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EVALUATION OF THE DOWNY MILDEW ATTACK (*Peronospora camelinae*) IN CAMELINA (*Camelina sativa* (L.) CRTZ.) DURING 2023-2024, DRACEA, TELEORMAN COUNTY

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Abstract

In recent years, Camelina sativa has emerged as a crop that can be considered an alternative to traditional oilseed plants. The primary objective of our research was to evaluate the downy mildew (Peronospora camelinae) attack. Observations were conducted during 2023 and 2024 under the conditions of the Dracea location in Teleorman County. The biological material consisted of two Romanian genotypes, Mădălina and Camelia, monitored in spring cultivation. In the conditions of 2023, the disease frequency in the Mădălina variety was 25%, while the Camelia variety showed a frequency of 34%. In the conditions of 2024, the frequency of the attack was 20% for the Mădălina variety and 22% for the Camelia variety. Throughout the research period, the Mădălina variety exhibited a lower disease frequency compared to the Camelia variety.

Key words*: Camelina sativa, downy mildew, frequency, row spacing.*

INTRODUCTION

Originally from Eastern Europe and Western Asia, *Camelina sativa* (L.) Crantz is a well-known plant from the *Brassicaceae* family (Vollmann & Eynck, 2015).

In Europe and North America, camelina is gaining increasing attention from both industry and research (Zanetti et al., 2017) due to its adaptability to various environmental conditions, high yield potential, and its unique oil, which can be used in a wide range of bio-applications (jet fuel, biofuels, oleochemical compounds, feed, and food) (Larsson, 2013). Regarding cultivation technology, camelina does not have special requirements (Dobre et al., 2014a), but special attention must be given to the phytosanitary conditions of the crop (Podgoreanu et al., 2015).

Camelina is naturally resistant to many diseases and pests that affect other plants in the *Brassicaceae* family (Putnam et al., 1993). However, under field conditions, cases of downy mildew caused by *Peronospora camelinae* have been reported (Vollmann et al., 2008) as well as reports of the occurrence of the pathogen *Sclerotinia sclerotiorum* (Cristea & Jurcoane, 2015).

Downy mildew is an obligate parasite that can only survive by infecting and depending on living plants (Turk, 2002). The symptoms of this disease include the presence of a grayish-white mycelium on the underside of the leaves, as well as on the upper third of the plant, on the internodes, and on the developing siliques (Séguin-Swartz et al., 2009). Severely infected plants exhibit twisted or bent growth (Vollmann et al., 2008).

This research was conducted to evaluate the effects of *Peronospora camelinae* on two varieties of *Camelina sativa*, focusing on the disease's occurrence under dry and temperate conditions. The study aimed to assess how these factors influence disease incidence, particularly downy mildew, which is the main disease identified in the crop, and to examine the relationship between disease occurrence and the overall performance of the plant.

MATERIALS AND METHODS

The main aim of this study is to investigate the occurrence and effect of the *Peronospora camelinae* pathogen on camelina crops under the environmental conditions in the Dracea locality of Teleorman County. At the same time, the research aims to assess the influence of plant density and row spacing on the severity of downy mildew infection in camelina crops. *Peronospora camelinae* was first reported in camelina fields in 2014 (Cristea & Manole, 2014) in the southern part of Romania. Since then, the pathogen has been reported for the first time in various parts of the world, such as the Northwestern United States in 2022 (Benzhong & Qing, 2022) representing a significant increase in the importance of the pathogen in the crop. The data from this research are useful for farmers in the southern part of the country, providing information about camelina downy mildew and optimizing cultivation technology in correlation with the pathogen in the crop.

