# The innovative RHEA airblast sprayer for tree crop treatment.

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# The innovative RHEA airblast sprayer for tree crop treatment.

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**Keyword:** Pesticide sustainable use, innovative machine for pesticide application in tree crops

**Abstract:** Authors present achievements in the research of appropriate solution about the RHEA sprayer for tree crops. The scenario of the most innovative technologies on airblast sprayer configuration has been analyzed and each solution on devices has been evaluated. UF unit has designed a semi-mounted sprayer applied to small autonomous tractor equipped with sensor able to recognize the presence, shape and thickness of the various horizontal bands of the canopy by adjusting the type of spraying. Spray application it is so variable separately on each band in term of direction of diffusors, airblast flow rate and liquid dose adequate to the presence or thickness of the canopy.
The new RHEA airblast sprayer concept, in addition to the implementation of automated functions, has the aims to apply the rules specified by the European Union to reduce pollution caused by distribution of PPP (plant protection products).

## Introduction

The sustainable use of PPP and the need of a renewed integrated system of agricultural knowledge and management in course of evolution by the Precision Agriculture approach moved the design of the EU FP7 RHEA Project (Robot fleets Highly for Effective Agriculture and forestry management).
The present report is related the third case study considered in the RHEA Project that involve the application of sprayed

chemicals to the woody crops canopy. A huge amount of researches has been done on spray chemical optimization and especially since the 1980s to adapt the spraying techniques to the crops.

Advances in sensors, actuators and electronic controllers have facilitated the boarding of electronics in sprayers for tree and bush crops: first step was the interruption of liquid flow rate when no foliage it is detected; further developments were achieved with the control on the different vertical bands of canopy. The next step was matching the sprayed flow rate proportional to the canopy width using ultrasound sensors and later the laser LIDAR (Light Detection And Ranging).

The spray jet, the dose and air energy applied, shall be in fact adequate to the morphological features of the treated canopy (Pergher et al, 2002). Other important researches were devoted to the appropriate sprayer scheme in order to better fit the treatment in variable canopy shape or weather condition (Escolà et al., 2007; Doruchowski et al., 2011); Hoçevar et al. (2010) investigated on a variable inclination and positioning of the spray diffusors to better fit air spray jet onto the canopy.

Latest studies have taken into account the georeferenced 3D prescription maps application to make an optimized Variable Rate Treatment; even on Olive tree crops (Moorthy, 2011; Pérez-Ruiz et al., 2011). It also permits to have the telemetric traceability of applied dose on each step of the canopy annual growth. More detailed references on state of the art are reported in Vieri M. et al., 2012.

## Materials and methods

The primitive configuration of the RHEA ground mobile units taken into consideration very small vehicles with 200-400 kg mass and less than 15 kW power, operating at a forward speed of 1.5 m/s and with only one operating arm.

In particular, for canopy treatment, this is really feasible only for spot spraying e.g. in the insects control, but not appropriate for other diseases like mushroom etc. In these cases arise at least two problems: one is the dosage that, even in a modern intensive

tree plant with an average of 5000 $m^2$ of canopy volume per hectare, requires not less than 100-200 l/ha; second it is the necessity of air assist device to well put the chemical sprayed droplets inside the canopy and the inappropriate use of only one manipulator (spray diffusor) that at the prescribed forward speed produce an unacceptable unequal sinusoidal application.

On these and other consideration the RHEA Consortium approved a more suitable ground mobile unit (GMU) with these specifications: 4x4 wheel drive, CVT transmission, 37.3 kW gross power, 10% of which available as electric power , with a mass of 1600 kg, 3 hitch points lift and standard 52 rad/s p.t.o. That make it possible to adopt a ready to common use and innovative air assisted sprayer.

Another important choice has been the Olive intensive plant for the final demonstration; this decision it is due to the fact that Olive crop is quite comparable to both modern Orchard and Woody Tree Crops as mentioned in the RHEA Project Proposal. Plantation scheme is 4.0 m inter-row and 1.5 distances on the row to reach a foliar wall as flat and regular as possible.

