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Phenological Diversity of Georgian Grapevine Cultivars in Northern Italy

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Abstract

One hundred thirty four Georgian native grapevine (*Vitis vinifera* L.) cultivars were tested in a field collection, located in Gorizia, Northern Italy within the framework of the international project of Bioversity International "Conservation and sustainable use of grapevine genetic resources in the Caucasus and Northern Black Sea area". Phenological timing and grape ripening profiling were recorded in the three year period 2004-2006. Average multi-year phenological data demonstrated that the timing of bud break and flowering of the Georgian germplasm was slightly later when compared with Western European cultivars. Veraison timing was clearly later and showed a very wide time span. Ripening time was, on average, also late. Ripening profiles in terms of juice soluble sugar concentration, pH and titratable acidity were ample; few cultivars were unable to reach an adequate maturity. The Georgian grape cultivars were separated into four main groups according to their time of ripening.

Georgia, a country of the South Caucasus, has an ancient viticultural and oenological history, dating back over 8000 years, as attested by the Shulavei–Shomu Tepe culture (VI-IV Millenium BC) which has provided early archaeological evidence, including palaeobotanical remains of domesticated cereals and grapes (6, 25). Long periods of cultivation and propagation activities by local populations led to the selection of local grapevine cultivars which have been collected in germplam repositories since 1890 (29). In the 1930's, expeditions across all of the provinces of Georgia allowed most of the local germplasm to be collected, which is now retained in nine collections in Georgia (21) and in other countries including Italy, Moldova, Ukraine, Russia, France and others. The origins of this germplasm have been confirmed by ampelographic descriptions that first occurred in 1846, and since then in many national and international ampelographies (1, 8, 9, 17, 18, 26, 31), books (32) and viticultural research papers, as well as by linguistic and historical investigations (15). The application of recently-developed molecular tools has demonstrated that there are significant genetic differences between Georgian and West European germplasm and have confirmed the uniqueness of these cultivars which have few parent–offspring relationships with germplasm from neighboring or West European cultivars (11, 14, 33).

There are a number of reasons that make the evaluation of Georgian grapevine (*Vitis vinifera* L.) germplasm in West European areas interesting. This germplasm comprises a very wide range of cultivars (525 according to Ketskhoveli *et al*. (17)), with various ampelographic characters and agronomical traits. They are most commonly wine grapes due to the deep-rooted Georgian oenological traditions. The cultivars, selected across a wide range of different environmental and cultural conditions within the country, have in general the expected patterns of low resistance to mildew-related fungal diseases (which is typical for the *V. vinifera* species). Grapes from the humid areas of West Georgia are quite resistant to berry splitting and cracking caused by rainfall. The oenological features of this genetic material are also very different from Western European material (9, 12, 22). With the exception of two cultivars, 'Rkatsiteli' and 'Saperavi', which are widely

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grown in Eastern Europe (13) and two others, 'Tavkveri' and 'Chinuri', which are grown in Azerbaijan, Uzbekistan, Russia and Moldova (4), Georgian cultivars are generally only currently cultivated exclusively in their regions of origin. Moreover, after the spread of Phylloxera (*Daktulosphaira vitifoliae* Fitch) and fungal diseases from North America, like powdery mildew (*Uncinula necator* (Schweinitz) Burrill) and downy mildew (*Plasmopara viticola* (Berkeley & Curtis) Berlease & de Toni), there has been a sharp contraction in the areas in Georgia that are cultivated compared to the past, and many of the cultivars are now available only in germplasm collections.

The viticultural and enological evaluation of these cultivars is interesting because of their possible cultivation for innovative wine quality profiles, which could be different compared to wines from Western cultivars. There is also an interest in possible sources of useful genes for breeding programs for qualitative characters and/or for tolerance to biotic and abiotic stresses.

Among other features, the phenological timing of ripening appears to be of real interest. Management of possible climate change might be possible by using cultivars more suited to expected climatic conditions in the future, thus allowing a close match between the timing of ripening and the temperature profile of the growing site. In particular, in warmer viticultural areas, the selection of late ripening cultivars would allow summer stresses during ripening to be avoided and for any reduced enological quality to be managed (16, 28, 34, 35).

This germplasm is highly significant and very important in Georgia - local viticulture and winemaking is based on native cultivars. The Georgian Law "About Vine and Wine" (20) recommends 37 wine and 13 table grape cultivars including both white and coloured berries. Of these, for those used for winemaking, 31 are local and only 6 are introduced, and for fresh consumption 4 are local and 5 are from local breeding programs. During the last 50 years, only a limited number of local cultivars have been grown in the majority of vineyards in the country (3, 4, 5, 17) (Table 1). A revival of neglected cultivars that possess unique and important qualities could, therefore, strengthen the local wine industry.

In the framework of the international project "Conservation and sustainable use of grapevine genetic resources in the Caucasus and Northern Black Sea Region" coordinated by Bioversity International (7, 23), data have been collected for characterizing, by genotyping and phenotyping, Georgian grapevine germplasm (14, 22, 23, 24, 27). We report data on the phenology and profiles of grape maturation for 134 grapevine accessions from Georgia, surveyed under Northern Italian climatic conditions, during a three year period (2004-2006).

Materials and Methods

One hundred and thirty four accessions of autochthonous Georgian grapevine cultivars (Table 2) were observed in a collection planted in 2000 at the regional experimental farm of ERSA "Centro Pilota per la Vitivinicoltura" in Gorizia (Friuli Venezia Giulia region, North-Eastern Italy), with plant material sourced in 1967-68 from a grapevine collection of

Table 1. Area of *Vitis vinifera* cultivars in Georgia based on the official censuses

Census	Total planted area (ha)	Area planted with Georgia cultivars		Total number of cultivars	Number and proportion of Georgian cultivars	
		ha	%		Number	%
2004	37419	37289	96.4	42	31	73.8
1985	86189	84269	97.8	27	21	77.0
1970	101002	98024	97.1	43	31	72.1
1953	39422	35349	89.7	37	33	89.2

Table 2. List of tested cultivars and their current importance in Georgian viticulture. Their region of origin is reported in brackets.

