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The influence of 110-Ritcher and SO4 rootstocks on the performance of scions of *Vitis vinifera* L. cv. Albariño clones

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Abstract

The use of rootstocks is widespread in modern viticulture; non-grafted *Vitis vinifera* vines are now grown in only a handful of places with very specific conditions. Since the need to graft vine-scions onto American rootstocks, a lot of work has been performed in which different aspects of the relationship between the vine and the rootstock have been studied. Despite this there are still many open questions, which remained unanswered. The present paper reports a study performed on five 'Albariño' clones (MBG-1, MBG-2, MBG-7, MBG-9 and MBG-10), in which the influence of rootstock type (110-R and SO4) on a number of agronomic variables was examined. The results show that these rootstocks have no influence on many of the variables which were studied (phenology, cluster size and weight, fertility, yield, and berry size and weight), although they do influence variables such as the probable alcohol content, the quantity of free-run juice, must total acidity and weight of pruned wood. Therefore it is possible to conclude, that rootstocks influence agronomic parameters.

Additional key words: agronomic traits, interclonal variability, *Vitis berlandieri* × *Vitis riparia, Vitis berlandieri* × *Vitis rupestris.*

Resumen

Influencia de los portainjertos 110-Ritcher y SO4 en el comportamiento de clones del cultivar Albariño (*Vitis vinifer*a L.)

En la viticultura actual está generalizado el uso del portainjerto, y únicamente se cultiva *Vitis vinifera* sin injertar en zonas muy puntuales del mundo, con unas condiciones muy particulares. Desde que se planteó la necesidad de injertar las viníferas sobre patrones americanos, numerosos trabajos han estudiado diferentes aspectos de la relación vinífera-portainjerto, a pesar de lo cual todavía quedan muchas cuestiones por clarificar. Se estudiaron cinco clones de 'Albariño' (MBG-1, MBG-2, MBG-7, MBG-9, MBG-10), en los que se analizaron la influencia de dos tipos de portainjertos (110-R y SO4) en diferentes parámetros agronómicos. Los datos obtenidos han permitido comprobar que el portainjerto no influyó en muchos de los parámetros objeto de estudio (estados fenológicos, peso y tamaño de racimo, fertilidad, rendimiento expresado en kg de uva por cepa, peso y tamaño de baya), pero sí en otros (grado alcohólico probable, rendimiento en mosto yema, acidez total, y peso de madera de poda). Se puede concluir por lo tanto, que el portainjerto influye en los parámetros agronómicos.

Palabras clave adicionales: parámetros agronómicos, variabilidad interclonal, *Vitis berlandieri* × *Vitis riparia, Vitis berlandieri* × *Vitis rupestris.*

Introduction[1]

European viticulture began with the use of non-grafted vines (*Vitis vinifera* L.). This changed, however, with the arrival of phylloxera in 1860, which destroyed nearly all of the continent's vineyards. To combat this pest, viticulturalists began to graft their cultivars onto phylloxera resistant rootstocks. With the exception of the Canary Islands, phylloxera was declared present all over Spain in 1918, and from that time the use of rootstocks was almost universal. Only a few places remain where, because of particular characteristics of the soil or climate, vineyards can be established with non-grafted plants. In areas where phylloxera occurs, the cultivation of *V. vinifera* on disease-

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[1] Abbreviations used: LSD (least significant difference), OIV (International Organisation of Vine and Wine), PCA (principal component analysis).

resistant rootstocks is the only reliable way to ensure the quality of the grapes produced (Hidalgo, 2002).

As well as offering phylloxera resistance, some rootstocks have other useful characteristics, such as nematode resistance, the ability to adapt to soils of different physical and chemical characteristics, like salinity, high or low moisture levels, low fertility and compaction (Iannini, 1980; Colapietra and Stramaglia, 1984; Corino and Castino, 1990; During, 1994; McKenry *et al.*, 2001; Corino *et al.*, 2002; Ollat *et al.*, 2003; Pinkerton *et al.*, 2005).

