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Effects of Kaolin and Shading Net on the Ecophysiology and Berry Composition of Sauvignon Blanc Grapevines

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Abstract: Rising temperatures in most viticultural regions are associated with a higher incidence of drastic weather circumstances such as heatwaves. The consequences are reflected in qualitative and quantitative white grapes characteristics. In fact, there is an enhancement in alcohol content and a jeopardized reduction in the aromatic potential. We performed a scientific test to assuage the bump of heatwaves and exposure of grapes on *Vitis vinifera* cv. "Sauvignon Blanc" with exposed vines (untreated) or with kaolin foliar treatment or with partial fruit-zone shading (shading net 30 and 70%). This work aimed to evaluate the effects of shading net (SD-30% and SD-70%) and foliar kaolin (K) treatment on physiology, technological maturity, and thiolic precursors in Italy during the 2020–2021 seasons. For this purpose, four treatments were established: SD-30% (green artificial shading net at 30%), SD-70% (green artificial shading net at 70%), K (foliar kaolin), and CTRL (no application). During the two vintages, single-leaf gas exchange appraisal, leaf temperature, berry temperature, chlorophyll fluorescence, pre-dawn, and leaf water potential were measured. Moreover, berry weight, pH, °Brix, acidity (technological maturity specifications), and the following thiolic precursors were analyzed: 3-S-glutathionylhexan-1-ol (Glut-3MH), S-4-(4-methylpentan-2-one)-L-cysteine (Cys-4MMP), and 3-S-cysteinylhexan-1-ol (Cys-3MH). SD-70% and K denoted less negative water potential, a lower berry temperature, and a higher level of all precursors than the other treatments. Acidity and sugar parameters indicated significant differences among treatments. The lower berry weight and the lower tartaric acidity were found in the CTRL treatment. In comparison, SD-70% and K showed lower and more balanced sugar contents. As a result of global warming, color shading net and kaolin have been demonstrated to be good practices to counterpoise the divergence between aromatic and technological maturity in Sauvignon Blanc grapevines.

Keywords: gas exchanges; grape quality; climate change; berry temperature; thiols; grapevine

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1. Introduction

Future climate change is generally believed to lead to a rise in climate variability and in the intensity and frequency of extreme events [1]. The Intergovernmental Panel on Climate Change (IPCC), in the fourth ascertainment report, avers: "Future metamorphosis in anthropogenic forcing will derive both from mean climate state mutations and by climate variability", and that "the intensity, frequency, and type of extreme events are foreseen to alter as Earth's climate vicissitudes, and with comparatively minute mean climate alterations" [2–5].

Owing to climate, the variability that determines year-to-year differences in the grape quality, the aptitude, and capacity to reach whole grape ripening is important to searching for the best variety to be planted in a particular climate [6,7]. In fact, the climate is pivotal to the overall style and aroma of a white wine produced from well-defined terroir [8,9]. Irradiance and temperatures are especially critical because of their quickest-related effect on the phenological stages, vine yield (for instance, flower and berry abscission), berry weight, and both synthesis and accumulation of primary and secondary compounds such as organic acids, sugar, vitamins, polyphenols, and aromatic metabolites [10–12].

Temperatures over 32 °C can lead to higher suspended solid concentrations, but more than 26–27 °Brix levels are probably due to concentration by evaporative loss and not to photosynthesis or sugar transport from leaves and wood [13,14]. High grape total soluble solids (TSS) concentration has an important effect on the fermentation process and wine composition, such as alterations in sensory parameters and modification in microbiological activity, joined substantially to lysis or inhibition growth of yeast cells, as did stuck and sluggish fermentations. These problematic phenomena are accentuated in warm seasons with a negative impact on wine composition. In addition, high total soluble solids stress was found to up-regulate pentose phosphate and glycolytic pathway genes leading to the formation of negative and unwanted by-products of fermentation, including glycerol and acetic acid [15–17].

The effects of global warming, from 1950 to 2000, have shown an average 1.3 °C warming of the growing season; moreover, the forecast over the next fifty years plans a 2 °C average warming [18], thus inducing increased heat summations in water supply, irrigation demand, as well as light exposure [19]. This can affect the white grape and white wine quality by increasing alcohol content and reducing two essential determinants: aroma and acidity [20,21]. Tartaric acid is relatively stable concerning temperature effects, while malic acid levels decrease with higher temperatures owing to metabolic decrease [22]. Secondary metabolites are extremely important for berries' quality traits; phenolics, terpenes, and thiols precursors contribute indeed to the color, flavor, texture, stabilization, and astringency of wine and exhibit antioxidant properties, too [23]. In fact, several techniques performed in the vineyard can indirectly impact the aromatic profile of the grapes by altering the bunch microclimate that, in turn, can influence the synthesis of aromatic compounds and their precursors linked to berry metabolism [24–26].

On the one hand, temperature and solar radiation are important for vine metabolism [27], but conversely, higher photosynthetically active radiation (PAR) values are linked with more transpiration and fruit dehydration, coupled with reductions in berry dimension [28–30]. Additionally, if either radiation or temperatures are excessive, tissue wrecking could be observed [31]. At temperatures higher than 30 °C, owing to the inhibition of photosystem II activity (the most thermally labile component of the electron transport chain), both the capacity and the quantum yield of CO_2 assimilation start to decline [32]. Grape's aromatic compounds are strongly influenced by sun exposure. In fact, excessive exposure to sunlight and high berry temperatures dwindle methoxpyrazines content [33,34]. In addition, Scafidi et al. [35] showed that in warm environmental conditions, heat and sunlight stress could have a negative effect on the flavor compounds of the white Grillo variety and on glycosylated aromatic typesetting.

However, it is generally accepted that shade results in significant alterations in grape composition, and its excess reduces wine quality [36]. In particular, red grapes shading decreased the 3′-hydroxylated anthocyanin concentration [37] owing to clampdown and/or lag of mRNA stock of VvmybA1, a presumptive regulatory gene of the biosynthesis of anthocyanins [38]. It is therefore of fundamental importance to find a balance in the adoption of mitigating techniques.

As a consequence, short-term adaptation strategies that allow balancing vine growth regulation and productivity should be studied under these environmental conditions [39,40]. Sunscreen equipment that shapes an inert particle film upon the leaf, such as kaolin, potassium silicate, and calcium carbonate, has been examined to heighten reflective capacity, lessen leaf and cluster sunburns, and allow leaf cooling under grave summer stress [41–43].

Kaolin-based particle film technology has been studied over the past fifteen years as an environment-friendly material (suitable for organic farming) that mitigates heat stress, ensures effective insect control, and enhances the production of fruit and vegetables [44]. Kaolin is an aluminum phyllosilicate, $Al_2Si_2O_5(OH)_4$ (engineered clay), classified as a reflective antitranspirant material [45]. Originally, kaolin was applied for pest control in many crops [46,47]. In viticulture, kaolin was proposed to supervise the diffusion of Pierce's disease [48]. It was demonstrated that the white kaolin film on the leaf surface heightens the solar radiation reflection, modifying the radiation and heat balance with a reduced risk of leaf and fruit damage from solar injury and high temperatures [49]. The reflected light modification is the achievement of the skill of the particle film to reflect infrared (IR), photosynthetically active radiation (PAR), and ultraviolet radiation (UV) [50]. Reflection of IR can reduce the canopy temperature by as much as 5 °C, reducing potential transpiration [51].

Shading nets (SD) engender a comparable effect, and they are suggested in viticulture as an adaptation system to temper the repercussions of high temperatures (global warming) and limit evapotranspiration [52,53]. Shading nets positioned over the canopy vine allowed to scale down the photosynthetic photon flow at the covering achievable leaves for the photosynthetic process, with a delay in berry ripening as a consequence [54,55]. It was shown that SD could reduce water stress and temperature of the whole canopy and the clusters close to 7 °C [31,56]. There is an important impact of vine shading on C6/C9 compound biosynthesis (products of the lipoxygenase pathway) and on the concentrations of linolenic and linoleic acids. Under detected high temperatures, the outflow of isoprene, monoterpenes, and C6 elements can balance photosynthetic membranes, preserving the photosynthetic apparatus from lipid peroxidation damage [57]. In addition, shading of the 'Muscat' bunch and leaves from the berry setting to harvest enhanced the concentration of hexanal ($C_6H_{12}O$) and (E)-2-hexenal compounds [58].

Nevertheless, more studies about the duration and timing of shading, type, color, and specific canopy portion shading must be performed for future technical and economic decisions.

In global warming scenario, this paper aims to compare two canopy shading levels (30% and 70%) and kaolin foliar application on *Vitis vinifera* L. cv. Sauvignon Blanc, in order to evaluate the performance of the grapevine in terms of berry quality, yields, and eco-physiology traits.

2. Materials and Methods

2.1. Setting and Pilot Design

A scientific test was accomplished in 2020 and 2021 vintages on *Vitis vinifera* L. Five-year-old grapevines, Sauvignon Blanc (white variety) clonal selection FPS 03 (Jackson), grafted on SO4 rootstock were chosen. It was set up in San Miniato (Lat 43.68034°N—Long 10.85764°E), Italy, sited at 275 m a.s.l. in a vineyard facing a South-West exposure. Vines were planted at 1.8 m × 1.0 m (5555 vines per hectare) and were spur-pruned with a single cordon system, at 63 cm above the soil with twelve buds/vine, six spurs.

