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SORTIMENTE DE SOIURI DE PERSPECTIVĂ PENTRU CULTURA ALUNULUI ÎN ROMÂNIA

ASSORTMENT OF PROSPECTIVE CULTIVARS FOR HAZELNUT CULTURE IN ROMANIA

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Abstract

Hazelnut growing is becoming more and more important in the last years in Romania. Area harvested increased from 14 ha of hazelnut orchards in 2011 up to 634 ha in 2016 and the hazelnut in-shell production increased from 51 t to 602 t recorded in 2016 (FAOSTAT Database, 2018). There is a visible trend to plant at least several hundred hectares with this nut crop in the next years. For having better results, favorable areas for planting new orchards and adapted and good quality cultivars should be used. The most favorable areas for intensive hazelnut culture in Romania are those where the lowest temperatures in the winter do not drop below -20…-22°C, such areas can be found mainly in Oltenia, Muntenia, Dobrogea, Crişana, Maramureş and Banat regions, but there are also suitable micro-areas in the other regions of the country. In order to recommend a suitable cultivar assortment for the given ecological conditions, UCv-SCDP Vâlcea has evaluated over 60 foreign hazelnut cultivars and 9 Romanian ones during the last 20 years. Cultivars were evaluated depending the in-shell nut yield recorded at 5 by 3 m planting distances (667 plants/ha), precocity, adaptability to the environmental conditions, tolerance to diseases and pests, nut and kernel quality. Trials were organized under no-irrigation conditions in Râmnicu-Vâlcea area. The cultivars have been grouped function on their nut sizes in table varieties (nut weight over 3.0 grams and nut size index over 18 mm) and varieties for industry (nut weight below 3.0 grams and nut size index between 16 to 18 mm). The table cultivars that have been emphasized are: 'Ennis' (3.3 t/ha yield and nuts of 4.0 grams in average), 'Vâlcea 22' (3.0 t/ha yield and nut weight of 3.8 g), 'Cozia' (2.4 t/ha and nut weight of 3.8 g), 'Uriaşe de Vâlcea' (2.6 t/ha and nut weight of 4.0 g), 'Butler' (2.5 t/ha and nut weight of 3.8 g) 'Hall's Giant' (2.3 t/ha and nut weight of 3.8 g) and 'Fertile de Coutard' (2.1 t/ha and nut weight of 3.6 g). Among the cultivars for industry, the following had the best results in the given environmental conditions and suitable nut quality: ''T.G.D.L.'' (3.0 t/ha yield), 'Romavel' (3.0 t/ha), 'Arutela' (3.0 t/ha), 'Clark' (2.9 t/ha), 'Lewis' (2.7 t/ha), 'Primval' (2.3 t/ha) and 'Tonda di Giffoni' (2.1 t/ha). Data collected showed that fruit yield of the cultivars studied is determined in a proportion of 48.2% by the genotype while 16.2% is determined by the environment x genotype interaction. The phenological data emphasized that dichogamy degree varies from cultivar to cultivar. The assortment of cultivars that can be planted by the farmers depends on the adaptability to the environmental conditions and type of varieties, table or industry use. Ratio between cultivars to be planted in the farm varies on pollination schemes, market demands but also on the commercial capacity of the farmer to sell the hazelnut production.

Cuvinte cheie: nucifere, *Corylus avellana*, alun.
Key words: nut crops, *Corylus avellana*, filbert.

1. Introduction

Hazelnut is a nut crop with prospects for expansion in many ecologically favorable areas of the Earth due to the increased demands on the market. Production of hazelnuts is affected more and more by variable climatic conditions and increased incidence of pest and diseases. The market needs a constant supply of quality hazelnuts, so one of the solutions to overcome the problems induced by variability of Turkish production (75% of the hazelnut world production) is planting of new orchards in different countries where the environmental conditions are suitable.

