CAN GRAPEVINE TOLERANCE TO BUNCH ROT BE DIRECTLY INDUCED BY GROUNDCOVER MANAGEMENT?

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Abstract:

Context and purpose of the study – Botrytis bunch rot occurrence is the most important limitation for the wine industry in humid environments. The effect of grapevine vegetative growth on bunch rot expression results from direct effects (cluster architecture, nitrogen status among others) and indirect ones (via microclimate). Previous studies of our group showed strong differences in bunch rot incidence between floor management treatments: cover crop (CC) vs weed-free strips under the trellis with herbicide (H). We observed that in some circumstances this reduction in bunch rot incidence occurred without major vine growth differences among treatments. The aim of the present study was to test the general hypothesis that other factors unrelated to grapevine vegetative expression could be more relevant to grapevine susceptibility to bunch rot.

Materials and methods – The experiment was conducted over two consecutive growing seasons in southern Uruguay (34°44′ S, 56°13′ W). Twenty plants of *Vitis vinifera* (Tannat), grafted on to SO4 rootstocks, grown in 100 L pots were used each season. Vines were trained to a vertical shoot positioning system (VSP) in north-south oriented rows (0.6 × 2.8 m, vine (pot) × row spacing) located inside an experimental vineyard. We tested two treatments: Cover crop (CC), consisting of full cover of plot soil with Tall fescue (*Festuca arundinacea*) versus weed-free pots, treated with herbicide (H). Supplementary irrigation was applied twice a week as needed to maintain equal water status during the entire growing season regardless of treatment. In order to minimize effects of treatments related to vine vigor, treatments were arranged interspersed in the row and the “arms” of contiguous plants were overlapped. To enhance cluster size and compactness variability, half of each plant was spur pruned, and cane pruned at the other side (2 two buds spur + 8 buds cane).

Results – Bunch rot incidence and severity were remarkably lower in CC compared to Herbicide treatments even when vegetative expression (Vine PW, cane PW, PW/m), PAR% at the fruit zone, cluster size and compactness and fruit composition (TSS, titratable acidity, pH) were comparable among treatments (H vs CC). Our experiment allows to compare the effect of the treatments, when clusters shared the same environment minimizing the effect of other factors such as primarily inoculum or microclimate. Our results do not allow to identify the specific mechanism by which CC induced a greater tolerance to bunch rot. However, it is possible to affirm that other factors besides vegetative expression/bunch compactness, and fruit zone environment, are playing an important role on the disease development.

Keywords: Vegetative growth, nitrogen, Bunch rot tolerance, under vine cover crop.

1. Introduction

Botrytis bunch rot occurrence is the most important limitation for the wine industry in humid environments. The effect of grapevine vegetative growth on bunch rot expression results from direct effects (cluster architecture, nitrogen status among others) and indirect ones (via microclimate) (Abad et al. 2021. Previous studies of our group showed strong differences in bunch rot incidence between floor management treatments: cover crop (CC) vs weed-free strips under the trellis with herbicide (H). We observed that in some circumstances this reduction in bunch rot incidence occurred without major vine growth differences among treatments (Coniberti et al. 2018). The aim of the present study was to test the general hypothesis that other factors unrelated to grapevine vegetative expression could be more relevant to grapevine susceptibility to bunch rot.

