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Article

Cluster-Zone Leaf Removal and GA_3 Application at Early Flowering Reduce Bunch Compactness and Yield per Vine in *Vitis vinifera* cv. Pinot Gris

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Abstract: Compact bunches have been often associated with higher susceptibility to *Botrytis cinerea* and therefore reduction in berry quality in grapevine. The objective of this study was to evaluate three management methods (early leaf removal, gibberellic acid, and their combination) for reducing bunch compactness in *Vitis vinifera* cv. Pinot gris trained in two different training systems with contrasting vigor (Guyot and pergola). Treatments were applied at BBCH 62 or BBCH 65 and yield components, total soluble solids, fruit set, and bunch compactness parameters were evaluated. Both treatments individually reduced berry number, mean bunches weight and bunches compactness as well as yield per vine when compared to control-untreated vines. However, no major differences were observed when both the treatments were applied in combination for Guyot or pergola although a higher reduction in yield was detected for Guyot and a significant increase in total soluble solids was observed in pergola. Our study suggests that intense leaf removal and gibberellic acid applied at early flowering can help reducing bunch compactness in Pinot gris and showing it in two training systems. In particular, leaf removal represents a valuable alternative to plant growth regulators (i.e., gibberellic acid) as applicable in organic viticulture.

Keywords: leaf removal; gibberellic acid; bunch compactness; yield per vine

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1. Introduction

Canopy management is a key factor in determining berry quality [1] particularly in cool and humid areas [2]. The combination of high vigor, dense canopies and sub-optimal environmental conditions (e.g., limited irradiance, high precipitations pattern) has been shown to be tightly associated with a delayed berry ripening [3]. This can result in an increased frequency of bunch rot such caused by *Botrytis cinerea* owing to elevated relative humidity and poor ventilation within the canopy [4–6]. Although bunch rot control can be successfully achieved via fungicides application, this often results in economical efforts for farmers and a negative impact on the environment [7].

One of the main factors determining the incidence of bunch rot is bunches architecture and relative compactness [8]. Indeed, compact bunches are more susceptible to diverse diseases and significant intra-bunch heterogeneous ripening often reported in compact bunches [9]. This causes important economic losses through a reduction in crop yield and berry and wine quality. Differences in bunch architecture are cultivar-specific with some varieties (e.g., Pinot varieties) being very susceptible to bunch rot since characterized by compact bunches [8,10]. Several methods have been proposed to reduce bunch compactness. For instance, early leaf removal has proved to be a suitable and a highly reproducible technique for improving grape quality, reducing the compactness and bunch rot incidence in many wine regions [11–14]. However, leaf removal significantly induces microclimatic modification in the bunch zone and can affect grape composition [15]. In addition, it can induce modifications to the source-sink balance, which can result in important physiological alteration such as reduced reserves accumulation [16], limited root growth [17], altered photoassimilate partitioning [18,19] and reduced water-use efficiency [20]. Other management approaches such as pre-flowering and/or flowering gibberellic acid (GA) application have been shown to be effective at reducing floral fertilization [21,22]. Application of GA at flowering in Pinot noir reduced bunches compactness and significantly reduced bunch rot with similar efficacy when compared to fungicide application [23]. In Chardonnay, the number of berries per bunch was reduced via flowering stage application of GA leading to limited incidence of bunch rot. However, the efficacy of the application was phenological stage-dependent with plants treated at flowering showing reduced bunches compactness and bunch rot when compared to pre-flowering treated plants [24].

Pinot gris, is a somatic mutation of the Pinot noir [25] and widely grown worldwide. Over 40% of the world Pinot gris production comes from Italy confirming its high economic importance. As for other Pinot varieties, Pinot gris displays a compact bunch and an elevated susceptibility to bunch rot [8–10,26]. Several studies provide evidence of potential usefulness of alternatives vine management techniques in Pinot gris such as plant growth regulators application and canopy management to reduce bunch rot infections [27], although there are no studies focusing at assessing their efficacy in different training systems and in the northern-Italian environment. Therefore, the goal of this study was to compare two management strategy to reduce bunches compactness:(1) flowering-stage leaf removal and (2) flowering-stage gibberellic acid (GA_3) application) in Pinot gris either Guyot- or pergola-trained in South Tyrol.

2. Materials and Methods

2.1. Plant Materials, Growing Conditions and Environmental Data

The trial was conducted in 2020 in two commercial vineyards, both located in Salorno, South Tyrol, (Italy). The vineyards are called "Fra gli Adigi" and "Puncli" and both vineyards lie at an average altitude of 230 m and have a north-to-south row orientation (Coordinates: 46°14′20.4″ N 11°11′45.9″ E and 46°15′19.2″ N 11°12′22.9″ E, respectively).

