PhD THESIS

The impact of conventional and unconventional agricultural inputs on tomato culture

SUMMARY OF THE Ph.D THESIS

PhD student **Roxana Alexandra SABO (PĂCURAR)**

Scientific coordinator **Prof. Antonia Cristina Maria ODAGIU Ph.D.**

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1. General considerations concernin tomato culture

Tomatoes belong to the Solanaceae family, which contains more than 3000 species, including many economically important plants including potatoes, eggplants, petunias, tobacco, peppers. Solanum is the largest genus in the Solanaceae family, comprising 1250 to 1700 species. The species of the genus Solanum are present on all continents in temperate and tropical zones and are remarkable for their morphological and ecological diversity. Solanum is probably the most economically important genus, containing cultivated species and many other species that produce both medicinal and even poisonous compounds (WEESE ŞI BOHS, 2007).

2. The tomato diseases

Tomatoes belong to the Solanaceae family, which contains more than 3000 species, including many economically important plants including potatoes, eggplants, petunias, tobacco, peppers. Solanum is the largest genus in the Solanaceae family, comprising 1250 to 1700 species. The species of the genus Solanum are present on all continents in temperate and tropical zones and are remarkable for their morphological and ecological diversity. Solanum is probably the most economically important genus, containing crop species and many other species that produce both medicinal and even poisonous compounds.To date, more than 200 diseases and pest attacks have been identified in tomatoes, which causes losses in their production directly or indirectly (NOWICKI AND COLAB. 2013). Tomato disease management is a difficult process that requires continuous attention throughout the crop cycle and represents a significant part of total production costs (PEET AND WELLES, 2005). Early detection can help reduce the cost of treatment, reduce the environmental impact of chemical inputs and mitigate risks of yield loss. Classical disease detection techniques are limited by the time required for experts to locate and individually and visually assess the disease, a task complicated by the volume of plants in fields and greenhouses and by the poor symptomatology of diseases in their early stages (SABO ROXANA ET AL. 2020, 2021).

3. Research objectives

In order to complete the doctoral thesis, the following objectives were established:

• identification of the content in active compounds of lavender, rosemary and thyme oils in order to use them to combat Phytophthora infestans (Mont.) de Bary in tomatoes

• testing the effectiveness of lavender, rosemary and thyme oils in combating Phytophthora infestans (Mont.) de Bary in tomatoes

• the study of the interrelationships between environmental factors and agricultural inputs in the context of the attack of the pathogen Phytophthora infestans (Mont.) de Bary in tomatoes

• quantification of the impact of conventional and non-conventional agricultural inputs on the morpho-productive characteristics of tomatoes.

4. Environmental peculiarities of the experimental site

The experiments took place in the commune of Gâlgău, characterized by the pedoclimatic conditions of Transylvania, taking into account the particularities of the location. Gâlgău commune is located in the north-east of Sălaj county, in the so-called "ses" of the Someș Valley. The commune is part of the Someșan Plateau or Someșana Platform and is located at a distance of 23 km from the city of Dej (Cluj county) and 88 km from the city of Zalău, the county seat, on the DN1C road, part of the European road E58 (ILIEȘ ȘI GABRIELA ILIEȘ, 2001).

5. Material and Method

In order to carry out studies on the impact of conventional and unconventional agricultural inputs on production, morpho-productive characteristics and the factors that influence them, in tomato, experiments were carried out in the years 2021 and 2022, respectively. Climatic indicators were monitored during the experimental period April - June corresponding to the two years, as well as the experimental conditions. The data related to the morpho-productive characteristics of the tomato crop were collected, as well as the attack degrees of Phytophthora infestans (Mont.) de Barry depending on the level of agricultural inputs administered (fertilizers and phytosanitary treatments). The biological material studied is represented by the tomato cultivar (Solanum lycopersycum L.), Ruxandra. It is an early variety, with medium vigor, produced by the largest company producing seeds in Romania, Agrosel, and introduced to the market in 2012. Chemical materials were used both for the extraction of the volatile oil from the aromatic plants intended for non-conventional phytosanitary treatments, for the treatments conventional, for soil and foliar fertilization, as well as for performing chemical analyzes aimed at quantifying the nutrients in tomato fruits. The physical materials used were part of both the category of those necessary for monitoring climatic

