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STUDY OF HARVESTING METHODS AND NECESSITY OF OLIVE HARVESTING ROBOT

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ABSTRACT: The optimization of harvesting methods is related to the goal of reducing costs of production of olive oil and table olive in Europe. To compete with the overseas producers (whose pricing structure is influenced by various subsidies) European producers must be able to produce good quality olive oil at around $4.50 liter and table olive. To achieve this, Europe must be able to harvest quickly at the ideal time of harvest and cost effectively (around 5-10 cents/kg of fruit or 30-60c/ liter of oil), the only way to archive all those needs is the use of a harvesting robot.
Keywords: agricultural industry, olives, production, collects, seasonal

1. INTRODUCTION

Disregarding hand harvesting (where the cost of labor makes Europe very uncompetitive i.e. 8c/kg in Argentina vs. 80c/kg in Europe) and hand held harvest aids such as pneumatic rakes (which may reduce costs but not significantly).

Modern olive harvest for the olive canning industry still relies on hand picking as the primary means of harvest. Since canning olives are picked green for maximum firmness and require delicate handling to preserve their cosmetic appearance, hand picking is the most effective and efficient mean of harvest. Green olives cling too tightly to their stems to be swatted or shook and olives can bruise when they fall on the ground.

Therefore, pickers working in the canning industry carefully remove the olives from the tree and place them into a lug box, or picking bucket, as illustrated here (Figure1).

Figure 1. Olive trees in plantations

2. OVER-THE-TOP HARVESTING

A variety of harvesters with parentage in grape harvesters or coffee-type harvesters, are in commercial use or are being trialed around the world.

The advantages are:

≡ Continuous harvesting (forward moving down the row without stopping), which is:
  = Faster than shakers; up to 10 tone/hour on super-intensive (eg. 2x5m) groves and 300 trees/hr plus.
  = Lower cost per kilo harvest (a range from 2c/kg to 25c/kg has been recorded with 5c/kg being a good budget figure)
≡ Higher percent fruit removal;
≡ One passes only;
≡ Highly effective on young intensively planted groves and dwarf varieties;
≡ Suitable for large-scale intensive groves in early years.

The disadvantages are:

≡ Less cost effective on plantings smaller than 350/ha;
≡ Tree vigor must be controlled; will not harvest older or bigger, vigorous or woody trees;
≡ Pruning must be carefully planned to maintain appropriate shape and size;
≡ Not able to harvest olives for table fruit;
≡ Takes all fruit at once regardless of fruit maturity;
≡ Very large machines for transporting;
≡ Very expensive machines;
≡ Heavy machines and in consequence problems of soil compaction; must have matching oil processing capacity to handle up to 10 tone/hour with one harvester;
≡ Not suitable for many European groves over 4-6 years of age;
≡ Not suitable for other crops.

Certain trees have too wide base to be harvested with the Shaker and Receiver combination. In these cases, the OMC Shockwave Shaker shown here is an ideal tool. The OMC Shaker was designed for harvesting nut trees, most commonly almond and walnut trees. The OMC Shaker employs a shaking clamp attached to a maneuverable boom. This boom has a reach of almost twenty feet and can be used on very large trees. This flexibility, coupled with its distinctive appearance and the rattle-like sound it emits, makes this Shaker a very impressive sight to see in action. When we harvest with this shaker, we have to use tarps to catch the olives instead of the receiver. The sight of the olives falling from the shaking tree is reminiscent of a slot-machine paying out a jackpot.

3. TRUNK SHAKERS

Traditional trunk shakers came out of the nut industry (pecan, almond, etc.). Most of these shakers have been specifically designed for nuts that are harvested off the ground, so modifications have been required for the olive industry. It is not possible to maintain oil quality if harvesting off the ground. The additions of catching frames, conveyor belts, leaf removal and fruit receive facilities need to be made, to handle fruit efficiently. However, these additions slow down the operation and increase the running and maintenance costs.

There are many different shaker head designs with various weights, amplitudes and frequencies. Nut shakers in general are designed for lower frequency, high amplitude shaking. With deciduous crops for nuts, the bark hardens right up at leaf senescence as coming into winter. Evergreen trees such as olives and citrus have relatively soft bark right through winter. In particular, with olives, some of the earliest maturing varieties may such as Leccino and Manzanillo may start harvest in March in Europe when ambient temperatures are still high. These varieties are very susceptible to trunk damage.

The key attributes of an efficient shaker head for olives are:

≡ High frequency; around 30 hertz
≡ Low amplitude
≡ Quick wind up and wind down to prevent trunk damage

The advantages are:

≡ Can shake larger range of tree sizes (trunks over 6-10cm through to fully grown trees);
≡ Gentler fruit removal in many cases, with less broken fruit (oil quality issues);
≡ Can shake twice for optimum fruit maturity;
≡ Capable of harvesting table fruit;
≡ Less expensive;

- Smaller machines for transporting etc.;
- Lighter machine so less soil compaction and better after rain;
- Recent designs incorporate forward moving/sideways shaking arms to increase speed;
- Suits most of the tree spacing in Europe;
- More cost effective on lower planting rates;
- Suits the current oil processing plants' capacities (1-4 tone/hr);
- Suitable for other nut and tree crops.

