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Research Note

Mantonico bianco Grapevine Cultivar Is the Second Parent of the Sicilian Catarratto

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Abstract: The molecular data provided in this paper add information on the very ancient presence of Mantonico bianco in southern Italy and the role it played in generating a number of southern Italian grapevine varieties. Using 47 SSR markers we showed that Mantonico bianco is the complementary genitor, with Garganega (syn. Grecanico dorato), of Catarratto, currently the main autochthonous white wine grapevine of Sicily and one of the most cultivated varieties in Italy. We discovered a first-degree relationship between Mantonico bianco and Guardavalle, one of the main and most diffuse autochthonous white wine grapes of Calabria region. SSR data also allowed some light to be shed on Mantonico/Montonico cultivars identity and revealed the wide spread of one of them, Montonico bianco, in central and southern Italy.

Key words: Garganega, Grecanico, Guardavalle, Montonico bianco, pedigree relationships, SSR markers

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Introduction

Pedigree studies have a considerable scientific and economic interest, because they significantly contribute to the knowledge of grapevine assortment evolution and increase the commercial appeal of traditional grape cultivars by teasing the curiosity of consumers about their history and geographical diffusion (Lacombe et al. 2013, Ruffa et al. 2016, Maul et al. 2016). They also offer the opportunity to re-evaluate and reconsider some ancient and little known varieties, which played an important role in the birth of those that are in vogue nowadays, especially ones with a high economic relevance worldwide. This is the case of Gouais blanc, involved in the parentage of Chardonnay, Gamay and tens of other French varieties (Boursiquot et al. 2004), of Hebén, a major founder of current varieties in the Iberian Peninsula viticulture (Lacombe et al. 2013, Zinelabidine et al. 2015), and of Mavasia aromatica di Parma, one of the genitors of many aromatic varieties of Piedmont (Ruffa et al. 2016). Previous studies revealed that Sangiovese and Garganega, syn. Grecanico dorato, two well-known ancient Italian cultivars used for top-quality wine production, are highly probably the genitors of a number of central and southern Italian varieties (Di Vecchi-Staraz et al. 2007, Crespan et al. 2008, Mercati et al. 2016). In particular, a first-degree relationship between Garganega and Catarratto was shown by different authors, based on SSR and SNP markers (Di Vecchi-Staraz et al. 2007, Crespan et al. 2008, Lacombe et al. 2013, Mercati et al. 2016). Catarratto is the most important autochthonous Sicilian cultivar and the fourth most cultivated in Italy, after Sangiovese, Montepulciano, and Merlot, as reported by the Italian Institute of Statistics in the sixth Italian census in agriculture (2010) (http://censimentoagricoltura.istat.it). Data referred to the production of Catarratto grafted vines showed an increasing trend, with more than 5,200,000 plants produced in 2014

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(http://catalogoviti.politicheagricole.it). Two cultivars of Catarratto *cépage* are registered in the Italian catalogue: Catarratto bianco comune and Catarratto bianco lucido, a somatic variant of the former, the name of which refers to the lower amount of waxes on its berry skin. Indeed, the two Catarratto cultivars share the same SSR molecular profile (Crespan et al. 2008, Mercati et al. 2016). In recent papers Mantonico bianco was recognized as the complementary parent of Gaglioppo, Mantonicone, and Nerello mascalese cultivars of Calabria and Sicily, Sangiovese being the other genitor (Cipriani et al. 2010, Gasparro et al. 2013). Starting from the large-scale SSR molecular characterization of the CREA-VIT grapevine collection, we noted that a first set of 13 SSR markers supported the possibility that Mantonico bianco could also be the second parent of Catarratto, by crossing with Garganega. An additional 34 SSR markers were therefore analyzed to support the parentage analysis. While Sangiovese and Garganega are widely known in Italy, Mantonico bianco is a minor, almost disappeared variety, only recently registered in the Italian Grapevine Catalogue (2014). It is grown in Calabria for varietal wines in the province of Reggio, along the Ionian coast, where it is recognized as "Mantonico of Bianco" and is localized mainly in the Locris area, a historical province of *Magna Graecia*. Mantonico bianco is supposed to have been brought to Calabria a very long time ago by the ancient Greek colonists. It is also named "Mantonacu viru" in this area, which means “true Mantonico” (Raimondi et al. 2008). Similarly to Greco di Bianco (syn. Malvasia delle Lipari, Crespan et al. 2006), Mantonico bianco is used to produce sweet wines according to the local tradition, harvesting the grapes at post-ripening, keeping them on racks to dry in the sun and crushing them when they are partially dehydrated. This white variety is also suitable for the production of quality table and sparkling wines (Cappelleri et al. 1987, Raimondi et al. 2008). Some other cultivars in Calabria have

