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Technical Note

Researches on the reliability of spraying machines in vineyards and orchards

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Abstract. The goal of the research was to determine the level of abrasion of different types of nozzles during different types of uses and at different pressure values.

The experiment assembly consists of an ATOM-300 carried sprayer, manufactured by S.C. TEHNOFAVORIT S.A. Bonţida-Cluj, and a stand for testing the distribution uniformity of the vineyard and orchard sprayers Herbst ED20-900, manufactured by Ernst Herbst Prüftechnik e. K. Hirschbach-Germany.

The 4 types of nozzles used were Lechler Ceramic 1.0 and 1.2; Lechler TR 80-30 and Lechler ITR 80-015 with air induction.

The measurements were made on a water pressure of 10 bar and 20 bar, and the testing period was equivalent with the duration of a campaign. The study below presents the variations of the debit measured in each type of nozzle according to the time and pressure.

Keywords: nozzle, atomizer, herbicide sprayer, vineyards

1. Introduction

The technical condition of atomizers in vineyards and orchards are greatly influenced by the pollution of the soil and the environment. These conditions induce loss of the treating solution and overrun of the application rules per hectare. The exact identification of nozzle wear stages allows us to have a knowledge of the maximum usage time when all application conditions are still met. Numerous scientific studies have contributed to the right choice of materials, the construction of nozzles, and the development of their operation principle.

2. Materials and methods

The trial and experiment assembly consists of an ATOM-300 carried sprayer, manufactured by S.C. TEHNOFAVORIT S.A. Bonţida-Cluj, and a stand for testing the distribution uniformity of the vineyard and orchard sprayers Herbst ED20-900, manufactured by Ernst Herbst Prüftechnik e. K. Hirschbach-Germany.

Figure 1. Irrigation machines

Table 1. The elements composing the statistical observation collection process

No	Name – producer	Testing pressure	Scattering head – codification	Observation period (min)	No of observations performed
1	Lechler Ceramics 1.2	10 BAR	LC_1,2_10BAR	15,873	42
2	Lechler TR 80-30	10 BAR	L_TR 80-30_10BAR	22,978	69
3	Lechler Ceramics 1.0	10 BAR	LC_1.0_10BAR	7,036	11
4	Lechler ITR 80-015	10 BAR	L_ITR 80-015_10BAR	8,795	16
5	Lechler ITR 80-015	20 BAR	L_ITR 80-015_20BAR	8,544	20
6	Lechler 1.0	20 BAR	L_ 1,0_ 20BAR	5,464	21
7	Lechler 1.0	20 BAR	L_ 1,0_ 20BAR	6,000	37
8	Lechler ITR 80-015	20 BAR	L_ITR 80-015_20 BAR	6,003	37

Note: the statistical interpretation of the results regarding the measurement of the flow released by the 4 types of nozzles, tested under a pressure parameter over a time range called observation period.

The purpose of the statistical processing is that of evaluating the studied phenomenon on the time axis, by means of a representation of the absolute values obtained through the measurement, as well as determining the phenomenon's proportions. For this purpose, classical instruments have been used (mediums, indices) as well as processing in order to obtain derivative statistical data (medium and index differences) and their graphic representation. For the drawing of the conclusions, we have tried to observe the basic phenomenon (flow variation depending on the time), the disrupting phenomena, along with the determination of their systematic or random determination. The partial conclusions are connected between them, creating a whole at the end.

Due to the fact that the tables and the figure presented in this chapter are prepared by the author of this paper, upon their presentation, this source should be implicitly considered, without explicitly mentioning him in this chapter each time.

Work hypotheses

- the series built based on the measured data creates *a chronological series of moments*;
- it is considered that the nozzles tested simultaneously (12 pieces) are of the same type, having the same manufacturing parameters;
- the distribution pipe is considered as having a constant section during the observation period (no deposits occur);
- the liquid circulating within the spraying system is considered as having the same physical and chemical parameters during the observation period;
- a constant liquid pressure is considered during the observation period;
- the work equation $Q = S * V$ is considered, where S – the nozzle section, V – the speed of the liquid;
- liquid viscosity is considered to be constant during the observation period;
- a measurement range of approximately 30s is considered, by means of which the flow sprayed by a nozzle is established;
- the statistical data is collected simultaneously from the 12 nozzles analysed (6 on the right and 6 on the left);
- the environmental temperature does not have significant variations during the observation period;
- the observation period for each chronological series unfolds for at least 5 days and up to 16 days.