The vines are grown with the organic management of the use of pesticides (Italian law n° 150/2012) without irrigation aid. Soil management provides for natural ground cover and tillage in alternate rows. The ground framework was clay; the soil horizons award the following characteristics: sand 19.2%, silt 31.3%, clay 49.5%, organic matter 2.1%, and pH 7.4 [59].

The experiment was organized in a complete randomized block design with four treatments and ten replications. One guard row was left between two contiguous treatments. On each replication of each treatment, sample grapevines were marked and employed for the surveys.

The following treatments were set up: green artificial shading net at 30% (SD-30%; 80 gr/m^2), green artificial shading net at 70% (SD-70%; 180 gr/m^2), kaolin foliar applications (K), and no treatments (CTRL) (Figure 1).

Figure 1. Different canopy management of *Vitis vinifera* cv. Sauvignon Blanc: SD-30% (green artificial shading net at 30%; (**A**)), SD-70% (green artificial shading net at 70%; (**B**)), and K (kaolin; (**C**)).

According to the manufacturer's suggestion, the first spraying of 1.5 kg of kaolin–Biosil (Agri 2000 Italia SRL, Alberone di Riva del Po, FE, Italy) per 100 L of water was made on 27 July 2020 and 19 July 2021 (veraison stage) using a 1000 L pneumatic nebulizer (Prima Ideal, Castelbaldo, PD, Italy). From the second application on 6 August 2020 and 29 July 2021, the dosage and spraying frequency were adjusted to 3 kg per 100 L of water at ~10-day intervals (with the last application on 9 August 2021 and 17 August 2020). The dosage rectification was determined owing to the not complete kaolin-film accumulation after the first spraying. For the fruit and canopy netting treatment (Retificio Padano, Ospitaletto, BS, Italy), the net was also installed on 27 July 2020 and 19 July 2021 and removed at harvest (31 August 2020 and 24 August 2021). Shading net application (a polyethylene UV stabilized net) was realized at 25% veraison and was accomplished along the bunch zone (approximately 35% of total leaf area) [60]. A preliminary proof was performed to reckon the percentage of global solar radiation passing the nets. In fact, the transmittance of global solar radiation with the green artificial shading nets was reduced by 29.40% and 71.20%, respectively.

A weather station nearby Meteosense Agrometeo (Netsens srl, Calenzano, FI, Italy) collected millimeters of rainfall, maximum/minimum/mean air temperatures (°C), maximum/minimum/mean relative humidity (%).

2.2. Leaf Gas Exchange, Predawn and Midday Leaf Water Potential, Leaf-Specific Hydraulic Conductance, Leaf Chlorophyll a Fluorescence, and Content

Eco-physiological measurements were performed on the tagged vines at three phenological stages: full véraison (100% full-color modified; 10 August 2020 and 4 August 2021; E-L 35 stage), mid maturation, berries with midway sugar values (21 August 2020 and 19 August 2021; E-L 36 stage), and harvest (31 August 2020 and 24 August 2021; E-L 38 stage) [61,62].

Net photosynthesis (Pn), leaf temperature (T Leaf), transpiration rate (E), and stomatal conductance (gs) were examed between 10:00 and 12:00 a.m. on each vine, 10 replicates (in each replica, one not sick and fully grown leaf per treatment was sampled) employing a Ciras 3 gas analyzer (PP Systems International, Inc., Amesbury, MA, USA), adjusting flow with the following parameters: CO_2 concentration at 410 ppm and ambient temperature. Water use efficiency (eWUE) was determined from Pn (μmol CO_2 m^{-2} s^{-1}) and E (mmol m^{-2} s^{-1}) ratio.

Using a pressure chamber (exemplary 600D, PMS Instrument Co., Albany, OR, USA) on one fully expanded leaf for treatments for the replica, leaf midday water potential

(12:00 a.m.–13:00 p.m.; Ψleaf, MPa) and pre-dawn leaf water potential (3:00–4:00 a.m.; ΨPD, MPa) were determined [63].

In leaf, the hydraulic conductance (Kl) was calculated by the relationship between E (mmol m^{-2} s^{-1}), Ψleaf (MPa), and ΨPD (MPa) as follows E/(Ψleaf-ΨPD) [64].

Chlorophyll concentration (Chl-a) in leaves was estimated with Markwell's calibration [65] by a movable chlorophyll instrument SPAD-502 Plus (Konica Minolta, Tokyo, Japan). With Handy-PEA® chlorophyll fluorometer (Hansatech Instruments, King's Lyn, UK) was measured chlorophyll a (Chl-a) fluorescence transients of thirty minutes dark-adapted healthy leaves. *Fv* (variable) and *Fm* (maximal) chlorophyll fluorescences were gathered employing a saturating-actinic light at a photon flux density of 3000 µmol m^{-2} s^{-1} for 1 s and calculating *Fv/Fm* in accordance with Maxwell [66].

Gas exchange measurements, leaf midday water potential, chl-a fluorescence, and content were collected on the same leaves during each phenological stage.

2.3. Berry Temperature and Composition

Internal berry temperature was measured with a Micro Temperature Probe–GMR_MTP thermocouple inserted into the berry (Figure 2). Outputs were stockpiled with a specific datalogger that controls four thermocouples. The measurements were carried out with a time step of 15 min from veraison to harvest. Inner berry temperature monitoring followed the protocol adopted by Cola [67]. Briefly, the thermocouple tip was inserted into the berry, previously pierced with a little spike; the thermocouple tip was placed on a berry in the external-middle part of the cluster; the thermocouple was shifted to a fresh berry every week to perpetuate the optimal status quo of the living organs, so that withering could not influence the measurements. Four thermocouples were installed in a single randomized block for each treatment. Five replicates of the measurements were taken.

Figure 2. Micro Temperature Probe–GMR_MTP thermocouple inserted into the berry.

One hundred berries, selected from the 10 grapevines for the eco-physiological measurements, were randomly sampled from each replication of each treatment (10 berries per plant for a total of 100 berries per sample) to accomplish technological maturity ratings. The sampled berries of treatments with a digital scale (Kern and SOHN GmbH, PCB 1000-1 model, Balingen, Germany) were individually compared. The berries were pressed and wrung to evaluate the different values of technological maturity. An RHA-503 refractometer (HHTEC, Heidelberg, Germany) was used to evaluate the sugar value (°Brix); a high accuracy portable pH meter (HHTEC, Heidelberg, Germany) was used to measure pH and tartaric acid (TA g L^{-1}). Briefly, an acid-base titration was performed using 0.1 M NaOH [68] up to pH 7.0 with glass burettes on a 10 mL sample.

In order to assess the aromatic maturity (i.e., S-4-(4-methylpentan-2-one)-L-cysteine (Cys-4MMP), 3-S-cysteinylhexan-1-ol (Cys-3MH), and 3-S-glutathionylhexan-1-ol (Glut-3MH)),100 more berries were collected for each treatment and replication. In must, thiol precursors were determined by an external laboratory according to the Larcher method [69] (LC-MS/MS).

2.4. Statistical Analysis

After running preliminary Shapiro–Wilk's ($p \leq 0.05$; [70]) and Levene's ($p \leq 0.05$; [71]) tests to verify the normal distribution and the homogeneity of variance of each dataset, the different treatments were also investigated with one-way ANOVA ($p \leq 0.05$). Mean values were separated by Fisher's least significant difference (LSD) post hoc test ($p \leq 0.05$, *p*-value adjustment method: Holm; [72]). Statistical analyses and graphic representations were executed by integrated process set R version 4.1.2. and RStudio (Development for R, Boston, MA, USA).

3. Results

3.1. Meteorological Conditions

Figure 3 informed on meteorological guidelines of the area in the 2020 and 2021 growing seasons.