2. Material and methods

2.1 Plant material, treatments and growing conditions

The experiment was conducted over two consecutive growing seasons 2019/20 to 2020/21 in southern Uruguay (34°44′ S, 56°13′ W). Twenty plants of *Vitis vinifera* (Tannat), grafted on to SO4 rootstocks, grown in 100 L pots with a mixture of compost and soil (30:70) were used each season. Vines were four years old at the beginning of the experiment. Vines were trained to a vertical shoot positioning system (VSP) in north-south oriented rows (0.6 × 2.8 m, vine (pot) × row spacing) located inside an experimental vineyard. The height of the cordon was 0.7 m, and the top of the canopy was approximately 2.1 m above the ground. At approximately 30 cm shoot length, all shoots not located on spurs and all unfertile shoots were removed. During the growing season, shoots were vertically positioned by hand ensuring homogeneous distribution of vine canopies. Catch wires were used to keep shoots in position. We tested two treatments: Cover crop (CC), consisting of full cover of plot soil with Tall fescue (*Festuca arundinacea*) versus weed-free pots treated with herbicide (H). CC was established in March 2019 (seeding rate: 6 g/m^2). Irrigation water was applied with drip emitters (4 L/hr emitters) located on each vine. A second line was used to add extra water on CC treatment when needed. To ensure correct water distribution, spiders with 4 elbow mini stakes were used on each drip emitter. Supplementary irrigation was applied twice a week as needed to maintain equal water status during the entire growing season regardless of treatment. Irrigation thresholds were −0.5 MPa until fruit set (stage 29; Eichhorn and Lorenz, 1977), −0.6 MPa from fruit set to veraison (stage 35; Eichhorn and Lorenz, 1977) and −0.8 MPa from veraison to harvest. Midday stem water potential (Ψstem) was measured from approximately 40 days after bud-break until harvest (~bi-weekly) between 14:00 and 16:00 h using a leaf pressure chamber (Soil Moisture Equipment Corp., Santa Barbara, CA) on one leave per plant (Allen *et al.* 1998). Nitrogen was applied twice at a rate of 6 and 10 g per plot on H and CC treatments respectively when shoots reached approximately 30 cm and after fruit set. To avoid excessive vine-cover crop competition, the grass was maintained short (less than 5 cm) between both fertilization times. In order to minimize effects of treatments related to vine vigor and cluster zone aeration (usually observed in soil management experiments), treatments were arranged interspersed in the row and the “arms” of contiguous plants were overlapped. To minimize differences of canopy exposure among vines, in half of the vines the pruning canes were tided to the face exposed to the east and the others to the west face. Additionally, to enhance cluster size and compactness variability, half of each plant was spur pruned, and cane pruned at the other side (2 two buds spur + 8 buds cane) (Fig. 1). To avoid possible effects of excessive canopy shade reducing bud fertility, plants were located in the same vineyard but 1.2 m apart until the end of the previous season of evaluation.

2.2 Harvest and vegetative growth measurements

All treatments were harvested on the same date. The percentage of bunches infected by Botrytis bunch rot (incidence) as well as the percentage of each bunch that was infected (severity) was determined by visual inspection using a seven-point scale (0, 5, 15, 25, 50, 75 and 100%). Botrytis severity (S) was calculated as follows: $S = \Sigma Si/n$; where Si = % severity for the i-th bunch and n= the total number of affected bunches. During 2021 harvest, every cluster from de experiment was characterized for its cluster compactness, bunch rot incidence and severity. Bunch compactness was rated by visual inspection according to OIV descriptor No 204

(O.I.V., 2007) by two experienced judges to reduce subjectivity. This descriptor categorizes a bunch under 9 categories, based on the amount of visible pedicels and the mobility of the berries. Every bunch was also morphologically described using quantitative and objective descriptors. The correlation between the average value assigned for each judge and the Bunch compactness index (Bunch weight (g)/[Rachis length (cm) + First ramification length (cm)] (Fermaud 1998)), is presented in Fig 2a. Total fruit yield and clusters per vine side (spur and cane pruned) were determined for each plant. Mean cluster weight and compactness index was calculated. Berry weight, total soluble solids (TSS), titratable acidity (TA), pH and free amino nitrogen (YAN) were analyzed (OIV, 2009). Leaf blade and petiole samples were taken for Nitrogen analysis at bloom and veraison, in 4 plants per treatment. Pruning weight and number of shoots, were determined at pruning time on each side of the vines (spur and cane pruned). Average cane pruning weight was calculated for each plant. All measurements were averaged by treatment and separately for each side of the vine. Before harvest, photosynthetically active radiation (PAR) available in the fruit zone, was estimated on individual vines with an average of two readings taken on each side of the canopy fruit zone, with the ceptometer (AccuPAR L80; Decagon Devices, Pullman, WA). Pruning weight/m of trellis was calculated for each vine (as a canopy density index), adding to the pruning weight of the "n" vine, the pruning weight of the portion of contiguous vines sharing the trellis (Pw/m = Pw (n vine) + spur side (n-1 vine) + cane side (n+1 vine).