White grape
Atcharuli Tetri (Adjara) germplasm
Avasirkhva (Abkhazeti) little cultivated
Bazaleturi (Imereti) germplasm
Brola (Adjara) germplasm
Bua Kurdzeni (Kakheti) germplasm
Buera (Kakheti) germplasm
Chekhardani (Samegrelo) germplasm
Chekobali (Samegrelo) germplasm
Chinuri (Kartli) cultivated
Chitiskvertskha Meskhuri (Kartli) germplasm
Chitistvala Kakhuri (Kakheti) germplasm
Chkhikoura (Imereti) germplasm
Chkhutcheshi (Samegrelo) germplasm
Dondghlabi (Imereti) little cultivated
Gomis Tetri (Imereti) germplasm
Gorula (Kartli) cultivated
Goruli Mtsvane (Kartli) cultivated
Jvari (Kartli) germplasm
Kakhis Tetra (Kakheti) germplasm
Kapistoni Tetri (Imereti) germplasm
Khapshira (Abkhazeti) germplasm
Khikhvi (Kakheti) little cultivated
Krakhuna (Imereti) cultivated
Kumsmtevana (Kakheti) germplasm
Kurkena (Kakheti) germplasm
Mirzaanuli (Kakheti) germplasm
Mskhviltvala Tetri (Kakheti) germplasm
Mtsvane Kakhuri (Kakheti) cultivated
Mtsvane Onidan (Racha) germplasm
Mtsvivani Mskhvilmartsvala (Kakheti) germplasm
Muradouli (Imereti) germplasm
Okroula (Kakheti) germplasm
Rkatsiteli (Kakheti) cultivated
Samarkhi (Guria) germplasm
Sapena (Kakheti) germplasm
Sirgula (Kakheti) germplasm
Tchetchipeshi (Samegrelo) germplasm
Tchvitiluri (Samegrelo) germplasm
Tita Kartlis (Kartli) little cultivated
Tkupkvirta (Kakheti) germplasm
Tsirkvalis Tetri (Imereti) germplasm
Tsitska (Imereti) cultivated
Tsitska Sachkheris (Imereti) little cultivated
Tskhvedianis Tetra (Racha-Lechkhumi) germplasm
Tsnoris Tetra (Kakheti) germplasm
Tsolikouri (Imereti) cultivated
Tsolikouri Mtsvivani (Imereti) germplasm
Tsulukidzis Tetra (Racha) cultivated
Ubakluri (Kakheti) germplasm
Vertkvitchalis Tetri (Imereti) germplasm
Zakatalis Tetri (Kakheti) germplasm

Pink grape
Mrgvali Vardisperi Kurdzeni (Kakheti) germplasm;
Rkatsiteli Vardisperi (Kakheti) germplasm.

Gray grape
Ghrubela Kakhuri (Kakheti) germplasm
Ghrubela Kartlis (Kartli) germplasm
Tvaldamtsvriseuli (Racha-Lechkhumi) germplasm

Red Grape
Akomshtali (Abkhzeti) germplasm
Badagi (Guria) germplasm
Seura (Racha) germplasm
Tsitelouri (Racha) germplasm
Zhghia (Kakheti) germplasm

Black grape
Abshiluri (Samegrelo) germplasm
Adanasuri (Imereti) germplasm
Akhmetis Shavi (Kakheti) germplasm
Aladasturi (Guria) cultivated
Alexandrouli (Racha) cultivated
Amlakhu (Abkhazeti) germplasm
Amotkhvizh (Abkhazeti) germplasm
Argvetula (Imereti) germplasm
Argvetuli Sapere (Imereti) germplasm
Aspindzura (Kartli) germplasm
Asuretuli Shavi (Kartli) cultivated
Batomura (Adjara) germplasm
Buza (Kartli) germplasm
Chkhaveri (Guria) cultivated
Danakharuli (Kartli) germplasm
Didshavi (Imereti) germplasm
Dzelshavi Obchuri (Imereti) cultivated
Dziganidzis Shavi (Imereti) germplasm
Dzveli Alexandrouli (Racha) germplasm
Endeladzis Shavi (Imereti) germplasm