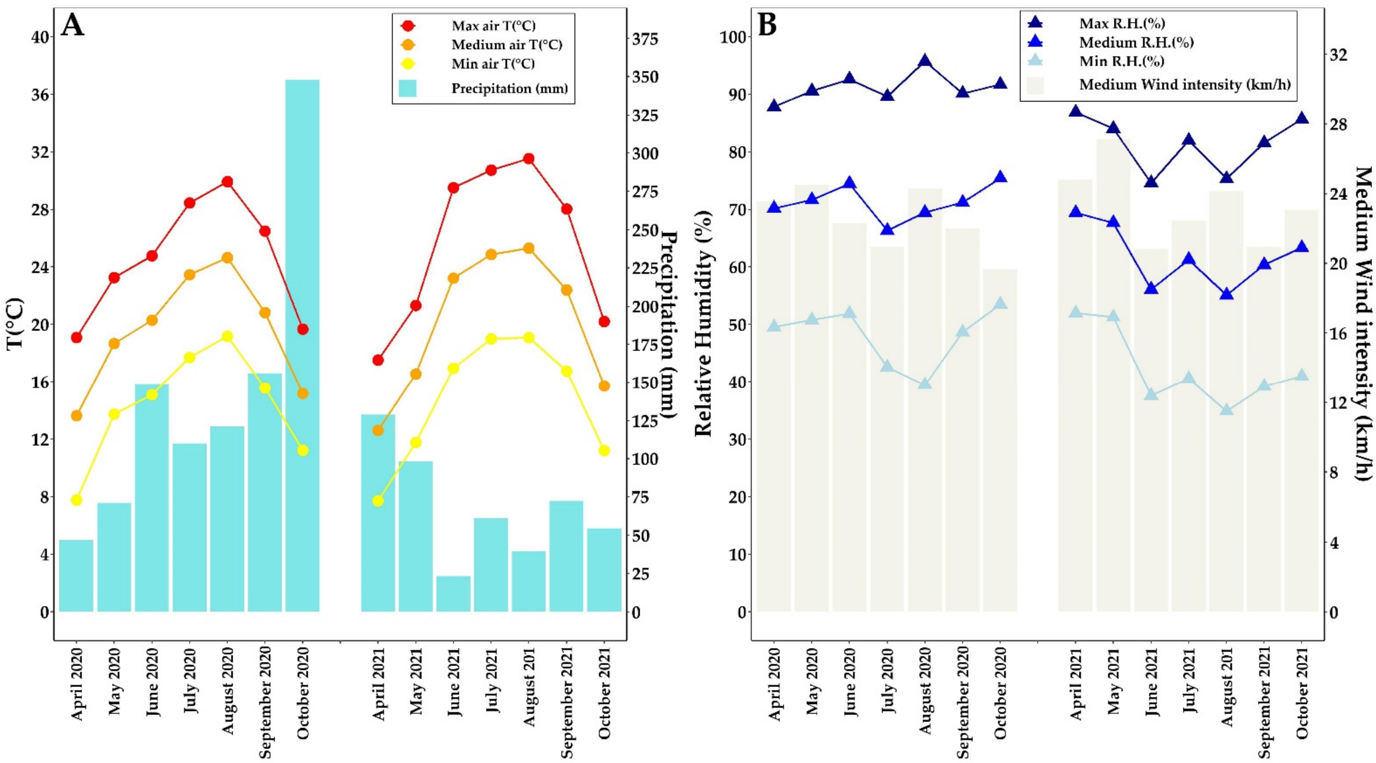

Figure 3. Meteorological conditions of the experiment location. Monthly averages of mean, maximum, minimum air temperature (°C), and summation monthly rainfall (mm) (**A**) were measured from April to October (2020–2021); monthly averages of mean, maximum, minimum relative humidity (%), and wind intensity (km/h) (**B**) were measured from April to October (2020–2021).

Minimum, mean, maximum air temperatures, and minimum, mean, maximum relative humidity were measured in both seasons (April–October 2020–2021). The 2021 growing-production season demonstrated to be the hottest and less rainy during July and August.

Max temperatures from June to August 2021 were higher than in the corresponding months of 2020; +4.75° during June 2021, +2.29° during July 2021, and +1.61° during June 2021. In contrast, 2020 proved to be a cooler and more rainy year from April to October (1001.5 mm rainfall compared to 477.4 mm in 2021). In particular, June 2020 recorded 148.8 mm of rain, July 110 mm, and August 120.9 mm, while in 2021, 23.2, 61, and 39.4 mm were recorded, respectively. The hottest period in both years was August: in 2020, the mean monthly temperature reached 24.69° centigrade compared to 25.32° in 2021.

Figure 4 reported specific meteorological conditions of the area in the 2021 and 2021 growing seasons (July and August).

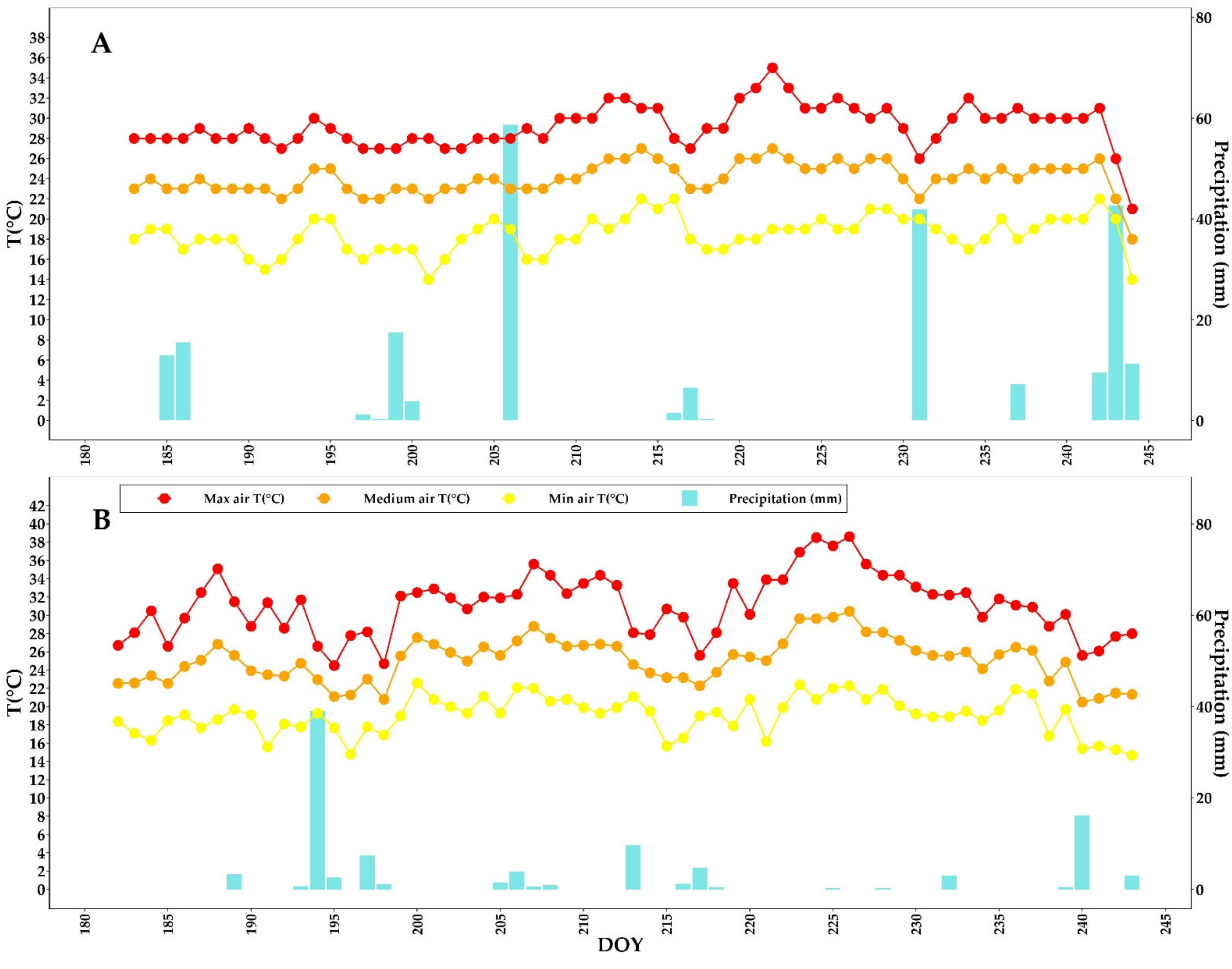

Figure 4. Meteorological conditions of the experiment location. Daily registrations of mean, maximum, minimum air temperature (°C), and summation daily rainfall (mm) were measured from July to August ((**A**)-2020; (**B**)-2021). The days were expressed in Julian Days (DOY).

Daily registrations of mean, maximum, minimum air temperature (°C), and summation daily rainfall (mm) were measured from July to August (2020–2021; Figure 4A,B). During July and August 2020, there were 14 days in which the maximum temperatures rose above 30°. The only day where the temperature rose to 35° was 9 August 2020 (222 DOY). While during July and August 2021, there were 38 days in which the maximum temperatures rose above 30°. The critical maximum temperatures were recorded on the following days: on 7 July 2021, there were 35.1° (188 DOY); on 24 and 30 July 2021, there were 34.4° (208-211 DOY); from 9 to 17 August 2021 (221-229 DOY) a week of heat and intense drought was recorded (33.9–33.9–36.9–38.5–37.6–38.6–35.6–34.4–34.4 °C).

The most consistent rain events were recorded on 4 July 2020 (15.5 mm; 186 DOY), 17 July 2020 (17.5 mm; 199 DOY), 24 July 2020 (58.7 mm; 206 DOY), 18 August 2020 (41.9 mm; 231 DOY), and 30 August 2020 (42.7 mm; 243 DOY). Instead, the most consistent rain events recorded in 2021 were only two, on 13 July 2021 (39.0 mm; 194 DOY) and on 28 August 2021 (16.2 mm; 240 DOY).

3.2. Leaf Gas Exchange, Predawn and Leaf Water Potential, Leaf-Specific Hydraulic Conductance, Leaf Chlorophyll a Fluorescence and Content

Net photosynthesis (Pn), stomatal conductance (gs), water use efficiency (eWUE), leaf temperature (Tleaf), leaf specific hydraulic conductance (Kl), transpiration (E), pre-dawn water potential, leaf water potential, leaf chlorophyll a fluorescence, and content of *Vitis vinifera* in the four different canopy managements (SD-30%, SD-70%, K, and CTRL) are presented in Table 1, Figures 5 and 6.

