PhD THESIS

Unconventional agricultural inputs. A case study: administration of *Allium cepa* L. extracts in potato culture

SUMMARY OF THE Ph.D THESIS

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INTRODUCTION

The benefits of using onion extracts in potato culture can be summarized as follows: protection against pests, increases antimicrobial effects, or improves soil quality. Bioactive substances from onion extracts can act as natural repellents or even as insecticides, protecting potatoes from pests such as aphids and beetles (CĂTUNA (PETRAR) TATIANA ŞI COLAB., 2022). The sulfuric compounds in the extracts can stimulate root development and nutrient uptake, thus contributing to the healthy growth of potato plants. Onion extracts may have antimicrobial properties, reducing the risk of fungal and bacterial infections in potato roots and tubers. The use of onion extracts can help create soil structure and increase the content of organic substances (CĂTUNA (PETRAR) TATIANA ŞI COLAB., 2024a).

1. Potato culture

The cultivated potato, Solanum tuberosum, still originates in the New World, where wild relatives can be found from the southern United States to Argentina and Chile (SPOONER AND COLAB., 2004). Potato cultivation began in South America about 8,000 years ago (LUTALADIO AND CASTALDI, 2009), resulting in many thousands of local crops still cultivated by small Andean farmers (BRADSHAW AND RAMSAY, 2009). Potatoes were first introduced to Europe in the 16th century by the Spanish Conquistadors during the Colombian exchange (LUTALADIO AND CASTALDI, 2009). By the end of that century, potatoes had been introduced to the United Kingdom and Ireland, where they had a transformative effect on societies, helping to fuel the Industrial Revolution (BRADSHAW ŞI RAMSAY, 2009).

2. The manifestation of diseases in potato

All potato varieties are vegetatively propagated clones through "seed" tubers and from this organisms are vulnerable to a wide range of pathogens, which they can transmit from crop to crop. Pathogens can be fungi, bacteria or viruses. Losses can occur when the crops are growing, when lifting and when the tubers are stored. Some diseases do not destroy the tubers, but the surface spots they cause reduce the sale value. In Romania's climate, the most important potato pathogens are *Phytophtora infestans* (Mont) de Barry and *Alternaria solani* Sorauer, which produce the diseases known under the common names of downy mildew and alternariosis (CĂTUNA (PETRAR) TATIANA ŞI COLAB., 2024b).

3. Research objectives

In the doctoral thesis with the title "Unconventional agricultural inputs. A case study: administration of *Allium cepa* L. extracts in potato culture" the objectives were pursued: determining the composition of bioactive substances of the volatile oil of *Allium cepa* L. used in the treatment against the attack of fungal pathogens in the potato culture; highlighting the performances of the oil of *Allium cepa* L. in the treatment against *Phytophthora infestans* (Mont.) de Bary and *Alternaria solani* Sorauer in the potato culture; determination of productivity and some quantitative characteristics in the potato culture and the study of the interaction of the experimental factors studied, related to the cultivar, phytosanitary treatment and fertilization strategy.

4. Environmental peculiarities of the experimental site

The experimental part of the research was carried out in the experimental field located in Gilău commune, Cluj county (46°45'20''N, 23°23'21''E), being located in the central part of the country. The southern part of Gilău commune is dominated by a series of smaller hills and peaks, which make up part of the Apuseni Mountains chain. These areas are mainly covered with forests, and during the summer, they offer a spectacular view of the surrounding areas. A significant part of the orography of Gilău commune is given by the presence of the Gilău Mountains. This mountain range is part of the Apuseni Mountains and is characterized by higher altitudes and more rugged terrain. The Gilau Mountains offer opportunities for hiking and outdoor activities. A significant part of the orography is covered by deciduous and coniferous forests, providing a source of wood and creating a rich natural environment for fauna and flora. Thus, it can be stated that the orography of Gilău commune in Cluj County includes a diversified combination of hills, mountains, valleys and lake landscapes. Gilău commune is crossed by several rivers and valleys, which add to the beauty of the landscape. Some of these rivers include Valea Someşului Mic and Valea Gilăului, which are surrounded by fertile lands and scenic trails. Near Gilău, there are also several natural lakes and reservoirs, which complete the landscape. A notable example is Lake Tarniţa, a nearby reservoir that is used for recreational activities and water sports.