Gabekhouri Tsiteli (Imereti) germplasm
Ghvanura (Adjara) germplasm
Ghvinis Tsiteli (Kakheti) germplasm
Ikaltos Tsiteli (Kakheti) germplasm
Imeruli Shavi (Imereti) germplasm
Jani (Guria) little cultivated
Jani Bakhvis (Guria) little cultivated
Jineshi (Adjara) germplasm
Kamuri Shavi (Guria) germplasm
Katchitchi (Samegrelo) cultivated
Khrogi (Racha) germplasm
Khupishizh (Abkhazeti) germplasm
Khushia Shavi (Imereti, Guria) germplasm
Kistauris Saghvine (Kakhuri) germplasm
Ktsia 40 (Kartli) germplasm
Kuprashviliseuli (Imereti) germplasm
Kvelouri (Imereti) germplasm
Maghlari Shavi (Imereti) germplasm
Maghlari Tvrina (Imereti) germplasm
Mamukas Vazi (Imereti) germplasm
Marguli Sapere (Imereti) germplasm
Mgaloblishvili (Imereti) little cultivated
Mtevandidi (Guria) germplasm
Mujuretuli (Racha) cultivated
Noshrio (Racha) germplasm
Ojaleshi (Samegrelo) cultivated
Okhtoura (Kakheti) germplasm
Opoura (Guria) germplasm
Orbeluri Ojaleshi (Lechkhumi) cultivated
Orona (Guria) germplasm
Otskhanuri Sapere (Imereti) little cultivated
Paneshi (Samegrelo) germplasm
Portoka (Imereti) germplasm
Rko Shavi (Imereti) germplasm
Samtchatcha (Imereti) germplasm
Saperavi Atenis (Kakheti) germplasm
Saperavi Grdzelmtevana (Kakheti) cultivated;
Satsuravi (Adjara) germplasm
Shavi Kurdzeni (Kartli) germplasm
Shavkapito (Kartli) cultivated
Shavtkhila (Kakheti) germplasm
Shonuri (Samegrelo) germplasm
Skhilatubani (Guria) little cultivated
Tamaris Vazi (Kartli) germplasm
Tavkara (Kakheti) germplasm
Tavkveri (Kartli) cultivated
Tchodi Salkhinosi (Samegrelo) germplasm
Tchumuta (Guria) germplasm
Tkvlapa Shavi (Imereti) germplasm
Tskobila (Kakheti) germplasm
Usakhelouri (Racha) cultivated
Vazisubnis Tsiteli (Kakheti) germplasm
Vertkvitchalis Shavi (Imereti) germplasm

ancient Georgian cultivars established by the Georgian State Agrarian University and led by the Georgian Professor in viticulture M. Ramishvili (in Dighomi, Tbilisi, Georgia). Each accession was represented by five plants.

Detailed information about the experimental site, including climatic traits and soil types, as well as the planting design and cultural practices of the vineyard, have been reported previously (24). Consequently, only the main climatic records are reported here. Adopting Koeppen's classification (30), Gorizia has a mesothermal climate with transitional characters between an oceanic (Cfb) and a Mediterranean type (Csa). It is characterized by hot but not humid summers and cold, rainy winters. Average summer and winter temperatures are approximately 21.5-22.5°C and 4°C, respectively. Annual rainfall is approximately 1350-1400 mm, with a pattern that presents two minima (February and July) and two maxima (November and June).

The observations were conducted only on normally developed plants. Phenological development was recorded following the fundamental phenophases selected from the classical scale proposed by Eichhorn and Lorenz (10).

During the course of grape development, samples of berries (ca. 300 g) were randomly taken from different (proximal, median and distal) parts of several bunches located in both internal and external canopy positions, and were collected from each accession at weekly intervals to follow ripening. Juice soluble sugars concentrations (°Brix) which was measured with a digital temperature-compensated refractometer, pH by a pH-meter, and titratable acidity by titration with 0.1 N of NaOH to pH 7.0 end-point and expressed as $g \cdot L^{-1}$ of tartaric

Table 3. Average temperature and total precipitation recorded during the three year survey period compared to the normal climatic data (1961-1990) recorded close to the germplasm collection.

Month	Mean temperature (°C)				Precipitation (mm)			
	2004	2005	2006	1961-1990	2004	2005	2006	1961-1990
January	2.9	3.1	2.5	3.9	46.6	19.8	76.2	100
February	4.1	3.2	4.1	4.6	178.2	8.2	70.0	81
March	8.3	7.8	7.1	8.7	60.2	49.2	132.4	99
April	13.2	12.1	13.1	12.1	89.0	180.6	81.2	117
May	15.7	18.3	17.2	17.7	80.8	86.4	91.8	113
June	21.9	22.7	23.0	21.1	136.2	38.2	18.0	121
July	23.4	24.1	25.7	23.0	76.0	132.4	13.4	100
August	23.2	21.3	20.2	23.6	149.8	271.6	193.2	116
September	23.8	24.1	24.0	18.6	146.4	341.6	36.8	131
October	15.9	14.4	16.3	14.1	333.2	90.8	13.8	134
November	9.6	8.6	10.2	8.9	106.2	129.0	101.8	138
December	6.4	4.3	6.8	4.6	131.6	88.2	118.0	106

acid, were determined in triplicate. Based on the course of maturation and observations of the berries (firmness and consistency), the time of maturity was defined using the following criteria: maximum concentration of sugars, minimum level of acidity and absence of visible dehydration.

Among the available phenological series (2003-2007), it was decided to use only the data from 2004-2006 as 2003 was characterized by an exceptionally hot and dry weather history and 2007 had an unusually early phenology as a consequence of a mild winter and an early bud emergence in spring.

The phenology of the Georgian germplasm was compared to two international reference cultivars: Chardonnay, representative of an early cultivar in all the phenological phases, and Cabernet Sauvignon, which is late for bud burst and flowering and is medium-late in maturity.

Weather records were obtained from a meteorological station of the regional agrometeorological service located a short distance from the grapevine collection (Gradisca of Isonzo).

Results and Discussion

Evaluation of weather conditions

The three survey years had obviously different weather patterns but, in general, were not very different from the normal conditions over the 1960-1990 thirty year period (Table 3). However the considerably higher average September temperatures recorded during the experimental period, in comparison with the reference thirty year period, was notable. Particular year-to-year variations in monthly rainfall patterns were also noted.

However, the weather conditions of the three years (2004, 2005 and 2006) were similar with regard to overall thermal history as the annual curves for heat summation above a base temperature of 10°C were very similar (Fig. 1). Consequently, Winkler's index ranged from 1894.4 to 1982.8 over the three years (Table 4). With regard to rainfall, a higher than average rainy period in August and September, 2005 did not impact on the survey of the cultivars as it did not cause any particular health problems on the grapevines.