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73 names that sound similar to Mantonico bianco, such as Montonico bianco, Montonico Pinto and
74 Montonico di Rogliano and it is very important not to confuse Mantonico bianco with them.
75 Their molecular profile is given in this paper, while ampelographic descriptions were proposed
76 in some papers that are difficult to find, but available on request (Antonacci and Placco 1984,
77 Antonacci et al. 1986, Antonacci and Placco 1986, Antonacci and Placco 1988). Using the
78 CREA-VIT molecular database, we noted that a first set of 13 SSR markers supported the
79 possibility that Mantonico bianco could also have a first-degree relationship with Guardavalle
80 cultivar. Guardavalle is one of the main and most widespread autochthonous white wine grapes
81 of Calabria; it is the main variety used to produce Cirò bianco wine and in the Cirò area
82 (Crotone) is called Greco bianco (Schneider et al. 2008a). We therefore extended our analysis to
83 47 SSR markers, in order to validate the parentage.

84 ## Materials and Methods

85 **Nuclear and chloroplast SSR analyses.** Twenty accessions from CREA-VIT
86 repositories and five samples from different places in central and southern Italy, recently
87 collected during prospections for old grapevine germplasm, were genotyped, using leaf or wood
88 tissues (Tab. 1). Thirteen SSR markers were used for varietal identification: the nine proposed as
89 common grape markers for international use within the framework of the GrapeGen06 European
90 project (VVS2, VVMD5, VVMD7, VVMD27, VrZAG62, VrZAG79, VVMD25, VVMD28,
91 VVMD32), plus ISV2 (VMC6e1), ISV3 (VMC6f1), ISV4 (VMC6g1), and VMCNG4b9. The
92 identity of each genotype was assessed by comparison with the literature data and CREA-VIT
93 molecular database, partially available in the Italian Grapevine Catalogue,
94 http://catalogoviti.politicheagricole.it/ and in the Italian Vitis Database, http://www.vitisdb.it/.

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Additional 34 SSR markers were used for pedigree analysis: VVS1, VVS29, VVMD17, VVMD21, VVMD24, VVMD26, VVMD31, VVMD36, VrZAG21, VrZAG64, VrZAG83, scu05, UCH11, VVIv37, VVIp31, VVIp60, VVIv69, VVIb09, VVIv33, VVIp77, VVIs21, VVIp37, VMC4f3, VMC1b11, VMC4c6, VMC1e12, VMC4g6, VMC2h9, VMC6e10, VMC3d7, VMC2g2, VMC4h6, VMC2h4, and VMC5g6.1 (see Crespan et al. 2008 and references herein). Garganega and Mantonico bianco were analyzed at 20 chloroplast microsatellite loci with the consensus primer pairs designed by Weising and Gardner (1999) for 5 ccmp loci, by Chung and Staub (2003) for 14 ccSSR loci, and by Bryan et al. (1999) for NTCP8 locus (Tab. 1S). The SSR analyses were performed following the protocols detailed in Crespan et al. (2008) (with silver staining) or in Migliaro et al. (2013), using fluorescent primers and an ABI3130xl genetic analyzer (Applied Biosystems, Foster City, CA), with some minor modifications. Reference varieties were used for allele calling.

Statistics. Statistical analysis of the Catarratto pedigree, i.e. the computation of the likelihoods of the hypothesized pedigree relationship and their significance as trio LOD scores, and for Guardavalle first-degree relationship was performed with Cervus software version 3.0.3 (Kalinowski et al. 2007), freely available at http://www.fieldgenetics.com. The molecular database used for computation encompassed 1702 unique SSR profiles of wine and table grapevine genotypes obtained by CREA-VIT. The number of genotypes analyzed per locus ranged from 205 to 1702 (Tab. 2S).

