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Root yield, quality and disease resistance of organically grown carrot (*Daucus sativus* Röhl.) hybrids and cultivars

Rasa KARKLELIENĖ, Audrius RADZEVIČIUS, Edita DAMBRAUSKIENĖ, Elena SURVILIENĖ, Česlovas BOBINAS, Laisvūnė DUCHOVSKIENĖ, Danguolė KAVALIAUSKAITĖ, Ona BUNDINIENĖ

Institute of Horticulture, Lithuanian Research Centre for Agriculture and Forestry
Kauno 30, Babtai, Kaunas distr., Lithuania
E-mail: r.karkleliene@lsdi.lt

Abstract

In 2008–2009, a field experiment was carried out on a silty loam, *Calc(ar)i-Epihypogleyic Luvisol* (*LVg-p-w-cc*) in the conditions of transitional maritime-continental climate. The study involved the carrot (*Daucus sativus* Röhl.) cultivars and hybrids 'Svalia' F_1, 'Skalsa' F_1, 'Bolero' F_1, 'Noveno' F_1, 'Garduolės', 'Vaiguva', 'Vytėnų nanto', 'Šatrija', 'Monanta', 'Tito', 'Samson', 'Magi' and 'Crona'. In 2008, the carrots were sown on the 29th of April and in 2009 on the 28th of April by a hand-operated seeding machine on a profiled surface, in two rows with 70 cm inter-rows. Natural fertilizers (Biokal 01–7.0 l ha^{-1}, potassium magnesia – 250 kg ha^{-1}, Ekoplant – 250 kg ha^{-1}) were used in the organic production system. A two years' study showed that root yield of carrot hybrids (at optimal growth conditions) was 10–20% higher compared with the cultivars. 'Bolero' F_1 and 'Noveno' F_1 (74.7 and 61.7 t ha^{-1}) produced the highest root yield. 'Noveno' F_1 had a high content of carotene (18.7 mg 100 g^{-1} in fresh weight). Carrot foliage was mostly (more than 20%) damaged by *Alternaria* leaf blight in hybrid 'Skalsa' F_1 and cultivars 'Tito' and 'Monanta'. Rots caused by *Alternaria radicina*, *Phoma* sp., *Botrytis cinerea*, *Sclerotinia sclerotiorum* and bacteria were found in stored edible carrots. 'Magi' roots were most damaged (up to 20%) by black (*A. radicina*) and dry (*Phoma* sp.) rots.

Key words: *Daucus sativus*, biochemical composition, yield, pathogen damage.

Introduction

One of the main tasks in modern vegetable growing is to produce not only good quality but also organic production without any negative influence on the environment. Organic agriculture is being intensively developed in Lithuania. Currently, the area under organic agriculture accounts for more than 1% of the total farming land of the country. Vegetable cultivars developed in Lithuania are characterised by high quality, productivity and good adaptation to the climatic conditions of the country (Gaučienė, 1997; Karklelienė et al., 2007). Carrot cultivars react to the changed growing conditions differently (Wiebe, 1987; Rosenfeld et al., 1997; Gaučienė, Viškelis, 2001). The most favourable temperature for carrot growth during vegetation is 15–20ºC. During intensive root growth, carrots need constant humidity, because its lack worsens root quality (Gaučienė, 2001). Soil physical composition is of special significance for carrot and most plants yield, which greatly varies under the influence of different soil and climatic conditions (Pietola, 1995; Karklelienė et al., 2009; Zaborskienė et al., 2009).

To initiate genetic improvement of vegetable quality the breeder must determine which quality attributes are important to consumers and develop methods to rapidly and accurately assess these attributes. The consumer quality can include such diverse attributes as vitamin content, absence of antimetabolic compounds, flavour, texture, colour, appearance and convenience. Consequently, quality improvement should be performed concurrently with improvement of productivity (Simon, 1993). Genetic selection for improved carotene content, sweetness, and harshness levels has no deleterious effect on productivity of carrots (Simon et al., 1987). Currently, organic farmers largely depend on varieties supplied by conventional plant breeders and developed for farming systems in which artificial fertilizers and agro-chemicals are widely used. The organic farming system differs fundamentally in soil fertility, weed, pest and disease management, and makes higher demands on product quality and yield stability than conventional farming. For further optimization of organic product quality and yield stability new varieties are required that are adapted to organic farming systems. In the short run, organic crop ideotypes per crop and per market segment can help to select the best varieties available among existing (conventional) ones (Lammerts van Bueren et al., 2002).