5. Material and method

The research on the case study related to non-conventional agricultural inputs, with particularity related to the administration of *Allium cepa* L. extracts to the potato culture, was carried out in 2022 and 2023. During this period, the climate data, degrees

of attack of the main pathogens of the studied potato cultivars, namely *Phytophthora infestans* (Mont.) de Barry and *Alternaria solani* Sorauer, as well as production, dry matter and starch contents of the studied potato cultivars. The biological material consisting of two autochthonous potato cultivars (*Solanum tuberosum* L.) was studied, respectively Roclas which is semi-early and Redsec which is semi-late. Also, the biological material consisted of onion (*Allium sativum* L.) used to obtain the extracts, procured from local markets. The research methodology involves a three-factor experiment with the factors: cultivar (with two gradations, namely the Redsec and Rooclas potato cultivars), fertilization (with five gradations, unfertilized, mineral fertilization with N14:P7:K28, organic fertilization with manure, fertilization foliar with Agroleaf product from CL Specialty Fertilizers, Everris International and mixed, foliar and mineral fertilization) and phytosanitary treatment with four gradations (untreated, conventionally treated with Polyram DF and unconventionally with solutions of *Allium cepa* L. in concentrations of 2% and, respectively 4%). Both in the experimental field and in the laboratory the experiments were carried out. Observations were made regarding the recording of the frequency and attack of the pathogens, respectively *Phytophthora infestans* (Mont.) de Barry and *Alternaria solani* Sorauer, but also the productions were recorded. The laboratory determinations consisted both in the identification of the main components of the volatile oil extracted from *Allium cepa* L., by gas-chromatography, and in the gravimetric and polarimetric determination of the dry substance of the starch. The mathematical methods used referred to the calculation of the degree of pathogen attack (PUIA ŞI COLAB., 2003), and the statistical methods to basic statistics and multivariate analysis. For this purpose the XLSTAT program was used.

6. Results concerning the impact of unconventional agricultural inputs used against the attack of the fungal pathogens in potato culture

In order to determine the effectiveness of non-conventional inputs consisting of aqueous extracts of *Allium cepa* L. in different concentrations, on combating the fungal attack on potatoes, respectively that produced by PA agents involving pathogens *Phytophthora infestans* (Mont.) de Barry and *Alternaria solani* Sorauer, the results were analyzed experimental results obtained following the implementation of the trifactorial experiment (variety x phytosanitary treatment x fertilization). The study of the attack of the pathogen *Phytophthora infestans* (Mont.) by Barry on the potato cultivar Redsec, depending on the level of fertilization and phytosanitary treatments reveals different efficacies. Regarding the unfertilized control experimental variant, it is noted that, in this case, it corresponds to the lowest average of the attack degree, respectively GA =

37.70%. It is also noted that the most favorable treatments are those made with the conventional product, regardless of the fertilization option, these taking values equal to 37.25% - 10.25% (Fig. 6.1)

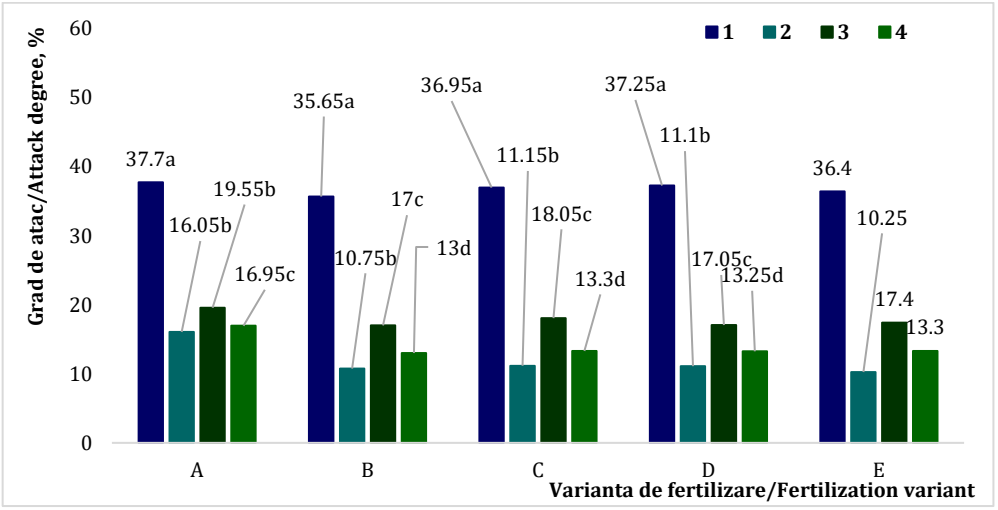

Figure 6.1. The evolution of the means of the *Phytophthora infestans* (Mont.) de Bary attack degrees in Redsec potato variety, reported by experimental period înregistrate 2022 – 2023, function of phytosanitary treatments and fertilization

The study of the attack of the pathogen *Alternaria solani* Sorauer on the Redsec potato cultivar, depending on the level of fertilization and phytosanitary treatments, shows different efficacies (Fig. 6.2).

