Fredonia, New York, USA
H. Ashby, French Camp Vineyards, Santa Margarita, California, USA
G. Berg, OXBO International, Kingsburg, California, USA
N. Dokoozlian, E&J Gallo Winery, Modesto, California, USA
P.F. Hayes, Viticultural Consultant, Glen Osmond SA, Australia
R. Smart, Smart Viticulture, Launceston, Tasmania

Session Abstract:

One of the many ways to ensure the economic health of the worldwide grape and wine industry is to reduce production labour through vineyard mechanisation, while maintaining vine vigour, yield and product quality.

Cesare Intieri will report on research in Italy that found training systems adaptable to horizontal shaking harvesters resulted in the best quality fruit. Additional research in Italy has shown that the best quality grapes are obtained using a vertical shaking harvester and vines trained to DC-like canopies. Three of these systems (MFC, MSPC, and COMBI) and the development of an improved harvester for use with them will be discussed.

Concord vineyard production efficiency with four pruning/crop management systems was the subject of a five-year trial in New York. Terry Bates will compare the production costs, required inputs, and fruit quality of these systems. Hank Ashby, French Camp Vineyards Manager, will describe implementing a total system of vineyard mechanisation into a commercial vineyard in California. Issues considered range from establishing equipment operation specifications to estimating harvest dates and timing and procedures for crop adjustment. The economics of mechanisation of a commercial vineyard will be discussed by Greg Berg.

Nick Dokoozlian will discuss how mechanization impacts fruit and wine composition. Peter Hayes believes that economics, labour issues, and the need for timely viticultural interventions make it inevitable that further mechanisation of vineyard activities must occur. He will look at the roles other new technologies, such as GIS, precision viticulture, scenario mapping, and nanotechnology will

play in conjuction with conventional mechanisation. Richard Smart will close the discussion by looking at the vineyard of 2056. He will discuss how societal changes along with technological advances have changed the way many viticultural operations are performed but how some things, such as disease-free, self-pruning vines, are still in the vineyard of the future.

Panellists' Abstracts

Italian Advancements in Training Systems and Harvesting Machines to Improve Vintage Quality

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After twenty years of research on grape quality, it has been found that many traditional training systems used in Italian vineyards are inappropriate for harvest mechanisation since training systems for mechanisation must feature a permanent cordon designed for spur pruning rather than cane pruning. There are many variations of spur-pruned systems; however, these can essentially be classified as the conventional Spur-Pruned Cordon (SPC), a single hedgerow with shoots vertically trained, and the GDC-derived Double Curtain (DC), a divided canopy with no foliage wires and shoots positioned down. The SPC is harvested by traditional over-row horizontal slapping units, while the DC is generally harvested one curtain at a time by the half-row inter-row machines that use a vertical-shaking spiked wheel.

Comparisons of horizontal and vertical harvesters clearly showed that the horizontal system led to the best quality harvested grapes since the spiked wheel shaker works by causing vibration of the main wire and the cordon. This vibration detaches the berries, or even whole clusters, about a meter ahead of the advancing shaker, reducing debris (MOG), and free-run juice in the harvest. Based on the efficiency of the vertical shaking method with the DC trellis, the harvester was evaluated with other training systems. Three of these will be discussed briefly:

i) One of the most promising training systems for harvest mechanisation, in terms of grape quality, is the Movable Free Cordon (MFC). This system features a trunk trained to develop into a single horizontal spur-pruned cordon 1.4-1.5 m from the ground. This cordon requires no shoot-support wires. To accommodate the vertical shaking machine, the cordon support wire passes through plastic caps that fit loosely over the post tops and enable the cordon to move up and down as the shaker advances. To adapt the vines to this movement, the trunks are bowed. Because the shoots and the bunches are mainly above the cordon and the shaker heads are working

below it, the harvest was practically free of MOG, averaged less than 4% free-run juice and about 15% intact or partial bunches. The MFC trellis has given rise to the design and construction of a specific over-row harvester (TRINOVA model), that uses two spiked-wheel vertical shaking heads. TRINOVA has been tested over a number of years in a large MFC vineyard with several cultivars (Chardonnay, Manzoni bianco, Carménère, Cabernet S., Cabernet F., Rhine Riesling).