Harvested roots carry the infection in leaf debris, in soil attached to the roots or on the root surface. The pathogen is usually present on stored carrots, e.g., in soil adhering to the root (Berg, Lentz, 1968). During storage, the fungus can spread into adjacent roots by contact or

over longer distances by air-borne spores (Goodliffe, Heale, 1977). Pathogens are able to spread at temperatures of −0.3 to 35°C, with a maximum rate at 20°C (Berg, Lentz, 1968). *Sclerotinia sclerotiorum* is one of the most successful and widespread plant pathogens. According to the information gathered by Boland and Hall (1994), 278 genera and 408 species are reported as host plants of the fungus. Carrot tissue infected by *S. sclerotiorum* is soft and watery but not discoloured. Pure white mould appears on the surface (Snowdon, 1992).

The aim of our experiment was to investigate and evaluate organically grown edible carrot hybrids and cultivars for root quality, yield and disease resistance.

Material and methods

Site, soil and experiment description. The study was carried out in the experimental field (in the area of organic vegetable growing) of the Lithuanian Institute of Horticulture (LIH) in 2008–2009. Two Lithuanian hybrids ('Svalia' F_1, 'Skalsa' F_1) and two foreign hybrids ('Bolero' F_1, 'Noveno' F_1), also four Lithuanian cultivars ('Garduolės', 'Vaiguva', 'Vytėnų nanto', 'Šatrija') and five foreign cultivars ('Monanta', 'Tito', 'Samson', 'Magi', 'Crona') of edible carrot (*Daucus sativus* Röhl.) were grown. Soil type: *Calc(ar)i-Epihypogleyic Luvisol* (*LVg-p-w-cc*) (Buivydaitė et al., 2001). In 2008, the carrots were sown on the 29th of April and in 2009 on the 28th of April by a hand-operated seeding machine on a profiled surface, in two rows with 70 cm inter-rows. The area of the replication plot was 5.6 m^2. For organic vegetable growing natural fertilizers were used (Biokal 01–7.0 l ha^{-1}, potassium magnesia – 250 kg ha^{-1}, Ekoplant – 250 kg ha^{-1}). In June, the carrot plants were sprayed twice against pests with a biological preparation NeemAzal-T/S (05%) and against diseases the plants were sprayed once with Champion (0.2%).

In 2008 and 2009, carrot roots were harvested on the 23rd of September and were measured for length, diameter, and 10-root weight. Ten carrot samples were selected per each replication for long term storage in controlled-climate chambers at ±1°C temperature and 85–90% humidity. The experiment was carried out in three replications.

Methods. Pathogen damage to carrots was evaluated during vegetation in July–October and during storage in October–March according to the standard methodology of disease and pest evaluation, analyzing 30 plants per each replication (Agriculture pest diseases..., 2002). For the identification of pathogens, the samples were collected from the damaged plants; for their diagnostics visual-symptomatic, humid chambers and microscopic methods were applied. The data were statistically processed by *ANOVA* method according to Duncan's test ($P = 0.05$).

At the Laboratory of Biochemistry and Technology of Lithuanian Institute of Horticulture, biochemical parameters were established in carrot fresh weight (f. w.). Carotene was measured by Murri method (Методы…, 1987), the amount of total sugar by Bertrane method, dry soluble solids by a numeric refractometer, nitrates by a potentiometer (AOAC, 1990), ascorbic acid by using 2,6 dichlorfenolindofenol sodium chloride solution (Методы…, 1987). The data of morphological and biochemical properties and yield of carrots were statistically processed by the *ANOVA* method (Systat 10. Statistics I, 2000; Tarakanovas, Raudonius, 2003).

The weather conditions. In the spring of 2008, dryer and cooler weather prevailed (Table 1). Carrots germinated unevenly but from the middle of plant vegetation to harvesting grew rather well. There was more precipitation in August–September; therefore, humidity was sufficient for plants.

Table 1. Meteorological conditions during carrot vegetation (data of the iMETOS®sm forecasting model) 2008–2009

Month	Air temperature °C			Precipitation mm		
	2008	2009	multi-year average	2008	2009	multi-year average
April	6.6	6.1	5.8	42.6	12.5	42.0
May	10.3	9.8	12.0	41.8	43.0	43.7
June	14.0	13.2	16.5	59.6	96.0	50.4
July	15.5	17.2	17.7	56.8	96.2	71.8
August	15.7	15.6	16.4	90.0	91.8	75.8
September	9.3	116	12.0	50.4	60.2	30.0

At the beginning of May in 2009, the weather was cooler; therefore germination of seeds was longer. Later carrots lacked moisture, especially in May, so they were watered additionally.

