A machine to improve the safety during the chestnut mechanical harvest in steep zone

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Abstract
A wire- driven machine able to perform chestnut mechanical harvest in steep zones it has been set up. By mean specific software, it has been possible to perform a simulation of the various runs planning soil slope higher than 25%, spaces wide maximum 80 cm and backs high 30 cm. Subsequently it has been realized the machine prototype. With the aid of the software Solidworks, it has been designed the 3D model to verify the compatibility of the dimensions of the considered machine, with the hypothesized spaces. The vehicle is composed of a tracked wagon surmounted by the aspirator and by the whole equipment of harvest. This machine is completely driven by wire. The operator has only to start the machine and to drive it from remote, avoiding so that the operator has to climb for steep slant exposing himself to danger conditions. The first harvest tests have been performed in only one passage, and they have been aimed to evaluate the functional and operational characteristics, related to the surface of an hectare. The tests of the machine prototype have been conducted with a speed of 1,8 km/h, with a soil moisture of 12%. Under these conditions, in the first tests series, the working operational capacity of the considered machine has been satisfying.

Keywords: chestnut mechanical harvesting

1. Introduction
The greatest part of the zones where is performed the chestnut cultivation, is characterized by slopes higher than 15%. The harvest machines available on the market still have notable operational limits as it regards the soil slope (steep zone), sensibly reducing their performances with soil slopes higher than 15%. In such cases aspirating machines are used with aspirating tubes managed by operators that climb them along the steep slant to perform the chestnut harvest. This is a danger situation, in how much the worker can slip on the steep slant (because of the soil slope and/or moisture). In fact the steep zones also result particularly insidious for how much it concerns to the safety on the work, and the accident risk it is always present to the point to strongly discourage the chestnut harvest with a further damage for the economy of the agricultural compartment already penalized by contingent factors of financial recession. The chestnuts harvest is a rather onerous practice, that requires for a big quantity of manpower. For this, with the purpose to decrease harvest cost, many farmers prefer to wait that all the fruits spontaneously fall from the trees, for natural falling, for then to pick up them with brushing and aspirant machines. Recently, machines for the chestnut mechanical harvest have been set up. They are suitable to operate on wide surfaces with small slopes (<10%). Most quantities of chestnut tree plant, nevertheless, over that for the farm property extremely fragmented, they are characterized by surfaces with high slope values (>15%) and by high difficulty of access to these areas, because the impossibility to create penetration footsteps.

In these zones, mechanization methods are not, currently, used and all the cultivation operations, in particular the soil cleaning before the harvest, must be performed by hand, with evident additional costs not always sustainable from the farmers . In the most quantities of the chestnut tree plant soils, because the high slope value, the harvest and the cleaning workmanships pre-harvest are performed completely by hand. The periodic pruning represent additional manpower costs. Indeed the aim of this research program has been to test innovative machine able to perform the chestnuts harvest in the steep zones. The innovation to be introduced will have to allow, an advantageous manpower saving for the harvest activities, considered also that to have available temporary workers, in the short period of the chestnut harvest, becomes more and more difficult. Further particular attention has been devoted to safety problems to eliminate the danger conditions.

2.Materials and methods

A wire- driven machine able to perform chestnut mechanical harvest in steep zones it has been set up. By mean specific software, it has been possible to perform a simulation of the various runs planning soil slope higher than 25%, spaces wide maximum 80 cm and backs high 30 cm. Subsequently it has been realized the machine prototype. With the aid of the software Solid-works has been designed the 3D model to verify the compatibility of the considered dimensions of the same with the hypothesized spaces. The vehicle is composed of a tracked wagon surmounted by the aspirator and by the whole equipment of harvest. This machine is completely driven by wire. The operator has only to start the machine and to drive it from remote, avoiding so that the operator has to climb for steep slant exposing himself to danger conditions.

Fig. 1 Chestnut Mechanical harvest by aspirant pipes.

The prototype is constituted by a rigid loom realized with C profiled steel with dimensions 40x80x25 mm. On the loom, there is a graft system to hook the further specific equipments. The tracks transmission is realized by back driven wheels, located on the loom, that are located at higher quote in comparison to the idle wheels. In this way, surely an angle is guaranteed, (angle of attack) allowing the vehicle to overcome obstacles in reverse. The transmission wheel, is connected to the loom by turnbuckle mechanism for track that allows the regulation of the stretch of the track. The tracks are in rubber and with width 130 mm. The UTV kinematics is allowed by a couple of brushless engines, opportunely connected to the driven wheels, managed, by mean opportune driver with a microchip located on board the

vehicle. As it regards the engine feeding, it has been possible to hypothesize to feed them by electric cable, without batteries on board the machine. In fact, because the considered machine has to be connected to the aspirator machine by mean a pipe (30-40 m long), it is possible to feed the engine by a cable connected to the pipe up to the generator of the aspirator machine.