ii) The traditional Spur-Pruned Cordon trained to a height of 0.8-1m with shoots vertically positioned was altered for vertical shaking by passing the cordon-support wire through a bracket secured to the side of each pole. This training system, called Moveable Spur-Pruned Cordon (MSPC), has the trunks bowed like the MFC to allow the cordons to move up and down as the shaker advances. These changes do not prevent the use of traditional horizontal harvesters, but also allow the use of the over-row TRINOVA unit. Comparisons of a commercial horizontal shaking machine and the vertical-shaking TRINOVA harvester were made on several cultivars that were MSPC trained (Tocai friulano, Chardonnay, White Pinot, Verduzzo friulano, Verduzzo trevigiano, Grey Pinot, Merlot, Cabernet S., Cabernet F., Carménère, Raboso Piave, Raboso veronese). Vertical shaking clearly gave a better harvested product, since the grapes had less MOG, much less free-run juice, and a greater number of full or partial bunches.

iii) Recently, a new training system has been developed, based on two horizontally-spaced spur-pruned cordons with vertically-growing shoots that give rise to a double parallel hedgerow. The shoots are trained up by foliage wires mounted on U-shaped frames. The main cordon support wires are made movable by passing them through brackets. The U-frames alternate along the row with arms like those used in the DC. Since this training method uses a combination of features employed in other systems, it has been dubbed COMBI. The COMBI yields quality grapes that can be harvested one hedgerow at a time with the same vertical shaking inter-row units used for the DC. Harvest trials performed with several varieties (Barbera, Bonarda, Sangiovese, Merlot, Shiraz) confirmed that the COMBI works well with vertical shaking. The harvested grapes were practically without MOG, free-run juice was less than 3% and about 15% of the product was intact or partial bunches. On the strength of these initial findings, new COMBI-trained vineyards are being created with more varieties to assess their suitability to vertical harvesting.

Integrating mechanization practices and hand labor for vineyard production efficiency

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Increasing economic pressures and decreasing profitability for Concord grape producers in Western and Central New York have increased the need for vineyard production efficiency. Efficiency in this case has been characterized as decreasing production costs while maintaining or increasing fruit yield and quality. Early attempts with vineyard mechanical pruning with Concord decreased production costs but also caused erratic results with yield and juice soluble solids. A five year trial was conducted in a commercial Concord vineyard in Western, NY to compare the vineyard production efficiency of four pruning/crop management systems. The treatments consisted of 100% manual pruning, mechanical pruning with hand pruning follow-up, 100% mechanical pruning, and minimal pruning. In addition, a technique for mechanical mid-season crop estimation and adjustment was refined for Concord and used on all the pruning treatments to match the crop size with the given growing season and vineyard yield potential. Over the five year trial, manual pruning, mechanical pruning with hand follow-up, and mechanical pruning alone were identical in yield and juice quality. Manual pruning had the highest production costs. Mechanical pruning alone had low pruning costs but required mechanical mid-season crop adjustment three out of the five years of the trial. Adding manual pruning follow-up to mechanical pruning increased pruning costs but allowed for individual vine adjustment and eliminated the need for mid-season crop adjustment. Minimal pruning had the lowest production costs but also required mechanical mid-season crop adjustment and delayed fruit maturity at a given crop level. Mechanical pruning with the additional management techniques of manual follow-up and/or mechanical crop adjustment represent viable options for Concord producers to improve production efficiency.