Fra gli Adigi (FGA) is located close to the river Adige and characterized by a sandy-silty soil and shallow water table. The Monte di Salorno, 1084 m high, located about 450 m south of the vineyard, reduces irradiance in autumn and winter (Supplementary Figure S1). In FGA, a 8-year old Pinot gris, SMA 505 and SMA 514 clones, grafted on SO4 rootstock are pruned in double Guyot at approximately 11 buds per m^2 with a vine spacing of 0.8 m and a row spacing of 2 m. In Puncli (PC) the soil is influenced by a greater distance to the river Adige (800 m from the riverbed) and the proximity of the calcareous mountain "Favogna", which lies approximately 400 m north-west of the vineyard, and consists of a medium sandy clay loam soil. In PC, 12-year-old Pinot gris vines, SMA 505 and SMA 514 clones, grafted on SO4 rootstock, are trained on a pergola system with approximately 12 buds per m^2 with a vine spacing of 0,8 m and a row spacing of 3 m. Pest management in both vineyards was carried out according to local standard practice. Environmental data were collected from the weather station in Salorno (46°14′10.3″ N 11°11′07.8″ E) provided by the weather service of the Autonomous Province of Bozen/Bolzano-South Tyrol (Italy).

2.2. Experimental Design

Eight adjacent rows in each vineyard were selected to build a block design in which four rows represent a block (two blocks). In each block, all the rows were assigned to a specific treatment. In total, four treatments were applied both in FGA and in PC: an untreated control (C), leaf removal (LR), GA_3 application (GA) and a combination of both (LRGA). Leaf removal was performed on 20 May 2020 at early flowering (BBCH62) and approximately 5–6 basal leaves were removed in each shoot. Leaf removal was carried out mechanically using an OLMI (Olmi s.n.c., Costigliole d'Asti, Italy) pneumatic leaf removal machine in PC and a Binger EVB 2000 (Binger France, Niederhergheim, France) de-leafer on FGA. Gibberellic acid (GA_3) was applied on 21 May 2020 at full flowering, which corresponds to BBCH65. The treatment was carried out with a Lochmann (Lochmann Plantatec, Nalles, Italy) RPS series sprayer with a concentration of 20 mg L^{-1} and a water volume of 1000 L ha^{-1}. Treatments and relative developmental stage application is summarized in Table 1.

Table 1. Overview of the treatments applied in each vineyard with relative developmental stage of application and acronym for each site.

Vineyard	Training System	Treatment	Developmental Stage
Puncli (PC)	Pergola	Control (C)	
Puncli (PC)	Pergola	Leaf removal (LR)	BBCH 62
Puncli (PC)	Pergola	GA_3 (GA)	BBCH 65
Puncli (PC)	Pergola	Leaf removal + GA_3 (LRGA)	BBCH 62 and BBCH 65
Fra gli Adigi (FGA)	Guyot	Control (C)	
Fra gli Adigi (FGA)	Guyot	Leaf removal (LR)	BBCH 62
Fra gli Adigi (FGA)	Guyot	GA_3 (GA)	BBCH 65
Fra gli Adigi (FGA)	Guyot	Leaf removal + GA_3 (LRGA)	BBCH 62 and BBCH 65

2.3. Phenotypic and Yield Assessments

Phenological stages were monitored from bud burst until harvest according to BBCH growth scale (Supplementary Table S1). Defoliation intensity was calculated by measuring the leaf area before and after leaf removal. Leaf area values were obtained by RGB imaging subsequently analyzed with ImageJ and expressed as cm^2 following the calibration of pixels to a sheet of known area included in the image (n = 20). Fruit set (%, n = 15) was determined by using the method proposed by [11] and calculated by dividing the number of berries, counted at BBCH 75, to the number of flowers, assessed at BBCH 57 in 15 main bunches per treatment per vineyard. For flower number quantification, 15 main bunches randomly selected were photographed against a dark background and the number of flowers on each inflorescence was manually counted. The linear regression between the number of visible flowers on the photograph and the actual number of flowers present on each bunch was calculated (Supplementary Figure S2). The resulting function ($y = 1.62x + 3.98$, $R^2 = 0.91$) was used to rapidly estimate the mean flower number of each treatment (n = 15 for each treatment in each vineyard). Subsequently, mean berry weight was determined by weighting 500 berries for each experiment at pea-size (BBCH 75) randomly selected in each treatment. The resulting total berry weight was then divided by the number of collected berries (i.e., 500) to obtain the mean berry weight. Subsequently, the number of berries was calculated by dividing the total weight of a bunch by the mean berry weight previously estimated. To exclude the influence of the rachis on the weight of the bunch, the berries were detached from the bunch for weighing. For weighing, a Kerbl 29,923 scale (Albert Kerbl GmbH, Buchbach, Germany) was used.

Fruit set (%) was then calculated following the equation:

$$\text{Fuit set} = \frac{\text{Number of berries}}{\text{Number of flowers}} \times 100$$

2.4. Total Soluble Solids and Yield

At harvest (31 August 2020) the sugar content for each treatment was determined by using a portable refractometer (Digital Hand-held PAL-3 ATAGO Co., LTD, Fukaya, Japan). For this, 50 berries per treatment were analyzed by randomly collecting the berries at different bunches position (top-mid-bottom) and total soluble solid (TSS, °Brix) was assessed in three distinct aliquots. Yield was expressed as yield per vine (YPV) (kg $vine^{-1}$) and calculated by multiplying the mean bunch weight estimated with a balance (n = 20) by the average number of bunches per vine count (n = 20).