Evaluation of cultivars

The statistics of phenology over the three years of observations are shown in Table 5. By comparing the phenology of Georgian germplasm with the two international cultivars selected as references, the periods of bud break, flowering and fruit set were slightly later than those for the reference cultivars. However, the time of veraison was significantly later and showed a very wide range of variation of over

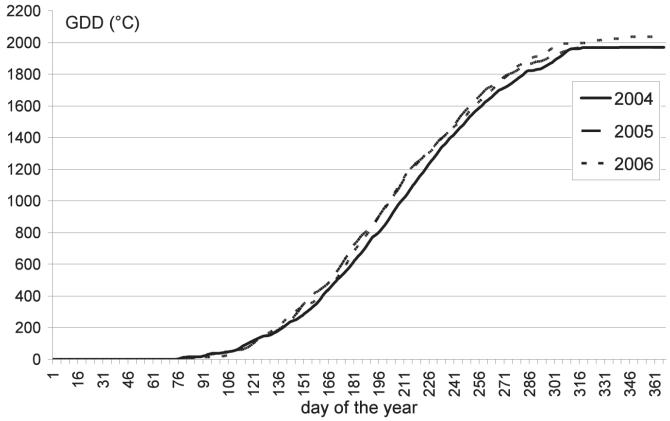

Fig. 1. Heat summation of active temperature (base 10°C) for the years of observation in the experimental site.

nearly two months amongst the germplasm selections that were evaluated. The period of maturity was also, on average, much later. Among the Georgian germplasm, only one cultivar which matured in the first week of September may be classified as early; four cultivars, which ripened in the last ten-days of September, can be classified as medium ripening; seventeen cultivars, ripening in early October, had a medium-late ripening period; and all the other cultivars, representing over 80% of the surveyed germplasm, can be considered late or very late ripening cultivars.

When the overall profiles of maturity (Table 6) were evaluated across the different times of ripening (Table 7), it was notable that there was considerable variability in the ability of cultivars to accumulate sugars, especially in conjunction with achieving levels of titratable acidity that are suitable for enological purposes (5-10 $g \cdot L^{-1}$). The range of variability in the maturity profiles was considerable (Fig. 2). However, it should be noted that some late-ripening cultivars, especially 'Akomshtali' (15.8 °Brix, 20.5 $g \cdot L^{-1}$ titratable acidity), were unable to complete their maturation in the climatic conditions of Northern Italy. Nevertheless, other late cultivars, such as 'Kamuri Shavi', 'Ojaleshi', 'Tavkara', 'Khushia Shavi', 'Satsuravi', 'Maghlari Tvrina', 'Mtevandidi', 'Argvetula', 'Dziganidzis Shavi', 'Adanasuri', 'Mamukas Vazi', and 'Otskhanuri Sapere', did reach good levels of sugar accumulation (18 - 22 °Brix).

Each of the cultivars studied, along with their main characteristics such as berry color, region of origin and distribution in Georgia, phenological stages from bud swell to maturation, juice soluble sugars concentration, pH and titratable acidity are listed in Appendix 1. The cultivars are ranked according to berry color and their time of ripening.

Average multi-year phenological data demonstrates that:

- The timings of bud break and flowering were only slightly later than the Western European reference cultivars.
- Veraison showed a very wide range of 55 days amongst cultivars: 'Dzelshavi Obchuri' started veraison on 6 August while the later cultivars like 'Akomshtali', 'Aladasturi', 'Orona' and 'Skhilatubani', started veraison on 30 September.
- The ripening time of the cultivars that were assessed was, on average relatively late; this is a particular characteristic of Georgian

Table 4. Seasonal weather courses for years of observation in Gorizia

Year	Winkler's index[z] (GDD)	Annual precipitation (mm)
2004	1894.4	1534.2
2005	1904.1	1436.0
2006	1982.8	946.6

[z]Heat summation of active temperature (base 10°C) from the 1st April to the 31st October

Table 5. Mean data for the main phenological phases and relative statistics in Julian days (and corresponding calendar date), recorded for the Georgian germplasm, over the three year survey period.

Phenological stage (Eichhorn and Lonenz stage)	Mean	S.D.[1]	Minimum	Maximum	Range	Chardonnay	Cabernet Sauvignon
Bud swell (E-L 02)	96 6 Apr.	2.1	92 2 Apr.	102 12 Apr.	11	88 30 Mar.	101 11 Apr.
Green tip (E-L 04)	101 11 Apr.	2.6	95 5 Apr.	112 22 Apr.	17	94 4 Apr.	106 16 Apr.
Full bloom (E-L 23)	161 10 June	1.8	156 5 June	166 15 June	10	153 2 June	160 9 June
Setting (E-L 27)	165 14 June	2.5	159 8 June	170 19 June	11	157 6 June	164 13 June
Veraison (E-L 35)	237 25 Aug.	10.8	218 6 Aug.	272 30 Sept.	55	216 4 Aug.	224 12 Aug.
Berry harvest-ripe (E-L 38)	286 13 Oct.	5.6	248 5 Sept.	291 18 Oct.	43	253 10 Sept.	275 2 Oct.

[1]Standard deviation

cultivars. Ripening started on 5 September ('Usakhelouri') while the latest group was harvested on 18 October. Several cultivars, like 'Ojaleshi' and 'Akomshtali', were unable to complete ripening due to insufficient heat unit accumulation at the experimental site.

Conclusions

Monitoring the phenology of a large sample of Georgian germplasm under Northern Italy climatic conditions for three years, highlighted how the timings of bud break and flowering were only slightly later than the corresponding time for the two reference cultivars, Chardonnay and Cabernet Sauvignon. In contrast, the time of ripening was relatively late and showed very wide variability. The profile of maturity, assessed in terms of soluble sugars concentration, pH and titratable acidity in juice, was also very diverse. Some cultivars, in fact, failed to complete their maturation.

