Research on Optimizing Techniques for Applying Phytosanitary Treatments in Vineyards

SUMMARY OF Ph.D. THESIS

PhD student **Tibor Rittner**

Scientific coordinator **Prof.univ. dr. Ovidiu RANTA**

CONTENTS

INTRODUCTION

Modern agriculture, based on the industrial revolutions of the twentieth century, has made significant advances in mechanization, the fight against diseases and pests, and the improvement of working technologies. These combined aspects have led to increased harvests, reduced hunger and improved working and living conditions for agricultural workers.

The tractor is the main source of energy for agricultural machinery, having a major importance within various technical systems. Spraying machines, essential components of this system, have evolved in complexity and performance to meet agricultural requirements, ensuring high working capacities and superior quality. The purpose of improving these machines is to improve the economy in operation. The increasing complexity of spraying machines requires rigorous control of their operation and maintenance.

Manufacturers focus on increasing reliability and availability, reducing downtime and intervention. The modern sprayer integrates mechanical, hydraulic, electrical, electronic and IT technologies, and current studies focus on optimizing operating and maintenance costs, ensuring maximum efficiency in agricultural production.

1. Structure of the doctoral thesis

The doctoral thesis comprises a total of 151 pages and was structured in two parts, The Current State of Knowledge and the Personal Contribution. The current state of knowledge comprises 44 pages. The second part of the thesis totals a number of 107 pages, structured in 3 chapters, which present the objectives pursued, the particularities of the natural environment, the results obtained, conclusions and recommendations based on the results obtained, as well as its originality and innovative contributions. The thesis includes a total of 50 tables, 74 figures and 70 bibliographic titles.

2. Research objectives

The main objective of the doctoral thesis consists of research aimed at optimizing the operation and increasing the reliability of machines used for combating diseases and pests in viticultural and pomological plantations.

To achieve the main objective, the following complementary objectives need to be addressed and resolved:

- Analysis of the current state and future directions in the field of machine reliability for combating diseases and pests
- Analysis of the technological process for performing phytosanitary treatments
- Identification of qualitative work parameters in performing phytosanitary treatments in viticultural crops
- Analysis of the influence of working pressure on qualitative work parameters
- Analysis of the influence of working speed on qualitative work parameters
- Distribution of the solution along the working height (determination position)

- Analysis of the interaction between experimental factors on qualitative work parameters
- Experimental laboratory research to determine the reliability of nozzles over well-defined time intervals
- Use of a special stand to determine the reliability of nozzles
- Development of a nozzle testing technology to establish the level of wear

3. Material and method

The research objectives included in the doctoral thesis project were pursued in the experimental fields located in Diosig-Ianca, Bihor County.

During the experimental research aimed at determining the qualitative working parameters, the following parameters were considered:

- DV1 (μm)
- DV5 (μm)
- DV9 (μm)
- Coverage rate (%)
- Number of droplets on the target surface (/cm^2)
- Amount of solution reaching the target surface (μL/cm^2)

The DV1 parameter value indicates that 10% of the spray volume has droplet sizes smaller than this value, making the droplets susceptible to drift. If a nozzle has a DV1 value of 200 microns, this means that 10% of the spray volume produced by the nozzle consists of droplets measuring 200 microns or less.

The DV5 parameter value indicates that half of the spray volume has droplets larger than this value and half have smaller droplets. This indicator is also known as the Volume Median Diameter (VMD). A VMD of 300 microns indicates that half of this volume consists of droplets smaller than 300 microns and half of droplets larger than 300 microns.

The DV9 parameter value indicates that 90% of the spray volume consists of smaller droplets (or 10% larger). If DV9 has a high value (900 microns), this indicates that too much of the spray volume may be absorbed into a few large droplets.

The coverage rate, expressed as a percentage, indicates the extent to which the target surface is uniformly and adequately covered with the treatment solution. This is one of the most important parameters of phytosanitary treatment.

The number of droplets on the target surface, expressed as droplets per square centimeter, is another important parameter that, alongside the coverage rate, evaluates the quality of the phytosanitary treatment.

The amount of solution reaching the target surface, expressed in microliters per square centimeter, is an additional parameter in evaluating the quality of the phytosanitary treatment.

