JOURNAL of Horticulture, Forestry and Biotechnology
Volume 28(1), 2024, 66-73
https://jhfb.ro/index.php/jhfb
Print ISSN: 2066-1797
Online ISSN: 3045-1876

The influence of the different diseases and pests control treatments on the physiological, technological and economic indicators in grapevine

Alin DOBREI[1], Eleonora NISTOR[1*], Florin BORCA[1], Mihaela MĂLĂESCU[1], Teodor CRISTEA[1], Daniela DOBROMIR[2], Alina Georgeta DOBREI[1*]

[1] University of Life Sciences "King Michael I" from Timisoara, Faculty of Engineering ang Applied Technologies, e-mail: alindobrei@usvt.ro, eleonoranistor@usvt.ro, florin_borca@yahoo.com, mihaelamalaescu@usvt.ro, teodorcristea@usvt.ro, alina.dobrei@usvt.ro
[2] Miniș Viticulture and Winemaking Research and Development Station, e-mail: daniela.dobromir@gmail.com

*Corresponding author: ghitaalina@yahoo.com, nisnora@yahoo.com

Manuscript received: 12 May 2024; revised: 09 June 2024; accepted: 10 June 2024

Abstract
Disease and pest control are a very important and costly technological phase that significantly influences the success of grape yield. The research was carried out in a vineyard from Buzias-Silagiu area, focusing on both table and wine grape varieties. The experimental trial was organized in plots with three different complex treatments and analysed their influence on the total and one-year-old wood growth, photosynthetic yield, grape yield quality and quantity, and economic indicators. The growing seasons, during which observations were made varied climatically, resulting in conclusive and informative findings. The experimental plots significantly influenced all the monitored indicators, with the impacts varying depending on the climate conditions during each year. In years with favourable conditions for grapevine growing, vineyard management with a smaller number of treatments proved to be efficient. In contrast, during years with less favourable climate conditions, the reliable experimental strategy that achieved satisfactory results was the complex treatments applied for disease and pest control.

Keywords: berry quality, climate conditions, disease and pest, grapevine, profit

Introduction

Pests and diseases affect grape production both in terms of quantity and quality and can also threaten the longevity of vineyards. Managing these issues in a changing climate can be challenging. Depending on grape varieties' resistance or susceptibility to diseases, significant production costs and economic losses may occur [11,12]. Modern integrated pest and disease management involves selecting effective management systems, utilizing complex monitoring tools, applying early warning technologies, and using plant protection products (PPP) in precise quantities and at optimal timings. These combined strategies can help protect vineyards effectively while minimizing environmental impact. Implementing this integrated approach requires advanced technology and substantial investments, which may not be accessible to all winegrowers. However, the wine sector is one of the most advanced in agriculture regarding integrated disease and pest management, primarily due to the higher revenues that enable such investments [7]. Nevertheless, every vineyard must address diseases with a major impact on grape production and quality.

Grapevine downy mildew *(Plasmopara viticola)* can have severe impacts in climates with relatively hot and humid summers. It affects all European grape varieties to varying degrees and can lead to significant production losses. Common symptoms include stem or shoot necrosis, berry discoloration (including brown spots), and yellow-green leaf tips [5]. Similarly, all European grape varieties are susceptible to powdery mildew, caused by *Erysiphe necator.* This disease infects all green parts of the vine, including young leaves and berries, and can result in considerable yield losses. Its prevalence is favoured by warmer, drier climates. Powdery mildew is easily recognizable by its dusty appearance on the upper surfaces of the leaves, although it can also infect the lower parts, as well as buds, flowers, berries, and young stems. This disease can lead to the deterioration of wine quality both directly and indirectly. In fact, any changes in the vineyard can affect the winemaking process. Even pesticides must be carefully selected and applied to avoid negatively impacting the wine production process [8, 9].

Cultural practices should be implemented to minimize conditions favourable to infection and disease spread and to improve treatments for leaves and bunches. These practices include orienting the rows in the prevailing wind direction to promote air circulation and sunlight penetration, using an appropriate planting density, and implementing management practices to achieve a balanced leaf mass. Additionally, careful management of water and fertilizers, particularly nitrogen, can help reduce vigour in cultivars prone to excessive crown development [10, 13, 15]. Biocontrol of harmful diseases in grapevines involves the use of biological control agents and inducers (fortifiers) of plant resistance against diseases and pests [14]. An alternative strategy to reduce pesticide use in grapevine production is the utilization of beneficial bacteria as biocontrol agents [1]. Since Lorenz Hiltner's concept of the rhizosphere (1904), which describes the influence of plants and microorganisms [6] on the soil around the roots, numerous studies have shown that some rhizosphere bacteria can stimulate plant growth and provide protection against pathogen infection [2].

