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Agronomic performance of 21 new disease resistant winegrape varieties grown in northeast Italy

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Summary

The goal of the field trial was to evaluate the agronomic performance of 21 (10 red and 11 white) winegrape varieties obtained from recent breeding programmes for disease resistance developed in Hungary, Germany, and Italy. The tested red varieties were as follows: 'Cabernet Carbon', 'Cabernet Eidos', 'Cabernet Volos', 'Julius', 'Merlot Khorus', 'Merlot Kanthus', 'Monarch', 'Prior', UD. 31.103, 'Vinera'. The tested white varieties were as follows: 'Aromera', 'Bronner', 'Fleurtai', 'Johanniter', 'Muscaris', 'Souvignier Gris', 'Sauvignon Kretos', 'Sauvignon Nepis', 'Sauvignon Rytos', 'Solaris', 'Soreli'. 'Merlot' (red) and 'Glera' (white) were included as control. The experimental vineyard was established in Castelfranco Veneto on the plain, in 2014. Spray treatments were applied against downy and powdery mildew, by using only copper and sulphur. Grape production, grape quality, and phenology were recorded over a six-year-period, while disease resistance (downy mildew, powdery mildew, black rot and anthracnose) was detected only during a few years. The most significant findings were: a) all varieties showed a good level of downy mildew resistance, especially 'Cabernet Carbon', 'Monarch', 'Prior', UD 31.103, 'Muscaris', 'Solaris', 'Souvignier Gris', 'Bronner', 'Fleurtai', 'Aromera'; b) no powdery mildew attacks were detected in any variety; c) 'Monarch', 'Muscaris', 'Solaris' and 'Souvignier Gris' also showed a high level of resistance towards black rot and anthracnose; d) red grape varieties had an earlier bud burst as compared to 'Merlot', and, concerning ripening, some varieties were earlier than 'Merlot', other ones were later; e) white varieties had a later bud burst but an earlier ripening time as compared to 'Glera'; f) grape production and quality changed significantly depending on the varieties, being titratable acidity higher than 6.4 g L^{-1} tartaric acid and pH lower than 3.5; also the year affected in a significant way those parameters as well as the interaction between the genotype and the year. In conclusion, the tested varieties behaved positively in terms of environmental sustainability.

Key words

grapevine, production, quality, diseases, phenology

Introduction

A way to cope with the need to reduce the use of pesticides in viticulture is to grow disease resistant/tolerant varieties (PIWI – *pilzwiderstandsfähige rebsorten*) (Bavaresco, 2019), which have been produced by inter-specific controlled crosses (Alleweldt and Possingham, 1988;; Reynolds, 2015; Schneider *et al.* 2019; Vezzulli *et al.*, 2022). In the Italian Register of Grapevine Varieties (www.catalogoviti.politicheagricole.it) 36 individuals are listed (35 only for wine making mostly of German and Italian origin, and one for both wine and fresh consumption), being the first ('Bronner' and 'Regent') registered in 2009 and the last ones ('Palma', 'Sevar', 'Ranchella') in 2021 (Bavaresco and Squeri, 2022). We can esteem that the Italian production area covered by these PIWI varieties is about 1,200 ha because official data are not yet available. Data on grafted cuttings production of Italian nurseries are available and the number of grafted cuttings increased over time reaching in 2021 about 2,376,000 (1.3 % of the Italian production).

The agronomic performances and the wine sensory profiles of PIWI are reported in the ampelographic descriptions de-

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veloped by the breeders, and referring to the environment were the new varieties were bred. When the cultivation is moved from the original place to another under different pedo-climatic conditions (different terroirs), it is necessary to test the interaction genotype-environment, in order to give the growers correct viticultural and oenological information (Nikolić *et al.*, 2017; Gonçalves *et al.*, 2020).

Material and Methods

The study was carried out in Castelfranco Veneto (Treviso province, Veneto region, Italy; 45° 40 'N; 11° 55' E; 43 m asl, temperate-warm climate) by the Agricultural High School-ISISS- Domenico Sartor. An experimental vineyard was established in spring 2014, on a loamy, sub-alkaline soil, using the following PIWI varieties grafted on SO4:

1. RED: 'Monarch', 'Prior', 'Vinera', 'Julius', UD 31103, 'Cabernet Carbon', 'Cabernet Volos', 'Cabernet Eidos', 'Merlot Khorus', 'Merlot Kanthus'.
2. WHITE: 'Solaris', 'Johanniter', 'Muscaris', 'Bronner', 'Aromera', 'Souvignier Gris', 'Soreli', 'Fleurtai', 'Sauvignon Rytos', 'Sauvignon Nepis', 'Sauvignon Kretos'.
3. 'Merlot' and 'Glera' were utilized as control, concerning the diseases.
4. Each PIWI variety included 24 vines, splitted in 3 sub-plots of 8 vines each (split-plot experimental design).

