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Rural Industries Research and Development Corporation

Guide to Efficient Olive Harvesting

RIRDC New ideas for rural Australia

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Foreword

The *Guide to Efficient Olive Harvesting* has been prepared to aid Australian olive growers to improve harvest efficiency in the olive grove.

'Harvesting efficiency' is defined as the ratio between the fruit that is effectively harvested and delivered to the processing plant, and the fruit that was originally on the trees.

Based on local experience and observations, harvesting efficiencies in Australia currently range between 60% and 98%. The expected minimum average harvesting efficiency for modern groves should be 85%.

This Guide aims to provide Australian olive growers with the necessary information to maximise harvesting efficiency without compromising the economy of harvesting operations.

This Guide was funded by industry partners Boundary Bend Ltd and Rural Industries Research and Development Corporation core funds that are provided by the Australian Government.

It is an addition to RIRDC's diverse range of over 1800 research publications and forms part of our New Plant Products Program that aims to facilitate the development of new rural industries based on plants or plant products that have commercial potential for Australia

Most of RIRDC's publications are available for viewing, downloading or purchasing online through our website www.rirdc.gov.au.

Peter O'Brien
Managing Director
The Rural Industries Research
and Development Corporation

Arbequinas

Executive Summary

What the manual is about

This manual has been prepared to provide olive growers with information that will assist them to achieve improved harvest efficiency. The manual presents optimal harvest efficiency options for the full range of mechanisation and scales of operation experienced by growers in the Australian environment - from hand harvesting through to large scale operations. The manual provides information concerning the theory and practice of harvest efficiency, including the physiology of the olive tree, grove design and management right through to the range of options of mechanisation.

Who the manual is targeted at

This manual is targeted at Australian olive growers.

Background

Harvesting efficiency is defined as the ratio between the fruit that is effectively harvested and delivered to the processing plant and the fruit that was originally on the trees. Based on local experience and observations, harvesting efficiencies in Australia currently range between 60% and 98%. The expected minimum average harvesting efficiency for modern groves should be 85%. It is the aim of this report to provide Australian olive growers with the necessary information to maximise harvesting efficiency without compromising the economy of harvesting operations.

Methods used

This report was prepared by Leandro Ravetti of Modern Olives in Victoria, who has extensive experience in olive management both nationally and internationally.

Results/Implications

A comprehensive harvesting efficiency manual for Australian olive growers has been produced. It is expected that use of this manual will increase the profitability of olive groves across Australia.

Contents

Harvesting Efficiency

Harvesting efficiency is defined as the ratio between the fruit that is effectively harvested and delivered to the processing plant and the fruit that was originally on the trees. Based on local experience and observations, harvesting efficiencies in Australia currently range between 60% and 98%. The expected minimum average harvesting efficiency for modern groves should be 85%. It is the aim of this report to provide Australian olive growers with the necessary information to maximise harvesting efficiency without compromising the economy of harvesting operations.

Olive harvest

Figure 1 summarises the potential impact of harvesting inefficiencies on the potential crop of the following season based on current Australian data and overseas research work.

To determine the optimal harvesting time, the following points need to be evaluated:

- The olives must have the maximum weight of oil.
- The quality of the oil must be optimal.
- Fruit and tree damage must be minimal.
- Next year's crop must not be affected.
- Harvesting must be as cheap as possible.

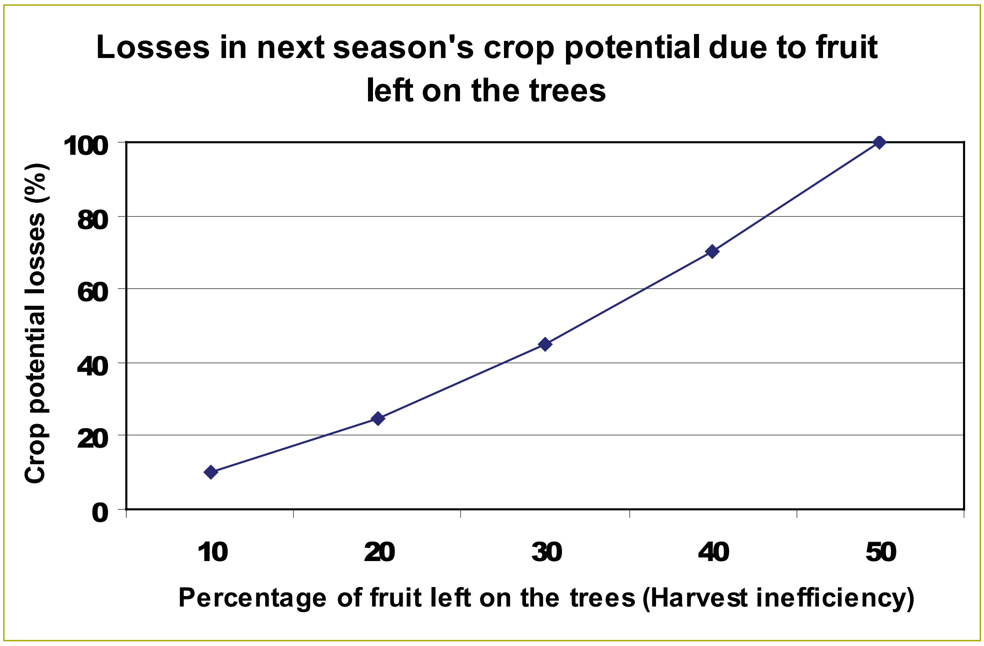

Figure 1. Estimated crop potential losses due to fruit left on the trees

Hojiblanca olives starting to change colour

Optimal Harvesting Period

Olive ripening

The period of fruit growth and development in olives takes 6 to 7 months and it is extremely long in comparison with other stone fruits. There are important differences between varieties, growing conditions, level of fruit yields per tree, etc. but the average cycle takes approximately 200 days to be completed.