parameters, obtaining seedlings, planting and maintaining crops, as well as the category of laboratory equipment intended for morphological and physico-chemical analyses. In order to identify the impact of conventional and non-conventional agricultural inputs on production, morpho-productive and quantitative characteristics and the factors that influence them, two series of experiments organized as bifactorial experiments were organized for tomatoes, respectively the study of the effectiveness of conventional and non-conventional treatments in combating Phytophthora infestans (Mont .) by Barry in tomatoes belonging to the cultivar Ruxandra, under conditions of differentiated fertilization (soil, foliar and mixed soil and foliar). This study was organized as a bifactorial experiment and the study of the influence of fertilization and phytosanitary treatments on the morpho-productive and quantitative characteristics of tomatoes belonging to the cultivar Ruxandra. The experiments were implemented in the experimental field located in , and the laboratory analyzes and data processing were carried out in the Environmental Quality Monitoring Laboratory. The collected experimental data were statistically processed and interpreted with the help of the STATISTICA v.8 for Windows and "XLSTAT" programs.

6. Results concerning the impact of conventional and unconventional agricultural inputs in fight against *Phytophthora infestans* (Mont.) de Bary in tomato

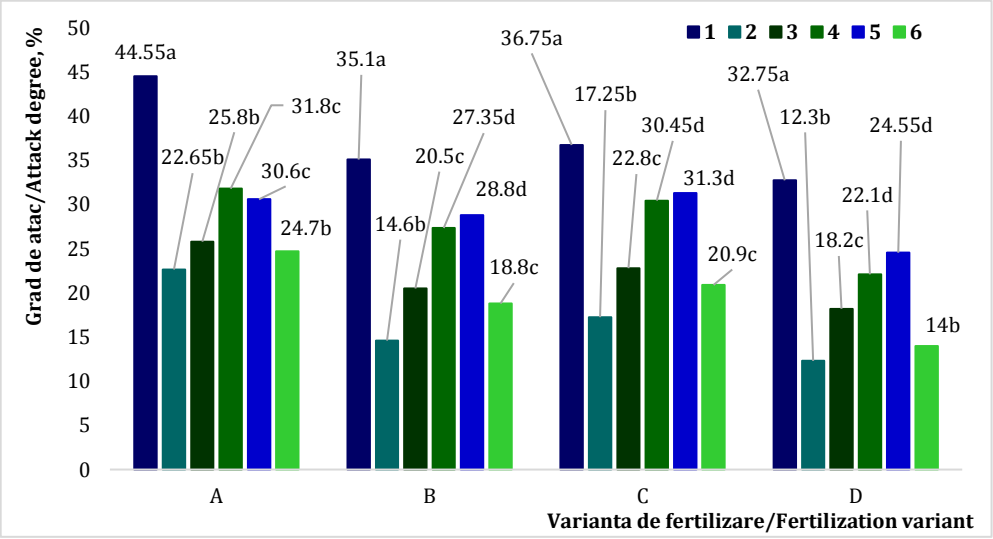
The analysis of the evolution of the attack of the pathogen Phytophthora infestans (Mont.) by Barry on the Roxana tomato cultivar, depending on the level of fertilization, highlights specific particularities.

In the case of the unfertilized control experimental variant, the highest average attack degree is reported, as expected, in the absence of any phytosanitary treatment (GA = 44.55%). The most effective are the conventional (GA = 22.65%) and non-conventional (GA = 24.70%) treatments with a mixture of lavender extracts 5%, thyme 1% and rosemary 5% (40:30:30, v/v /v). There are no statistically significant differences between the degrees of attack recorded following the application of conventional and non-conventional phytosanitary treatments with 5% lavender oil and mixture of extracts (Fig. 6.1).

Irrespective of the fertilization option, the lowest means of attack degrees of the pathogen correspond to the conventional phytosanitary treatments (GA = 14.60% for soil fertilization, GA = 17.25% for foliar fertilization and GA = 12.30% for fertilization mixed soil and foliar) and unconventional with the mixture of extracts of lavender 5%, thyme 1% and rosemary 5% (40:30:30, v/v/v), which corresponds to the following

means of attack degrees: GA = 18.80% for soil fertilization, GA = 20.90% for foliar fertilization and GA = 14% for mixed soil and foliar fertilization) and unconventional with the mixture of lavender extracts 5%, thyme 1% and rosemary 5%, 40:30:30, v/v/v (Fig. 6.1).

