

Walnut cultivars with perspectives for ecological culture in Romania

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ABSTRACT

The objectives of the present study were to analyze the behavior of 11 Romanian walnut cultivars and one French cultivar ('Franquette') in North East of Oltenia, under conventional and during conversion to organic nut production. During conventional growing, the highest mean yields were recorded for 'Jupânești' (2.88 t/ha), 'Valcor' (2.77 t/ha), 'Verisval' (2.58 t/ha), 'Unival' (2.55 t/ha) and in the case of organic production the highest yields were observed for 'Jupânești' (3.5 t/ha), 'Valcor' (2.95 t/ha), 'Unival' (2.67 t/ha), 'Verisval' (2.62 t/ha), 'Valrex' (2.56 t/ha) and 'Redval' (2.54 t/ha). Nuts of these cultivars were subject to measurements regarding fruit size index, index of roundness, nut weight, kernel weight and kernel ratio. The nuts of each cultivar were divided according to class sizes for the international markets. Cultivars with more than 80% of nuts larger than 32 mm were: 'Valcris', 'Sibișel 44', 'Valcor', 'Germisara' and 'Franquette'. The walnut cultivars were evaluated depending on the attack of walnut blight (*Xanthomonas arboricola* pv. *juglandis*) and anthracnose (*Gnomonia leptostyla*) on leaves and fruits. Walnut blight and anthracnose attacks were observed on 'Sibișel 44', 'Germisara', 'Velnița' and 'Franquette', while the least affected proved to be: 'Valcor', 'Valcris', 'Unival', 'Jupânești' and 'Verisval'. As consequence, the following walnut cultivars have perspectives to be used for the ecological culture in Romania: 'Valcor', 'Jupânești', 'Valrex', 'Verisval', 'Unival', 'Redval', 'Velnița', 'Timval', 'Germisara', 'Valcris' and 'Franquette'.

Keywords: organic culture, *Juglans regia*, cultivar testing, crop, nut trees

INTRODUCTION

Walnut (*Juglans regia* L.), known also as Carpathian, Persian, or English walnut is a crop grown in over 60 countries in both hemispheres of the globe.

According to the FAO Stat Database (2021), Romania ranks 8th (49,580 t) in the world in 2019 and 1st in the E.U. (before France) in walnut production. This production comes mostly from semi-spontaneous walnuts on their roots, and only a small part comes from newly organized orchards (1,620 ha in 2019). Most walnuts, which are scattered in different areas, do not benefit from fertilizers and phytosanitary treatments, but they lack the official ecological certification and at the same time, they produce nuts of great variability and with diminished commercial value.

Besides the general trend of establishing new and modern walnut orchards in most walnut-growing countries there is an increasing interest for organic orchards and production Globally, organic walnut orchards occupied in 2019 an area of 50.540 ha, out of the 29.247 ha are fully converted and the rest under conversion. 37.000 ha of organic walnuts were counted in 2019 in China, 3728 ha in the U.S.A., 3262 ha in the Republic of Moldova, 1057 ha in Ukraine; 959 ha in Spain in 2018; 5499 ha in Turkey, 3625 ha in Italy, 682 ha in Serbia in 2017 (FIBL, 2021).

Organic agriculture comprised in Romania in 2019 an area of 395.228 ha, which represents 2.0% of the total area of farmland. Fruit crops occupy only 7.641 ha, respectively a share of 5.8% of the total organic agriculture at the national level. Out of 7641 ha of fruit orchards, 4144 ha are in a complete ecological system and the rest are under conversion. Nut crops are grown on 1273 ha, which is fully converted, while 2768 are under conversion (FIBL, 2021).

The cultivars recommended for organic farming in temperate continental climate countries are rustic genotypes, resistant to low winter temperatures, tolerant to main diseases and adapted to a climate quite rich in rainfall. Most of these cultivars come from selection activities carried out in local walnut populations.

The ecological principles (climate, orchard location, soil, and biocenosis), genetic and geographical origin of cultivars and rootstocks, and technological conditions are responsible for increasing productivity, fruit quality, and economic efficiency of the crop (Burke *et al.*, 1976; Grimo, 1979; Botu, 1998; Botu *et al.*, 2001; Aleta *et al.*, 2014; Botu and Achim, 2014).

