FORCING VINE REGROWTH IN *VITIS VINIFERA* cv. TOURIGA NACIONAL AT DOURO REGION

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Abstract:

Context and purpose of the study - Douro Region, characterized by a Mediterranean climate type and schist soils, is subjected to water and heat stresses conditions during summer. In some locations, the temperatures registered during berry maturation, lead to fruit ripen during warmer months, increasing the degradation of organic acids, tannins and phenolics that can negatively affect the quality of wines. Forcing vine regrowth is a new practice, being currently tested in Mediterranean countries, that aims to shift fruit ripening to cooler months of the year by pruning the plants after fruit set - Crop Forcing (CF) - removing all the leaves and bunches and leaving five buds per shoot, in order to reduce the negative effect of high temperatures during berry maturation on its quality.

Material and methods - This work aims to study the effect of forcing vine regrowth in cv. 'Touriga Nacional' under Regulated Deficit Irrigation conditions, in vines irrigated with 30% of the evapotranspiration. Three modalities were established: vines with no forcing regrowth (Control - CTRL), vines with CF set 15 days after fruit set (CF15) and plants with CF performed 30 days after fruit set (CF30). The effects on phenology, canopy development, berry development and fruit composition were assessed.

Results - Plants subjected to CF15 were severely damaged after phenological stage of full bloom due to exceptional conditions to downy mildew (*Plasmopara viticola*) infections, boosted by the new phenological stages due to crop forcing. On the other hand, the crop forcing modality CF30 registered a delay of nearly two months in all phenological stages, since fruit set until harvest. Shorter internodes (50%) and lower leaf area (35%) were observed in CF30 when compared to the CTRL plants at ripening stage. The number of shoots at fruit set was also significantly different between the three treatments, with higher values in CF modalities and lower values in CTRL plants. In terms of yield, comparing CF30 (harvested in November, 27th) and CRTL (harvest in October, 6th), it was found that CF reduced the number of bunches (39%), the number of berries per bunch and the average berry weight (60%). Moreover, berries from the forced crop modalities (from grapes) had a pH slightly lower (3.35), higher titratable acidity (8.82 g/L) and lower ˚Brix (17.02˚Brix) when compared to CRTL, with pH values of 3.74, titratable acidity of 4.16 g/L and Brix of 23.93˚. Despite these results, further study should be carried out to evaluate the long-term effects of CF and its applicability depending on the climatic conditions for each year.

Keywords: Douro Region, Crop Forcing, Grapevine, Phenology, Quality, Yield

1. Introduction

Climate warming related to climate change has been associated to potential impacts in European viticulture and therefore influences the production of premium grapes and high-quality wines. Warmer temperatures will have impact on fruit composition, both in red and white cultivars (Sadras and Moran, 2012; Bonada *et al.*, 2013) and in particular, increasing temperatures can potentially lead to unbalanced fruit where high sugar content is reached before colour and flavour development (Sadras and Moran, 2012; Dequin, *et al.,* 2017).

According to model predictions, in Douro, the Port Wine Demarcated Region, temperatures will increase, with overall warmer days and nights and higher heat stress events as well as less precipitation will occour, specially during the growing season (Jones and Alves, 2013). For this reason, a inovative technique, Crop Forcing (CF) which consists on a second pruning performed after fruit set where all laterals, leaves and primary clusters are removed, retaining five nodes per shoot, is being studied in order to shift ripening to cooler months, resulting in smaller berries with higher acidity content, lower pH, deeper colour and higher phenolic compouds, as tannins (Gu *et al.*, 2012).

2. Material and methods

The presented trial was performed during 2018 in Douro Superior sub-region, at Quinta do Ataíde (41º14'36''N, 7º06'55''W), an organic farm, property of Symigton Family Estates. The grape variety was 'Touriga Nacional' grafted in 196-17 Cl. The vines were planted in 2014, 2.2m × 1.0 m (4545 vines/ha), Vertical Shoot Positioned, pruned in Royat cordon (10 buds/ vine). Vines were drip irrigated at 30% of evapotranspiration (ETc), prior to ripening until 15 days before harvest. The experimental trial consisted of 4 blocks × 3 treatments × 8 plants. The treatments were: (1) Control (CTRL); (2) CF set 15 days after fruit set (CF15); (3) CF performed 30 days after fruit set (CF30) at stage 'Pea size', (Baggiolini, 1952). Water status of vines was monitored every week by measuring pre-dawn leaf water potential (Ψpd), according to the methodology described by Schölander *et al.* (1965).

Harvest date of CTRL was on Day of the Year (DOY 279; 6 October) and the CF30 was harvested on DOY 331 (27 November). The CF15 was severely damaged after full bloom due to favourable conditions for downy mildew (*Plasmopara viticola*) infections, intensified by the delay of phenological stages due to CF. At full bloom stage, the bunch number was counted and at harvest the yield per vine and the bunch number were recorded. Average berry weight was measured on 200 randomly sampled berries per modality and subsequently crushed allowing to measure pH and titratable acidity (TA), analysed by standard methods (OIV, 2018), and total soluble solids (TSS), tartaric acid and malic acid, determined using OENOFOSS™ (FOSS Analytics, Hilleroed, Denmark).

The results were recorded in Excel format and the statistical analysis was done using statistical package SPSS program version 25.0 (SPSS In., Chicago, US) for Windows. Data was subjected to analysis of variance (ANOVA) and means were compared by Least Significant Difference (LSD) multiple comparison test at $P<0.05$.

3. Results and discussion

Weather conditions and phenological stages

In 2018, after a cold and dry winter, spring and part of summer were cold and extremely rainy turning to hot and extremely dry on the second part of the summer. There was a prolonged period of hot weather during July, August and September with some days in July attaining extreme temperatures. Because of the cold events during spring and summer, all treatments experienced a delay in the vegetative cycle, enabling favourable conditions for downy mildew.