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Results

Cultivar identification. The first set of 13 loci used for grapevine variety identification produced six molecular profiles reported in Tab. 2. Mantonico bianco, Mantonicone, Montonico bianco, Montonico Pinto, Montonico di Rogliano and Montonico nero were different varieties, as corroborated by ampelographic descriptions (Antonacci and Placco 1984, Antonacci et al. 1986, Antonacci and Placco 1986, Antonacci and Placco 1988, Bruni 1962). Their molecular profiles were compared with the CREA-VIT database, literature and web site information. All accessions named Montonico di Rogliano showed the same molecular profile and corresponded to Guardavalle (Tab. 1). Montonico bianco was found under many different names: Montonico bianco di Bruni, Greco bianco del Pollino, Scala, Dolciolo, Chiapparone, Pagadebiti, Raspazzese, Trebbianone, Cioccolontano, Montonico Poggio delle rose, Ingannacane bianco, Chiapparù, Uva Regno (Tab. 1). Mantonico bianco and Mantonicone SSR profiles matched those reported by Gasparro et al. (2013); instead, Montonico nero and Montonico Pinto showed two original SSR profiles.

Catarratto's parentage. 1702 unique table and wine genotypes were used for Cervus software data computation. Statistics on the SSR markers used are reported in Tab. 2S. The number of alleles per locus ranged from 4 (VVS29) to 30 (VVMD28), with a mean of 15.87. The minimum number of individuals typed at one locus was 205. The mean proportion of individuals typed was 0.371; the mean expected heterozygosity was 0.781 and mean polymorphic information content was 0.752.

The molecular profiles of Mantonico bianco, Garganega and Catarratto at 47 SSR markers are reported in Tab. 3S. Catarratto shared one allele per locus with each of the presumed

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genitors. Our Mantonico bianco accession was shown to be triallelic at VMC2h4 locus, with 198, 216 and 232 bp alleles. The 216 bp allele is highly probably the mutant one, the other two being inherited by Guardavalle and Catarratto, respectively. No mismatching loci were found and the trio LOD score value computed by Cervus software was very high, 8.47E+15, similar to that obtained with the same set of SSRs for other already established pedigrees, as reported in Tab. 4S. Unfortunately, Mantonico bianco and Garganega did not show polymorphisms at any of the 22 chloroplast SSR loci analyzed (Tab. 1S), Catarratto was therefore not analyzed because the sexual role played by each genitor could not be determined. Guardavalle shared one allele per locus with Mantonico bianco at the 45 SSR markers analyzed (Tab. 3S). Cervus computation showed no pair loci mismatching and a high pair LOD score value of 3.67E+15, supporting the hypothesis of a first-degree relationship between the two varieties.

Discussion

Pedigree studies largely contribute to the knowledge of grapevine cultivars' evolution, showing that some ancient and little known varieties played an important role in the birth of those that are more or less widely cultivated nowadays (Ruffa et al. 2016, Maul et al. 2016). Previous papers showed that Mantonico bianco had played a key role in the birth of some southern Italian varieties, in particular of Calabria and Sicily (Raimondi et al. 2008). In this paper we have shown that Mantonico bianco is the second parent of Catarratto, the most important white wine grapevine of Sicily, in a cross with Garganega. Moreover, we found a first-degree relationship between Mantonico bianco and Guardavalle, one of the main and most widespread autochthonous white wine grapes of Calabria. Our data increase the information on the key role played by Mantonico bianco, in combination with Garganega and Sangiovese, in

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generating a number of southern Italian grapevine varieties, some of them of considerable economic and historical relevance (Fig. 1).

The long list of Montonico bianco synonyms, some of them coincident with those reported in the Italian Catalogue (http://catalogoviti.politicheagricole.it/), support the ancient presence of this interesting, now declining, cultivar. Montonico bianco is a double use variety, for wine and table grape, very resistant to late cold; it has medium resistance of leaves and grapes to downy and powdery mildew; in wet years, its grapes are easily attacked by rot (Bruni 1962). This genotype had spread mainly along Italian Adriatic regions, particularly Abruzzo and Marche, until Apulia and Calabria, suggesting a former wide distribution throughout central and southern Italy, with a copious number of different names. Thanks to the present research, Montonico bianco was found also in Tuscany and Umbria, in this last region as anonymous vines in ancient vineyards. Montonico Pinto is grown in the province of Cosenza, where it is also called Montonico Ciarchiarisi (Antonacci et al. 1986). This variety differs morphologically from the Montonico bianco described by Bruni (1962), for leaf and cluster traits, phenology and sensitivity to the major fungal diseases, especially powdery mildew (Antonacci et al. 1986). Montonico di Rogliano was shown to be another synonym of Guardavalle. In Calabria the names "Greco" and "Mantonico" or "Montonico" are very common and used to indicate different varieties with white and black berries (Schneider et al. 2008b). This tradition, probably linked more to the wines than cultivars, has caused great difficulties in developing knowledge on the rich grape varietal assortment of this region. A first-degree relationship between Montonico bianco and Garganega had already been evidenced (Crespan et al. 2008, Lacombe et al. 2013), the third variety to define the trio parents-offspring still being missing.