The disadvantages are:

- Slower (170-200 trees/hr is around the limit);
- More expensive per kilo;
- must have skirt of tree lifted by pruning;
- Trunk damage more likely if machine not set up properly;
- Lower and variable fruit removal efficiency depending on design and fruit ripeness (average 60-90%);
- May require two passes 2-4 weeks apart;
- Not suitable for super-intensive/intensive grove designs (eg. 2m spacing) or young trees with small trunks (less than 6-10cm diameter);
- Require more machines for large-scale operations.

Examples of machines include Pellenc, OMC, Lymin Coe, Verdegiglio, De Masi, RPR and Express harvesters.

The Shaker pulls up to the left side of the tree, in this case an Ascalano that is similar in structure to a prune tree, clamps on to the tree, extends the telescopic frame, and begins to shake the tree relative strong. Olives that fall from the tree are directed to a conveyor belt on the receiver.

4. THE FUTURE

There is little doubt that the forward moving continuous harvester is the ideal harvesting method (as the wine industry has highlighted). The problem is the olive tree. The olive tree is a relatively large tree and is a very vigorous tree when taken out of its traditional "tough" environmental conditions and placed in modern irrigated orchards. Dwarfing rootstocks, dwarfing viruses and breeding small less vigorous varieties: methods which are all used in industries such as pomes and stone fruit production have so far been relatively unsuccessful in the olive industry.

Due to the economical and social importance of olive trees, it is necessary to design and manufacture an olive-harvesting robot, thus eliminating human operators, which are employed in large numbers for a limited time. Consequently, harvesting costs decrease, this being reflected in the final product.

An additional arm is necessary, fitted with a net to collect the olives which fall off the trees and with sensors which will allow it to position itself under the braches shaken by the shaker. A trailer is also necessary, to store the harvested olives. The navigation system can be autonomous, using the global positioning system, or remote-controlled by a human operator. It is powered by electricity from batteries, which are recharged at the end of the day.

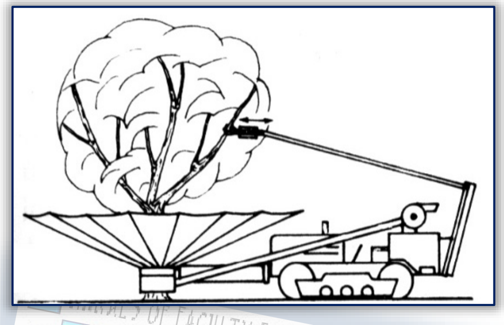

Figure 2. Olive shaking robot

The olives are harvested by shaking the olive tree branches. This robot (Figure 2) can operate autonomously, the greatest advantage in this case being the elimination of the human operator, and therefore higher productivity, but also extremely high development and manufacture costs for such a robot, or it can be remote-control operated. In the latter case, a human operator is necessary to operate the system. The robot will be fitted with two video cameras, one used by the robot to move around the plantation, and the other to recognize the olives and shake the tree branches. This robot should be designed with a built-in olive storage bin. It will have a mobile platform fitted with a shaker arm, which will have a sensor to detect the branches and the olives.

5. CONCLUSIONS

Europe's success will depend on mechanization in harvesting and pruning in large-scale groves. Europe has the benefit of irrigation, suitable climates and large-scale groves on flat terrain to enable efficient mechanical pruning and harvesting.

Developing or importing suitable trunk shakers and over-the-top harvesters is the future challenge for European growers. A major investment in harvesting equipment is required in Europe over the next five years. Assuming that 11 over-the-top harvesters and 30 shakers are required for the existing groves (Harvesting Workshop figures) then an investment of approximately $10-12 million in harvesters and another probably 50% of this expenditure in ancillary equipment, trucks, forklifts, bins, training personnel etc. will be required. Additionally the oil processing capacity of the industry will need to match the harvesting capacity eg.10 tones hour harvesting potential requires 10 tone/hour oil processing capacity. In other words, for every harvester, there is a requirement for another 10 tone/hour processing line. This will require an additional expenditure of approximately $40-50 million in processing.

Breeding of suitable varieties for mechanical harvesting is also important for the future progress of the industry. The major olive growing countries are increasing research expenditure in this area; with the emphasis on breeding small trees with high regular fruiting, good oil quality and disease resistance. Europe could also be involved in this breeding because of the suitability of most of the world's varieties to European climatic conditions. However, it may take 10-20 years to breed these ideal varieties.

Meanwhile the harvesting needs of existing groves in Europe must be met. For most groves that were planted 4-6 years ago on 8x5m spacing, efficient trunk shaking seems the most suitable harvesting system. The challenge is to have a trunk shaker/harvesting/collection system that does 3 trees/minute i.e. 200 trees/hr and 50kg/tree with 10 tones fruit/hr. At present, the overseas harvesting systems that are fast enough to be viable in large groves are very expensive to purchase because of our exchange rate.

For the large scale irrigated, intensive groves that have been planted since 1999, the most suitable harvesting system is likely to be the over-the-top harvesters. The present capacity of the over-the top Gregoire harvesters in the super-intensive Arbequina groves in Spain is 10 tone/hour at 0.5ha/hour. The present restrictions are the vigor of the trees, particularly their size at 6-10 years of age (or less in warmer climates) and the challenge is to be able to prune the trees to restrict the woodiness and size.

In summary, the European Olive Industry must focus on pruning and harvesting to be able to produce high quality oil at world competitive prices i.e. $4.50/L or less. Individual growers must choose the harvesting system they intend to use and rapidly apply the requisite pruning techniques.

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