In the last 15 years, different walnut cultivars with terminal and lateral bearing were introduced in Romania, without any prior testing. That was the result of increased interest for planting new walnut orchards with the help of E.U. funds, lack of sufficient planting material, and aggressive advertising carried out by the plant material importers. In the areas with colder climates from Romania some of the introduced cultivars, in particular with lateral bearing, proved less adapted, temperatures below -22° to -24°C during winter caused the death of young trees or affected their growth and yielding capacity. DeBuse, (2009); Aslamarz *et al.*, (2010), Charrier *et al.*, (2013), Gandev, (2013), Aleta *et al.*, (2014), Botu *et al.*, (2017 and 2018), confirmed the susceptibility of lateral bearing walnut cultivars to low temperatures and recommended that such cultivars be grown under suitable climatic conditions.

Research conducted at SCDP Valcea over the last 30 years has highlighted the value of walnut cultivars and the possibility of growing some of them organically (Botu *et al.*, 2001; Botu and Tudor, 2005, Botu *et al.*, 2010; Achim *et al.*, 2018).

MATERIALS AND METHODS

The research has been carried out at Fruit Growing Research and Extension Station (SCDP) Vâlcea, belonging to the University of Craiova.

The walnut trial, without irrigation, is located in Bujoreni, in the North East of Oltenia Region, on an alluvial soil with pH=6.8. The area has a Cfb Köppen - Geiger type (Rubel and Kottek, 2010) of climate, an average annual temperature of 10.2°C and 715 mm rainfall.

The study includes 12 walnut cultivars, all with terminal bearing. Eleven of them have been obtained in Romania: 'Jupâneşti' (from ICDP Pitesti – Maracineni); 'Germisara' and 'Sibişel 44' (from SCDP Geoagiu); 'Velnita' (from SCDP Iasi); 'Redval', 'Timval', 'Unival', 'Valcris', 'Valcor', 'Valrex' and 'Verisval' (obtained at SCDP Valcea) and one French cultivar ('Franquette'). Planting distances were 9 by 8 m (139 trees/ha) and each cultivar was represented by 5 trees. All cultivars were grafted on *Juglans regia* L. seedling rootstocks. Measurements and observations were carried out on the trees regarding growth, fruiting

capacity, fruit quality, adaptability to environmental conditions, and natural resistance to diseases like walnut blight, caused by *Xanthomonas arboricola* pv. *juglandis* (Pierce) Vauterin, Hoste, Kersters & Swings, and walnut anthracnose, caused by *Gnomonia leptostyla* (DC.) Traverso, syn. *Ophiognomonia leptostyla* (Fr.) Sogonov.

Statistical analysis was performed using the Microsoft® Excel® (2016) software for the analysis of variance (ANOVA) and DSAASTAT ver. 1.514 (2015) for the Tukey Multiple Range Test at a significance level of $p<0.05$. DSAASTAT is an Excel VBA Macro developed by Onofri (2007). The data on conventional and organic yields were presented as mean \pm standard deviation (SD).

RESULTS AND DISCUSSIONS

The present study refers to the behavior of 11 Romanian walnut cultivars and the French cultivar 'Franquette' (Table 1), all of them with terminal bearing. 'Franquette' was used in the past as one of the main cultivars in different countries, due to its quality nuts and kernels. In the last decades 'Franquette' was used in the new orchards as a pollinating cultivar for lateral bearing ones.

Table 1. Nut yields of walnut cultivar grown conventionally* (18-year mean) and organic** (2-years mean)