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No information is available on Montonico nero. Raimondi et al. (2008) reported that at least four distinct cultivars named Mantonico nero were found in Calabria region, representing a complex and so far unsolved case of homonymy. Interestingly, our Montonico nero accession shared one allele per locus with Mantonico bianco (Tab. 2), suggesting the possibility of it being another offspring of this ancient cultivar.

One of the possible reasons results from the widespread and deeply rooted practice of using a common name for several different varieties, like 'Moscato', 'Malvasia', 'Greco'. This habit may create misunderstandings when exchanging information on specific varieties and probably results from an overlap of the names of the wines with those of the varieties used to produce them. In the present research, we faced a similar case with Mantonico/Montonico cultivars, one of them, Montonico di Rogliano, corresponding to the better-known Guardavalle, syn. Greco bianco of Cirò. It would be appropriate to remove Mantonico bianco from the official synonyms of Montonico bianco in the Italian Catalogue, because it is confusing.

Conclusion

In this paper we have shown that Mantonico bianco is the second parent, with Garganega (syn. Grecanico dorato), of Catarratto, currently the most important autochthonous white wine grapevine of Sicily. Moreover, Mantonico bianco is linked as parent-offspring with Guardavalle, an important autochthonous cultivar of Calabria region. The molecular data produced in this study add information on the role that Mantonico bianco played in generating a number of southern Italian grapevine varieties, some of them, such as Catarratto, having considerable economic and historical value. The identification of the “missing” parent allowed these genealogical trees to be drawn up with greater precision. In addition, this research emphasizes

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the very ancient presence of Garganega and Mantonico bianco in southern Italy. SSR data allowed some light to be shed on Mantonico/Montonico cultivars identity and showed the wide diffusion of one of them, Montonico bianco, in central and southern Italy.

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Figure caption.

Fig. 1 - The role of Mantonico bianco in the pedigree of some cultivars of Sicily and Calabria regions.

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Table 1 List of accessions studied.

Accession name	Berry color*	Accession provenance	Repository	Identity by SSR	Literature references
Guardavalle	B	Calabria	CREA-VIT Susegana (Treviso, Italy)	Guardavalle	*V*IVC
Montonico di Rogliano_1	B	Rogliano (Cosenza)	CREA-VIT Spresiano (Treviso, Italy)		
Montonico di Rogliano_2	B	Rogliano (Cosenza)	CREA-VIT Spresiano (Treviso, Italy)		
Montonico di Rogliano_3	B	Rogliano (Cosenza)	CREA-VIT Spresiano (Treviso, Italy)		
Greco bianco di Cirò	B	Cirò (Crotone)	CREA-VIT Spresiano (Treviso, Italy)		
Montonico bianco	B	S. Severo (Foggia)	CREA-VIT Spresiano (Treviso, Italy)	Montonico bianco	Di Vecchi Staraz et al., 2007; Schneider et al., 2013
Montonico bianco di Bruni	B	Calabria	CREA-VIT Spresiano (Treviso, Italy)		
Greco bianco del Pollino	B	Calabria	CREA-VIT Spresiano (Treviso, Italy)		
Scala	B	Crispiano (Taranto)	CREA-VIT Spresiano (Treviso, Italy)		
Dolciolo	B	Vico del Gargano (Foggia)	CREA-VIT Spresiano (Treviso, Italy)		
Chiapparone or Pagadebiti	B	Torremaggiore (Foggia)	CREA-VIT Spresiano (Treviso, Italy)		
Raspazzese	B	Old collection in Velletri (Roma)	CREA-VIT Spresiano (Treviso, Italy)		
Trebbianone	B	Old collection in Velletri (Roma)	CREA-VIT Spresiano (Treviso, Italy)		
Cioccolontano	B	Old collection in Velletri (Roma)	CREA-VIT Spresiano (Treviso, Italy)		
Montonico Poggio delle rose	B	Cermignano (Teramo)	CREA-VIT Spresiano (Treviso, Italy)		
Ingannacane bianco	B	Siena	CREA-VIT Susegana (Treviso, Italy)		
Chiapparù	B	Carassai (Ascoli Piceno)			
Uva Regno	B	Carassai (Ascoli Piceno)			
Unknown white (Rantola 30)	B	Umbria			
Unknown (Pizziconi 1)	B	Umbria			
Mantonico bianco	B	Bianco (Reggio Calabria)	CREA-VIT Spresiano (Treviso, Italy)	Mantonico bianco	Gasparro et al., 2013
Mantonicone	B	Calabria	CREA-VIT Spresiano (Treviso, Italy)	Mantonicone	Gasparro et al., 2014
Montonico bianco Pinto	B	Calabria	CREA-VIT Spresiano (Treviso, Italy)	Montonico Pinto	present paper
Montonico nero	N	Calabria	CREA-VIT Spresiano (Treviso, Italy)	Montonico nero	present paper
Unknown (GP06)	N	Altomonte (Cosenza)			