The vines were Guyot (one bended cane with 12 buds/vine) trained, 2.75 m × 0.75 m vine spacing (4,850 vines ha^{-1}), green covering as soil management, 50 Kg N ha^{-1} as organic fertilizer, drip irrigation, one trimming per year, with the following plant protection program: 2015-2016: no spray treatments on one sub-plot per variety and spray treatments (according to organic farming, by using only copper and sulfur) on the other two sub-plots per variety; 2017-2020: 3 to 4 treatments in each sub-plot per variety according to organic farming (only copper and sulfur), at 4th leaf (stage 9 by Eichhorn and Lorenz, 1977), pre-blooming (stage 17 by Eichhorn and Lorenz, 1977), after blooming (stage 25 by Eichhorn and Lorenz, 1977); 2021: integrated farming (systemic product at the beginning and then copper against downy mildew, and systemic product and sulfur against powdery mildew). Meteorological data (temperature and rainfall) were recorded during the experimental period (2015-2021), as well as the heat summation (Growing Degree Days, from April to October, according to Winkler *et al.*, 1974), relying on climatic data obtained from a meteorological station located in the vineyard.

The following evaluations were performed:

1. downy mildew (*Plasmopara viticola*) and powdery mildew (*Erysiphe necator*) damage on young leaves and clusters (mid-July, 2016 and 2017) was evaluated with the classification of about 100 organs (4 leaves per plant and 4 clusters per plant, from 4 representative shoots per plant, and 24 vines per variety) for each experimental unit, according to the Townsend-Heuberger formula (1943);
2. anthracnose (*Elsinoë ampelina*) damage on the middle part of the shoots and on the clusters (2017 and 2020), was evaluated with the classification of about 100 organs chosen as above described, for each experimental unit, according to the Townsend and Heuberger (1943) formula;
3. black rot (*Guignardia bidwellii*) damage on the young leaves and on the clusters (2017) was evaluated with the classification of about 100 organs chosen as above described, and phylloxera (*Daktulosphaira vitifoliae*) occurrence on the top leaves (2020) was evaluated with the classification of about 100 organs chosen as above described, for each experimental unit, according to the Townsend and Heuberger (1943) formula;
4. phenology (2015, 2016, 2017), was studied by checking about 100 organs (4 representative shoots per vine) every 7 days, with the date determination of the main growth stages: bud burst (by monitoring every cane per vine, stage 5 by Eichhorn and Lorenz, 1977), full blooming (stage 23 by Eichhorn and Lorenz, 1977), beginning of veraison (stage 35 by Eichhorn and Lorenz, 1977), berry juice at 18°Brix;
5. productive parameters of the vines, at harvest (2015, 2016, 2017, 2018, 2019, 2021): yield per vine (kg), cluster mass (g) and bud fertility;
6. qualitative parameters of grapes, at harvest (2015, 2016, 2017, 2018, 2019, 2021): soluble solids (°Brix), titratable acidity ($g \cdot L^{-1}$) and pH.

The data of fungal infections were processed according to one-way ANOVA, while the productive and qualitative parameters were processed according to a two-way-ANOVA, after the control of the normal distribution of the data; in the case of the productive parameters only the values of the different varieties are reported in this paper. The differences were tested according to a Tukey test for $p<0.05$. Concerning the percentages, the statistics were calculated after the angular transformation and the differences among the values were tested according to the Duncan test for $p<0.05$, with the use of the IBM SPSS statistics 27.

Results

The patterns of the monthly average temperatures and the monthly rainfall of the 2015-2021 period (supplementary Fig. 1) represent the typical temperate climate with the hottest month in July (average temperature 24.6 °C) and two rainfall picks in May (163 mm) and November (113 mm). As concerning the heat summations (supplementary Fig. 2) six out of seven years were warmer than the last 25-year- average (1960 °C), while five out of seven years were less rainy than the last 25-year- average (1130 mm) (supplementary Fig. 3).

Concerning the downy mildew resistance, only data from 2016 are reported; the tested varieties performed well especially at cluster level (Tables 1, 2); the damages were nil for 'Cabernet Carbon', 'Solaris', 'Muscaris', 'Fleurtai', very low (< 3%) for most of the varieties and low for 'Cabernet Volos', 'Vinera' and 'Sauvignon Rytos' (8%, 10% and 12% respectively); 'Merlot' and 'Glera' (reference varieties), had a very high value (87.5%), as expected.

Data on powdery mildew attack are not reported because no symptoms were observed.