The experimental factors influencing the qualitative working parameters were:

Working pressure with the following gradations:

1: 3 bar

2: 5 bar
3: 7 bar
4: 9 bar

Working speed with the following gradations:

1: 5 km/h
2: 7 km/h

Determination position with the following gradations:

1: Determination at the lower part of the plant (0.8 m)
2: Determination at the middle part of the plant (1.3 m)
3: Determination at the upper part of the plant (1.8 m)

For experimental research under field conditions, the phytosanitary treatment unit was adjusted to maintain a constant working pressure. A solution rate per hectare of 900 L for a speed of 5 km/h and 650 L for a speed of 7 km/h was used for the Lechler LC1.2 nozzles. For the Lechler ITR 80-015 air injection nozzles, the solution rate was 650 L for a speed of 5 km/h and 450 L for a speed of 7 km/h.

All experimental determinations were performed in three repetitions. Hygroscopic paper was used to determine the qualitative working indices, which changes color upon contact with solution droplets. The hygroscopic paper was then scanned using a CANON scanner.

The imaging software used was Deposit Scan for ImageJ (Download: USDA ARS). Deposit Scan is designed to quantify the distribution of deposits on any type of paper collector that shows color differences between the solution deposits and the background.

The dynamic determination of nozzle flow rates was performed for the LC1, LC1.2, Lechler TR80-03, and Lechler ITR 80-015 nozzles.

4. Results and discussions

4.1. Results regarding the qualitative working parameters of the Lechler ITR 80-015 nozzle

In order to interpret the data regarding the working quality parameters in the case of the Lechlet ITR 80-015 air injection nozzle, the Anova test was used and different correlations between them were identified. The working speed (Table 4.1) of the aggregate for phytosanitary treatments influenced the DV1 parameter. Thus, in the case of the speed of 5 km/h, the average of this parameter was 239.4 µm. In the case of the velocity of 7 km/h, the average droplet diameters (189.6 µm) were about 50 µm lower. The difference recorded is distinctly significant. The DV5 parameter registers, like the DV1 parameter, a decrease in the average droplet diameter from 600.24 µm (5 km/h) to 473.84 µm (7 km/h). The difference recorded is distinctly significant. Distinctly significant differences are also recorded by the DV9 parameter, the average diameter of the droplets decreasing from 934.21 µm (5 km/h) to 728.86 µm (7 km/h). The parameters Degree of coverage and Number of droplets/cm2 follow the same trend with a decrease in their values with the increase in the speed of movement in work. The differences recorded are insignificant. The amount of solution reaching the target surface also decreases with increasing speed. Thus, at 5 km/h, the amount of solution reached the target surface was 58.31 µL/cm2. The increase in speed to 7 km per hour caused the amount of solution to reach the target surface to decrease to 36.64 µL/cm2. The difference recorded is distinctly significant.

Table 4.1

Influence of working pressure on the quality parameters (significance level p≤.05)

	Mean	Working speed 5 km/h	Working speed
DV1			
5 km/h	239,4 µm	-	0,04
7 km/h	189,6 µm	-	-
DV5			
5 km/h	600,24 µm	-	0,02
7 km/h	473,84 µm	-	-
DV9			
5 km/h	934,21	-	0,02
7 km/h	728,86	-	-
Coverage			
5 km/h	56,54 %	-	0,12
7 km/h	48,04 %	-	
Droplets/cm^2			
5 km/h	22,88 pic/cm^2	-	0,74
7 km/h	21,96 pic/cm^2	-	-
Deposition (µL/cm^2)			
5 km/h	58,31 µL/cm^2	-	0,02
7 km/h	36,64 µL/cm^2	-	-

Influence of working pressure on quality parameters

In order to identify the influence of working pressure on the qualitative parameters, the data obtained were interpreted with the anova test and are presented in the following tables.

The influence of working pressure on the DV 1 parameter is shown in Table 4.2.

Table 4.2

Influence of working pressure on DV 1 parameter (significance level p≤.05)

Presiune/ Pressure	3 bari	5 bari	7 bari	9 bari
Diametru/ Diameter	Media/ Mean 194,89 µm	Media/ Mean 220,82 µm	Media/ Mean 231,72 µm	Media/ Mean 241,46 µm
3 bari		0,42	0,32	0,24
5 bari			0,74	0,56
7 bari				0,81
9 bari				

As can be seen in Table 5.1, regardless of the working pressure there are no significant differences between the experimental variants.