This research was conducted during the spring seasons of 2023 and 2024 in experimental fields located in Dracea, Teleorman (44.15° N latitude, 25.35° E longitude). The field was organized into a randomized block design, with each block measuring 48 meters in length. Two main factors were tested: row spacing and sowing rate. Factor 1, concerning row spacing, included 13 cm and 25 cm variants. Factor 2, concerning sowing rate, with 6 kg/ha (corresponding to 525 germinable seeds/m²) and 8 kg/ha (corresponding to 700 germinable seeds/m²). Camelina seeds were sown using a conventional seeder at a depth of 2.0 cm, ensuring uniform distribution for optimal germination.

The study analyzed two local camelina varieties, developed and adapted to the environmental conditions in Romania. The first variety, Mădălina (Matei et al., 2014), was developed at the University of Agronomic Sciences and Veterinary Medicine in Bucharest, while the second, Camelia (Toncea, 2014), was developed at ICDA Fundulea.

The experimental design was the randomized complete block design (RCBD) in a mirrored layout for the two varieties, as it helps control field variability, ensuring a more accurate comparison between factors. The inclusion of all factor combinations in each block and their randomization within the block, minimizes the effects of soil variations, microclimate, and other factors that could influence the results. Thus, the observed differences between the factor combinations are more likely to be attributed to the factors themselves, rather than environmental variations.

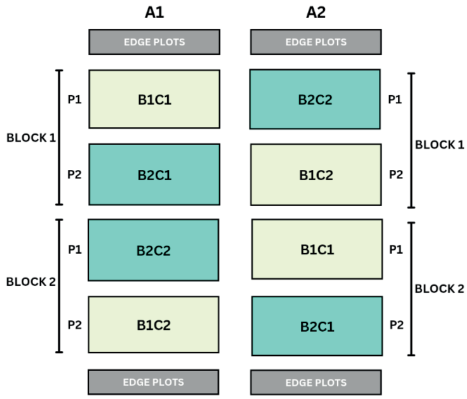

Figure 1. Layout of the plots in the experimental field. Factors in the experimental field are: A1 - Mădălina; A2 - Camelia; B1C1 - 6 kg/ha & 13 cm; B2C1 - 8 kg/ha & 13 cm; B2C2 - 8 kg/ha & 25 cm; B1C2 - 6 kg/ha & 25 cm

The disease evaluation was conducted twice during the plant growth period. The first evaluation took place before flowering (BBCH stage 6), at the maximum leaf development stage, and the second evaluation was performed during seed development and maturation (BBCH stage 8).

The evaluation was conducted according to an "N" pattern (Robertson, 2008) on the plot area to ensure representative sampling. In total, 100 plants were analyzed, with 25 plants sampled at each designated point (Figure 2). This approach allowed for a comprehensive assessment of the disease incidence and severity in the field.

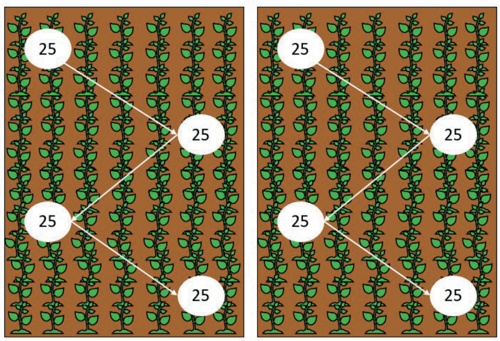

Figure 2. Evaluation in a “N” pattern

The disease frequency (F%) was calculated as the proportion of plants showing symptoms (n) relative to the total number of plants evaluated (N), expressed as a percentage.

$$F(\%) = \frac{n * 100}{N}$$

The intensity of the attack (I%) was calculated by assessing the extent of plant surface infection using a percentage scale from 0 to 100% of the plant's surface with symptoms. It was calculated using the following formula, where i = the percentage assigned, f = the number of plants with the assigned percentage, and n = the total number of infected plants analyzed.

$$I(\%) = \frac{\sum(i * f)}{n}$$

The degree of attack (DA%) was calculated to express the severity of the attack in the crop by correlating the frequency (F%) data with the intensity (I%) data using the following formula:

$$DA(\%) = \frac{F * I}{100}$$

The data were analyzed using ANOVA to determine the significance of the differences between the variants, with statistical calculations performed using R software and GraphPad Prism.

