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FIELD EFFICACY OF PLANT PROTECTION TREATMENTS AGAINST APPLE SCAB AND POWDERY MILDEW UNDER ORCHARD CONDITIONS IN SOUTHERN ROMANIA

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ABSTRACT

Apple scab and powdery mildew are major fungal diseases affecting apple orchards and require effective protection strategies adapted to local conditions. This study evaluated selected treatments against apple scab (Venturia inaequalis) and apple powdery mildew (Podosphaera leucotricha) under field conditions in southern Romania in 2024. Disease frequency was assessed on susceptible plant organs and compared with untreated controls. Champ 77 WG and Chorus 50 WDG + Merpan 80 WDG reduced apple scab frequency on leaves by 71.43 % and 85.71 %, respectively, while both treatments completely prevented visible fruit infection. For powdery mildew, Limocide and Topas 100 EC reduced disease frequency by 60.00 % and 80.00 % on leaves and by 78.95 % and 73.68 % on annual shoots, respectively. The results showed that treatment performance depended on the target pathogen and plant organ assessed, supporting organ-specific evaluation when selecting disease-management strategies for apple orchards.

INTRODUCTION

Apple (*Malus domestica* Borkh.) is one of the most important temperate fruit crops, but its productivity and fruit quality are strongly affected by fungal diseases. Among these, apple scab and powdery mildew are major constraints in commercial orchards. Both pathogens affect leaves, shoots and/or fruits and may reduce tree vigour, yield and marketable fruit quality when disease pressure is insufficiently controlled (Besleaga et al., 2015; Morariu et al., 2025).

Apple scab management relies largely on preventive and curative fungicide applications adapted to infection risk and orchard conditions. Effective control is particularly important during susceptible phenological stages, while treatment performance may vary according to fungicide characteristics, application timing and disease pressure (Boualleg et al., 2024; Rancane et al., 2024). Powdery mildew requires similarly targeted protection because the pathogen develops predominantly on young, actively growing tissues, making adequate protection of newly formed leaves and shoots essential for limiting disease development (Strickland et al., 2022; Strickland et al., 2023).

Repeated fungicide use may, however, favour the selection of less sensitive pathogen populations. Reduced sensitivity and resistance to several fungicide groups have been reported in *V. inaequalis*, emphasizing the importance of diversified disease-management programmes and the use of active ingredients with different modes of action (Chatzidimopoulos et al., 2022; Gur et al., 2021). Evaluating different protection strategies under field conditions remains relevant for identifying treatments capable of maintaining adequate disease suppression while supporting more rational fungicide use.

In Romania, apple scab and powdery mildew remain important components of orchard disease management, while their occurrence and intensity vary with cultivar susceptibility, environmental conditions and protection practices. Field-based assessments are consequently useful for determining the practical response of these diseases to different plant protection products under local growing conditions (Ciciu Tudosie & Mitrea, 2012; Iancu et al., 2023).

The aim of this study was to evaluate and compare the response of apple scab and powdery mildew to selected plant protection treatments under natural field infection conditions during the 2024 growing season. Treatment performance was assessed through disease frequency on relevant plant organs and expressed as the reduction in disease occurrence relative to untreated controls. The study also examined whether treatment response differed between leaves, fruits and annual shoots, providing a comparative basis for the practical management of the two major apple diseases.

MATERIAL AND METHODS

Experimental site and study design

The field study was conducted during the 2024 growing season in an apple orchard located in the Dâmbovița fruit-growing area, southern Romania. The experiment focused on two major fungal diseases: apple scab, caused by *Venturia inaequalis* (Cooke) G. Winter, and apple powdery mildew, caused by *Podosphaera leucotricha* (Ellis & Everh.) E.S. Salmon. Disease development occurred under natural field infection conditions, allowing the performance of the tested plant protection treatments to be evaluated under the prevailing orchard environment.

Separate treatment schemes were considered for the two pathogens. Each treated variant was evaluated in relation to an untreated control maintained under the same field conditions. Disease assessments were performed on the plant organs characteristically affected by each pathogen: leaves and fruits for apple scab, and leaves and annual shoots for powdery mildew.