Statistical processing included in the analysis

- the measured variable has the following characteristics:
  - is quantitative – the flow of the scattering nozzles (litre/min),
  - is continuous – it can take any rational value;
- the flow average is calculated for the 6 nozzles on the right and on the left respectively, in each observation moment – it is marked as Medie DR (Right Average) and Medie ST (Left Average);
- the difference between the LA and the RA is calculated in each moment of observation – it is marked as Dif Medie ST/DR (Average difference left/right – Av. Dif. L/R);
- the flow average is calculated for each nozzle during the observation period;
- the observation period is calculated both in minutes and in hours. The unit of measurement for the time axis is the minute.
- the index of the fixed-base modification is calculated. The first observation is considered to be the fixed-base. This index is calculated not only for each information collected but for the calculated averages, as well.

The index of the fixed-base modification represents the proportion of the level registered during a certain period as compared to the level considered to be the basis for comparison.

$$I_{i/1} = Y_i / Y_1$$

- the rhythm of the fixed-base dynamics is calculated. The first observation is considered to be the fixed-base. This index is calculated not only for each collected information but for the calculated averages, as well.

The dynamics index relatively expresses the increase or the decrease achieved during each period as compared to the level considered to be the basis for comparison.

$$R_{i/1} = (Y_i - Y_1) / Y_1$$

Table 2. The flow averages for each set of the 12 nozzles tested

Scattering head	Left Flow 1 l/min	Left Flow 2 l/min	Left Flow 3 l/min	Left Flow 4 l/min	Left Flow 5 l/min	Left Flow 6 l/min	Right Flow 1 l/min	Right Flow 2 l/min	Right Flow 3 l/min	Right Flow 4 l/min	Right Flow 5 l/min	Right Flow 6 l/min
LC_1.0_10Bar	0.706977	0.601365	0.653865	0.647241	0.612631	0.698492	0.636846	0.663252	0.605831	0.622062	0.639459	0.638630
LC_1,2_10BAR	1.307134	1.283532	1.188960	1.393289	1.230324	1.242091	1.230345	1.328430	1.295547	1.260897	1.295228	1.266359
L_TR 80-30_10BAR	0.698741	0.712719	0.679419	0.676859	0.679824	0.712216	0.687547	0.705964	0.697420	0.701139	0.713367	0.666631
L_ITR 80-015_10BAR	0.899795	0.855730	0.872197	0.833251	0.843524	0.844013	0.884155	0.862268	0.846560	0.872669	0.864369	0.854336
L_ITR 80-015_20BAR	1.252275	1.200043	1.213929	1.171041	1.120641	1.126362	1.114366	1.208063	1.190978	1.222932	1.219810	1.204761
L_ 1,0_ 20BAR	1.736204	1.604845	1.339802	1.698188	1.694300	1.527014	1.673509	1.697086	1.316252	1.601409	1.622324	1.692860
L_ 1,0_ 20BAR_BIS	1.546021	1.551065	1.498367	1.377175	1.638868	1.638333	1.546021	1.551065	1.498367	1.377175	1.638868	1.638333
L_ITR 80-015_20BAR_BIS	1.073176	1.076875	1.061221	1.102604	1.062743	1.076067	1.073176	1.076875	1.061221	1.102604	1.062743	1.076067

Based on the data above, the following graphic representation is created:

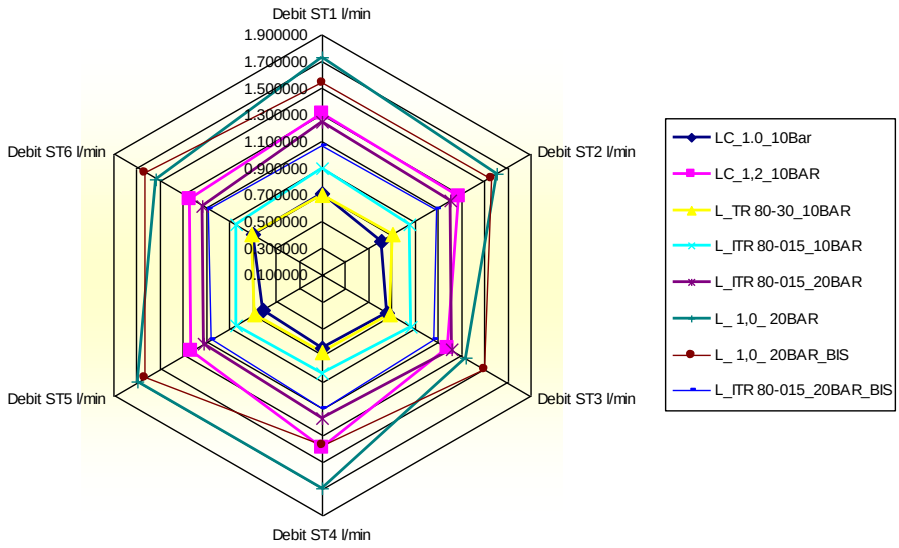

Figure 2. Representation of the average flows

The average flows are represented during the observation period for each 6 LEFT nozzles and 6 RIGHT nozzles, corresponding with the 8 measurements conducted with the 4 nozzle types subject to the 2 testing pressures (10 and 20 ba).

A concentric layout can be noticed, corresponding with the pressure which the nozzle is supplied with.

3. Conclusions

1. Given the initial hypotheses:
   - the series built based on the measured data creates a chronological series of moments;
   - the simultaneously tested nozzles taken into consideration (12 nozzles) are of the same type, having the same manufacturing parameters;
   - the distribution pipe is considered as having a constant section during the observation period (no deposits occur);
   - it is considered that the liquid circulating within the spraying system has the same physical and chemical parameters during the observation period;
   - the pressure of the liquid is considered to be constant during the observation period;

- the work equation is considered to be Q = S·V, where: S – nozzle section, V – liquid speed;
- it is considered that the viscosity of the liquid is constant during the observation period;
- it is considered that the measurement range is approximately 30 s, by means of which the flow sprayed by a nozzle is established;
- statistical data is collected simultaneously with those from the 12 nozzles analysed (6 right and 6 left);
- the environmental temperature does not vary significantly during the observation period;
- the observation period for each chronological series unfolds for at least 5 days and up to 16 days.

2. The statistical data – the measurements – are values of high-precision flows. The measurements have been conducted on 4 types of nozzles, in 3 different conditions, represented by means of the "work pressure" variable, 7 different situations resulting from such measurements. After analysing the data, we were able to observe the following:

- in the Lechler Ceramics 1.0 nozzle, with a 10-bar pressure swirl element, a slight increase of the flow was noticed during the determination period; the increase variation was linear, but the behaviour of the two average values was slightly different on the two spraying ramps. This increase was owing to the wear of the ceramic plate during the run-in phase, followed by a decrease of this trend, and the nozzle flow became almost constant.
- in Ceramic 1.2 nozzle, with a 10-bar pressure swirl element, the evolution featured a slight decrease trend, then a uniform increase, and then reaching a stability afterwards.

The two averages, Right and Left, feature the same evolution, and the trends are expressed by means of the same 1st-degree equation; therefore, we may say that the 12-piece nozzles have a homogeneous behaviour.

3. In the special TR 80-030 and ITR 80-015 nozzles, we have found that the evolution was generally a decreasing one, with slight increases in the beginning, but the trend is a flow decrease one.

The nozzle behaviour on the two ramps is symmetrical, reacting in the same manner upon external shocks in the case of external perturbations.

The two averages, Right and Left, feature the same evolution, and the modification trends are expressed by means of the same 1st-degree equation; thus, we can conclude that the 12-piece nozzles have a homogeneous behaviour.

4. The evolution of the difference between the Averages of the fixed-base index feature a constant decrease, but, at the same time, the existence of an external

factor can be noticed, which influences this evolution. This factor, in our case, can be the water homogeneity modification, the sliding of the driving belt, the water heating, or calcification deposits.

5. I believe that during the experiments the 4 types of nozzles have passed through run-in and have been well operating long enough. A slight flow decrease has been noticed, caused by the deposits inside the nozzles, which made the liquid passage section smaller, but it did not reach that level of deterioration for exploitation reasons.

6. I believe that by means of this measurement session I have managed to observe and analyse those stages in the life of the product where it calibrates and behaves in a constant manner. The flow variation, in both the positive and the negative direction, does not influence the quality of the treatment work and does not generate spraying-substance additional loss or quantitative insufficiency.