Material and Method

The purpose of the research is to establish the most suitable scheme for combating diseases and pests as concerns complexity and the number of treatments for each variety in correlation with the climatic conditions of each year, to can achieve the most favourable ratio between the cost of treatments and their influence on the analyzed indicators. The research was carried out between 2017-2019 years, in a vineyard from Buzias-Silagiu Vineyard Centre, located in Timis County. The vineyard is located on a plot of land with a slight slope and southern or south-eastern exposure depending on the plot. Vineyard established in 2007-2008, was at the beginning of the period of full maturity during the research. Planting distance were 2.2 m between rows and 1 m between vines per row, resulting a density of 4545 vines per hectare. The research focused on table grape varieties ('Victoria' and 'Muscat de Hamburg') and grape varieties for superior wines ('Merlot', 'Cabernet Sauvignon', 'Fetească Neagră', 'Fetească regală'). The experimental plots for the influence of the anthropic activity and the diseases and pests control on grapevine growing, were: V1(MT) - the complex variant; V2 - variant of medium complexity; V3 - reduced complexity version. On each experimental plot, within each analysed technological sequence, was observed the influence on the physiological indicators (total annual growth, annual matured wood, leaf area and photosynthetic yield), on the technological indicators (grape yield, grape production per hectare, the sugar accumulation in the must, must acidity, the maturity index) and on the economic indicators (production expenses, cost price and profit).

Results and Discussion

The average results per research cycle indicate that all experimental treatments across all varieties yield satisfactory total and matured growth, ensuring that winter hardiness and crop load are not significantly impacted. However, a difference exists between the treatments, with the best results naturally observed in the control group, which performed the most comprehensive disease and pest control management.

Both the absolute and relative values of annual and matured growth decreased across all varieties as the treatment protocol was simplified.

Table 1. The impact of anthropogenic interventions regarding pest and disease control on annual shoots and canes, on average, during 2017-2019 growing seasons

Experimental plot	Variety	Annual growth			Difference to control (%)	Significance
		Total (m/vine)	Mature (m/vine)	Mature (% from total)		
V_1(C)	Merlot	13	10.1	77.69	-	-
	Cabernet Sauvignon	15.27	12.35	80.88	-	-
	Fetească neagră	16.17	12.37	76.5	-	-
	Fetească regală	11.7	9.37	80.09	-	-
	Victoria	14.03	10.97	78.19	-	-
	Muscat Hamburg	11.7	9.07	77.52	-	-
V_2	Merlot	11.03	8.43	76.43	-1.26	-
	Cabernet Sauvignon	12.7	9.67	76.14	-4.74	0
	Fetească neagră	13.87	10.23	73.76	-2.74	-
	Fetească regală	9.57	7.9	82.55	2.46	-
	Victoria	11.9	9.07	76.22	-1.97	-
	Muscat Hamburg	9.8	7.6	77.55	0.03	-
	Merlot	10.23	7.47	73.02	-3.41	0

V_3	Cabernet Sauvignon	11.93	8.93	74.85	-1.29	-
	Fetească neagră	12.7	9.17	72.2	-1.56	-
	Fetească regală	9.17	6.93	75.57	-6.98	0
	Victoria	10.87	8.4	77.28	1.06	-
	Muscat Hamburg	9.13	6.73	73.71	-3.84	0

During the research, the use of a simplified treatment protocol presented challenges regarding total annual growth, particularly in 2019, a year considered less favourable for viticulture. In years with favourable or even moderately favourable climatic conditions, the application of simplified disease and pest control protocols does not suppose issues related to annual growth, wood maturation, winter hardiness, or crop load. According to these circumstances, implementing fewer treatments becomes viable option. (Table 1).

Effective control of diseases and pests is crucial for maintaining the canopy within appropriate quality parameters. By preventing disease and pest damage, the photosynthetic area remains at maximum, resulting in superior photosynthetic efficiency.