Plant protection treatments

Apple scab control was evaluated using two plant protection strategies. The first consisted of Champ 77 WG applied at a concentration of 0.2 %, whereas the second consisted of Chorus 50 WDG at 0.07 % in combination with Merpan 80 WDG at 0.15 %. The treatments were applied during the early part of the growing season, under natural orchard conditions. Disease assessment was subsequently performed on leaves and fruits.

For apple powdery mildew, Limocide at 0.5 % and Topas 100 EC at 0.02 % were evaluated. An untreated control was included for comparison. Disease occurrence was assessed separately on leaves and annual shoots to account for differences in symptom expression between vegetative organs. The experimental treatments considered in the study are summarized in Table 1.

Table 1

Plant protection treatments evaluated against apple scab and powdery mildew under field conditions in 2024

Target disease	Pathogen	Treatment	Concentration (%)	Assessed organ
Apple scab	*Venturia inaequalis*	Control	–	Leaves, fruits
		Champ 77 WG	0.20	Leaves, fruits
		Chorus 50 WDG + Merpan 80 WDG	0.07 + 0.15	Leaves, fruits
Powdery mildew	*Podosphaera leucotricha*	Control	–	Leaves, annual shoots
		Limocide	0.50	Leaves, annual shoots
		Topas 100 EC	0.02	Leaves, annual shoots

Source: own research design

Disease assessment and data processing

Disease occurrence was evaluated by recording the presence of characteristic symptoms on the examined plant organs. Disease frequency (F%) was used as the principal quantitative indicator and represented the proportion of affected organs within the total number of organs examined:

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

where *n* is the number of plant organs showing characteristic disease symptoms and *N* is the total number of organs examined.

Disease intensity was additionally recorded according to the assessment scale used in the original experimental protocol. Because the available field records report intensity as scores or score intervals rather than as directly measured percentages, these values were retained in their original form and were not converted into percentage severity. This distinction is important because disease incidence/frequency and disease severity represent different epidemiological variables.

For comparative evaluation of treatment performance, the reduction in disease frequency relative to the untreated control (RDF) was calculated as:

$$RDF(\%) = \frac{F_c - F_t}{F_c} \times 100$$

where Fc represents disease frequency in the untreated control and Ft represents disease frequency in the treated variant. RDF was used as a comparative indicator of disease suppression and was not interpreted as a formally calculated fungicide efficacy coefficient.

Results were analysed separately according to pathogen and affected plant organ. For *V. inaequalis*, treatment performance was compared on leaves and fruits, whereas for *P. leucotricha*, comparisons were made on leaves and annual shoots. This organ-specific approach was adopted because disease expression and susceptibility differ among apple tissues; field assessment of incidence and/or severity on defined susceptible organs is standard practice in epidemiological evaluations of these pathogens.

Because the original experimental records provide aggregated observations at treatment level and do not document a replication structure that would support

independent experimental units, the data were evaluated descriptively. No inferential statistical tests were applied. Treatment comparisons were therefore based on the observed disease frequency and the calculated reduction relative to the corresponding untreated control.

RESULTS AND DISCUSSIONS

Both apple scab and powdery mildew developed under natural infection conditions during the 2024 growing season, but disease occurrence differed according to pathogen and affected organ. In the untreated variants, *Venturia inaequalis* was recorded at frequencies of 7 % on leaves and 4 % on fruits, whereas *Podosphaera leucotricha* reached 15 % on leaves and 19 % on annual shoots (Table 2). Thus, powdery mildew showed a higher observed incidence than apple scab under the conditions of the experiment, particularly on actively growing shoots.