Concerning anthracnose (Tables 3 and 4), some varieties showed severe symptoms, increasing from 2017 to 2020. Among the red varieties 'Monarch', 'Prior', 'Vinera', 'Cabernet Carbon' and 'Cabernet Eidos' showed the lowest infection levels while 'Julius', UD 31103, 'Cabernet Volos', 'Merlot Khorus' and 'Merlot Kanthus' showed the highest infection (up to 75%). Among the white varieties 'Solaris', 'Muscaris', 'Souvignier Gris' and 'Bronner' were the less infected, while the others were the most infected, especially 'Soreli' (75%). Leaf phylloxera (Table 3) did not affect at all 'Monarch' and 'Vinera', while 'Cabernet Volos' showed the highest infection rate (66.7%); within the white varieties 'Johanniter' and 'Aromera' showed no symptoms and 'Muscaris' was the most damaged by phylloxera (66.7%) on the apical leaves (Table 4).

Within red varieties, black rot leaf symptoms were significantly lower in 'Monarch', 'Cabernet Eidos' and 'Merlot Kanthus', without differences in 'Merlot', but the bunch symptoms didn't vary significantly among the varieties. 'Solaris', 'Muscaris', 'Souvignier Gris' and 'Bronner' (within the white

Table 1: Downy mildew damage (%) in the red varieties, assessed mid-July 2016, in young leaves and clusters, according to Townsend and Heuberger (1943) formula

Damage %	2016			
Varieties	**Downy mildew leaves**		**Downy mildew clusters**	
Monarch	0.4	ab	0.4	ab
Prior	0.8	ab	0.4	ab
Vinera	5.0	bc	9.6	cd
Julius	0.4	ab	0.8	abc
UD 31103	1.2	ab	0.4	ab
Cabernet Carbon	0.01	a	0.01	a
Cabernet Volos	3.7	abc	8.3	bc
Cabernet Eidos	11.7	bc	0.8	abc
Merlot Khorus	0.4	ab	1.2	ab
Merlot Kanthus	27.9	cd	1.7	abc
MERLOT	87.5	d	87.5	d
F Variety (V)	4.97	**	4.76	**

F (Fisher statistic) ns = not significant, * = significant $p < 0.05$, ** = significant $p < 0.01$; the values followed by different letters were significantly different according to Fisher and Duncan tests calculated on the angular transformations of the %.

Table 2: Downy mildew damage (%) in the white varieties, assessed mid-July 2016, in young leaves and clusters, according to Townsend and Heuberger (1943) formula

Damage %	2016			
Varieties	**Downy mildew leaves**		**Downy mildew clusters**	
Solaris	2.9	a	0.0	a
Joahnniter	2.9	a	2.1	a
Muscaris	0.0	a	0.0	a
Bronner	1.2	a	1.4	a
Aromera	0.4	a	0.4	a
Souvignier Gris	0.6	a	0.4	a
Soreli	0.0	a	2.9	a
Fleurtai	2.9	a	0.0	a
Sauvignon Rytos	37.5	b	12.1	b
Sauvignon Nepis	30.4	b	1.7	a
Sauvignon Kretos	5.8	a	1.2	a
GLERA	87.5	c	87.5	c
F Variety (V)	6.12	**	6.41	**

F (Fisher statistic), ns = not significant, * = significant $p < 0.05$, ** = significant $p < 0.01$; the values followed by different letters were significantly different according to Fisher and Duncan tests calculated on the angular transformations of the %.

varieties) were completely resistant toward black rot at leaf level (supplementary Table 1 and 2) while 'Sauvignon Kretos', 'Soreli', 'Fleurtai' and 'Johanniter' were the most affected.

Bud burst and ripening time (considered when the grapes reached 18 °Brix) were compared to 'Merlot' and 'Glera' (supplementary Fig. 4 and 5). Among the red varieties 'Cabernet Carbon', 'Cabernet Eidos' and 'Merlot Kanthus' had the same bud burst date as 'Merlot' (4th week of April) while the others were earlier (especially 'Prior'). All the white varieties (especially 'Aromera', 'Soreli', 'Sauvignon Rytos') had a later bud burst time than 'Glera'. UD.31.103 ripened very early (1st week of August) while 'Cabernet Eidos' and 'Vinera' ripened later (4th week of August); the others, including 'Merlot', were in between. All the white varieties ripened earlier than 'Glera', ranging from 'Solaris' and 'Muscaris' (1st week of August) to 'Aromera' (3rd week of August).

