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【Short Report】

Influence of Rootstock Type on the Agronomic Characteristics of Two Grape (*Vitis vinifera* L.) Cultivars Grown in the Northwestern Iberian Peninsula

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The physiology of grafted plants has been studied by several authors (During, 1994; Ollat et al., 2003) and some rootstock are known to be better than others with respect to the use of water resources and in terms of their adaptation to calcareous soils (Corino and Castino, 1990; Corino et al., 2002). The choice of rootstocks is also important with respect to the resistance against various diseases (Chambre d´ Agriculture de L´Aude, 2004; Pinkerton et al., 2005). Several papers have shown that certain agronomic and ampelographic characteristics of vines can change depending on the area of cultivation (Martínez et al., 1997), the weather (Corino and Castino, 1990; Corino et al., 1999), and the rootstock used (Climaco et al., 1999; Corino et al., 1999). The effect of the rootstock on the vegetative growth of the plant, on its fruit production, and on the composition and quality of its wine have been studied for several years (Main et al., 2002; Vanden-Heuvel et al., 2004). Since the effects of a particular rootstock on different cultivars, and the effects of the rootstock in different growing environments have not been elucidated, it is important to know the cultivar-rootstock-environment interactions before any selection is made.

Two grape cultivars, Caíño Tinto and Albariño, are widely grown in Galicia (northwestern Spain) and northern Portugal (where they are known as Borraçal and Alvarinho respectively) (Pinto-Carnide et al., 2003; Santiago et al., 2005). Although Albariño is a leading cultivar in this area, their economic interest was only noticiable in the last 20 years and no results have been reported concerning the influence of rootstock type within these two cultivars. Among the rootstocks most commonly used in the study area are those of *Vitis berlandieri* hybrids. These show high adaptability to saline soils and have good affinity for cultivated grapevines (Hidalgo, 2002). The rootstock 110 Richter is a hybrid between *Vitis berlandieri* and *V. rupestris*, while SO4, Selection Oppenheim of Teleki No. 4, 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 the present work was to study the influence of rootstock type on a number of production variables in the two grape cultivars.

Materials and Methods

1. Plant materials

The plants used in the present study were two cultivars of *Vitis vinifera* L., one for white wine–Albariño–and one for red wine–Caíño Tinto. These were grown on either 110R or SO4 rootstocks. The study plants have been growing at the *Misión Biológica de Galicia* Research Station (*Consejo Superior de Investigaciones Científicas*, CSIC), Spain, since 1993. All were grown as an espalier and pruned according to the Sylvoz method. Ten plants per cultivar/rootstock (C/R) combination were used, all of which were cultivated in the same way and which received the same crop protection treatments.

2. Sampling and variables measured

Production variables were measured in three consecutive years (2001, 2002, 2003). For each cultivar, harvesting was harvested at the same time irrespective of the rootstock type. The most representative grape cluster of each of the ten vines per combination was selected. Five berries were then taken from the central area of each of these ten clusters (i.e., fifty berries per combination). These berries were then opened with a scalpel and the seeds extracted. The cluster, berry and seed samples described above were used to determine the following variables: total fruit weight/plant, number of clusters per shoot, cluster weight (g),

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Table 1. Results of the analysis of variance for all the parameters measured in clusters, berries and seeds of cvs. Albariño and Caíño Tinto.

Parameters	cv. Albariño			cv. Caíño Tinto		
	Rootstock	Year	Rootstock×Year	Rootstock	Year	Rootstock×Year
Cluster weight	NS[a]	**	NS	*	*	NS
Cluster length	NS	**	NS	NS	NS	**
Cluster width	NS	**	NS	NS	NS	NS
Berry weight	NS	NS	*	NS	*	NS
Berry length	NS	NS	NS	NS	NS	***
Berry width	NS	NS	**	NS	NS	***
No. of seeds per berry	**	NS	NS	NS	NS	NS
Pedicel length	NS	NS	**	NS	NS	***
Weight of the seed	NS	NS	NS	NS	NS	NS
Length of the seed	NS	NS	***	NS	NS	***
Yield	NS	NS	NS	NS	NS	*
Fertility	NS	NS	NS	*	NS	NS
No. of clusters per shoot	NS	**	NS	NS	NS	NS
Pruning wood weight	NS	NS	NS	*	**	NS
Alcohol	NS	**	NS	NS	NS	NS
Must acidity	NS	NS	NS	NS	**	NS
Must yield	NS	***	NS	NS	NS	*
Must pH	NS	NS	**	NS	NS	***