No.	Cultivar	Country of origin	Type of bearing	Conventional yields – mean of 18 years* (t/ha)	Organic yields for 2019-2020 period** (t/ha)	Compared to the 18-year mean (%)
1	'Sibișel 44'	Romania	terminal	1.97 ± 0.30 g	2.05 ± 0.25 b	+4.06
2	'Valcor'	Romania	terminal	2.77 ± 0.14 a	2.05 ± 0.26 b	+6.50
3	'Verisval'	Romania	terminal	2.58 ± 0.29 b	2.52 ± 0.27 ab	+1.55
4	'Valrex'	Romania	terminal	2.25 ± 0.13 ef	2.56 ± 0.32 ab	+13.80
5	'Jupânești'	Romania	terminal	2.88 ± 0.10 a	3.05 ± 0.24 a	+5.90
6	'Valcris'	Romania	terminal	2.25 ± 0.20 ef	2.24 ± 0.25 ab	-0.40
7	'Germisara'	Romania	terminal	2.22 ± 0.26 f	2.18 ± 0.24 ab	-1.80
8	'Velnîța'	Romania	terminal	2.41 ± 0.28 cde	2.49 ± 0.28 ab	+3.30
9	'Unival'	Romania	terminal	2.55 ± 0.22 bc	2.67 ± 0.40 ab	+4.70
10	'Timval'	Romania	terminal	2.32 ± 0.18 def	2.4 ± 0.24 ab	+3.40
11	'Redval'	Romania	terminal	2.42 ± 0.22 bcd	2.54 ± 0.27 ab	+5.00
12	'Franquette'	France	terminal	2.51 ± 0.20 bc	2.53 ± 0.17 ab	+0.80
<i>Mean \pm SD</i>				2.43 ± 0.07	2.54 ± 0.11	+4.53

Means followed by the same letter are not significantly different (Tukey multiple range test. $p<0.05$).

The results obtained count 18 years of production of these cultivars, followed by two years on organic production, in the same trial, under conversion. From this point of view, during conventional growing, the highest mean yields were recorded for 'Jupânești' (2.88 t/ha), 'Valcor' (2.77 t/ha), 'Verisval' (2.58 t/ha), 'Unival' (2.55 t/ha), etc. The lowest mean yield was observed for 'Sibișel 44' (1.97 t/ha). Mean yields of 'Valcor' (2.77 t/ha) and 'Verisval' were statistically different ($p>0.05$) from those of 'Verisval' (2.58 t/ha), 'Unival' (2.55 t/ha), etc., but not different from each other. Yields obtained were largely affected in some years by low temperatures during blooming. Although during the study time the absolute minimum temperature was -22.7 °C (February 9th, 2012), the terminal bearing cultivars were not affected. Since the fall of 2018, the cultivars were studied under conversion to organic (ecological or biological) conditions, during 2019 and 2020. The cultivars maintained their yielding capacity in 2019 and 2020 on a relatively natural fertile soil, confirming the adaptability to the environmental conditions, including temperatures of -2°C

to -3°C during April and drought during summer. Yields recorded were good for 'Jupânești' (3.5 t/ha), 'Valcor' (2.95 t/ha), 'Unival' (2.67 t/ha), 'Verisval' (2.62 t/ha), 'Valrex' (2.56 t/ha) and 'Redval' (2.54 t/ha). Statistically, differences ($p>0.05$) were observed between 'Jupânești', 'Valcor' and 'Sibișel 44', but no differences between the other cultivars tested.

The mean yields during 2019 and 2020 were 0.8-1.38 t/ha higher than the yield under conventional conditions (18 years mean), although low temperatures during flowering time negatively influenced walnut yields in 2019 and 2020.

Romanian walnut cultivars have biometric characteristics similar to other cultivars grown in different countries. Size index expressed as a mean of length, width, and height of walnuts varied during conventional conditions between 34.0 mm ('Jupânești') and 42.5 mm ('Sibișel 44') (Table 2). From the size point of view, large fruits, similar to 'Franquette' (35.6 mm) are found for all the other Romanian cultivars, except for ('Jupânești'). Differences are very small (0.94-2.0%) between nuts of the same cultivar from the conventional system and those from the organic system. In the case of an average weight of fruits, the general mean was 13.83 g for the conventional system and 13.21 g for the organic one. Largest weight of walnuts was observed for the following cultivars: 'Valcris' (15.9 g, respectively 15.51 g), 'Sibișel 44' (15.7 g, and 15.56 g), 'Germisara' (14.6 g, and 15.11 g), 'Unival' (14.5 g, respectively 13.31 g), 'Valrex' (14.3 g, and 13.38 g), 'Timval' (14.3 g, and 13.11 g). On average, nut weight decreased by 4.52% in the case of the organic system. Medium sized fruits were obtained for 'Jupânești', 'Verisval' and 'Franquette'. Kernel weight of the cultivars varied from medium-small ('Jupânești' and 'Franquette') to medium ('Verisval' and 'Velnița') and large ('Valcris', 'Sibișel 44', 'Germisara', 'Redval', etc.). 'Redval' is the first Romanian cultivar with so called "red kernel", actually the tegument of the kernel is red. During the conventional orchard management, kernel ratio varied from 46.8% ('Franquette') to 53.9% ('Verisval'), while in the case of organic approach oscillated from 47.0% ('Sibișel 44') to 51.4% ('Timval'). Kernel ratio decreased on average by 1,8% for the organic systems (Table 2).