Ferrero Group, one of the major hazelnut buyers (25% of the world production) and manufacturer of Nutella®, established its own 6 hazelnut farms abroad in order to assure a constant supply for its

needs. The Agrifarms owned by Ferrero are located in Georgia (3,500 ha), Chile (3,100 ha), Australia (2,600 ha), South Africa (550 ha), Argentina (200 ha) and Serbia (200 ha). Through this approach, sustainable business model with local farmers is developed along with promotion of hazelnut growing in new locations (Ferrero CSR, 2015). In Serbia, there is interest to increase the surface of hazelnut orchards up to 10,000 ha, until the year 2020 (Pekic, 2015). The supply of Agri Australis, owned by Ferrero will provide 5,000 t of hazelnuts annually by 2020 (Nieburg, 2017).

Hazelnut world production in 2016 was over 743,455 t, lower than in 2015, which was 932,718 t due to unfavorable environmental conditions. In 2014 the production level reached 707,894 t, after 869,072 t recorded in 2013 (FAO Stat Database, 2018).

The main hazelnut producers in 2016 are: Turkey (420,000 t), Italy (120,572 t), U.S.A. (34,473 t), Azerbaijan (33,941 t), Georgia (29,500), China (26,071 t), Iran (16,327 t), Chile (16,173 t), Spain (15,306 t), France (11,041 t), etc. Romania is on the 18th place in rank, with 602 t produced in 2016 (FAO Stat Database, 2018).

Traditional growing areas of hazelnut are located mainly in Samsun, Ordu, Giresun and Trabzon (Turkey); Campania, Sicily, Piedmont and Lazio (in Italy); Tarragona and Asturias (Spain), Oregon (USA), etc (Vicol, 2010).

At present, over 400 hazelnut varieties are known, most of them belonging to *Corylus avellana* and *Corylus maxima* species, but only 20 to 40 varieties are cultivated on large areas in different countries (Mehlenbacher, 1991).

Hazelnut cultivars assortments are specific to particular ecological areas of tradition, here with a superior compaction (Romisondo et al., 1983; Baratta et al., 1994).

Assortment of hazelnut cultivars in Turkey is dominated by: 'Tombul', 'Palaz', 'Çakıldak', 'Foşa', 'Mincane', 'Kalınkara', 'Uzunmusa', 'Kan', 'Kargalak', 'Cavcava', 'Sivri', 'İncekara', 'Acı', 'Kuş', 'Yuvarlak Badem', 'Yassı Badem' and the new ones: 'Okay 28', 'Giresun Melezi' and 'Allahverdi' (Anil et al., 2016). In Italy, the main hazelnut cultivars grown are: 'T.G.D.L.' (in Piemont), 'Mortarella', 'San Giovani', 'Tonda Giffoni', 'Tonda Romana' (in Lazio), 'Siciliana', etc. (Turcu, 1997).

In Spain are grown mainly the following varieties: 'Negret', 'Gironell', 'Culpla', 'Grifoll', 'Trenet', 'Pauetet', etc., while in the U.S.A., the traditional cultivars like 'Barcelona' (syn. 'Fertile de Coutard'), 'Ennis', 'Butler', 'Hall's Giant' (syn. 'Merveille de Bollwiller'), 'Casina', etc., grown in Oregon are replaced by new ones issued by the hazelnut breeding program of Oregon State University ('Jefferson', 'Yamhill', 'Wepster', 'Dorris', 'Sacajawea', 'Lewis', 'McDonald', etc.).

In Romania, hazelnut can be found in spontanous or semi-spontanous status at the edge of deciduous forests, along the rivers and roads, almost in all hilly and mountain areas, up to 900-1200 m elevation. Evaluation of hazelnut varieties for growing in organized orchards started only after 1970. Nowadays, hazelnut is spread in many home gardens, but also in new orchards. The interest for planting hazelnut increased in the last years and in the future more orchards are planned. The total area harvested in Romania in 2016 reached 664 ha of hazelnut (FAOSTAT Database, 2018).

2. Material and methods

Research activities concerning hazelnut breeding culture have been started at Fruit Growing Research and Development Station (SCDP Vâlcea) since 1978. More than 70 varieties of hazelnuts with different geographical origins (from Turkey, U.S.A., France, Italy, Spain, U.K., Serbia, Croatia and Germany) along with 9 varieties issued by the breeding program from SCDP Vâlcea have been evaluated in the conditions of North East of Oltenia region, in the area of sub Carpathian hills. The results of testing of 24 cultivars (16 foreign and 8 domestic) are presented and represent the continuation of previous studies (Botu et al., 2018).