RESULTS AND DISCUSSIONS

During the experimental periods in the springs of 2023 and 2024, weather conditions varied at different stages of camelina development. Meteorological data were collected daily from March 1st to June 30th using the autonomous meteorological station Meteobot® Mini 2022, placed in the experimental field. In 2023, the total precipitation accumulated during the growing season was 222.6 l/m², and the average temperature was 14.8°C. In 2024, the total precipitation for the entire period was significantly lower, at 120.2 l/m², while the average temperature was higher, at 17.2°C.

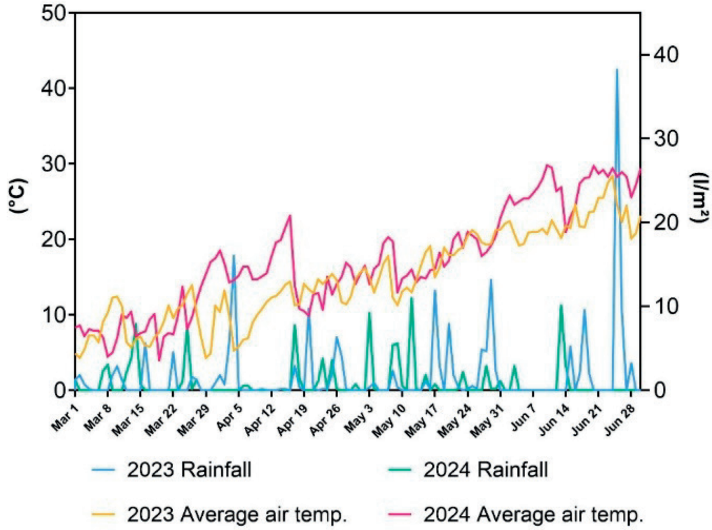

Figure 3. Daily average temperature and rainfall (Source: Meteobot)

The comparative analysis of the average air temperature between 2023 and 2024 reveals a significant increase in 2024, with higher and more variable temperatures throughout the observation period (March 1st - June 30th). Both periods show a gradual and normal increase in temperatures as the months progress; however, in 2024, temperatures exhibited a more abrupt rise. In 2024, temperatures were visibly higher (Figure 3). A t-test was conducted to assess the statistical significance of the difference between the average temperatures in 2023 and 2024. The results indicate a significant difference (P = 0.0051), confirming that the average temperature in 2024 (17.21°C) was 2.35°C higher than in 2023 (14.87°C), with a 95% confidence interval between 0.71 and 3.99°C.

The 2.35°C difference had an impact on the senescence of camelina plants in 2024, as camelina shortens its growing period when subjected to heat stress (Smith & Lu, 2024). Consequently, in 2024, camelina was harvested just 80 days after the seeding. In 2023, the precipitation levels were higher, characterized by irregular distribution and multiple pronounced peaks, including an extreme event at the end of June. This event did not affect the crop since, at that time, camelina was in the seed maturation phenophase. In contrast, 2024 had a considerably lower and more uniform precipitation regime, with no sudden increases in rainfall. These climatic discrepancies are crucial for camelina development, as precipitation affects soil water availability, disease incidence, and plant productivity. The difference between the two years was -102.4 l/m² for the entire period, indicating that 2024 was a year with drought conditions.

Table 1. Statistical analysis ANOVA of meteorological data

ANOVA summary	
F	310.6
P value	<0.0001
P value summary	****
Significant diff. among means (P < 0.05)?	Yes
R squared	0.6582

The ANOVA analysis indicated extremely significant differences between the temperature and precipitation values analyzed in 2023 and 2024 ($F = 310.6$, $P < 0.0001$), suggesting considerable climatic variability between these two periods. The R^2 coefficient = 65.82% indicates that a large portion of the observed variation can be explained by the differences in temperature and precipitation, highlighting a significant climatic impact. The high statistical significance ($P < 0.0001$) confirms that these changes are not random but reflect a clear trend that influences biological and agricultural processes in the given system.