Table 2. Characteristics of walnuts cultivars under conventional* and organic** conditions

No.	Cultivar	Mean fruit size index (mm)		Mean nut weight (g)		Mean kernel weight (g)		Mean kernel ratio (%)	
		18 years*	2019-2020**	18 years*	2019-2020**	18 years*	2019-2020**	18 years*	2019-2020**
1	'Sibișel 44'	42.5	41.37	15.7	15.56	7.6	7.3	48.4	47.0
2	'Valcor'	36.9	37.05	13.3	13.24	7.1	6.78	53.3	51.2
3	'Verisval'	37.2	36.37	12.6	11.76	6.8	5.89	53.9	50.1
4	'Valcris'	37.6	37.07	15.9	15.51	7.9	7.54	49.7	48.6
5	'Valrex'	35.6	37.78	14.3	13.38	7.3	6.64	51.3	49.6
6	'Timval'	37.0	35.95	14.3	13.11	7.35	6.73	51.4	51.4
7	'Unival'	36.4	37.28	14.5	13.31	7.4	6.67	51.0	50.1
8	'Jupânești'	34.0	34.59	11.2	10.63	5.9	5.34	52.6	50.3
9	'Germisara'	42.4	39.36	14.6	15.11	7.3	7.37	50.0	48.8
10	'Redval'	35.7	35.31	13.5	13.48	6.8	6.82	50.4	50.6
11	'Velnița'	37.5	34.74	13.5	12.44	6.2	6.31	49.7	50.7
12	'Franquette'	35.6	33.93	12.6	11.00	5.9	5.39	46.8	49.0
		<i>Mean</i>	37.28	36.93	13.83	13.21	6.96	6.57	50.7
		Differences (%)	100	98.52	100	95.48	100	94.4	100
									98.2

Walnut fruits from the cultivars analyzed showed coefficients of variability ($s\%$) between 18.5% ('Velnița') and 22,7% ('Jupânești'). The mean value of $s\%$ for all the 12 cultivars reached 19.53%. As consequence, fruit variability falls into classes: below 20% (8 cultivars)

and between 20-30% (4 cultivars). In total, the variability of fruits is more or less medium (Table 3).

Table 3. Coefficients of variability and size classes for the nuts of the studied cultivars

No.	Cultivar	Coefficient of variability for nut size (s%)	Large diameter of nuts (mm)	Size classes according to the equatorial diameter of nuts (%)				Index of roundness (IR)
				>32 mm	30-32 mm	>28-30 mm	<28 mm	
1	'Sibişel 44'	20.1	38.2	84.2	15.2	0.6	0	0.69
2	'Valcor'	17.5	36.6	82.0	16.1	1.9	0	0.86
3	'Verisval'	19.2	34.8	79.1	18.2	2.7	0	0.83
4	'Valcris'	18.9	38.8	84.5	14.8	0.7	0	0.85
5	'Valrex'	19.1	34.1	76.6	16.2	7.2	0	0.74
6	'Timval'	18.5	35.6	75.4	18.4	6.2	0	0.85
7	'Unival'	19.6	35.7	77.2	19.6	3.2	0	0.86
8	'Jupâneşti'	22.7	30.2	59.8	33.7	4.7	1.8	0.69
9	'Germisara'	21.4	40.4	81.7	17.7	0.6	0	0.78
10	'Redval'	18.7	34.8	75.6	18.4	6.0	0	0.77
11	'Velniţa'	18.5	35.8	76.4	19.5	4.1	0	0.81
12	'Franquette'	20.2	34.2	81.7	16.8	1.5	0	0.79
	Mean	19.53	35.77	77.85	18.72	3.28	0.15	0.79

Nuts were measured to determine the large diameter, which is an important indicator for grouping into size classes. All the 12 walnut cultivars fall into the extra (>32 mm) and 1st class (30-32 mm) groups. Walnuts with diameters over 30 mm are more valuable on the international walnut trade. Cultivars with more than 80% of nuts >32 mm are: 'Valcris', 'Sibişel 44', 'Valcor', 'Germisara' and 'Franquette' (Figure 1).