The olive development follows, like other stone fruits, a double sigmoid curve with a latent period at the beginning of the process and another one at the end. After pollination, the cell division process is relatively fast. During this first phase of fast growing conditions, almost all the cell division processes are completed. During the second phase of slow growing conditions, the pit hardening process takes place. Both pit and embryo reach their final size that will not vary in the following months. The final phase of fast growing conditions determines the real size of the fruit due to the enlargement of the cells in the flesh and the processes of oil and moisture accumulation.

At the end of this period, the oil accumulation slows down and finally stops and the fruit starts its colour change process.

The colour changes in olives and the total amount of oil are not linked.

Our research has proven during the last five years that the colour index is not the best method to determine when the oil accumulation has stopped and when the harvesting period should start.

Fruit attachment force

Regardless of the harvesting method, separation of the fruit from the tree depends on how strongly this fruit is attached to the shoot. This strength of attachment is defined as Fruit Attachment Force or Fruit Removal Force (FRF). The FRF for olives can range from 0 to 1,200 grams measured with the help of a small hand held dynamometer or spring scale.

Other authors consider that more than the FRF itself, it is the ratio between FRF and fruit weight, which better describes how easily a fruit will be harvested, particularly if using trunk shakers. This ratio typically reaches average levels of 200-400 with oil varieties and of 100-200 with table olive varieties. Looking at those figures, it becomes quite evident that olives are one of the hardest fruits to harvest in comparison with other mechanically harvested products, which FRF/Fruit Weight ratios are much lower (e.g. peaches 40-60, plums 30-70 and cherries 50-100).

The FRF in olives decreases as fruit ripens. However, this is not an even linear process and suffers daily variations based on weather conditions and grove management. A lower FRF will also have an increasing impact on natural fruit drop.

Oil content in the fruit

Oil accumulation starts immediately after pit hardening. In oil synthesis, the carbon source can be either the leaves or the fruits. The oil accumulation process shows three typical phases.

During the first phase, oil accumulation is slow and the total oil content reaches up to 4% being mainly constituted by structural lipids.

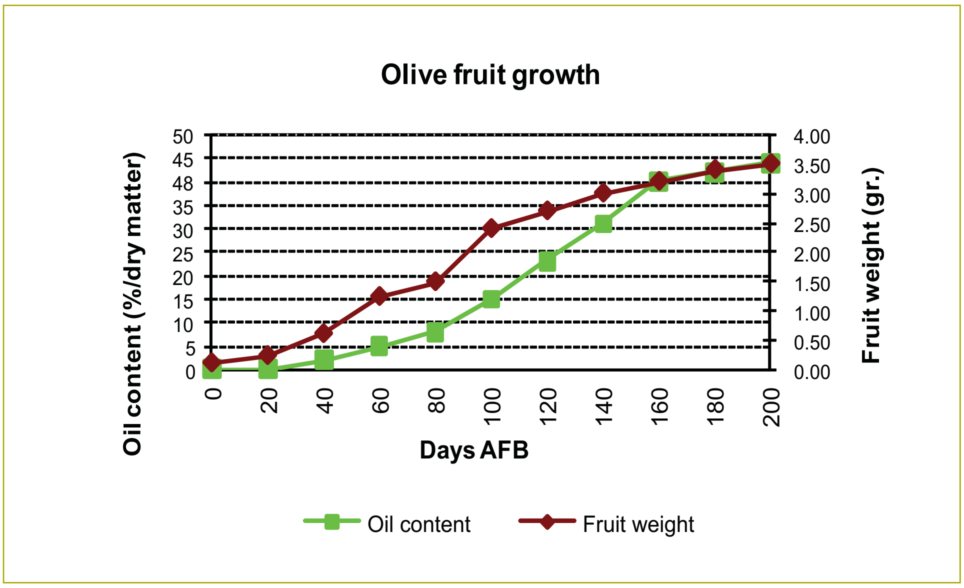

Figure 2. Fruit growth patterns showing typical fruit weight and oil content evolution

The second phase is the most important part of the process reaching its peak approximately 18 weeks after full bloom. Finally, the third phase responds to the slowing down of the process and usually concludes around 28 weeks after full bloom.

Moisture content in the fruit

The olive fruit has normally between 40 and 75 % of water in its composition. Even when this water has no direct effect on the oil quality or quantity it has an important role in the extractability of the oil. Furthermore, it gives a good indication of the irrigation regime as lower or higher than normal levels could lead to oil accumulation problems or lower character oils and also oils with a shorter shelf life.

Figure 3 shows an almost ideal oil and moisture evolution in the fruit during the oil accumulation period. It is important for all grove technicians to correlate these graphs and the moisture values with the soil moisture monitoring values as well as with the climatic conditions and irrigation regime for a better understanding of these values.

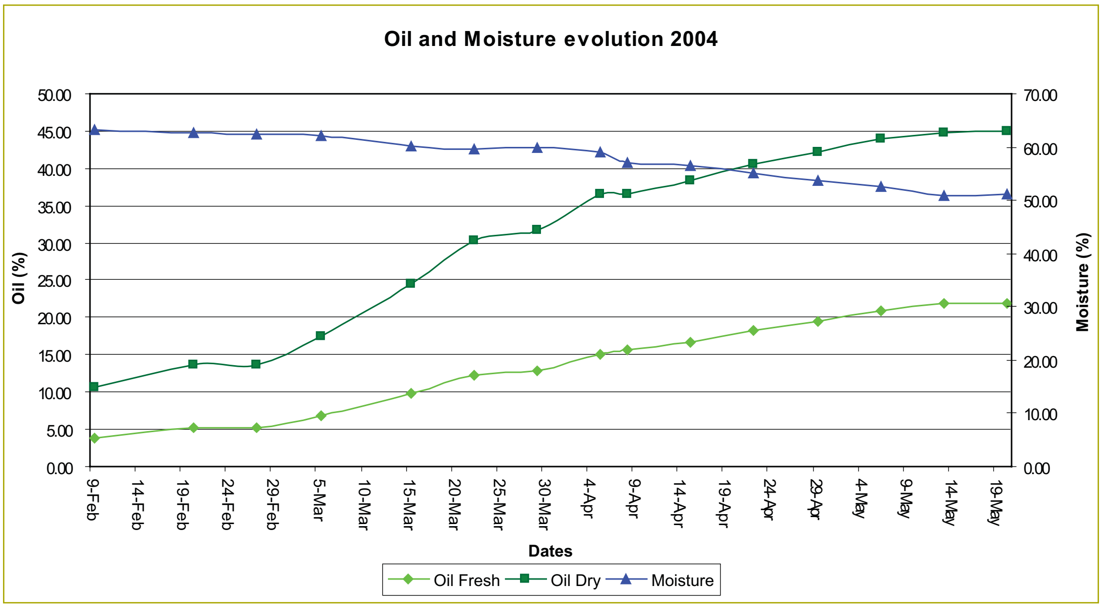

Figure 3. A real example of accurate fruit moisture management to maximise oil accumulation and good fruit characteristics at crushing time