The average results from the research regarding leaf area and photosynthetic efficiency are evident, because climatic conditions during the study ranged from highly favourable to less favourable. On average, over the three years of research, applying a complex treatment management yielded the best results for all three analysed indicators. Using a treatment protocol of moderate complexity led to a decrease in photosynthetic efficiency compared to the control group, though the differences were not substantial. Statistically significant decline was observed only in the 'Feteasca Neagra' and 'Muscat de Hamburg' varieties, which required large leaf area, over 26 m^2, to produce one kilogram of sugars (Table 2).

Table 2. The impact of anthropogenic interventions regarding pest and disease control on leaf area and photosynthetic efficiency, on average, during 2017 -2019 growing seasons

Experimental plot	Variety	Leaf area			Difference to control (%)	Significance
		m^2/ vine	m^2/ kg grapes	m^2/ kg sugar		
V_1(C)	Merlot	5.5	1.94	13.2	-	-
	Cabernet Sauvignon	8	3.11	20.01	-	-
	Fetească neagră	9.4	3.57	22.97	-	-
	Fetească regală	7.1	2.11	14.78	-	-
	Victoria	8	2.29	20.84	-	-
	Muscat Hamburg	8.3	2.77	22.61	-	-
V_2	Merlot	5.1	2.08	15.01	1.81	-
	Cabernet Sauvignon	7.5	3.12	20.73	0.72	-
	Fetească neagră	9	3.96	26.44	3.47	0
	Fetească regală	6.5	2.09	15.23	0.45	-
	Victoria	7.5	2.51	23.13	2.29	0
	Muscat Hamburg	7.6	3.12	26.69	4.08	0
V_3	Merlot	4.7	2.28	17.33	4.13	0
	Cabernet Sauvignon	6.6	2.94	20.29	0.28	-
	Fetească neagră	7.9	3.91	27.79	4.82	0
	Fetească regală	6.1	2.08	15.64	0.86	-
	Victoria	6.7	2.38	23.61	2.77	0
	Muscat Hamburg	6.6	3.16	29.31	6.7	00

In the V3 plot, the lower numbers of treatments negatively influence the leaf area, resulting in the lowest values, ranging from 4.7 m² per vine in the Merlot variety to 7.9 m² per vine in the Feteasca Neagra variety. While this plot had the lowest sugar accumulations, the photosynthetic efficiency was also the most ineffective, for both one kilogram of grapes and accumulation of one kilogram of sugar. It can be concluded that the methods for diseases and pests control significantly influence both leaf area and photosynthetic efficiency for grape and sugar production. The less favourable the climatic conditions during growing season, the greater the leaf area needed with fewer treatments to produce one kilogram of grapes or sugar. In years with favourable conditions for grapevine growing and low precipitation, options with fewer treatments may offer viable alternatives both economically and for photosynthetic efficiency.

JOURNAL of Horticulture, Forestry and Biotechnology
Volume 28(1), 2024, 66-73
https://jhfb.ro/index.php/jhfb
Print ISSN: 2066-1797
Online ISSN: 3045-1876

Grape yield is the technological indicator most significantly influenced by diseases and pests management. Maintaining a healthy canopy, without disease and pest damage, facilitates proper photosynthesis and high yields. Alongside pruning, disease and pest control represents the most impactful aspect of vine production. The average results during the research regarding the influence of disease and pest control on grape yield were reasonable and informative, given the climatic variability across the three years of study; these observations allowed the assessment of the experimental plots influence on production under conditions of precipitation deficit, considered favourable for viticulture in 2017, as well as under conditions of excessive precipitation, generally unfavourable for grapevine growing. On average, during research and for all varieties, the plot that yielded the highest production was the control, where the most treatments were applied. Reducing the number of treatments within a protocol of moderate complexity still resulted in high yields for all varieties, but lower than the control, ranging from 788 kg/hectare for the Cabernet Sauvignon variety to 2,448 kg/hectare for the 'Muscat Hamburg' variety. The application of a simplified disease and pest control protocol during the research achieved relatively satisfactory yields, but these were significantly lower compared to the control plot for all varieties. The largest differences were recorded in varieties more vulnerable to disease and pest damage, such as Muscat Hamburg, Victoria, and Merlot. In Muscat Hamburg variety, this experimental plot resulted in a significantly lower production, over 4,000 kg/hectare, compared to the control (Table 3). In conclusion, for all researched varieties, the production level is clearly influenced by the complexity of the disease and pest control protocol, with evident differences between the experimental plots. However, in years with favourable climatic conditions, both the V2 and V3 plots yielded higher grape productions.