*B = blanc, white, N = noir, black.

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Table 2 SSR profiles of the six cultivars studied. Allele lenghts are in bp..

SSR marker	GUARDAVALLE	MANTONICO BIANCO	MANTONICONE	MONTONICO BIANCO	MONTONICO NERO	MONTONICO PINTO
ISV2 (VMC6E1)	167	141	141	141	141	137
	169	169	143	169	165	143
ISV3 (VMC6F1)	133	133	133	139	139	133
	145	145	139	145	145	139
ISV4 (VMC6G1)	187	169	177	169	169	177
	191	191	191	177	191	191
VMCNG4B9	150	150	150	158	150	150
	164	164	158	176	164	158
VrZAG62	195	201	193	187	187	187
	201	201	201	199	201	193
VrZAG79	246	250	242	250	250	256
	250	250	250	250	250	258
VVMD5	226	226	226	232	226	232
	232	240	240	232	232	236
VVMD7	239	239	249	239	239	239
	253	249	263	249	239	249
VVMD25	245	245	245	245	245	243
	259	259	259	259	253	245
VVMD27	179	179	179	179	179	179
	189	179	185	185	189	179
VVMD28	231	231	231	249	231	251
	247	239	247	251	261	261
VVMD32	253	253	253	251	253	257
	273	253	257	253	259	259
VVS2	145	143	133	143	133	133
	151	151	151	145	143	133

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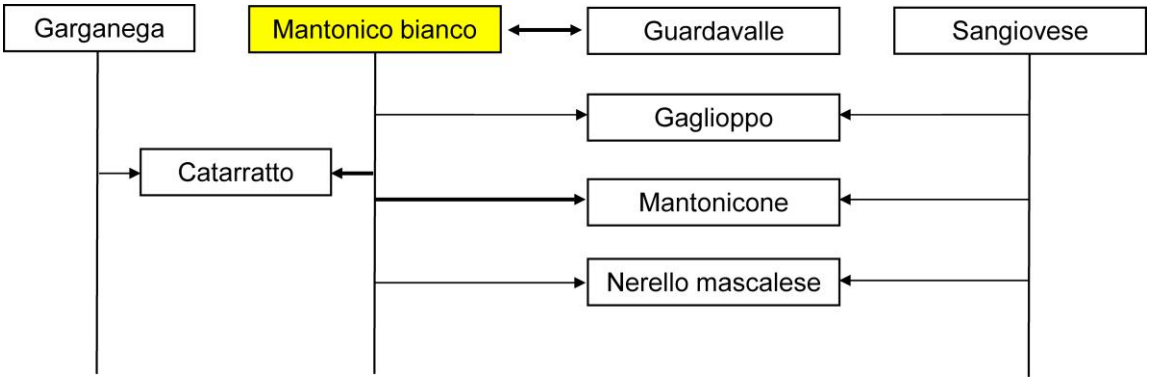

Figure 1 The role of Mantonico bianco in the pedigree of some cultivars of the Sicily and Calabria regions of Italy.