2.5. Bunch Compactness

In our study, bunch compactness was assessed through a series of previously proposed indexes. The first index is calculated from the ratio between bunch weight (g) and bunch length (cm), as proposed by [28] (LDI). The second index, SDI, was proposed by [29], and it is calculated via a ratio between the number of berries per bunch and bunch length (cm). Subsequently, we used a third index, proposed by [9], where the ratio between bunch weight (g) and the exponentiation of bunch length (cm) (TDI) were used to calculate bunch compactness. The fourth index was proposed by [30] (IDI) and consists in categorizing bunches into five classes following the negative association between bunch compactness and the angle at which the rachis can be bended: (1) very loose: bending of the rachis up to 90°-2) loose: bending of the rachis up to 45°–90°-3) dense: bending of the rachis up to 10°–45°-4) compact: bending of the rachis up to 10°-5) very compact: bending of the rachis not possible).

For all the indexes (LDI, SDI, TDI and IDI) and when needed, bunch weight (used for LDI and TDI) was determined at harvest (BBCH 89) by using a precision scale (n = 30). The estimation of IDI was carried out at harvest with a protractor and the measurement of bunch length (used for LDI, TDI and SDI) was assessed at harvest. Berry number estimated at pea-size was used for SDI as described above.

2.6. Bunch Rot Incidence

Bunch rot incidence (BRI) was determined at harvest. BRI was assessed via visual observation as percentage of infected bunches divided by the number of bunches analyzed (n = 180 for each vineyard).

2.7. Statistical Analysis

All data were analyzed with Rstudio. Data were assessed for normal distribution and residual vs. fitted values. All the data were analyzed with One-way ANOVA with treatments as factor. When presented (i.e., different letters), treatment comparison was performed either by Tukey's test or t-test at $p < 0.05$. Differences for IDI and between treatments were assessed via Z-test. Associations were tested via linear regression.

3. Results

3.1. Environmental Conditions

The experiments were carried out under relatively cool summer conditions (Figure 1) with a maximum daily temperature of 25.8 °C on average and a minimum daily temperature of 14.3 °C on average from 1 April to 31 August 2020. Cumulative rainfall from bud burst to harvest were 441 mm evenly distributed from May to August.

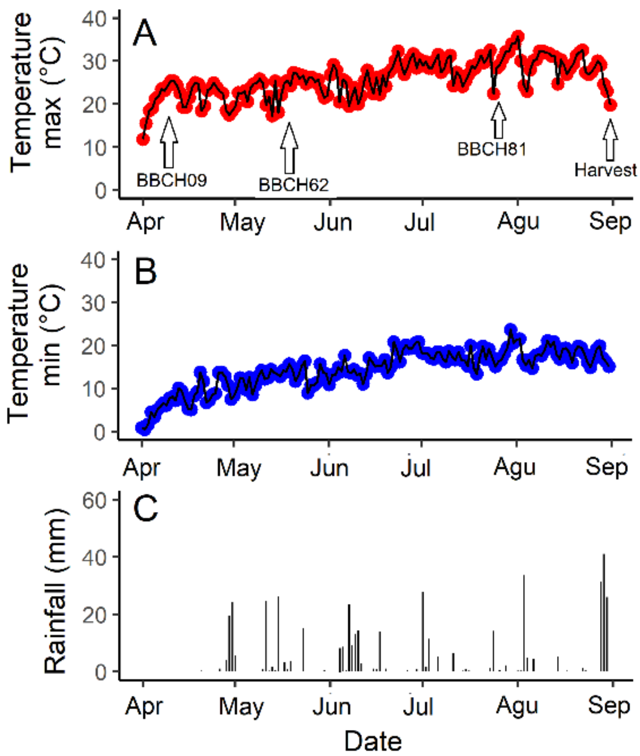

Figure 1. Dynamic of environmental conditions during spring 2020. In (**A**) the maximum daily temperature while in (**B**) the minimum daily temperatures are shown. In (**C**) daily rainfall is presented. In (**A**) some of the key phenological stages are included (phenological screening is shown in Supplementary Table S1).

3.2. Leaf Area, Flower Number and Fruit Set

Total leaf area per shoot and per vine were comparable between FGA and PC (Table 2). Leaf removal leaded to a reduction in LA up to 49% in FGA (Guyot) while in PC (pergola) the reduction in LA following leaf removal was lower (21%).

Table 2. Average leaf area (LA) per shoot and per vine (n = 20) assessed both in FGA and PC before and after leaf removal (LR) at BBCH62. Average LA removed and % of defoliation are shown as well (n.a.; not applicable).