UTV On board - Electronics
The used microchip on-board is the "Arduino Mega2560" with processor ATmega2560. ATmega2560 has 256 KB of memory flash to memorize the code (of which 8 KB are used for the boot-loader), 8 KB of SRAM and 4 KB of EEPROM (that is possible to read and to write with the bookstore EEPROM). The controller can be programmed by mean software owner open-source in Arduino environment, and with Matlab program.
For the on board sensors and transducers, the under-wagon has been endowed with ultrasounds sensors SRF05 that can denote obstacles up to 4 meters distance

Tele-control
The UTV can be managed by the operator, by tele-control joystick. A specific graphic interface, allows to check and to manage, from remote, the vehicle in the place in which it is located.

Autonomous control
The UTV can be programmed to manage operations in autonomous way, once defined the necessary parameters to the controller, what:
-information on the soil operative condition, where it will have to operate;
-possible paths predetermined that the vehicle has to perform;
-possible parameters required for the chestnut harvest operations.
For the considered machine it has been performed the risk analysis.

2.1 Risk analysis
The Directive CEE and law 626/94 and following integration, define *Danger* an ownership or intrinsic quality of a determined factor (work material, raw material or intermediary, work method, machine and tool) able to cause damages to the people or to the environment.
The term *Risk is* used instead for pointing out the concrete probability that, under the use conditions or exposure, the potential level of damage and the possible dimensions of the possible damage is reached.
The formula with which this concept is represented is:

$$R = P\,X\,M \qquad (1)$$

where *R is* the risk, *P* the probability that happens the event and *M* the magnitude, that is the gravity of the event on the people.
It is evident, therefore, that not all of this that represents a *Danger* also constitutes a *Risk.*
Difference can be born from the quantities of substances in game, from the time or from the frequency of exposure, from the measures precautionary takings, from the major or minor evidence of the same danger.
The working risks can be classified as:
-risk for machines,
-risk for the users;