Table 3: Anthracnose and phylloxera damage (%) in red varieties assessed mid-July 2017 and 2020, in shoots and clusters, according to Townsend and Heuberger (1943) formula

Damage %	Anthracnose shoots		Anthracnose grapes		Anthracnose shoots		Anthracnose grapes		Phylloxera top leaves	
Varieties	**2017**				**2020**					
Monarch	0.0	a	0.0	a	4.2	a	8.3	b	0.0	a
Prior	0.0	a	0.0	a	12.5	ab	16.7	ab	25.0	ab
Vinera	0.0	a	0.0	a	33.3	c	41.7	cd	0.0	a
Julius	41.7	cd	45.8	c	75.0	d	75.0	e	29.2	ab
UD 31103	9.2	ab	9.2	ab	75.0	d	75.0	e	33.3	ab
Cabernet Carbon	0.0	a	0.0	a	16.7	abc	16.7	ab	37.5	ab
Cabernet Volos	39.2	bcd	30.8	abc	75.0	d	75.0	e	66.7	b
Cabernet Eidos	10.8	abc	16.7	abc	25.0	bc	33.3	bc	4.2	a
Merlot Khorus	54.2	d	37.5	bc	58.3	d	75.0	e	29.2	ab
Merlot Kanthus	20.8	abc	22.5	abc	66.7	d	58.3	de	8.3	a
MERLOT	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a
F Variety (V)	*5..94*	**	*3.48*	**	*27.21*	**	*22.36*	**	*5.47*	**

F (Fisher statistic), ns = not significant, * = significant p < 0.05, ** = significant p < 0.01; the values followed by different letters were significantly different according to the Fisher and Duncan tests calculated on the angular transformations of the %.

Table 4: Anthracnose and phylloxera damage (%) in white varieties, assessed mid-July 2017 and 2020, in shoots and clusters, according to Townsend and Heuberger (1943) formula

Damage %	Anthracnose shoots		Anthracnose grapes		Anthracnose shoots		Anthracnose grapes		Phylloxera top leaves	
Varieties	**2017**				**2020**					
Solaris	0.0	a	0.0	a	29.2	bc	8.3	a	25.0	cd
Joahnniter	25.8	bc	29.2	ab	41.7	cd	75.0	d	0.0	a
Muscaris	12.5	ab	0.0	a	16.7	bc	12.5	a	66.7	f
Bronner	9.2	ab	14.2	abc	41.7	cd	58.3	bc	41.7	de
Aromera	29.2	bcd	41.7	bcd	50.0	d	50.0	b	0.0	a
Souvignier Gris	0.8	a	0.8	a	41.7	cd	0.0	a	45.8	e
Soreli	66.7	f	66.7	d	66.7	d	75.0	d	8.3	ab
Fleurtai	50.0	d	45.8	cd	75.0	e	75.0	d	16.7	bc
Sauvignon Rytos	41.6	cde	45.8	cd	66.7	d	66.7	cd	29.2	cd
Sauvignon Nepis	21.7	abc	22.5	ab	41.7	cd	66.7	cd	8.3	ab
Sauvignon Kretos	58.3	ef	58.3	d	75.0	e	75.0	d	33.3	cd
GLERA	0.0	a	0.0	a	0.0	a	0.0	a	0.0	a
F Variety (V)	*14.54*	**	*9.57*	**	*37.31*	**	*84.48*	**	*21.71*	**

F (Fisher statistic), ns = not significant, * = significant p < 0.05, ** = significant p < 0.01; the values followed by different letters were significantly different according to the Fisher and Duncan tests calculated on the angular transformations of the %.

All productive parameters at harvest, were significantly affected by genotype, year and their interaction in the case of both red (Table 5) and white varieties (Table 6). Due to space limitations only the role of the variety is reported below; it is interesting to notice the high bud fertility of all varieties, especially 'Cabernet Volos' (3.1) and 'Sauvignon Rytos' (2.7).

Soluble solids and titratable acidity of red varieties (average values of six years) are plotted in Figure 1; soluble solids ranged from 19.3 °Brix ('Vinera' and 'Cabernet Eidos') to 22.4°Brix ('Julius'), while titratable acidity ranged from 6.7 g L^{-1} ('Merlot Kanthus') to 10.1 g L^{-1} ('Merlot Khorus'). Concerning the white varieties (Fig. 2) 'Solaris' accumulated the highest level of soluble solids (23.1 °Brix), while 'Aromera' the lowest (18.3°Brix); 'Fleurtai' had the lowest acidity level (6.4 g L^{-1}) and 'Sauvignon Nepis' the highest one (10.4 g L^{-1}).