Results and discussion

Our research data showed that the total edible carrot yield during the experimental years fluctuated from 26.3 up to 74.7 t ha^{-1}; marketability ranged between 52.8–87.5% (Table 2). During the study years, 'Bolero' F_1 and 'Noveno' F_1 were distinguished for productivity (74.7 and 61.7 t ha^{-1}, respectively) out of the investigated hybrids. The total yield of hybrid 'Bolero' was significantly higher compared with Lithuanian hybrids ('Svalia' and 'Skalsa'). The data of two-year investigation showed that edible carrots of cultivar 'Garduolės' were productive and produced roots of marketable appearance (marketability – 87.5%). The least total yield was produced by 'Samson' and 'Crona' carrots (26.3–31.5 t ha^{-1}). Marketable production accounted for 52.8% to 87.5% of the total yield. Rembialkowska (2003) compared the nutritive, sensory and storage quality of edible carrots from organic farms to the crop quality from conventional farms. It was found that organic vegetables produced lower yields, but most of their nutritive, sensory and storage quality attributes were better than in conventional crops (Sorensen et al., 1997; Rembialkowska, 2003).

The size of an individual root increases with growing time and the total fresh mass and is affected by plant density. The required root size depends on the purpose for which the edible carrots will be used,

but the uniformity of size is a common demand. A genotype is primarily responsible for the root shape, which changes during growth and can be modified by environmental conditions. Low (10–15°C) temperature and low soil moisture content increase the root length relative to width. Although Rosenfeld (1998) points that cylindricity showed the closest connection with chemical variables and might be used, together with root weight, as a criterion for fully developed roots.

Table 2. The productivity of various edible carrot cultivars and hybrids

LIH organic field, 2008–2009

Cultivars and hybrids	Total yield t ha^{-1}	Marketable yield %
'Svalia' F_1	53.6	87.1
'Skalsa' F_1	51.8	79.7
'Bolero' F_1	74.7	83.9
'Noveno' F_1	61.7	79.7
'Garduolės'	65.0	87.5
'Vaiguva'	48.3	79.6
'Vytėnų nanto'	48.5	75.3
'Šatrija'	45.6	84.2
'Monanta'	53.6	77.8
'Tito'	56.5	79.5
'Samson'	26.3	52.8
'Magi'	38.5	77.5
'Crona'	31.5	77.8
LSD_{05}	18.9	–

It was established that the edible carrot cultivar 'Tito' produced significantly biggest (206.6 g) roots among the investigated cultivars and hybrids. The carrot hybrids 'Noveno' F_1 (118.0 g) and 'Bolero' F_1 (125.7 g) produced significantly smallest roots (Table 3). The edible carrot cultivar 'Tito' was distinguished for the longest (23.6 cm) roots. The roots of 'Vaiguva' and 'Skalsa' F_1 had significantly biggest diameter (4.7 and 4.6 cm, respectively), compared with other hybrids and cultivars; this also agrees with earlier research done at the Lithuanian Institute of Horticulture (Karklelienė et al., 2007). During the experimental years, the hybrid 'Noveno' F_1 and cultivar 'Magi' produced the roots of small diameter (3.2 cm).

Table 3. The evaluation of edible carrot roots for morphological properties

LIH organic field, 2008–2009

Cultivars and hybrids	Average root		
	weight g	length cm	diameter cm
'Svalia' F_1	166.8	19.6	3.9
'Skalsa' F_1	139.4	19.0	4.6
'Bolero' F_1	125.7	20.5	3.5
'Noveno' F_1	118.0	21.6	3.2
'Garduolės'	154.2	20.7	3.9
'Vaiguva'	163.0	18.0	4.7
'Vytėnų nanto'	165.2	20.6	3.9
' atrija'	191.0	22.3	4.1
'Monanta'	150.7	20.8	3.3
'Tito'	206.6	23.6	3.9
'Samson'	166.9	20.4	3.9
'Magi'	175.9	20.9	3.2
'Crona'	160.6	21.7	3.7
LSD_{05}	31.7	1.8	0.6