It is quite normal to find that different varieties, even when planted in similar soils and managed according to similar criteria, will show a significant variation in the moisture levels between them. This variation is determined genetically and it will force different management techniques per variety in order to arrive at harvesting time with the ideal moisture levels without compromising vegetative growth and/or oil yields.

Those varieties showing high moisture levels are generally the ones which are classified as varieties producing more difficult pastes for oil extraction. Leccino, Picual or Manzanillo could be included in this group. There is also one group of intermediate varieties. Coratina, Arbequina and Barnea could be included in this group. Finally, there is one group of easy paste varieties like Frantoio and Koroneiki.

When the fruit arrives to the processing plant with more than 58% moisture, this level of moisture will most likely lead to emulsions in the paste. These emulsions will not only reduce the extraction efficiency of the machinery but also will force the processing speed to slow down, thereby increasing the crushing costs per tonne.

Figures 4 and 5 show the correlation between fruit moisture and extraction efficiency for two different processing plants in Australia.

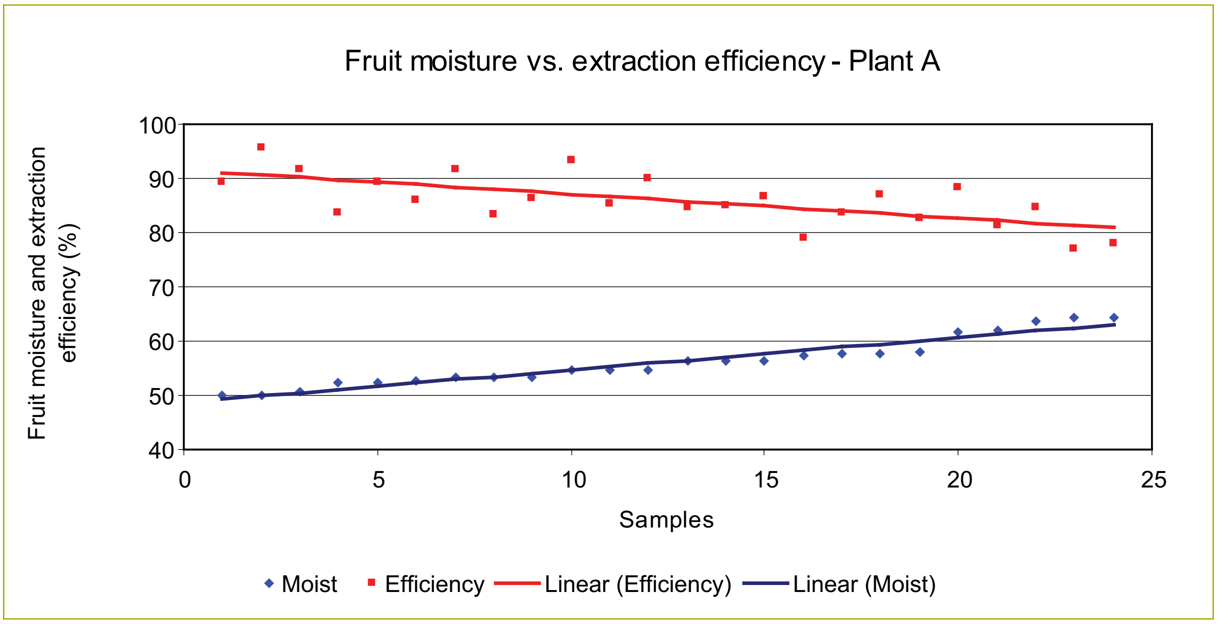

Figure 4.