According to Martínez de Toda (2002), rootstocks seem to exercise their influence fundamentally through plant vigour, and consistently have an effect on leaf exposure and on water and nitrogen availability at maturation. Rootstocks that induce less vigour tend to produce higher quality wine (McCarthy and Cirami, 1990), except in poor soils where leaf surface area is insufficient. However, no generalisations can be made regarding the effect of a single rootstock type across cultivars (Clímaco *et al.*, 1999, 2003). It is also not clear whether all the effects on fruit quality in grafted vines are due directly to the rootstock or whether they are a product of the microclimate formed around the plant.

The effects of rootstocks on plant vegetative growth, production, and wine composition and quality have been studied for many years in different vine varieties. Studies have also been performed on different clones of Chardonnay (Chambre d'Agriculture de l'Aude, 2004) to determine the influence of rootstock type on their susceptibility to powdery mildew (*Uncinula necator* Schw. Burril.) and botrytis (*Botrytis cinerea* Pers.). No influence was seen on the former, but rootstocks that conferred greater vigour led to increased susceptibility to the latter. These results confirm the observations of Cristinzio *et al.* (2000).

Among the rootstocks most commonly used in the study area are those of *V. berlandieri* hybrids. These show high adaptability to saline soils and have good affinity with cultivated vines (Hidalgo, 2002). The rootstock 110 Richter is a hybrid between *V. berlandieri* and *V. rupestris,* while SO4 is a hybrid between *V. berlandieri* and *V. riparia*. Both are commonly used for their ability to adapt to many types of soil and environmental conditions (Reynier, 2002).

The aim of this work was to compare five Albariño clones grafted onto 110 Richter or SO4 and determine how rootstock type influences the agronomic characteristics of the clones. These clones show variability at the agronomic level (Boso *et al.,* 2004a) and in their resistance to downy mildew (Boso *et al.*, 2004b), although the latter is not influenced by rootstock type (Boso *et al.*, 2007).

Material and Methods

Plant material

The study was conducted over five years from 2000-2004 on five *Vitis vinifera* cv. Albariño clones (MBG-1, MBG-2, MBG-7, MBG-9 and MBG-10) grafted on Ritcher 110-R (*Vitis berlandieri* × *V*. *rupestris)* and SO4 rootstocks (*V. berlandieri* × *V. riparia*)*,* the most common and best adapted to the study area. Each clone/rootstock (C/R) combination was represented by 10 randomly distributed vines. Every year a different group of these vines was used. All the vines were seven years old at the start of the work. The experiment was located at the *Misión Biológica de Galicia* Research Station (Consejo Superior de Investigaciones Científicas) in the province of Pontevedra (north-western Spain). All plants were therefore subject to the same soil, climatic and cultivation conditions. The soil had a sandy loam texture (13.88% clay, 16.1% silt, 70.1% sand, 8% organic matter). The soil was ploughed several times a year, but received no irrigation.

Plants were grown *en espalier* with a distance between rows of 2.5 m and a distance between plants of 2 m. The *Sylvoz* pruning method was used, leaving one horizontal vine 1.10 m from the ground with two-budded renewal spurs and 4-5-budded fruit canes. The latter curved downwards and were tied to a wire at 70 cm above ground. Two parallel wires were situated 1.30 m and 1.70 m from the ground, and all green shoots were placed between them as they grew. Twenty buds were left on each sample plant.

Sample collection and variables studied

Stages in grapevine shoot development

The shoot and bud development was recorded weekly for two years, from mid-March 2001, following the methods of Eichhorn and Lorenz (1977) and Baggliolini (1952).

Fertility and characteristics of berries and seeds

Clones were sampled between the end of September and the second week of October (berry ripening stage).

From physiological stage 38 of Eichhorn and Lorenz (1977) (i.e., soft berries, tasty flavour and yellow colour), maturation was monitored to select full maturity berries. Both sugar concentration and total must acidity were measured daily, from this stage, and the evolution of these parameters in each clone was observed. When berries were at optimum ripeness (when they stopped concentrating sugar) they were harvested. The number of grape clusters per vine shoot on each of the 10 specimens per clone was counted. They were then removed, placed in a bag and weighed (yield = kg plant^{-1}).