Edible carrot biochemical composition shows root quality. Edible carrot is a significant source of vitamin A accounting for the estimated 30% of the dietary vitamin A in the human diet. One medium-sized (60 g) edible carrot provides enough provitamin A carotene to fulfil adult vitamin A daily need. Carotenoids, including α- and β-carotene, are abundant in carrot and they account for both high provitamin A content and familiar orange colour (Simon, 1992; Grune et al., 2010). One of the main properties is the amount of carotene in them (Table 4). Significant genetic variation occurs for carotenoid levels in adapted carrot germplasm. Carotene content in U.S. carrots has increased over 50% since 1970 due to new darker orange varieties developed from a broad germplasm base (Simon, 1992). Baranski and colleagues (2012) have reported that total carotenoid content is related to root colour and range from 0 to 40 mg 100 g^{-1} in fresh weight. Orange rooted European accessions were more carotenoid-rich than Asian accessions, and advanced cultivars contained on average 20% more than older cultivated material (Baranski et al., 2012). According to our data of the two-year study, the edible carrots of Lithuanian breeding accumulated the biggest amount of carotene – 'Svalia' F_1 (19.6 mg 100 g^{-1}) and 'Skalsa' F_1 (19.4 mg 100 g^{-1}). Out of the investigated foreign cultivars and hybrids 'Bolero' F_1 (17.2 mg 100 g^{-1}) and 'Noveno' F_1 (16.4 mg 100 g^{-1}) edible carrots were distinguished by the amount of carotene (Table 4). During the years of investigation, the edible carrots 'Magi' accumulated the least amount of carotenes – 13.3 mg 100 g^{-1}.

In addition to the nutrients provided by edible carrots, flavour is also an important component of the overall quality. Consumers generally prefer sweet edible carrots without harsh, turpentiney aftertaste or bitterness (Simon, Freeman, 1985). Sugars account for sweetness and harshness, respectively (Simon, 1992). In contrast to sweet and harsh flavour, bitterness is only found in stored carrots exposed to ethylene and is thought to be caused by isocoumarin, although this is not well-established. Over a broad range of germplasm, sugar content ranges from 3% to 7% for carrots grown in organic soil (Stommel, Simon, 1989). Production of edible carrots on mineral soils can yield edible carrots with 7% to 16% of sugar. Realized heritability for sugar content is 40% to 45%. In addition to the quantitative variation for the total sugar content, a single gene controls the sugar type (sucrose *vs.* reducing sugar) in carrots (Simon, Freeman, 1985). Our research data showed that 'Garduolės' and 'Vytėnų nanto' accumulated the biggest amount of the total sugar – 8.4% and 7.8%. 'Svalia' F_1 was distinguished for the amount of dry soluble solids and dry matter – 14.1% and 18.3%. The biggest amount of nitrates was established in 'Noveno' F_1 (222.0 mg kg^{-1}), the least one – in 'Garduolės' and 'Svalia' F_1 (65.9–66.7 mg kg^{-1}).

There were no pests found in the crop of organically grown edible carrot. According to the signs of damage, very insignificant injuries by aphids were established. Since the parasites themselves were not found, it was not possible to establish their type.

In 2008, a slight damage by *Alternaria* leaf blight (*Alternaria dauci*) was established in 'Monanta', 'Vytėnų nanto', 'Garduolės' edible carrots, while in 'Magi' the damage was a little greater (Table 5). In 2009, more leaf diseases among different hybrids and varieties of carrots were found. This was caused by meteorological conditions. The amount of rainfall in June and July was 61.1–69.4% higher in 2009 than during the same period in 2008. The leaves of 'Skalsa', 'Tito' and 'Monanta'

Table 4. The biochemical properties of roots (f. w.) of edible carrot cultivars and hybrids
LIH organic field, 2008–2009

Cultivars and hybrids	Carotene mg 100 g^{-1}	Dry soluble solids %	Dry matter %	Total sugar %	Nitrates Mg kg^{-1}
'Svalia' F_1	19.6	14.1	18.3	7.5	66.7
'Skalsa' F_1	19.4	13.4	16.5	7.0	74.7
'Bolero' F_1	17.2	12.4	14.9	7.2	69.3
'Noveno' F_1	16.4	11.7	12.3	7.1	222.0
'Garduolės'	17.0	13.2	16.5	8.4	65.9
'Vaiguva'	18.5	13.0	16.2	6.9	91.7
'Vytėnų nanto'	17.6	13.7	15.2	7.8	120.0
'Šatrija'	16.8	13.9	16.5	6.5	71.6
'Monanta'	15.3	12.7	15.0	6.8	93.0
'Tito'	15.0	12.9	13.1	7.0	98.7
'Samson'	14.8	12.8	13.4	6.6	102.4
'Magi'	13.3	11.4	12.3	7.0	173.7
'Crona'	16.2	11.8	13.4	6.9	159.3
LSD_{05}	2.2	1.2	1.3	1.1	78.0

edible carrots were injured most of all – more than 20%. In 'Magi', the only observed damage was bacterial leaf blight (*Xanthomonas campestris* pv. *carotae*), the symptoms of which were very similar to those of *Alternaria* leaf blight.

