Optimized design of a simplified interceptor for olive harvesting

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Abstract
It was been designed and realized a simplified interceptor system with olives harvest nets, to use during the olives harvesting phase for existing olives tree-plant on small surfaces. Such equipment complied to the design requirements of: inexpensiveness for investment and operative use, machine working in continuous, with possibility to use it for other similar crops, minimum employment of workman (an operator). The machine was constituted by a rectangular base climbed on wheels and hauled. It was surmounted by a grate that allowed the sieve of the olives and by a cage of nets, with form of trunk of inverted pyramid that, sustained by mechanically driven bars, succeeded in surrounding the tree locks. The machine tangentially worked to the trees trunks along the convenience order of the olive-tree-plant. By mean a pneumatic command, two telescopic bars that sustained the nets, escaped, so that they surrounded the whole tree trunk, in few second. At this point the shaking phase began. The olives harvested, by mean the inclination of the planes formed by the base nets, they went in the grate impending the tank of the considered machine, and therefore they were collected in the vain underlying. During the performed experimental tests, the detected losses on soil have practically almost been void. Finished such phase, reversing the pneumatic command, the return in initial condition of the nets was had, that is, they were displaced on the right broadside of the considered machine, and it was ready to be reallocated, under the following tree.

Keywords: nets for olive harvesting, olive interceptor, olive mechanical harvest.

Introdution

Today it is very important the interest to have agricultural productions on marginal soils located in particular sites, where the typical products obtained, by mean particular crops, can be exalted (Montedoro F., Servili M., Baldioli M., Pannelli G. 1991); (Vieri M., 2000). Among all, they result of notable importance the revaluations of agricultural sectors and the cultivation of soils until now uncultivated, able to assure an alternative source of income (Tombesi A., Guelfi P., Nottiano G.,1998), (Tombesi A.,2001).

A case of this type is represented by the cultivation of the olives tree plant, also whereas such tree plants are located in parks and therefore they represent, for law, an irreplaceable crop, and therefore they constitute , by a determined point of view, a "forced crop". Besides, such crop in some zones is in "way of abandonment", because of manpower high cost, that is besides in continuous increase, and of the little dimensions of the fields and their high slopes, that have not allowed any sort of agricultural mechanization.

Whereas it continues to be performed, the problem of the mechanical harvest of the olives has to be faces, (Formato A., Romano F. ,2003); (Giametta G.,1975);(Giametta G.,2001); (Liguori A., Formato A., Amirante M.,2000); (Parchomchuc P.,Cooke J.R.,1972); (Tsatsarelis C.A., Akritidis C.B., Siatras A.,1990); and it is more and more pressing because of the reduction of the available manpower, with exorbitant costs and the too much long times

required for the harvest phase, that negatively engrave on the inexpensiveness of the production as well as on the quality of the final product. The diffusion, in this last ten years, of machineries that aid the olive harvest, it has in part solved these problems (Stefanelli G.,1971); (Vieri M., Bazzanti N., Toma M. ,2001); (Vitali G. ,1967).

Unfortunately, there is still now, the critical phase of collecting the product mechanically removed by the trees, that involves long and fatiguing times for the use of the nets on the soil to complete the olives harvest. An alternative is constituted by enough simple and not expensive machineries that facilitate the manual layout and the pick-up of the nets from the soil, but it remains the necessity of manual operations for the layout and the rewinding of the nets, with relative increase of the operative times. Moreover, in the case (the most frequent) to use machineries aiding the harvest, it is not avoided the risk to stamp on the olives falls, and to damage the quality of the obtained product.

Finally, since the nets are positioned on the soil, however wide, they offer scarce interception to the olives tangentially bounced by the vibrating machines. Besides the interception can result difficult under numerous conditions with the nets not in plain, when, the nets are positioned on soils with high slope. More recently, machineries able to spool the tree locks with a special inverted umbrella, are available on the market and able to carry the product harvested in containers. But the complexity and technological sophistication of such machineries make them rather expensive for small or medium farms, indeed it remains exclusive appanage, because of the high cost, of great farms or of specialized operators.