Five representative clusters from each of the 10 specimens planted per clone were then selected according to the norms of the OIV (1983), and their weight (g), length (cm), width (cm) and number of berries were recorded. Stem length (cm) was also measured.

Fifty berries per clone were selected from the central part of the clusters, and each berry was numbered. The length of the pedicel (cm) and the length (cm), width (cm), and weight (g) of each berry were recorded, and the number of seeds per berry was counted. Once seeds were dry, 50, from each clone, were randomly selected and their individual length, width and weight were recorded.

Free-run juice

Berries were selected from each of the 10 specimens per clone, and were placed in a centrifuge tube, gently ground, and centrifuged for 3 min at 3,000 r.p.m. The supernatant volume was measured (mL) and the must yield per berry (%) estimated as follows: (must of berries/weight of berries) × 100.

Probable alcohol content

A 50 mL sample of the supernatant was taken with a Pasteur pipette and placed in a refractometer to obtain the sugar concentration (Brix). The probable alcohol content of the juice (degrees Baumé) was estimated using conversion charts (OJ, 1990b).

Total must acidity

Sampling was conducted following the same procedures as for determining must yield per berry. Total must acidity was estimated using the colouration pattern volumetric method (OJ, 1990a).

Must pH

Must pH was measured with a pH meter (Crison micro pH 2000).

Fertility

Taking into account the number of buds left at the last pruning, the fertility index was calculated using the equation: number of clusters per plant × 10/number of buds per plant.

Weight of pruned wood

Vines were pruned by the end of February, and the wood obtained from each of the 10 specimen plants per clone was weighed.

Statistical analysis

Each variable was examined separately by analysis of variance (ANOVA) using triple factorial. Year was considered as a random factor whereas clones and rootstocks were considered as fixed factors. Fisher's protected test [least significant difference (LSD) method], was used to establish whether there were significant differences among the clones ($P \leq 0.05$) and rootstocks. All calculations were performed using the GLM procedure of SAS System software, version 9.1.2. (SAS, 2004).

Using data from the full five years of the study, principal component analysis (PCA) was performed on the results for cluster and must variables, the weight of pruned wood, and berry and seed variables.

Results

Phenolological stages

There were no significant differences among clones with respect to influence of rootstock type. Nor was there a significant influence of the interaction clone × rootstock type (Table 1). Bud-break (stage B) always occurred in March, sometimes at the beginning of the month and sometimes towards the end of the second week. Harvest was generally in September, although

Table 1. Average number of days to reach different stages in grapevine shoot development following the method of Baggliolini (1952) and Eichhorn and Lorenz (1976), counting from C stage (opening the buds) over five years of the study according to rootstock type

Stages	Rootstock 110-R (days)	Rootstock SO4 (days)
Baggliolini (1952)		
Days to C (opening the buds)	6.89a[a]	6.93a
Days to D	12.62b	12.81b
Days to E	19.56c	19.73c
Days to F	28.39d	28.77d
Days to G	40.02e	40.56e
Days to H	48.97f	49.30f
Flower	58.36g	58.66g
Eichhorn and Lorenz (1976)		
Days to 27	69.24h	69.34h
Days to 29	75.14i	75.44i
Days to 31	83.19j	83.45j
Days to 33	90.89k	91.21k
Days to 35	132.28l	132.68l
Days to 38 (maturity)	159.21m	160.27m

[a] Mean separation by Fisher's protected test [least significant difference (LSD) method], at $p \leq 0.05$. Means within main effect and column having the same letters are not significantly different at $p < 0.05$.

