# Development of a Towed Multi-Function Row Straddling Machine for the Cultivation of Goblet Vineyards

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**Abstract**
**To guarantee the mechanisation of a goblet vineyard, a handmade pre-prototype of a multi-function row straddle machine towed by a common vineyard tractor was built. Trials carried out in vineyards gave encouraging results (Schillaci et al., 2008, 2009, 2010). Currently a project is under way for the improvement of the pre-prototype as an innovative machine (ENAMA, 2009) with collaboration between the constructing company FA.MA (MN), the DIA in Catania and the CRA-ING in Treviglio (BG). The pre-prototype has been redesigned to increase the number of tools applicable to the frame and the quality of operations carried out, respecting both the safety of the workers and quality of the product. The final aim is to guarantee mechanisation of goblet at a contained cost. The frame has been redesigned to optimise size, weight, sections and attachment devices for the accessory equipment which it will carry and/or activate. The newly adopted technical solutions were chosen taking into account the form of the goblet vines (expanded foliage, short trunk, vegetation near the soil), the availability of reliable but simple tools, stability, safety and flexibility of their use. The modifications were identified also by means of field trials carried out with the first version of the pre-prototype. After the redesigning phase, trials were carried out to study the performance of the mechanisms. The multi-function frame works on both sides of the row, so with only one passage the machine is able to complete the operation on the row. The modifications made to the original prototype allowed for a reduction in the attachment and detachment times of the tools to the frame. Furthermore, they increased the number of applicable tools as vine shoot tipping, leaf stripper and a sprayer equipped with a liquid recovery system thereby significantly reducing the amount of the product lost in the air or on the ground. Finally, to guarantee better performance in the field, it is now possible to regulate the working position of the tools and their height from the ground. Further results are expected when the work will be completed.**

**Keywords:** vine cultivation, ENAMA, vine mechanisation, pruning, spraying

## 1. Introduction

In Italy each region is said to have its own forms of viticulture; however, all the machines that have appeared on the market over the years have been designed for VSP trellised vines (Spezia et al, 2008), which has led to a reduction in the number of cultivation systems, and a generalized leveling of viticulture towards single models (Fregoni M., 2005).
The need has arisen for technological solutions aimed also at the cultivation of the goblet vine to satisfy the needs of the growing number of firms who have chosen to privilege this form of cultivation for the benefits that, thanks to current techniques regarding both planting and agronomic management, can be seen in terms of quality of the product (Fregoni, 2005) and environmental sustainability (Schillaci *et al* 2009).

The greatest obstacles to the mechanized cultivation of the goblet are the voluminous form (three dimensional, expanded), the foliage that is close to the ground and the distance between the rows that is reduced and/or irregular. In order to resolve some of these inconveniences, some vineyard managers have adopted a two-dimensional wall form, growing two branches parallel to the row and resting them on a wire held up by short poles. In this case, it is possible to adopt expensive self-propelled row-straddling machines equipped with specially built operating machinery. Others have kept the three dimensional form and increased the distance between the rows; the distance between plants on each row has been reduced (to keep a high load of fruit buds per hectare despite the widening between the rows) and the height of the plants has been raised (for the same agronomical reason), though keeping the relationship height/distance to <1 to avoid the reciprocal shadowing of the rows. In this case, it is possible to carry out cultivation operations by using common vine tractors equipped with tools that can easily be found on the market. However, given the height of the plant a row-straddling tool-carrier frame may be used, which can operate at the same time on both sides of the row. Tests carried out on a handmade pre-prototype of a multifunction tool-carrier, equipped in a basic way with easily found tools, have guaranteed an efficient mechanization in goblet vineyards (Schillaci *et al*., 2008), particularly concerning treatments for weed-killing and anti-fungal protection (Botrytis), tilling the soil and pruning.

Through a project of development of innovative machinery (ENAMA, 2009) and the collaboration between the building company FA.MA (MN), the DIA of Catania and the CRA-ING of Treviglio (BG), the handmade pre-prototype has been redesigned and perfected, and a towed, row-straddling tool-carrier has been created which satisfies the requirements of the rational cultivation of goblet vines. This work refers to the implementation of the machines to make their use more efficient and economical, increasing the number of utensils that can be applied to the main structure, which has been redesigned to guarantee safety and speed in assembling the numerous tools required.