2.3 Statistics

A split-plot ANOVA was used to analyze the significance of treatments main effects and their interactions using INFOSTAT free software (Di Rienzo et al. 2011). The fixed effects of the model were under-trellis ground cover (Herbicide vs. Cover crop), pruning (spur vs. cane) and their interactions; the random effects were block interactions with main effects. Bunch rot incidence and severity variables were transformed (square-root) to fit a normal distribution. A Tukey's HSD test (5% significance level) was used to compare treatment means. Graphs were performed in R (R Core Team 2018).

3. Results and discussion

Bunch rot incidence and severity were remarkably lower in CC compared to Herbicide treatments even when vegetative expression (Vine PW, cane PW, PW/m), PAR% at the fruit zone, cluster size and compactness and fruit composition (TSS, titratable acidity, pH) were comparable among treatments (H vs CC) (Table 1). Cluster compactness had a major effect on bunch rot development in both treatments. Bunch rot severity increased with cluster compactness, however in any clusters from CC treatment the disease affects more than 25% of the clusters. On the other hand, in most compact clusters from H treatment (> 5 compactness index) more than 50% of the cluster was affected and in some cases the disease reached the hole cluster (Fig 2b).

Abad *et al.* (2021), in a systematic review of the implications of cover crops on vineyard agronomic performance in viticulture report that in most studies, Botrytis incidence on cover-cropped vineyards, resulted in no change or in a significant reduction of the disease. These results were generally linked to a reduction of vine vegetative growth. Guilpart *et al.* (2017) concluded that reduced plant growth linked to water stress at flowering had a direct effect on reducing grapevine susceptibility to Botrytis. In this study, berry weight was also affected what may reduce cluster compactness and also could affect disease development. Other authors (Jacometti *et al.* 2007) attributes the reduction of *Botrytis cinerea* severity observed in cover crops treatments to a higher rate of soil biological activity, increased vine debris degradation and the reduction of primary inoculum compared to bare soil. Even all these factors may have a significant effect on bunch rot, in our study strong differences were detected in bunch rot development when grapevines had comparable growing conditions and development. Additionally, our experimental design allows to compare the effect of two groundcover management treatments, when clusters from both treatments shared the exact same environment, minimizing also the effect of other factors such as primarily inoculum or microclimate. On the other hand, although no significant differences were detected in leaf nitrogen content or vine growth development, the potential effect of the lower YAN content observed in CC treatment can't be discarded. However, previous studies suggest that these slight YAN differences observed in grapes, may not explain by themselves the major variation of bunch rot development observed in this study (Mundy and Beresford 2007, Coniberti *et al.* 2018).

4. Conclusions

Our results do not allow to identify the specific mechanism by which CC induced a greater tolerance to bunch rot. However, it is possible to affirm that other factors besides vegetative expression/bunch compactness, and fruit zone environment, are playing an important role on the disease development.

5. Acknowledgments

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Table 1. Canopy characteristics and fruit composition of *Vitis vinifera* (Tannat) grapevines as affected by groundcover management.