Table 2. Means square of the combined analysis of variance across 5 years and two rootstocks for agronomic traits (cluster, berry and pruning wood) in clones of the Albariño cultivar

Source of variation	Parameters[a]													
	Df	WC	LC	WdC	Lp	Nb	°AP	Juice	Ac	pH	Yield	Wp	CT	Fer	Cs
Clone (C)	4	24,145 *	62.19 ***	36.79 ***	12.95 ***	20,189 ***	6.73 ***	232.4 ***	16.72 **	0.13 ***	3.41 **	2.10 **	412.3 *	213.5 ***	4.05 ***
Rootstock (R)	1	1,348 ns	0.09 ns	0.11 ns	0.60 ns	2,491 ns	1.20 *	144.6 *	8.20 *	0.010 ns	0.11 ns	3.50 **	0.007 ns	0.62 ns	0.09 ns
Year (Y)	4	11,198 **	114.9 ***	165.7 ***	0.51 ns	52,217 *	42.23 *	248.1 *	107.6 **	0.72 *	44.04 ***	0.28 ns	37.71 ns	15.53 ns	0.04 ns
C × Y	16	8,628 ***	3.20 ***	1.59 **	1.14 ***	2,933 ***	0.78 ns	29.11 *	3.10 *	0.006 ns	0.56 ns	0.36 ns	175.2 *	26.41 ns	0.09 **
C × R	4	142 ns	0.88 ns	1.24 ns	0.02 ns	233 ns	0.37 ns	41.5 *	1.30 ns	0.06 **	0.13 ns	0.13 ns	50.9 ns	28.40 ns	0.04 ns
R × Y	4	2,079 **	0.40 ns	0.93 *	0.13 ns	4,373 ***	0.23 ns	22.6 *	3.51 *	0.01 ns	0.26 ns	0.17 ns	29.82 ns	3.19 ns	0.05 *
C × R × Y	16	235.28 ns	0.23 ns	0.26 ns	0.06 ns	335.63 ns	0.67 ***	14.01 ns	1.46 ns	0.009 ns	0.34 ns	0.34 ***	52.18 ns	14.20 ns	0.01 ns
Error	171	1,085.7	1.21	1.53	0.77	452.96	0.21	10.22	1.49	0.01	0.28	0.11	45.73	15.11	0.06

[a] Parameters: df: degrees of freedom. WC: weight of cluster (g). LC: length of cluster (cm). WdC: width of cluster (cm). Lp: length of stem (cm). Nb: number of berry per cluster. °AP: alcohol potential (°Baumé). Juice: free-run juice (%). Ac: total acidity expressed as tartaric acid ($g\ L^{-1}$). Yield (kg grapes $vine^{-1}$). Wp: weight of pruning wood (kg). CT: total number of clusters. Fer: fertility (No. of clusters per plant × 10 / No. of buds per plant). Cs: clusters per vine shoot. *, **, ***: significant at 0.05, 0.01 and 0.001 level. ns: not significant.

in some years it was in the second week of October. The minimum sugar concentration recorded, 11° Baumé, was in 2000, and the maximum, 13°, was in 2004.

Clusters, musts and pruned wood

Table 2 shows the results of the ANOVA for these variables. There was no significant difference with respect to rootstock type with the exception of probable alcohol content, quantity of free-run juice, acidity and weight of pruned wood. Clones grafted onto the 110-R rootstock had a higher probable alcohol content, less free-run juice, a lower must total acidity and produced less pruned wood than clones grafted onto SO4 (Fig. 1). There were significant differences in the interaction clone × rootstock type with respect to quantity of free-run juice and must pH. With respect to these two variables, the same clone behaved differently depending on the rootstock used. For some parameters such as cluster weight, cluster width, berries per cluster, quantity of free-run juice, acidity and clusters per vine shoot, each rootstock type gave different results depending of the year (Table 3). The interaction clone × rootstock type × year had no significant effect on any variable except for probable alcohol content ($P = 0.01$) and weight of pruned wood ($P = 0.05$). These discrepancies were due to different slopes shown by few clones (MBG-1R, MBG-7R and MBG-2S for probable alcohol content, and MBG-9R and MBG-7S on weight of pruned wood).

The differences observed for the different variables were always attributable to the rootstock type. Therefore, the rootstock with greater or smaller magnitude according to each variable, always showed this behaviour irrespective of year or clone (Table 4).