Supplemental Table 1 cpSSR profile of Mantonico bianco and Garganega. Allele lenghts are in bp.

ccmp3	107	ccSSR15	264
ccmp4	128	ccSSR16	356
ccmp5	104	ccSSR17	227
ccmp6	107	ccSSR18	264
ccmp10	115	ccSSR19	359
ccSSR4	279	ccSSR20	329
ccSSR6B	299	ccSSR21	281
ccSSR9	167	ccSSR22	185
ccSSR12	236	ccSSR23	281
ccSSR13	279	NTCP8	250

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Supplemental Table 2 Diversity statistics computed with Cervus software on 1702 unique genotypes using 47 SSR markers.[a]

SSR marker	k	N	HObs	HExp	PIC	HW	F(Null)
ISV2 (VMC6E1)	28	1672	0.85	0.855	0.839	***	0.0006
ISV3 (VMC6F1)	16	1459	0.797	0.668	0.614	***	-0.1025
ISV4 (VMC6G1)	14	1613	0.77	0.82	0.797	***	0.032
scu05	16	260	0.796	0.844	0.824	NS	0.0294
UCH11	9	249	0.783	0.787	0.754	NS	0.0018
VMC1b11	17	258	0.806	0.787	0.758	NS	-0.0123
VMC1E12	12	320	0.825	0.827	0.804	NS	0.0002
VMC2G2	10	285	0.67	0.728	0.682	NS	0.0405
VMC2H4	15	263	0.848	0.825	0.807	NS	-0.0192
VMC2H9	9	276	0.678	0.726	0.681	NS	0.0352
VMC3D7	8	267	0.678	0.692	0.645	NS	0.0152
VMC4C6	8	254	0.728	0.694	0.64	NS	-0.0261
VMC4f3	27	253	0.862	0.892	0.881	NS	0.0164
VMC4G6	9	277	0.762	0.764	0.732	NS	0.0032
VMC4H6	10	265	0.694	0.706	0.657	NS	0.0077
VMC5G6.1	24	255	0.867	0.831	0.815	NS	-0.0219
VMC6E10	17	300	0.907	0.901	0.892	NS	-0.0036
VMCNG4b9	27	1645	0.833	0.847	0.834	NS	0.0084
VrZAG21	11	360	0.822	0.786	0.754	NS	-0.0243
VrZAG62	24	1701	0.835	0.853	0.836	***	0.011
VrZAG64	25	402	0.836	0.836	0.816	NS	-0.0016
VrZAG79	16	1672	0.832	0.853	0.839	***	0.0119
VrZAG83	17	322	0.739	0.757	0.719	***	0.0056
VVIb09	5	243	0.691	0.737	0.688	NS	0.0313
VVIp31	22	252	0.889	0.902	0.891	NS	0.0058
VVIp37	10	238	0.739	0.751	0.724	NS	0.0068
VVIp60	19	267	0.704	0.758	0.724	NS	0.034
VVIp77	12	205	0.888	0.857	0.84	NS	-0.02
VVIs21	8	210	0.762	0.769	0.731	NS	0.0019
VVIv33	11	234	0.799	0.837	0.813	NS	0.0227
VVIv37	21	245	0.788	0.86	0.844	NS	0.0439
VVIv69	12	232	0.668	0.675	0.629	NS	0.0039
VVMD5	23	1635	0.829	0.858	0.842	***	0.016
VVMD7	20	1702	0.818	0.826	0.805	***	0.004
VVMD17	7	315	0.765	0.732	0.689	NS	-0.0233

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VVMD21	20	350	0.731	0.728	0.694	NS	-0.0061
VVMD24	12	371	0.69	0.683	0.648	NS	-0.0032
VVMD25	25	895	0.796	0.794	0.763	NS	-0.0019
VVMD26	8	310	0.561	0.574	0.494	NS	0.0108
VVMD27	25	1700	0.809	0.834	0.812	***	0.0145
VVMD28	30	1630	0.867	0.878	0.866	NS	0.0065
VVMD31	11	348	0.756	0.76	0.729	NS	0.0012
VVMD32	20	900	0.833	0.833	0.815	**	-0.0045
VVMD36	19	374	0.856	0.854	0.839	NS	-0.0044
VVS1	13	376	0.566	0.636	0.603	NS	0.068
VVS2	20	1686	0.837	0.849	0.833	NS	0.0061
VVS29	4	336	0.467	0.455	0.408	NS	-0.0177

[a]k = number of alleles, N = number of observed genotypes, Hobs = observed heterozygosity, Hexp = expected heterozygosity, PIC = polymorphic information content, HW Hardy–Weinberg equilibrium, NS not significant, **significant at the 1% level, ***significant at the 0.1% level, F(Null) = estimated frequency of null alleles.

Supplemental Table 3 Molecular profiles of Catarratto and presumed parents at 47 SSR loci (allele lenghts are in bp), and of Guardavalle. MD, missing data.