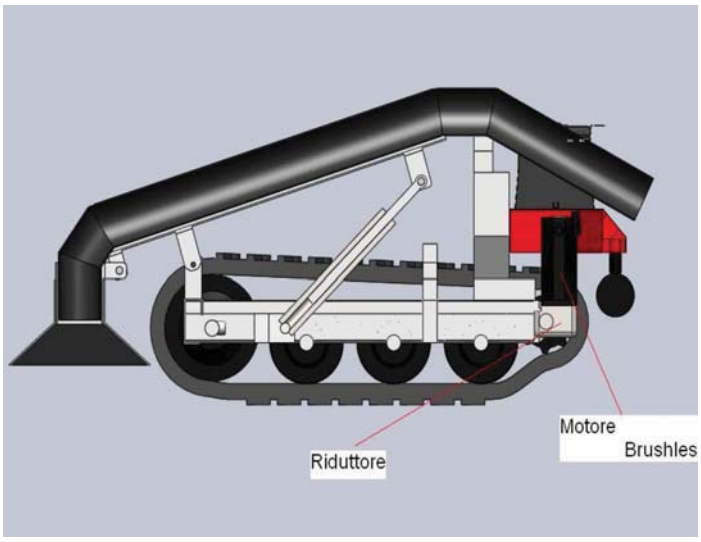

Fig.3 UTV scheme

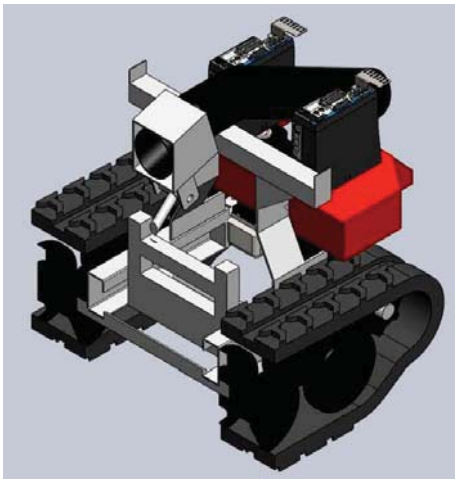

Fig.4 UTV scheme

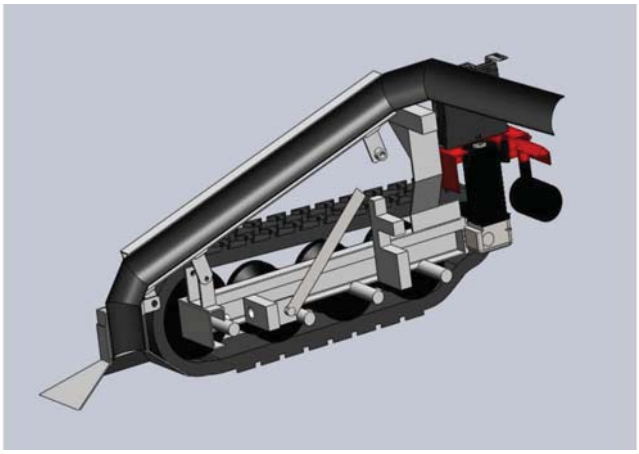

Fig. 5 UTV scheme

- risk for environment;

All that concerns users that work, in a working place in which are present machines or simple or complexes plants. On the base of all that exposed, the following shrewdness have been prepared to increase the safety of the machine.

3. SAFETY DEVICES ON BOARD MACHINE

Direct management of the machine by the user placed to the handlebar:

-Between the engine and the track, on the right side of the machine, with point of view by the guide seat, there is a metallic carter that has the function to protect the user from the mechanisms in movement: the transmission strap and the pulleys.

-There is an idle-brake handle that, only if it is managed, it allows the working of the machine, but in case of release it causes the immediate arrest of the machine. This device results very useful in case of immediate danger.

-On the considered machine, there are protective carters to avoid the contact with warm or incandescent parts of the engine.

The vehicle has been designed for the automatic harvest of the chestnuts and not for improper uses what the transport of people or things. To avoid this circumstance has been realized a structure over the machine in way that it occupies all the empty spaces and to avoid plane potential to support or to grip able to allow the transport of people or things. All that could provoke direct accidents to people or things and to influence the stability of the machine during the operative conditions.

It has been used, as safety measure, a suitable arrangement designing, specific for the considered machine, that has kept into account both of the data inferred by the professional experience matured in the sector of the agricultural mechanization and of the respect of the followings principles:

-mechanical safety and sizing

-safety to the fire

-safety of the accesses

-safety of the users

As it concerns the mechanical safety and sizing, the machine has been designed in way to obtain a remarkable reduction of the direct human intervention in the activation of the different operative functions of the considered machine. In fact, they have been avoided, as already underlined above, no-protected rotating parts with the aim to avoid entangling and dragging; the oleo-dynamic plant is provided of special safety valves; it has been turned particular attention to the turnover of the machine, in fact the barycenter quota, it has been the lower possible.

As it regards the machine *sizing*, the different parts have been designed according to the following rules:

-the stresses are generally limited to the 70% of the elastic limit and we have kept into account of a 15% dynamic increase coefficient applied to the vertical loads on the structures of the considered machine.

Noise: The noise level of the machine is nearly equal to that of the mechanical wheelbarrow from which it derives the over-truck considered, with the addition – in regime condition- of the noise produced by the aspirator machine.

INDICATIONS ON THE LEVEL OF DAILY EXPOSURE TO THE NOISE (LEP,D) OF THE WORKERS:

To evaluate the level of daily exposure to the noise, the considered method has been followed that has these phases:

1.subdivision of the working phases and evaluation of the level of noise in the single working places;

2.the workers' subdivision in homogeneous groups according to the performed activities and measurement of the noise level referred to every considered group;

3.calculation for every homogeneous group, of the level of personal exposure.

Once performed the above mentioned evaluation, the workers have been separated in 4 categories:

-workers submitted to a personal exposure lower than 80 dB(A) for which no prevention activity is required.

-workers submitted to a personal exposure ranged between 80 and 85 dB(A) for which is required the sanitary control, on demand. While the information is obligatory.

-workers submitted to a personal exposure ranged between 85 and 90 dB(A). Here we are to a watch level: the workers must have submitted to periodic medical check; they have to be endowed with devices for the protection individual and informed on the risks caused by the noise exposure.

-workers submitted to a personal exposure higher than 90 dB(A). The risk becomes real and they must be used specific shrewdness : annual medical checking and obligation of use of the devices of individual protection.

