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Impact assessment of cover crops on the risk of frost in the Anjou vineyard

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The increase in the frequency of spring frosts and the rising precocity of the phenological stages of the vine have been threatening the wine production in the Anjou vineyard for several years[1]. In addition to these effects of climate change, the developing practices of grassing and sowing cover crops[2] have the effect of modifying the vine's microclimate and can increase frost damage[3]. Hence, a study on the impact of cover crops and destruction method on the risk of frost was carried out in the Anjou vineyard.

Experimental Setup

The experimental facility was set up in 2024 on a plot of Grolleau Noir grafted onto Gravesac, which had been planted in 2020 at a density of 5,200 vines/ha. The vines were pruned using the Cordon de Royat method at a height of 100 cm.

The two different factors studied (Figure 1) were the type of cover crop species and the cover crop destruction method. The different types of cover crop were: i) a cover crop of natural grass cover mainly comprising *Lolium perenne, Poa trivialis, Rumex obtusifolius, Medicago arabica, Ranunculus sardous, Allium schoenoprasum, Veronica arvensis* and *Crepis mollis* in the inter-rows (N), ii) a cover crop of *Vicia faba* only sown in four successive inter-rows (Vf), and iii) natural grass cover and a multi-species cover crop of *Vicia faba*, *Avena sativa*, *Pisum sativum* and *Vicia sativa* (M) in alternate inter-rows. The destruction methods used on the cover crop were: i) rolling 5 days before frost (Roll day-5), ii) mulching a month before frost (Mulch day-30) and iii) no destruction of the cover crop (Nd). A total of 12 plots were set up following a randomised block design.

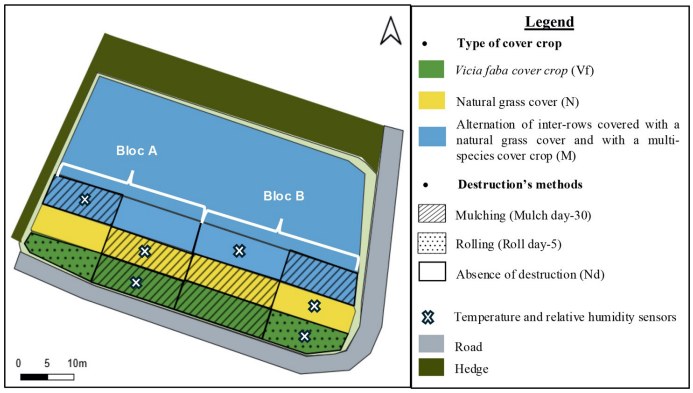


FIGURE 1. Diagram of the experimental design.

To study the impact of the factors on temperature and humidity, 6 sensors were installed at 60 cm above ground level. Thermal camera photographs were also taken on the morning of frost to assess the surface temperature of cover crops present on the soil surface. Then, a count of the percentage of frozen buds on 25 vines per plot was carried out to estimate frost damage to the vine. A rating of the average intensity of frost damage was also carried out using a scale of 0 to 3 (0 corresponding to the majority of the vine's buds being deprived of damage and 3 to the majority of the vine's buds being entirely damaged by frost).

Results

Conditions at time of frost

A radiative frost episode occurred during the night of 22 to 23 April, when the vine had reached a stage of 3-4 spread leaves (BBCH 13-14). Temperatures dropped from -1.8°C to -2.7°C at 60 cm above ground level. Relative humidity recorded by the sensors was between 78 % and 87 % at 60 cm above ground level. In the undestroyed treatment, the natural grass cover (N-Nd) measured approximately 25 cm in height, whereas the multi-species cover crop (M-Nd) measured up to 50 cm.

Cover crop management that influences the microclimate of the vines

The effects of the type of cover crop in the inter-rows and of the destruction method on the microclimate of the vines differed. Rolling cover crops 5 days before the frost (Roll day-5) resulted in the lowest average cover crop surface temperature, while mulching carried out a month before the frost (Mulch day-30) led to the highest (Table 1).

Relative humidity recorded at 60 cm above ground resulted in the interaction of the type of cover crop and the destruction method. The plot containing *Vicia faba* cover crop rolled 5 days before frost (Vf-Roll day-5) and the plots with undestroyed cover crops (N-Nd and M-Nd) had significantly higher relative humidities at 60 cm compared to the plots with mulched cover crops a month before frost (Mulch day-30) (Table 1). Moreover, at 60 cm, temperatures stayed for a longer period at values significantly inferior or equal to the dew point temperatures in the treatments without destruction (Nd) or rolled 5 days before the frost (Roll day-5).