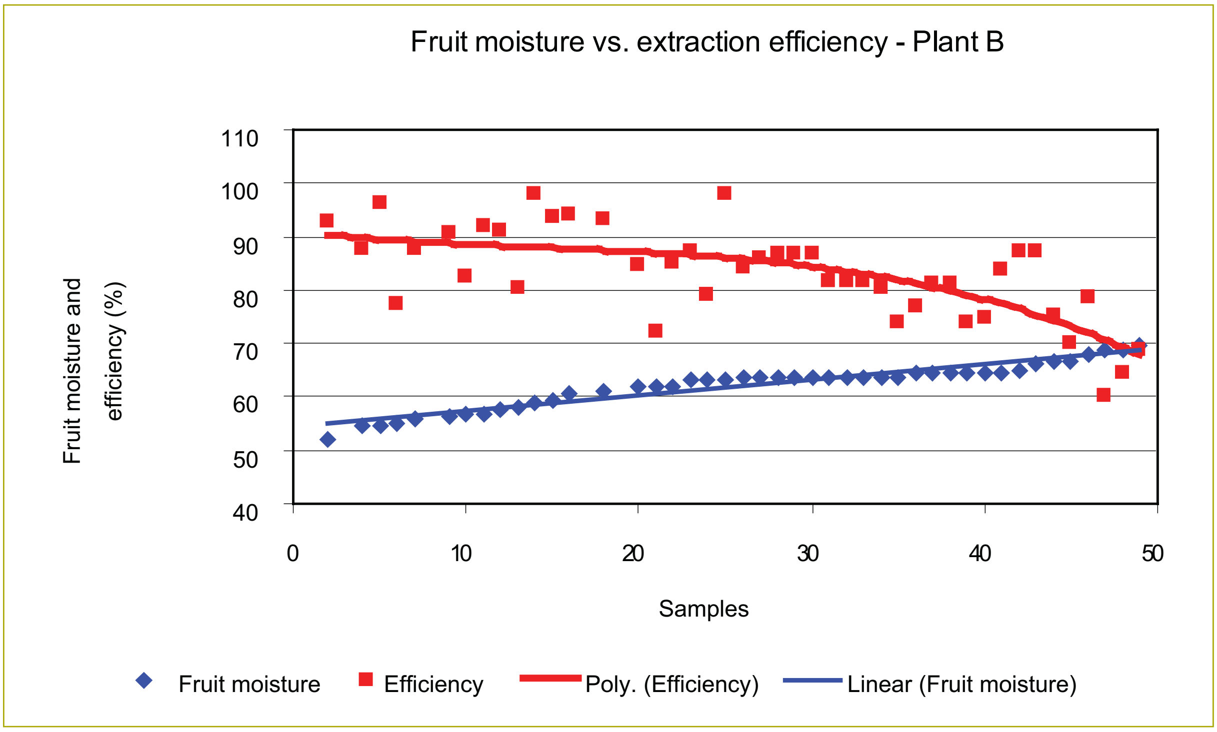

Figure 5.

Figures 4 and 5 graph Curves showing the opposite relationship between fruit moisture levels and processing efficiency with two different decanters

Samples of solvent extracted oils from extremely early, middle and extremely late harvest

Oil quality evolution

Organoleptic quality analysis of oils from early harvested fruit show consistently greater fruitiness, pungency and bitterness than the sweeter oils produced from more mature fruits. The polyphenols level also drops with the ripening of the fruit.

The acidity of the oil increases with the level of damage to the fruit at harvest and to the time between harvest and processing. The free fatty acid (FFA) value tends to increase slightly during the first 36 hours between harvest and processing.

After 36 hours FFA values initiate a sharper increment with both damaged and undamaged fruit but the increase is more significant in the damaged fruit and in riper fruit.

Optimal harvest times in Australia are strongly related to environmental conditions and varieties. Harvesting may start in Queensland by middle March and may finish in Southern Victoria at the end of June.

Optimal harvest times in Australia are strongly related to environmental conditions and varieties.

Once the fruit reaches the optimal time for harvesting, the oil quantity remains almost constant.

Natural fruit drop

Natural fruit drop depends mainly on the variety, but it can be modified by climate or tree health. Normally, there is a small fruit drop during the beginning of the harvesting period; however, it can reach significant percentages in a later period, particularly in warmer climates. Figure 6 represents an average value of fruit losses due to natural drop

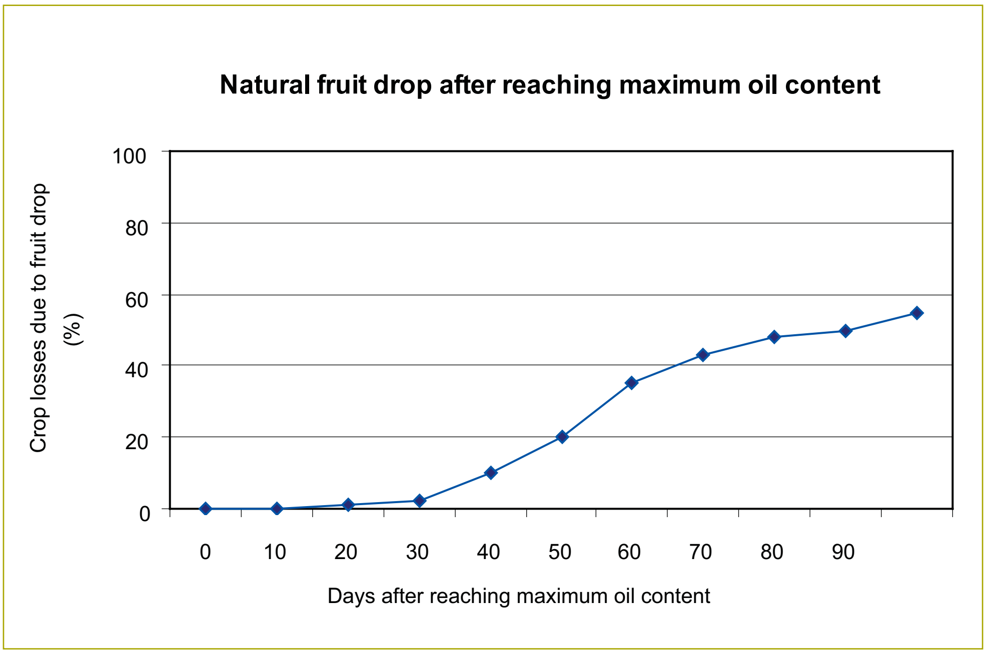

Figure 6. An example of fruit drop evolution after reaching maximum oil content

Impact of harvesting time on next year's crop

The time of harvest also has a significant influence on next year's crop. When the fruit remains for an extended period without being harvested, the flower differentiation of the next season is inhibited. Certainly, it is observed that early harvested trees always crop heavier than those harvested later in the season. Ideally, trees should be harvested within the first two weeks after their fruit reaches the maximum oil content. Nonetheless, almost all trees harvested after that period would have shown significant losses in their fruiting potential for the following season. This situation is represented in Figure 7.