Significant differences in Tleaf, Pn, gs, and E (physiological parameters) during 2020 and 2021 were found. No significant difference in Tleaf during the 2020 season (mid maturation and harvest) was found (Table 1).

In K grapevines, higher rates of gs, Pn, and E were generally noticed (2020 and 2021 vintages).

Table 1. Plant physiology. Net photosynthesis (Pn), stomatal conductance (gs), water use efficiency (eWUE), leaf temperature (Tleaf), leaf specific hydraulic conductance (Kl), and transpiration (E) of *V. vinifera* treated with four different canopy management. Measurements were conducted at full veraison (10 August 2020 and 4 August 2021), mid maturation, berries with intermediate sugar values (21 August 2020 and 19 August 2021), and harvest (31 August 2020 and 24 August 2021). Data (mean ± SE, n = 10) were subjected to one-way ANOVA. In each measured parameter (Pn, gs, eWUE, T leaf, Kl, and E) the statistical difference is represented by letters; within the single date, single row, the statistical differences between the treatments (SD30%, SD70%, K, and CTRL) are represented by different letters (a, b, c) (LSD test, $p \leq 0.05$). The same letter pictured on different treatments indicates no significant difference among them.

	Pn (μmol CO_2 m^{-2} s^{-1})				gs (mmol H_2O m^{-2} s^{-1})			
Stage	**SD30%**	**SD70%**	**K**	**CTRL**	**SD30%**	**SD70%**	**K**	**CTRL**
10 August 2020	4.21 ± 1.24 c	3.36 ± 1.34 c	6.91 ± 3.16 b	8.29 ± 2.40 a	129.10 ± 30.44 c	120.24 ± 12.82 c	167.50 ± 27.63 a	142.40 ± 24.10 b
21 August 2020	3.42 ± 1.03 b	2.21 ± 0.37 c	10.97 ± 4.10 a	10.40 ± 1.31 a	145.65 ± 27.87 ab	139.35 ± 33.54 b	154.21 ± 27.31 a	156.00 ± 32.11 a
31 August 2020	3.61 ± 1.95 c	1.52 ± 0.29 d	8.40 ± 1.31 b	9.76 ± 2.11 a	148.00 ± 13.12 a	140.4 ± 21.22 a	148.40 ± 31.31 a	152.8 ± 35.51 a
4 August 2021	2.44 ± 1.10 bc	1.66 ± 0.34 c	4.78 ± 1.27 a	2.98 ± 0.98 b	100.50 ± 22.10 b	75.11 ± 5.23 c	131.40 ± 37.67 a	125.70 ± 31.07 a
19 August 2021	3.25 ± 1.01 b	1.71 ± 0.20 c	5.31 ± 1.55 a	4.05 ± 2.14 b	42.23 ± 15.01 a	44.62 ± 9.72 a	59.34 ± 21.00 a	48.75 ± 26.27 a
24 August 2021	2.95 ± 1.60 b	1.51 ± 1.57 c	4.93 ± 1.94 a	4.35 ± 2.14 a	41.30 ± 8.37 b	49.55 ± 2.13 b	63.50 ± 15.78 a	62.00 ± 55.18 a

	eWUE (μmol CO_2/mmol H_2O)				T leaf (°C)			
Stage	**SD30%**	**SD70%**	**K**	**CTRL**	**SD30%**	**SD70%**	**K**	**CTRL**
10 August 2020	1.67 ± 1.38 b	1.28 ± 1.46 b	3.33 ± 0.75 a	3.10 ± 1.12 a	32.17 ± 0.84 ab	31.88 ± 2.68 b	32.27 ± 0.86 a	32.48 ± 2.58 a
21 August 2020	2.81 ± 0.88 c	2.05 ± 0.42 c	4.02 ± 0.66 b	5.80 ± 0.32 a	31.71 ± 1.37 a	31.11 ± 1.13 a	31.89 ± 0.95 a	31.99 ± 0.62 a
31 August 2020	2.00 ± 1.37 a	2.33 ± 1.12 a	2.13 ± 1.67 a	2.14 ± 1.05 a	20.94 ± 0.68 a	20.27 ± 1.92 a	20.96 ± 0.96 a	20.93 ± 1.41 a
4 August 2021	1.03 ± 0.77 ab	0.84 ± 0.91 b	1.59 ± 1.52 a	1.87 ± 0.82 a	34.32 ± 0.60 b	32.95 ± 1.01 d	33.61 ± 0.68 c	35.89 ± 0.66 a
19 August 2021	2.39 ± 0.32 ab	1.35 ± 0.52 c	3.22 ± 1.30 a	2.09 ± 1.00 b	36.16 ± 0.48 b	35.88 ± 1.31 bc	35.32 ± 0.37 c	38.38 ± 0.81 a
24 August 2021	2.64 ± 0.51 a	0.70 ± 1.35 b	2.86 ± 1.10 a	2.09 ± 1.56 a	36.93 ± 1.06 b	34.52 ± 2.65 c	35.06 ± 1.59 c	39.20 ± 1.13 a

	Kl (mmol MPa^{-1} m^{-2} s^{-1})				E (mmol H_2O m^{-2} s^{-1})			
Stage	**SD30%**	**SD70%**	**K**	**CTRL**	**SD30%**	**SD70%**	**K**	**CTRL**
10 August 2020	5.24 ± 1.20 b	3.91 ± 2.28 c	6.28 ± 2.92 a	7.06 ± 2.74 a	3.63 ± 0.74 b	2.74 ± 2.07 c	4.25 ± 2.01 ab	4.48 ± 0.14 a
21 August 2020	4.55 ± 1.33 b	3.85 ± 0.46 b	3.94 ± 1.89 b	5.43 ± 1.00 a	3.28 ± 0.85 ab	3.15 ± 1.04 b	3.22 ± 1.16 ab	4.18 ± 1.08 a
31 August 2020	5.94 ± 0.96 a	5.25 ± 1.36 a	6.00 ± 2.09 a	5.90 ± 1.70 a	4.34 ± 0.60 ab	3.91 ± 1.07 b	5.28 ± 0.99 a	4.94 ± 1.10 a
4 August 2021	3.31 ± 1.73 b	2.14 ± 0.73 c	5.31 ± 1.39 a	1.60 ± 1.13 d	2.97 ± 1.15 ab	1.96 ± 0.52 c	3.74 ± 1.12 a	2.36 ± 0.88 bc
19 August 2021	1.53 ± 1.14 b	1.00 ± 0.78 b	2.07 ± 0.88 a	0.82 ± 1.12 b	1.61 ± 0.34 ab	0.93 ± 1.03 b	1.91 ± 0.61 a	1.66 ± 1.25 ab
24 August 2021	1.32 ± 0.97 b	2.63 ± 1.72 a	2.30 ± 1.24 a	1.08 ± 0.84 b	1.41 ± 0.69 a	1.77 ± 0.69 a	2.15 ± 0.83 a	1.51 ± 0.73 a

In chlorophyll content in Sauvignon Blanc leaves (SPAD Units), significant difference was not detected; differences in *Fv/Fm* leaves were found between treatments during the 2021 season (Figure 5A–D).