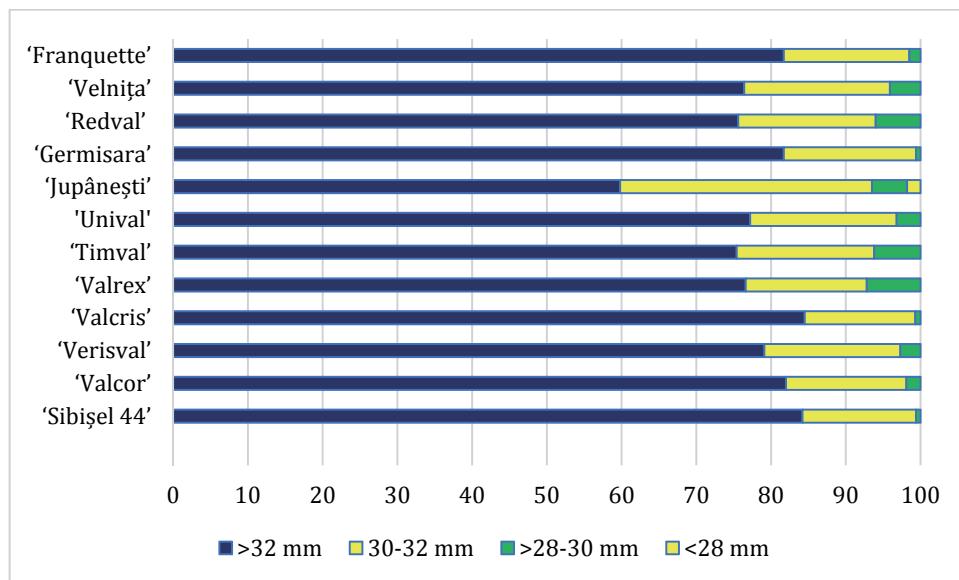


Figure 1. Diagram of nut sizes depending on the cultivar (%)

In order to determine the shape of nuts, the index of roundness (IR) was calculated for the walnut cultivars as $IR = (D + d)/2h$, where D is the length or the large diameter, d is the width and h the height of the nut. The roundness index varied between 0.69 ('Jupâneşti' and 'Sibişel 44') to 0.86 ('Valcor' and 'Unival'). When the index of roundness is closer to 1.0, the more round is the nut (Botu *et al.*, 2019).

During the study, under the conversion to the organic system, the behavior of the walnut cultivars on main diseases like walnut blight (*Xanthomonas arboricola* pv. *juglandis* or *Xaj*) and anthracnose (*Gnomonia leptostyla*) was analyzed. During the study, treatments with pesticides were accepted into organic agriculture (fungicides: Bouille bordelaise WDG and Funguran OH50WP; Microfort bactericide and insecticides: Laser 240 SC, Deffort and Ovipron Top). Disease incidence (DI) or frequency of attack (%), disease severity (DS) or intensity of the attack (%) and degree of attack (DA) were calculated.

Studies previously carried out by Botu M. et al., (2019) and Giura et al., (2020) on the behavior of walnut cultivars to the main diseases showed that the native cultivars are less affected than those with lateral bearing ones.

However, during the conversion to organic system, in the last three seasons, the attack of *Xaj* (Table 4) is different and oscillates on leaves from lower levels on 'Valcor' (DI = 5.90%, DS = 4.16%, DA = 0.26), to higher levels on 'Velnița' (DI = 12.55 %, DS = 7.53%, DA = 1.06%) and on fruit from lower levels for 'Unival' (DI = 8.0%, DS = 6.27%, DA = 0.56%) to higher levels on 'Germisara' (DI = 15.36%, DS = 11.37%, DA = 2.40%).