	FGA		PC	
	Before LR	**After LR**	**Before LR**	**After LR**
LA per shoot (cm^2)	656.2	336.1	657.4	522.3
LA per vine (cm^2)	8530.6	4370.2	9203.6	7312.5
LA removed per shoot (cm^2)	n.a.	320.0	n.a.	135.0
Defoliation (%)	n.a.	49	n.a.	21

Average flower number per bunch and irrespective of treatment application was 265 in FGA and 257 in PC on average. No significant differences were observed for flower number and between treatments in either FGA ($p = 0.325$) and PC ($p = 0.428$) (Figure 2A,D). LR, GA and LRGA reduced berry number per bunch in FGA by 37% on average ($p < 0.001$) although no significant differences were observed between treatments. Similarly, reductions in berry number (36%) were observed in PC (Figure 2B,E) and to a similar extent when LR, GA and LRGA were applied. Similar fruit set were observed between vineyard (50–55% on average) (Figure 2C,F). On the contrary, significant reduction in fruit set were observed between control and treated vines, with a reduction in fruit set by 45% in PC ($p < 0.001$)

and by 26% in FGA ($p < 0.001$). There were no significant differences between LR, GA and LRGA for fruit set.

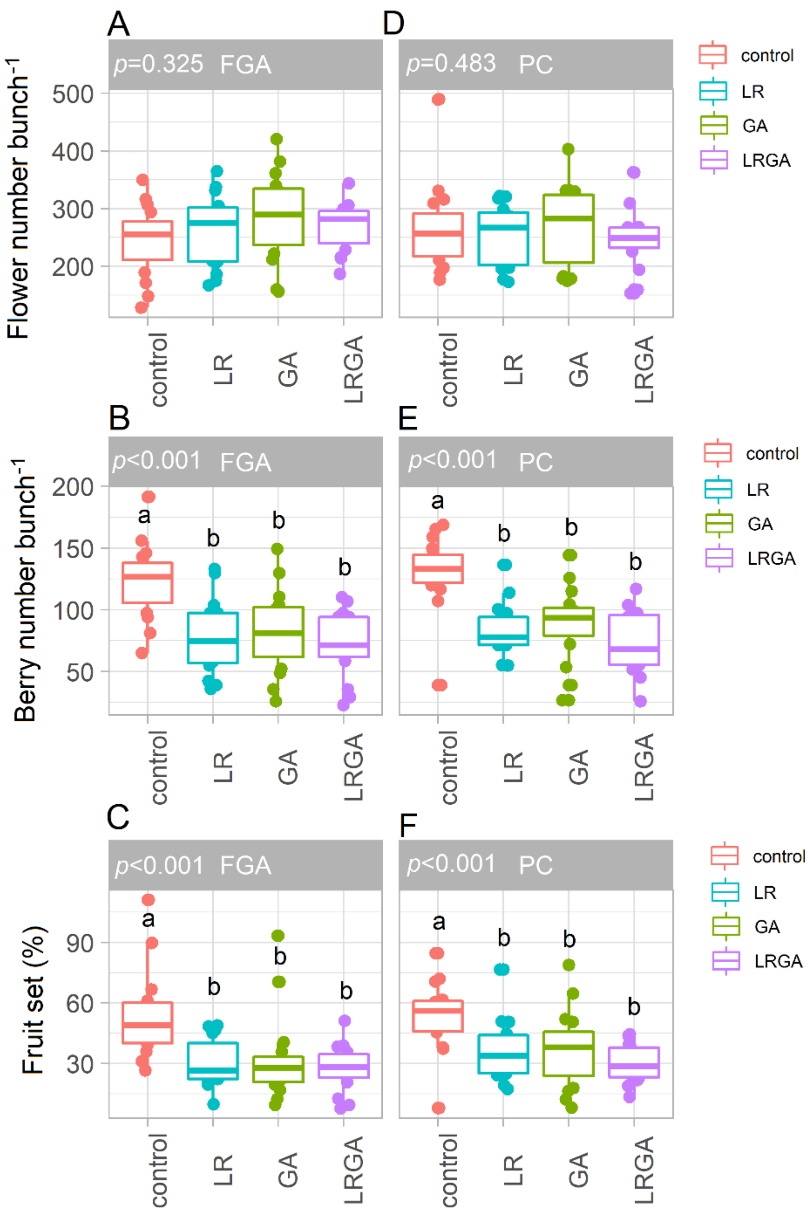

Figure 2. Number of flowers per bunch (**A**,**D**) number of berry per bunch (**B**,**E**) and fruit set % (**C**,**F**) assessed either in FGA and PC vineyard and in control, leaf removal (LR), GA_3 application (GA) and leaf removal plus GA_3 application (LRGA) plants (n = 15). In graphs, points represent raw data, horizontal lines within boxes indicate the median and boxes indicate the upper (75%) and lower (25%) quartiles. Whiskers indicate the ranges of the minimum and maximum values. Data were analyzed with one-way ANOVA with treatments as factor and *p*-value is shown in the graph. Different letters represent significant differences between treatments according to Tukey's test.