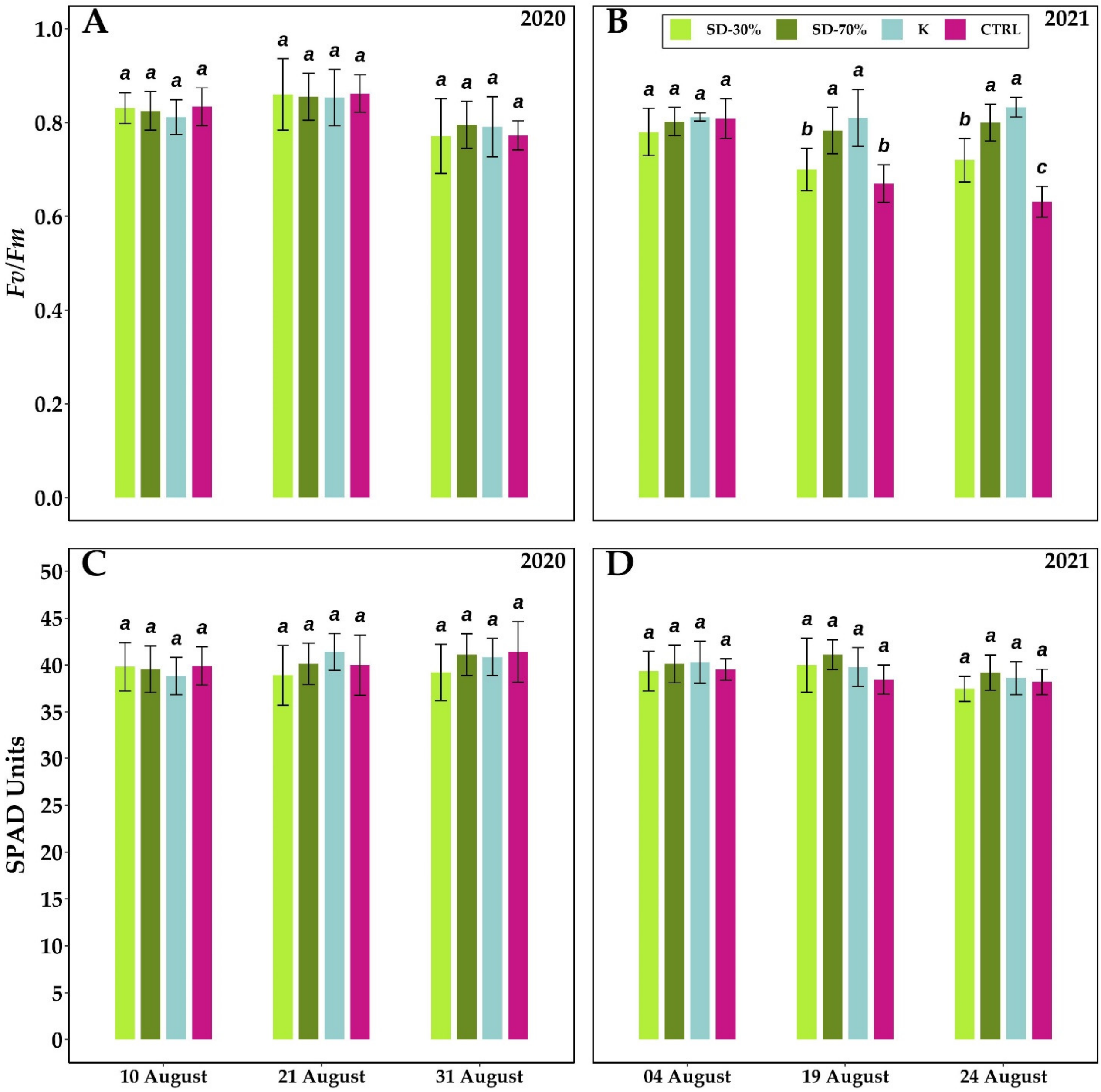

Figure 5. Maximum quantum yield of PSII (*Fv*/*Fm*) ((**A**), 2020; (**B**), 2021) and chlorophyll content ((**C**), 2020; (**D**), 2021) of *V. vinifera* with four different canopy management: SD-30% (green artificial shading net at 30%; light green columns), SD-70% (green artificial shading net at 70%; dark green columns), K (kaolin; light blue columns), and CTRL (control; purple columns). Measurements were conducted at full veraison (10 August 2020 and 4 August 2021), mid maturation, berries with intermediate sugar values (21 August 2020 and 19 August 2021), and harvest (31 August 2020 and 24 August 2021). Data (mean ± SE, $n = 10$) were subjected to one-way ANOVA. In each measured parameter (*Fv/Fm* and SPAD) the statistical difference is represented by letters; within the single date, a grouping of columns, the statistical differences between the treatments (SD30%, SD70%, K, and CTRL) are represented by different letters (a, b, c) (LSD test, $p \leq 0.05$). The same letter pictured on different treatments indicates no significant difference among them.

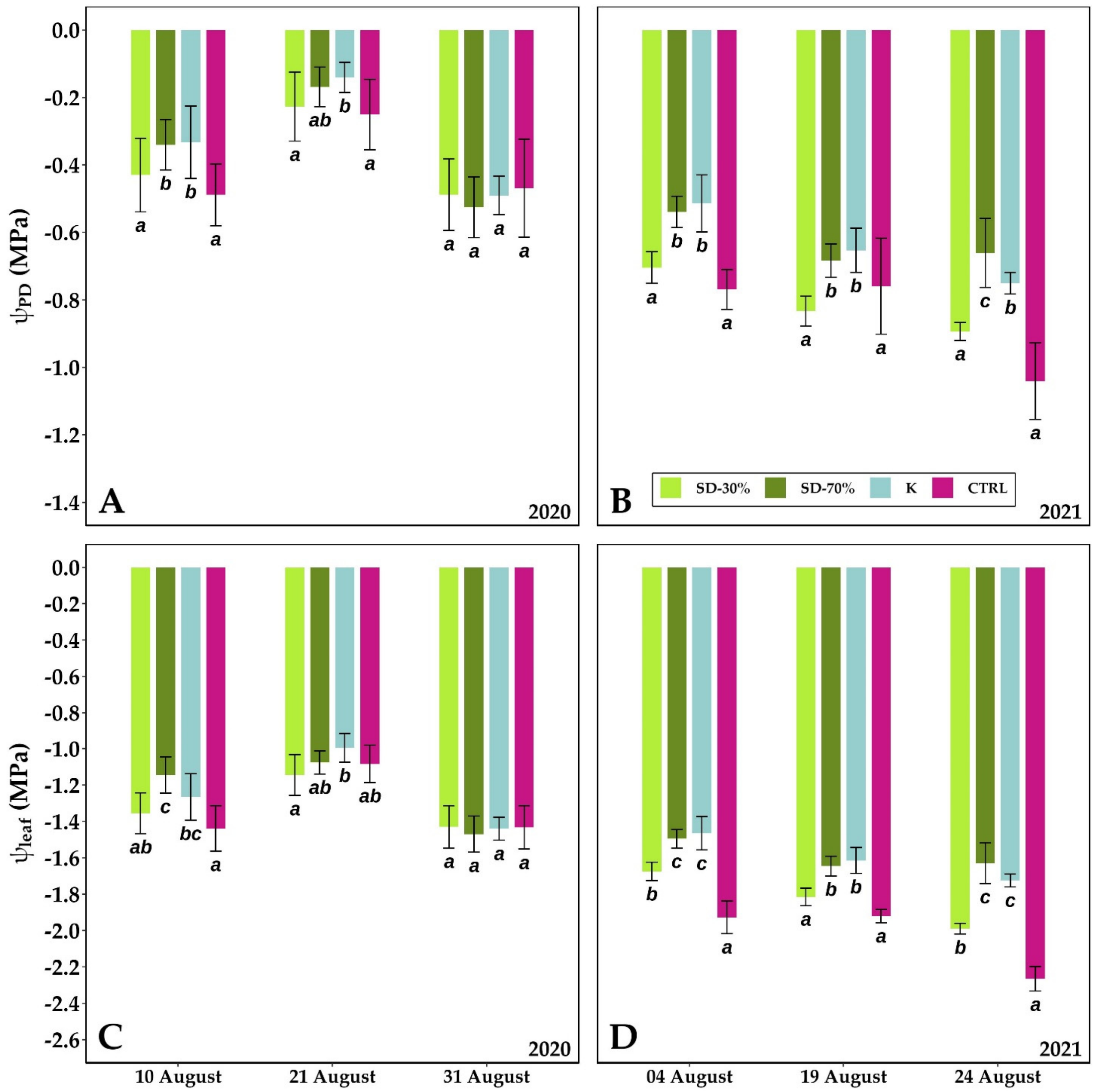

Figure 6. Pre-dawn water potential (ΨPD) ((**A**), 2020; (**B**), 2021) and leaf water potential (Ψleaf) ((**C**), 2020; (**D**), 2021) of *Vitis vinifera* with four canopy management: SD-30% (green artificial shading net at 30%; light green columns), SD-70% (green artificial shading net at 70%; dark green columns), K (kaolin; light blue columns), and CTRL (control; purple columns). Measurements were conducted at full veraison (10 August 2020 and 4 August 2021), mid maturation, berries with intermediate sugar values (21 August 2020 and 19 August 2021), and harvest (31 August 2020 and 24 August 2021). Data (mean ± SE, n = 10) were subjected to one-way ANOVA. In each measured parameter (ΨPD and Ψleaf) the statistical difference is represented by letters; within the single date, a grouping of columns, the statistical differences between the treatments (SD30%, SD70%, K, and CTRL) are represented by different letters (a, b, c) (LSD test, $p \leq 0.05$). The same letter pictured on different treatments indicates no significant difference among them.

Significant differences in leaf water potential parameters (Ψleaf) in both seasons were found. No significant difference in pre-dawn water potential parameters (ΨPD) during the 2020 season was found (Figure 6).

3.3. Berry Temperature and Composition

Figure 7A–D show, during two seasons of experimentation, the *Vitis vinifera* berry temperature among treatments.