The PCA of all five years data for cluster and must variables and weight of pruned wood showed the first three axes accounted for 79.35% of the variance (Prin1: 43.52%, Prin2: 23.77%, Prin3: 12.06%). Figure 2 shows the distribution of the different clones with respect to these three axes. With respect to Prin1, the most important variables were: berries per cluster, cluster weight, length and width, total acidity (there was a negative correlation between this variable and all others) and yield (kg grapes plant^{-1}). Clone MBG-9 grafted onto either the

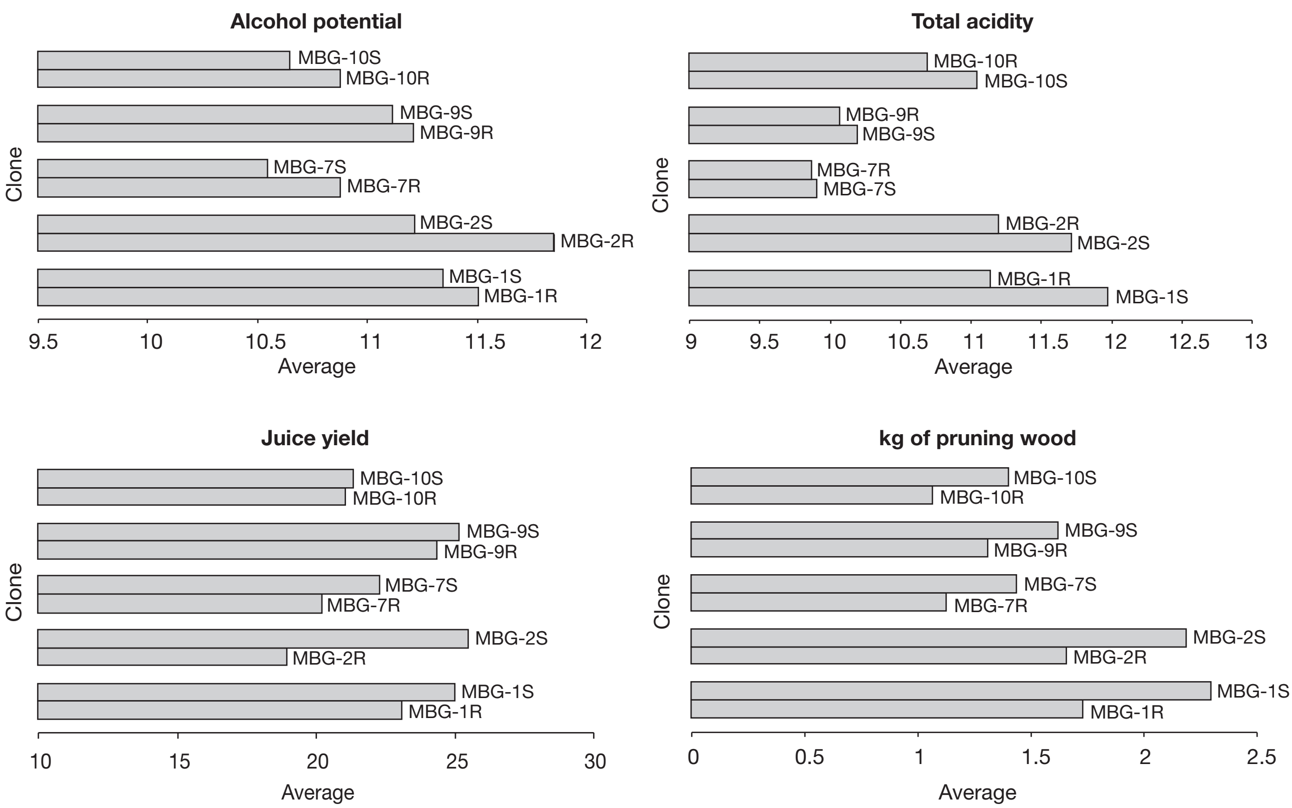

Figure 1. Mean, over five years of alcohol potential (°Baumé), total acidity (g L^{-1} tartaric), free-run yield (%) and pruned wood (kg).