Table 2

Disease frequency and reduction relative to the untreated control following plant protection treatments against apple scab and powdery mildew in 2024

Disease / pathogen	Treatment	Plant organ	Disease frequency, F(%)	RDF (%)
Apple scab / *Venturia inaequalis*	Control	Leaves	7	–
	Champ 77 WG, 0.20%	Leaves	2	71.43
	Chorus 50 WDG + Merpan 80 WDG, 0.07% + 0.15%	Leaves	1	**85.71**
	Control	Fruits	4	–
	Champ 77 WG, 0.20%	Fruits	0	**100.00**
	Chorus 50 WDG + Merpan 80 WDG, 0.07% + 0.15%	Fruits	0	**100.00**
Apple powdery mildew / *Podosphaera leucotricha*	Control	Leaves	15	–
	Limocide, 0.50%	Leaves	6	60.00
	Topas 100 EC, 0.02%	Leaves	3	**80.00**
	Control	Annual shoots	19	–
	Limocide, 0.50%	Annual shoots	4	**78.95**
	Topas 100 EC, 0.02%	Annual shoots	5	73.68

Source: own data

Response of apple scab to the tested treatments

Both protection strategies markedly reduced apple scab frequency compared with the untreated control. On leaves, Champ 77 WG at 0.20 % reduced disease frequency from 7 % to 2 %, corresponding to a 71.43 % reduction, while Chorus 50 WDG + Merpan 80 WDG reduced it to 1 %, representing an 85.71 % reduction relative to the control. On fruits, no visible symptoms were recorded following either treatment, compared with a disease frequency of 4% in the untreated variant.

The high level of disease suppression observed in the present study is consistent with field investigations showing that appropriately selected and timed fungicide strategies can substantially reduce *V. inaequalis* infection, although their performance is influenced by infection pressure, application strategy and orchard conditions (Boualleg et al., 2024; Rancane et al., 2024).

The stronger numerical response obtained with Chorus 50 WDG + Merpan 80 WDG on leaves may be associated with the complementary characteristics of cyprodinil and captan. The use of fungicides with different modes of action is also relevant for resistance management, since reduced sensitivity and resistance may develop and vary among *V. inaequalis* populations following repeated fungicide exposure (Gur et al., 2021; Heaven et al., 2023; Rancane et al., 2023; Weber et al., 2025).

The absence of visible fruit symptoms in both treated variants is particularly relevant from a practical perspective because fruit infection directly affects commercial quality. Nevertheless, the relatively low scab frequency recorded in the untreated control indicates moderate disease pressure at the time of assessment. Consequently, the complete suppression of visible fruit infection should be interpreted within the epidemiological conditions of the 2024 season rather than as evidence of equivalent performance under higher disease pressure.

Response of apple powdery mildew to the tested treatments

Powdery mildew showed a more differentiated response according to the plant organ assessed. On leaves, Topas 100 EC at 0.02 % reduced disease frequency from 15 % in the untreated control to 3 %, corresponding to an 80.00 % reduction, whereas Limocide at 0.50 % reduced it to 6 %, representing a 60.00 % reduction. Topas therefore showed the stronger numerical response against leaf infection.

On annual shoots, however, the relative ranking of the treatments changed. Limocide reduced disease frequency from 19 % to 4 %, corresponding to a 78.95 % reduction, while Topas reduced it to 5 %, equivalent to a 73.68 % reduction. The difference between the treatments was small and, because the available experimental records do not support inferential statistical testing, it should be regarded as a numerical difference rather than evidence of statistically demonstrated superiority.

The organ-dependent response is consistent with the biology of *P. leucotricha*, which primarily develops on young, actively growing tissues. Previous orchard studies have similarly demonstrated that powdery mildew suppression depends on fungicide choice and application timing and that effective protection of newly developing tissues is particularly important for disease management (Strickland et al., 2022; Strickland et al., 2023). Under the conditions of the present experiment, Topas provided stronger suppression on leaves, whereas both treatments achieved substantial reductions on annual shoots. These results indicate that evaluation on a single plant organ may not adequately characterize treatment performance against powdery mildew.

Comparative performance of the disease-management strategies

Across both diseases and assessed organs, reductions in disease frequency ranged from 60.00 to 100.00%. The strongest response was recorded for apple scab on fruits, where neither treatment resulted in visible infection. For powdery mildew, treatment performance was more strongly dependent on the assessed organ. This variability supports previous observations that disease

response in apple orchards is influenced by the interaction among pathogen biology, host tissue, environmental conditions and protection strategy (Ciciu Tudosie & Mitrea, 2012; Morariu et al., 2025).