Discussion

The field trial allowed to give important agronomic data for growers of northeast Italy, considering that most of the tested PIWI varieties (the German ones) were obtained in other environments. It is crucial to assess the viticultural performance including the real degree of resistance/tolerance to diseases, considering different fungal pressure in different growing environments (Stefanini *et al.*, 2019). When the experiment started (2014) it was not yet clear how many spray

Table 5: Productive parameters of the red varieties at harvest

Varieties	bunches/node (#)		bunch mass (g)		yield/vine (kg)		bunches/vine (#)	
Monarch	2.0	ab	148	de	2.9	c	21	ab
Prior	1.8	a	155	e	2.8	c	18	a
Vinera	2.1	ab	135	d	2.9	c	22	ab
Julius	2.4	bc	103	bc	2.3	b	25	bc
UD 31103	2.2	ab	110	c	2.4	b	24	bc
Cabernet Carbon	1.8	a	79	a	1.4	a	18	a
Cabernet Volos	3.1	d	86	ab	2.8	bc	35	d
Cabernet Eidos	2.7	c	74	a	1.8	a	21	ab
Merlot Khorus	2.0	ab	90	ab	1.8	a	26	ab
Merlot Kanthus	1.8	a	100	bc	1.7	a	18	a
F Variety (V)	17.08	**	35.79	**	16.87	**	22.79	**
Year (Y)	63.95	**	70.22	**	60.74	**	63.55	**
V × Y	1.51	*	3.14	**	3.21	**	3.82	**

F (Fisher statistic), ns = not significant, * = significant $p < 0.05$, ** = significant $p < 0.01$; the values followed by different letters were significantly different according to Fisher and Tukey tests.

Table 6: Productive parameters of the white varieties at harvest

Varieties	bunches/node (#)		bunch mass (g)		yield/vine (kg)		bunches/vine (#)	
Solaris	2.5	c	81	b	2.4	c	28	cd
Joahnniter	1.8	a	98	c	1.8	b	20	b
Muscaris	2.2	b	94	c	2.3	c	25	c
Bronner	2.3	bc	110	d	2.7	c	25	c
Aromera	1.6	a	69	a	1.2	a	18	ab
Souvignier Gris	1.8	a	122	e	2.5	c	21	b
Soreli	2.6	c	101	cd	3.0	d	29	cd
Fleurtai	2.6	c	84	b	2.4	c	30	cd
Sauvignon Rytos	2.7	c	69	a	1.8	b	29	cd
Sauvignon Nepis	1.5	a	71	a	1.2	a	16	a
Sauvignon Kretos	2.1	b	95	c	2.5	c	26	c
F Variety (V)	18.85	**	30.99	**	27.80	**	17.96	**
Year (Y)	151.04	**	48.16	**	180.45	**	127.01	**
V × Y	6.05	**	4.36	**	6.15	**	7.07	**

F (Fisher statistic), ns = not significant, * = significant $p < 0.05$, ** = significant $p < 0.01$; the medium values followed by different letters were significantly different according to Fisher and Tukey tests.

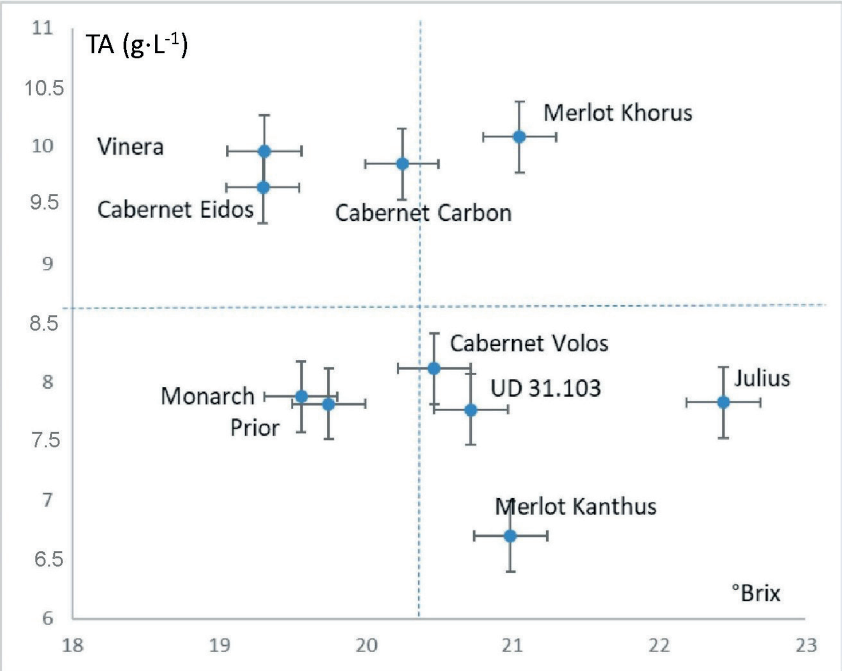

Fig. 1: Red varieties: grape soluble solids (°Brix) and titratable acidity (TA) at harvest (average values and standard error): the values are the mean of the six years.