The area is characterized by Köppen Geiger Cfb type of climate (Kottek et al., 2006), with average annual temperature of 10.2°C and 720 mm annual rainfall.

The trials have been set up in Râmnicu Vâlcea area, under non-irrigation conditions using 5 trees per cultivar. Trees trained as single trunk have been planted at 5 by 3 m.

Observations and determinations referred to elements of growth, nut yield, biometric features of nuts, etc.

Data collected on hazelnut cultivars has been processed using analysis of variance.

3. Results and discussions

The 24 hazelnut varieties presented in the paper have different geographic origin (16 of them are foreign and 8 Romanian) (Table 1). These hazelnut varieties proved to have a different genetic background (Vicol, 2010). In hazelnut, self-incompatibility is present and is of sporophytic type, being under the control of a single locus with multiple alleles. Until now, 33 *S*-alleles have been detected for

different hazelnut cultivars (Mehlenbacher, 2014). In the case of Romanian cultivars such as 'Cozia', 'Uriaşe de Vâlcea', 'Arutela' and 'Primval', the *S*-alleles were not yet determined through the florescence microscope method.

The trees of the hazelnut cultivars are characterized by different growth vigor determined function of the trunk cross sectional areas, crown volumes and tree heights. Taking into account the three elements, the cultivars were classified into the following categories of vigor:

- weak vigor: 'Vâlcea 22' and 'Imperiale de Trebizonde';
- medium vigor: 'Cozia', 'Daviana', 'Corabel', 'TGDL', 'Tonda di Giffoni', 'Romavel', 'Arutela',
- 'Lewis', 'Clark';
- strong vigor: 'Hall's Giant', 'Ennis', 'Fertile de Coutard', 'Du Chilly', 'Butler', 'Uriaşe de Vâlcea' and 'Natval'.

Hazelnut varieties have the genetic feature to form suckers, that's way in many countries hazelnut is trained as bush. When less suckers are formed, is easier to remove them and train hazelnut cultivars as trees. Reduced number of suckers every year was observed in case of 'Hall's Giant', 'Ennis', 'Fertile de Coutard', 'Daviana', 'Lewis', 'Romavel' cultivars in the given conditions. 'Cozia', ' Vâlcea 22', 'Butler', 'TGDL', 'Segorbe' produced between 10 to 20 suckers per plant per year while 'Natval', 'Red Lambert', 'Valverd' and 'Primval' produced over 20 suckers per plant. In order to reduce the consumption of nutrients, it is necessary to remove the suckers from the plants once or twice per year.

Under the climatic conditions from northern Oltenia, the hazelnut varieties showed very different phenological characteristics in the last 20 years (Table 2).

The earliest first male bloom occurred on December 2nd and the latest end of bloom on March 22nd, while the female ones bloom between December 2 and March 20. Differences in flowering time between varieties are very high, differences also occur from one year to another for the same variety.

Varieties with late blooming of male flowers are: 'Cozia', 'Ennis', 'Du Chilly', 'Butler', 'Uriaşe de Vâlcea', 'TGDL' 'Tonda Giffoni', 'Cosford', 'Valverd'. Late blooming of female flowers occurs for 'Vâlcea 22', 'Butler', 'Uriaşe de Vâlcea', 'Natval', 'Roverd', 'Arutela', 'Clark', etc. Dichogamy in flowering time is present also in hazelnut cultivars. Thus, six varieties are protogynous, 14 are protandrous and 3 varieties are protandrous and 1 protogynous with homogamy tendency. Hazelnut cultivars need allogamous pollination and when choosing pollinators, they have to be compatible function of the *S*-alleles.

Although the hazelnut varieties bloom mostly in January-March period, when negative temperatures are recorded, the appearance of the styles of the female flowers occur gradually in time and from the 4 to 16 female flowers in the cluster, some are not affected by the low temperatures during winter. Therefore, the hazelnut varieties generally yield fruits almost every year in the areas with mild winters. The catkins are affected at -8°C during pollen shedding time and, as consequence, pollination of female flowers is deficient in such situation. During the last 2 years, climatic accidents (-2.1°C recorded on April 22nd, 2017 and -18.9°C recorded on March 1st, 2018) affected drastically the hazelnut yields.