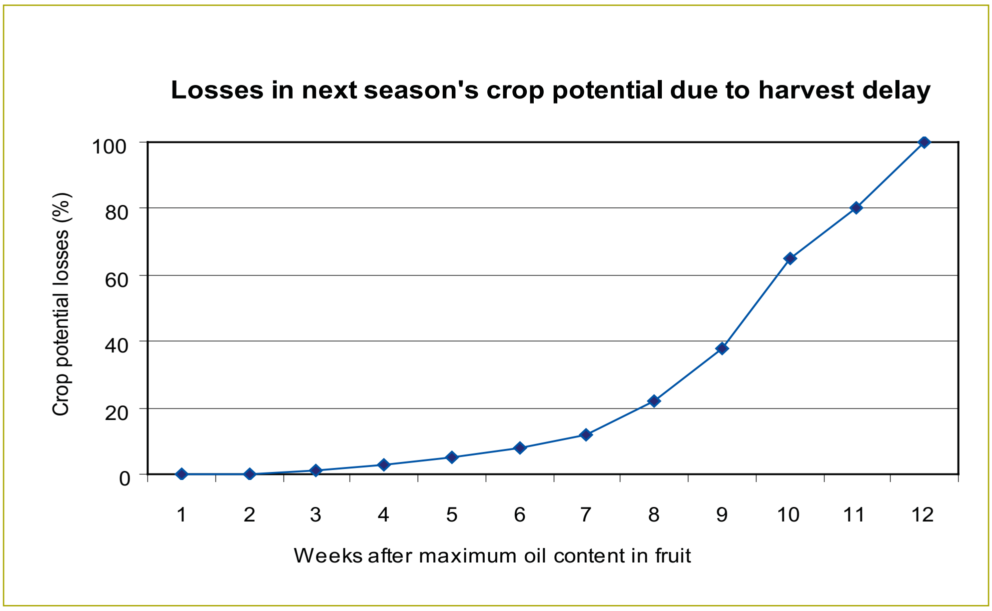

Figure 7. An approximate evolution of crop potential losses due to harvest delays

Optimal harvesting time

Many aspects need to be considered simultaneously while deciding when to harvest the fruit. To determine the optimal harvesting time, the following points need to be evaluated.

- The olives must have the maximum weight of oil.
- The quality of the oil must be optimal.
- Fruit and tree damage must be minimal.
- Next year's crop must not be affected.
- Harvesting must be as cheap as possible.

The moment at which the olives have the maximum amount of oil of the highest quality varies according to environmental conditions, variety characteristics and amount of fruit per tree. It is commonly said that this critical point is reached once there are no more green olives in the tree and the majority have changed colour. However, this Mediterranean rule can lead to harvesting the fruit with other than optimal timing when implemented under different environmental conditions. In the emerging Australian olive industry the optimal harvest time must be studied for each local environment. The results that we have obtained during the past seasons confirm that the external and internal colour of the fruit is not a good indicator for the optimal harvesting time.

It is important to point out that once the fruit reaches the optimal time for harvesting, the oil quantity remains almost constant. Despite this, it is possible to perceive that oil percentage per fresh fruit weight may still increase. However, the loss of moisture from the fruit falsely indicates a higher amount of oil, whereas really there is no additional oil that has accumulated in the fruit.

Hand harvesting in Australia

Harvesting Methods

Hand harvest

With hand harvest, the fruit is handpicked into bags or to nets around trees then collected into a crate. The fruit picked in this way typically shows very little damage and it is relatively free from foreign matter (soil, branches, leaves, etc.). This method is particularly suitable for table olives.

The main limitations of this technique are picking of the upper part of the trees and its cost and manual labour requirements. This technique is not limited to any particular tree shape. However, lower and wider canopies are best suited for the reasons stated above.

Hand harvest could also be complemented with semi automated machines. There are two main types of hand held harvesting equipment: Branch shakers and Combing machines. Both groups of machines can be powered by different kind of motors: 2T, hydraulic, air or electric.

Like with hand picking this technique does not have any limitation as regards tree shape. It can also speed up the harvest operation but at the expense of a larger proportion of damaged fruit and foreign material.

- **Hand harvest**
- **Trunk shakers**
- **Straddle harvesters with beaters**
- **Straddle harvesters with rotating heads**

Side-by-side trunk shaker operating in 5 year old trees

Trunk shakers

Most of the harvesting machines designed for olives during the past decades were based on shaking principles. The shaker can shake the main trunk or each scaffold branch separately; the fruit is then unattached and falls on a net or into a collecting device, which is part of the same machine.

There are several types of shakers but basically they can be divided into two main types: Stiff arm shakers and eccentric- mass vibrators or inertia vibrators. The first type consists of a stiff arm that links the branch, or trunk, to the shaker. The movement is unidirectional, wide and not frequent. The effectiveness is never higher than 80% of fruit removal. The second type generates its vibrating force by one or more eccentric masses (usually two in opposite direction). This vibrator is generating a centrifugal force, and needs a relatively small motor to generate its power.

This harvest system does not require any special tree shape, but it will function better if trees have a main trunk of 70-100cm high and scaffold branches are at an angle of 40-50°. Trees with large canopies, heavy cropping trees with low hanging branches or actively growing trees at harvest time often show poorer results with this kind of harvester.

The shaker in the picture below is a COE/Haslett side-by-side shaker. This harvester consists of two machines with sloping padded frames, which traverse either side of a tree row being harvested. One machine has a shaker head located beneath the catching frame. This catching frame overlaps past the tree trunk and delivers fruit to a conveyor system carried on the other machine which also carries a catching frame, elevator, blower and bin or bulk carrier. This kind of harvester harvested approximately 2,700 tonnes of fruit in 2007, which represents 5% of the Australian production.

Grape harvester working in 3.5 year-old trees (left) and detail of the picking mechanism (right)

Straddle harvesters with beaters

Trying to improve the performance of the previously described discontinuous systems, a new generation of continuous harvesting machines has been adapted from other industries or developed and used in many olive-growing regions. Grape harvesters have been one of the main initial choices, particularly for young trees where they continue offering good to optimal results, but they are normally limited to trees not higher than 2.5 to 3.5 meters or wider than 2 or 2.5 meters.

The New Holland®/Braud® grape harvester shown in the picture below has been used with minimal modifications. Its beaters are manufactured using a very flexible material and bent into an arc. The ends of the beaters are fixed both sides and are maintained at a constant distance from the centre of the machine. It has also a unique bucket collection system that consists of two conveyors, each with soft baskets in food-quality polyurethane. The system runs directly on stainless steel rails at a rate inversely proportional to the machine's travel speed. The grape harvesters picked approximately 3,200 tonnes of fruit in 2007, representing 6% of the Australian harvest.

