RESEARCH ARTICLE **(Open Access)**

Effect of Sprayer Nozzles Parameters on Effective Microorganisms (EM)

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Abstract

The article presents a review of literature in the field of microbiological preparations used in agriculture. The aim of the article is to test the substance called EmFarma Plus™ and establish the correlation between the pressure and design of crop sprayer nozzles and the survival of beneficial microorganisms. The data obtained was used to design an appropriate nozzle for the application of microbiological preparations.

Keywords: Microbiological preparations, crop spray nozzles, bacterial mortality.

1. Introduction

Over the last decade, an increase in the sales of microbiological preparations has been noticeable on the domestic market. This is supported by the tendency towards organic field crops which has been fostered since Poland's accession to the European Union. In 2012, the share of biopesticides in relation to pesticides was estimated at about 3% and at about 1.5% on the national scale [1]. One of the reasons for this trend is the low effectiveness of microbiological preparations compared to conventional methods. As an example, stalk base necrosis may be given, causing root rot of cereal plants, against which these preparations do not exhibit effective action despite about 1000 different biocompounds registered [1]. Another reason that can be given as the cause for the small amount of sold preparations is the cost of registering this liquid. An example is the Swedish company Bioagri which has spent approximately EUR 4 million for the registration of two substances [1].

Microbial preparation is a term given to substances containing live microorganisms. The origins of preparations containing beneficial microorganisms dates back to the 1970s and their assumed objective was to fight certain fungi by isolating bacteria with properties suppressing the spread of diseases. One of the currently proposed types of substances described is EmFarma Plus™. The exact ingredients of the fluid are protected by a patent, which means that the contents cannot be determined. When drawing a literature review, one can specify them as a group of natural products based on carefully selected compositions of beneficial microorganisms, purposefully selected, genetically unmodified microbial strains, their metabolites, contained in a fermented mixture of natural ingredients [2]. The main goal of the preparation EmFarma Plus™ is: displace pathogenic microflora, change of the microbiological process direction to regenerative or revitalizing, condition the soil, promote the formation of crumbly soil structure, optimise water management, accelerate organic mass biodegradation [3].

In the literature review, the effectiveness of microbiological preparations was often found to be low [1.5], however, research methodology does not address the impact of crop sprayer components on the survival of living organisms contained in the substance, which translates directly into their amount reaching the soil. This gives the basis for investigating this dependence and thus determining the number of live bacteria while applying them under given pressure through a spray nozzle.

The most popular spray nozzles used on the domestic market are flat-jet elements [4] and it was their construction that was selected for examination after consideration. The preview graphic presenting the element is presented in Figure 1. In order to investigate the dependence of the nozzle type on bacterial

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mortality, the size of the applicator opening, all elements from one Polish manufacturer [6] were used in order to obtain the same accuracy of component design.

Figure 1. RS crop spray nozzles intended for plant protection products [6].

2. Material and Methods

Due to the innovative nature of the research, the methodology was determined experimentally. The entire research was divided into two stages, first a classical field sprayer, having a valid technical condition examination was used, which, according to the manufacturer, is suitable for applying the preparation. The second stage was to create a methodology for the proper count of living organisms in the preparation.

According to the manufacturer, the possible dilution is within the following limits 1:50 – 1:2,5. It was decided to use two concentrations, which resulted indirectly from a large number of samples necessary for collection, causing their collection to be distributed in time, followed by their counting. At a later stage, this action stipulated bringing all values to percentage figures. The first attempt at a concentration of 1:50, which concerned nozzles sized 0.1; 0.15; 0.2; 0.25; 0.3; 0.4; and concentration 1:45 for nozzles sized 0.5; 0.6; 0.8; 1; 1.5; 2. All of the liquid was left in the sprayer, with pumping activated, for 1 h for precise mixing. For the highest objectivity of measurements, 10 samples of water and preparation mixture were obtained, living organisms counted, the average number of measurements taken, and the whole process was repeated three times, thus obtaining the total number of 30 measurements and 3 sets of average results for a given pressure setting. In order to regulate the working pressure, a manifold, which is part of the sprayer, together with a pressure gauge were used to read the set pressure. The construction of the manifold is shown in Figure 2. The spray nozzles were mounted on a pendulum holder that allowed the nozzle in use to be changed immediately; its design is shown in Figure 3.

Figure 2. Crop sprayer manifold. Authors' own elaboration.

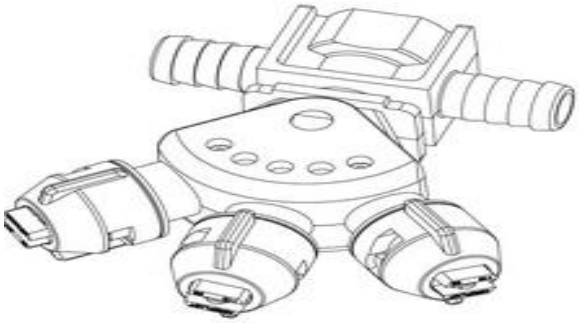

Figure 3. Pendulum nozzle of the crop sprayer [7].