The wide variability in phenology and maturity profiles in the Georgian germplasm confirms its considerable potential value to grapevine breeding programs, as it contains sources of genetic traits that are apparently

Figure 2. Average data of sugar concentration (°Brix) and titratable acidity (mean for the three year 2004-2006 period) for the Georgian cultivars. Each point represents a single accession.

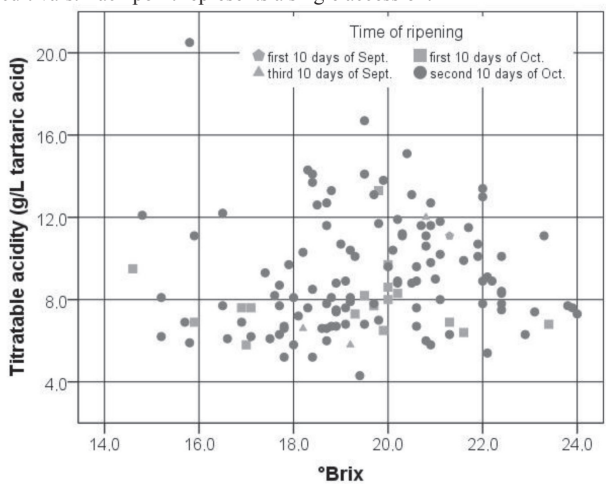

Table 6. General statistics of ripening profile of Georgian germplasm recorded during the three year survey.

Main ripening traits	Mean	S.D.	Minimum	Maximum	Range
°Brix	19.5	2.02	14.6	24.0	9.4
pH	3.0	0.14	2.7	3.0	0.3
Titratable acidity ($g \cdot L^{-1}$ tartaric acid)	9.0	2.71	4.3	20.5	16.2

Table 7. Classification of the Georgian cultivars according to their ripening timing and relative average ripening profiling

Period of maturation	Cultivar		°Brix		pH		Titratable acidity ($g \cdot L^{-1}$ tartaric acid)	
	No.	Name	Mean	S.D.	Mean	S.D.	Mean	S.D.
First ten-days of September	1 0.7%	Usakhelouri	21.3	-	3.00	-	11.1	-
Third ten-days of September	4 3%	Tita Kartlis, Tchetchipeshi, Tsulukidzis Tetra, Chekobali	19.0	1.3	3.08	0.96	7.4	3.1
First ten-days of October	17 12.7%	Chkhutcheshi, Chitistvala Kakhuri, Asuretuli Shavi, Ghvinis Tsiteli, Mrgvali Vardisperi Kurdzeni, Mskhviltvala Tetri, Kakhis Tetra, Ghrubela Kakhuri, Aspindzura, Sapena, Ubakluri, Vazisubnis Tsiteli, Dzelshavi Obchuri, Portoka, Argvetuli Sapere, Kurkena, Tchumuta	19.2	2.2	3.10	0.14	7.9	1.7
Second ten-days of October	112 83.6%	All others	19.6	2.0	3.04	0.14	9.2	2.8

not represented in the germplasm of Western Europe. The late and very late ripening cultivars that are well represented in the Georgian germplasm may be of particular interest to breeding programs that aim to extend the timing of ripening in a viticultural region or which are anticipating shifts in grapevine maturity due to climate change.

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Appendix

Average phenological and maturation data for Georgian cultivars recorded during the three year survey.

Cultivar	Berry color[z]	Region of origin	Distribution	Bud swell (E-L 02)	Green tip (E-L 04)	Rosette of leaf tip visible (E-L 05)	2-3 leaf separated from the shoot tip (E-L 09)	Inflorescence clear (E-L 12)	Single flower in compact group (E-L 15)	Single flower separated (E-L 17)	Full bloom (E-L 23)	Setting (E-L 27)	Veraison (E-L 35)	Berry harvest-ripe (E-L 38)	Soluble sugars concentration	pH	Titratable Acidity (g/L Tartaric Ac.)
Tsulukidzis Tetra	W	Racha	Major	95	99	105	114	118	121	137	161	164	222	269	18.2	3.0	6.6
Chekobali	W	Samegrelo	Germplasm	97	104	111	119	121	125	140	160	163	254	273	20.8	3.0	12.0
Tchetchipeshi	W	Samegrelo	Germplasm	94	97	104	112	116	119	134	159	162	220	273	19.2	3.1	5.8
Tita Kartlis	W	Kartli	Minor	93	101	108	116	118	124	140	161	165	229	273	17.8	3.2	5.2
Ubakluri	W	Kakheti	Germplasm	94	98	105	114	118	119	133	160	162	229	274	20.0	3.0	8.0
Chitistvala Kakhuri	W	Kakheti	Germplasm	93	99	105	115	117	120	133	157	161	228	275	21.6	3.1	6.4
Kurkena	W	Kakheti	Germplasm	93	98	103	115	118	121	136	158	161	225	275	20.0	3.1	9.7
Sapena	W	Kakheti	Germplasm	96	101	108	114	118	120	141	160	162	226	280	19.7	3.3	7.7
Kakhis Tetra	W	Kakheti	Germplasm	99	107	113	118	121	126	144	163	168	228	280	19.3	3.2	7.3
Chkhutcheshi	W	Samegrelo	Germplasm	94	100	105	113	117	121	142	161	164	233	280	17.0	3.1	5.8
Mskhviltvala Tetri	W	Kakheti	Germplasm	92	96	100	111	115	120	140	160	163	230	280	15.9	3.1	6.9
Atcharuli Tetri	W	Adjara	Germplasm	96	101	108	116	119	122	142	163	167	242	284	22.4	3.0	8.4
Tsnoris Tetra	W	Kakheti	Germplasm	100	104	110	117	120	124	141	162	168	229	284	22.4	3.0	7.5
Mtsvane Kakhuri	W	Kakheti	Major	93	96	105	114	117	120	135	159	161	229	284	22.1	3.3	5.4
Rkatsiteli	W	Kakheti	Major	97	102	109	116	119	123	143	162	167	229	284	21.3	3.1	6.3
Tskhvedianis Tetra	W	Racha-Lechkhumi	Germplasm	100	102	107	115	118	121	138	161	164	229	284	20.5	3.0	8.8
Zakatalis Tetri	W	Kakheti	Germplasm	94	100	109	117	119	123	138	159	162	231	284	19.1	3.2	6.8
Buera	W	Kakheti	Germplasm	96	103	109	116	119	123	137	162	167	230	284	18.9	3.2	7.4
Tkupkvirta	W	Kakheti	Germplasm	92	95	101	112	116	119	136	160	162	232	284	18.8	3.2	8.1
Gorula	W	Kartli	Major	94	100	106	115	118	122	139	161	165	231	284	18.7	3.2	6.6
Okroula	W	Kakheti	Germplasm	99	104	110	117	119	123	138	160	163	231	284	18.1	3.1	7.2
Gomis Tetri	W	Imereti	Germplasm	99	104	110	117	119	124	136	161	167	233	284	17.7	3.1	7.7
Avasirkhva	W	Abkhazeti	Minor	96	102	109	116	119	123	137	161	164	233	284	17.5	3.0	6.1
Kumsmtevana	W	Kakheti	Germplasm	98	103	109	117	119	122	139	162	166	234	284	17.1	3.1	6.2
Brola	W	Adjara	Germplasm	92	97	102	111	116	119	138	160	163	237	284	16.5	3.1	7.7