A more specific straddle harvester developed for slightly larger olive trees is the Gregoire® 133V olive harvester. This over-the-row machine shows a flexible frame with 3.5-metre headroom. It has beating bars that hit the trees from both sides simultaneously and knock the olives onto a moving conveyor belt that transports them to holding bins which are emptied periodically at the end of the rows. This over-the-row machine has harvested 9,000 tonnes during the past season, which represents approximately 17% of the Australian crop.

Aerial view of a Colossus harvester working on fully mature trees

Straddle harvesters with rotating heads

An evolution of the previous straddle harvesters are the over-the-row harvesters with rotating heads. These harvesters could be considered as an evolution of machines operating on other industries such as coffee harvesters. There are some of those slightly modified coffee harvesters for specific olive harvesting in Australia. These machines are over-the-row spindle harvesters. The spindles have fibre glass vibrating fingers and rotate in the direction of travel at ground speed. These two prototypes removed 900 tonnes during 2007, adding up to 2% of the Australian crop. Much larger versions of these machines have been developed during the past five years. Colossus® is the most popular equipment of this kind with more than 23 units in Australia and several more in Argentina, USA and Spain. This large straddle harvester has been developed by MaqTec® in Argentina and it has been imported to Australia in 2003. Since then a number of improvements have been introduced and they are currently manufactured for the Australian market by MaqTec® Australia in Mildura under MaqTec® licence. This machine has been designed to harvest larger trees in an over-the-row configuration. Essentially, the Colossus XL harvester has a 4.9-metre by 4-metre rigid frame with spindle heads on a sliding structure, which can expand or reduce the passage width by manual control. This large straddle machine harvested 26,000 tonnes of olives during 2007 accounting for 48% of the Australian crop.

Other harvesting methods

Apart from shakers and new straddle harvesters, it was also possible to observe the emergence and evolution of other innovative systems based on different principles like the Hawke Harvester or the Racamba Olive Harvester.

Image of a modern olive grove pruned for continuous harvesting

Management for Improving Harvesting Efficiency

Grove design

There are several aspects of grove design that should be considered prior to planting, or afterwards if possible, in order to improve the overall harvesting efficiency in an olive grove. Designing your grove in such way that you leave enough turning/manoeuvre room for the harvesters and trailers at the end of the rows will be extremely critical to allow a free selection of machinery and to reduce the non picking time of the harvesters.

In a similar way, designing a grove with the largest possible rows and successive blocks of the same variety contributes to more efficient harvesting and more cost effective operations. Special attention should also be paid to the location of irrigation valves and other field structures and obstacles (e.g. power lines) so they do not interfere with the normal path of the harvesters.

If in doubt about the suitability of an olive grove for its mechanisation, it is usually a good idea to ask your machinery operator or harvester contractor to conduct a pre-harvest inspection to discuss the grower needs and to evaluate the grove's particular characteristics.

Tree spacing

When we consider the new Australian Olive Industry, we have to think about a modern olive growing model pursuing maximum profit with sustainable production methods. In order to achieve this objective, it will be necessary to obtain maximum fruit and oil yields, the highest price for the final product and minimal production costs. These yields must be achieved with consideration of environmental conditions and sustainability. Optimal profitability will not be achieved with yields alone. Quality throughout production management and the processing systems will have a strong influence on the final price. Furthermore, minimal production costs will be achieved only if mechanisation is adopted in a grove. This concept of modern olive growing is completely opposed to the idea of traditional olive culture, where horticultural limitations do not allow the grove to reach maximum and constant profitability. Even though yields may reach satisfactory levels, the limitations of introducing mechanical harvesting or pruning can mean that the olive grove is still uneconomic. This was the main reason why the traditional growing system of 100 trees per hectare with multiple trunks per tree has been replaced in new producing countries with an intensive modern model of 250 to 550 trees per hectare and single trunks per tree. Furthermore, during the last decade, a super dense model with the establishment of more than 1,000 trees per hectare has been promoted under the premises of high yields in the early years and the possibility of utilization of straddle harvesters already available in other industries. Like any other ideas, these advantages are also compensated for some disadvantages associated with high initial investment and difficulties in maintaining the small size of the trees.

Before analysing the models themselves, it is important to introduce the concept of optimal volume of canopy. Many scientific works around the world have proven that there is a single optimal volume of canopy per hectare that depends exclusively on the environmental conditions and is independent of the chosen spacing within certain limits. The optimal volume will be determined by a combination of climate, soil, irrigation and other management practices, and with this volume the grove will produce consistently high yields of high quality fruit. Average data from different olive growing areas of the world indicates that dry land groves can expect an optimal volume within a range of 6,000 to 10,000 m3/ha, while fully irrigated groves could support volumes between 11,000 and 15,000 m3/ha.

At full canopy size there will be no differences in the yields per hectare between an intensive or a super dense grove. The super dense grove will achieve these levels of production earlier but it will require earlier severe pruning interventions in order to control the size of the canopy affecting consequently the yields.

Without considering extremely wide spacings, it is possible to achieve the same optimal volume of canopy per hectare, and consequently yields.

The main advantage of higher densities is the possibility of achieving the optimal volume in a shorter period of time.

Consequently, the cost benefit ratio between earlier income and the higher costs associated with more trees per hectare, must be one of the fundamental elements to evaluate when deciding the planting density of a grove.

Various ripening stages of different varieties growing under the same conditions

Variety selection

There are many aspects to be considered simultaneously when deciding which will be the variety mix of our olive grove. Local information, productivity and oil or fruit quality are some of the most commonly evaluated elements. These aspects are certainly crucial for the future development of the grove but other facets may be analysed as well. Tolerance or sensitiveness to different pests, diseases or climatologic phenomena together with ripening periods are important points to evaluate in the final layout of the grove.