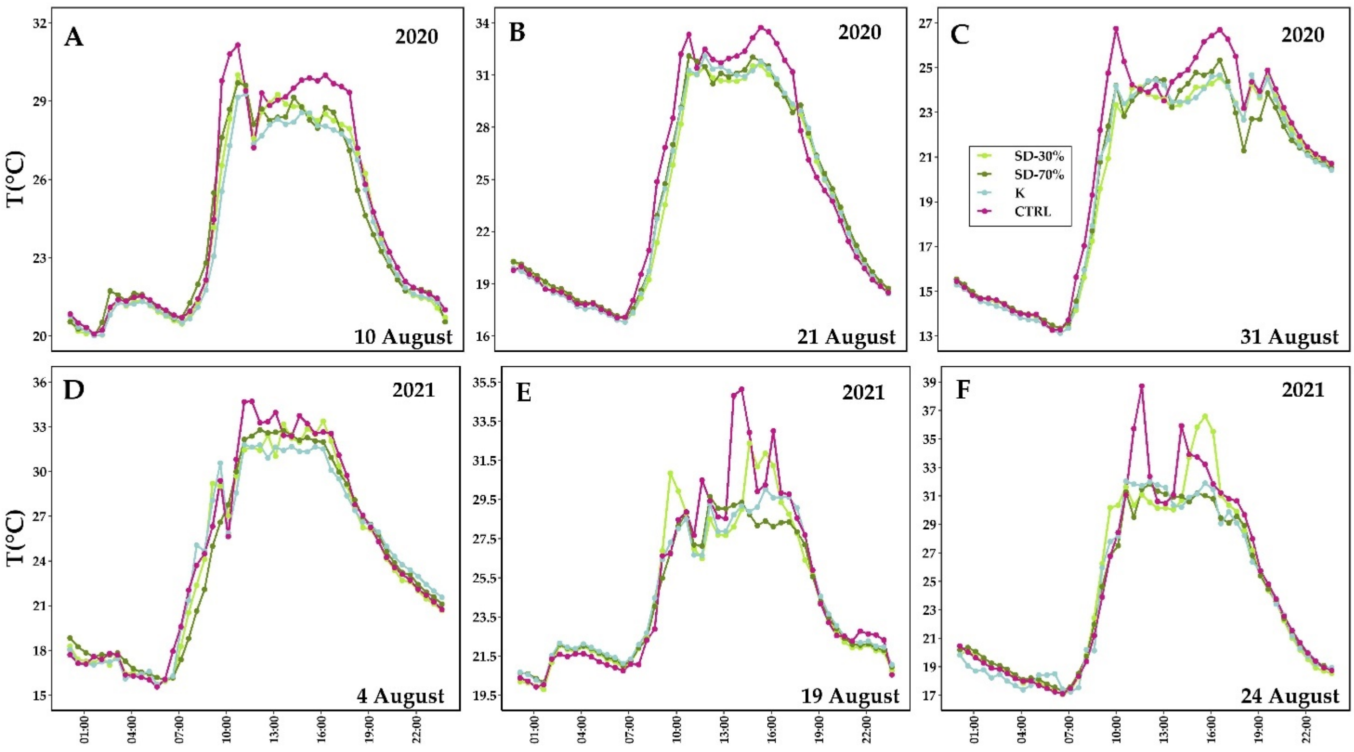

Figure 7. Berry temperatures ((**A**–**C**) 2020; (**D**–**F**) 2021) of *Vitis vinifera* with four different canopy management: SD-30% (green artificial shading net at 30%; light green lines), SD-70% (green artificial shading net at 70%; dark green lines), K (kaolin; light blue lines), and CTRL (control; purple lines). Measurements were conducted at full veraison (10 August 2020 and 4 August 2021), mid maturation, berries with intermediate sugar values (21 August 2020 and 19 August 2021), and harvest (31 August 2020 and 24 August 2021).

The berry temperatures during 2020 never exceeded 32 °C, while in 2021, they reached peaks of 38.72 °C. The CTRL treatment in both seasons showed higher berry temperatures. On the other hand, treatments with 70% shading net and kaolin measured lower temperatures during the hottest time of the day.

Table 2 and Figure 8 show *V. vinifera* berry composition among treatments (SD-30%, SD-70%, K, and CTRL) in terms of technological maturity (titrable acidity, pH, sugar content, and berry weight) and 3-S-glutathionylhexan-1-ol (Glu-3MH), S-4-(4-methylpentan-2-one)-L-cysteine (Cys-4MMP), and 3-S-cysteinylhexan-1-ol (Cys-3MH) (thiolic precursors).

In both seasons, 2020 and 2021, no significant differences in pH were found (Table 2). On the contrary, at mid maturation and harvest, significant differences in sugar content were observed in the two seasons. Ctrl treatment showed a higher sugar content compared to other treatments. At veraison, mid maturation, and harvest, significant differences in acidity (g L^{-1} tartaric acid) were observed in the two seasons. SD-70% treatment showed a higher tartaric acid content compared to other treatments.

The greatest differences in the composition of thiolic precursors were found in the 2021 seasons among treatments (Figure 8). On 24 August, K and SD-70% were significantly different from the other treatments for the Cys-3MH precursor. Moreover, on August 24, SD-70% showed a higher value in the Glu-3MH precursor. At harvests, there were no differences between treatments in Glu-3MH and Cys-4MMP thiols precursors.

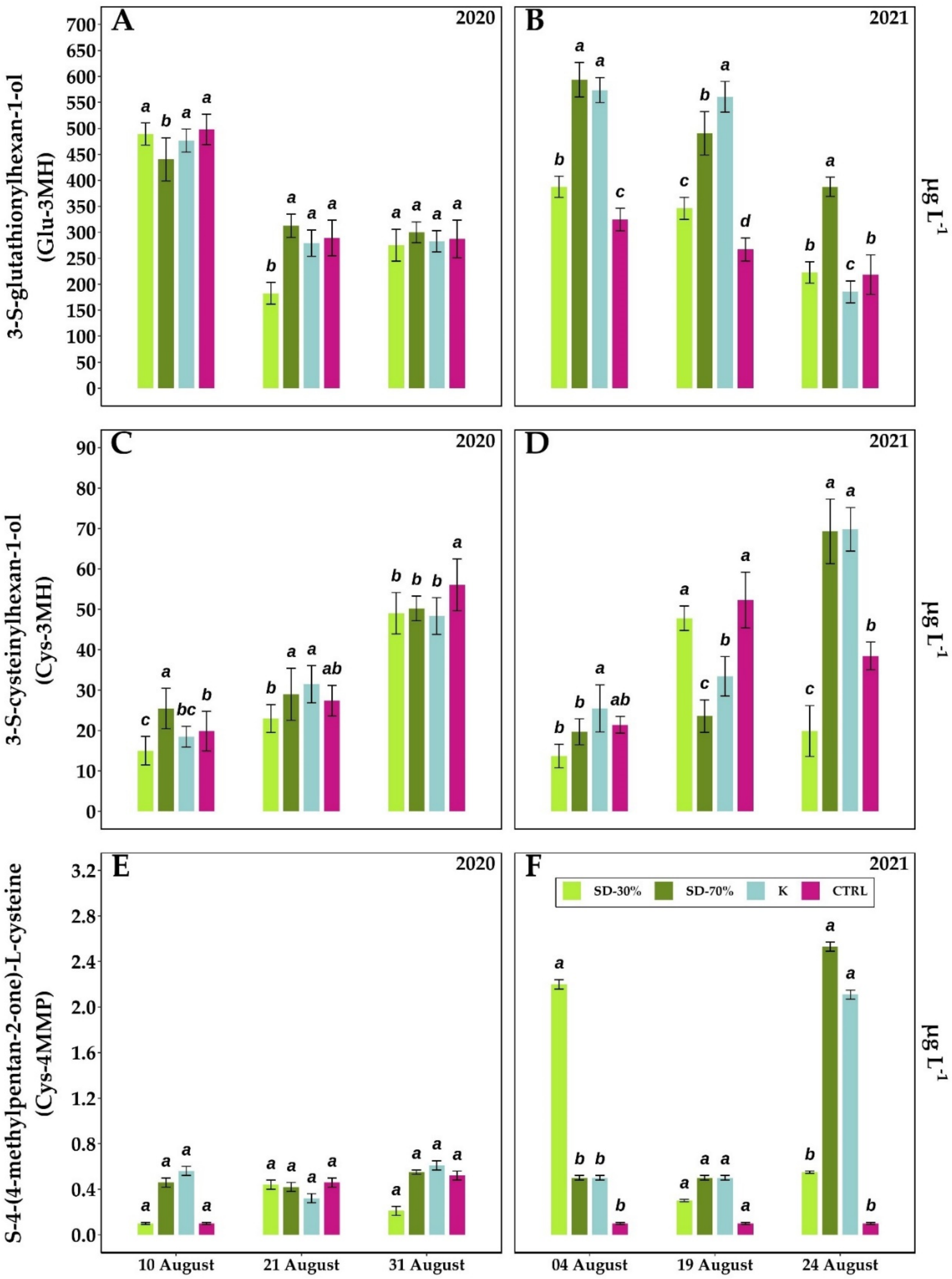

Figure 8. Aromatic maturity. 3-S-glutathionylhexan-1-ol (Glu-3MH; **A**,**B**), 3-S-cysteinylhexan-1-ol (Cys-3MH; **C**,**D**), and S-4-(4-methylpentan-2-one)-L-cysteine (Cys-4MMP; **E**,**F**), contents of *Vitis vinifera* treated with green artificial shading net at 30% (SD-30%), green artificial shading net at 70% (SD-70%), kaolin (K), and no treatment (CTRL), during two seasons (2020–2021). Measurements were conducted at full veraison (10 August 2020 and 4 August 2021), mid maturation, berries with intermediate sugar values (21 August 2020 and 19 August 2021), and harvest (31 August 2020 and 24 August 2021). Data (mean ± SE, n = 10) were subjected to one-way ANOVA. In each measured parameter (Cys-4MMP, Cys-3MH, and Glu-3MH) the statistical difference is represented by letters; within the single date, a grouping of columns, the statistical differences between the treatments (SD30%, SD70%, K, and CTRL) are represented by different letters (a, b, c) (LSD test, $p \leq 0.05$). The same letter pictured on different treatments indicates no significant difference among them.

