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Intra-varietal diversity for agronomic traits in 'Garnacha Blanca'

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Summary

'Garnacha Blanca' is a somatic variant derived from 'Garnacha Tinta', an old variety with large genetic and phenotypic variability. In this work we have studied for two years the phenotypic variation existing in 'Garnacha Blanca' for yield and quality related traits in accessions from 14 sampling locations of ancient vineyards in the Ebro Valley, Spain. The results showed high variability among the accessions in many of the traits studied in 'Garnacha Blanca'. Different accessions could be distinguished both years using several traits, including two important traits in terms of quality and yield: bunch compactness and yield per plant. A large environment effect, intrinsic to the 'Garnacha' group, enhances phenotypic variation among years, what requires increasing the number of bunches and years for clonal characterization in this variety. The dimensions of the berry showed the least variability, while traits related to bunch architecture like bunch length were discriminant and also stable.

K e y w o r d s : cluster architecture; reproductive performance; somatic variation.

Introduction

'Garnacha Blanca' is cultivated principally in Mediterranean Europe (98.3 % of the total). France is the main producer country (5,589 ha) and Spain the second one (2,297 ha) (OIV 2018). In Spain, it is mainly cultivated in the Ebro Valley, including the region of Navarra. In 2008, the Government of Navarra collected and reproduced plants of this variety from ancient vineyards in order to save the variety diversity. In 2011, a conservation plot was established, including 55 accessions from 14 sampling locations (Cibriáin *et al.* 2014). 'Garnacha Blanca', already cited in 1865, is a somatic variant derived from 'Garnacha Tinta'. Genomic studies on these accessions point out that this mutation event has occurred more than once (Rodríguez-Lorenzo, in preparation).

In this work we have studied the phenotypic variation for yield and quality related traits in some of these accessions. Yield and quality are important because of their direct impact on the economic value and sustainability of viticulture. Among the principal determinants of grapevine yield are flowering and fruitset, as a reduced fruitset usually leads to undesired phenomena such as coulure. Another factor with a high influence on yield and quality is bunch compactness (Tello and Ibañez 2018). 'Garnacha Blanca' produces, in general, very compact bunches, which are more susceptible to infection by *Botrytis cinerea* and display a more heterogeneous ripening. The degree of compactness depends on different bunch features, and among them, rachis architecture, number of berries per bunch and berry size have been identified as the main components determining bunch compactness (Tello *et al*. 2015). The aim of this work was to analyse the existing variation for traits related to yield and quality within 'Garnacha Blanca', using a number of accessions selected from previous studies.

Material and Methods

P l a n t m a t e r i a l : One 'Garnacha Blanca' accession from each one of the 14 sampling locations was selected based on criteria of coulure, compactness, weight of 100 berries and juice characteristics from previous studies. In addition, one commercial clone of 'Garnacha Blanca' planted in the same plot was used as a reference. The 15 accessions are located in a plot at Baretón state (396 m above sea level) (Olite, Navarra, Spain) managed by the Government of Navarra and includes five plants by accession, planted in 2011, with 2.6 m between rows and 1.3 m between plants (2,958 plants$\cdot$ha^{-1}). All the plants are grafted onto 110 Richter rootstocks, share the same training system (double cordon de Royat), row orientation (East-West) and cultural practices. From pre-flowering to harvest plants received 13 (2015) and 15 (2017) irrigations by means of a drip irrigation system (around 435 m^3$\cdot$ha^{-1} in 2015 and around 500 m^3$\cdot$ha^{-1} in 2017).

E d a p h o c l i m a t i c c h a r a c t e r i s t i c s : the soil is a terrace calcareous soil, loamy clay texture and depth of 40 cm in the first horizon; it has a pH of 8.25 and the organic matter content is 2.39 %. The average temperature in 2015 during the vegetative phase was 19.7 °C and 19.3 °C in 2017, while the accumulated rainfall was 133.8 L$\cdot$m^{-2} in 2015 and 159.2 L$\cdot$m^{-2} in 2017.