	Season 2019/2020						Season 2020/2021					
	Herbicide (H)		Cover crop (CC)		Whole vine		Herbicide (H)		Cover crop (CC)		Whole vine	
	SP	CP	SP	CP	H	CC	SP	CP	SP	CP	H	CC
Cluster w. (g)	212 a	183 b	209 a	165 b	**198**	**187**	269 a	220 b	256 a	200 b	**244**	**228**
Cluster CI							5.19 a	4.30 b	5.10 a	4.34 b	**4.76**	**4.70**
Yield (kg)	1.66 a	1.40 b	1.72 a	1.32 b	**3.06**	**3.04**	2.54 a	2.06 ab	2.40 b	1.97 c	**4.60**	**4.47**
Pw (kg)	0.31 a	0.20 b	0.29 a	0.19 b	**0.50**	**0.48**	0.30 a	0.19 b	0.28 a	0.19 b	**0.50**	**0.48**
Cane Pw. (g)	49.3 a	34.2 b	48.5 a	31.2 b	**41.7**	**39.9**	45.8 a	32.6 b	43.1 a	31.4 b	**39.2**	**37.2**
Pw/m (kg)					**0.82**	**0.82**					**0.81**	**0.80**
PAR (%)					**5.8**	**6.1**					**4.3**	**4.7**
Brix					**24.8**	**25.3**	23.5	23.6	23.6	23.7	**23.6**	**23.6**
pH					**3.66**	**3.67**	3.54	3.55	3.59	3.59	**3.55**	**3.59**
T. acidity (g/L)					**6.19**	**6.08**					**6.61**	**6.48**
YAN (mg/L)					**124 a**	**116 b**					**122 a**	**110 b**
	Botrytis bunch rot						Botrytis bunch rot					
Incidence (%)	29.1 a	25.1 a	12.1 b	11.2 b	**27.1 a**	**11.6 b**	73.3 a	64.3 a	42.2 b	30.0 c	**60.8 a**	**36.0 b**
Severity (%)	13.3 a	13.0 a	5.7 b	7.0 b	**13.2 a**	**6.25 b**	46.0 a	37.5 a	16.1 b	11.2 b	**41.8 a**	**13.7 b**

CC: complete floor cover crop; H: herbicide; SP: Spur pruning; CP: Cane pruning; Cluster w.: Cluster weight; Pw: Pruning weight; Pw/m: Pruning weight per meter of trellis; PAR: photosynthetic active radiation received in the fruit zone; T. acidity: Titratable acidity; YAN: must free amino nitrogen, Cluster CI: Cluster compactness index OIV descriptor No 204 (O.I.V., 2007). Botrytis bunch rot severity was determined by visual inspection using a seven-point scale (0, 5, 15, 25, 50, 75 and 100%). Botrytis severity was calculated as follows: S = Σ Si/n; where Si = % severity for the i-th bunch and n = the total number of affected bunches. Values with different letters in single rows are significantly different at $p < 0.05$.

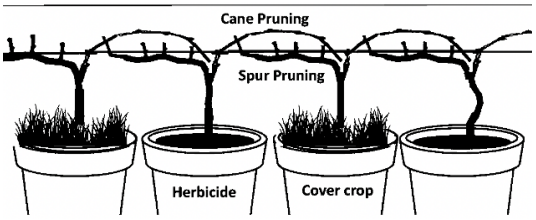

Fig. 1. Experimental design

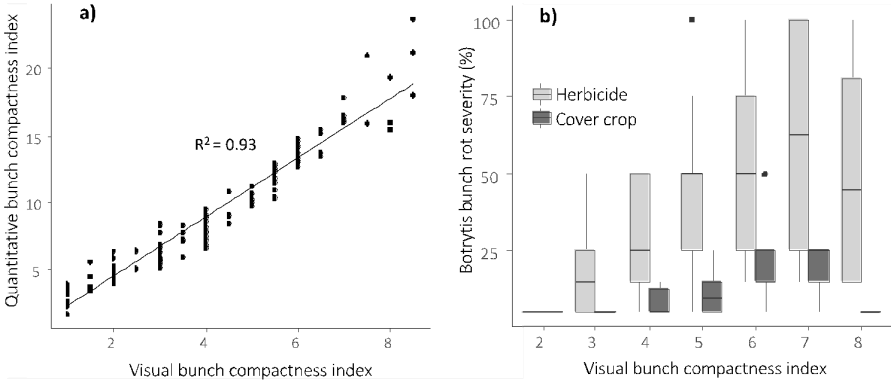

Fig. 2. a) Relationship between visual bunch compactness index OIV descriptor No 204 (O.I.V., 2007) and quantitative method: (bunch weight (g)/[rachis length (cm) + first ramification length (cm)] (Fermaud 1998). b) Bunch rot severity (%) according to visual compactness index (2-8), for two groundcover management treatment (cover crop and herbicide). Botrytis bunch rot severity was determined by visual inspection using a seven-point scale (0, 5, 15, 25, 50, 75 and 100%). Botrytis severity was calculated as follows: $S = \Sigma Si/n$; where Si = % severity for the i-th bunch and n = the total number of affected bunches.