Adapting Vineyard Mechanization Research to Commercial Conditions in California

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French Camp Vineyards is a 1,750-acre, Region III commercial vineyard near Paso Robles, California. When it was decided mechanization should be implemented in this vineyard, French Camp's management selected the total

systems approach provided by the Morris-Oldridge Vineyard Mechanization system and concept developed at the University of Arkansas. This system was chosen because it offered a total approach to mechanization and would have a positive effect on fruit and vine quality. In addition, this system incorporates methods of crop and vine balance which would require less hedging and produce consistent yields. In 2002 the Arkansas-patented machines and attachments which were constructed by Tommy Oldridge were used to manage 6 grape varieties on 475 acres. During this initial year of mechanization, we determined that there were certain production issues that needed to be modified when using the mechanization system. For example, more shoots could be left on the vines when shoot thinning mechanically than when thinning by hand. It also was observed that there is a critical need to determine the timing and amount of fruit thinning. Balanced cropping by mechanization was done on an incremental basis with machine dormant pruning, followed by machine shoot thinning and final adjustments, when needed, with machine fruit thinning. The methods being used at French Camp to improve the accuracy of crop estimation and accomplish balanced cropping with the Morris-Oldridge system will be discussed. In 2003 improved commercial versions of the equipment from OXBO International, an agricultural mechanization company that bought the rights to the University of Arkansas patent were used to machine farm six wine grape varieties on 900 acres. Two wineries with major labels contracted for these grapes. 1,100 acres were machine farmed in 2004 and two additional wineries contracted for the machine-farmed grapes. The machine farming has resulted in fairly accurate achievement of target yields with fruit quality comparable to hand-farmed grapes. The French Camp Vineyard management plans to continue to increase machine-farmed acreage and to refine the use of the Morris-Oldridge (vMech®) vineyard mechanization system.

Economics of Mechanization

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In cooperation with local growers in California and Washington (USA), OXBO International Corp., Inc. has made successful advances in the commercial implementation of the patented Morris-Oldridge Total Vineyard Mechanization Systems. From trial-sized beginnings in 2001, the machinery and systems now known as OXBO vMech^{tm} have been further refined each year and are now utilized on over 1500 acres in the USA. Mechanized activities include precision box pruning, shoot thinning, cordon cleaning, leaf removal, fruit thinning, and summer trimming/hedging. Substantial labor hour and labor cost savings have been realized in mechanized vineyard blocks. Furthermore, growers have gained more control over their operational risks by using mechanization in their favor to effectively delay crucial yield management decisions, thereby improving accuracy

in meeting target yields. Yields and wine quality comparisons have shown no deleterious effects due to mechanization across eight common cultivars. Data regarding labor hour savings, cost savings, and impacts on gross revenue to be gained by balanced cropping through mechanization will be presented and discussed.

Status and future of vineyard mechanisation in Australia and New Zealand

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The Australian viticultural landscape is comprised of a nominal 150,000 Ha of which 90,000 Ha is “Warm region” (Inland Irrigated) and 60,000 Ha “Cool Region” vineyard (i.e. so-called Non-Irrigated region). This latter region produces an average 6-8T/Ha compared with a “Warm Region” average of 15-18T/Ha both from generally wider row spacings (2.5-3.3m), and with respectively, annual production costs ranging from around A$6000 to A$18,000/Ha. In comparison, New Zealand would appear able to produce substantially higher average yields, albeit from more densely spaced vineyards.

Mechanisation has been a serious focus in a large proportion of the Australian vineyard, but most notably in the Inland Irrigated areas and the larger-scale, cooler vineyards with accommodating topography.

This applies particularly to the operations of mechanical harvesting, the mechanical pre-pruning of cordon trained/spur pruned vines, and in very high yield years, mechanical thinning of crops.

Given the fundamental issues of

- Pressure on productivity and financial returns; the “cost-price squeeze”
- Uncertain availability, irregular adequacy of skills and the relative expense of labour
- The heightened demands for critical timeliness of viticultural interventions

it appears increasingly inevitable that further mechanisation must occur, especially in the relatively high cost/low productivity regions. In accepting this premise, the likely influence of climate change on vineyard site, vine performance and operational imperatives should equally be considered.