It is commonly accepted that large areas planted with only one variety is one of the weakest points in the traditional Mediterranean olive industry. The main consequences of this situation are an over sizing of the processing plants and harvesting facilities to cope with all the production being picked at the same time. A lower quality product is another result as a consequence of processing the fruit in a moment other than the optimal. New olive growing areas have the opportunity of avoiding this problem through an accurate variety mix selection including early, intermediate and late ripening varieties. However, lack of local experience or information is one of the main problems to deal with, for maturation process is strongly influenced by environmental conditions.

Modern Australian olive grove

Grove management

While different aspects of grove management (e.g. irrigation, fertilisation) will have a significant influence on the performance of the grove. A number of management practices can positively (or negatively) influence the outcome of harvesting efficiency.

Weed control along the tree row is probably one of the most important aspects to take into account. The presence of woody or large weeds can interfere with harvester sensors and catchment systems increasing the amount of losses and reducing harvesting efficiency.

Clean, well mowed inter rows are also a desirable situation as it will facilitate the work of the harvesters minimising driving errors, breakdowns and down times.

Tree training

Pruning is defined as a set of operations that can be used to control vegetative growth and fruit yields. These operations normally imply the removal of certain vegetative parts of the trees and/or the modification of their growing habits.

It is important to understand that pruning must not be considered as an isolated management practice in order to achieve balanced tree development. Irrigation and fertilisation have a strong influence on pruning results when trying to achieve a balance between vegetative growth and high constant bearing. Pruning, or tree training, is a complex practice and there is no single way to prune an olive tree correctly.

The main goal of pruning is to improve canopy efficiency. This objective is obtained through controlling the growth of scaffold branches, keeping a high leaf to wood ratio, optimising light interception and reducing eventual excessive crops, which can start an alternate bearing cycle.

Pruning techniques vary according to the chosen training system, for each of them requires specific manipulations. However, any rational method follows the same basic principles, which can also be also applied to other fruit woody perennials.

The objectives of pruning trees in full production are to: produce high yields of high quality, stimulate vegetative growth of fruiting shoots, maintain an adequate tree structure, prevent ageing of the canopy, eliminate dead wood, and improve air circulation and light penetration. Machinery for cultural practices and harvesting should have enough room to be moved without difficulties.

Pruning should be also aimed at maintaining the canopy within a size compatible with economical management of the grove. However, the expansion of the canopy in an adult tree can be restricted by pruning only to a certain extent, because size and vigour depend on genetic, climatic and cultural conditions. If the tree is pruned too severely, it will react with an excess of vegetative growth that will inhibit fruiting partially or completely.

The main operations routinely used for pruning mature trees are:
- Thin shoots in the upper part of the canopy;
- Identify the maximum height at which the tree will be allowed to grow and cut the main branches at the point of insertion of a secondary branch or mechanically top at the desired height;
- Eliminate suckers and water shoots;
- Shorten secondary branches to contain the lateral expansion of the canopy;
- Eliminate exhausted shoots and renew secondary and tertiary branches;
- Eliminate the vigorous shoots inserted with a narrow angle on the primary branches and those inserted at narrow spacing or overlapping;
- Remove damaged or dead shoots and branches.

The fruiting volume of the canopy is renewed by either thinning individual shoots, or by the suppression of entire secondary and/or tertiary branches. In modern pruning, the selective thinning of individual shoots should be kept to a minimum because it is extremely time-consuming and not cost effective.

Once we reach full canopy size pruning should aim to maintain this optimal volume of canopy per hectare according to figure 8.

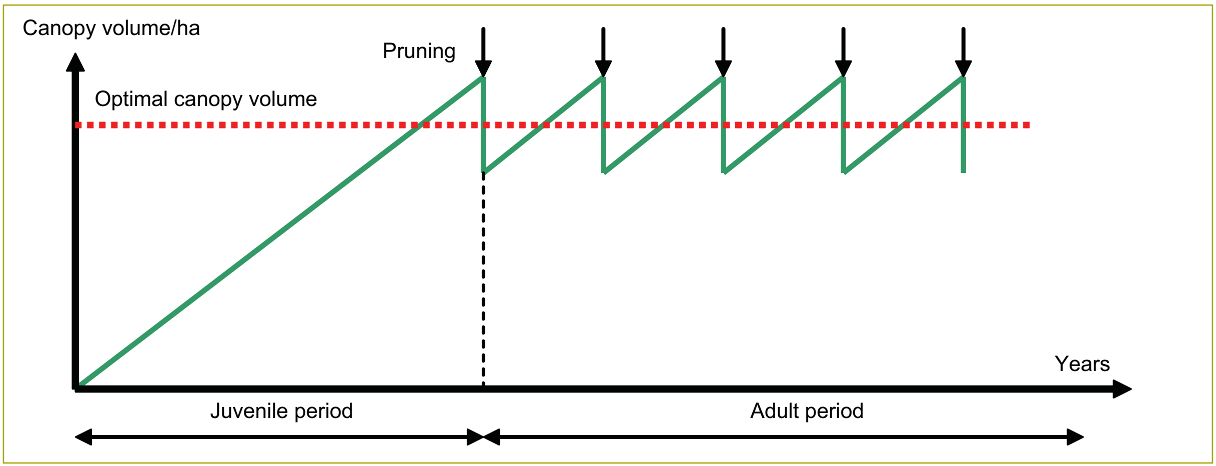

Figure 8. Graphic representation of an ideal case of canopy volume evolution and management

Fruit loosening agents

Overseas research in chemical loosening agents has lead to several trials undertaken in Australia (see RIRDC Publication # 08/052). These trials evaluated the effect of foliar treatments in weakening the FRF (Fruit Retention Force) and improving mechanical harvesting efficiency and economics. The advantages of products increasing fruit abscission could be of value for an earlier harvest, with the consequent improvement in oil quality, reduction of biannual bearing and increased efficiency of mechanical harvesting.

Statistical analysis of fruit retention force revealed there were significant differences between the treatments. Seven days after their application, all chemical treatments showed a clear decrease in the fruit retention force in comparison with the non treated trees. Untreated olive fruit showed a slower decrease in the fruit retention force than treated olives. The chemicals used were effective in reducing fruit retention force from application time to harvest. Maximum effect of agents occurred, in general, between two to three weeks after application.