Table 3. The impact of anthropogenic interventions regarding pest and disease control on grape production, on average, during 2017-2019 growing seasons

Experimental plot	Variety	Grape production			Difference to control (%)	Significance
		kg / vine				
V_1(C)	Merlot	2.854	12971	100	-	-
	Cabernet Sauvignon	2.535	11523	100	-	-
	Fetească neagră	2.586	11753	100	-	-
	Fetească regală	3.343	15194	100	-	-
	Victoria	3.464	15745	100	-	-
	Muscat Hamburg	3.019	13720	100	-	-
V_2	Merlot	2.465	11205	86.4	-1766	000
	Cabernet Sauvignon	2.362	10735	93.2	-788	0
	Fetească neagră	2.262	10279	87.5	-1474	00
	Fetească regală	3.094	14064	92.6	-1130	00
	Victoria	2.983	13557	86.1	-2188	000
	Muscat Hamburg	2.48	11272	82.2	-2448	000
V_3	Merlot	2.095	9522	73.4	-3449	000
	Cabernet Sauvignon	2.214	10064	87.3	-1459	00
	Fetească neagră	2.039	9265	78.8	-2488	00
	Fetească regală	2.883	13103	86.2	-2091	00
	Victoria	2.757	12529	79.6	-3216	000
	Muscat Hamburg	2.078	9443	68.8	-4277	000

The quality of the grape yield is critical for producing competitive wines in a dynamic market with increasing competition (3). From this perspective, the application of effective treatment protocols for diseases and pest control, which maintain the canopy healthy, is essential. Additionally, the rising prices of phyto-pharmaceutical products make this technological sequence one that must be carefully managed.

On average, over the three years of research, the influence of experimental plots on sugar concentration was evident, increasing as the favourability of the year decreased. The highest sugar concentration was achieved for all varieties when the treatment protocol was most complex, with wine varieties accumulating over 200 g of sugar per litre. 'Fetească Neagră' and 'Cabernet Sauvignon' varieties reached the highest concentrations, with 222 g/l. The V2 experimental plot also recorded high sugar concentration during the research, slightly lower than the control plot; however, the differences were statistically significant only in the Merlot variety.

Table 4. The impact of anthropogenic interventions regarding pest and disease control on the quality of grape production, on average, during 2017-2019 growing seasons

Experimental plot	Variety	Sugar (g/l)	Acidity (g/l H_2SO_4)	Maturity index	Difference to control (%)	Significance
V_1(C)	Merlot	210	4.4	47.73	-	-
	Cabernet Sauvignon	222	4.1	54.15	-	-
	Fetească neagră	222	4.3	51.63	-	-
	Fetească regală	204	4.4	46.36	-	-
	Victoria	157	3.3	47.58	-	-
	Muscat Hamburg	175	4.2	41.67	-	-
V_2	Merlot	198	4.8	41.25	-12	0
	Cabernet Sauvignon	215	4.4	48.86	-7	-
	Fetească neagră	214	4.5	47.56	-8	-
	Fetească regală	196	4.6	42.61	-8	-
	Victoria	155	3.7	41.89	-2	-
	Muscat Hamburg	167	4.4	37.95	-8	-
V_3	Merlot	188	5.1	36.86	-22	00
	Cabernet Sauvignon	207	4.6	45	-15	0
	Fetească neagră	201	4.7	42.77	-21	00
	Fetească regală	190	5.1	37.25	-14	0
	Victoria	144	4.1	35.12	-13	0

Conversely, the simplest treatment protocol applied in the V3 plot, yielded the lowest results compared to the control, with statistically significant differences across all varieties (Table 4). As climate circumstances worsen, particularly for disease and pest sensitive cultivars, complex control solutions become increasingly important for high sugar accumulation. In rainy years, the application of fewer treatments negatively influence sugar accumulation, particularly in sensitive varieties such as 'Merlot', which may not reach the sugar levels needed to produce high quality wines. In favourable years, when precipitation is low, simplified treatment protocol can be effective, enabling substantial sugar accumulation, but lower compared with the complex protocol.

Establishing an effective treatment protocol for disease and pest control requires considering the climatic conditions of each year, each variety sensitivity to diseases and pests, and the qualitative potential of each wine-growing area. Applying a high number of treatments is not always advisable, as it can increase production costs and potentially harm both production and the environment due to excessive chemical usage.