## 2. Materials and Methods

### 2.1. The Pre-prototype

The project idea arose from the need to perfect a pre-prototype built by an artisan and subject of the first positive tests in a vineyard in eastern Sicily consisting of goblet vines with inter-row spaces at least 1.8 m wide (Balloni *et al* 2008).

The machine consists of a steel frame, supported by wheels with tyres (see figs. 1 and 2); it is rectangular, (1,60 m x 0,95 m), with a carriage of 2.20 m, ground clearance 1.4 m and support headframe situated at a height of 1.80 (Schillaci, 2009). It holds utensils to carry out some cultivating operations including common trimmers for pruning that can be found commercially. All the equipment is assembled on the main frame by rudimental clamping systems. For antibotrytical treatments, carried out during the setting of the fruit, a distribution apparatus fitted with a 300-litre tank is mounted on the frame; the initial tests have shown good efficiency, given the machine can proceed to a speed of about 4.6 km an hour.[1] Regarding the mechanical pruning, it was possible to obtain a unitary time of 1.1 h $ha^{-1}$, with a progress speed of 1,2 m $s^{-1}$, which is restricted by the requirement that the vegetation should not be bent backwards (that would cause undesirable not clear cut in the vine branches). There is a considerable saving in manpower in the pruning compared to the traditional method of bending and knotting shoots in the upper parts of the plant, called "*ammazzonatura*" (bending the shoots) quantified in 50 h $ha^{-1}$ (Schillaci *et al* 2009) (figs. 3 e 4).

| **Multifunction tool-carrier – technical characteristics** | | |
|---|---|---|
| Transversal size | (m) | 1.60 |
| Longitudinal dimension | (m) | 0.95 |
| Ground clearance (excluding wheels) | (m) | 1.40 |
| Height of support headframe | (m) | 1.80 |
| Track | (m) | 2.20 |
| Tank capacity | (L) | 300 |
| Engine power | (kW) | 65 |

Figs. 1 e 2 – the towed row-straddling carrier

Fig. 3 – Pruning

Fig. 4 – Chemical weed-killer

## 3. RESULTS

### 3.1 Technical characteristics of the innovative machine

On the basis of the observations and trials carried out, a complete revision of the pre-prototype has been carried out, including detailed designs of the frame. The choice of technical solutions was made considering the form of goblet vines (wide foliage, short trunk, vegetation near the ground), the use of simple, dependable tools, and the stability and flexibility of the use of the tool. The frame was streamlined as regards weights, measures and sections; it is rectangular (1,80 m x 0,95 m), with a carriage of 2.24 m, ground clearance 2,24 m and maximum height (including frame for tank) of 2,61 m.

The structure was raised by 50 cm compared to the initial model in order to be able to apply a