[a] NS, not significant; *, significant at the 0.05 probability level; **, significant at the 0.01 probability level; ***, significant at the 0.001 probability level.

cluster length and width (cm), berry weight (g), berry length and width (cm), pedicel length (cm), number of seeds per berry, seed weight (g), and seed length (cm). During pruning before each growth cycle, the number of buds left on each plant was counted. This information, plus the total number of clusters produced, was used to calculate the fertility index according to the equation:

$$\text{Fertility Index} = \frac{\textit{number of clusters} \times 10}{\textit{number of buds}}.$$

The weight (kg) of pruned wood taken from each plant was recorded. The must yield was calculated following the method of Boso et al. (2004). The probable alcohol content (°Baumé) was measured using a hand held brix refractometer and the pH using a pH meter. The total acidity was determined according to the volumetric method (Official Diary of the European Communities, 1990).

3. Statistical analysis

All variables were examined by ANOVA using SAS System v 9.1 software. The F test was performed contrasting each fixed factor with its error. All variables that were significant in the F test were analysed by Fisher's protected least significant difference (LSD) test. In all analyses the sources of variation were the rootstock, year and the interaction rootstock×year. "Rootstock" was considered a fixed factor and "year" a random factor.

Results and Discussion

1. Influence of rootstock type

Albariño showed differences ($p<0.01$) in the number of seeds per berry depending on the rootstock type (Tables 1 and 2). The rootstock had no influence on the remaining variables studied in this cultivar. The influence of the rootstock was more noticeable in the productive behaviour of Caíño Tinto. Rootstock SO4 led to a significant increase ($p<0.05$) in the weight of pruning wood produced per plant (Tables 1 and 3). Rootstock 110R (Tables 1 and 3) induced lower vigour, greater fertility and a greater cluster weight. These differences were seen every year. Thus, when Albariño and Caíño Tinto cultivars are grown on these rootstocks they do not behave in the same way. As indicated by other authors (Giorgessi and Pezza, 1992; Climaco et al., 1999), the influence of the rootstock differs depending on the scion cultivar.

2. Influence of the factor year

As expected, the conditions of each year had a significant influence on the growth cycle (Tables 1–3), affecting more variables than the rootstock type (Corino and Castino, 1990; Main et al., 2002).

Table 2. Parameters measured in cluster, berry and seed of cv. Albariño.