The influence of working pressure on the DV 5 parameter is shown in Table 4.3.

For this air-injected nozzle, the average of the DV5 parameter shows an upward trend with the increase in pressure. At the average pressure of 3 bar being 415.88 µm, it increases to 6 33.44 µm in the case of the pressure of 9 bar. In the case of comparing the means, it is observed that the pressure of 7 bar compared to the pressure of 3 bar registers significant distinct differences, the value of the DV 5 parameter increasing to 640.71 µm. Distinctly significant differences are also observed when comparing the pressure of 9 bar with the pressure of 3 bar. These differences indicate that in the case of this air-injected nozzle, with the increase in pressure, the average droplet size also increases. The DV5 parameter is also the parameter that characterizes the droplet spectrum, in the case of the data obtained they fall into a very coarse and ultra coarse spray.

Table 4.3

Influence of working pressure on DV 5 parameter (significance level p≤.05)

Pressure	3 bari	5 bari	7 bari	9 bari
Diameter	Mean 415,88 µm	Mean 547,49 µm	Mean 640,71 µm	Mean 633,44 µm
3 bari		0,06	0,01	0,01
5 bari			0,18	0,25
7 bari				0,93
9 bari				

4.2 Results on the working quality parameters of the Lechler 1.0 nozzle

For the interpretation of the data regarding the qualitative working parameters in the case of the Lechler 1.0 nozzle, the Anova test was used and different correlations between them were identified.

Influence of working pressure on quality parameters

In order to identify the influence of working pressure on the qualitative parameters, the data obtained were interpreted with the anova test and are presented in the following tables.

As can be seen in Table 4.4, the lowest value of this parameter was recorded for the pressure of 5 bar (138,36 μm), followed by the pressure of nine bar (178,67 μm), the pressure of 3 bar (204 μm) and the pressure of 7 bar (222,65 μm). A significant difference can be seen in the case of increasing the pressure from 5 bar to 7 bar, in the sense of increasing the average droplet size by 88 μm.

Table 4.4

Influence of working pressure on DV 1 parameter (significance level p≤.05)

Pressure	3 bari	5 bari	7 bari	9 bari
Diameter	Mean 204 μm	Mean 138,36 μm	Mean 222,65 μm	Mean 178,67 μm
3 bari	-	0,09	0,62	0,50
5 bari	-	-	0,03	0,28
7 bari	-	-	-	0,24
9 bari	-	-	-	-

4.3 **Flow dynamics of ITR80-015 nozzles depending on the distance from the supply**

ITR 80-015 D1 nozzles are characterized by a potential dispersion of flow rates during the determinations performed (Fig. 4.1). Half of the recorded data are placed within the 95% confidence interval, which means their stability during technological use. However, at the beginning of use, the flow rates are below the level predicted by the standards, while in the next hourly interval, the flow rate increases above the forecast level. After this period, the flow rate normalizes and the values are within the limits allowed by the normal flow model.

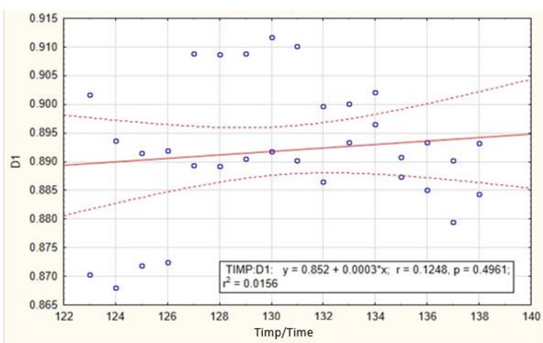

Fig. 4.1. Flow dynamics of ITR80-015 D1 nozzles depending on the distance from the water supply

5. Conclusions and recommendations

Phytosanitary treatments carried out in vineyards represent a very important technological link in obtaining crops that correspond both qualitatively and quantitatively. Optimizing the application technologies of plant protection products is an important objective both for reducing input expenses and for obtaining quality products without residues.

The use of properly equipped machines, tested and adjusted according to technological requirements in the application process of phytosanitary treatment products, can reduce the amount of solution applied to the plant.