With the scope to contribute to solve the problem above mentioned during the olives harvest for crop on small surface, an optimized design has been performed , (Pahl G., Beitz W.,1996) (Ulrich, K., Eppinger, S.,2003), to realize a prototype that complied to the following requirements:

1) inexpensiveness of investment and operative costs;
2) machineries working in continuous, with possibility to use the equipment also for other similar crops;
3) minimum use of manpower (an operator);
4) increasing of profitable for the picked product in comparison to that obtained with manual harvest.

To comply to such design requirements, it has been proposed as solution, a very simple equipment inexpensiveness to be realized, as well as simple to use, that eliminated the manipulation of the nets on the soil, that was able to perform the positioning, intercepting, stowing and transporting of the picked product in rapid times.

Materials and methods

The equipment was formed by a system of interception constituted by harvesting nets moved by mean pneumatic pistons. The machinery was constituted by a rectangular basis, with a stake body, climbed on wheels and hauled. It was surmounted by a grate that allowed the sieve of the olives and by cage of nets, with a form of trunk of inverted pyramid, that, sustained by mean bars driven mechanically, succeeded in surrounding the tree locks.

The left side of the machine acted as static support for the nets; the right one, was instead an asset, and it was the peculiar nucleus of the considered equipment. The machine tangentially worked to the trees trunks along the most convenience order of the olive-tree plant. It was parallelly hauled to the tree rows, and it already resulted in position when the central part of its right side coincided with the tree trunk axis considered. At this point, by mean a command, was activated an air-compressed distributor, and two telescopic bars that sustained the nets were moved.

Contemporarily, by mean the same mechanical movement, two supports moved and they arranged in vertical position. They were hinged at the extremity of the telescopic bars, that supported the nets cage, in way that, they surrounded the whole trunk. The whole phase developed in few second and therefore the machine immediately can work. (fig.1,2,3)

Figure 1. Machine with nets rewinded

Figure 2. Machine with nets in operative conditions

Figure 3. Machine during the working phase

At this point the olives shaking and harvesting phases began. By mean the slope of the nets, they were carried in the grate, above the stake body, and therefore collected in the volume underlying. Completed such phase, reversing the pneumatic command, the unfolding of the nets is had, and they were rewinded in the right broadside of the machine. Indeed the considered machine was ready to be transferred, under the following tree.

The considered equipment is composed by:

- A base with a stake dump body, with hydraulic hoist, in plate placed on the loom with two wheels and a rudder with hooking device to allow the towing,
- a system of elastic connecting rods and 3 nets for the olive interception,
- two pneumatic pistons (pneumatic jack), jointed in parallel with a small compressor, with voltage of 12Volt, installed on the tractor
- hydraulic jack for the stake dump body turnover.

The loom has been designed by mean the aid of the computational codes pro/E 3.0 and ANSYS 10.0, that have allowed to perform an optimized design of such equipment, and they have also furnished the quoted constructive sketches for the considered equipment.
Geometry was similar to that of a common agricultural wagon with some changing ones:

- it was formed by 3 steel longerons (two longitudinal and one in cross direction).
- absence of the wheels axle, that were located on independent supports.

Further there was a longeron for the reinforcement of the loom, between the wheels supports to decrease the encumbrances under the stake dump body. The dynamic analysis of such design artifice was been verified by mean the computational code ANSYS 10.0

- the drawbar had a telescopic device and it was fixed on the loom with an hinge that allowed to rotate it so that to allow the off- set towing. This shrewdness allowed tractors with high outline to move in the center, between two trees rows, while the machine is hauled under the trees locks.
- the oleo-dynamic jack for the overturn of the stake body is in foreword position and that it avoided encumbrances in the centre of the loom so that to allow the use of the large stake body with regular fund. It was opportunely been designed and verified by mean the computational code ANSYS 10.0.

Stake body, with suitable ribs, it is set up on the loom by mean spherical joints that allow the back overturn. It has rectangular parallelepiped form, with three closed sides and only the back side it is possible to open it during the overturn and loading / unloading operations. The dimensions of the stake body were such, to be content inside the loom and its depth it was been calculated by mean the program code ANSYS 10.0 so that it did not form too many olive layers in overlap. It succeeded in containing about 35 boxes on a single plane.