For the considered chestnut tree plant :

Working Typology: chestnut mechanized harvest Working group: machine operator and assistant (installation working place)		
ACTIVITY	EXPOSURE AVERAGE %	ENERGETIC AVERAGE Leq dB(A)
Start of the machine engine and the aspirator engine	5	83
Machine Movements on the working site	76	68
Movements of the aspiration pipe	14	68
Physiological	5	0
Lep =	72	dB(A)

Machine management by remote (with special radio-control)

In alternative to the direct use, the machine can also be managed by remote by radio system. In this formality the machine offers greater safety guarantees in how much the operator results distant from the same one, and therefore the risk of interferences is sensitively reduced. The following safety measures are been applied.

It has been complianced, the norm EN 300-220-2 related to the electric equipment of the considered machine. To pursue this aim, the management system by remote it has been realized in way to guarantee the followings conditions:

1.the safety of the people and of the things;

2.the congruence of the answers to the input commands;

3.the facility of the maintenance;

Besides the plant works in low voltage;

It has been used a radio-control, of the type "marsupium pouch", to allow to operate with both the hands. Such equipment has n° 06 functions, for the management of 6 controls in safety. The push-buttons is of ergonomic type and it is provided of an emergency button for the instant annulment of all the active functions.
Further guarantee is offered by the possibility to get the turning off of the engine, with the stop of all the functions in action when the system goes to damage.
Besides, the plant is provided of a hydraulic actuator constituted by an unique block with four controls, provided of proportional electronic-valve with mechanical retroaction, that has the function to manage the machine movements in gradual way, that is it performs the command according to the linear law of the movement, to avoid abrupt and dangerous movements.
All these arrangements are in compliance to the CE requirements on the electromagnetic Compatibility and items related to the radio wave (ERM); Short Range Device (SRD) particularly to the norm **EN 300-220-2**
The user that manage the maneuvers has to make use of special shoes accident-prevention. It results besides necessary to wear gloves in leather to protect the hands and in the sunny days it is opportune that the users wear fit headgear and sunglasses, while in the cold days they must be uses protective garments suitable to the climate.

4.RESULTS AND DISCUSSION

The harvest tests have been performed in only one passage, and they have been aimed to evaluate the functional and operational characteristics, related to the surface of an hectare. The tests of the machine prototype have been conducted with a speed of 1,8 km/h, with a soil moisture of 12%. Under these conditions, in the first tests, the working operational capacity of the considered machine has been satisfying.

Experimental tests

The tests have been performed in a chestnut tree plant of about 23 years of age, with distances of plant of 8,0 x 8,0 m. The regulations of the aspirating machine prototype with the purpose to set-up it, in optimal order of job, has been effected by technical personnel of the farm, and they have concerned the regulation of the job height of the aspiration anterior heading and the working speed. The harvest has been performed in only one passage, and they have been therefore determined the functional and operational characteristics, related to the surface of an hectare. The tests of the aspirating machine have been conducted with a speed of 1,8 km/h. Under these conditions, the working operational capacity of the considered machine results equal to 434 m^2/h, thanks also to the low incidence of the times accessories of turning on the total time. From the analysis of the losses happened during the tests, it has resulted that the operative machine is able to pick up the chestnuts with a percentage of lost product equal to 1,4%. The analysis of the picked product has been effected, to the purpose to underline the working quality performed by the operative machine considered. It is been noticed as in the picked product there were impurities equal to 2,2%. Such level of cleaning can also be defined good in consideration of the washing operation in water of the chestnuts that is performed as a rule subsequently in the farm center. The tests of the aspirating machine have been conducted in a chestnut tree plant, with a maximum slope values of 25%. The picked production during the tests has resulted equal to 201 kg/h, in consideration of the optimal conditions of preparation of the soil, that has also allowed an high working speed in presence of a notable quantity of product on the soil (0,264 kg/m^2).
Further the use of the machine in formality "manual", with operator to the handlebar has been examined, and indications on the use of the lever-friction brake to automatic return has been

furnished: if pressed it able to the movement the considered machine, if released it allows the parking of it.

Conclusions

Insofar it has been designed and realized a machine able to perform the mechanical harvest of the chestnuts in the steep zones. With the aid of a specific software it has been possible to perform a simulation of the different runs planning soil slopes higher than 35%, on spaces with maximum width of 80 cm and backs high 30 cm. Subsequently with the aid of the software Solidworks has been drawn the model in 3D to verify the compatibility of the dimensions of the considered machine with the hypothesized spaces. For such machine, once it goes on, the operator can manage all the functions by remote, simply maneuvering by wire. In such way it is avoided that the operator has to climb on steep slant, all of this to advantage of the operator safety.

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