Foreign researchers have reported that the severity of leaf and petiole blight and leaf chlorosis varied among isolates and carrot varieties in each of three experiments. Visible differences in disease severity ranged from 10.9% to 45.1% of the leaf area affected. Significant differences were noted among carrot varieties in response to *Alternaria* leaf blight (Rogers, Stevenson, 2010).

Table 5. Disease prevalence in organically grown edible carrot crop
LIH organic field, 2008–2009

Cultivars and hybrids	Damage by diseases %		
	Alternaria leaf blight		Bacterial leaf blight
	2008	2009	2008
'Magi'	8.3 b	4.4 abc	6.7
'Monanta'	5.0 b	21.1 fgh	0
'Crona'	0 a	4.4 abc	0
'Bolero' F_1	0 a	7.8 cd	0
'Samson'	0 a	0 a	0
'Noveno' F_1	0 a	2.2 ab	0
'Skalsa' F_1	0 a	26.7 h	0
'Svalia' F_1	0 a	4.44 abc	0
'Tito'	0 a	22.22 fgh	0
'Vytėnų nanto'	1.7 ab	17.8 ef	0
'Šatrija'	0 a	12.2 de	0
'Garduolės'	4.5 ab	5.6 bc	0
'Vaiguva'	0 a	7.8 cd	0
Average	1.5	10.5	0.5

Note. Means followed by the same letter do not differ significantly within the column at $P = 0.05$ (Duncan's multiple range test).

Carrot has good physiological storability. Provided that carrots are not infected by microbes causing storage diseases, they can be stored for 6–8 months without loss of quality under the optimal storage conditions: temperature 0ºC and relative humidity 98% (Balvoll, 1985). Carrot has low metabolic activity at low temperatures, as shown by the low respiration rate (Stoll, Weichmann, 1987). However, carrot is sensitive to wilting, if not protected from water loss. In commercial refrigerated stores, storage diseases, mainly caused by pathogenic fungi, pose the greatest risk. Ethylene in the air may impair the sensory quality by inducing the synthesis of phenolic compounds, which give rise to a bitter taste (Sarkar, Phan, 1979; Lafuente et al., 1989; 1996).

Storage diseases may cause considerable storage losses, since roots showing even minor damage must be discarded before marketing. Major pathogenic fungi are: *Alternaria radicina*, *Phoma* sp. (dry rot), *Botrytis cinerea* (grey rot), *Sclerotinia sclerotiorum* (sclerotinia rot) and bacteria (bacterial soft rot). Lewis and Garrod (1983) have defined them as being the most harmful ones. Weight loss of roots increases the incidence of infections: water loss of more than 5% markedly reduces the ability of the phloem parenchyma to resist infection (Aguilar et al., 1986). Root tip, which has a high surface to weight ratio and is often damaged at harvest, is more easily infected than are other areas of the root. The ability of the roots to resist infection varies from year to year, due to differences in growing and storage conditions. Sclerotia can persist in the soil for many years (Snowdon, 1992). After wet weather or irrigation, the sclerotia germinate by producing apothecia and ascospores. The spores are injected into the air and foliage. Le Cam et al. (1993) have reported that *S. sclerotiorum* was the most aggressive of the pathogens tested on carrot but only at temperatures above 5°C.

Table 6. Disease prevalence in organically grown edible carrot during storage
LIH organic field, 2008–2009

Cultivars and hybrids	Damage by diseases %	
	Black and dry rots	Grey, sclerotinia and bacterial soft rots
'Magi'	20 b	13.3 ab
'Monanta'	13.4 ab	0 a
'Crona'	3.3 a	13.3 b
'Bolero' F_1	3.3 a	0 a
'Samson'	3.3 a	6.7 a
'Noveno' F_1	6.7 a	10 ab
'Skalsa' F_1	13.3 ab	0 a
'Svalia' F_1	3.3 a	3.3 a
'Tito'	6.7 a	6.7 a
'Vytėnų nanto'	10 ab	0 a
'Šatrija'	6.7 a	0 a
'Garduolės'	10 ab	0 a
'Vaiguva'	13.3 b	0 a
Average	9.2	4.1

Note. Means followed by the same letter do not differ significantly within the column at $P = 0.05$ (Duncan's multiple range test).

Our investigation showed that carrots stored till 17th of April 2009 were damaged by *Alternaria radicina*, *Phoma* sp., *Botrytis cinerea*, *Sclerotinia sclerotiorum* pathogenic fungi and bacteria. Most of all (up to 20%) 'Magi' root-crops were damaged by black (*A. radicina*) and dry (*Phoma* sp.) rots. 'Magi', 'Crona', 'Noveno' F_1, 'Samson', 'Tito' and 'Svalia' F_1 edible carrot roots were damaged by grey, sclerotinia and bacterial soft rots – correspondingly from 3.3% up to 13.3%, which is 4.1% on the average (Table 6).