Table 2. Technological maturity. Sugar content (°Brix), total acidity (TA), pH, and berry weight of *Vitis vinifera* treated with green artificial shading net at 30% (SD-30%), green artificial shading net at 70% (SD-70%), kaolin (K), and no treatment (CTRL) during two seasons (2020–2021). Measurements were conducted at full veraison (10 August 2020 and 4 August 2021), mid maturation, berries with intermediate sugar values (21 August 2020 and 19 August 2021), and harvest (31 August 2020 and 24 August 2021). Data (mean ± SE, n = 10) were subjected to one-way ANOVA. In each measured parameter (sugar content, TA, pH, and berry weight) the statistical difference is represented by letters; within the single date, single row, the statistical differences between the treatments (SD30%, SD70%, K, and CTRL) are represented by different letters (a, b, c) (LSD test, $p \leq 0.05$). The same letter pictured on different treatments indicates no significant difference among them.

	Sugar Content (°Brix)				**TA (g L^{-1} Tartaric Acid)**			
Stage	**SD30%**	**SD70%**	**K**	**CTRL**	**SD30%**	**SD70%**	**K**	**CTRL**
10 August 2020	12.88 ± 0.35 a	12.85 ± 0.15 a	12.35 ± 0.12 a	13.31 ± 0.25 a	13.35 ± 0.22 a	13.54 ± 0.68 a	13.23 ± 0.28 a	11.17 ± 0.73 b
21 August 2020	15.95 ± 0.70 ab	15.00 ± 0.47 b	15.80 ± 0.45 ab	16.00 ± 0.55 a	9.55 ± 0.23 b	10.00 ± 0.43 ab	10.30 ± 0.26 a	9.05 ± 0.12 b
31 August 2020	18.58 ± 0.42 b	18.25 ± 0.15 b	18.02 ± 0.37 b	19.82 ± 0.09 a	7.22 ± 0.50 b	8.41 ± 0.53 a	8.15 ± 0.40 ab	7.20 ± 0.33 b
4 August 2021	14.95 ± 0.15 a	13.54 ± 0.32 b	13.88 ± 0.30 b	15.18 ± 0.50 a	12.11 ± 0.47 ab	12.64 ± 0.46 a	12.60 ± 0.41 a	11.30 ± 0.33 b
19 August 2021	18.40 ± 0.32 a	17.21 ± 0.22 b	17.36 ± 0.25 b	18.72 ± 0.25 a	6.48 ± 0.20 b	8.00 ± 0.15 a	7.90 ± 0.10 a	6.44 ± 0.35 b
24 August 2021	21.72 ± 0.22 a	19.00 ± 0.33 c	20.40 ± 0.41 b	22.46 ± 0.20 a	4.22 ± 0.02 b	5.91 ± 0.07 a	6.16 ± 0.08 a	4.04 ± 0.04 b
	pH				**Berry Weight (g)**			
Stage	**SD30%**	**SD70%**	**K**	**CTRL**	**SD30%**	**SD70%**	**K**	**CTRL**
10 August 2020	2.94 ± 0.05 a	3.01 ± 0.08 a	2.95 ± 0.07 a	3.00 ± 0.07 a	1.34 ± 0.13 a	1.27 ± 0.11 a	1.31 ± 0.13 a	1.15 ± 0.15 a
21 August 2020	3.30 ± 0.06 a	3.21 ± 0.10 a	3.18 ± 0.11 a	3.20 ± 0.03 a	1.54 ± 0.27 a	1.51 ± 0.17 a	1.49 ± 0.14 a	1.51 ± 0.29 a
31 August 2020	3.28 ± 0.04 a	3.25 ± 0.11 a	3.22 ± 0.06 a	3.55 ± 0.07 a	1.77 ± 0.07 a	1.71 ± 0.80 a	1.73 ± 0.16 a	1.69 ± 0.13 a
4 August 2021	3.01 ± 0.08 a	3.09 ± 0.07 a	3.08 ± 0.11 a	3.26 ± 0.11 a	0.95 ± 0.21 b	1.11 ± 0.18 ab	1.28 ± 0.12 a	0.88 ± 0.09 b
19 August 2021	3.21 ± 0.07 a	3.16 ± 0.05 a	3.30 ± 0.04 a	3.33 ± 0.12 a	1.27 ± 0.15 b	1.54 ± 0.12 a	1.49 ± 0.08 a	1.33 ± 0.08 b
24 August 2021	3.24 ± 0.10 b	3.28 ± 0.07 b	3.46 ± 0.05 ab	4.02 ± 0.09 a	1.30 ± 0.07 b	1.51 ± 0.11 a	1.44 ± 0.08 a	1.27 ± 0.12 b

4. Discussion

Viticultural activity is basically joined with climatic variations and is extremely reliant on weather conditions [73]. Collectively, the existing inquiry highlighted the crucial role winemakers play in wine assets [74]. The interaction between farmer and agroecosystem generates unique combinations that determine the characteristics of the grapes and the style of the wine [75]. In fact, it is the individual choices that the winegrower makes to be able to counterbalance external adversities to maintain profitability and productivity unchanged. In fact, the principal intention of agronomic approaches is to keep a habitat that promotes an equalized vegetative growth bound towards quality production.

The present study gauges the importance of agronomic techniques such as shading net and kaolin foliar spray as a potential climate adaptation device to guarantee the quality of aromatic Sauvignon Blanc vines in the Mediterranean area.

The different agronomic techniques highlighted significant differences, in particular during the 2021 season. The 2020 vintage was mitigated by frequent rains and not extreme summer temperatures, while 2021 was recorded as a hot and dry year.

In our study, at veraison, mid maturation, and harvest leaf gas exchanges were basically lower in SD-70% than in other treatments. In fact, shade is reported to decrease transpiration (E), stomatal conductance (gs), photosynthesis (Pn), stomatal density (SD), hydraulic conductivity, and water use efficiency (WUE) [76,77]. Plants generally acclimatize to shade by perceiving light marks such as low PAR (photosynthetic active radiation), low red-to-far red ratios, and low blue light levels (plant photoreceptors cross talk) [78].

Literature reporting data on K effects of single leaf Pn rates are variable. However, our results fit nicely with a current review [79] that postulates that when K is used in environments characterized by low irradiance and rainy weather conditions, the effect on Pn rates is depressing (31 August 2020: 8.40 µmol m^{-2} s^{-1} K vs. 9.76 µmol m^{-2} s^{-1} CTRL). Conversely, any time the environment shows prevalent limiting factors (i.e., high light, water supply, high temperature, and VPD), K might exert a positive effect on leaf Pn (19 August 2021: 5.31 µmol m^{-2} s^{-1} K vs. 4.05 µmol m^{-2} s^{-1} CTRL).

Under the quite stressful conditions of the 2021 season, the K sprayed on leaves and the grapevines with a 70% shading net displayed decreased susceptibility to photo-inhibition owing to the elevated efficiency of the photosystem II (PSII) and a greater efficient photochemical quenching [80], probably due to an enhance sucrose concentration in leaf, sucrose transport, and phloem loading aptitude [81,82].

Leaf temperature was positively influenced by shading net and kaolin application; their temperature maintenance up to 5° lower than the CTRL treatment reduced leaf stress linked to high temperature and irradiance regimes, as highlighted in studies, by the decrease in H_2O_2 content and catalase activity in the leaves [83,84]. K and SD-70% were able to improve leaf cooling while slightly reducing photosynthetic and water loss rates [85]. Indeed, the photo-inhibition absence and the leaf evaporative cooling preservation detected in these two treatments at the water-stress culmination (*Fv/Fm* = 0.83/0.80, T Leaf = 35.06/34.52 °C, and E = 2.15/1.77 mmol m^{-2} s^{-1}) is supposed to have guaranteed a prompter recovery of leaf functions that did not occur in CTRL vines. Under severe water stress, K and SD-70% were very effective at preserving the integrity of photosynthetic machinery. The maximum potential quantum efficiency of photosystem II quantified through the chlorophyll *Fv/Fm* ratio indicates that strong limitation (down-regulation and impairment of photochemical activity; *Fv/Fm* approaching 0.6 at the beginning of stress and held thereafter) was reached only in CTRL treatment [86], whereas K and SD-70% still set at sub-optimal values. Such behavior had a strong impact on the longevity of basal leaves in the different treatments. While in chlorophyll content (SPAD Units) significant difference was not found in each season.

In addition to the leaf temperature, pre-dawn leaf water potential and leaf water potential proved to be simple and precise physiological indicators for assessing grapevine water status [87,88].

Sauvignon Blanc reflected its anisohydric behavior by allowing the leaf water potential to decrease with an increasing vapor-pressure deficit in order to continue the gas exchange [89,90].