Forcing vine regrowth, as expected, delayed the budbreak date (C stage) and shortened the interval between this phenological stage and fruitset (J stage; Table 2), after the second pruning. Nevertheless, the effect of CF on delaying these stages was only noticeable until veraison (M stage), since the number of days from budbreak to this stage was almost equivalent. CTRL ripening occurred during a period with higher Growing Degree Days, GDD (data not presented), whereas CF30 ripening happened when the temperatures and ETc started decreasing. Forcing vine regrowth by doing a second pruning about six months after the winter pruning, inducing the regrowth of shoots, leaves and clusters, managed to move successfully the fruit maturity period to a cooler temperatures season.

Canopy development and ecophysiological conditions

Regarding the shoot number, CF treatments presented significant differences in number of shoots and pruning weight, as shown in table 1. However, pruning weight, was lower in CF15 and CF30 having thinner and shorter shoots in comparison to the CTRL, with values of 7.5 g/shoot on CF plants and 34.0 g/shoot on CTRL plants.

Pre-dawn leaf water potential (Ψpd) measured 14 times along the season revealed a decrease until DOY 206, the day were weekly irrigation has started. Despite the irrigation, Ψpd decreased until DOY 247, and significant differences at DOY 233 were achieved between the CTRL and CF treatments, as well as at DOY 247 between CTRL and CF30 (Table 2). At DOY 254, Ψpd was very high due to rainfall occurred along the previous days. After this date, the values begun to decrease again revealing higher stress in all the treatments until DOY 275, where the precipitation increased and temperatures decreased. It is also shown in table 2, that in the majority of the measurements, the water stress in CF treatments was lower than in CTRL which can be explained by the number of younger leaves with lower transpiration rate.

Fruit composition and yield

CF treatments had, in general, as observed in table 3, fewer number of clusters, being this clusters 50% smaller and with little and less berry number, when compared to the CTRL. The number of clusters was statically different between the CTRL, 26 clusters/vine and CF treatments with 19 clusters/ vine.

At the end of fruit ripening, TA values were significant higher in CF30 and, consequently, lower pH values were encountered (Table 3). As observed in this table, higher TA is achieved by an equilibrium between tartaric and malic acid, which was not found in CTRL that had higher content in tartaric acid and a very low in malic acid. Regarding the sugar content, CTRL registered higher contents than CF plants. This lower sugar accumulation is related to the considerably lower GDD during ripening as the low temperatures might restraint the photosynthetic activity (Keller, 2015). Higher content of sugar in CTRL can also be related to the increase of berry dehydration (Silvestroni *et al.*, 2018).

4. Conclusions

The results obtained throughout the year showed that CF had an effect on delaying phenology, lowering yield and delaying grape ripening. Crop forcing induced vine regrowth and shifted fruit ripening from hot months to a cooler period, leading vines to produce less and smaller clusters, smaller berries with lower pH, higher titratable acidity content, lower sugar content, higher malic acid and less tartaric acid content.

CF also had effect on water stress, which can involve less irrigation requirements, with less water consumption over the most critical period of water scarcity, but had also significant impact in reducing vegetative expression.

Delaying harvest seems to be a promising way to produce wines with more acidity decoupled by the warming climate, despite the risk for *Botrytis cinerea spp*., other diseases like downy mildew (*Plasmopara viticola*) or powdery mildew (*Uncinula necator*) and severe decline in production. This way, further study should be carried out to evaluate the long-term effects of CF and its applicability depending on the climatic conditions for each year.

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Table 1: Effect of Crop Forcing on phenology (Baggiolini, 1952), yield and vegetative growth, "Touriga Nacional".

Treatment	CF DOY	Phenology				Yield		Vegetative growth	
		C	J	M	N	No. clusters/vine	Yield (Kg/vine)	No. shoots/vine	Pruning weight (kg/vine)
CTRL	-	100	155	221	279	26a	1.91a	15b	0.51a
CF15	158	165	-	-	-	19b	-	29a	0.22b
CF30	178	186	220	306	331	19b	0.88b	30a	0.22b
Sig. (1)						***	***	***	***

(1) Significance of F test: *** – p<0,001.

Table 2: Predawn leaf water potential (Ψ_{pd}) (-MPa), Touriga Nacional.

DOY	158	178	192	206	213	220	233	247	254	261	268	275	288	318
CTRL	0.10a	0.10b	0.15a	0.39a	0.18a	0.19a	0.78a	1.01a	0.15a	0.43a	0.78a	0.83a		0.28b
CF15	0.03a			0.35a	0.21a	0.22a	0.46b							
CF30	0.02a	0.26a				0.28a	0.58b	0.64b	0.28a	0.35a	0.65a	0.74a	0.68a	0.43a
Sig. (1)	n.s.	*	-	n.s.	n.s.	n.s.	***	***	n.s.	n.s.	n.s.	n.s.	-	*

(1) Significance of F test: n.s. – not significant; * – p<0.05; ** – p<0.01; *** – p<0.001.

Table 3: Effect of Crop Forcing on berry fresh weight and fruit composition at the end of ripening, "Touriga Nacional".

Treat.	DOY	Weight/berry (g)	pH	˚Brix	Titratable Acidity (g L^{-1})	Tartaric Acid (g L^{-1})	Malic Acid (g L^{-1})
CTRL	276	1.31a	3.74a	23.93a	4.16b	7.35a	0.98b
CF30	318	0.82b	3.35b	17.02b	8.82a	5.25b	5.13a
Sig. (1)		**	**	*	**	n.s.	**

(1) Significance of F test: n.s. – not significant; * – p<0.05; ** – p<0.01.