Conclusions

1. The edible carrot hybrids 'Bolero' F_1 and 'Noveno' F_1 produced the highest total yield 74.7 and 61.7 t ha^{-1}, respectively, compared with the other hybrids tested. The cultivar 'Garduolės' produced the highest total yield (65.0 t ha^{-1}) of all the cultivars studied.

2. The Lithuanian carrot hybrid 'Svalia' F_1 produced average total yield 53.6 t ha^{-1}, but distinguished itself among the investigated carrot genotypes for high marketability (marketable yield – 87.5%). It accumulated the largest amount of carotene (19.6 mg 100 g^{-1}) and dry soluble solids (14.1%). 'Svalia' F_1 produced roots 19.6 cm in length, 3.9 cm in diameter and 166.8 g in weight on average.

3. Pests were not detected on the organically grown carrot crop. A higher *Alternaria* leaf blight (*Alternaria dauci*) incidence was observed in 2009, compared with that in 2008. 'Skalsa' F_1, 'Tito' and 'Monanta' leaves were damaged most of all – more than 20%.

4. The damage by bacterial leaf blight (*Xanthomonas campestris* pv. *carotae*) was observed in 'Magi' carrot plants. Nevertheless, it was not observed that this disease would more significantly influence productivity and root quality. The pathogens of bacterial leaf blight may be seed-borne.

5. The rots caused by *Alternaria radicina*, *Phoma* sp., *Botrytis cinerea*, *Sclerotinia sclerotiorum* and bacteria were found in stored edible carrots. Most of all 'Magi' root-crops (up to 20%) were damaged by black (*A. radicina*) and dry (*Phoma* sp.) rots. The rots of this type in the roots of other cultivars comprised 9.2% on average. The roots of 'Magi', 'Crona', 'Noveno' F_1, 'Samson', 'Tito' and 'Svalia' F_1 were damaged by grey, sclerotinia and bacterial soft rots – correspondingly from 3.3% up to 13.3%, which is 4.1% on average.

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References

Agriculture pest diseases and their accounting [Žemės ūkio augalų kenkėjai, ligos ir jų apskaita] / compiled by J. Šurkus, I. Gaurilčikienė. – Akademija, Kėdainių r., 2002, p. 14–15 (in Lithuanian)

Aguilar J. A. E., Reifschneider F. J. B., Rossi P. F. E., Della Vecchia P. T. Levels of *Alternaria dauci* resistance in carrot and interaction with chemical control // Horticultura Brasileira. – 1986, vol. 4, p. 19–22

AOAC. Sucrose in fruits and fruit products // Official methods of analysis (15th ed.). – Arlington, USA, 1990, 922 p.

Balvoll G. Stores for and storage of vegetables and potatoes // Landbruksforlaget. – 1985, Oslo, Norway, 112 p.

Baranski R., Allender C., Klimek-Chodacka M. Towards better tasting and more nutritious carrots: carotenoid and sugar content variation in carrot genetic resources // Food Research International. – 2012, vol. 47, iss. 2, p. 182–187

Berg V. D. L., Lentz C. P. The effect of relative humidity and temperature on survival and growth of *Botrytis cinerea* and *Sclerotinia sclerotiorum* // Canadian Journal of Botany. – 1968, vol. 46, p. 1477–1481

Boland G. J., Hall R. Index of plant hosts of *Sclerotinia sclerotiorum* // Canadian Journal of Plant Pathology. – 1994, vol. 16, p. 93–108

Buivydaitė V., Vaičys M., Juodis J., Motuzas A. Lietuvos dirvožemių klasifikacija. – Vilnius, 2001, p. 76 (in Lithuanian)

Gaučienė O. Morkų hibridas *Svalia* F_1 [Carrot hybrid *Svalia* F_1] // Sodininkystė ir daržininkystė. – 1997, vol. 16, p. 57–62 (in Lithuanian)

Gaučienė O. Morkos. – Babtai, Kauno r., 2001, 67 p. (in Lithuanian)

Gaučienė O., Viškelis P. Tinkamiausių Lietuvoje auginti morkų (*Daucus carota* L.) derlius ir kokybė [Yield and quality of most suitable for growing in Lithuania carrot (*Daucus carota* L.) varieties] // Sodininkystė ir daržininkystė. – 2001, vol. 20 (4), No. 1, p. 17–24 (in Lithuanian)

