Efficiency of Unmanned Aerial Spraying Systems (UASSs) for specialty crops in Greece grown under nethouse and hail protection nets

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ABSTRACT- submitted separately

INTRODUCTION

- In Greece –member of the European Union (a group of 27 member countries), a number of very important crops species mainly grapes and fruit trees (peaches, apples, pears etc.) and new vegetable species (baby leaves) are gown under light nethouses of hail-protection .
- The nets used are of variable materials and with variable "opening-mesh", ranging from 1 to 5 mm.
- The "under net" crop land covered is recently increasing significantly, due to additional risks posed by the climate change (increasing number of adverse events such as hails in the last few years) and the increasing production costs.
- The recent CAP (Common Agricultural Policy , period of 2023-2027) in EU heavily supports and subsidies the construction of these facilities and the Hellenic Agricultural Insurance Agency (a division of the Ministry of Rural Development and Food) pays the appropriate costs by damages.
- Crop protection takes place with equipment used inside and some main problems/issues are the poor protection of farmers to the exposure of chemicals and the over-dose of Plant Protection Products (PPP) used.
- Comparisons of conventional ground spraying systems and aerial systems were investigated and the miscellaneous advantages of UASS were shown an a high density olive grove in Greece (Gertsis and Karampekos, 2021).
- Recent reports by OECD underline the future potential and issues of UASSs in the world (OECD 2021a and b).
- No literature research was found on the issue of spraying with UASSs above net covered crops.

OBJECTIVE

The efficiency of droplet penetration through various types of net covered greenhouses and nets used for shade or hail protection, will be tested and evaluated. The Null hypothesis (Ho) is that less percent coverage by UASSs n crops grown INSIDE than OUTSIDE of the structures.

MATERIALS & METHODS

- **Three drone models were used:** 1. Topxgun 16 liters with 4 regular T-Jet nozzlesEAvi 2. sion 30 liters with 2 centrifugal nozzles and 3. Joynace with 8 regular jets (4 double ones)
- **Water Sensitive Papers (WSPs)** were placed, in four replicates, **Inside and Outside** the net structures, to measure the percent coverage (PC%-reported here) and other droplet characteristics (number, size and uniformity-not reported in this paper).
- The spraying settings used to develop a database of various settings for a thorough understanding of the process were kept ca. similar for all 3 drones:
  - 30-32 l/ha water application dose,
  - 2 m/s speed of spraying drone,
  - 5 m height above the ground.
  - 3-6 m operation space
- **In the upcoming season more settings will be evaluated and under additional crop species (stone fruits, grapes, etc.)**
- **Two – open access** – software were used to measure spraying characteristics (Fig. 4)
  - a. **DEPOSIT SCAN** b. **SNAPCARD**
- The study was performed over a **nethouse** (Fig.1 and 2) covered with a net of 0.74 mm x 1 mm opening and over a **vineyard protected with a hail net** of 5.4 mm X 5.4 mm opening (Fig. 3)
- Additional data will be recorded for an overall assessment of the drone benefits: **time of operation, amount of spraying used by each system (ground and aerial)**
- Statistical analysis will be performed with JMP v. 17 (www,jmp.com) and the Student's t test will be used means comparison.

CONCLUSIONS

- The results (Tables 1, 2 and 3) have shown clear advantages of using agricultural spraying drones to spray from the top of net-protected crops, such as less time, less human exposure to PPPs and much less a.i. used.
- No significant differences were shown in PC% between Inside and Outside the nets positions using all 3 types of drone models and the two net sizes, **in the simple pass**.
- However, there were significant higher PC% shown inside then outside by **using a double pass over the nethouse but not over the haill net**. These results are not clearly explained and will demand additional flights probably under different wind conditions. A hypothesis is that drift is reduced inside the nethouse as physicaly was evidenced during the flight. This study is continued during this summer for additional data accumulation.
- The study included two extreme net opening ranges (a very fine and a coarse one) and the results were quite similar.