The pronounced fluctuations in 2023, with wet conditions and low temperatures, created favorable conditions for the development of pathogens such as *Peronospora camelinae*, while the more stable, hot and dry days in 2024 reduced the infection rate.

Sampling was done in the two phenophases BBCH 6 and BBCH 8. Plants showing symptoms were harvested and evaluated. The leaves and upper stem exhibited specific symptoms (Cristea & Manole, 2014), including discoloration spots on the upper side, which, over time, turned into necrotic areas. On the lower side, beneath these spots, a fine layer of whitish or grayish-white powder formed (Figure 4), a result of sporangiophores and sporangia of the pathogen. Plants with a higher intensity of downy mildew exhibited the specific phenomenon of downy mildew, namely, the twisting of the stem (Vollmann et al., 2008).

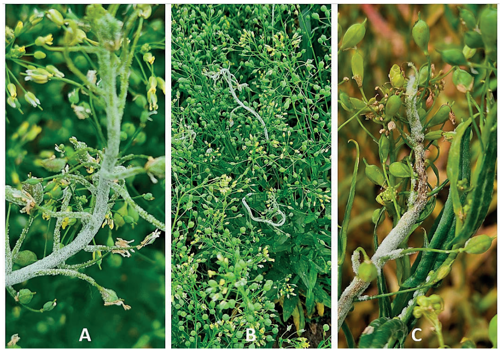

Figure 4. Specific symptoms of downy mildew in camelina plants (Source: Original)

Microscopic identification of the pathogen was done based on sporangiophores and sporangia morphology using the Zeiss Promo Star microscope (Figure 5).

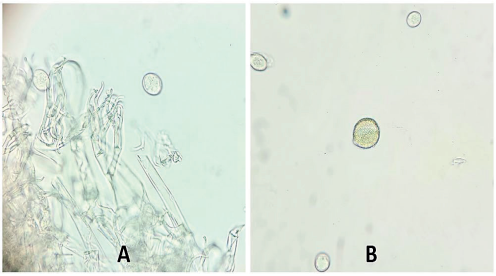

Figure 5. A- Sporangiophores; B- Sporangium (Source: Original)

Microscopic observations revealed characteristic structures, such as hyaline sporangia and dichotomously branched sporangiophores, belonging to the genus *Peronospora*. The observed sporangia had a lemon-shaped form and a yellow color (Figure 5 B), typical for the *Peronospora* genus. These observations were compared with descriptions in the scientific literature, confirming the pathogen's identity (Cristea & Manole, 2014, Salcedo et al., 2021).

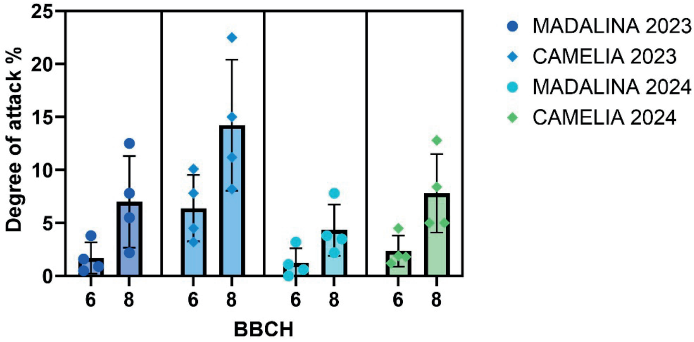

Figure 6. Evaluation of downy mildew attack (*Peronospora camelinae*)