Parameters	cv. Albariño Year 1						cv. Albariño Year 2						cv. Albariño Year 3					
	110R			SO4			110R			SO4			110R			SO4		
	Mean	S.D.	V.C.	Mean	S.D.	V.C.	Mean	S.D.	V.C.	Mean	S.D.	V.C.	Mean	S.D.	V.C.	Mean	S.D.	V.C.
Cluster weight (g)	161.01	50.08	31.1	159.90	50.75	31.7	83.10	51.81	62.3	80.60	17.94	22.3	136.64	24.09	17.6	149.08	73.01	49.0
Cluster length (cm)	9.17	0.50	5.4	9.12	0.49	5.4	7.58	1.56	20.5	7.54	1.55	20.5	9.10	1.21	13.3	8.91	1.50	16.9
Cluster width (cm)	9.50	0.29	3.1	9.32	0.34	3.7	6.04	1.50	24.8	5.99	1.50	25.1	9.11	1.54	16.9	9.28	2.71	29.2
Berry weight (g)	1.12	0.24	21.1	1.14	0.23	19.9	1.13	0.24	20.7	1.11	0.34	30.5	1.36	0.17	12.6	1.19	0.20	17.2
Berry length (cm)	1.20	0.14	11.9	1.17	0.11	9.6	1.20	0.09	7.3	1.18	0.10	8.4	1.20	0.07	5.5	1.20	0.16	13.3
Berry width (cm)	1.19	0.08	6.8	1.20	0.11	9.2	1.25	0.10	7.7	1.17	0.11	9.7	1.25	0.07	5.5	1.25	0.09	7.0
No. of seeds per berry	2.78	1.00	35.8	2.12	0.87	41.1	2.86	0.78	27.4	2.04	0.78	38.3	3.02	0.80	26.3	2.32	0.77	33.1
Pedicel length (cm)	0.62	0.15	25.0	0.58	0.10	17.1	0.54	0.10	18.8	0.53	0.10	18.3	0.62	0.09	15.1	0.69	0.10	15.2
Weight of the seed (g)	0.042	0.006	13.7	0.030	0.003	10.7	0.028	0.004	15.2	0.026	0.005	20.0	0.022	0.004	15.7	0.025	0.004	14.6
Length of the seed (cm)	0.64	0.05	8.3	0.59	0.05	8.5	0.56	0.06	10.0	0.55	0.07	12.2	0.57	0.04	6.8	0.57	0.03	5.6
Yield (kg plant^{-1})	3.58	0.88	24.5	2.99	0.90	30.1	1.67	0.46	27.5	1.54	0.38	24.6	4.23	2.27	53.6	3.02	0.41	13.6
Fertility	14.43	4.90	34.0	14.20	5.11	36.0	12.02	3.28	27.3	12.68	4.27	33.7	17.68	1.73	9.8	15.33	4.78	31.2
No. of clusters per shoot	1.20	0.45	37.3	1.20	0.45	37.3	1.20	0.45	37.3	1.20	0.45	37.3	1.94	0.25	12.8	1.82	0.27	14.6
Pruning wood weight (kg)	1.39	0.22	16.1	1.47	0.36	24.2	1.06	0.23	21.5	1.50	0.34	22.6	3.20	1.01	31.5	4.66	1.47	31.5
Alcohol (°Baumé)	11.34	0.09	0.8	11.26	0.05	0.5	9.68	0.65	6.7	9.24	0.43	4.7	13.40	0.48	3.6	12.74	0.52	4.1
Must acidity (g L^{-1} tartaric)	8.87	0.97	10.9	9.00	0.25	2.8	11.01	1.28	11.7	10.91	0.94	8.6	7.79	0.94	12.1	9.61	1.65	17.1
Must yield (%)	23.89	7.96	33.3	24.37	2.71	11.1	16.72	2.49	14.9	17.00	2.45	14.4	28.78	2.55	8.8	29.52	3.84	13.0
Must pH	2.94	0.02	0.8	3.05	0.03	0.9	2.81	0.05	1.7	2.76	0.06	2.1	3.12	0.10	3.1	3.05	0.08	2.5

S.D., Standar deviation; V.C., Variation coefficient.

Table 3. Parameters measured in cluster, berry and seed of cv. Caíño Tinto.

Parameters	cv. Caíño Tinto Year 1						cv. Caíño Tinto Year 2						cv. Caíño Tinto Year 3					
	110R			SO4			110R			SO4			110R			SO4		
	Mean	S.D.	V.C.	Mean	S.D.	V.C.	Mean	S.D.	V.C.	Mean	S.D.	V.C.	Mean	S.D.	V.C.	Mean	S.D.	V.C.
Cluster weight (g)	160.37	35.03	21.8	113.62	35.07	30.9	148.12	27.55	18.6	75.14	19.98	26.6	220.60	59.18	26.8	150.55	27.41	18.2
Cluster length (cm)	10.42	0.86	8.3	10.15	1.03	10.2	10.58	1.41	13.3	7.83	1.54	19.6	10.20	1.36	13.4	9.93	0.93	9.4
Cluster width (cm)	7.78	1.52	19.5	8.22	2.05	25.0	8.54	1.38	16.2	5.95	0.98	16.5	8.22	3.25	39.5	7.71	1.62	21.1
Berry weight (g)	2.55	0.52	20.4	1.90	0.51	26.9	2.03	0.63	31.0	1.83	0.45	24.5	2.06	0.50	24.3	1.90	0.51	26.9
Berry length (cm)	1.66	0.13	7.6	1.42	0.12	8.3	1.38	0.16	11.4	1.43	0.11	7.6	1.46	0.13	9.1	1.42	0.12	8.3
Berry width (cm)	1.66	0.13	7.9	1.45	0.14	9.6	1.35	0.19	14.3	1.43	0.11	7.9	1.49	0.13	9.0	1.45	0.14	9.6
No. of seeds per berry	1.50	0.68	45.2	2.32	0.89	38.4	1.76	0.94	53.3	1.60	0.64	39.9	1.96	0.76	38.5	2.32	0.89	38.4
Pedicel length (cm)	0.64	0.11	17.0	0.57	0.08	14.6	0.51	0.12	24.2	0.56	0.13	22.4	0.59	0.08	14.1	0.61	0.12	19.5
Weight of the seed (g)	0.045	0.006	14.1	0.035	0.001	2.5	0.039	0.005	12.1	0.038	0.006	14.9	0.039	0.006	15.9	0.044	0.006	13.9
Length of the seed (cm)	0.76	0.03	3.8	0.75	0.04	4.8	0.68	0.04	6.0	0.65	0.05	7.6	0.67	0.04	5.7	0.69	0.05	6.7
Yield (kg plant^{-1})	3.76	1.29	34.3	2.05	1.09	53.4	2.94	0.62	21.1	1.08	0.62	57.1	6.95	1.59	22.9	3.20	1.38	43.3
Fertility	16.77	4.45	26.5	11.75	3.17	27.0	14.40	3.45	24.0	10.41	2.24	21.5	14.75	2.28	15.5	11.92	2.16	18.2
No. of clusters per shoot	2.50	0.43	17.3	2.00	0.00	0.0	2.28	0.26	11.6	1.85	0.24	13.1	1.98	0.19	9.8	1.82	0.20	11.2
Pruning wood weight (kg)	1.98	0.60	30.1	2.58	0.87	33.9	1.56	0.31	19.7	2.19	0.39	17.7	2.87	0.85	29.4	3.74	0.72	19.3
Alcohol (ºBaumé)	9.88	0.33	3.4	9.11	0.22	2.5	9.37	0.17	1.8	8.89	0.29	3.2	10.10	0.59	5.9	9.77	0.50	5.1
Must acidity (g L^{-1} tartaric)	12.80	0.21	1.6	12.92	0.56	4.3	15.76	1.14	7.3	16.01	0.89	5.6	13.71	0.96	6.7	13.42	0.81	6.1
Must yield (%)	38.86	4.76	12.2	38.62	2.30	6.0	30.49	3.95	12.9	28.16	3.35	11.9	38.83	11.31	29.1	46.43	2.53	5.5
Must pH	2.96	0.05	1.7	3.14	0.04	1.3	2.80	0.02	0.6	2.83	0.05	1.7	3.02	0.06	2.0	3.14	0.05	1.6