Table 4. Behavior of walnut cultivars to the attack of *Xanthomonas campestris* pv. *juglandis* (*Xaj*) on fruits and leaves in September (average of 3 years)

No.	Cultivar	Attack on leaves			Attack on fruits		
		Disease incidence (%)	Disease severity (%)	Degree of attack (%)	Disease incidence (%)	Disease severity (%)	Degree of attack (%)
1	'Sibișel 44'	11.03	7.63	0.93	12.89	16.67	1.58
2	'Valcor'	5.90	4.16	0.26	9.50	6.75	0.78
3	'Verisval'	7.41	4.21	0.68	8.21	5.85	0.53
4	'Valcris'	8.47	4.64	0.37	8.10	5.42	0.48
5	'Valrex'	7.57	4.82	0.38	7.49	5.69	0.46
6	'Timval'	7.25	4.72	0.34	8.30	6.31	0.59
7	'Unival'	6.56	4.82	0.55	8.00	6.27	0.56
8	'Jupânești'	10.92	6.74	0.84	14.25	11.20	2.12
9	'Germisara'	12.17	9.83	1.45	15.36	11.37	2.46
10	'Redval'	8.71	5.72	0.41	8.12	6.11	0.52
11	'Velnița'	12.55	7.53	1.06	11.87	8.85	1.18
12	'Franquette'	10.09	7.73	0.94	15.70	9.26	1.65
Mean		9.05	6.04	0.68	10.65	8.31	1.03

Table 5. Behavior of walnut cultivars to the attack of *Gnomonia leptostyla* on leaves and fruits in September (average 3 years)

No.	Cultivar	Attack on leaves			Attack on fruits		
		Disease incidence (%)	Disease severity (%)	Degree of attack (%)	Disease incidence (%)	Disease severity (%)	Degree of attack (%)
1	'Sibișel 44'	16.06	8.79	1.41	9.16	7.09	0.65
2	'Valcor'	6.69	3.77	0.25	4.73	4.51	0.21
3	'Verisval'	6.24	3.85	0.24	4.3	3.81	0.16
4	'Valcris'	6.63	3.10	0.21	4.03	2.42	0.10
5	'Valrex'	6.10	3.33	0.20	4.83	3.53	0.17
6	'Timval'	6.08	3.24	0.20	4.75	4.50	0.21
7	'Unival'	6.45	3.07	0.20	3.75	2.45	0.09
8	'Jupânești'	11.87	6.53	0.78	7.09	4.42	0.31
9	'Germisara'	13.56	7.97	1.08	8.23	3.09	0.25
10	'Redval'	6.14	3.72	0.23	5.02	3.54	0.18
11	'Velnița'	11.25	8.04	0.90	6.31	5.29	0.33
12	'Franquette'	11.98	8.45	1.01	8.54	5.14	0.44
Mean		9.09	5.32	0.55	5.90	4.15	0.26

In case of anthracnose attack on leaves, the DI varied between 6.08 % ('Timval') to 16.06% ('Sibișel 44') and DS between 3.07% ('Unival') to 8.79% ('Sibișel 44'). DA ranged between 0.20% ('Timval') and 1.44% ('Sibișel 44'). On fruits, the attack levels were low in case of 'Valcris' (DI = 4.03%, DS = 2.42%, DA = 0.11%) and higher for 'Sibișel precoce' (DI = 9.16%, DS = 7.09%, AA = 0.71%).

Walnut blight and anthracnose attacks were more obvious on 'Sibișel 44', 'Germisara', 'Velnița' and 'Franquette', while the least affected were: 'Valcor', 'Valcris', 'Unival', 'Jupânești' and 'Verisval'.

The tolerant or less susceptible walnut cultivars to these diseases can be used successfully in organic orchards, as they have other qualities as it turned out from this study.

CONCLUSIONS

The results obtained in the 18 years of conventional cultivation and 2 years of organic cultivation under the conversion phase show that the Romanian walnut cultivars are better adapted to existing ecological conditions, have good productivity, are less affected by walnut blight and anthracnose, and produce quality fruits and kernels that meet international trade requirements.

Taking into account the ecological principles of walnut cultivation and trends in increasing the production of healthy organic food, in accord with Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labeling of organic products, the following walnut cultivars are of perspective for the ecological culture in Romania: 'Valcor', 'Jupânești', 'Valrex', 'Verisval', 'Unival', 'Redval', 'Velnița', 'Timval', 'Germisara', 'Valcris' and 'Franquette'.

Organic farming can be improved with the help of new organic inputs and cultivars to be planted in the coming years in different suitable growing areas from Romania.

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