Goodliffe J. P., Heale J. B. Factors affecting the resistance of cold-stored carrots to *Botrytis cinerea* // Annals of Applied Biology. – 1977, vol. 87, p. 17–28

Grune T., Lietz G., Palou A., Ross A. C. Stahl W., Tang G., Thurnham D., Yin S., Biesalski H. K. β-carotene is an important vitamin A source for humans // The Journal of Nutrition. – 2010, vol. 140, No. 12, p. 2268S-2285S

Karklelienė R., Juškevičienė D., Viškelis P. Productivity and quality of carrot (*Daucus sativus* Röhl.) and onion (*Allium cepa* L.) cultivars and hybrids // Sodininkystė ir daržininkystė. – 2007, vol. 26, No. 3, p. 208–216

Karklelienė R., Radzevičius A., Dambrauskienė E., Duchovskienė L., Bobinas Č., Kavaliauskaitė D. Reproduction features of organically grown edible carrot (*Daucus sativus* Röhl.) of Lithuanian cultivars // Agronomy Research. – 2009, vol. 7 (special issue 1), p. 305–310

Lafuente M. T., Cantwell M., Yang S. F., Rubatzky V. Isocoumarin content of carrots as influenced by ethylene concentration, storage temperature and stress conditions // Acta Horticulturae. – 1989, vol. 258, p. 523–534

Lafuente M. T., Lopez-Galvez G., Cantwell M., Yang S. F. Factors influencing ethyleneinduced isocoumarin formation and increased respiration in carrots // Journal of the American Society for Horticultural Science. – 1996, vol. 121, p. 537–542

Lammerts van Bueren E. T., Struik P. C., Jacobsen E. Ecological concepts in organic farming and their consequences for an organic crop ideotype // Wageningen Journal of Life Sciences. – 2002, vol. 50, No. 1, p. 1–26

Le Cam B., Rouxel F., Villeneuve F. Analyse de la flore fongique de la carotte conservée au froid: prépondérance de *Mycocentrospora acerina* (Hartig) Deighton // Agronomie. – 1993, vol. 13, No. 2, p. 125–133 (in French)

Lewis B. G., Garrod B. Carrots // Post-harvest pathology of fruits and vegetables / Dennis C. (ed.). – London, UK, 1983, p. 218–257

Pietola L. Effect of soil compactness on the growth and quality of carrot // Agricultural Science in Finland. – 1995, vol. 4, No. 2, p. 139–237

Rembialkowska E. Organic farming as a system to provide better vegetable quality // Acta Horticulturae. – 2003, vol. 604, p. 473–479

Rogers P. M., Stevenson W. R. Aggressiveness and fungicide sensitivity of *Alternaria dauci* from cultivated carrot // Plant Disease. – 2010, vol. 94, No. 4, p. 405–412

Rosenfeld H. J. Maturity and development of the carrot root (*Daucus carota* L.) // Gartenbauwissenschaft. – 1998, vol. 63, p. 87–94

Rosenfeld H. J., Risvik E., Samuelsen R. T., Rodbotten M. Sensory profiling of carrot from northern latitudes // Food Research International. – 1997, vol. 30, No. 8, p. 593–601

Sarkar S. K., Phan C. T. Naturally occurring and ethylene induced phenolic compounds in the carrot root // Journal of Food Protection. – 1979, vol. 42, p. 526–534

Simon P. W. Genetic improvement of vegetable carotene content // Biotechnology and nutrition: proceedings of the International Symposium. – London, UK, 1992, p. 291–300

Simon P. W. Breeding carrot, cucumber, onion and garlic for improved quality and nutritional value // Horticultura Brasileira. – 1993, vol. 11, No. 2, p. 171–173

Simon P. W., Freeman R. E. A rapid method for screening reducing sugar in carrot roots // HortScience. – 1985, vol. 20, p. 133–134

Simon P. W., Peterson C. E., Bassett M. J., Strandberg J. O., White J. M., Rubatzky V. E. B2566 carrot inbred // HortScience. – 1987, vol. 22, No. 2, p. 327

Snowdon A. L. Colour atlas of postharvest diseases and disorders of fruits and vegetables // Vegetables. – Aylesbury, UK, 1992, vol. 2, 416 p.

Sorensen J. N., Jorgensen U., Kuhn B. F. Drought effects on the marketable and nutrition quality of carrots // Journal of the Science of Food and Agriculture. – 1997, vol. 74, No. 3, p. 379–391

Stoll K., Weichman J. Root vegetables / Post harvest physiology of vegetables. – New York, USA, 1987, p. 541–553

Stommel J. R., Simon P. W. Phenotypic recurrent selection and heritability estimates for total dissolved solids and sugar type in carrot // Journal of the American Society for Horticultural Science. – 1989, vol. 114, p. 695–699

Systat 10. Statistics I // SPSS Inc. – USA, 2000, 663 p.