3.3. Yield per Vine and Total Soluble Carbohydrates

Significant differences in yield per vine were observed between FGA and PC (i.e., between Guyot and pergola) with PC (pergola) showing greater yield (4.3 kg on average) compared to FGA (Guyot, 3.2 kg on average) (Figure 3A,B). Both LR and GA reduced yield per vine significantly on both vineyard ($p < 0.001$) and by 35% on PC and by 25% on FGA on average ($p < 0.001$). Yield reduction following LRGA application was comparable to LR and GA alone in PC while a more severe reduction was observed in FGA (50% compared to control) ($p < 0.001$). TSS were higher in control plants of FGA when compared to PC (21 and 20.5 °Brix respectively) (Figure 3C,D). Treatment application (LR, GA and LRGA) did not have an effect on TSS of FGA ($p = 0.0119$) while a significant increase in TSS was observed in PC for LR, GA and in particular LRGA (1 to 1.5 °Brix respectively, $p < 0.001$).

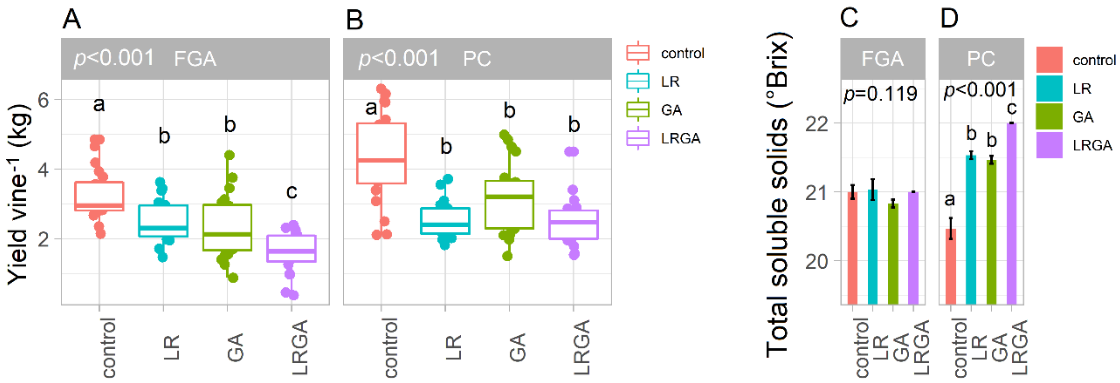

Figure 3. Yield per vine (**A**,**B**) assessed either in FGA and PC vineyard and in control, leaf removal (LR), GA_3 application (GA) and leaf removal plus GA_3 application (LRGA) plants (n = 20). In graphs, points represent raw data, horizontal lines within boxes indicate the median and boxes indicate the upper (75%) and lower (25%) quartiles. Whiskers indicate the ranges of the minimum and maximum values. In (**C**,**D**), total soluble solid (TSS, °Brix) in FGA and PC vineyard and in control, leaf removal (LR), GA_3 application (GA) and leaf removal plus GA_3 application (LRGA) plants is shown and error bars represent ± standard deviation (n = 3). Data were analyzed with one-way ANOVA with treatments as factor and *p*-value is shown in the graph. Different letters represent significant differences between treatments according to Tukey's test.

3.4. Bunch Compactness: LDI, TDI, SDI and IDI Indices

Significant differences were observed for LDI and TDI between vineyard (i.e., training system) with PC (pergola) showing more compact bunches when compared to FGA (Figure 4). This however less evident when the ratio between the number of berries per bunch and bunch length (SDI) was used (Figure 4C,F). On the contrary, all the indices showed a marked reduction in bunch compactness (between 30 and 50% on average) when LR, GA and LRGA were applied and in both the vineyard ($p < 0.001$). In particular, in FGA, application of LR and GA were significantly effective at reducing LDI, TDI and SDI and the combined application leaded to a greater reduction in bunch compactness, especially when assessed via TDI and LDI ($p < 0.001$) (Figure 4A–C). In PC, TDI and SDI did not show significant differences between LR, GA and LRGA although a higher reduction in LDI was observed in LRGA-treated plants when compared to LR and, in particular, GA-treated plants (Figure 4D–F).

When bunches were categorized according to bending capacity, control plants showed a higher presence of bunches with no possibility of curvature (class 5, between 75 and 80 bunches out of 100) coupled with a limited number of class 4 bunches and in both FGA and PC (Figure 5A,B). All the treatments reduced the presence of class 5 bunches and between 5 to 10 on average leading to an increase of class 3 and in particular class 4 bunches ($p < 0.001$ when compared to control according to Z-test). A higher number of class 4 bunches were observed in PC when compared to FGA where class 3 and 2 bunches were more numerous. A higher presence of classes 1 and 2 were observed after LRGA in PC (Guyot) compared to FGA (pergola).