Of the types of cover crop, natural grass cover (N) showed the highest average cover crop surface temperature during the frost episode (Table 1). Additionally, the type of cover crop showed a significant effect on the period of time temperatures were inferior or equal to the temperature at which buds at the 3-4 leaf stage are sensitive to frost in humid conditions, i.e., at temperatures inferior or equal to -1°C[4]. Indeed, temperatures at 60 cm above ground level remained for a longer period under -1°C in the treatments sown with cover crops (Vf and M), for which lower temperatures were also recorded at the time of frost (Table 1).

TABLE 1. Changes in the microclimate of the vines depending on the studied factor (Vf = *Vicia faba* cover crop; M = multi-species cover crop; N = natural grass cover; Roll day-5 = rolling 5 days before frost; Mulch day-30 = mulching a month before frost; Nd = no destruction). Different letters (a, b, c) indicate significant differences.

Type of cover crop	Destruction methods	Average cover crops surface temperature (°C)	Average relative humidity at 60 cm above ground (%)	Period of time temperatures were ≤ -1°C at 60 cm (hours)	Average temperature at 60 cm between 05:20 and 08:30 AM the morning of frost (°C)
Vf	Roll day-5	-9.05 ***a***	86.88 ***b***	2h10 ***a***	-1.79 ***b***
	Mulch day-30	-3.79 ***de***	80.24 ***ab***		
M	Nd	-6.07 ***b***	85.92 ***b***	2h10 ***a***	-2.00 ***a***
	Mulch day-30	-6.01 ***b***	78.03 ***a***		
N	Nd	-4.75 ***c***	84.96 ***b***	1h40 ***b***	-1.53 ***c***
	Mulch day-30	-3.50 ***e***	84.53 ***ab***		

Impact of the studied factors on frost damage on vine buds

By modifying the microclimate of the vines, the studied factors impacted

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frost damage, with the results showing an interaction between the two factors studied. The alternate undestroyed inter-rows comprising a natural grass cover and a multi-species cover crop (M-Nd) showed the highest percentage of frozen buds (75.65 % per vine), whereas the same type of cover crop mulched a month before frost (M-Mulch day-30) only showed 55.50 % of frozen buds (Figure 2).

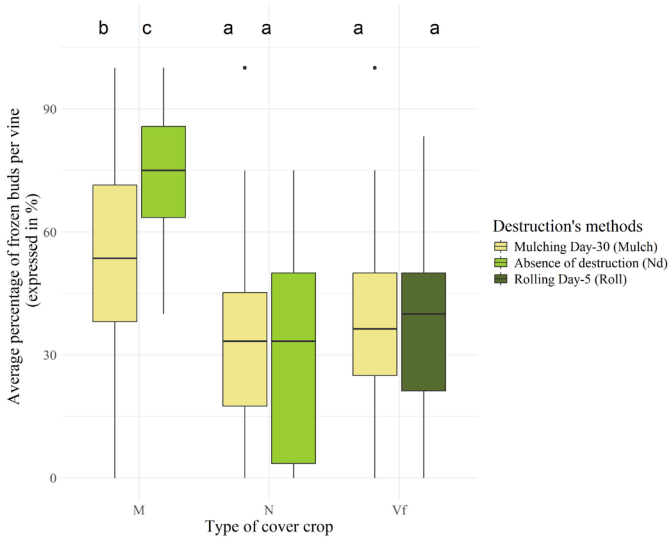


FIGURE 2. Average percentage of frozen buds per vine depending on studied factor (Vf = *Vicia faba* cover crop; M = multi-species cover crop; N = natural grass cover). Different letters (a,b,c) indicate significant differences.

Moreover, only the type of cover crop showed a significant effect on the intensity of frost damage, being the lowest in the natural grass cover treatment (N) with buds which mainly showed frost damage on leaves (Intensity level 1). Conversely, the sown cover crop treatments (Vf and M) showed the highest number of vines on which buds had frozen leaves, apexes and/or inflorescences, with the exception of the shoots (Intensity level 2) (Figure 3).

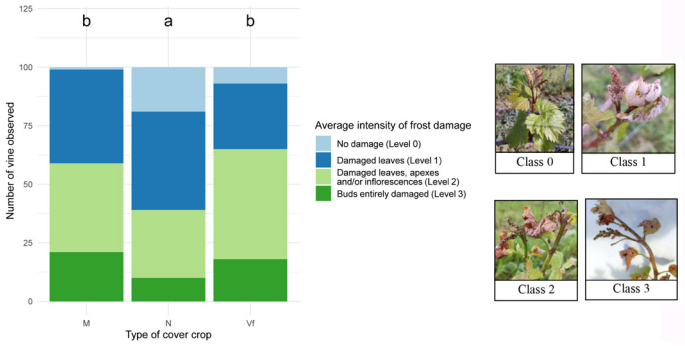


FIGURE 3. Average intensity of frost damage to buds (scale of 0 to 3) depending on the type of cover crop (Vf = *Vicia faba* cover crop; M = multi-species cover crop; N = natural grass cover). Different letters (a, b, c) indicate significant differences.