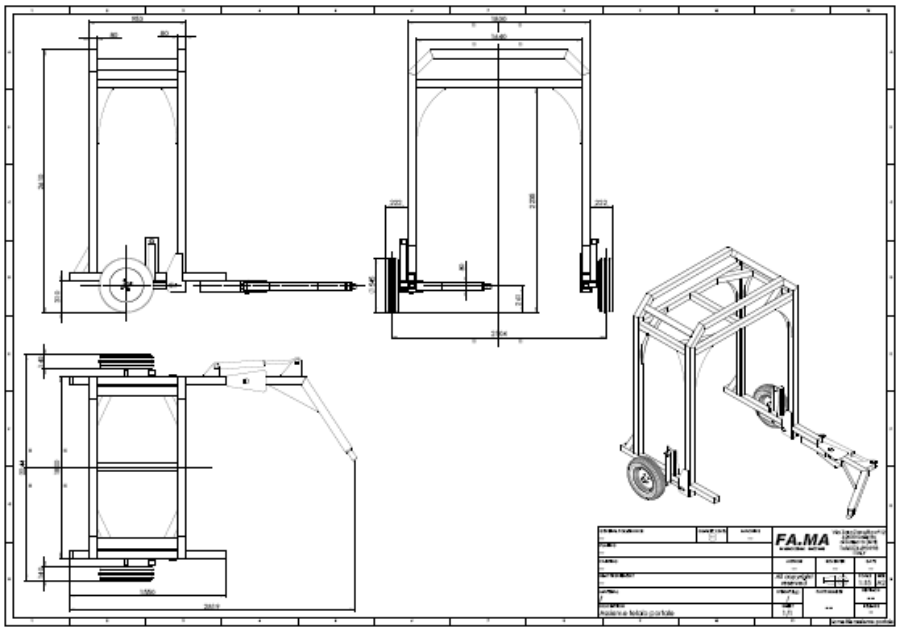
standard system of tunnel spraying that can be found on the market. Two tires, each equipped with a hydraulic piston, adjust the height of the frame according to the desired height of the work. The tow-bar has also been equipped with a hydraulic piston able to keep the frame in the required path also on ground that is sloping and/or soft and makes turning easier at the end of the row, even in narrow spaces. The machine is equipped with supports for the application of mechanical systems, a piston pump, an extra tank for oil and oil-pressure components.

To obtain a swift, easy application of the utensils, a counter-frame has been prepared. For trimming and pruning, the lateral mowing bars are used and, where needed, the bars for topping, all equipped with mechanisms to regulate the distance between the bars and the rows.

The soil is turned over with a pair of rotovators, each with 4 blades that straddle the rows and stagger operations between them. They are equipped with rotors with a vertical axle and a mechanism that makes them withdraw automatically on contact with a trunk. In the case of compact soil, also two inter-row cutters with a horizontal blade can be mounted.

The spraying apparatus is constituted by a tunnel system equipped for catching and recovering liquid released out of target (that often reaches rates higher than 50% of the total amount sprayed (Ade *et al.* 2005, Baldoin *et al*. 2009, Pergher *et al*. 2007, 2009)).
The tunnel comprises two lateral sides (m 2,2 x m 1,20) each equipped with a bar with 5 nozzle-holders, nozzles (Albuz APE 80 red) and a lower recuperation tank linked to the recirculation of the recuperated liquid.

The frame allows the tunnel to be lowered so that it touches the surfaces of the ground, favoring the spraying of vegetation nearer to the ground. The tank, with a capacity of 500 litres (according to the standard, like all spraying machines), is situated in the upper part, in its own support frame with equipment.



| ***Multifunction row-straddling holder – technical characteristics*** | | |
|---|---|---|
| Transversal dimension (including wheels) | (m) | 2,24 |
| Longitudinal dimension of the frame (without wheels) | | 1,80 |
| Longitudinal dimension of the frame | (m) | 1,55 |
| Ground clearance (including wheels) | (m) | 2,24 |
| Track | (m) | 2,10 |
| Maximum height | (m) | 2,61 |
| Tank capacity | (L) | 500 |
| Engine power required | (kW) | 65 |

## 4. Conclusions

The "multifunction towed row-straddling frame" is a specific proposal for the goblet vine, a cultivation form that was been practically abandoned because of the high level of manpower it requires. The row-straddling feature has the advantages of providing stability to the whole, and doubling the work front, compared to equipment that operates on only one side of the row.

The functions carried out by the machine, opportunely redesigned and perfected, make it particularly interesting for all vine-growing firms with surfaces cultivated with single stake goblet vines, without wires and support poles, and with wide rows which allow common vine tractors to pass through.

Currently, the frame holds the tools for pruning, tilling the land, using chemical weed-killing and spraying the foliage. Other operations can be added, as shoot tipping and defoliation.

The innovative prototype doubtlessly brings ecological-environmental advantages, thanks to the spraying apparatus which is equipped with a mechanism for spraying pesticides, which would otherwise be dispersed in the air and in the ground, thus enabling savings in the use of such products.

As soon as the prototype is completed, it will undergo tests in the field to assess the functionality of each part.

We maintain that the completion of this machine will enable us to overcome the limits connected to the historical unavailability of adequate mechanization for goblet vines.

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