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PRODUCTIVITY AND ROOT-CROP QUALITY OF LITHUANIAN CARROT (*Daucus Sativus* Röhl.) BREEDER LINES

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The investigation was carried out at the Lithuanian Institute of Horticulture in 2004–2006. Nine promising Lithuanian breeder lines of carrots: 2030, 2046, 2049, 2056, 2065, 2075, 2084, 2091, 2095, and hybrid Svalia F_1 were included in our experiment. The following sets of parameters were estimated: plant phenology, morphology (length, diameter and mass of root), yield and biochemical composition (carotene, dry soluble matter, total sugar, nitrates). Carrots were cultivated in sandy or sandy-loam Calc (ar)i – Epihypogleyc Luvisols (LVg-p-w-cc), on a profiled surface in four replications. Multiyear results show that carrot root-crop quality depends not only on genotype but also on soil type and growing conditions. In Lithuania the most popular hybrid root-crops have the same shape, about 18–25 cm length and 3.6–3.9 cm diameter. Thus, for our experiment we chose breeder lines meeting to these popular standards. Breeder lines 2030 and 2075 had the best root shape: root length 18.0–21.0 cm and diameter 3.7–3.9 cm. During three years of observation, we found that breeder line 2056 carrots were large (root mass 172.7 g). Yield analysis showed that the highest total and marketable yield was achieved by breeder line 2030 and 'Svalia' F_1. Carrot breeds 2030, 2091 and 'Svalia' F_1 had the best biochemical composition.

Key words: *yield, biochemical composition, carrots, morphological characteristics, breeder lines.*

INTRODUCTION

Lithuanian agroclimatic conditions are favourable for carrot growing. The nutritional carrot value is not only contributed by good dietetic properties, but also by pro-vitamin A-β carotene content. Carrot yield can be increased by agrotechnical means, but the amount of carotene is more determined by the genetic nature of the cultivar (Wiebe, 1987; Rosenfeld *et al*., 1998). Lately, heterosic carrot hybrids of the first generation have been widely spread, which under the conditions of high quality agrotechnique are more productive and qualitative than cultivars. In Lithuania carrot hybrid breeding was started in 1985, after creation of sterile analogues of cultivars. In 1993, the first hybrid 'Svalia' was developed (O. Gaučienė). Lithuanian carrot breeds are distinguished for the amount of carotene and productivity (Gaučienė, 1997). Carrot seeds germinate best when soil temperature is 16–18 ^{o}C, air — 16–20 ^{o}C and moisture is sufficient. During the vegetation period, the most favourable temperature for carrot growing is 15–20 ^{o}C. During the intensive growth of roots, constant moisture conditions are required (Gaučienė, 2001).

The main aim of the breeding work was to create productive carrot hybrids with good biochemical composition. In this article we describe the most perspective breeding lines developed in the Lithuanian Institute of Horticulture.

MATERIALS AND METHODS

In the experiments carried out at the Lithuanian Institute of Horticulture in 2004–2006, nine Lithuanian perspective breeder's lines — 2030, 2046, 2049, 2056, 2065, 2075, 2084, 209, 2095 — were investigated and compared with 'Svalia' F_1.

Investigations were carried out in crop rotation of the experimental field. Soil was sandy light loamy calcaric epihypogleyic luvisol (*IDg 8-k, /Calc(ar)i – Epihypogleyc Luvisols – LVg-p-w-cc*) (Buivydaitė *et al*., 2001). Carrot sowing was carried out by a manual sowing machine on a profiled surface, in two rows, inter-rows of 70 cm, in 12–15 May 2004 and 2006. Carrots were harvested in October 21. Plot size was 5.6 m^2 and replications were 3×. For morphological features (length and diameter of root) and carrot root yield data significant differences were determined by ANOVA (Tarakanovas and Raudonius, 2003). Carotene was determined at the Laboratory of Biochemistry and Technology by Murri method (Ермакова, 1987), dry soluble solids by numerical refractometer ATAGO (Ермакова, 1987); total amount of dry matter gravimetrically at 105 °C up to the constant weight (Manuals of food quality control, 1986); sugar content by Bertrand method, acidity by 0.1 N NaOH solution titration and estimation of the amount of citric acid

(Ермакова, 1987); and nitrates by potentiometer (Anonymous, 1990).

Spring 2004–2006 was dryer and cooler (Table 1). Carrots germinated unevenly, but in the mid vegetation season and up till harvest grew rather well. Precipitation was higher in August–September. In 2005, when July–August had fewer cloudy days, carrots accumulated more carotene.

Table 1

METEOROLOGICAL CONDITIONS DURING VEGETATION SEASON, KAUNAS METEOROLOGICAL STATION, 2004–2006

Month	Air temperature, °C				Precipitation, mm			
	2004	2005	2006	mean 1924–2000	2004	2005	2006	mean 1924–2000
April	9.6	13.8	6.5	5.8	32.3	28.9	29.0	42.0
May	10.7	11.3	11.0	11.9	46.2	58.8	24.9	43.7
June	13.7	14.8	16.3	16.6	77.4	66.6	13.8	50.4
July	16.1	19.4	19.3	17.6	50.4	109.4	30.2	71.8
August	16.7	18.2	17.5	16.3	123.4	80.2	173.4	75.8
September	11.6	11.3	14.5	12.0	36.2	53.6	83.0	30.0

RESULTS

Perspective breeder lines were compared with Lithuanian carrot hybrid 'Svalia'. Evaluation of the total carrot yield showed that during three years of investigation breeder line 2030 was the most productive – 68.9 t·ha^{-1}. This breeder's line surpassed the control hybrid 'Svalia' by 7.1 t·ha^{-1}. Carrot hybrids 2056 and 2084 were more sensitive to environmental conditions, with total yields only 47.3 t·ha^{-1} and 46.2 t·ha^{-1} (Table 2).