Under the conditions of northern Oltenia, nut ripening occurs from end of August ('Vâlcea 22', 'Imperiale de Trebizonde', 'Natval' and 'Primval', continues at beginning of September ('Ennis', 'Fertile de Coutard', 'Du Chilly', 'TGDL', 'Romavel', 'Lewis', 'Clark') and ends mid-September with 'Uriașe de Vâlcea' and 'Cozia' varieties.

Average nut yield oscillated during study period in normal years between 1660 kg/ha for 'Tonda Romana' and 3300 kg/ha for 'Ennis' (Table 3). The most productive cultivars, compared to 'Tonda Romana' (as control) are: 'Ennis' (3300 kg/ha), 'Vâlcea 22' (3050 kg/ha) and 'TGDL' (3080 kg/ha).

Along with these, significant yields were observed for: 'Hall's Giant' (2680 kg/ha), 'Du Chilly' (2780 kg/ ha), 'Butler' (2505 kg/ha), 'Uriaşe de Vâlcea' (2630 kg/ha),'Romavel' (2985 kg/ha), 'Arutela' (2965 kg/ha), 'Clark' (2890 kg/ha) and 'Lewis' (2700 kg/ha). The hazelnut yield between 1500 and 3300 kg/ha, under non-irrigation conditions, ensures a profitable nut crop. Water intake by irrigation will increase the hazelnut yield per hectare.

Depending on the nut size index (SI), calculated as mean of sum of length, width and thickness and the average nut weight (NW) of hazelnuts and according to international trade standards (OECD Standard, 2011), the varieties studied are divided into two groups:

- A - Cultivars with large nuts for table consumption (SI >18mm and NW >3g);
- B - Cultivars with fruits for industry (SI <18 mm and NW <3 g).

In the first category are included the following cultivars: 'Ennis', 'Vâlcea 22', 'Hall's Giant', 'Butler', 'Fertile de Coutard', 'Uriașe de Vâlcea', etc. The varieties that can be used for industry are: 'TGDL', 'Tonda Romana', 'Tonda di Giffoni', 'Romavel', 'Arutela', 'Clark', 'Lewis', etc.

A biometric element of the nut with great importance is the kernel efficiency. Table fruit varieties have kernel percentages between 46.0% ('Fertile de Coutard') and 50.2% ('Natval').

Varieties for industry have kernel efficiency from 47.8% ('Segorbe') to 55.5% ('Red Lambert'). It is worth mentioning that from this group, the more productive varieties have high kernel efficiency, which benefits the industrialization process (52.0% for 'TGDL', 50.0% for 'Romavel' and 'Arutela', 55.2% for 'Lewis' and 55.0% for 'Clark').

Blank nuts can be found for all hazelnut varieties, the percentage varies from 0.78% ('Vâlcea 22') to 5.80% ('Du Chilly') and affects the production capacity. The most productive varieties belonging to both groups shows a relatively low percentage of blank nuts, from 0.78 to 4.25%, which fall within the results obtained in other hazelnut growing areas of the world.

Hazelnut is attacked by many diseases and pests. Under the conditions from Northern Oltenia, where hazelnut can be found in the spontaneous flora, the most damaging diseases are: bacterial canker of hazelnut decline, caused by *Pseudomonas avellanae* (between 0.1 to 6.1% affected trees) and grey mould fungal disease, caused by *Botrytis cinerea* (0.2 to 2.6% of nuts attacked) (Table 4).

The main pests are: hazelnut weevil (*Curculio nucum*) and big bud mite (*Phytoptus avellanae*). The percentage of affected nuts by hazelnut weevil ranged depending on variety from 0.3% to 4.6% while the percentage of generative buds attacked by big bud mite varied from 0.7 to 6.8% (Table 4).

The hazelnut cultivars with superior behavior from point of view of yield and nut quality, are quite resistant in the study area to diseases and pests. 'Vâlcea 22', 'Ennis', 'Hall's Giant', 'Butler' and 'Uriaşe de Vâlcea', from table varieties group and 'TGDL', 'Romavel', 'Arutela', 'Lewis' and 'Clark', from varieties for industry, emphasized a good behavior against the attack of pests and diseases.