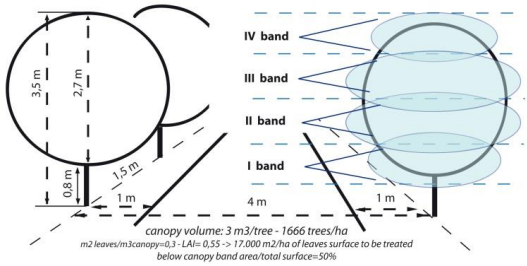



Fig.1 - RHEA Olive demonstration plant scheme

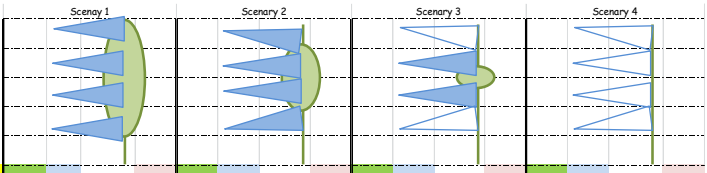
On these aims we investigated different solutions in terms of spraying and air vector devices: the Proptec Rotary Sprayer module, The Sardi fan module, the Tangential cross-flow module, the Oktopus spraying technique.

Where also analyzed: the equipment configuration as single side or double side and number of modules, the device system (DS) and the control system or Low Level Actuation System (LLAS), the main parameters controlled: spray cloud features, liquid flow rate, air flow rate and air jet direction.

Where finally defined rules for each devices to better fit optimum spray features on each vertical bands of the canopy.

Fig. 2 a,b,c: Proptec, Sardi and Tangential (cross flow) fans.

RULES




| spray module & ultrasonic sensor | Scenay 1 canopy | Scenay 1 spray | Scenay 1 inclination | Scenay 1 air | Scenary 2 canopy | Scenary 2 spray | Scenary 2 inclination | Scenary 2 air | Scenary 3 canopy | Scenary 3 spray | Scenary 3 inclination | Scenary 3 air | Scenary 4 canopy | Scenary 4 spray | Scenary 4 inclination | Scenary 4 air |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ok | yes | 0° | yes | no | yes | -15° | yes | no | no | -15° | no | no | no | -15° | no |
| 2 | ok | yes | 0° | yes | ok | yes | 0° | yes | no | yes | 0° | yes | no | no | 0° | no |
| 3 | ok | yes | 0° | yes | ok | yes | 0° | yes | no | yes | 0° | yes | no | no | 0° | no |
| 4 | ok | yes | 0° | yes | no | yes | +15° | yes | no | no | +15° | no | no | no | +15° | no |

Fig. 3 – Operative rules adopted on RHEA airblast sprayer

## 3. Results and conclusions

The RHEA robot airblast sprayer for precision tree crops treatment represent an unique innovative integrated system that includes suggestions derived from advanced researches.

The entire spray robot module has both remote and proximal controls; remote to control tractor and proximal to control spraying. This choice has a double aim to have an innovative sprayer that can be used and tested as independent autonomous equipment also with normal tractors.

The spraying configuration provides 8 different vertical bands of independent treatment with separate controls of chemical dose applied and air flow direction and rate. It consists in 30 controls devices (8 butterfly valve at the air conveyor; 1 main

butterfly valve at the manifold fan inlet; 4 actuator to control upper and lower outlet diffusor inclination; 16 solenoid valve; 1 pressure valve), 8 controller and 1 PLC, 12 sensors (1 for forward speed ; 1 for liquid pressure, 8 Ultrasound Sensors, 1 for tank level, 1 for pressure).

The 8 US sensors could be replaced by on board LIDAR or by a remote control directly send by the HLDMS (High Level Decision Making System) that could use the LIDAR on the scouting Aerial Unmanned Vehicle to provide a 3D prescription map able to command the different operating system of the air sprayer in the different vertical bands.


Fig. 4 – the 1° RHEA airblast sprayer prototype (left).

Fig. 5 a,b,c – the “butterfly valves” to control airblast on each horizontal band (right).

The expected chemical dosage saving is ranging from 50 and 70% of the conventional rate of application maintaining the right quality and quantity of deposition on the foliage.

The next two years of tests will give data on technical and operative characteristic of this complex system.

Fig. 6 – tilt diffusor *(left)* with double nozzles *(right)*.

Particular interest is placed on airjet vector characterization and its effect on the canopy by means of the butterfly valve control on each single side band.

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