T r a i t s e v a l u a t e d : Traits were evaluated in two years (2015 and 2017) at harvest time (09/10/2015 and 09/13/2017 respectively) (Table). Five bunches per accession and year were taken from at least four plants per accession. Each bunch was processed and analysed independently

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Table

Mean, minimum (min), maximum (max), standard deviation (SD), coefficient of variation (CV) for the traits studied and *p*-value of the ANOVA within each year and *p*-value of the T-test between years. Fr is (SedBeBu+SelBeBu+LGO)/FlBu x 100; Col is 10-((SedBeBu+SelBeBu+LGO) x 10/FlBu), (DRY *et al.* 2010); BeWe is ToBeWe/ToBeBu and BeVo is ToBeVo/ToBeBu. SelBeBu: total number of seedless berries of the bunch; LGO: total number of live green ovaries of the bunch; ToBeWe: total mass of berries; ToBeBu: total number of berries; ToBeVo: total volume of berries. Significant *p*-values (< = 0.05) are highlighted in bold

Trait		2015						2017						15-17
		Mean	Min	Max	SD	CV	***p*-value** ANOVA	Mean	Min	Max	SD	CV	***p*-value** ANOVA	***p*-value** t-test
Bunches per plant	ToBuP	15.7	7.0	24.0	3.9	0.24	0.80	15.5	7.0	25.0	4.3	0.27	**0.06**	0.81
Yield per plant (kg)	YP	3.8	0.9	11.7	1.8	0.48	**0.00**	2.3	0.1	7.0	1.3	0.56	**0.00**	**0.00**
Bunch width (cm)	BuWi	11.3	7.1	18.5	2.4	0.21	**0.00**	11.0	5.5	19.0	2.8	0.25	0.18	0.46
Bunch length (cm)	BuLe	12.6	9.0	17.5	1.9	0.15	**0.01**	13.3	5,0	21.0	3.0	0.22	**0.00**	0.12
Bunch mass (g)	BuWe	286.0	112.1	891.9	140.4	0.49	**0.00**	217.8	18.6	570.7	124.0	0.57	**0.01**	**0.00**
First ramification length (mm)	1RmLe	37.8	16.4	65.6	11.2	0.29	**0.00**	36.8	13.5	63.2	11.5	0.31	0.08	0.60
Second ramification length (mm)	2RmLe	35.0	6.3	61.0	10.2	0.29	**0.01**	31.4	14.4	57.1	10.0	0.32	0.03	**0.05**
Rachis length (mm)	RaLe	7.8	5.0	12.3	1.4	0.18	**0.00**	8.6	3.7	14.3	2.4	0.28	0.40	**0.02**
Rachis mass (g)	RaWe	9.2	3.7	24.4	4.0	0.43	**0.00**	8.2	1.1	24.0	4.6	0.56	0.07	0.18
Ramifications per bunch	RmBu	13.0	6.0	24.0	3.7	0.29	**0.00**	14.7	2.0	31.0	5.3	0.36	**0.02**	**0.03**
Flowers per bunch	FlBu	576.6	219.0	1,147.0	207.6	0.36	0.44	667.5	146.0	1,267.0	309.3	0.46	0.32	**0.05**
Seeded berries per bunch	SedBeBu	171.8	50.0	493.0	81.0	0.47	**0.00**	127.8	13.0	320.0	68.4	0.54	**0.02**	**0.00**
Fruitset (%)	Fr	34.4	9.5	75.0	15.6	0.45	**0.00**	24.1	1.6	51.0	12.3	0.51	**0.03**	**0.00**
Coulure Index	CoI	6.5	2.5	9.0	1.6	0.24	**0.00**	7.6	4.9	9.8	1.2	0.16	**0.03**	**0.00**
Compactness	Comp	5.8	3.0	9.0	1.9	0.32	**0.01**	4.2	1.0	9.0	2.3	0.55	**0.00**	**0.00**
Berry width (mm)	BeWi	12.8	10.2	14.7	1.0	0.08	0.13	12.8	9.1	14.2	0.8	0.06	**0.00**	0.87
Berry length (mm)	BeLe	13.3	10.8	15.7	1.2	0.09	0.11	13.0	9.1	14.6	0.9	0.07	**0.00**	0.09
Berry mass (g)	BeWe	1.5	0.7	2.5	0.4	0.25	0.71	1.6	0.7	2.2	0.2	0.16	**0.00**	0.24
Berry volume (ml)	BeVo	1.5	0.6	4.1	0.5	0.34	0.46	1.4	0.7	2.0	0.2	0.16	**0.02**	0.18
Seeds per berry	Sbe	1.8	1.1	2.9	0.4	0.20	**0.00**	1.3	1.0	1.9	0.2	0.14	**0.03**	**0.00**