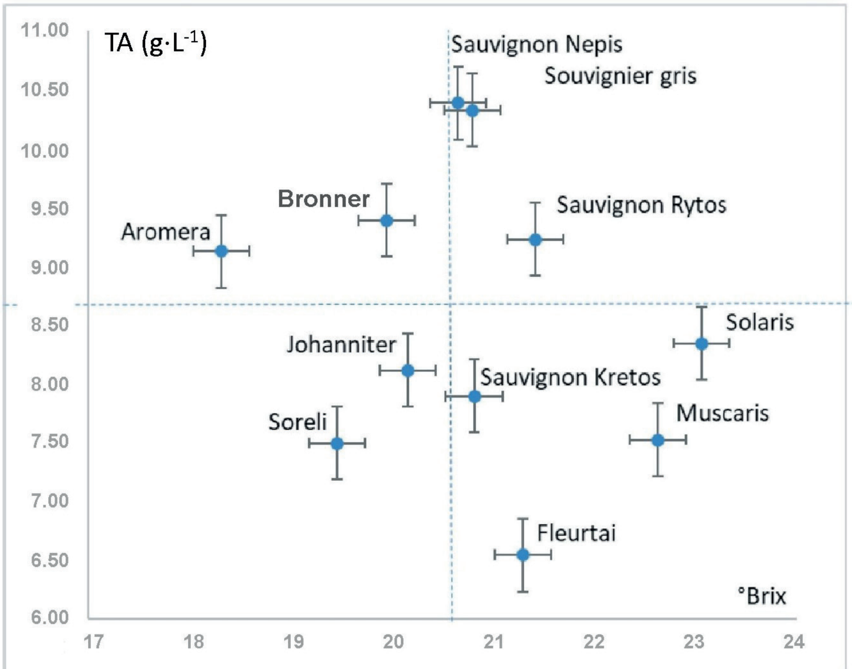

Fig. 2: White varieties: grape soluble solids (°Brix) and titratable acidity (TA) at harvest (average values and standard error): the values are the mean of the six years.

treatments (not any or a few) were needed for the different grape varieties in order to perform well in terms of downy mildew resistance. That is why during the first two years, a subset of vines (per each variety) was kept unsprayed, resulting in an unexpected severe spread of anthracnose and black rot in some varieties in the following years, which were not controlled by the organic farming protection plan. As concerning black rot, it is interesting to observe that varieties having 'Merzling' in the pedigree (like 'Monarch', 'Prior', 'Solaris', 'Muscaris', 'Bronner') were unaffected or very low affected. 'Merzling' is a complex genotype derived from 'Seyval' × ('Riesling' × 'Pinot Grigio'), obtained by the Staatliches Weinbauinstitut Freiburg (Germany) showing a major QTL for black rot resistance (Bettinelli *et al.*, 2022). According to these data we can conclude that it is necessary to protect the vines against all the fungi from the beginning. All the tested PIWI varieties were anyway able to resist downy mildew and powdery mildew infection under an organic farming protection program (providing 3 to 4 sprays/year) and in an environment quite warm and humid during the vegetative cycle. Phenology was another important element described in this experiment. The mid/late bud burst was a positive aspect for all varieties, allowing them to escape spring frost damages, while the ripening time was early for all of them, occurring during the month of August; this seems not to be good in terms of resilience to global warming, even though vinification and sensory analysis were not done in the current experiment. No problems seem to occur concerning the grape production, as all varieties are very fertile (up to 3 clusters/shoot) with no double shoot per node. Even sugar accumulation was not a problem (high values) as well as the acidity which was quite high despite the warm harvest time (August).

Conclusions

The tested PIWI varieties showed a good downy mildew and powdery mildew resistance under an organic farming protection plan with 3 to 4 spray treatments per year, while some of those were affected by anthracnose and black rot. They all accumulated a good level of sugars while keeping an acidity above 6 g L^{-1} at harvest, ripening early (August), especially the white ones.

Conflicts of interest

The authors declare that they do not have any conflicts of interest.