The comparative reduction in disease frequency obtained with the individual treatments is presented in Figure 1. The graphical representation emphasizes differences in treatment response according to pathogen and assessed plant organ.

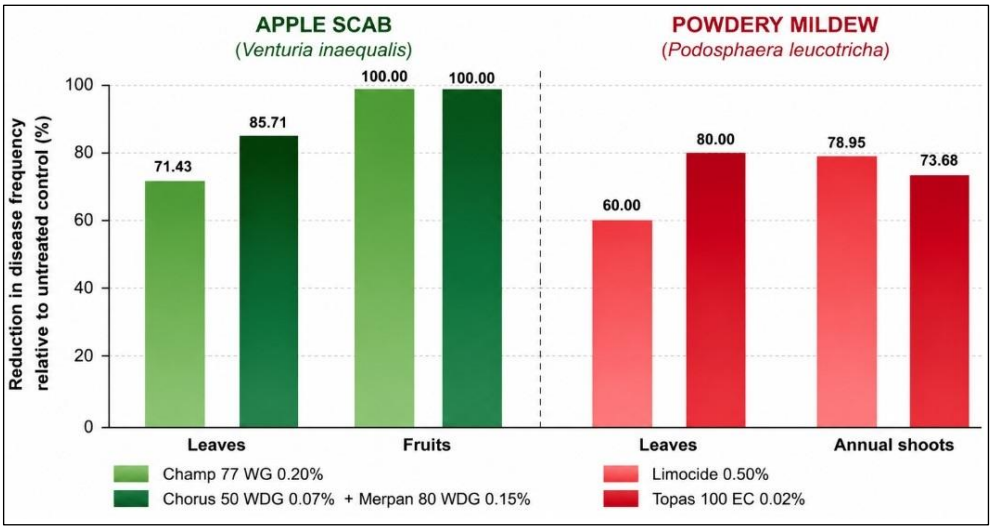


Figure 1. Reduction in disease frequency (%) of apple scab (*Venturia inaequalis*) and powdery mildew (*Podosphaera leucotricha*) following the tested plant protection treatments relative to the corresponding untreated controls under field conditions in 2024

Figure 1 highlights the more consistent suppression of apple scab, particularly on fruits, and the organ-dependent response observed for powdery mildew. Chorus 50 WDG + Merpan 80 WDG produced the greatest reduction in apple scab frequency on leaves, whereas Topas 100 EC performed better numerically against powdery mildew on leaves and Limocide showed a slightly greater reduction on annual shoots. These findings reinforce the importance of evaluating plant protection strategies in relation to both the target pathogen and susceptible plant organ rather than assuming a uniform treatment response.

Overall, all tested treatments substantially reduced disease occurrence compared with the corresponding untreated controls. However, the results should remain specific to the environmental and epidemiological conditions of the 2024 growing season. Further evaluation across years with contrasting infection pressures would be necessary to determine the stability of these treatment responses.

CONCLUSIONS

The field experiment conducted in 2024 demonstrated that all tested plant protection treatments reduced the frequency of apple scab and powdery mildew compared with the untreated controls, although the magnitude of disease suppression varied according to the pathogen and plant organ assessed.

For apple scab, the Chorus 50 WDG + Merpan 80 WDG programme provided the highest reduction in disease frequency on leaves, while both tested strategies completely prevented visible fruit infection under the conditions of the experiment. For powdery mildew, Topas 100 EC showed a greater numerical reduction in disease frequency on leaves, whereas Limocide provided a slightly greater reduction on annual shoots. These differences confirm that treatment performance should be evaluated in relation to both the target pathogen and the susceptible plant organ.

Overall, the results support the use of differentiated disease-management strategies in apple orchards rather than relying on a uniform treatment response across diseases and plant tissues. The findings provide useful field-based information for optimizing apple protection programmes under the environmental conditions of southern Romania. Further multi-year investigations under contrasting disease pressures are required to assess the consistency of these responses and to strengthen recommendations for integrated orchard disease management.

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