The degree of attack of *Peronospora camelinae* for the two varieties, Mădălina and Camelia, in the BBCH 6 and BBCH 8 developmental stages, analyzed during the 2023 and 2024 seasons is presented in Figure 6. The ANOVA analysis indicates significant differences between treatments, with a *P* value of 0.0289, confirming notable variations between the varieties. In 2023, Camelia exhibited a higher degree of attack at the BBCH 8 stage compared to Mădălina, suggesting greater susceptibility at this developmental phase. In 2024, the degree of attack was lower than the previous year, but the trend between the varieties remained, with Camelia still being more affected. The error bars highlight significant variability, especially for Camelia at BBCH 8 in 2023, which could suggest external influences, such as the variable climatic conditions in 2023, with Camelia showing increased vulnerability to environmental fluctuations. In contrast, data from 2024 are more homogeneous, suggesting a stabilization of factors such as higher temperatures and lower precipitation, reducing the pathogen's virulence. Hot, dry weather keeps the disease from spreading in the crop (Petcu et all. 2022). To summaries, the attack was more severe in 2023, especially for Camelia at BBCH 8, and the differences between years and treatments remain significant.

Table 2. The influence of seeding rate per hectare and row spacing on downy mildew incidence in camelina (2023-2024) at Dracea, Teleorman location

Variety	Variant*	Phenological stage / year											
		BCCH6 / 2023			BCCH8 / 2023			BCCH6 / 2024			BCCH8 / 2024		
		F	I	DA	F	I	DA	F	I	DA	F	I	DA
		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Mădălina	V1	5	18	0.9	15	36.7	5.5	0	0	0	8	22.5	2.2
	V2	12	31.7	3.8	25	50	12.5	10	32	3.2	20	39	7.8
	V3	7	22.9	1.6	18	43.3	7.8	2	55	1.1	12	29.2	3.5
	V4	2	25	0.5	10	22	2.2	5	11	0.6	10	22	3.8
Camelia	V1	15	30	4.5	22	56	11.2	8	22.5	1.8	12	41.7	5
	V2	25	40.4	10.1	34	66.2	22.5	11	40.9	4.5	22	58.2	12.8
	V3	22	35.5	7.8	28	53.6	15	5	38	1.9	19	44.2	8.4
	V4	10	32	3.2	15	54.7	8.2	5	24	1.2	16	31.3	5.0

*V1-6 kg/ha & 13 cm; V2-8 kg/ha & 13 cm; V3-8 kg/ha & 25 cm V4-6 kg/ha & 25 cm.

The Table 2 shows that variant V4 (6 kg/ha & 25 cm) provides the best results, with the lowest values for downy mildew frequency, intensity, and severity in both varieties during 2023 and 2024. On the other hand, variant V2 (8 kg/ha & 13 cm) is the most affected, recording the highest values for all indicators, indicating increased susceptibility to downy mildew. These results suggest that a lower seeding rate and wider row spacing help reduce downy mildew incidence, while a higher seeding rate and narrower rows promote disease development. Comparing the two varieties, Camelia appears to be more vulnerable to downy mildew than Mădălina, showing higher values for frequency, intensity, and degree of attack in almost all tested conditions. For example, in the seeding rate and narrow-row variant (V2: 8 kg/ha & 13 cm), the infection was more severe in Camelia, with a frequency of up to 66.2% compared to 50% in Mădălina, and nearly double the severity. Even in the most favorable variant (V4: 6 kg/ha & 25 cm), Camelia showed slightly higher values, suggesting it is more susceptible to the disease. Therefore, Mădălina appears to have low susceptibility to downy mildew.