Climate change in recent years, combined with increased input prices, has made the technological process of diseases and pests control one of the most expensive components of grapevine production, accounting for a major rate of total production costs. Management of this technological process must be approached with utmost care, considering the cultivated variety, the climate conditions of the year, and the natural resources of the growing location, in order to select the most effective management in terms of both expenses and grapevine protection.

In 2019, the higher amounts of precipitation resulted in the highest costs for disease and pest control across the entire research. This year, expenses for disease and pest control amounted to 3,350 lei/ha in experimental plot V1, 2,730 lei/ha for plot V2, and 2,215 lei/ha for plot V3. These values also contributed to an increase in production costs, which were the highest for the entire research.

The average expenses on disease and pest control over the three years of research was 3,100 lei/ha for the V1 plot, 2,413 lei/ha for the V2 plot, and 2,013 lei/ha for the V3 plot. Plot V1 accounted for 23.2% to 27.45% of total expenses depending on the variety, with the highest rate observed for the 'Cabernet Sauvignon' and 'Fetească Regală' varieties. In the V2 plot, the rate decreased for all varieties, ranging from 19.64% for the Victoria variety to 23.61% for the 'Cabernet Sauvignon' and 'Fetească Regală' varieties; the cost difference compared to the control for this plot was 687 lei/ha.

The V3 plot had the lowest costs and the lowest rate of total expenses compared to the control, with savings of 1,087 lei/ha compared to the control and resulted in the lowest production costs (Table 5).

JOURNAL of Horticulture, Forestry and Biotechnology
Volume 28(1), 2024, 66-73
https://jhfb.ro/index.php/jhfb
Print ISSN: 2066-1797
Online ISSN: 3045-1876

Table 5. The impact of anthropogenic interventions regarding pest and disease control, on production expenses in grapevine cultivation, during 2017-2019 growing seasons

Experimental plot	Variety	Production expenses (lei/ha)	Experimental variant expenses (lei/ha)	Experimental variant expenses as % of total	Difference to control
V_1(C)	Merlot	11329	3100	27.36	-
	Cabernet Sauvignon	11293	3100	27.45	-
	Fetească neagră	11329	3100	27.36	-
	Fetească regală	11293	3100	27.45	-
	Victoria	13360	3100	23.2	-
	Muscat Hamburg	13317	3100	23.28	-
V_2	Merlot	10256	2413	23.53	687
	Cabernet Sauvignon	10220	2413	23.61	687
	Fetească neagră	10256	2413	23.53	687
	Fetească regală	10220	2413	23.61	687
	Victoria	12287	2413	19.64	687
	Muscat Hamburg	12244	2413	19.71	687
V_3	Merlot	8906	2013	22.6	1087
	Cabernet Sauvignon	8870	2013	22.69	1087
	Fetească neagră	8906	2013	22.6	1087
	Fetească regală	8870	2013	22.69	1087
	Victoria	10937	2013	18.41	1087
	Muscat Hamburg	10894	2013	18.48	1087

Table 6. The impact of anthropogenic interventions regarding pest and disease control on the cost price of grapevine cultivation, on average, during 2017-2019 growing seasons

Experimental plot	Variety	Production expenses (lei/ha)	Grape production (kg/ha)	Expenses (lei/kg grapes)	Expanses (lei/tonne grapes)	Difference to control
V_1(C)	Merlot	11329	12971	0.87	870	-
	Cabernet Sauvignon	11293	11486	0.98	980	-
	Fetească neagră	11329	11753	0.96	960	-
	Fetească regală	11293	15243	0.74	740	-
	Victoria	13360	15899	0.84	840	-
	Muscat de Hamburg	13317	13720	0.97	970	-
V_2	Merlot	10256	11205	0.92	920	50
	Cabernet Sauvignon	10220	10700	0.96	960	-20
	Fetească neagră	10256	10313	0.99	990	30
	Fetească regală	10220	14064	0.73	730	-10
	Victoria	12287	13733	0.89	890	50
	Muscat de Hamburg	12244	11272	1.09	1090	120
V_3	Merlot	8906	9488	0.94	940	70
	Cabernet Sauvignon	8870	10030	0.88	880	-100
	Fetească neagră	8906	9232	0.96	960	0
	Fetească regală	8870	13280	0.67	670	-70
	Victoria	10937	12655	0.86	860	20
	Muscat de Hamburg	10894	9443	1.15	1150	180