SSR	Variety			
	GARGANEGA	**CATARRATTO**	**MANTONICO BIANCO**	**GUARDAVALLE**
ISV2 (VMC6E1)	141	165	141	167
	165	169	169	169
ISV3 (VMC6F1)	133	139	133	133
	139	145	145	145
ISV4 (VMC6G1)	177	177	169	187
	187	191	191	191
scu05	165	165	165	MD
	169	165	190	
UCH11	242	236	236	MD
	246	242	242	
VMC1B11	172	172	172	172
	186	186	172	186
VMC1E12	240	240	250	254
	240	254	254	260
VMC2G2	125	119	119	125
	127	125	125	125
VMC2H4	206	206	198	198
	214	**232**	216 and 232	198
VMC2H9	123	117	117	123
	125	123	123	123
VMC3D7	163	161	161	159
	175	175	163	163
VMC4C6	163	163	157	157
	163	163	163	163
VMC4F3	188	174	174	190
	204	188	190	190
VMC4G6	129	129	129	129
	133	133	129	133
VMC4H6	152	152	158	158
	158	162	162	162

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VMC5G6.1	139	139	139	139
	151	151	139	139
VMC6E10	93	93	111	111
	117	113	113	119
VMCNG4B9	176	150	150	150
	178	176	164	164
VrZAG21	190	190	190	200
	202	200	200	206
VrZAG 62	199	199	201	195
	199	201	201	201
VrZAG64	137	139	137	137
	139	141	141	137
VrZAG79	250	250	250	246
	250	250	250	250
VrZAG83	190	194	190	190
	194	194	194	194
VVIb09	269	269	269	269
	269	269	269	275
VVIp31	173	173	173	181
	187	187	187	187
VVIp37	142	118	118	118
	144	144	118	138
VVIp60	324	320	316	316
	330	324	320	324
VVIp77	173	173	181	181
	187	181	191	191
VVIs21	280	280	280	280
	286	280	280	286
VVIv33	352	338	338	338
	352	352	338	342
VVIv37	148	156	156	158
	166	166	174	174
VVIv69	258	258	258	258
	272	258	278	258
VVMD5	226	226	226	226
	232	226	240	232
VVMD7	249	239	239	239
	253	249	249	253
VVMD17	222	221	220	220
	222	222	221	221
VVMD21	249	243	243	249
	249	249	249	258
VVMD24	210	210	210	210
	210	210	210	210
VVMD25	245	259	245	245
	259	259	259	259
VVMD26	251	249	249	251
	263	251	251	251
VVMD27	179	179	179	179
	194	179	179	189
VVMD28	239	231	231	231
	251	239	239	247
VVMD31	210	210	210	210
	213	210	216	210
VVMD32	251	251	253	253
	259	253	253	273
VVMD36	254	254	244	264
	266	296	296	296
VVS1	181	181	181	181
	181	181	190	190
VVS2	133	143	143	145
	143	151	151	151
VVS29	171	171	171	171
	171	171	171	171

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Supplemental Table 4 Computational results obtained with Cervus software about Catarratto presumed parents LOD score plus other known trios, for comparison.

Offspring	Parent 1	Parent 2	Trio loci compared	Trio loci mismatching	Trio LOD score
Catarratto	**Garganega**	**Mantonico bianco**	47	0	8.47 E+15
Raboso veronese	Raboso Piave	Marzemina bianca	47	0	1.12 E+16
Cabernet Sauvignon	Cabernet franc	Sauvignon blanc	47	0	1.05 E+16
Manzoni bianco	Pinot	Riesling weiss	47	0	9.59 E+15
Gaglioppo	Mantonico bianco	Sangiovese	47	0	8.45 E+15
Calmeria	Ohanez	Sultanina	47	0	7.93 E+15
Chardonnay	Gouais	Pinot	47	0	7.35 E+15
Delight	Koenigin der weingaerten	Sultanina	47	0	7.32 E+15
Cardinal	Alphonse Lavallee	Koenigin der weingaerten	47	0	6.93 E+15
Muscat of Alexandria	Heptakilo	Muscat à petits grains blancs	47	0	6.62 E+15
Gamay	Gouais	Pinot	47	0	6.29 E+15
Italia	Bicane	Muscat of Hamburg	47	0	6.15 E+15
Exalta	Muscat of Hamburg	Perlette	47	0	6.07 E+15