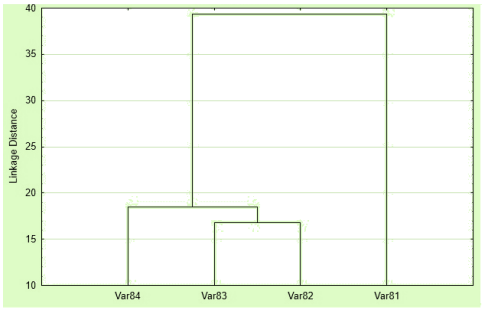
The analysis of the results shows, however, that only in the case of soil fertilization the differences between the average attack degrees corresponding to the non-conventional treatments and with the mixture of lavender extracts 5%, thyme 1% and rosemary 5% (40:30:30, v/ v/v) are statistically ensured at the 5% threshold, which highlights the effectiveness of using unconventional treatment with mixed structure.



1 - control; 2 - conventional treatment with azoxistrobine; 3 – unconventional treatment with levender extract, 5%; 4 – unconventional treatment with thym extract, 1%; 5 –unconventional treatment with rosemary extract, 5%; 6 –unconventional treatment with a mixture of 5% levender extract, 1% thym extract, and 5% rosemary extract (40:30:30, v/v/v); A no fertilization; B –soil fertilization; C –foliar fertilization; D –soil and foliar mixed fertilization; the differences between any two variants are significant, if their values are followed by letters, or groups of different letters.

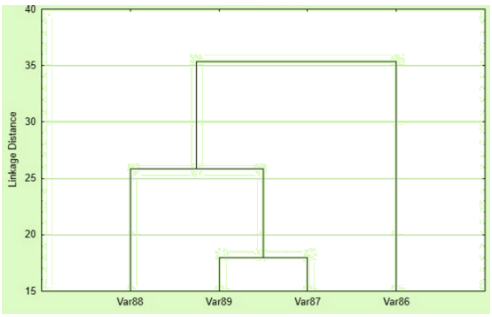
Figure 6.1. The evolution of the means of the *Phytophthora infestans* (Mont.) de Bary attack degrees in Ruxandra tomatoes variety, reported by experimental period înregistrate 2021 – 2022, function of phytosanitary treatments and fertilization

Cluster analysis was applied in order to identify the most favorable phytosanitary treatments under different fertilization conditions (Fig. 6.6). Regardless of the phytosanitary treatment variant applied, including in the case of the untreated control experimental variant, taking into account the average attack degrees of Phytophthora infestans (Mont.) de Bary, it is found that two main clusters are obtained. One of them consists of a single branch and corresponds to the lack of fertilization, and the other is composed of two subclusters, null consisting of a single branch and the other of two branches (Fig. 6.6).



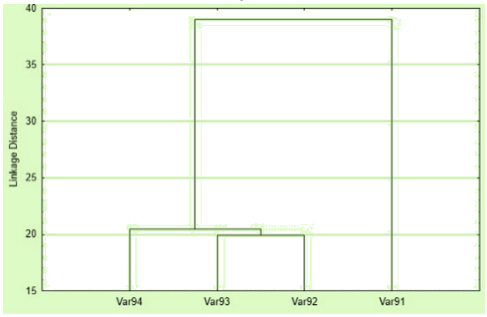
Var 81-control; Var 82-soil fertilization; Var 83-foliar fertilization; Var 84-mixed fertiliation administred at soil and foliar

a



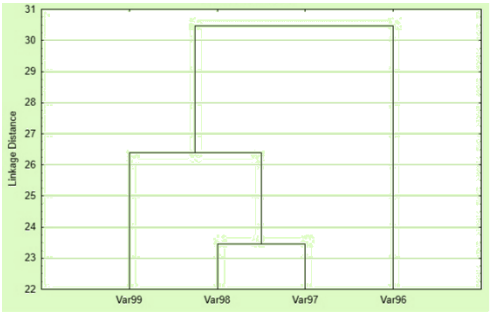
Var 86-control; Var 87-soil fertilization; Var 88-foliar fertilization; Var 89 mixed fertiliation administred at soil and foliar

b



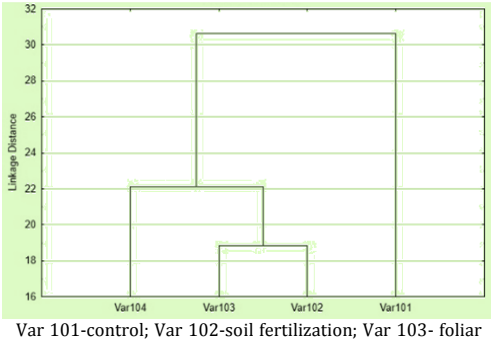
Var 91-control; Var 92-soil fertilization; Var 93-foliar fertilization; Var 94-mixed fertiliation administred at soil and foliar