The nozzles used, being the last component that the solution comes into contact with before leaving the machine, have an overwhelming influence in achieving the quality working parameters. There is a trend lately to replace classic nozzles with air-injected nozzles that ensure a longer droplet life and a more stable trajectory towards the target surface.

Conclusions on the working quality parameters of the LC 1.0 nozzle

The increase in pressure from 3 to 9 bar causes a significant increase in the average droplet size and the amount of solution applied to the target surface. The DV5 and DV9 parameters indicate an upward trend in droplet size, with significant differences between certain pressure levels, and the degree of coverage and the amount of solution on the target surface increase significantly at higher pressures. The number of drops does not show significant variations depending on the pressure.

The working speed influenced the DV1, DV5 and DV9 parameters, but without significant differences. The degree of coverage and the amount of solution did not show significant variations, but the number of drops/cm^2 increased significantly with increasing speed.

Conclusions on the working quality parameters of the LC 1.0 nozzle

The increase in pressure from 3 to 9 bar causes a significant increase in the average droplet size and the amount of solution applied to the target surface. The DV5 and DV9 parameters indicate an upward trend in droplet size, with significant differences between certain pressure levels, and the degree of coverage and the amount of solution on the target surface increase significantly at higher pressures. The number of drops does not show significant variations depending on the pressure.

The working speed influenced the DV1, DV5 and DV9 parameters, but without significant differences. The degree of coverage and the amount of solution did not show significant variations, but the number of drops/cm^2 increased significantly with increasing speed.

Conclusions on the interaction of the factors Working Pressure and Type of Nozzle on the DV1 parameter

At specific pressures, the Lechler ITR 80-015 and Lechler 1.0 nozzles show significant differences in the average diameter of the droplets. At lower pressures, these differences are not significant, but at higher pressures, the differences become obvious. It is important to take these differences into account in the selection of nozzles in order to achieve optimal results in phytosanitary treatments.

Conclusions on the interaction of the factors Working Speed and Type of nozzle on the parameter DV1

At a speed of 5 km/h, the Lechler ITR 80-015 nozzle produced smaller droplets compared to the Lechler 1.0 nozzle. At the speed of 7 km/h, there were no significant differences between the two nozzles, but differences close to the significance threshold were observed between the speeds of 5 km/h and 7 km/h for the Lechler 1.0 nozzle.

SELECTIVE REFERENCES

1. Tibor RITTNER, Alexandru Bogdan GHEȚE, Ovidiu MARIAN, Ovidiu RANTA, Valentin CRIȘAN, Cătălin BOGDAN, Adrian MOLNAR, 2024 The influence of working speed on the quality parameters for spraying in vineyards, Vol. 72, No. 1 / 2024 https://doi.org/10.35633/inmateh-72-55
2. Ranta, O., Marian, O., Muntean, M. V., Molnar, A., Ghețe, A. B., Crișan, V., ... & Rittner, T. (2021). Quality analysis of some spray parameters when performing treatments in vineyards in order to reduce environment pollution. Sustainability, 13(14), 7780.
3. Franck E. Dayan, Current Status and Future Prospects in Herbicide Discovery, Plants 2019, 8(9), 341; https://doi.org/10.3390/plants8090341
4. McGrath, M.T. 2004. What are Fungicides. The Plant Health Instructor. DOI: 10.1094/PHI-I-2004-0825-01. Updated 2016.
5. Akashe, Megha & Pawade, Uday & Nikam, Ashwin. (2018). CLASSIFICATION OF PESTICIDES: A REVIEW. International Journal of Research in Ayurveda and Pharmacy. 9. 144-150. 10.7897/2277-4343.094131. Megha M Akashe, Uday V. Pawade, Ashwin V Nikam, CLASSIFICATION OF PESTICIDES: A REVIEW
6. Akashe, Megha & Pawade, Uday & Nikam, Ashwin. (2018). CLASSIFICATION OF PESTICIDES: A REVIEW. International Journal of Research in Ayurveda and Pharmacy. 9. 144-150. 10.7897/2277-4343.094131. Megha M Akashe, Uday V. Pawade, Ashwin V Nikam, CLASSIFICATION OF PESTICIDES: A REVIEW