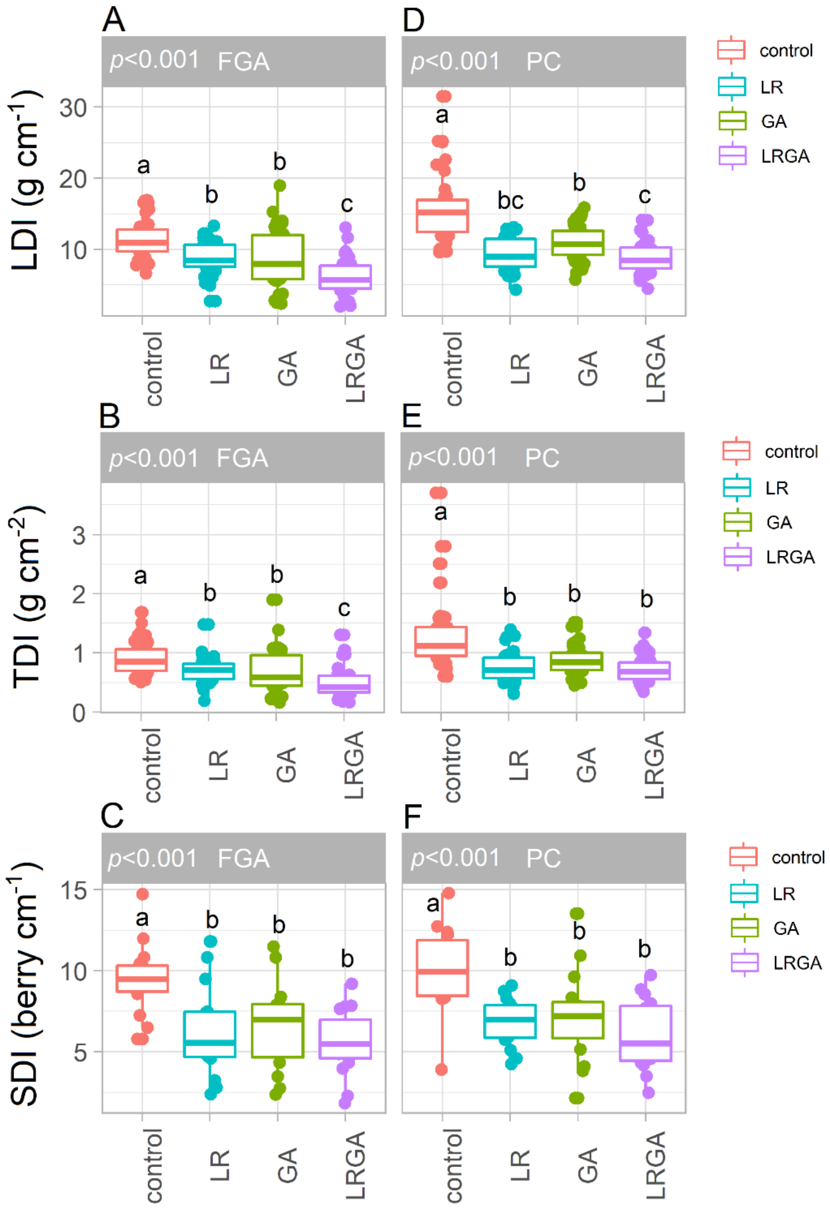

Figure 4. Ratio between bunch weight (g) and bunch length (cm) (LDI, (**A**,**D**)), between bunch weight (g) and the exponentiation of bunch length (cm) (TDI, (**B**,**E**)) and between the number of berries per bunch and bunch length (cm) (SDI, (**C**,**F**)) assessed either in FGA and PC vineyard and in control, leaf removal (LR), GA_3 application (GA) and leaf removal plus GA_3 application (LRGA) plants (n = 15). In graphs, points represent raw data, horizontal lines within boxes indicate the median and boxes indicate the upper (75%) and lower (25%) quartiles. Whiskers indicate the ranges of the minimum and maximum values. Data were analyzed with one-way ANOVA with treatments as factor and *p*-value is shown in the graph. Different letters represent significant differences between treatments according to Tukey's test.