Table 3. Averages and standard deviations (SD) for the variables that showed significant differences depending on rootstock type used and year of the study for clusters, berries and seed

Rootstock	Year		WC[a]	WdC	Nb	Juice	Ac	Cs	Lp	Lb	Wdb	Wb	Wds
110R	2000	Mean	70.29	6.17	45.12	10.64	13.27	1.33	0.71	1.23	1.25	1.34	0.33
		SD	34.87	1.97	16.2	0.53	2.42	0.52	0.14	0.12	0.11	0.29	0.03
110R	2001	Mean	178.33	9.60	74	11.69	10.04	1.48	0.63	1.18	1.19	1.14	0.32
		SD	103.28	1.94	25.49	0.37	1	0.58	0.14	0.11	0.10	0.27	0.05
110R	2002	Mean	86.58	6.33	76	10.11	11.76	1.44	0.57	1.20	1.25	1.20	0.33
		SD	37.95	1.83	32.65	0.75	1.90	0.58	0.11	0.11	0.31	0.31	0.03
110R	2003	Mean	141.32	9.26	104	11.92	9.49	1.44	0.70	1.20	1.23	1.26	0.33
		SD	45.82	2.10	55.75	0.60	1.26	0.58	0.09	0.10	0.12	0.29	0.02
110R	2004	Mean	174.24	9.82	142	11.96	9.53	1.51	0.77	1.16	1.18	1.14	0.32
		SD	40.49	1.51	38.57	0.89	1.10	0.55	0.14	0.09	0.09	0.26	0.02
SO4	2000	Mean	65.10	6.04	40.26	10.31	12.02	1.34	0.68	1.17	1.19	1.22	0.36
		SD	35.85	2.01	1.62	0.84	1.48	0.53	0.13	0.11	0.11	0.36	0.03
SO4	2001	Mean	176.88	9.49	74	25.49	9.99	1.48	0.68	1.23	1.23	1.29	0.32
		SD	103.16	1.97	25.49	11.62	0.89	0.58	0.13	0.12	0.11	0.66	0.06
SO4	2002	Mean	81.64	6.30	76	32.65	11.20	1.44	0.55	1.16	1.18	1.10	0.36
		SD	35.37	1.75	32.65	9.72	1.38	0.58	0.12	0.12	0.11	0.33	0.03
SO4	2003	Mean	139.15	9.09	102	44.44	9.41	1.44	0.70	1.19	1.22	1.18	0.36
		SD	38.70	1.65	44.44	11.77	1.23	0.58	0.13	0.13	0.12	0.33	0.03
SO4	2004	Mean	154.05	9.46	100	44	9.54	1.44	0.72	1.20	1.23	1.21	0.36
		SD	41.63	1.43	38	11.79	1.14	0.56	0.13	0.13	0.12	0.32	0.03

[a] WC: weight of cluster (g). WdC: width of cluster (cm). Nb: number of berries per cluster. Juice: free-run juice (%). Ac: total acidity expressed as tartaric acid (g L^{-1}). Cs: clusters per vine shoot. Lp: Length of pedicel (cm). Lb: Berry length (cm). Wdb: Berry width (cm). Wb: Berry weight (g). Wds: Seeds width (cm).

110-R or SO4 rootstock had the largest and heaviest clusters and the greatest number of berries. It also produced the most kg grape per plant and its must had one of the lowest acidities. Clone MBG2 on either rootstock showed opposite characteristics. With respect to Prin2 the most important variables were: clusters per vine shoot, fertility and weight of pruning wood (kg). In this component these clones lay towards the back of the graph. MBG-1R (i.e., MBG-1 on 110-R) and MBG-1S (i.e., MBG-1 on S04) showed the highest numbers of clusters per shoot, the highest fertility indices, and produced the greatest amount of pruned wood clones. The clones MBG-9R, MBG-10R and MBG-10S lay in the front part of the graph, with characteristics opposite to those of MBG-1R and MBG-1S. With respect to Prin3 the most important variable was alcohol potential (°Baumé). Clones MBG-1R, MBG-1S, MBG-2R and MBG-9R lay in the upper part of the graph with the highest probable alcohol contents. Clone MBG-7, on either rootstock, occupied the lower part of the graph with the lowest values for these variables.