The results of this study may indicate that the suitability of reducing the light interception of the vines is able to maintain midday ΨPD between −0.50 and −0.70 MPa for a long period before harvest in spite of water shortage (2021 vintage, SD-70% treatment) [91,92]. Physiological analysis (ΨPD and Ψleaf) validated that kaolin really enhanced plant summer stress tolerance, maybe for a slight drop in ABA (abscisic acid), and enhancement in IAA (indole-3-acetic acid) activated to support plasticity in growth and competence to fit harsh environmental states [93]. Overall, kaolin treatment may have prevented the ABA biosynthesis by avoiding the deviation of the xanthophyll's epoxidation/de-epoxidation cycle into the ABA precursor (i.e., neoxanthin) biosynthetic direction. The active xanthophylls cycle preservation and transpiration may have led to an ameliorated exceeding electrons dissipation, unfolding the resilience of canopy functionality spoken by kaolin sprayed canopies [94,95]. In fact, other results showed that kaolin-coated leaves had a higher antheraxanthin + violaxanthin + zeaxanthin pool and a remarkably lesser neoxanthin content when the water deficit became severe [93,95–97].

As also evidenced in many non-wine studies, from the point of view of technological maturity, the various parameters were influenced by the various treatments [98–100]. According to Martinez-Luscher et al., [101] berries under the nets often had significantly lower pH and higher TA than CTRL. No differences in pH values were found during the 2020 season. However, it increased in response to elevated temperature in both seasons in all treatments [102]. While during the other vintage, must pH tended to be higher in CTRL than SD-70%, including harvest point.

Sugar levels in the grape's samples in SD-30%, SD-70%, and K treatments were less than 6.67%, 8.60%, and 9.98% compared to CTRL (2020 vintage) and were less than 3.41%, 18.21%, and 10.09% compared to CTRL (2021 vintage) [103]. Probably due to the high temperature, CTRL clusters induced the accumulation of galactinol in berries through the action of VvHsfA2 (heat stress factor A2) and VvGolS1 (galactinol synthase 1), providing more carbon skeletons [104]. In fact, even though most investigations on sugar sensing in vine have been carried out with fructose, sucrose, and glucose, contemporary studies suggest that other sugars such as galactinol and trehalose may also play a significant role during abiotic stress [105].

Berry's weight was influenced by the two different seasonal patterns. During the 2021 season, the high temperatures (>33 °C) may have reduced cell division earlier than the lag phase of berries growth and consequently caused berry shrinkage phenomena, owing to the breakdown of cortex parenchyma cell walls (limited berry size) [39,106]. In fact, in this hottest vintage, the dehydration of the CTRL berries via the apoplast path involved dwindling productivity, thus slackening the pericarp volume [107]. This suggests that the water status was an important factor that can affect the size of berries [108]. Indeed, significant differences in berry weight were found; SD-70% and K tended to have greater berry weight throughout the growing season [109].

In every treatment, maximum berry temperature was registered from noon to early afternoon. At that time, the maximum berry temperature was 5–15 °C warmer than the maximum air temperature in treatments. Berry temperature was significantly affected by kaolin applications and shading nets reducing sunburn, berries temperature, and other berry detriments correlated with clusters solar exposure [110]. In CTRL treatment, where clusters were most exposed to direct sunlight, berries were +6.14 °C, +5.78 °C, and +5.96 °C warmer than SD-30%, SD-70%, and K, respectively (19 August 2021) and +7.63 °C, +7.26 °C, and +7.01 °C warmer on 24 August 2021. Note that in CTRL treatment without kaolin application or shading, net berries spent more than 4 h per day over 31 °C, reaching temperatures above 38 °C during the afternoon (24 August 2021).

As regards thiolic precursors, S-4-(4-methylpentan-2-one)-L-cysteine (Cys-4MMP), 3-S-cysteinylhexan-1-ol (Cys-3MH), and 3-S-glutathionylhexan-1-ol (GSH-3MH), the differences were discovered proceeding from veraison in the season 2021 and in the season 2020 for Cys-3MH precursor.

During the 2021 vintage, at harvest, thiolic precursors (Cys-4MMP, Cys-3MH, and Glu-3MH) proved quantitatively superior in the SD-70% treatment. The biosynthesis of volatile thiol precursors was negatively related to severe water deficit (ΨPD > −0.7 MPa; [111]) since, as found in studies, water deficit steers to a curtailment of volatile thiol precursor content in the berry [112]. In fact, the CTRL treatment showed lower contents of the following thiol precursors at harvest: S-4-(4-methylpentan-2-one)-L-cysteine (Cys-4MMP), 3-S-cysteinylhexan-1-ol (Cys-3MH), and 3-S-glutathionylhexan-1-ol (Glu-3MH) also recording a reduction in the effectiveness of PSII (*Fv/Fm*). Moreover, in agreement with Wu et al., [113] thiol precursors exhibited lower content in the berries that were exposed by about +1.5 °C in mean value compared to the berries collected from the grape protection treatments. It was published that shade nets could efficiently palliate temperature spikes, notably in the previous weeks before the vintage, while transmitting enough radiation into the grape zone compared to uncovered grapes [101]. On average, during the harvest stage, the content of Cys-3MH and GSH-3MH was higher during the less parched vintage (2020); however, the 70% shading net and kaolin in the 2021 harvest increased the values of thiolic precursors, bringing them to optimal levels with respect to the CTRL treatment [114]. As demonstrated by Rienth et al. [115], the biosynthetic pathway of these thiol precursors is correlated to the glutathione (GHS) conjugation and α,β-unsaturated carbonyl compounds by S-glutathione transferase (vine's endogenous metabolism). Assuming that, so far, it has not been clarified how biosynthesis is activated in grapes under stress conditions, some results suggest that environmental stress (cold shock, heat shock, UV-C irradiation, and biological stimulation) only just improved the transcription of VvGST1, VvGST3, VvGST4, and GGT (γ-glutamyl transferase) in the grapevine [116,117]. In fact, UV irradiation increased up to 24 h the glutathione S-transferase (GST) and GGT enzyme activities in clusters but rapidly decreased thereafter. It is therefore believed that the stress condition in the CTRL treatment (water and thermal stress) has led to a rapid decrease in their content. SD-70% and K treatments during the harvest stage experienced the following percentage increases in the precursors compared to CTRL treatment: vintage 2021, Glu-3MH +77.41% SD-70%, Cys-3MH +80.18% SD-70%, Cys-3MH +81.32% K; Cys-4MMP +2430.00% SD-70%, Cys-3MH +2010.00% K. These results are in agreement with other studies where different shading treatments (50 and 100% reduction) imposed at fruit set on clusters of the white grapevine in Sicily, a zone characterized by a torrid climate, had shown a fewer proanthocyanidins but more flavors than the exposed clusters [35]. On Cabernet Sauvignon cv., under high light exposure, the precursor 3-isobutyl-2-hydroxypyrazine (IBHP) and the gene responsible for the final step in metoxypyrazine biosynthesis (VvOMT3) were both drastically reduced causing a significant reduction in the overall aroma [118]. However, the amount of knowledge relating to light and aroma components still seems to be insufficient.

5. Conclusions

The results of this research can be used for not irrigated grapevines vineyards during warmer seasons for maximizing aroma expression in Sauvignon Blanc grapes. In fact, our study shows that in vineyards with low water availability and excessive light radiation, stress from severe water deficiency and damage from photoinhibition are limiting factors for the aromatic potential in Sauvignon Blanc grapes. On the other hand, one of the objectives of today's modern precision viticulture is to produce fresher balanced white wines by reducing the alcohol content, enhancing acidity, and providing a high aromatic plump.

The benefit in vine water status along with the maintenance of leaf photosynthesis in SD-70% and K treatments allowed to have higher marketable yields (higher berry weight) than in plants without SD. This may indicate that if grapevines are exposed to an excess of light, such as in warmer Mediterranean regions, they can still perform well until a light reduction of 70% in the cluster band. Shading and kaolin treatments delayed the technological maturity in comparison with CTRL vines, also preserving the water state. Winegrowers should take this equipoise into consideration depending on their production objectives, as the sugar excess is generally associated with difficult fermentations.

The advantages of net shading and foliar kaolin on grapes were explained by several additive factors: (a) improved water status, (b) delay in fruit maturity, providing more time for the fruit to develop, and (c) photo-inhibition reduction. These results may encourage winegrowers to install nets in their vineyards or make use of treatments with kaolin when water is limited. However, further research is necessary to determine the sustainability of shading over multiple years.

Finally, to reduce the misalignment process between aromatic and technological maturity, assignable to the conjunction between global warming and unsuitable approaches to vineyard management, the application of shading net first or the foliar kaolin during the season depicts an effectual agronomic rule to valorize the aromatic template of Sauvignon Blanc (Cys-3MH, Glu-3MH, and Cys-4MMP thiolic precursors).

Author Contributions: The experiment was planned and structured by E.C. and G.B.M. E.C. and M.F. ensued the application of SD and K and made all measurements (leaves and berries). E.C. processed data and made statistical analyses. E.C. also wrote the original draft manuscript that was corrected by G.B.M. All authors have read and agreed to the published version of the manuscript.

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