Hazelnut Collection, Calibration and Shelling

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Abstract

Manual harvesting is the most limiting operational handicap for the expansion of hazelnut cropping in Portugal, but importing equipment is not a realistic alternative because it is very expensive and is not adapted to Portuguese hazelnut orchards.

In an attempt to overcome this shortcoming, a small-sized and low-cost equipment is being developed for mechanical harvesting and two others were prepared for calibration and shelling, all within the scope of an AGRO 162 project called "Yield increase of hazelnut crops in Portugal".

The hazelnut harvesting equipment is composed of a hopper, a four-stroke engine, a ventilator, two flexible tubes for conveying the draw-in material and a wheelbarrow required to drive the assemblage. The calibrator is built with three iron sieves mounted in a sloping position to allow the hazelnuts to roll. The shelling equipment is essentially made of a metallic roll driven by an electrical engine, with two rulers, positioned in accordance with the generating roll, that compress the hazelnuts against a wood ruler. The distance between the roll and the wood ruler can be adjusted.

The trials on hazelnut harvesting allowed us to obtain a work rate of between 23 to 40 h/ha, depending on the conditions of the test. The calibrator was designed to obtain four different lot sizes. The shelling equipment performances depended greatly on the size of the lot, the best results being obtained with the biggest hazelnuts.

To summarise it can be stated that this harvesting equipment is a reasonable solution for low acreage orchards, where a low work rate is allowed, due to its low price. The shelling equipment provides a good percentage of shelled hazelnuts in the upper lots, but in the lower ones it is necessary to do more than one shelling operation; this limitation can be reduced with the incorporation of more sieves to get more lots of small hazelnuts.

INTRODUCTION

Hazelnut orchards represent an important aspect of the agriculture of northern Portugal, but the low prices of foreign hazelnuts together with the high labour costs, in particular due to the lack of mechanization of certain cultural operations, namely harvesting, have contributed to the diminishing hazelnut crop growing area.

After analysing some foreign harvesting equipment, we still had not found the right solution for most Portuguese hazelnut orchards, as the small machines are hard to operate and have a low work rate, hence increasing labour excessively, and the biggest ones are too expensive and would have problems going through the trees.

With the purpose of lowering production costs, making the harvest labour tasks easier, and facilitating the equipments' use in the orchards, we decided, in the scope of the AGRO 162 project "Yield increase of hazelnut crops in Portugal", to invent some simple equipment for the harvesting, calibration and shelling of the fruits.

MATERIAL AND METHODS

The Hazelnut Harvester AGRO 162

Manual harvesting is becoming a much less used operation because of its low work rate, 6-8 kg/h (50-60 kg/day), which causes an excessive increase in production

costs. The work rate can be improved by assembling the tree productions in piles, or strips or by putting traps under the canopy, but these solutions are only suitable for countries with cheap labour.

For mechanised collection there are several kinds of machines whose use depends on the kind of orchard, especially the tree training, distances between trees, soil characteristics, etc.

Analysing the different available options for collecting hazelnuts, either the manual or the mechanised systems, and considering the Portuguese orchard characteristics, we decided to develop equipment with the following characteristics.

1. Machine Description. The hazelnut harvester AGRO 162, shown in Fig. 1, is a vacuum harvester basically built with a hopper, a four stroke engine, a ventilator, two flexible tubes for conveying the aspirated material and a wheelbarrow to allow the operator to move the set.

The hopper is part (2/3) of a 200 L tank, where a bottom door can be opened to remove the material deposited inside the tank and where, in the upper part, there are two air inlets which are connected tangentially to the two flexible aspiration tubes.

The four stroke combustion engine has 6 hp at 3000 rpm and was taken from a cutter bush.

The ventilator, 42.5 cm in diameter, is in cast iron, and has 8 horizontally-positioned blades. It is mounted off-centre in the engine shaft; inside a carter, with one hole connected to the hopper and another tangentially to the outlet for the low-weight aspirated material.

The aspiration tube, which is 12 cm wide and 3.5 m long, has an aluminium tube with a handle on the upper part, to be held by the operator.