Fruit and leaf drop, after three counts over the trial period, resulted in no substantial losses in either fruit or leaf when applied in non stressed trees. Leaf losses showed significant differences between treated and not treated trees but in most cases they were below acceptable limits. It is important to highlight that reports of severe defoliation (> 25% leaf drop) have been received from groves where ethephon has been applied at higher than recommended concentration or on severely stressed trees.

Harvest efficiency was measured according to the percentage of fruit mechanically removed, knowing the actual yield before harvest and then hand harvesting and weighing the remaining fruit in the tree.

The evaluated fruit loosening agents (Ethephon and mono potassium phosphate (MKP)), when applied at correct rates,

Equipment spraying fruit loosening agents prior to harvest

times and conditions, showed a positive effect on decreasing the fruit retention force and on increasing harvest efficiency. This efficiency is reflected in larger fruit removal percentages and the possibility of harvesting faster, reducing the length of harvest, its costs and risks associated with late harvest (Frost damage, biannual bearing).

Fruit loosening application is a potential aid in the harvesting of olives, especially at a time of high cropping levels, or when harvesting greener fruit earlier in the season, or to lower the FRF on certain varieties that prove difficult to harvest, for example Frantoio, Koroneiki and Arbequina.

Being a hormonal product, there is always a potential risk of undesirable fruit losses and/or defoliation. Consequently, growers' education as regards to the use of this tool will be absolutely essential to avoid negative effects.

If growers are to use the approved fruit loosening agent, Ethephon (contains 480g/L ethephon as the active ingredient), they should refer to the APVMA Minor Use Permit #PER9153 for appropriate application rates (i.e 0.01-0.02% or 0.05% + MPK 3% + 0.7% non-ionic surfactant).

During the fruit loosening trials, it was the experience of the grower involved that the chemical had a negative impact on stressed trees and should not be applied when this is the case.

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Shade cloths placed under the tree to measure fruit drop from the harvester during the QA process

Quality control on harvesters

The continuous control on the work performed by the harvesters is extremely important in order to improve and/or to maintain acceptable efficiency levels. The grower should visually inspect the performance of each harvester. In order to do this inspection, the grower would drive past a minimum of 500 m of inter row (Approximately 125 trees long) that have been harvested during the each shift. While driving, the grower must carefully check the trees at both sides paying special attention to the following aspects:

- Tree damage (Trees being pushed over or seriously ringbarked).
- Canopy damage (Number of broken branches).
- Fruit losses through the catchment system.
- Fruit left on the trees:
  - Top of the trees.
  - Skirt of the trees.
  - Front and back of the trees.
  - Inside the canopy.
  - Outside the canopy.

All observations could be rated with numbers ranging from 0 to 5. These numbers would have the following meaning based on the different kind of observations.

Tree Damage:

0: No damage observed in the entire drive.
1: One damaged tree observed.
2: Two damaged trees observed.

3: Three damaged trees observed.
4: Four damaged trees observed.
5: Five or more damaged trees observed.

Canopy Damage:

0: No damaged branches observed in the entire drive.
1: One damaged branch every 40 trees or more.
2: One damaged branch every 20– 9 trees.
3: One damaged branch every 10–19 trees.
4: One damaged branch every 5–9 trees.
5: Damaged branches in almost every tree.

Catchment Efficiency:

0: Almost impossible to see fruit under any tree.
1: Only one every 20 trees show some level of fruit on the ground.
2: Fruit noticeable only around most trunks.
3: Fruit noticeable around every trunk and other areas under most trees.
4: Fruit noticeable around every trunk and other areas under all trees with discontinuous patterns.
5: Fruit noticeable around every trunk and other areas under all trees with a continuous pattern.

Harvest Efficiency:

0: Almost impossible to see fruit in any tree.
1: Only one every 20 trees show some significant level of fruit left.
2: One every 10–19 trees show significant fruit left.
3: One every 5–9 trees show significant fruit left.
4: One every 3–4 trees show significant fruit left.
5: Almost every tree shows significant fruit left.

In all cases, levels of 0 or 1 did not require any action. A level 2 observation indicates a warning sign while a level 3 observation or higher would require a corrective action.

Direct measurements

Visual Inspection should be complemented with sampling direct measurements to provide hard evidence of the harvesting efficiencies.

In order to do these observations, 2 average trees per harvester and shift will be harvested after the mechanical harvest went through them. Fruit left on the ground will be collected and weighed first. Setting up shade cloth under the trees before the harvester will make the operation faster. After that, fruit left on the trees will be picked and weighed. Fruit left on the trees and dropped on the ground will be compared vs. the expected crop for the block and/or the actual yields achieved in that area to determine harvesting and catching efficiencies.

When a difference of more than 20% occurs between visual observations and direct measurements occur, the grower will need to double check that area to re-confirm the accuracy of both and to confirm the final result.

Conclusions

Harvesting efficiency is defined as the ratio between the fruit that is effectively harvested and delivered to the processing plant and the fruit that was originally on the trees. It is extremely important for all growers to try to maximise this efficiency and to lower harvesting costs.

The most critical things that will need to be considered in order to achieve this are:

- Determine the optimal harvesting period based on the maximum oil content in the fruit of the different varieties in the grove.
- Try to harvest each variety within 2-3 weeks of that moment.
- Evaluate and, when possible, modify the grove design to suit harvesters' needs.
- Prune the trees according to the selected harvest method.
- Evaluate the possibility of using fruit loosening agents if dealing with high FRF, heavy crops or excessively green fruit.
- Set up realistic benchmarks and carry out a careful continuous evaluation of the harvesters' performance.

Guide to Efficient Olive Harvesting

by Leandro Ravetti
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This *Guide to Efficient Olive Harvesting* provides olive growers with information to help them to achieve improved harvest efficiency.

The Guide discusses optimal harvest efficiency options for the full range of mechanisation and scales of operation experienced by growers in the Australian environment—from hand harvesting to large scale operations.

It also has information on the theory and practice of harvest efficiency, including the physiology of the olive tree, grove design and management and thhe range of options of mechanisation.

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