The studied varieties showed that the genotype (G) is responsible for 48.2% of the yield, while the environment (E) has a 25.6% influence and the G x E interaction 16.2%. The varieties at which genotypic and environmental determinism are higher ('Ennis', 'Vâlcea 22', 'Hall's Giant' and 'TGDL', 'Romavel', etc.), have higher adaptability to the environmental conditions from Northern Oltenia.

Therefore, we consider that the areas with similar climatic conditions may be favorable to hazelnut growing in Romania and to the assortment of varieties (Table 5). Taking into account the minimum absolute temperature during last 50 years from different areas and the number of years with temperatures below -20°C and -26°C respectively and the rainfall and irrigation possibilities, favorable areas for hazelnut growing can be selected. Occurrence of minimum temperatures below -26°C jeopardizes hazelnut orchards and yields, in particular, in these years. From this point of view, areas from Oltenia, Dobrogea, Banat, Crişana, Maramureş and Muntenia regions are favorable for hazelnut growing. In all these areas it is necessary to irrigate intensive the hazelnut orchards in order to be profitable.

There can be also other favorable micro-zones used for hazelnut growing, with the condition of knowing well the climatic and soil conditions.

4. Conclusions

Under the ecological conditions of the Northern Oltenia region, 24 varieties of hazelnuts of different geographic origin were studied.

The average hazelnuts yield in the non-irrigation conditions oscillated between 1600 kg/ha ('Tonda Romana') and 3300 kg/ha ('Ennis'). The most productive varieties proved to be: 'Ennis', 'Vâlcea 22', 'TGDL', 'Hall's Giant', 'Romavel', 'Arutela', 'Uriaşe de Vâlcea', 'Butler' and 'Lewis'. They can form an assortment of hazelnut cultivars suitable for the environmental conditions in the study area for intensive plantings.

This assortment can be extended to other areas with similar climatic conditions, in well-chosen micro-zones of culture, where annual absolute temperatures rarely fall below -20°C; -22°C, but only under irrigation conditions.

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Tables and figures

Table 1. Main characteristics and origin of hazelnut cultivars studied at UC_V-SCDP Vâlcea

No.	Cultivars	Country of origin	Pollen incompatibility alleles formula	Growth vigor	Plant suckering*
	A - Cultivars with large nuts for table consumption				
1	'Vâlcea 22'	Romania	S_2S_{10}	weak	medium
2	'Cozia'	Romania	$S_?S_?$	intermediate	medium
3	'Hall's Giant'	Germany	S_2S_5/S_2S_{15}	high	weak
4	'Ennis'	USA	S_1S_{11}	high	weak
5	'Fertile de Coutard'	France	S_1S_2	high	weak
6	'Du Chilly'	Spain	$S_{10}S_{14}$	high	weak
7	'Butler'	USA	S_2S_3	high	medium
8	'Imperiale de Trebizonde'	Turkey	S_2S_{10}	weak	medium
9	'Uriaşe de Vâlcea'	Romania	$S_?S_?$	high	weak
10	'Daviana'	UK	S_3S_{11}	intermediate	weak
11	'Natval'	Romania	$S_{10}S_?$	high	strong
12	'Corabel'	France	S_3S_1	intermediate	medium
	B - Cultivars with fruits for industry				
13	'T.G.D.L.'	Italy	S_2S_7	intermediate	medium
14	'Tonda Giffoni'	Italy	S_2S_{23}	intermediate	medium
15	'Romavel'	Romania	$S_{10}S_?$	intermediate	weak
16	'Arutela'	Romania	$S_?S_?$	intermediate	weak
17	'Tonda Romana'	Italy	$S_{10}S_{20}$	intermediate	medium
18	'Red Lambert'	Germany	S_5S_{10}	intermediate	strong
19	'Cosford'	UK	S_3S_{11}	intermediate	medium
20	'Valverd'	Romania	S_5S_{10}	intermediate	strong
21	'Lewis'	USA	S_3S_8	intermediate	weak
22	'Primval'	Romania	$S_?S_?$	intermediate	strong
23	'Segorbe'	Spain	S_9S_{23}	intermediate	medium
24	'Clark'	USA	S_3S_8	intermediate	weak

*Plant suckering: weak (<10 suckers/plant); medium (10-20 suckers/plant); strong (>20 suckers/plant).