The equipment is easily transported since its weight is mainly supported by the wheels of the wheelbarrow. At first the equipment was mounted on a tractor but this made it too noisy, more expensive, and more time consuming to move.

2. Management. The engine, positioned at the operator's arm-level, is started up manually and works at high speed. The tangentially-connected tubes, allow the heavier material, due to friction with the hopper walls, to deposit in the hopper bottom, while the lighter material is transported to the outside.

It is important to leave the bottom door open a little in order to aid the removal of material, the rising air blowing light material towards the ventilator carter; this opening does not significantly reduce the suction power.

3. Harvest. In hazelnut harvesting the work rate is significantly improved when the ground is even, dry and clean, hence preparatory work to achieve these conditions is advisable. Unevenness in the soil alters the distance between the aspiration tube and the fruits, changing the suction power. Wet soils make hazelnut suction more difficult and causes the aspirated soil to settle inside the tubes and hopper, further decreasing the suction capacity. Contact of the aspirated material with the soil deposited inside the hopper increases friction, causing such material to be deposited in the hopper, thereby increasing the amount of unwanted debris.

Grasses, especially the gloves, make it more difficult to see the fruits, and the tube end also gets stuck in the vegetation, complicating the operation still more; this situation occurs mainly in the presence of gramineous weeds.

As for the methodology used in the hazelnut harvesting, which could lessen the work rate, several trials were carried out under different conditions, being especially important to display the material in one, or two bands, between rows. The stripe, that can not be very compact, makes the work more easily, because it is not necessary to work close to the trees, a task which is particularly difficult in bunched plantations (multistem bush), which is the species' natural tendency of growth, used in a great number of Portuguese orchards; the long-handled rake used to strip the material makes its use easier. The string mesh allows separation of the different material, retaining leaves at this level and letting the fruits pass through. This acts as a preliminary leaf remover, increasing the fruit harvesting work rate.

Not striping the material involves the aspiration of all the ground surface, with decrease of the working rate and an increase of the aspiration of land, little stones and vegetable debris; in this situation it is important to work from the middle of the space between rows to the trees, to avoid fruit damage.

Calibrator AGRO 162

1. Machine Description. The calibrator is built with three iron sieves mounted in a slope, positioned to allow the hazelnuts rolling; the sieves, shown in Fig. 2, can be mounted in two positions, according to hazelnut roundness. If the hazelnuts roll easily in the sieve we can mount them one under the other but, if not, it is better to mount one after the other, because it is easier to move them with a rake.

If the sieves are mounted one after the other, it is advisable to adapt a cloth structure, in funnel shape, to conduct the hazels to boxes, preventing them from falling on the ground.

2. Management. Hazelnuts are deposited in the upper sieve, which allows the fruits smaller than the distance between separators to falling or rolling down, to the next sieves, until they reach their boxes.

The lot formation is essential because, only this way, it is possible to adjust the shelling machine to crack the shell without breaking the kernel; the bigger the fruit kernels are, the higher will be their sales price.

The Shell Equipment AGRO 162

1. Machine Description. The shell equipment is built, basically, by a metallic roll, with two round metallic bars positioned according the generating roll, driven by an electrical engine, which shrinks the hazelnuts against a wood ruler. The distance between the roll and the wood ruler is adjusted according to the lot dimension; the round metallic bars, welded to the metallic roll, help the hazelnut transport to the region shrink.

The transfer from the electrical engine to the roll is reduced to ± 50 rpm, which was the speed that allowed to get a considerable rate of undamaged kernels and a high equipment debit; the possibility of changing the rate transmission will be very important as it allowed to adjust the regime to the different hazelnut sizes, but a gear box or a hydraulic transmission will raise the equipment price.

In the bottom the hopper has an adjusted opening to change the hazels amount carried out to the shrink zone and the lateral bottom parts are slopped to avoid the hazelnuts from staying there.

2. Regulation. The adjustment of this equipment achieves the right distance between the roll and the wood ruler. At the start the distance corresponding to respective sieves is used and, by gradually changing the distance, the biggest percentage of shelled hazelnuts and the lowest of broken kernels is reached. This approach is done turning a crank that allows the wood ruler approach the roll.