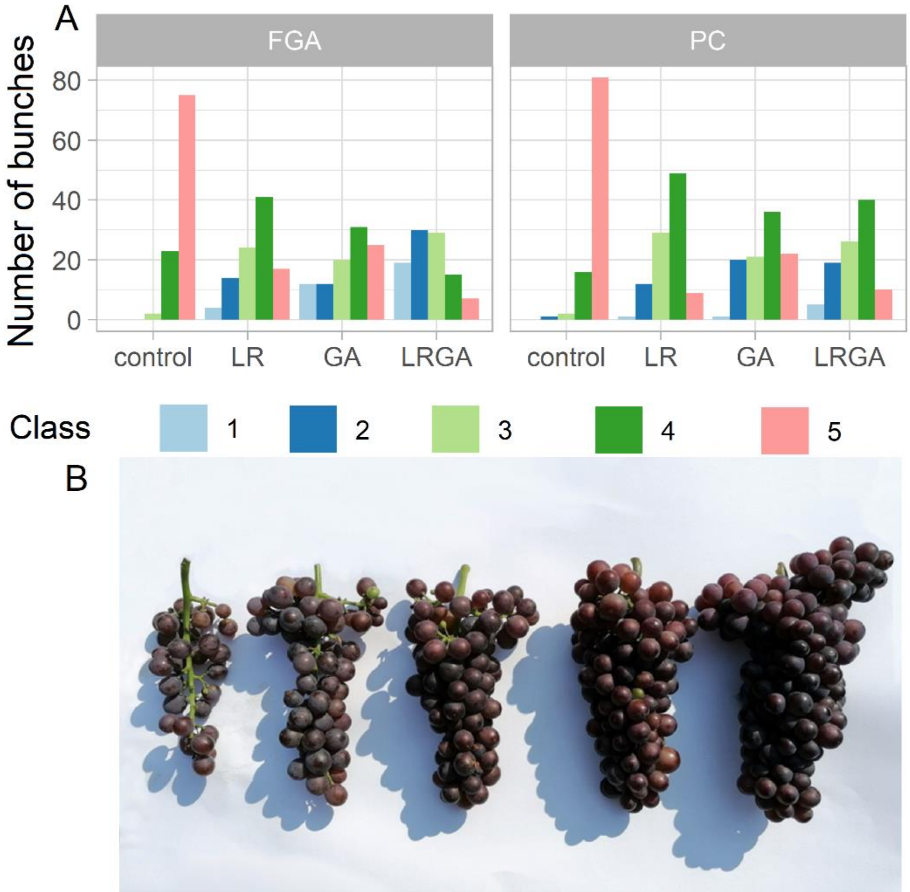

Figure 5. (**A**) Distribution of bunches classes according to [30] assessed at harvest either in FGA and PC vineyard and in control, leaf removal (LR), GA_3 application (GA) and leaf removal plus GA_3 application (LRGA) plants (n = 100 per treatment). Differences between treatments were tested via Z-test with $p < 0.001$ between control and treated (LR, GA, LRGA) while no significant differences were observed between treated bunches. In (**B**) and example of different bunch classes in relation to compactness and bending capacity of the rachis is shown.

4. Discussion

Bunch compactness is a specific grapevine trait affecting both berry quality and the sanitary status of the bunch [31]. Indeed, compact bunches were previously associated with a pronounced susceptibility to bunch rot mainly due to the pressure exercised by the growing berry that may cause berry cracking, juice leakage and free water and nutrients availability for conidia germination and mould growth [9,31,32]. Similarly, compact bunches are subjected to heterogeneous ripening following the exacerbated intra-bunch variability in berry temperature and solar radiation interception [8,33]. Indeed, a large number of studies provide evidence of reduced crop yield and wine quality in varieties characterized by a compact bunch [31]. Natural variation for bunch compactness in clones [34], cultivars [35] and in interaction with different rootstocks [36] has been shown to exist in grapevine, suggesting that breeding and selection can provide viticulture with preferable cultivars or clones with optimal bunch openness. On the other hand, several management strategies were successfully used to produce loose bunches mainly by manipulating three key components of the bunch architecture (1) reducing berry number, (2) reducing berry size, (3) increasing rachis length via either (i) agronomic strategies (e.g., leaf removal, artificial shading) and (ii) plant growth regulators application (GA and NAA) [31]. We showed that in Pinot gris both leaf removal and gibberellic acid application at early flowering reduced bunch compactness mainly by decreasing number of berries per bunch. In particular, this response was in some cases training-system specific with Guyot being more sensitive (i.e., higher yield reduction) than pergola to the application of the combined treatment.

4.1. LR and GA Reduce Fruit Set, Berry Number and Yield per Vine in Both Training Systems

Previous work focusing at assessing different strategies to reduce bunch compactness highlighted that either LR or GA applied pre-flowering or early flowering, reduce berry number mainly by limiting fruit set, although following two distinct mechanisms [31] LR induces a source-limitation during flowering [19], i.e., the stage during which berry number is determined [37]. Source availability around flowering may be accounted as the primary regulator of fruit set [19]. Therefore limiting assimilates availability following LR may reduce pollen viability and finally hinders flower fertilization (i.e., reduced berry per bunch) or limits cell division rates during the green berry growth leading to reduced beery size [19]. However, severe leaf removal treatments have been associated with reduced inflorescence primordia initiation the year after the treatment [29] and, in Pinot noir, removal of leaves around six-to-eight basal nodes was effective at reducing bunch compactness without major effects on reserves availability for the following season [38]. In our work, mechanical leaf removal was more severe in FGA (Guyot) than in PC (pergola) although the reduction in yield when compared to the control was higher in PC than FGA, suggesting two distinct source-sink ratios for the two training systems, with pergola (PC) being more responsive to source-limitations. Pre-and full-flowering applications of GA, although with cultivar and dose rate specificity [31] have been shown to reduce bunch compactness mainly by increasing rachis length and by reducing berry number following flower abscission, respectively. However, in some cultivars, early flowering GA application has been reported to cause severe reduction in crop yield [39], and therefore GA dose rate and cultivar GA sensitivity should be carefully evaluated. In our work, GA applied at 20 mg L^{-1} reduced yield per vine and fruit set to a similar extent to LR and in both vineyards suggesting that, in Pinot gris, this management approach can lead to a tolerable, if not desirable, reduction in yield. In general, both the strategies seem to have a direct effect on fruit set and yield per vine and in line with previous work on LR and GA application.