In order to determine the tendency of changes in the number of microorganisms after their passage through nozzles of various sizes, a microbiological examination was carried out. A patented mixture of bacterial strains from EmFarma Plus ™ was used in it. As a result of the fact that its exact ingredients are not given by the manufacturer, the nutritional and oxygen requirements of the micro-organism were determined experimentally. It was decided that the best method would be to breed them on a simple solid medium. It contained 2% of agar and 2% of yeast. The selected microbiological methodology was taken from [8] describing, i.a., cases of unknown compositions of substances necessary for testing. The prepared nutrient solution was poured in a quantity of 1 ml onto Petri dishes and allowed to cool, after which carpet culture was carried out using the aforementioned mixture in a quantity of 2 ml as well. The inoculated dishes were incubated for 48 hours at 28°C, after which 30 µl of the accumulated bacteria were collected with an electronic pipette . They were diluted with distilled water at a ratio of 1:20 and stirred in a centrifuge at a low speed of 1000 revolutions for about 15 seconds. The counting of the obtained number of microorganisms was carried out by means of a traditional microscope and an improved Neubauer chamber [9], into which a solution of the cultured bacteria was transferred with a pipette. In the next stage, the number of live bacteria per 1 ml of the substance was calculated according to the formula (1).

$$\text{number of cells / 1 ml} = \frac{\text{number of counted cells} \cdot 10000}{\text{No. of chamber fields} \cdot \text{dilution coeff.}} \qquad (1)$$

3. Results and Discussion

On the basis of the conducted examination, the following relationships were found, which show the effect of pressure and structure of the "RS" flat jet nozzle on survival of microorganisms during application. The results, due to the high values of the figures, were presented in the form of exponential notation for the clarity of comparisons.

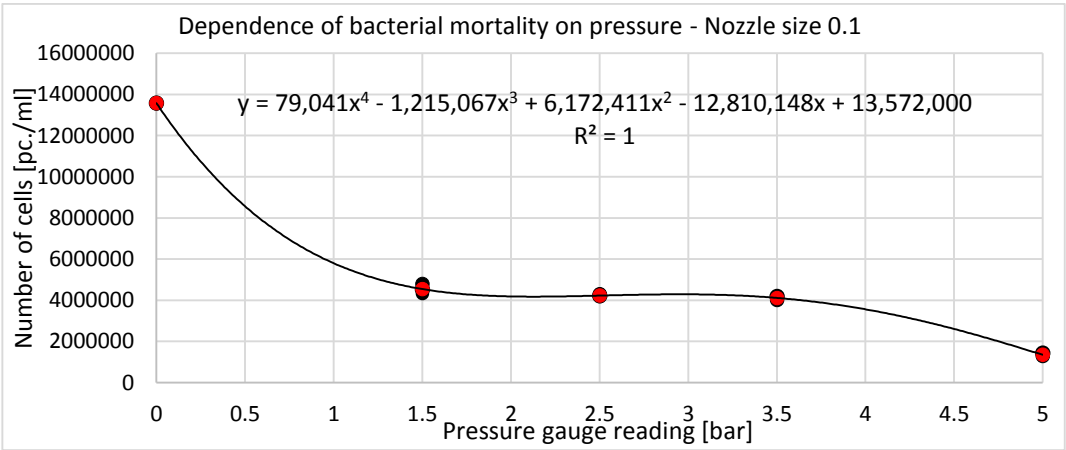

Figure 4. Flat jet nozzle 0.1. Characteristics of pressure-dependent bacterial mortality for EmFarma Plus substance. Authors' own elaboration.

The nozzle in size 0.1 showed a decrease in the number of live bacteria at a pressure of 1.5 bar down to the value of about 4.54 10^6, at a pressure of 2.5 bar the correlation was $4.22 \cdot 10^6$, at a pressure of 3.5 bar the correlation was 4.11 10^6, at a pressure of 5 bar, it was 1.35 10^6.

The nozzle in size 0.15 showed a decrease in the number of live bacteria at a pressure of 1.5 bar down to a value of about 4.42 10^6, at a pressure of 2.5 bar the correlation was 4.43 10^6, at a pressure of 3.5 bar, the correlation was $4.11 \cdot 10^6$, at a pressure of 5 bar, it was 1.75 10^6.