The dimensions of longitudinal and transversal encumbrance of the considered machine have been verified by mean the computational code pro/E 3.0 that it allowed a management optimized of the considered volumes involved in this design. On the upper perimeter there were, on the fixed sides and on the hatch, plate shelves tilted upward. On the hatch, they were been shaped so that to contain a rectangular longitudinal hollow in which a grating plane was inserted, opportunely designed to sustain a workman weight. Every vertical bar had fixed at its extremity a tubular support with square section, in which a bar long 1 m was installed, tilted of 45° respect the vertical. In this tubular bar was inserted a bar long 1,50 m.

These bars acted as supports for the nets and they were suited, "una tantum", for the height of the trees locks of every specific tree plant. On the stake body, telescopic bars with square cross section of 4 x 4 cm were fixed (long around 2 m), tilted of around 15° in comparison to the horizontal plane and with the mobile part jointed to pneumatic pistons at "double effect" that moved them. At the extremity of the telescopic bars two horizontal

supports were settled in orthogonal way, within which were allocated the support bars for the nets. The nets for the base of the trees locks were three, with trapezoidal form and, situated in the centre, they resulted partly overlapped.

This overlap allowed to connect them on the shelf of the side right of the stake body, on off-set planes of around 10 cm, realizing three floors for the olives interception, tilted and separated. If the planes were not off sets, the picked olives in the uncovered triangle of the lower net, they were stopped, by the welding of the nets.

The three nets realized a "modellable tray" with three crossing nets that, as soon as they were positioned, they surrounded the tree trunk, and they close it more and more, intercepting the considered trunk with an angle that became more little. Insofar by mean this particular conformation it was possible to perform the automatic occlusion of the under locks nets, enveloping – as a scarf - the tree trunk, and contemporarily it allowed the carriage of the olives in the stake body.

This was been possible to realize since the sides of the three nets were bounded at rigid supports. Insofar this device with three overlapped nets allowed to form a carriage plane for the olives, after they were been occluded around the tree trunk.

Working phases

During the working operation of this equipment there are two phases:

1. the positioning of the machine,
2. the unfolding of the interception nets.

a) Positioning. The machine is towed along the tree plants rows , and it resulted in correct position when the median part of the stake body coincided with the tree trunk axis. The movements under tree locks were possible in how much, retracting the telescopic bars, the nets were compacted along the machine broadside.

b) Unfolding of the nets. The device for the unfolding of the nets was performed by mean the use of an air compressor, (with p max=10 $x10^5$ Pa.), fed with 12 Volts (storage battery of the tractor), connected to a distributor that fed in parallel two pneumatic pistons that, they operated the telescopic bars.

The compressor and the distributor were installed on the tractor. The machine was connected to the tractor, over that with the draw bar, also by two small flexible pipes for the compressed air to allow the "double way" operations of the pistons. The system need not of reservoir for the compressed air. When the telescopic bars moved, they drag in their motion the three trapezoidal nets that " enveloped" the trunk.

Contemporarily, with the same movement they put on in tension the steel ropes that moved the bars that drag upward the nets. The necessary time for the unfolding of the nets was equal to that was necessary for the translation of the bars (few seconds). At this point the machine was in operative condition.

There was a small passage on the left side of the net overlooking the tractor by which the user quickly entered on the stake body. The passage was obtained cutting out a rectangle of nets with suitable dimensions and overlapping them, a wider edge sewn aloft to the inside and, heaved on the base by mean an iron rod.

At the end of the harvest operation, it was performed the reversing of the command for the telescopic bars, to activate the retraction of the bars to compact the 3 nets: the base nets were displaced as a packet, the vertical nets were withdraw for gravity effect, because of the rotation toward the machine of the bars, that were not held back by the constraint.

Constructive choices

The machine was designed to be simple and with constructive and maintenance inexpensiveness as well as it had to have operative versatility. The choice to use compressed air for pneumatic movement instead of oleo-dynamic systems involves notable advantages:
The pneumatic pistons were very lighter (aluminium), not expensive.
To overturn the stake body, in lack of hydraulic distributors, it was possible to use an oil reservoir with a manual pump, it was a less expensive solution.