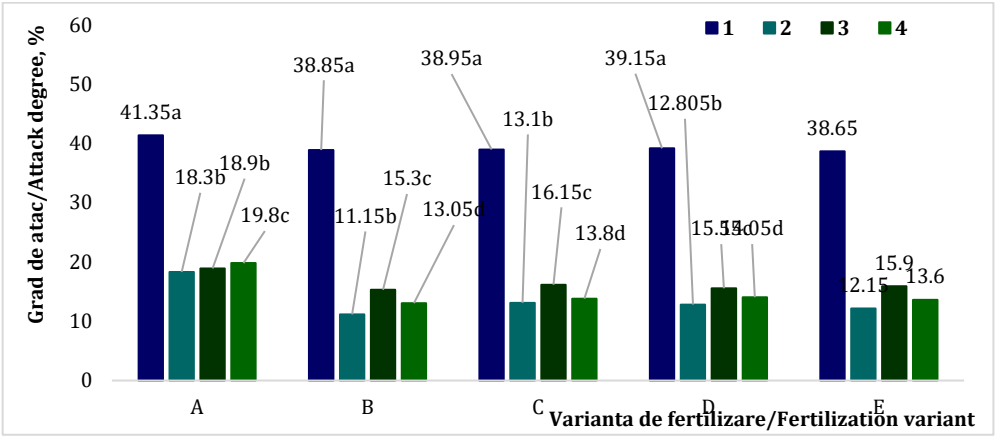

Figure 6.2. The evolution of the means of the *Alternaria solani* Sorauer attack degrees in Redsec potato variety, reported by experimental period înregistrate 2022 – 2023, function of phytosanitary treatments and fertilization

The study of the attack of the pathogen *Phytophthora infestans* (Mont.) by Barry and *Alternaria solani* Sorauer on the Roclas potato cultivars, depending on the level of fertilization and phytosanitary treatments shows different efficacies (Fig. 6.3 şi 6.4).

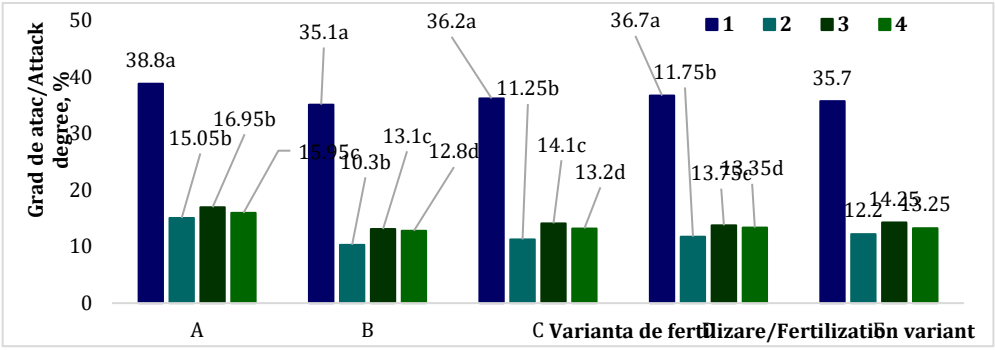

Figure 6.3. The evolution of the means of the *Phytophthora infestans* (Mont.) de Bary attack degrees in Roclas potato variety, reported by experimental period înregistrate 2022 – 2023, function of phytosanitary treatments and fertilization

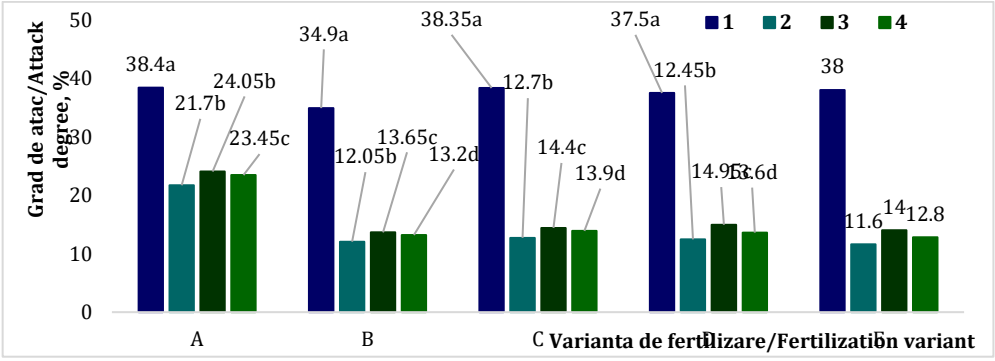

Figure 6.4. The evolution of the means of the *Alternaria solani* Sorauer attack degrees in Roclas potato variety, reported by experimental period înregistrate 2022 – 2023, function of phytosanitary treatments and fertilization

7. The study of the yield and some quantitative traits in potato culture

Productivity, dry matter content and starch content related to the potato cultivars studied have evolutions that reflect the quantitative performances of the crops in different experimental conditions, which are characterized by the application of differentiated fertilization and different, conventional and non-conventional, control strategies of manna and alternaria. Over the entire experimental period, the average

productivity reported for the experimental variant treated unconventionally with the 4% *Allium cepa* L. solution, for the Redsec potato cultivar, falls within the range of 53.77 t/ha corresponding to the lack of fertilization, and respectively 61.25 t/ha corresponding to mixed, soil and foliar mineral fertilization (Table 7.16).