according to TELLO *et al.* (2015). Bunch compactness was scored according to the OIV descriptor N° 204 (OIV 2007). A panel of five judges was trained in the use of this descriptor, and their mode value was considered in this study. Total number of flowers of the bunch was determined by counting florals buttons before flowering in the field, and fruitset and coulure index were calculated after DRY *et al.* (2010).

Statistical analysis: ANOVA was used to compare accessions for each trait each year. Additionally, we used t-Student to analyse the traits over time. Results were considered statistically significant if *p*-value ≤ 0.05. Analyses were done using SPSS v. 25.

Results and Discussion

Intra-varietal diversity is common in grape varieties (PELSY *et al.* 2010, MENEGHETTI *et al.*, 2012). Varieties of the 'Garnacha' group are not an exception, displaying diversity both at genetic and phenotypic levels. Mutations in the 'Garnacha Tinta' genome have resulted in changes at the phenotypic level, giving rise to 'Garnacha Blanca', 'Garnacha Roya' or 'Garnacha Peluda'. MENEGHETTI *et al.* 2011 found genetic differences between 'Garnacha' vines from different geographical areas of Europe, and different works (MERCENARO *et al.* 2016; GRIMPLET *et al.* 2017) found phenotypic diversity among accessions of 'Garnacha Tinta'.

In this work, 15 accessions of 'Garnacha Blanca' were initially studied for two years. The first analysis of the results revealed a very large dispersion of the data in one of the accessions, and it was excluded from the following analyses. The results showed high variability among the accessions in many of the traits studied (Table). The yield traits Bunch mass (BuWe) and Yield per plant (YP) presented the highest coefficients of variation (CV) both in 2015 and 2017. On the contrary, berry dimensions (BeWi, BeLe) showed the lowest CV values. MERCENARO *et al.* 2016 also found low variability in the size of the berry in 'Garnacha Tinta'.

The variability found allowed the 'Garnacha Blanca' accessions to be significantly differentiated in ANOVA analysis with 14 traits in 2015 and other 14 in 2017; ten of them were common in the two years (YP, BuLe, BuWe, 2RmLe, RmBu, SedBeBu, Fr, Col, Comp and Sbe) (Table). However, t-tests showed significant differences between the two years studied in all of them, except for the length of the bunch (BuLe), the only discriminant and stable variable (Table). MERCENARO *et al.* 2016 also observed differences among accessions for Comp and YP traits in 'Garnacha Tinta'. As in this work with 'Garnacha Blanca', GRIMPLET *et al.* 2017 observed differences in several morphological traits over the years in 'Garnacha Tinta', but Comp measurements were consistent through seasons. In total, eleven traits showed significant differences between 2015 and 2017. This shows the influence of the environment on this variety for some traits, indicating that a complete characterization for clonal selection requires studying a large number of bunches and plants during several years. Globally, berry dimensions and bunch architecture behaved as the most stable variables.

Conclusion

Phenotypic diversity for relevant agronomic traits was observed in 'Garnacha Blanca' in a similar way as previously described for the 'Garnacha' group. Different accessions could be distinguished both years using several traits, including two important traits in terms of quality and yield, compactness and yield per plant. A large environment effect, intrinsic to the 'Garnacha' group, enhances phenotypic variation among years, what requires increasing the number of bunches and years for clonal characterization in these varieties. The dimensions of the berry were the traits with less variability, while traits related to bunch architecture like bunch length were discriminant and also stable.

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