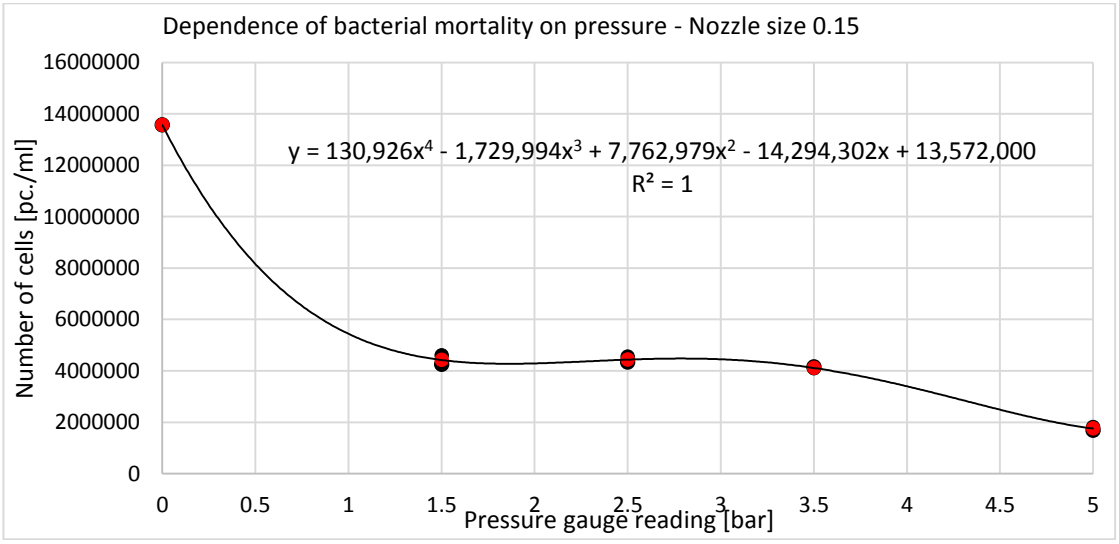

Figure 5. Flat jet nozzle 0.15. Characteristics of pressure-dependent bacterial mortality for EmFarma Plus substance. Authors' own elaboration.

The nozzle in size 0.2 showed a decrease in the number of live bacteria at a pressure of 1.5 bar down to a value of about $4.42 \cdot 10^6$, at a pressure of 2.5 bar the correlation was $4.43 \cdot 10^6$, at a pressure of 3.5 bar, the correlation was $4.11 \cdot 10^6$, at a pressure of 5 bar it was $1.75 \cdot 10^6$.

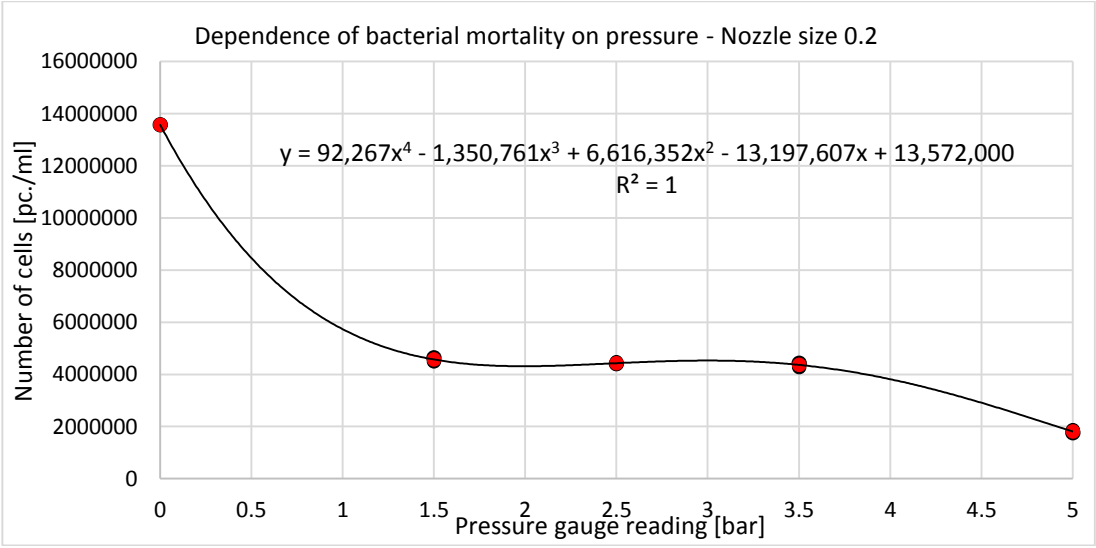

Figure 6. Flat jet nozzle 0.2. Characteristics of pressure-dependent bacterial mortality for EmFarma Plus substance. Authors' own elaboration.

The nozzle in size 0.25 showed a decrease in the number of live bacteria at a pressure of 1.5 bar to a value of about $5.07 \cdot 10^6$, at a pressure of 2.5 bar the correlation was $5.09 \cdot 10^6$, at a pressure of 3.5 bar the correlation was $5.13 \cdot 10^6$, at a pressure of 5 bar it was $1.66 \cdot 10^6$.