As for the overturn of the stake body, it was to specify that it was not essential to the goals of the operative machine in how much it had 3 options of loading:
- on the fund of the stake body it was possible to locate the boxes - more than 35 - that they were automatically filled and that then it was possible to remove them making to flow them through the back hatch or transferring them upward removing the grating;
- on the fund of the stake body, the plastic large cases, for industrial use, were prepared, but in this case it was necessary to use the mechanical forks ;
- direct harvest in the large case: the hydraulic overturn was essential.

The pneumatic pipes were less expensive than those hydraulic, they were smaller (with diameter of 10 mm) and flexible, easily replaceable. A mini pneumatic compressor, fed with 12Volt, with consumptions of 30-50 A/h allowed to connect the machine to a simple tractor battery and, considered its intermittent use for few second, the load for the accumulator it was very low. The connection of the compressor to a pressure switch, it automated the ignition of it avoiding the manual operations.

The use of the only electric energy with 12 Volt, over that to be sure from the point of view of the safety, it allowed a great versatility of use in how much, by mean the due mechanical adjustments , it can be hauled by whatever machinery without hydraulic plant. This last characteristic allowed the considered machine a notable mobility in tree plant with inter spaces irregular or with little manoeuvre spaces, even if with scarce ability of loading.

The nets used were the same in use for the olive harvest from the soil; besides they were divided (one for side and two for the component under locks) in how much more comfortable and easy resulted the dismantlement for the stocking of them or replacement. The elastic ropes to pull the nets were those available on the market.

This machine was easily transformable in a wagon with double fund. Removed the nets by mean the unhook of the elastic ropes, and removing all the bars, it resulted in a wagon with double fund and a grating platform.

Results

Some experimental tests was been performed during the olives harvests in a tree plant situated near Salerno city. During the tests it has been noticed that the olives losses on the soil have been almost void, with operative time very low (about 1 minute) besides the following constructive and functional advantages for the considered machine have been found:
- it was built with a very simple components ,
- constructive simplicity made it economically very competitive in comparison to more complex machineries,
- the rapids convertibility in wagon it increased enormously the value of it and therefore the investment is more profitable,
- it allowed the olives harvest with a single workman,
- it eliminated the use of soil nets and the times necessary for the layout and unfolding of the nets,
- it annulled the times to pick up the olives from the nets and to put them in the boxes,

- it excluded the use of staircases,
- it improved the quality of the olives harvested in how much it eliminated the accidental stamping of the olives in the soil caused by the workman,
- it automatically eliminated branches and sprigs from the picked olives,
- it was operative in few second,
- it can circulate on road removing the encumbrances,
- for its use need not specialization,
- it need not any specific maintenance.

Conclusions

A machine was been designed and realized, able to comply at all the project requirements that were been preset, with satisfactory results. Such project requirements are typical for "niche" products harvest machines. Such machine had the following characteristic merits:

1) the machine was able to automatically form a complete cage with olives harvest nets with contemporary formation of base and external collecting planes;
2) the particular geometry of the bars and rods allowed to exclusively create with linear motion a triple plan tilted with under locks nets, so that don't hold back the olives harvested, but they allowed directly to carry the olive drupes in the containers;
3) the assemblage peculiar geometry for the elastic ropes, rods and crossed nets, realized an occlusive contact with the trees trunk;
4) the machine allowed the harvest with harvest facilitators and it automatically stowed the product in containers;
5) the machine, during the harvest phase, avoided that the olives harvested were stamped on the soil by the operators;
6) the machine, during the harvest phase, automatically performed a pre-selection of the olives drupes from the sprigs, that inevitably they detach during the phase of mechanical harvest;
7) the machine utilized only linear motion to form a system with flowing tray and not with "umbrella" that is notoriously more complex in the construction and in the maintenance and more expensive;
8) the machine can easily be turned into wagon and profitably used for the whole year and not only for the olives harvest period.

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