The average production cost during the three years of research was strongly influenced by the results from 2019 with excessive precipitation and consequently increased production costs. The lowest cost prices were recorded for the control plot. For more resilient varieties such as 'Cabernet Sauvignon', options with fewer treatments proved cost-effective, resulting in lower cost prices compared to more complex control plots. Sensitive varieties such as 'Merlot', 'Muscat Hamburg', and 'Victoria' experienced higher cost prices when fewer treatments were applied, especially in unfavourable climatic conditions. It can be concluded that the cost price is a highly sensitive indicator, influenced by production costs, production level, yearly climatic conditions, and variety sensitivity to diseases and pests.

More resistant varieties can achieve lower cost prices with fewer treatments in years with high to medium favourability, only requiring more treatments in challenging climatic years (Table 6). Profit is the most critical economic indicator, influenced by production costs on one hand and the market price of production on the other. Disease and pest control make up a significant rate of production expenses, making its optimization essential.

Table 7. The impact of anthropogenic interventions regarding pest and disease control on the profit obtained in grapevine cultivation. on average. during 2017-2019 growing seasons

Experimental plot	Variety	Production expenses (lei/ha	Grape production value (lei/ha)	Profit (lei/ha)	Difference to control
V_1(C)	Merlot	11329	38914	27585	-
	Cabernet Sauvignon	11293	34458	23165	-
	Fetească neagră	11329	35258	23929	-
	Fetească regală	11293	30486	19193	-
	Victoria	13360	63596	50236	-
	Muscat Hamburg	13317	48021	34704	-
V_2	Merlot	10256	33614	23358	-4227
	Cabernet Sauvignon	10220	32099	21879	-1286
	Fetească neagră	10256	30940	20684	-3245
	Fetească regală	10220	28127	17907	-1286
	Victoria	12287	54931	42644	-7592
	Muscat Hamburg	12244	39453	27209	-7495
V_3	Merlot	8906	28465	19559	-8026
	Cabernet Sauvignon	8870	30091	21221	-1944
	Fetească neagră	8906	27697	18791	-5138
	Fetească regală	8870	26559	17689	-1504
	Victoria	10937	50620	39683	-10553
	Muscat Hamburg	10894	33051	22157	-12547

Analysing the results during the research, all three treatment protocols for diseases and pests control proved efficient, allowing for profit generation regardless of the year's climatic conditions. However, profit values varied depending on the climatic conditions of the year, being higher in favourable years than in unfavourable ones. In years with favourable conditions for grapevines, although profit values were higher for the plot with higher number of treatments, the profit differences between this experimental plot and the V2 plot with a moderate number of treatments were smaller than the cost differences between the two plots. Thus, economically, the most effective disease and pest control plot was the plot with a moderate number of treatments.

Conclusions

In years with favourable or moderately favourable climatic conditions, applying simplified treatment protocol for disease and pest control does not create issues for annual growth, wood maturation, or winter resistance. It also does not jeopardize crop load, making the option of using fewer treatments viable. Disease and pest control options significantly impact both leaf area and photosynthetic grapes and sugar yield. When climatic conditions are less favourable, experimental plots with fewer treatments require higher leaf area to produce the same number of grapes or sugar.

Using a simplified treatment protocol for disease and pest control during the research allowed for relatively satisfactory yields, although grape yield was much lower across all varieties compared to the control. Even in favourable climatic conditions, the positive impact of complex and moderate treatment protocol on grape production was evident. Complete treatment protocol produced statistically significant increases in yields in all varieties. In favourable years with reduced precipitation, simpler treatment protocol was still effective, achieving large sugar accumulations, albeit lower than complex protocol. Effective treatment protocol must consider the climatic conditions of each year, each variety's sensitivity to diseases and pests, and the qualitative potential of each wine-growing area. Cost price is a sensitive indicator influenced by production costs, production levels, climatic conditions, and the variety's sensitivity to diseases and pests. More resilient varieties yield lower cost prices with fewer treatments in years of high and medium favourability, only requiring numerous treatments in challenging climatic years. Analysing the research results, it is clear that regardless of the climatic conditions of the year, all three diseases and pest control protocols were effective and allowed for profit. However, profit values varied according to the year's climatic conditions, being higher in favourable years compared to unfavourable ones. In years with challenging climatic conditions, experimental plots V2 and especially V3 showed much larger profit differences compared to the control, beyond the difference in expenses between plots. In such years, applying medium complexity disease and pest control treatments protocol is effective only for varieties relatively resistant to diseases and pests.