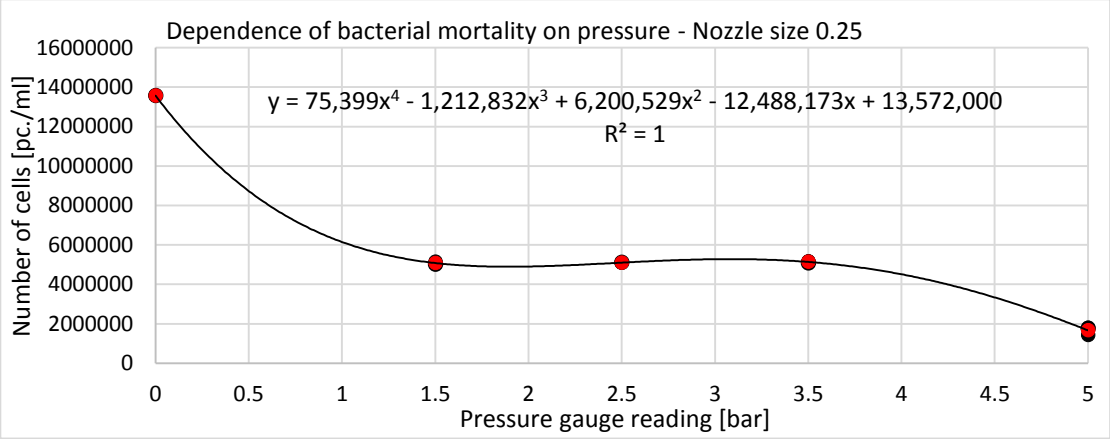

Figure 7. Flat jet nozzle 0.25. Characteristics of pressure-dependent bacterial mortality for EmFarma Plus substance. Authors' own elaboration.

The nozzle in size 0.3 showed a decrease in the number of live bacteria at a pressure of 1.5 bar to a value of about $5.41 \cdot 10^6$, at a pressure of 2.5 bar the correlation was $5.3\ 10^6$, at a pressure of 3.5 bar the correlation was $5.18\ 10^6$, at a pressure of 5 bar, it was $1.97\ 10^6$.

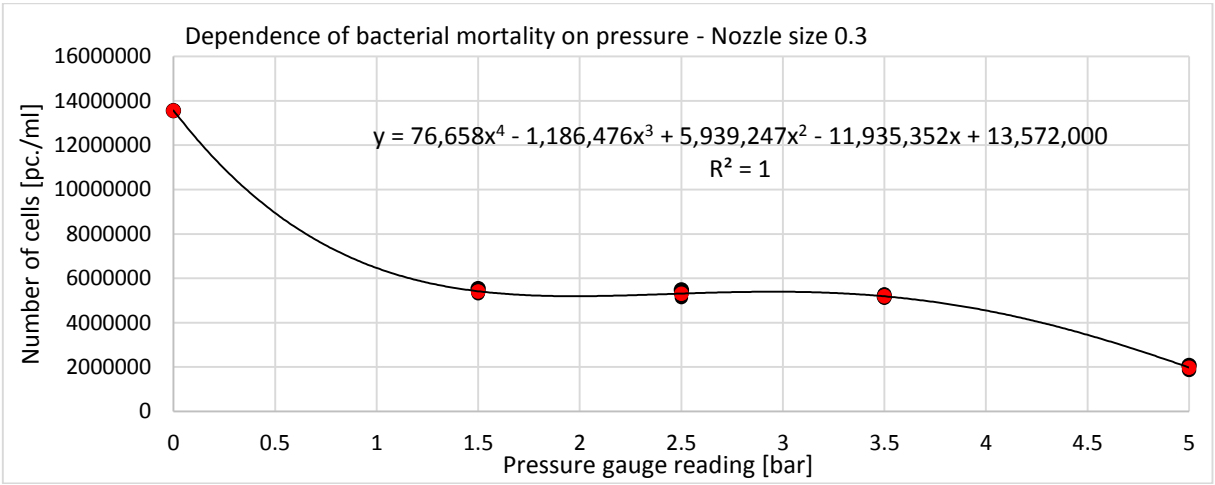

Figure 8. Flat jet nozzle 0.3. Characteristics of pressure-dependent bacterial mortality for EmFarma Plus substance. Authors' own elaboration.

The nozzle in size 0.4 showed a decrease in the number of live bacteria at a pressure of 1.5 bar to a value of about $5.74 \cdot 10^6$, at a pressure of 2.5 bar the correlation was $5.54 \cdot 10^6$, at a pressure of 3.5 bar the correlation was $5.21 \cdot 10^6$, at a pressure of 5 bar, it was $2.19 \cdot 10^6$.