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Agronomic performance of 21 new disease resistant winegrape varieties grown in northeast Italy

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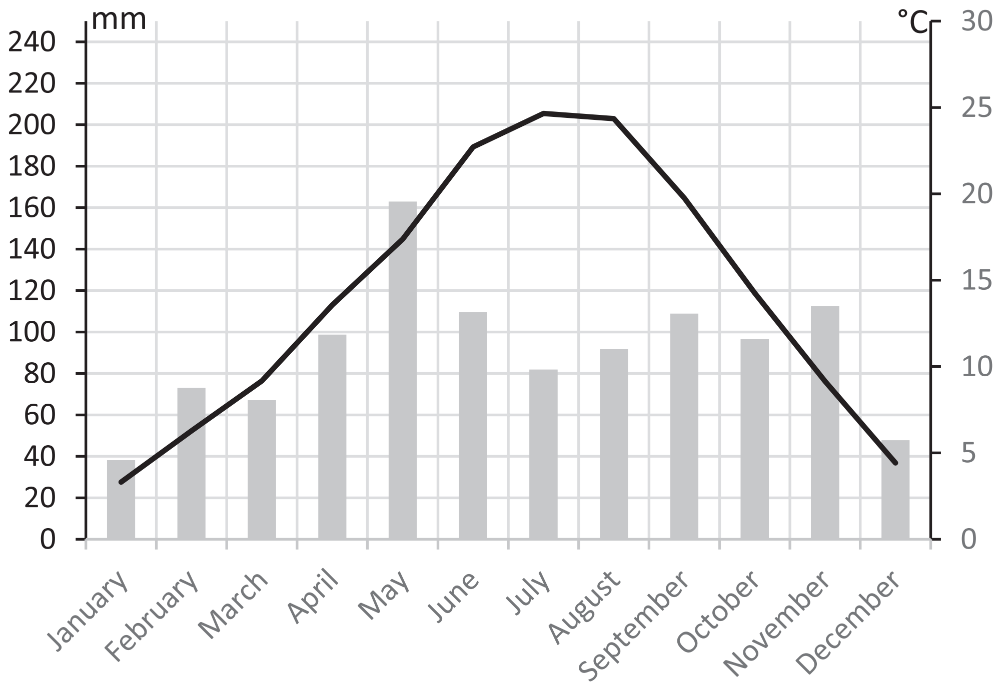
Supplementary material



Supplementary Fig. 1: Castelfranco Veneto: monthly average temperature (T °C, line) and rainfall summation (R mm, histogram) for the period 2015-2021; average annual rainfall = 1089 mm

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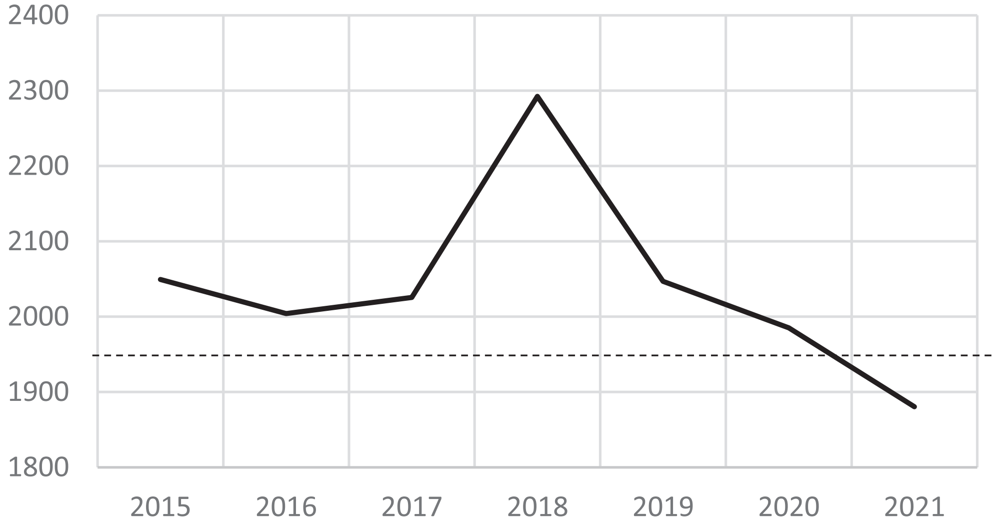
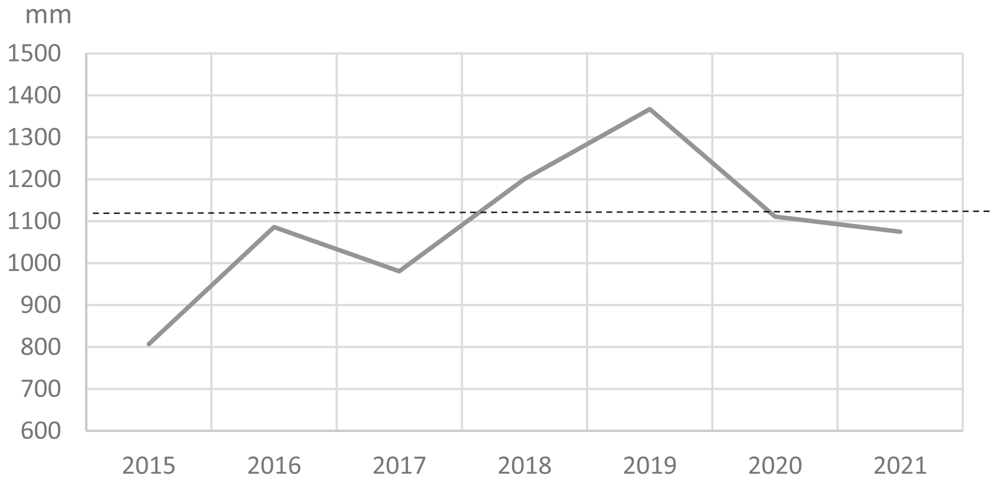