Jvari	W	Kartli	Germplasm	97	102	106	115	119	123	142	164	165	236	285	21.1	3.0	11.8
Mtsvane Onidan	W	Racha	Germplasm	100	106	112	119	121	127	141	162	167	225	287	21.1	3.	8.0
Chitiskvertskha Meskhuri	W	Kartli	Germplasm	96	103	110	116	119	122	139	161	165	219	287	20.8	3.1	6.0
Tsirkvalis Tetri	W	Imereti	Germplasm	94	102	108	115	118	121	138	159	161	227	287	18.8	3.0	6.7
Tsitska Sachkheris	W	Imereti	Minor	96	105	-	-	-	-	-	160	-	230	287	17.7	3.2	6.3
Tsitska	W	Imereti	Major	102	108	113	120	122	126	143	164	169	245	287	16.5	3.0	12.2
Goruli Mtsvane	W	Kartli	Major	100	105	111	118	120	124	141	161	165	233	288	23.9	3.3	7.6
Khikhvi	W	Kakheti	Minor	95	101	108	116	118	121	134	158	160	230	288	23.8	3.2	7.7
Chekhardani	W	Samegrelo	Germplasm	96	100	106	114	118	121	143	163	167	247	288	22.9	3.3	6.3
Krakhuna	W	Imereti	Major	100	108	114	119	122	126	144	163	168	242	288	22.4	3.0	8.3
Mtsvivani Mskhvilmartsvala	W	Kakheti	Germplasm		102	109	117	119	124	143	161	166	235	288	22.0	3.1	7.8
Bazaleturi	W	Imereti	Germplasm	100	106	111	118	120	124	141	161	165	247	288	21.9	3.0	10.7
Tsolikouri	W	Imereti	Major	94	102	108	117	119	124	139	160	163	247	288	21.9	2.9	10.1
Tsolikouri Mtsvivani	W	Imereti	Germplasm	93	99	106	116	119	123	137	162	167	253	288	21.6	3.0	9.9
Khapshira	W	Abkhazeti	Germplasm	94	100	106	116	119	122	139	161	166	248	288	20.8	2.9	10.6
Tchvitiluri	W	Samegrelo	Germplasm	94	100	106	116	119	121	139	161	164	245	288	20.7	3.0	11.6
Dondghlabi	W	Imereti	Minor	100	106	112	117	120	125	142	162	166	237	288	20.1	3.0	10.4
Sirgula	W	Kakheti	Germplasm	97	102	109	116	119	124	143	162	166	232	288	19.4	3.2	4.3
Muradouli	W	Imereti	Germplasm	100	105	111	117	121	124	143	162	168	258	288	19.3	3.0	10.1
Chinuri	W	Kartli	Major	95	104	109	117	119	123	140	160	162	232	288	18.0	3.2	5.8
Vertkvitchalis Tetri	W	Imereti	Germplasm	96	105	111	119	121	125	142	162	166	253	288	17.9	3.0	9.7
Mirzaanuli	W	Kakheti	Germplasm	97	103	109	117	120	124	138	160	164	232	288	17.8	3.1	6.7
Chkhikoura	W	Imereti	Germplasm	97	104	110	117	120	124	143	162	167	252	288	15.9	2.9	11.1
Bua Kurdzeni	W	Kakheti	Germplasm	96	103	109	115	119	123	143	162	166	231	288	15.8	3.1	5.9
Kapistoni Tetri	W	Imereti	Germplasm	93	97	105	114	117	121	138	161	164	232	288	15.2	3.1	6.2
Samarkhi	W	Guria	Germplasm	94	99	105	113	116	119	142	163	168	258	291	20.9	3.1	5.8
Mrgvali Vardisperi Kurdzeni	P	Kakheti	Germplasm	98	103	109	117	119	124	141	161	165	230	280	21.3	3.3	6.9