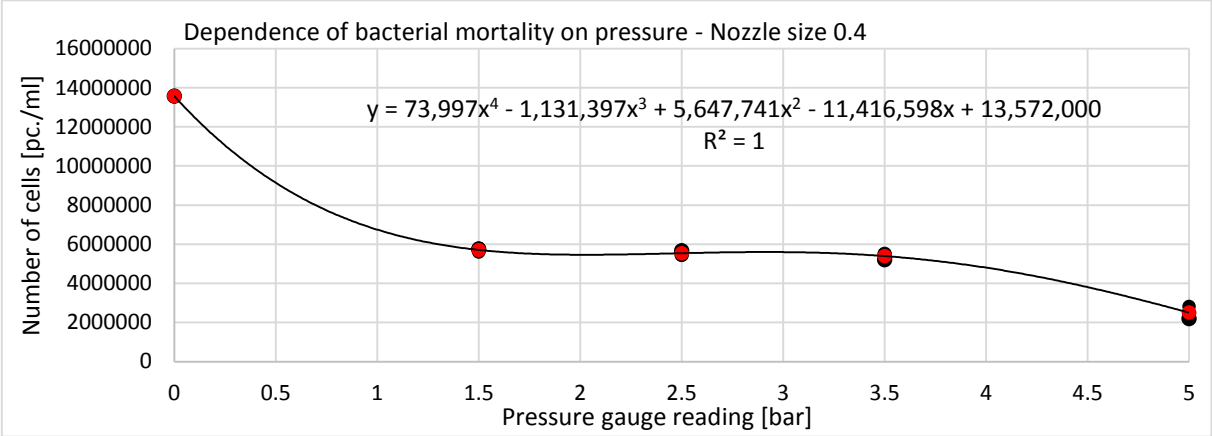

Figure 9. Flat jet nozzle 0.4. Characteristics of pressure-dependent bacterial mortality for EmFarma Plus substance. Authors' own elaboration.

The nozzle in size 0.5 showed a decrease in the number of live bacteria at a pressure of 1.5 bar to a value of about $8.33 \cdot 10^6$, at a pressure of 2.5 bar the correlation was $7.9 \cdot 10^6$, at a pressure of 3.5 bar the correlation was $7.76 \cdot 10^6$, at a pressure of 5 bar, it was $4.04 \cdot 10^6$.

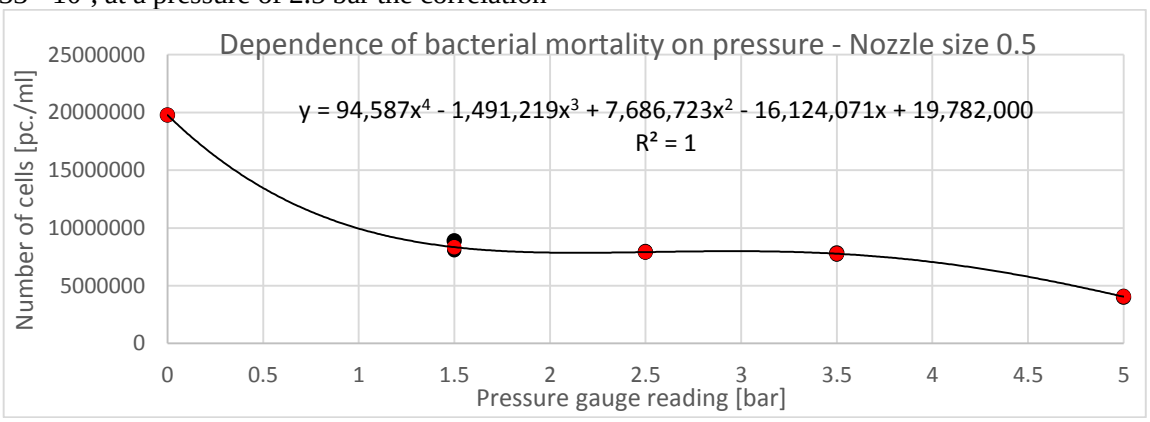

Figure 10. Flat jet nozzle 0.5. Characteristics of pressure-dependent bacterial mortality of the EmFarma Plus substance. Authors' own elaboration.

The nozzle in size 0.6 showed a decrease in the number of living bacteria at a pressure of 1.5 bar to a value of about $8.33 \cdot 10^6$, at a pressure of 2.5 bar, the correlation was $8.17 \cdot 10^6$, at a pressure of 3.5 bar, the correlation was $8.09 \cdot 10^6$, at a pressure of 5 bar, it was $3.22 \cdot 10^6$.