References

[1] Bent, E. (2006), *Induced systemic resistance mediated by plant growth-promoting rhizobacteria (PGPR) and fungi (PGPF). In: Tuzun S. Bent E (eds) Multigenic and induced systemic resistance in plants*. Springer. New York. USA; pp. 225–258.

[2] Berg, G. (2009), *Plant-microbe interactions promoting plant growth and health: perspectives for controlled use of microorganisms in agriculture*. Appl Microbiol Biotechnol. 84:11–18.

[3] Dobrei, A., Dobrei, A.G., Nistor, E., Poșta, Gh., Mălăescu, M., Balint, M. (2018). *Characterization of grape and wine quality influenced by terroir in different ecosystems from Romania cultivated with Fetească neagră*- Scientific Papers. Series B. Horticulture. Vol. LXII. Print ISSN 2285-5653. CD-ROM ISSN 2285-5661. Online ISSN 2286-1580. ISSN-L 2285-5653.

[4] Dobrei, A., Nan, R., Nistor, E., Dobrei, A. (2021), *Comparative research on the influence of some technological sequences from conventional and organic viticulture*. Scientific Papers. Series B. Horticulture. Vol. LXV. No. 2. 2021. PRINT ISSN 2285-5653. http://horticulturejournal.usamv.ro

[5] Gessler, C. Pertot, I. Perazzolli, M. (2011), *Plasmopara viticola*: *a review of knowledge on downy mildew of grapevine and effective disease management.* Phytopathologia Mediterranea. 50(1): 3-44.

[6] Hartmann, A., Rothballer, M., Schmid, M., Lorenz Hiltner. (2008*), A pioneer in rhizosphere microbial ecology and soil bacteriology research.* Plant Soil. 312:7–14.

[7] Lessio, F., Alma, A. (2021), *Models applied to grapevine pests: A review*. Insects. 12(2): 169.

[8] Nan, R.D., Dobrei, A.G., Nistor, E., Borca F., Nan, A., Dobrei, A. (2021), *The impact of soil management systems on the grape quality and production in five wine grape varieties during different growing seasons.* Vol 25 (1) JOURNAL of Horticulture. Forestry and Biotechnology. www.journal-hfb.usab-tm.ro

[9] Nakova, M.B., Nakov, B.K., Tityanov, M. (2017), *Grapevine powdery mildew (Uncinula necator (Schw.) Burr.)–a permanent issue concerning the health status of grapes cenosis in Bulgaria.* In BIO Web of Conferences. EDP Sciences. 9: 01021.

[10]Nistor, E., Dobrei, A.G., Dobrei, A., Camen, D., Sala, F., Prundeanu, H. (2018), *N_2O, CO_2 production and C sequestration in Vvneyards: a Review.* Water. Air. & Soil Pollution (Vol. 229. Issue 9).

[11]Pennington, T., Reiff, J.M., Theiss, K., Entling, M.H., Hoffmann, C. 2018. *Reduced fungicide applications improve insect pest control in grapevine.* BioControl. 63(5): 687-695.

[12]Pennington, T., Kolb, S., Kaiser, J., Hoffmann, C., Entling, M.H. (2019), *Does minimal pruning and reduced fungicide use impact spiders in the grapevine canopy?* The Journal of Arachnology. 47(3): 381-384.

[13]Reis, P., Pierron, R., Larignon, P., Lecomte, P., Abou-Mansour, E., Farine, S., Fontaine, F. (2019), *Vitis methods to understand and develop strategies for diagnosis and sustainable control of grapevine trunk diseases.* Phytopathology. 109(6): 916-931

[14]Rondot, Y., Reineke, A., (2018). *Endophytic Beauveria bassiana in grapevine Vitis vinifera (L.) reduces infestation with piercing-sucking insects*. Biological Control. 116: 82-89.

[15]Silvestroni, O., Lanari. V., Lattanzi. T., Palliotti, A., Vanderweide, J., Sabbatini, P. (2019), Canopy management strategies to control yield and grape composition of Montepulciano grapevines. Australian Journal of Grape and Wine Research. 25(1). pp. 30-42.