Table 2. Phenology of hazelnut cultivars studied at UC_V-SCDP Vâlcea

No.	Cultivars	Flowering time		Dichogamy*	Nut ripening time
		Male flowers (♂)	Female flowers (♀)		
	A - Cultivars with large nuts for table consumption				
1	'Vâlcea 22'	14.12-15.03	27.01-15.03	P	20-30.08
2	'Cozia'	07.02-16.03	14.12-14.03	P	10-20.09
3	'Hall's Giant'	10.01-15.03	14.12-12.03	P	1-10.09
4	'Ennis'	02.12-14.03	02.12-14.03	PR	1-10.09
5	'Fertile de Coutard'	14.01.-12.03	11.01-02.03	PR	1-10.09
6	'Du Chilly'	02.12-14.03	02.12-13.03	PR	1-10.09
7	'Butler'	03.02.-22.03	03.02-20.03	PR-H	1-10.09
8	'Imperiale de Trebizonde'	05.01-11.03	20.01-11.03	P	20-30.08
9	'Uriaşe de Vâlcea'	03.02-20.03	07.02-12.03	P-H	10-20.09
10	'Daviana'	27.01-13.03	07.02-20.03	PR	1-10.09
11	'Natval'	14.12-12.03	15.02-10.03	PR	20-30.08
12	'Corabel'	16.12-10.03	12.01-15.03	PR	1-10.09
	B - Cultivars with fruits for industry				
13	'T.G.D.L.'	02.12-07.03	10.01-15.03	PR	1-10.09
14	'Tonda Giffoni'	02.02-17.03	04.01-20.02	P	1-10.09
15	'Romavel'	10.01-16.03	07.02-18.03	PR	1-10.09
16	'Arutela'	10.01-18.03	03.02-16.03	PR-H	1-10.09
17	'Tonda Romana'	02.12-10.03	10.01-10.03	P	1-10.09
18	'Red Lambert'	02.12-14.03	2.12-14.03	PR	1-10.09
19	'Cosford'	17.02-15.03	05.01-14.03	PR	1-10.09
20	'Valverd'	07.02-16.03	2.12-16.03	PR	1-10.09
21	'Lewis'	08.01-03.03	02.02-06.03	PR	1-10.09
22	'Primval'	12.01-18.03	11.01-16.03	H	20-30.08
23	'Segorbe'	10.01-11.03	02.12-20.03	PR	1-10.09
24	'Clark'	14.01-17.03	10.02-10.03	PR	1-10.09

*Dichogamy: PR = protandrous; P = protogynous; H = homogamous

Table 3. Average hazelnut yields and main nut characteristics

No.	Cultivars	Hazelnut average yield (15 years)		Size index (mm)	Nut weight (g)	Kernel percentage (%)	Blank nuts (%)
		Yield (kg/ha)	Significance				
	A - Cultivars with large nuts for table consumption						
1	'Vâlcea 22'	3,050	***	21.9	3.8	46.8	0.78
2	'Cozia'	2,370	**	20.2	3.8	47.4	2.60
3	'Hall's Giant'	2,680	***	21.5	3.8	46.8	3.45
4	'Ennis'	3,300	***	22.6	4.0	47.5	3.12
5	'Fertile de Coutard'	2,100	*	20.8	3.6	46.0	2.15
6	'Du Chilly'	2,780	***	18.8	2.9	47.3	5.80
7	'Butler'	2,505	***	20.2	3.8	50.0	2.25
8	'Imperiale de Trebizonde'	2,308	**	19.9	3.2	46.2	2.20
9	'Uriaşe de Vâlcea'	2,630	***	22.8	4.0	50.0	4.25
10	'Daviana'	1,760	n.s.	18.9	2.8	48.8	4.02
11	'Natval'	2,400	**	18.7	2.8	50.2	3.66
12	'Corabel'	2,570	***	19.3	3.1	48.7	2.80
	B - Cultivars with fruits for industry						
13	'T.G.D.L.'	3,080	***	17.6	2.5	52.0	2.15
14	'Tonda Giffoni'	1,940	n.s.	18.8	2.8	48.1	2.85
15	'Romavel'	2,985	***	16.9	2.6	50.0	2.28
16	'Arutela'	2,965	***	16.5	2.5	50.0	2.20
17	'Tonda Romana' (Control)	1,660	-	17.2	2.4	48.1	3.41
18	'Red Lambert'	2,180	*	15.1	1.8	55.5	3.10
19	'Cosford'	1,880	n.s.	16.0	2.3	52.2	1.85
20	'Valverd'	1,950	n.s.	16.7	1.9	52.6	3.15
21	'Lewis'	2,700	***	17.7	3.1	55.2	2.85
22	'Primval'	2,300	**	17.8	2.4	50.0	3.20
23	'Segorbe'	1,820	n.s.	17.2	2.3	47.8	2.90
24	'Clark'	2,890	***	16.2	2.6	55.0	2.96