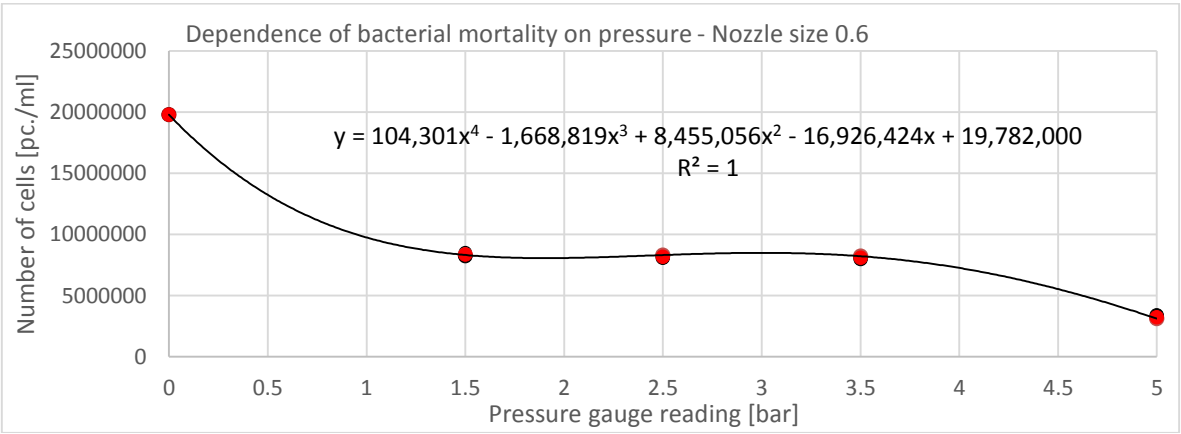

Figure 11. Flat jet nozzle 0.6. Characteristics of pressure-dependent bacterial mortality of the EmFarma Plus substance. Authors' own elaboration.

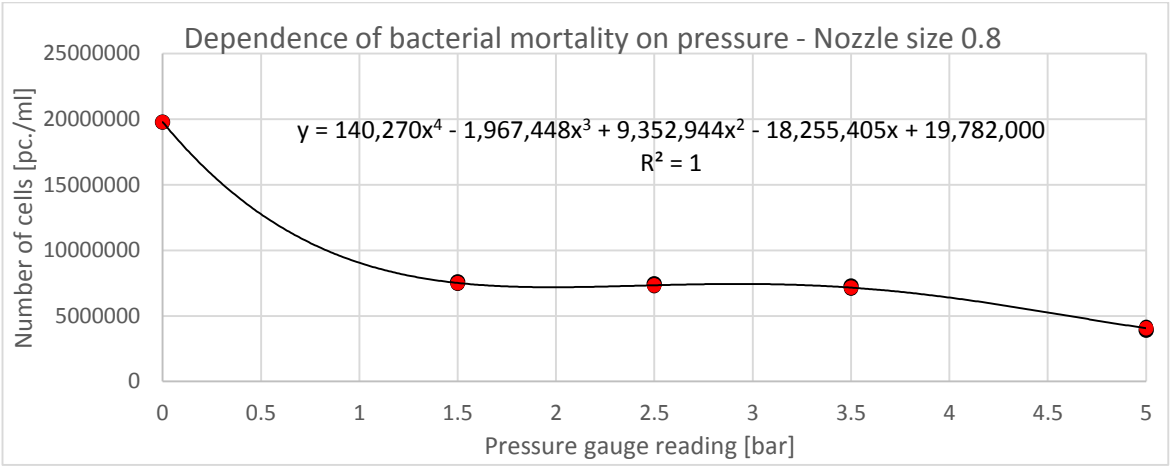

Figure 12. Flat jet nozzle 0.8. Characteristics of pressure-dependent bacterial mortality of the EmFarma Plus substance. Authors' own elaboration.

The nozzle in size 0.8 showed a decrease in the number of living bacteria at a pressure of 1.5 bar to a value of about $7.51 \cdot 10^6$, at a pressure of 2.5 bar, the correlation was $7.33 \cdot 10^6$, at a pressure of 3.5 bar, the correlation was $7.15 \cdot 10^6$, at a pressure of 5 bar, it was $4.06 \cdot 10^6$.

The nozzle in size 1.0 showed a decrease in the number of living bacteria at a pressure of 1.5 bar to a value of about $9.36 \cdot 10^6$, at a pressure of 2.5 bar, the correlation was $9.1 \cdot 10^6$, at a pressure of 3.5 bar, the correlation was $9.1 \cdot 10^6$, at a pressure of 5 bar, it was $4.89 \cdot 10^6$.