Discussion and conclusion

The formation of mulch on the soil surface after rolling cover crops or the presence of undestroyed cover crops appeared to limit the accumulation of heat in the soil during the day and its infrared radiation during the night[5]. During a night of radiative frost, aboveground temperatures remained low near the vines in these treatments and often corresponded to dew point temperatures[6]. This phenomenon then led to the condensation of water and an increase in the vulnerability of buds to frost, since low temperatures and high humidity increase the vulnerability of buds to frost[4].

Sown cover crops also enhanced the intensity of frost damage compared to a natural grass cover. This is because sown cover crops are denser than a natural grass cover and tend to trap the cool air above ground during a frost[6]. Moreover, legumes present in sown cover crops, and particularly the *Vicia faba*, have a lower dry matter content than grasses. Once destroyed, legume residues then release more water vapour into the environment.

It is important to note that a certain amount of experimental bias could have influenced the results. To begin with, the sensors were placed at 60 cm above ground, whereas the vines were pruned using the Cordon de Royat method at 100 cm in height and there is a difference of +0.3°C to +0.4°C between 60 cm and 100 cm in height[7]. Additionally, the destruction by mulching a month before the frost (Mulch day-30) was done using a strimmer, and only the *Vicia faba* cover crop (Vf) was rolled 5 days before the frost (Roll day-5) due to rainy conditions at the start of the 2024 vintage preventing an earlier passage of the tractor. Finally, the difference in destruction date influenced the humidity level of the vine plot: the emission of water vapour from cover crop residues was greater when the cover crops were destroyed shortly before the frost, i.e., when the *Vicia faba* cover crop (Vf) was rolled 5 days before the frost (Roll day-5).

To conclude, both the type of species in the cover crop and the cover crop destruction method influenced the risk of spring frost in the Anjou vineyard: regardless of the type of species, cover crops seem to increase the risk of spring frost, especially if not destroyed. Therefore, one could advise wine growers to favour the implantation of cover crops in frost-free areas and to destroy them by mulching at least 6 days before frost in humid conditions. ■

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1 Petitjean, T., Tissot, C., Thibault, J., Rouan, M., Quenol, H., & Bonnardot, V. (2022). Évaluation spatio-temporelle de l'exposition au gel en régions viticoles traditionnelle (Pays de Loire) et émergente (Bretagne). In J.-M. S. (Météo F. et D. S. (Toulouse III) (Éd.), 35ème colloque de l'Association Internationale de Climatologie. Météo-France et Université Toulouse III. https://hal.science/hal-03757680

2 Gaviglio, C. (2022). Gestion des sols viticoles 2e édition (France Agricole).

3 Hirschy, M., Badier, M., Bernos, L., Delanoue, G., Dufourcq, T., Fabian, T., Labeyrie, B., Limousin, T., & Gautier, J. (2020). Gel et grêle en viticulture et arboriculture—Etat des lieux des dispositifs de protection contre les aléas climatiques [Technical Report]. ACTA - Association de Coordination Technique Agricole. https://hal.science/hal-02769435 Agreste. (2023). Essentiel- Fiche filière vigne Pays de la Loire. https://draaf.pays-de-la-loire.agriculture.gouv.fr/IMG/pdf/essentiel_2023_11_filviti.pdf.

4 Fraser, H., Slingerland, K., Ker, K., Fisher, K. H., & Brewster, R. (2009). Reducing Cold Injury to Grapes Through the Use of Wind Machines. https://traubenshow.de/images/stories/CCCC_2010/15_Hans_Peter_Pfeifer_Ontario_Canada/Presentation/2010%20Jan%2011%20Final%20Wind%20Machine%20Report.pdf

5 White, R.E., 2009. Understanding Vineyard Soils. Oxford University Press, Inc, New York.

6 Boekee, J., Dai, Y., Schilperoort, B., van de Wiel, B. J. H., & ten Veldhuis, M.-C. (2023). Plant–atmosphere heat exchange during wind machine operation for frost protection. *Agricultural and Forest Meteorology*, 330, 109312. https://doi.org/10.1016/j.agrformet.2023.109312

7 De Rességuier, L., Pieri, P., Mary, S., Pons, R., Petitjean, T., & van Leeuwen, C. (2023). Characterisation of the vertical temperature gradient in the canopy reveals increased trunk height to be a potential adaptation to climate change. *OENO One*, *57*, 4153. https://doi.org/10.20870/oeno-one.2023.57.1.5365

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