Tarakanovas P., Raudonius S. Agronominių tyrimų duomenų statistinė analizė taikant kompiuterines programas *ANOVA*, *STAT*, *SPLIT-PLOT* iš paketo *SELEKCIJA* ir *IRRISTAT*. – Akademija, Kauno r., 2003, 58 p. (in Lithuanian)

Wiebe H. J. Effects of plant densities and nitrogen supply on yield harvest date and quality of carrots // Acta Horticulturae. – 1987, No. 198, p. 191–198

Zaborskienė G., Garmienė G., Jasutienė I., Bundinienė O., Jankauskienė J. Auginimo sąlygų įtaka biogeninių aminų, azoto, nitritų bei nitratų kaupimuisi daržovėse [The influence of environmental conditions on biogenic amines, nitrogen, nitrite and nitrate content in leafy vegetables] // Veterinarija ir zootechnika. – 2009, vol. 45, No. 67, p. 97–103 (in Lithuanian)

Методы биохимического исследования растений / Ермаков А. И. (ред.) – Ленинград, 1987, 431 с. (in Russian)

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Ekologiškai augintų valgomosios morkos (*Daucus sativus* Röhl.) veislių bei hibridų šakniavaisių derlius, kokybė ir atsparumas ligoms

R. Karklelienė, A. Radzevičius, E. Dambrauskienė, E. Survilienė, Č. Bobinas, L. Duchovskienė, D. Kavaliauskaitė, O. Bundinienė

Lietuvos agrarinių ir miškų mokslų centro Sodininkystės ir daržininkystės institutas

Santrauka

Bandymai vykdyti 2008–2009 m. Lietuvos sodininkystės ir daržininkystės instituto ekologinio ūkio bandymų lauke. Dirvožemis – karbonatingasis sekliai glėjiškas priesmėlio ant lengvo priemolio išplautžemis (IDg8-k). Auginti valgomosios morkos (*Daucus sativus* Röhl.) veislių ir hibridų 'Svalia' F_1, 'Skalsa' F_1, 'Bolero' F_1, 'Noveno' F_1, 'Garduolės', 'Vaiguva', 'Vytėnų nanto', 'Šatrija', 'Monanta', 'Tito', 'Samson', 'Magi', 'Crona' augalai. Morkos pasėtos balandžio 29 d. (2008 m.) ir balandžio 28 d. (2009 m.) rankine sėjamąja profiliuotame paviršiuje, 70 cm tarpueiliais, dviem eilutėmis. Daržoves auginant ekologiškai, naudotos natūralios trąšos („Biokal 01", kalio magnezija ir „Ekoplant").

Tyrimų metu nustatyta, kad morkų derlingumą ir biocheminę sudėtį lemia jų genetinė kilmė bei augimo sąlygos. Dvejų metų duomenimis, morkas auginant ekologiškai nustatyta, kad didžiausią suminį derlių suformavo 'Bolero' F_1 ir 'Noveno' F_1 (74,7 ir 61,7 t ha^{-1}) hibridinės morkos. Hibrido 'Noveno' F_1 morkos turėjo didesnį kiekį (18,7 mg 100 g^{-1}) karoteno. Tarp veislių didžiausias suminis derlius (65,0 t ha^{-1}) gautas veislės 'Garduolės' morkų. Lietuviško hibrido 'Svalia' F_1 morkos davė vidutiniškai 53,6 t ha^{-1} suminį derlių, tačiau iš visų tirtų morkų išsiskyrė dideliu prekingumu (prekinis derlius – 87,5 %). Ekologiškai augintų morkų pasėliuose kenkėjų nerasta. Didesnis morkų lapijos sergamumas alternarioze (*Alternaria dauci*) nustatytas 2009 m. Labiausiai pažeista buvo veislių 'Skalsa' F_1, 'Tito' ir 'Monanta' morkų lapija – pažeidimai siekė daugiau kaip 20 %. Sandėliuotose morkose nustatyti *Alternaria radicina*, *Phoma* sp., *Botrytis cinerea*, *Sclerotinia sclerotiorum* ir bakterijų sukelti puviniai. Juodojo (*A. radicina*) ir sausojo (*Phoma* sp.) puvinių daugiausia (iki 20 %) buvo pažeisti veislės 'Magi' morkų šakniavaisiai.

Reikšminiai žodžiai: *Daucus sativus*, biocheminė sudėtis, derlius, ligos.