Generally, the number of clusters per shoot on all clones was 1-2, and sometimes 3. Clusters were generally small. The mean number of berries per cluster varied from 50 for clones MBG-1S and MBG-2S to a maximum of 120 on clone MBG-9R.

Berries and seeds

There was no significant differences in berry and seed variables with respect to rootstock type, with the exception of seed width. Clones on the 110-R rootstock produced wider seeds (0.35 cm) than those grafted onto SO4 (0.33 cm). There was no significant effect of the interaction clone × rootstock type on the measured variables. However, there were significant difference in the interaction rootstock × year for all variables ($P = 0.05$-0.01), except for seeds per berry, seed weight and seed length (Table 3). The interaction clone × rootstock type × year had a significant influence on all variables except seed weight. However, as for clusters, must and pruned

Table 4. Averages and standard deviations (SD) for the parameters probable alcohol content (°AP) and weight of pruned wood (Wp) measured in clones of the Albariño cultivar

Clones	Year 2000		Year 2001		Year 2002		Year 2003		Year 2004	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Wp										
CSIC-1R	1.64	0.15	1.96	0.56	1.73	0.13	1.79	0.55	1.66	0.41
CSIC-2R	1.51	0.63	1.97	0.70	1.71	0.65	1.89	0.54	1.38	0.25
CSIC-7R	1.14	0.18	1.39	0.22	1.06	0.22	1.20	0.36	0.97	0.41
CSIC-9R	1.50	0.32	0.75	0.25	1.49	0.34	1.28	0.50	1.39	0.26
CSIC-10R	0.95	0.20	1.56	0.28	0.94	0.24	1.03	0.52	0.92	0.27
CSIC-1S	2.32	0.86	2.06	0.48	2.33	0.54	2.39	1.06	2.39	1.06
CSIC-2S	1.71	0.55	2.45	0.46	2.39	0.61	2.27	0.35	2.33	0.23
CSIC-7S	1.20	0.13	1.47	0.35	1.50	0.33	1.63	0.22	1.63	0.32
CSIC-9S	1.50	0.35	1.82	0.44	1.66	0.32	1.60	0.76	1.60	0.16
CSIC-10S	1.04	0.25	1.81	0.41	1.10	0.20	1.60	0.16	1.60	0.76
°AP										
CSIC-1R	11.08	0.56	11.92	0.19	9.26	0.78	12.30	0.70	12.58	0.40
CSIC-2R	11.04	0.39	11.90	0.54	10.79	0.38	12.72	0.04	12.77	0.36
CSIC-7R	10.43	0.39	11.34	0.08	9.68	0.65	11.54	0.28	11.37	0.66
CSIC-9R	10.55	0.19	11.88	0.32	10.48	0.37	11.68	0.14	11.65	1.15
CSIC-10R	10.11	0.39	11.44	0.13	10.34	0.42	11.40	0.14	11.42	0.39
CSIC-1S	10.94	0.21	11.84	0.30	10.40	0.54	11.84	0.20	11.94	0.08
CSIC-2S	10.27	1.07	11.80	0.50	9.30	0.83	12.58	0.08	12.57	0.06
CSIC-7S	9.85	1.22	11.26	0.05	9.24	0.43	11.48	0.26	11.45	0.75
CSIC-9S	10.52	0.27	11.80	0.28	10.42	0.23	11.62	0.10	11.60	0.08
CSIC-10S	10.10	0.43	11.42	0.10	9.24	0.73	11.36	0.08	11.35	0.05

wood, this interaction was due to rootstock type independent of year or clone.