Such circumstance is likely to see the conjunction of “conventional mechanisation’ with other new technologies including GIS, precision viticulture techniques (near and remote sensing and control), field sensor and communication networks, scenario modelling (site, season, yield-quality targeting etc) and nanotechnologies. The resolution focus will range from a broad or

narrow-scale zonal management outcome to individualised vine treatments such as selective harvest or thinning on a vine-by-vine basis.

These innovations will see a need for development of

- Effective R&D linkages between viticultural sciences, engineering and the related geographic, oenological and sensory sciences
- Specific skills in the consultancy/service sector and
- New management approaches and operational capacity within vineyards

WHAT WILL MECHANISED VINEYARDS LOOK LIKE IN 50 YEARS?

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I think that by 2056, there will be many changes in the world of viticulture. Of course the greatest will be that of climate change. Many of the traditional regions of 2005 will have ceased to exist; of those that do, varietal mix has changed drastically, and there are few vineyards older than 10 years. Most of the traditional bulk wine areas in hot regions no longer exist. New regions have emerged and continue to do so. Immigration to these regions is not as free as it was in Europe in the 1890's to escape phylloxera, and so there is a general shortage of skilled labour. The mechanization boom of the 2020's was happily coincident with these changes.

Concomitant social changes have influenced the need for mechanization. At the turn of the century, there were often ten times or more grapegrowers than wineries. While the number of wineries has now decreased, the number of growers has been decimated, so that in most regions there are only one or two grape suppliers. The once important vineyards of Europe have all but disappeared, along with the European Union, as subsidies were not paid to allow necessary changes to vineyard practice.

Apart from a few European vineyards supplying limited wine amounts to the world markets, most vineyards are now mechanized, to a greater or lesser extent. The widespread adoption of GPS/GIS technology in the first decade of the new millennium gave mechanization a new impetus, and allowed machines to become more "intelligent". Planting machines do not require marking out, as was done by hand. Vine training is performed also by machine, guided by cameras mounted on robot arms. Similarly, combinations of vigour imaging and on board sensing guide robot arms which individually prune each vine to bud numbers appropriate to its cane weight.

The first operation of the growing season is shoot thinning, and shoot removal is performed for pre-decided categories. The first shoot positioning pass is carried out just before bloom, dividing canopies both upwards and downwards for the system with the prior quaint name of Smart Dyson (This system is now the only one used, as all others failed to match its performance). Shoots are individually trained by robot arms, Two more shoot positioning passes occur before veraison, and shoot trimming is also done. Interestingly, this is the only machine which has any resemblance to machines used earlier in the century. While the need for fruit thinning has decreased, it is now done also by camera guided arms during shoot positioning passes.

Vineyard spraying entered a new phase in the 2030s when intelligent, recycling sprayers were finally introduced. Chemical application amounts were drastically reduced, which explains why chemical manufacturers wanted to stall this development for so long. Application is targeted to the required zone and no other, and no chemical escapes to the environment. Similar approaches are used for weed spraying and cultivation.

The concept of harvesting all fruit into the one receptacle was abandoned early in the 2020's, and now individual bunches are selected by NIR driven sensors and sent into one of ten or more receptacles.

The changes in mechanization have resulted in labour inputs of the order of 30 hours per hectare as an average for a region. The tendency of the 2010's to have only one power unit for all operations has long since been abandoned. Not only capital cost, inflexibility for multi operations and capital cost were responsible. It was realized that the heavy machines caused soil compaction and decreasing vine performance. Now smaller units with appropriate and lower horsepower are used for all operations apart from harvesting and occasionally spraying.

One thing has not changed however. Molecular biologists who in the early 2010's promised disease free, self-pruning grapevines are still at the bench. While wine consumers now enjoy wine from 40-50 "international" varieties, all of these were known before 1850, and none are genetically modified. Machines adapted to the vine, rather than the vines being adapted to man's whim.