LSD 5% = 436 LSD 1% = 632 LSD 0.1% = 841

Table 4. Behavior of hazelnut cultivars to the most frequent pests and diseases in Oltenia region

No.	Cultivars	Diseases		Pests	
		Pseudomonas avellanae **(% of trees affected)**	***Botrytis cinerea*** **(% of nuts affected)**	***Phytoptus avellanae*** **(% of buds affected)**	***Balaninus nucum*** **(% of nuts affected)**
	A - Cultivars with large nuts for table consumption				
1	'Vâlcea 22'	3.4	2.1	2.4	3.1
2	'Cozia'	2.4	2.6	4.5	2.4
3	'Hall's Giant'	2.5	2.3	1.7	2.1
4	'Ennis'	2.8	2.4	2.4	2.6
5	'Fertile de Coutard'	2.7	2.4	2.3	2.7
6	'Du Chilly'	3.0	2.6	2.9	2.2
7	'Butler'	1.8	2.3	4.0	2.3
8	'Imperiale de Trebizonde'	1.9	1.8	4.0	2.3
9	'Uriaşe de Vâlcea'	1.0	2.6	1.9	2.6
10	'Daviana'	4.6	0.8	6.8	2.3
11	'Natval'	1.9	2.1	3.1	2.4
12	'Corabel'	1.4	1.3	1.6	1.1
	B - Cultivars with fruits for industry				
13	'T.G.D.L.'	2.4	2.2	1.9	2.0
14	'Tonda Giffoni'	6.1	0.5	0.7	1.1
15	'Romavel'	3.3	2.1	2.1	2.2
16	'Arutela'	0.9	1.1	2.2	2.1
17	'Tonda Romana'	2.1	2.4	1.9	2.5
18	'Red Lambert'	7.2	0.2	2.6	3.6
19	'Cosford'	2.1	2.4	5.4	4.6
20	'Valverd'	0.7	1.7	1.9	2.6
21	'Lewis'	0.1	0.2	1.6	0.3
22	'Primval'	0.9	1.9	1.8	2.7
23	'Segorbe'	1.8	1.7	3.5	2.0
24	'Clark'	0.3	0.2	1.7	0.3

Table 5. Areas from Romania with favorability for hazelnut growing

No.	Surrounding areas Meteorological Stations	Average of absolute minimum temperatures (1961-2010) (°C)	Absolute minimum temperatures within 50 years (°C)	Number of years with minimum temperatures below -20°C	Number of years with minimum temperatures below -26°C	Annual average rainfall (mm)
1	Rm. Vâlcea	-13.60	-22.0	1	0	715
2	Craiova	-16.61	-29.4	6	1	523
3	Drăgăşani	-13.90	-20.2	1	0	585
4	Constanţa	-12.29	-17.8	0	0	423
5	Mangalia	-12.65	-18.5	0	0	461
6	Piteşti	-15.72	-23.8	5	0	618
7	Ploieşti	-19.88	-29.5	23	5	588
8	Alexandria	-18.54	-26.2	17	2	578
9	Giurgiu	-17.60	33.6	10	0	583
10	Timişoara	-16.46	-35.3	11	1	595
11	Arad	-17.36	-29.8	11	2	585
12	Lugoj	-17.60	-33.6	10	4	623
13	Oradea	-16.74	-22.8	10	0	635