In PCA analysis, the first three axes accounted for 90.02% of the variance (Prin1: 49.53%, Prin2: 25.43%, Prin3: 15.05%). Figure 3 shows the distribution of the clones with respect to these axes. With respect to Prin1, the most important variables were: length and width of berry and pedicel length. Clone MBG-9R lay to the right of the graph since it had the largest berries and the longest pedicel. Clone MBG-10S lay to the left with the smallest berries and the shortest pedicels. With respect to Prin2, the most important variables were: seed weight and width and berry weight (There was a negative correlation between this variable and all others). Clones MBG-7R and MBG-7S lay to the back of the graph, with the widest berries and lightest seeds. Finally, with respect to Prin3, the most important variable was the number of seeds. Clone MBG-7, on either rootstock, had the greatest seed number. Clones MBG-2 and MBG-1 on either rootstock were

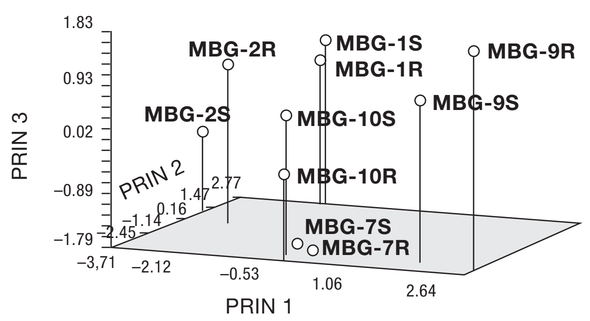

Figure 2. Principal component analysis for parameters measured in cluster, juice and pruned wood of Albariño clones.

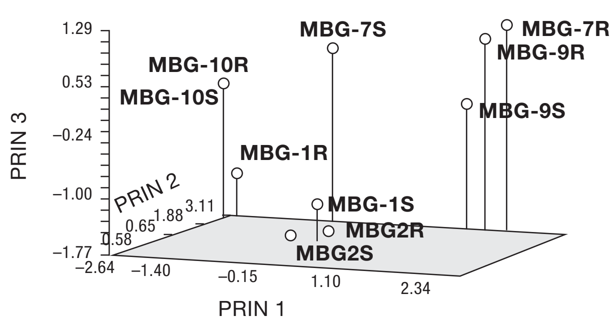

Figure 3. Principal component analysis for parameters measured in berry and seeds of Albariño clones.

at the bottom of the graph with the smallest number of seeds.

Discussion

With regard to phenological stage, all clones behaved in the same way, irrespective of rootstock. However, clones grafted onto the SO4 rootstock (S) always took longer to reach the same stage of development as their counterparts grafted onto 110-R rootstock (R). Based on the time required to reach the different phenological stages proposed by Baggliolini (1952) and Eichhorn and Lorenz (1977), all clones had a long growth cycle and did not reach optimum ripeness until the first weeks of October.

The variables probable alcohol content, quantity of free-run juice, must total acidity and weight of pruned wood were influenced by the rootstock type. Other authors have reported the same results in table grape varieties (Venegas and Martínez-Peniche, 2004) and in grapes destined for winemaking (Main *et al.,* 2002; Clímaco *et al.*, 2003; Van den Heuvel *et al.*, 2004). All clones grafted onto the S04 rootstocks produced must with a lower probable alcohol content, produced more free-run juice, had a high total must acidity and produced greater quantities of pruned wood. The result for the last of these variables agrees with the results of Galet (1990), Hidalgo (2002), Reynier (2002) and Santiago (2004) who suggest that the SO4 rootstock confers greater vigour. High must pH values were seen for MBG-9 on rootstock 110-R. However, on SO4 the must pH of these varieties was the lowest. Clone MBG-10 on SO4 rootstock had the lowest value for kg grapes per plant, berry weight and pedicel length. On the 110-R rootstock these values were intermediate.

In some clones the rootstock type influenced some parameters but only in specific years. Considering the climatic conditions in the years that this happened, it does not seem that this would be the reason, because the climatic conditions did not differ much among the years of the study. Therefore we could not identify an explanation for these results. Continued data collection over the coming years, could help clarify this question.

In the Albariño clones studied, rootstock type has no influence on many agronomic variables [e.g., phenology, cluster size and weight, fertility, yield (kg grapes plant^{-1}), and berry size and weight] —as seen for resistance to downy and powdery mildew (Chambre d'Agriculture de l'Aude, 2004; Boso *et al.*, 2007)— but did have considerable influence on probable alcohol content, quantity of free-run juice, must total acidity and weight of pruned wood. Therefore it can be concluded, that the rootstocks influence agronomic parameters.

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