Supplementary Fig. 2: Castelfranco Veneto: heat summation ∑ DD (Apr-Oct) for the 7 experimental years and the average value of the period 1994-2021 (dotted line = 1960 ∑ DD). DD: Degree-Days (°C)



Supplementary Fig. 3: Castelfranco Veneto: annual rainfall for the 7 experimental years and the average value of the period 1994-2021 (dotted line = 1130 mm).

		Monarch	
<u>*Bud burst*</u>		UD 31.103	
		Vinera	Cabernet Carbon
		Cabernet Volos	Merlot Kanthus
		Julius	**Merlot**
	Prior	Merlot Khorus	Cabernet Eidos
April			
1st week	*2nd week*	*3rd week*	*4th week*
Glera	Sauvignon Nepis	Fleurtai	Aromera
	Muscaris	Souvignier gris	Soreli
		Solaris	Sauvignon Rytos
		Sauvignon Krethos	
		Johanniter	
		Bronner	

Supplementary Fig. 4: Graphic representation of bud burst time for the red (above) and the white (below) varieties.

		Merlot		
Ripening		Monarch		
	Julius	Cabernet Carbon		
	Merlot Kanthus	Prior	Cabernet Eidos	
UD 31.103	Cabernet Volos	Merlot Khorus	Vinera	
August				*September*
1st week	*2nd week*	*3rd week*	*4th week*	*1st week*
Solaris	Sauvignon Krethos	Aromera		**Glera**
Muscaris	Sauvignon Nepis			
	Fleurtai			
	Johanniter			
	Bronner			
	Souvignier gris			
	Soreli			

Supplementary Fig. 5: Graphic representation of ripening time for the red (above) and white (below) varieties.

Supplementary Table 1: Black rot damage (%) in young leaves and clusters of the red varieties, assessed mid-July 2017, according to Townsend and Heuberger (1943) formula

Damage %	2017			
Varieties	**Black rot leaves**		**Black rot clusters**	
Monarch	0.0	a	5.0	
Prior	0.8	ab	20.7	
Vinera	12.5	bc	20.8	
Julius	25.0	c	16.7	
UD 31103	2.4	ab	11.7	
Cabernet Carbon	8.3	ab	14.2	
Cabernet Volos	9.2	ab	12.5	
Cabernet Eidos	0.8	a	5.0	
Merlot Khorus	5.8	ab	16.7	
Merlot Kanthus	1.7	a	20.8	
MERLOT	0.0	a	0.0	
F Variety (V)	*4.87*	**	*0.48*	*ns*

F (Fisher statistic), ns = not significant, * = significant p < 0.05, ** = significant p < 0.01; the values followed by different letters were significantly different according to the Fisher and Duncan tests calculated on the angular transformations of the %.

Supplementary Table 2: Black rot damage (%) in young leaves and clusters of the white varieties, assessed mid-July 2017, according to Townsend and Heuberger (1943) formula

Damage %	2017			
Varieties	**Black rot leaves**		**Black rot clusters**	
Solaris	0.0	a	1.7	a
Joahnniter	12.5	ab	30.0	cde
Muscaris	0.0	a	0.0	a
Bronner	0.8	a	2.5	a
Aromera	21.7	bcd	25.0	bcd
Souvignier Gris	0.0	a	0.0	a
Soreli	20.8	bc	41.7	de
Fleurtai	33.3	d	33.3	de
Sauvignon Rytos	5.0	a	8.3	ab
Sauvignon Nepis	5.0	a	14.2	abc
Sauvignon Kretos	25.0	de	45.8	e
GLERA	0.0	a	0.0	a
F Variety (V)	14.37	**	13.19	**

F (Fisher statistic), ns = not significant, * = significant p < 0.05, ** = significant p < 0.01; the values followed by different letters were significantly different according to the Fisher and Duncan tests calculated on the angular transformations of the %.