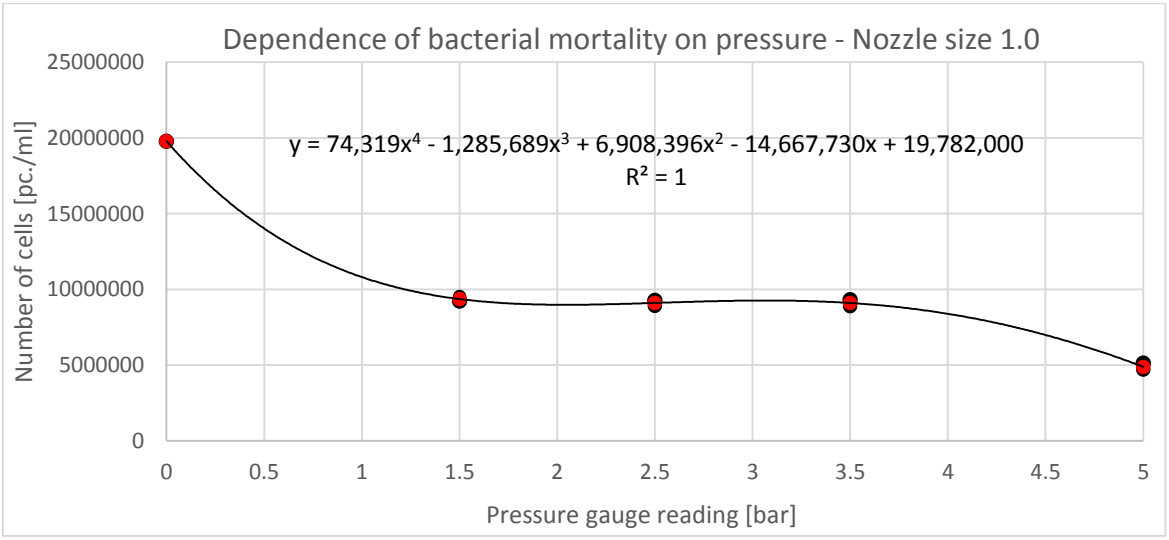

Figure 13. Flat jet nozzle 1.0. Characteristics of pressure-dependent bacterial mortality of the EmFarma Plus substance. Authors' own elaboration.

The nozzle in size 1.5 showed a decrease in the number of living bacteria at a pressure of 1.5 bar to a value of about $1.42 \cdot 10^7$, at a pressure of 2.5 bar, the correlation was $1.29 \cdot 10^7$, at a pressure of 3.5 bar, the correlation was $1.34 \cdot 10^7$, at a pressure of 5 bar, it was $8.5 \cdot 10^6$.

The nozzle in size 2.0 showed a decrease in the number of living bacteria at a pressure of 1.5 bar to a value of about $1.81 \cdot 10^7$, at a pressure of 2.5 bar, the correlation was $1.76 \cdot 10^7$, at a pressure of 3.5 bar, the correlation was $1.7 \cdot 10^7$, at a pressure of 5 bar, it was $1.09 \cdot 10^7$.

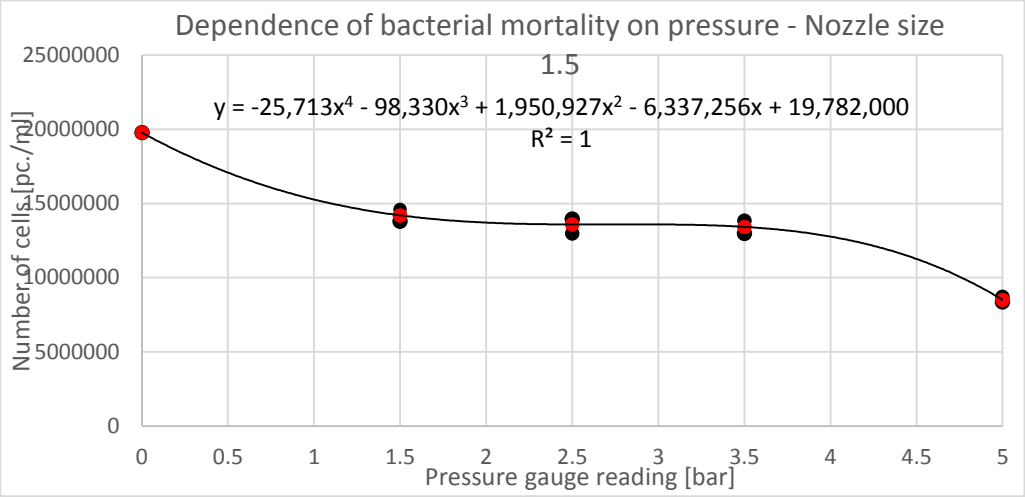

Figure 14. Flat jet nozzle 1.5. Characteristics of pressure-dependent bacterial mortality of the EmFarma Plus substance. Authors' own elaboration.