Rkatsiteli Vardisperi	P	Kakheti	Germplasm	99	104	110	118	120	124	144	162	166	233	284	19.7	3.0	7.8
Ghrubela Kakhuri	G	Kakheti	Germplasm	92	99	104	114	117	121	133	159	161	229	280	17.1	3.1	7.6
Tvaldamtsvriseuli	G	Racha-Lechkhumi	Germplasm	92	97	104	113	117	120	134	158	161	227	287	15.7	3.1	6.9
Ghrubela Kartlis	G	Kartli	Germplasm	93	99	104	113	116	119	132	159	161	227	288	16.9	3.2	6.9
Badagi	R	Guria	Germplasm	93	99	105	115	118	121	143	161	166	244	288	23.3	2.9	11.1
Zhghia	R	Kakheti	Germplasm	94	101	108	115	119	122	142	161	164	231	291	20.6	3.0	7.6
Seura	R	Racha	Germplasm	92	99	105	114	117	120	139	160	163	231	291	19.1	3.0	7.6
Tsitelouri	R	Racha	Germplasm	96	102	108	116	119	123	139	161	165	243	291	17.8	3.1	5.2
Akomshtali	R	Abkhzeti	Germplasm	96	101	106	115	118	122	144	166	170	273	291	15.8	2.8	20.5
Usakhelouri	B	Racha	Major	96	99	103	114	116	119	138	160	165	232	248	21.3	3.0	11.1
Argvetuli Sapere	B	Imereti	Germplasm	97	102	111	117	120	123	143	161	165	225	278	14.6	3.1	9.5
Portoka	B	Imereti	Germplasm	97	108	113	117	120	124	143	162	165	225	280	20.0	3.1	8.6
Tchumuta	B	Guria	Germplasm	93	101	108	116	119	123	143	163	169	245	280	19.8	2.7	13.3
Vazisubnis Tsiteli	B	Kakheti	Germplasm	96	100	106	114	118	122	143	159	162	231	280	19.5	3.2	8.2
Aspindzura	B	Kartli	Germplasm	95	101	107	116	118	120	136	160	164	231	281	16.9	3.0	7.6
Dzelshavi Obchuri	B	Imereti	Major	95	101	108	115	118	122	139	161	164	218	282	20.2	3.0	8.3
Ghvinis Tsiteli	B	Kakheti	Germplasm	96	100	106	113	116	119	135	156	160	228	283	23.4	3.2	6.8
Asuretuli Shavi	B	Kartli	Major	95	101	107	115	118	121	139	161	165	231	283	19.9	3.1	6.5
Mujuretuli	B	Racha	Major	95	100	106	114	118	122	138	158	162	223	284	24.0	3.3	7.3
Marguli Sapere	B	Imereti	Germplasm	94	99	106	115	119	124	141	161	165	229	284	20.2	3.3	8.8
Shavtkhila	B	Kakheti	Germplasm	95	100	106	114	118	121	142	160	164	236	284	19.8	3.2	7.0
Argvetula	B	Imereti	Germplasm	94	101	106	115	118	122	141	161	166	255	284	19.5	2.7	14.1
Maghlari Shavi	B	Imereti	Germplasm	95	99	106	115	118	122	136	161	165	227	284	19.2	3.2	7.9
Adanasuri	B	Imereti	Germplasm	96	101	107	115	119	122	141	162	167	244	284	18.3	2.9	14.3
Tamaris Vazi	B	Kartli	Germplasm	93	101	107	115	118	121	141	160	163	226	284	15.2	3.2	8.1
Ktsia 40	B	Kartli	Germplasm	94	98	104	112	116	119	140	162	166	238	286	21.0	3.1	9.0
Ghvanura	B	Adjara	Germplasm	96	100	107	115	118	123	139	160	164	245	286	20.9	2.9	12.7
Tkvlapa Shavi	B	Imereti	Germplasm	98	100	105	116	118	122	134	156	159	219	286	18.7	3.3	6.0