For smaller lots, shell removal is improved when it is done in two or three steps, so that the hazelnuts not unshelled after the first time are placed in the hopper again and the distance between the wood ruler and the metallic roll is shortened. This process takes more time, but it improves the amount of shelling fruits, and its interest should be analysed for each situation, especially for the smaller lots, where the shell crack without damaging the kernel is more difficult.

RESULTS

The available results refer only to one trial year, they must be faced with some care.

Hazelnut Collector AGRO 162

Tests realized in good conditions, with the material spread on the ground (not stringed), allow to get times of 3-4 min/tree with ± 2 kg/tree production. Tree spacing was 3 x 5 m which corresponds to 33-34 h/ha, only to the collection and, for an average

production of 1,335 kg/ha (667 trees ± 2 kg/tree), to empty the hopper, when it has ± 30 kg, are necessary more than 2-3 h/ha (1,335/30 x 3min), as an average of ± 3 min is needed to empty it. Total collection time, considering the factors mentioned and the time to fill the engine tank, is estimated in ± 40 h/ha.

In tests realized in hard conditions (wet material), with strings of ± 1.5 m width, we had collecting times from 10 to 15 min, for 20 m string length. The production was not measured, as a manual collection was done before. At a 3 x 5 m tree spacing, which corresponds to a 2000 m string, under the most difficult circumstances are necessary (15 min/20 m) ± 25 h/ha for collecting, which corresponds to a total time of ± 30 h/ha; while under the best circumstances are necessary 17 h/ha (10 min/20 m) for collecting which correspond to a total time of ± 20 h/ha.

Calibrator AGRO 162

The incorporation of one more sieve, to get one more lot for the smaller hazelnut, allowed to increase the percentage of shelled fruits with only one operation. One more shelling operation can be done, shortening the distance between the wood ruler and the metallic roller, to shell the smaller nuts.

The precise distance between the metallic roller and the wood ruler is fundamental to get good shelling results as the lot scope size must be as uniform as possible.

Shelling Equipment AGRO 162

The lots of the biggest hazelnuts are easier to shell as there exists some space between the shell and the kernel.

CONCLUSIONS

As main conclusions we can point out:

- The hazelnut orchard conditions are essential to get the best performance of the harvest equipment.
- The vacuum hazelnut equipment is a cheap machinery that improves significantly the harvesting rate, especially when the material is previously stripped.
- The performance of calibrator equipment, to get homogenous lots, is determinant to the shelling equipment.
- When the standard size deviation is high, it is better to shell the hazelnuts several times, beginning with the high metallic roll - wood ruler distance, diminishing the distance each time.
- The smaller hazelnuts are, more difficult is their shelling as the kernel is close to the shell;
- Better performance of these equipments is basic to keep Portuguese hazelnut orchards going.

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Tables

Table 1. Average hours/per ha for hazelnuts harvesting.

	Stripped material		Not stripped material
	Good conditions	Bad conditions	Good conditions
Collection	17	25	34
Empty the hopper	3	3	3
Others (fill the tank)	3	5	3
Total	23	33	40

Table 2. Calibrator dimensions, in mm.

	Lot 1 (< 14 mm)	Lot 2 (14-16 mm)	Lot 3 (16-18 mm)	Lot 4 (> 18 mm)
Minimum	10.92	14.28	16.19	17.89
Maximum	14.72	17.58	19.12	22.56
Average	13.75	15.91	17.23	19.65
Standard deviation	0.72	0.68	0.56	0.97

Table 3. Average results, in %, with the shelling equipment.

Lots sizes (mm)	Intact hazelnuts (%)	Shell hazelnut (%)	Broken kernel (%)
> 18.0	10	85	5
16.0-18.0	5	80	15
14.0-16.0	15	70	15
< 14.0	10	65	25

Fig. 1. Hazelnut harvester AGRO 162.

Fig. 2. Calibrator AGRO 162.

Fig. 3. Shell equipment AGRO 162 and shelled hazelnuts.