4.2. LR and GA Reduce Bunch Compactness

Reduced fruit set leaded to a significant decrease in bunch compactness assessed via four indices previously proposed in the literature. In general, both LR and GA reduced LDI and SDI by up to 50% when compared to control untreated, and this is in line with previous studies where LR and GA was applied in different cultivars.

In [40] LR at BBCH63-68 significantly reduced bunch compactness in Pinot gris and Sauvignon blanc following a significant reduction in berry number by up to 23% and this was effective at limiting bunch rot severity at harvest. In other studies, carried out in Aglianico LR was efficient at reducing berry number per bunch although a compensation in rachis length (i.e., shortening of the total length of the bunch axes) leaded to a similar bunch compactness when compared to control [41]. However, LR per se can improve fruit zone microclimate in specific training systems (e.g., Guyot). LR applied at the cluster zone can enhance wind circulation, temperature and solar radiation in turn reducing berry surface humidity and increase fungicide penetration [42]. On the other hand, LR can cause an excessive bunch exposure to light that may lead to undesirable berry sunburns and increase in must pH, which may negatively impact wine composition [43,44]. For instance, in (Hed and Centinari, 2011) [42], LR was not effective at reducing bunch compactness due to rachis length compensation in Vignoles although bunch rot incidence was reduced when compared to the control un-defoliated. Since it is well established that bunch architecture is under genetic control despite strong interactions with environmental cues has been often shown to exist [31] LR efficacy may be subjected to a combination of varietal specific sensitivity to source-limitation and environmental signals that deserves further investigation for better integrate LR into bunch rot management programs.

In contrast, GA application has been shown to consistently reduce berry number in several cultivars, although to different extents and in some cases in line with our work [39,45,46]. Indeed, in [39] application of 25 mg L^{-1} of GA_3 at flowering reduced bunch compactness (assessed as berry per cm, LDI) by 25% when compared to the control un-treated, mainly associated with a reduction in berry number per bunch. The reduction in bunch compactness, integrated with two fungicide applications was successful at reducing bunch rot incidence. However, in our study, GA produced a broader distribution of bunch classes either more or less compacted (i.e., class 5 and 1–2) when compared to LR and especially in FGA (i.e., Guyot not defoliated in the cluster zone). At this stage, we speculate that the elevated variability in bunch compactness following GA application may be due to variable spray coverage within the canopy and further studies should focus at optimizing GA application in relation to the agronomic purpose (e.g., reduction in compactness associated with reduction in yield per vine). Therefore, although in 2020 bunch rot incidence was very low (around 1%, data not shown) and we were unable to associate a reduction in bunch compactness with reduced bunch rot, GA and LR were both efficient alone at producing more open bunches in Pinot gris. However, a reduction in the compactness of the bunches and a consequent reduction in productivity per plant led to a qualitative improvement (increase in TSS) in the vineyard cultivated with the most productive training system (pergola). Both strategies however may show drawbacks including: (i) potential limited reserves availability for the next season (LR) [29], (ii) if not appropriately applied, can reduce yield per vine to an unacceptable level (LR and GA) [9; 29], (iii) may show high degree of variability in terms of classes of bunch compactness after the application (GA), (iv) may be limited in several countries due to restricted legislation for plant growth regulators application (GA), (v) time of application is critical with limited phenological window for optimal bunch compactness reduction (GA) [9]. Further work should focus at understanding the most suitable method and optimizing appropriate management approaches for reducing bunch compactness in different varieties and environmental conditions.

5. Conclusions

Leaf removal and gibberellic acid application reduce bunch compactness and yield per vine in Pinot gris by up to 40% depending on the training system. Bunch compactness has been often associated with bunch rot incidence and we show that, in a cultivar characterized by a compact bunch such as Pinot gris, these management approaches can be accounted as cost-effective and easy-to-do alternatives to fungicide application. In particular, LR may be suitable in increasing bunch openness (and potentially controlling bunch rot incidence) in organic viticulture where both plant growth regulators and fungicides are not permitted. Further investigations should focus at optimizing these fungicide-alternative in different varieties and environments.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/horticulturae8010081/s1, Figure S1: Outline of horizon for FGA (**A**) and PC (**B**). Data from the European Photovoltaic Geographical Information System (PVGIS); Figure S2: Relationship between flower number counted via visual observation (y) and flower counted via RGB imaging (x). Points are raw data (n = 15) and curve fitting was performed via linear regression; Table S1: Phenological stage onset for both the field site.

Author Contributions: Conceptualization, M.W. and M.B.; methodology, M.W. and M.B.; validation, M.B. and M.F.; formal analysis, M.F.; investigation, M.W.; resources, M.W.; data curation, M.F.; writing—original draft preparation, M.W., M.B. and M.F.; writing—review and editing, M.F.; visualization, M.W., M.B. and M.F.; supervision, M.B.; project administration, M.B. All authors have read and agreed to the published version of the manuscript.

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