Okhtoura	B	Kakheti	Germplasm	95	104	113	119	122	126	143	160	164	232	286	18.7	3.2	7.8
Shavkapito	B	Kartli	Major	93	100	105	113	116	119	133	157	160	229	286	18.3	3.1	7.6
Amotkhvizh	B	Abkhazeti	Germplasm	93	100	106	115	118	123	139	161	166	252	286	16.6	3.1	6.1
Alexandrouli	B	Racha	Major	96	98	105	114	118	122	139	159	161	222	287	23.1	3.2	7.4
Abshiluri	B	Samegrelo	Germplasm	96	101	108	116	119	124	137	160	163	229	287	19.2	3.1	8.1
Didshavi	B	Imereti	Germplasm	95	101	107	116	119	124	142	163	168	233	287	18.9	3.1	7.5
Amlakhu	B	Abkhazeti	Germplasm	96	100	105	115	117	121	139	160	163	243	287	18.4	3.0	8.5
Maghlari Tvrina	B	Imereti	Germplasm	96	101	108	116	119	123	142	161	165	244	287	18.4	2.8	13.7
Rko Shavi	B	Imereti	Germplasm	95	101	108	117	119	124	138	160	163	253	287	18.2	2.9	10.3
Imeruli Shavi	B	Imereti	Germplasm	96	101	107	115	118	121	138	160	164	235	287	17.7	3.0	8.7
Kistauris Saghvine	B	Kakhuri	Germplasm	95	101	106	115	118	122	136	159	162	231	288	22.2	3.1	8.9
Shavi Kurdzeni	B	Kartli	Germplasm	95	101	106	114	117	122	139	162	169	231	288	20.6	3.2	6.7
Jineshi	B	Adjara	Germplasm	96	101	106	115	118	122	142	161	163	242	288	20.3	2.9	11.2
Kuprashviliseuli	B	Imereti	Germplasm	98	101	106	117	119	124	145	164	167	247	288	19.1	3.0	8.9
Aladasturi	B	Guria	Major	92	102	109	117	119	123	144	165	170	253	288	19.0	2.9	10.7
Danakharuli	B	Kartli	Germplasm	94	97	102	112	115	118	134	159	162	235	288	18.9	3.2	8.8
Khrogi	B	Racha	Germplasm	93	101	108	116	118	122	136	164	168	228	288	18.6	3.1	6.6
Saperavi Atenis	B	Kakheti	Germplasm	94	100	106	115	118	122	135	157	161	225	288	18.4	3.3	5.2
Tavkveri	B	Kartli	Major	94	100	105	113	117	123	143	161	166	227	288	18.0	3.1	8.1
Paneshi	B	Samegrelo	Germplasm	96	101	108	115	118	121	137	161	164	232	288	17.8	3.2	6.6
Jani	B	Guria	Minor	98	102	108	116	118	121	138	160	165	235	289	20.6	2.9	9.6
Mgaloblishvili	B	Imereti	Minor	97	105	111	117	120	124	140	160	165	243	289	18.7	2.9	12.7
Kvelouri	B	Imereti	Germplasm	102	102	110	118	120	124	142	161	166	239	289	17.6	3.0	8.2
Opoura	B	Guria	Germplasm	96	112	118	121	124	128	141	163	169	247	290	22.0	3.1	8.9
Tskobila	B	Kakheti	Germplasm	97	101	107	115	118	123	139	162	169	232	291	22.4	3.3	7.8
Jani Bakhvis	B	Guria	Minor	95	101	107	115	118	122	139	161	166	258	291	22.4	2.8	10.1
Vertkvitchalis Shavi	B	Imereti	Germplasm	93	101	106	115	118	122	139	161	167	234	291	22.1	3.2	9.1
Satsuravi	B	Adjara	Germplasm	94	99	105	114	117	120	139	160	163	244	291	22.0	2.9	13.4
Kamuri Shavi	B	Guria	Germplasm	96	101	108	116	119	124	140	162	167	253	291	22.0	2.9	13.0
Shonuri	B	Samegrelo	Germplasm	95	101	106	115	118	122	142	161	166	251	291	21.7	2.9	11.5
Noshrio	B	Racha	Germplasm	95	101	106	115	118	122	140	160	163	242	291	21.1	3.1	10.2
Samtchatcha	B	Imereti	Germplasm	95	100	106	115	119	123	143	161	165	247	291	20.9	3.0	9.8
Katchitchi	B	Samegrelo	Major	97	101	106	115	118	121	139	161	166	251	291	20.9	2.9	11.6
Khupishizh	B	Abkhazeti	Germplasm	93	101	107	115	118	123	139	163	168	250	291	20.8	3.0	11.1
Saperavi Grdzelmtevana	B	Kakheti	Major	97	98	103	112	115	119	134	160	162	227	291	20.6	3.1	8.9
Ojaleshi	B	Samegrelo	Major	98	103	108	117	120	124	143	163	167	261	291	20.5	2.8	13.1
Mamukas Vazi	B	Imereti	Germplasm	94	106	111	117	120	124	139	160	163	235	291	20.4	2.9	15.1
Endeladzis Shavi	B	Imereti	Germplasm	94	100	104	114	117	119	133	157	160	229	291	20.3	2.9	11.1
Orbeluri Ojaleshi	B	Lechkhumi	Major	94	100	106	115	118	123	139	161	168	231	291	20.2	3.2	8.9
Chkhaveri	B	Guria	Major	98	100	107	115	117	121	143	163	167	251	291	20.2	2.9	11.9
Ikaltos Tsiteli	B	Kakheti	Germplasm	95	104	-	-	-	-	-	161	-	241	291	20.0	2.9	9.6
Mtevandidi	B	Guria	Germplasm	95	101	106	115	118	122	142	160	166	258	291	19.9	2.7	13.8
Gabekhouri Tsiteli	B	Imereti	Germplasm	94	99	104	114	117	120	137	159	162	252	291	19.8	3.0	11.7
Tavkara	B	Kakheti	Germplasm	97	102	109	118	121	126	143	161	167	253	291	19.7	2.9	13.1
Dzveli Alexandrouli	B	Racha	Germplasm	98	101	106	115	118	121	139	160	162	236	291	19.5	3.1	6.8
Otskhanuri Sapere	B	Imereti	Minor	97	103	110	117	120	125	143	166	167	-	291	19.5	2.9	16.7
Tchodi Salkhinosi	B	Samegrelo	Germplasm	98	101	106	115	118	122	137	161	166	263	291	19.2	3.0	10.4
Buza	B	Kartli	Germplasm	96	102	108	115	118	122	136	159	163	228	291	18.9	3.1	6.7
Khushia Shavi	B	Imereti, Guria	Germplasm	98	102	108	116	120	124	145	166	169	248	291	18.8	2.8	13.3
Orona	B	Guria	Germplasm	100	104	111	117	120	124	145	164	170	251	291	18.7	2.8	11.6
Skhilatubani	B	Guria	Minor	95	105	111	118	121	126	143	164	170	253	291	18.5	2.8	12.6
Dziganidzis Shavi	B	Imereti	Germplasm	96	100	107	115	118	123	142	161	166	241	291	18.4	2.9	14.1
Akhmetis Shavi	B	Kakheti	Germplasm	96	99	104	114	118	122	144	162	166	240	291	17.4	3.1	9.3
Batomura	B	Adjara	Germplasm	96	102	110	117	120	126	145	162	167	253	291	14.8	2.8	12.1

[z] Berry color: W=White, P=Pink, G=Gray, R=Red, B=Black