c



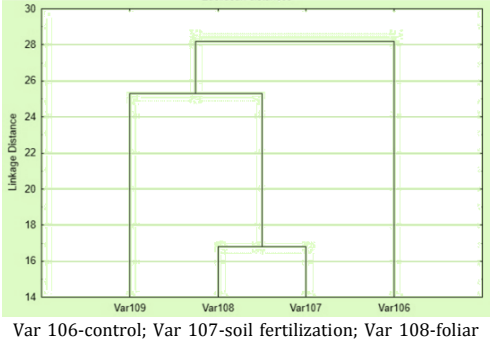
Var 96-control; Var 97-soil fertilization; Var 98-foliar fertilization; Var 99- mixed fertiliation administred at soil and foliar

d



Var 101-control; Var 102-soil fertilization; Var 103- foliar fertilization; Var 104- mixed fertiliation administred at soil and foliar

e



Var 106-control; Var 107-soil fertilization; Var 108-foliar fertilization; Var 109- mixed fertiliation administred at soil and foliar

f

a–control; b–conventional treatment with azoxistrobine; c–unconventional treatment with levender extract, 5%; d – unconventional treatment with thym extract, 1%; e–unconventional treatment with rosemary extract, 5%; f–unconventional treatment with a mixture of levender, thym, and rosemary extracts, 40:30:30, v/v/v (%).

Figure 6.6. The cluster analysis applied to *Phytophthora infestans* (Mont.) de Bary attack degrees when conventional and unconventional inputs are applied in tomato

7. Results concerning the impact of conventional and unconventional agricultural inputs on morpho-productive traits in tmato

For the study of the evolution of the morpho-productive features in tomatoes, both conventional inputs, represented by conventional soil and foliar fertilization products, with N15:P30:K15 and, respectively, with a multimineral complex, as well as phytosanitary treatments carried out with with the help of a conventional product with the active substance azoxythrombin and, respectively, an unconventional one with a mixture of lavender, thyme and rosemary volatile oils (Table 6.49).

Table 6.49

The multiple correlations between production and plants morpho-quantitative traits in Ruxandra tomato variety

Experimental variant	Regresion line	R	R^2
V1	Y= 17,233 + 0,324X1+ 0,134X2 + 0,039X3 + 0,116X4 – - 0,041X5+0,334X6+0,498X7	0,458	0,235
V2	Y = 40.555 + 0,591X1 + 0,249X2 + 0,482X3 + 0,126X4 - 0,043X5 + 0,756X6 + 0.223X7	0,554	0,308
V3	Y = 43.295 + 0,178X1 + 1,283X2 + 0,058X3 + 0,921X4 - - 0,046X5 + 1.041X6 + 0.578X7	0,751	0,564
V4	Y = 12.504 + 0,179X1 + 0,206X2 + 0,221X3 + 0,247X4 - 0,085X5 + 0,157X6 + 0.375X7	0,453	0,206
V5	Y = 120.003 + 0,614X1 + 0,245X2 + 0,137X3 + 0,424X4 - 0,053X5 + 0,078X6 + 0.326X7	0,595	0,354
V6	Y = 50.083 + 0,328X1 + 0,465X2 + 0,236X3 +0,317X4 - - 0,021X5 + 0,183X6 + 0.729X7	0,661	0,437
V7	Y = 6.591 + 0,062X1 + 0,355X2 + 0,058X3 + 0,427X4 – - 0,065X5 + 0,144X6 + 0.437X7	0,429	0,184
V8	Y = 4.575 + 0,238X1 + 0,148X2 + 0,067X3 + 0,114X4 - 0- ,209X5 + 0,254X6 + 0.4358X7	0,741	0,549
V9	Y = 18.046 + 0,472X1 + 0,259X2 + 0,135X3 + 0,329X4 - - 0,055X5 + 0,179X6 + 0.562X7	0,782	0,612
V10	Y = 69.467 + 0,120X1 + 0,355X2 + 0,109X3 + 0,562X4 - - 0,049X5 + 0,381X6 + 0.529X7	0,574	0,455
V11	Y = 7.159 + 0,470X1 + 0,041X2 + 0,523X3 + 0,079X4 – - 0,032X5 + 0,209X6 + 0.591X7	0,698	0,488
V12	Y = 35.251 + 0,280X1 + 0,176X2 + 0,026X3 + 0,533X4 - - 0,057X5 + 0,159X6 + 0.798X7	0,711	0,505