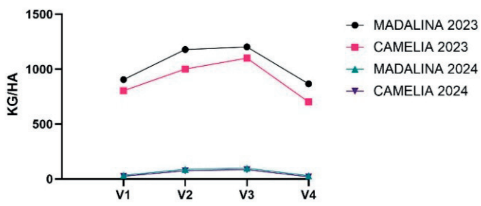

Figure 7. Yield of the two varieties in 2023 and 2024

Regarding the yields in 2024 were significantly lower than in 2023, indicating a strong negative impact of downy mildew and drought (Figure 7). It can be observed that Camelia was more affected than Mădălina, consistently recording lower yields across all tested variants. In 2023, the highest yields were obtained in variants V2 and V3, where the seeding rate and row spacing combination favored better crop performance. On the other hand, variants V1 and V4 showed lower yields, suggesting that both a lower seeding rate (V1) and a wider row spacing (V4) were less effective in maximizing yield. Similar studies, such as (Dobre et al., 2014b) reported a yield of 1,387 kg/ha for the Camelia variety under the 25 cm row spacing and 8 kg/ha seeding rate variant.

Table 3. Yield obtained in 2023-2024

Variety	Variant	Yield kg/ha	
Mădălina		2023	2024
	V1	905	34
	V2	1,179	88
	V3	1,203	98
	V4	867	31
Camelia			
	V1	804	25
	V2	1,002	75
	V3	1,101	86
	V4	702	21

In 2024, yields decreased dramatically across all variants, highlighting the combined impact of drought and downy mildew (Table 3). Unlike 2023, the differences between variants are smaller, suggesting that under extreme conditions, none of the variants were able to significantly counteract the effects of the climate and the disease. In short, the 2024 yield was heavily impacted by both drought and downy mildew. In a favorable year, variants V2 and V3 were the most productive (Table 4), but under challenging conditions, the impact of stress factors became much stronger, underscoring the importance of management strategies adapted to extreme climatic conditions.

Table 4. Average yields from 2023 and differences in 2024

Variety	Year	Average Yield (kg/ha)	% Change from 2023
Mădălina	2023	1,038.5	-
	2024	62.75	-93.97%
Camelia	2023	902.25	-
	2024	51.75	-94.25%

CONCLUSIONS

The results of this study highlight the significant impact of meteorological conditions on the development of *Peronospora camelinae* in *Camelina sativa* crop. Under conditions of abundant rainfall and moderate temperatures, as in 2023, the pathogen thrived, particularly affecting the Camelia variety. In contrast, the drought conditions of 2024 significantly limited the spread of the disease.

These findings align with previous research that has emphasized the sensitivity of *Peronospora camelinae* to humidity (Vollmann et al., 2001) (Séguin-Swartz et al., 2009). Furthermore, our study reveals varietal differences in occurrence of downy mildew, with Camelia being more susceptible compared to Mădălina.

Additionally, we observed that seeding density and row spacing influence disease incidence. A lower seeding density and wider row spacing reduced downy mildew attack, suggesting that these practices contribute to disease management.

Understanding the impact of meteorological conditions and agricultural practices on disease development can help camelina growers develop more effective management strategies. Specifically, in years with high rainfall, growers should take additional measures to protect crops, especially varieties like Camelia.

The variant that yielded better results in the study was 6 kg/ha & 25 cm, which provided the best outcomes with the lowest values for frequency, intensity, and degree of attack in both varieties, both in 2023 and 2024. On the other hand, variant 8 kg/ha & 13 cm was the most affected, showing the highest values for all indicators. These results suggest that a lower seeding density and wider row spacing help reduce downy mildew incidence, while a higher seeding density and closer rows favor disease development.

Comparing the two varieties, Camelia appears more susceptible to downy mildew than Mădălina, showing higher values for frequency, intensity, and severity in almost all tested conditions. For example, in the variant with higher seeding density and closer rows 8 kg/ha & 13 cm, the attack was more severe in Camelia, with a frequency of up to 66.2%, compared to 50% in Mădălina, and nearly double the severity, even in the most favorable variant 6 kg/ha & 25 cm.

In conclusion, this research provides valuable insights into the seeding rate and row spacing regarding the behavior of *Peronospora camelinae* and the importance of integrated disease management in *Camelina sativa* crop.

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