Evaluation of the average marketable root weight showed that 'Svalia' F_1 produced the lowest root crop (121.0 g) of the investigated breeds. A significantly higher marketable root crop (in comparison with the control hybrid) was produced by breeder lines 2046, 2049, 2056, and 2065. Carrot breeds 2046 and 2084 had the longest roots, breeder line 2075 had the shortest roots (18.0 cm). Breeder line 2056 had the biggest roots (weight 172 g, length 23.5 cm and diameter 4.9 cm). The other investigated breeder lines had average length and diameter (Table 3).

Table 2

ESTIMATED CARROT CROP YIELD, BABTAI, 2004–2006

Hybrid and breeder's lines	Total yield, t·ha^{-1}	Marketable yield, t·ha^{-1}	Marketable output, %
'Svalia' F_1	61.8	52.5	85.0
2030	68.9	59.0	85.6
2046	51.3	40.3	78.6
2049	53.0	38.8	73.2
2056	47.3	36.5	77.2
2065	51.0	43.0	84.3
2075	59.0	48.2	81.7
2084	46.2	34.7	75.1
2091	61.9	53.5	86.4
2095	53.3	44.2	82.3
LSD_{05}	6.43	6.74	-

Table 3

EVALUATION OF CARROT MORPHOLOGICAL PARAMETERS, BABTAI, 2004–2006

Hybrid and breeder lines	Root-crop		
	Average weight of marketable root crop, g	Length, cm	Diameter, cm
'Svalia' F_1	121.0	21.8	4.1
2030	130.0	21.0	3.9
2046	165.3	26.8	3.6
2049	160.7	24.3	3.4
2056	172.7	23.5	4.9
2065	148.0	24.6	3.6
2075	135.0	18.0	3.7
2084	137.0	26.0	3.8
2091	135.0	21.2	4.0
2095	145.0	23.0	3.9
LSD_{05}	12.86	2.65	0.40

Carrot quality is determined by biochemical composition. One of the main indices is the amount of carotene, the accumulation of which is significantly influenced by temperature, number of sunny hours and precipitation at the end of the carrot season – in August and especially in September. Control hybrid 'Svalia' F_1 and 2030 accumulated the largest amount of carotene of the investigated carrots — correspondingly, 24.4 mg per 100 g^{-1}and 24.7 mg per 100 g^{-1}. Of the investigated breeder lines, 2046 and 2049 accumulated the lowest amount of carotene – correspondingly 17.9 mg per 100 g^{-1} and 17.0 mg per 100 g^{-1} (Table 4). No significant differences were observed for dry matter and dry soluble solids among the investigated breeder lines. Carrots accumulate from 7.2% to 8.3% of total sugar. The largest amount of nitrates was found in line 2075 (341.3 mg·kg^{-1}),

Table 4

CARROT BIOCHEMICAL PARAMETERS, BABTAI, 2004–2006

Hybrid and breeder lines	Carotene, mg·100g^{-1}	Dry soluble solids, %	Dry matter, %	Total sugar, %	Nitrate, mg·kg^{-1}
'Svalia' F_1	24.4	10.5	12.5	8.3	190.6
2030	24.7	10.5	12.3	8.2	184.7
2046	17.9	10.3	11.5	7.5	217.7
2049	17.0	11.0	13.6	7.6	222.3
2056	20.8	10.4	12.1	7.6	157.0
2065	20.3	9.4	11.5	7.2	181.3
2075	21.0	9.8	11.4	7.7	341.3
2084	20.4	10.7	11.3	7.3	160.0
2091	22.4	11.3	13.1	8.0	182.0
2095	18.1	11.0	13.5	7.8	182.0
LSD_{05}	3.57	1.29	1.94	0.53	104.01

while other breeder's lines during the years of investigations accumulated nitrates in amounts similar to the control hybrid.

DISCUSSION

Vegetable internal and external quality depends not only on the genotype, but also on soil and growth conditions (Бооc и др., 1990; Michalik *et al*., 1997; Угарова, 2003). The evaluation of edible carrot breeder lines showed that carrots of different genotype react differently to the environmental conditions (Gaučienė, 2001). According to the data of our three-year investigations, breeder line 2030 was the most productive one (68.9 $t \cdot ha^{-1}$). 'Svalia' F_1 reacted less to change in growth conditions, as carrots had almost equal root form (marketability reached 85%) during the years of study. According to the data of Gaučienė, this is stabile heterosic hybrid of the first generation, which little reacts to environmental conditions (1997). It was earlier established that carotene content varies from 17.0 up to 24.7 mg per 100 g^{-1}, depending on carrot maturity. Later harvest had influenced a higher carotene amount in carrots (Nilson, 1987). 'Svalia' F_1 and lines 2030 and 2091 accumulated 8.0% to 8.3% nitrate content. A high nitrate content is harmful to human health, but carrots accumulate only low amounts (Staugaitis, 1997). Under the influence of unfavourable factors, nitrates can exceed the permissible amounts. Our investigations showed large differences in breeder lines to accumulate nitrates. During the year of investigation carrots breeder lines 2056 accumulated the least amount of nitrates (157.0 $mg \cdot kg^{-1}$), and 2075 the largest amount (341.3 $mg \cdot kg^{-1}$).

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