S.D., Standar deviation; V.C., Variation coefficient.

However, this influence differed with respect to cultivar (Table 1). Variables such as cluster weight, length and width ($p<0.01$), the number of clusters per shoot ($p<0.01$), probable alcohol content ($p<0.01$) and must yield ($p<0.001$) were all affected in Albariño, while cluster weight ($p<0.05$), berry weight ($p<0.05$), weight of pruned wood ($p<0.01$) and total acidity ($p<0.01$) were more affected in Caíño Tinto. These variables showed significant differences from one year to the next, clearly demonstrating the influence of weather conditions (Hidalgo, 2002). The behaviour of Caíño Tinto with respect to the variables "weight of pruned wood" and "cluster weight" changed significantly depending on both the rootstock type and year (Tables 1 and 3). However, the interaction of these variables was not significant. Rootstock SO4 always induced greater vigour and a lower cluster weight.

3. Influence of the rootstock × year interaction

The analysis of this interaction shows whether a rootstock is able to promote greater consistency in terms of production variables consistently every year. The rootstock × year interaction (Table 1) had a significant effect in Albariño with respect to the variables berry weight ($p<0.05$), berry width ($p<0.01$), seed length ($p<0.001$), pedicel length ($p<0.01$) and must pH ($p<0.01$), while in Caíño Tinto it affected cluster length ($p<0.01$), berry length and width ($p<0.001$), pedicel length ($p<0.001$), total fruit weight ($p<0.05$), must yield ($p<0.05$) and must pH ($p<0.001$). None of these variables showed any significant difference with respect to the influence of either rootstock or year alone. According to Vanden-Heuvel et al. (2004), who studied different C/R combinations, the type of rootstock can significantly influence the must pH. Giorgessi and Pezza (1992), however, indicated no significant rootstock × year interaction.

In conclusion, these results show that rootstock type used can influence some of the production variables of Caíño Tinto and Albariño. Even though Albariño and Caíño Tinto are ancient cultivars, it is necessary to note that first large plantations were made only just 20 years ago in Albariño and in the last 3-5 years in the case of Caíño Tinto. Due to this situation, it is no possible to compare our data, since no investigations at the agronomic level have been made concerning these two cultivars by other authors. Regarding the agronomic behaviour of Albariño and Caíño Tinto, our results suggest that the 110R rootstock is suitable under the edaphoclimatic conditions in the region where this study was carried out. However, the efficacy of these rootstocks concerning production of each cultivar in other regions where Albariño and Caíño Tinto are planted should be studied in future.

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** In Italian with English abstract.