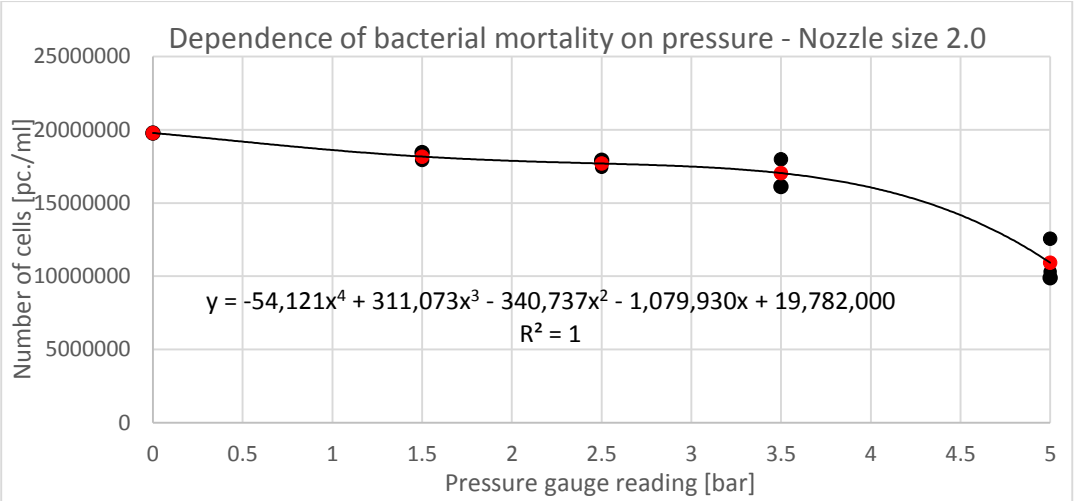

Figure 15. Flat jet nozzle 2.0. Characteristics of pressure-dependent bacterial mortality of the EmFarma Plus substance. Authors' own elaboration.

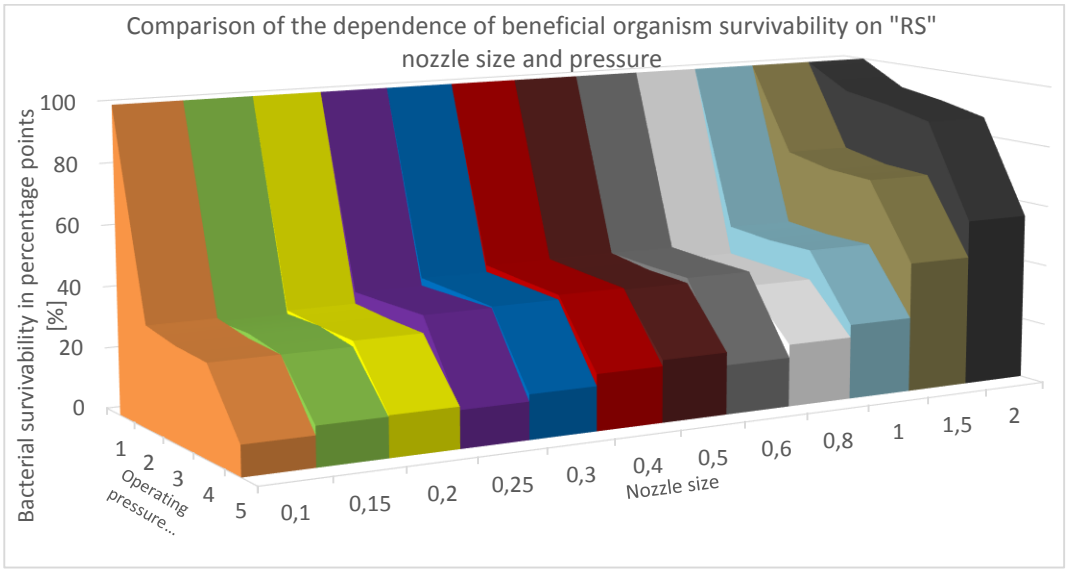

Figure 16. The characteristic of the dependence between the pressure and size of the "RS" nozzle and the survivability of microorganisms in the EmFarma Plus™ preparation. Authors' own elaboration.

4. Conclusions

For a clear comparison of the value of bacterial mortality for the EmFarma Plus™ preparation it is necessary to convert the values into percentage figures due to the two types of concentrations used. The following conclusions were drawn on the basis of the examination:

- despite research on microbiological preparations conducted since the 1970s and broad commercial availability, they are characterized by low effectiveness and , consequently, do not enjoy great interest among farmers [1.5],
- tests were performed on "RS" flat jet nozzles due to their widespread availability and the greatest interest of users [4],
- there is a direct correlation between the pressure set on the crop sprayer manifold and the survivability of beneficial microorganisms in the EmFarma Plus™ preparation as evidenced by the test results shown in Fig. 4 – 15,
- there is a direct correlation between the size of the outlet opening of the crop sprayer nozzle and the survivability of beneficial microorganisms in the EmFarma Plus™ preparation. The dependence is possible to compare in Fig. 16, where the test values were compiled as percentage figures for comparison purposes.

5. References

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