RECOOMENDATIONS for farmers

- Reduced cost, more efficient coverage and health issues for PPP spraying are the most critical considerations by farmers *
- The farmer opinions are very positive and they are willing to either buy their own drone or ask from a certified UASS sprayer to conduct the work (most preferable choice). These opinions came largely from the farmers who were aware about the research results of **Perrotis College** in Greece *
- When the EU legislation becomes clear and definite, a new world will open in agricultural spraying systems*
- Additional advantages of **Agricultural Spraying drones** are recently become more evident (i.e. air-seeding in steeply slopes, greenhouse painting/shading in summer)

**** Preliminary results of a Farmer Survey in the context of an MSc Thesis at Perrotis College (in progress).***

REFERENCES

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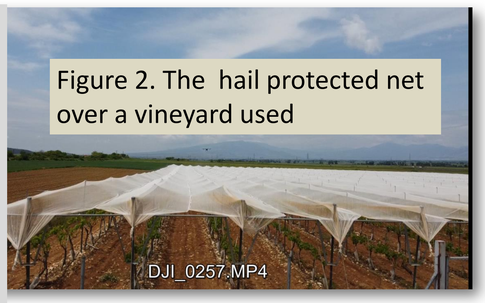

Figure 2. The hail protected net over a vineyard used

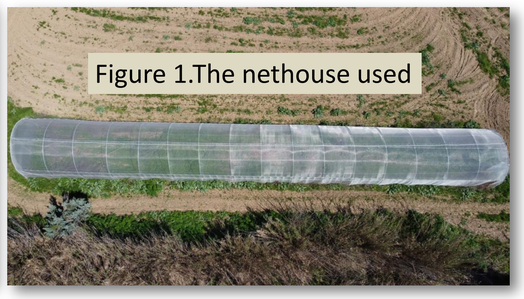

Figure 1.The nethouse used

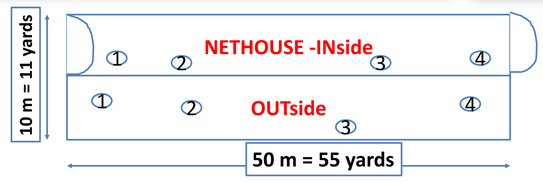

Figure 3. Position of the 4 WSPs (replications) inside and outside of the Nethouse
- **Two flights were performed with each drone: a "simple" pass and a "double" pass (twice the Simple)**

RESULTS & DISCUSSION

Tables 1a and b. PC% by **Using the 16 L Topxgun UASS**

Case #1: Spraying over a nethouse (NH)
A. Using the 16 L Topxgun UASS

Treatment (One pass)		Mean PC%
NH -OUT	A	2,51
NH-IN	A	2,04

Treatments not connected by same letter are significant different

Treatment (Double pass)		Mean PC%
NH-OUT	B	1,88
NH-IN	A	4,19

In the "SIMPLE-pass" flight application, there were no significant differences between IN and OUT PC%.
In the "DOUBLE – pass" flight, there were significant differences shown

16 L Topxgun UASS

Tables 2a and b. PC% by **Using the 30 L Eavision UASS**

Case #1: Spraying over a nethouse (NH)
B. Using the 30 L Eavision UASS

Treatment (One pass)		Mean PC%
NH -OUT	A	2,07
NH-IN	A	2,08

Treatments not connected by same letter are significant different

Treatment (Double pass)		Mean PC%
NH-OUT	B	2,49
NH-IN	A	4,04

In the "SIMPLE-pass" flight application, there were no significant differences between IN and OUT PC%.
In the "DOUBLE – pass" flight however, there were significant differences shown. However, there were significant higher PC% shown inside then outside **using a double pass**. These results are not clearly explained and will demand additional flights probably under different wind conditions. A hypothesis is that drift is reduced inside the nethouse.

EAvision 30 L UASS

Table 3. PC% by **Using the 16 L Joyance UASS**

Case #2: Spraying over a hail net protected vineyard
Using the Joyance UASS.

Results are shown for two positions of WSP, in the upper part and the lower part of the vineyard lines, with a simple or double pass and inside and outside of the hail net.
In all case no significant differences were shown

TREATMENTS		PC %
Inside	A	2.69
Outside	A	1.95
Upper position	A	2.05
Lower position	A	1.85
Simple pass	A	2.31
Double pass	A	2.06

Joynance 16L UASS

Net sample (NETHOUSE for vegetable prodcution)
Net sample (for vineyard hail protection)

Note: Videos from spraying will be available during the poster session