V1–control; V2–unfertilized, conventional treatment; V3–unfertilized, unconventional treatment; V4–soil fertilized, untreated; V5–soil fertilized, conventionally treated; V6–soil fertilized, unconventionally treated; V7–foliar fertilized, untreated; V8–foliar fertilized, conventionally treated; V9–foliar fertilized, unconventionally treated; V10–mixed fertilized, untreated; V11–mixed fertilized, conventionally treated; V12–mixedfertilized, unconventionally treated; Y-production; X1- leaf area; X2- no. of leaves; X3- no. of fruits; X4- fruit weight; X5-NUE; X6- chlorophylle; X7- dry matter.

In order to identify the influence of the morpho-quantitative characteristics on tomato production, Ruxandra cultivar, the multiple correlations between the mentioned factors were calculated (Table 6.49).

Analyzing the intensity of the multiple correlations between production and the main morpho-productive characteristics in tomatoes belonging to the cultivar Ruxandra, it is found that they are positive and fall into the medium and strong category, with values in the ranges R = 0.429 (the experimental variant foliar fertilized, untreated phytosanitary) with a representativeness equal to 18.40% and R = 0.782 (experimental variant foliar fertilized, non-conventional phytosanitary treated with extract of volatile oils of lavender 5%, thyme 1% and rosemary 5% (40:30:30, v/v/v) with a representativeness equal to 61.20%.

8. Conclusions and recommendations

Following the study carried out on the composition of the volatile oils from the three species of plants with potential in combating the attack of Phytophthora infestans (Mont.) by Barry on tomato, it appears that the optimal method of obtaining is the hydrodistillation of the aqueous extracts and consequently, in experiments to combat the pathogen, non-conventional treatments consisted of the use of aqueous solutions of volatile oils of lavender, thyme and rosemary.

The analysis of the evolution of the attack of the pathogen Phytophthora infestans (Mont.) by Barry on the Roxana tomato cultivar, depending on the level of fertilization, highlights specific particularities. In the case of the unfertilized control experimental variant, the highest average attack degree is reported, as expected, in the absence of any phytosanitary treatment (GA = 44.55%). The most effective are the conventional (GA = 22.65%) and non-conventional (GA = 24.70%) treatments with a mixture of lavender extracts 5%, thyme 1% and rosemary 5% (40:30:30, v/v /v).

According to the cluster analysis, regardless of the phytosanitary treatment variant applied, taking into account the average attack degrees of Phytophthora infestans (Mont.) de Bary, two main clusters result. According to Cestora, it follows that the application of soil and foliar fertilization accompanied by the use of conventional and/or non-conventional treatment with a mixture of lavender extracts 5%, thyme 1% and rosemary 5% (40:30:30, v/v/ v, %) leads to a much superior result of combating the pathogen, compared to the situation of the other fertilization options.

The study of the intensity of the multiple correlations between the production and the main morpho-productive characteristics of the tomatoes of the cultivar Ruxandra, highlights the fact that they are positive and present a variable intensity, from the average (R = 0.429, R2 = 0.184, the experimental variant foliar fertilized, untreated phytosanitary) to strong (R = 0.782, R2 = 0.612, foliar fertilized experimental variant, non-conventional phytosanitary treatment). According to the regression lines,

regardless of the experimental variant, it is found that the leaf surface and, to a greater extent, the dry matter content of the fruit have the greatest contribution to tomato production.

Taking into account the research carried out in the framework of the doctoral thesis, we consider it appropriate to formulate some recommendations, respectively: ▶ the use of water as a unique extraction system in order to obtain extracts intended for non-conventional phytosanitary treatments; ▶ considering as a sustainable, environmentally friendly alternative and using the mixture of aqueous extracts of lavender 5%, thyme 1% and rosemary 5% (40:30:30, v/v/v); ▶ maintaining an appropriate level of fertilization to increase the effectiveness of phytosanitary treatments; ▶ careful monitoring and management of phytosanitary treatments in the context of the climatic regime specific to the cultivation area to ensure adequate protection of tomato crops; ▶ careful management of fertilization to achieve quality tomato production.

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