Table 7.16

The yield in Redsec potato variety, experimental variant unconevtionally treated with 4% *Allium cepa* L., 2022 – 2023, %

Issue	N	X	s	CV(%)
Control unfertilized	20	53.77	4.91	9.13
Mineral fertilization	20	57.98	5.14	8.87
Organic fertilization	20	56.26	3.13	5.56
Foliar fertilization	20	59.80	4.81	8.04
Mixed fertilization, mineral and foliar	20	61.25	4.63	7.56

Over the entire experimental period, the average productivity reported for the experimental variant treated unconventionally with the 4% *Allium cepa* L. solution, for the Roclas potato cultivar, falls within the range of 59.36 t/ha corresponding to the lack of fertilization, and respectively 62.33 t/ha corresponding to organicl fertilization (Table 7.40).

Table 7.40

The yield in Roclas potato variety, unconventionally treated variant, with 4% *Allium cepa* L. solution, 2022 – 2023, %

Specificare/Issue	N	X	s	CV(%)
Control unfertilized	20	59.36	1.16	1.95
Mineral fertilization	20	62.33	2.03	3.26
Organic fertilization	20	60.82	1.32	2.17
Foliar fertilization	20	59.85	1.50	2.51
Mixed fertilization, mineral and foliar	20	60.40	1.42	2.35

9. Conclusions and recommendations

From the results of the extractions using n-pentane and water as solvents in different proportions, we can conclude that these processes led to obtaining variable amounts of active compounds from the volatile oil extracted from *Allium cepa* L. However, the hierarchy of the predominant active compounds of remained constant regardless of the proportion of solvents used. It is notable that n-pentane extraction resulted in the lowest proportion of undetermined active compounds in *Allium cepa* L.

oil, i.e. 24.03%. On the other hand, maceration in water led to obtaining the highest proportion of undetermined active compounds in the oil, namely 28.34%. These findings indicate that the choice of solvents and their proportions can significantly influence the chemical composition of the extracted volatile oil, especially with regard to the content of undetermined active compounds. However, the predominant active compounds in *Allium cepa* L. oil remained relatively stable across these extractions, suggesting some consistency in the chemical profile of the oil regardless of the extraction variables used.

The application of phytosanitary treatments with non-conventional products, which involved aqueous solutions of *Allium cepa* L. extract in concentrations of 2% and 4%, led to the recording of averages of the attack degree of the pathogen over the entire experimental period 2022 - 2023.

Principal Component Analysis (PCA) was used to assess the relationships between environmental variables (temperature, relative humidity, wind speed, and rainfall), agricultural inputs (fertilization type and phytosanitary treatment), and attack levels of pathogens in potato crops. - they identified four main factors: the type of fertilization, the phytosanitary treatment, the climatic parameters and the cultivar. However, only the first two factors (fertilization type and phytosanitary treatment) were taken into account due to the Eigenvalues. In the absence of fertilization, the administration of phytosanitary treatments was positively associated with relative air humidity, wind speed, amount of precipitation and conventional or organic fertilization.

The use of conventional and non-conventional phytosanitary treatments (with Allium cepa L. solution at concentrations of 2% and 4%) did not lead to significant increases in productivity. The average starch content did not show significant variations depending on the phytosanitary treatments and the type of fertilization. The results of the experiment did not reveal significant differences in the average productivity and starch content of potatoes depending on the phytosanitary treatments and fertilization systems used for the Roclas potato cultivar.

The recommendations that we believe can be formulated following the conduct of the present study are the following: ▶ conducting detailed tests to determine the optimal proportion of solvent and the appropriate type of solvent for the extraction of active compounds from *Allium cepa* L. oil; ▶ the use of phytosanitary treatments, with attention to the choice of products and the evaluation of their effectiveness; ▶ to take into account the climatic factors that can have a significant impact on crop yield and to consider these factors in the planning and management of potato crops and the fertilization systems used; ▶ the use of factor analysis, through its PCA component in assessing the complex relationships between environmental variables, agricultural inputs and pathogen attack levels; ▶correct choice of fertilization and phytosanitary

treatments can be essential for effective pathogen management in potato crops, but local climatic conditions and specific soil variables must also be taken into account.

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