Productivity and nutritional value of dill and parsley

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Abstract

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Investigations of productivity and biochemical value of dill cvs Moravan, Szmaragd, Common, Mammoth and parsley cvs Moss Curled, Astra, Festival, Gigant d'Italia were estimated. Dill cv. Common was the highest, 62.3 cm, and the most productive, up to 29.1 t/ha. The analyses of biochemical compounds showed that cv. Szmaragd accumulated significantly highest amount of the dry matter (14.7%) and total sugar (3.07%). Dill cvs Moravan and Common were close as to the ability for chlorophyll accumulation (2.04–2.02 mg/g). The highest amount of essential oils was estimated in the cvs Szmaragd and Mammoth, 0.17 and 0.18%, respectively. Investigations of parsley showed that even-leaved parsley cv. Gigant d'Italia formed rosette with higher leaf up to 56.7 cm, whereas cv. Festival was the most productive – 36.0 t/ha. Parsley cv. Moss Curled accumulated the highest amount of dry matter (19.4%) and ascorbic acid (162.8 mg/100 g). Cv. Astra accumulated the highest amount of essential oils (0.10%) and chlorophyll (1.44 mg/g).

Keywords: *Anethum graveolens*; *Petroselinum crispum*; cultivar; yield; leafy vegetables

Dill (*Anethum graveolens* L.) and parsley *(Petroselinum crispum* L.) belong to the parsley family (Umbelliferae) and are mostly grown outdoors and harvested seasonally. Leafy vegetables including those used as seasoning are highly valued for the biologically active compounds they contain (Kmiecik et al. 2005).

Dill and leafy parsley are popular fresh herbs both in our country and in the world for aromatic and valuable biochemical compounds. Their diversity is resumed and increased regularly, with the aim to grow vegetables with not only the highest productivity, but with valuable biochemical compounds as well (Viškelis et al. 2012). Investigation of different dill cultivars and the influence of optimal sowing time for dill productivity and quality were carried out in Lithuania. According to Dambrauskiene et al. (2006), the productivity of dill reached from 15.3 to 31.4 t/ha, while dry mater was from 10.5 to 11.1%, total sugar amount from 0.63 to 1.52%, ascorbic acid from 47.0 to 52.4 mg/100 g, carotenoids from 10.5 to 11.1 mg%. Yield structure of different dill cultivars and the best time for sowing were investigated in Poland (Kmiecik et al. 2005; Kawecka, Dyduch 2006a,b). A comparison of productivity of different cultivars grown in containers under different light conditions was carried out (Frąszczak 2009). Biochemical value changes during different stage of growth were determined in Finland (Huopalahti, Linko 1983; Huopalahti et al. 1988). Important

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subject is the ability for fresh herb storage and processing. Investigations of dill and parsley drying were carried out in Estonia (Orav et al. 2003; Vokk et al. 2011). Amount and composition of essential oils are often discussed, as well (Freeman et al. 1975; Pino et al. 1995; Callan et al. 2007). The influence of fertilization with nitrogen and phosphorus, different sowing time and row spacing for accumulation of essential oils were determined (Singh et al. 1987). Volatile compounds were investigated in leaves and seeds of dill and parsley. Composition and antimicrobial activity of volatile compounds were determined (Kasting et al. 1972; Vokk et al. 2011). Novac (2011) showed the influence of genotype to carotenoids and chlorophylls accumulation in parsley leaves. The amount of carotenoids reached from 2.0 to 2.8 mg/g, chlorophylls from 0.6 to 3.9 mg/g.

Dill and parsley are the most valuable for the nutritional benefit. Mineral matter, ascorbic acid and other biologically active compounds supply human food allowances with the stuff of natural origin, therefore investigations in this case are very important and useful (Lisiewska et al. 2004, 2006; Viškelis et al. 2012).

The aim of this study was to investigate and to evaluate the productivity and biochemical composition of different dill and leafy parsley cultivars.

MATERIAL AND METHODS

The study was carried out in the experimental field of the Institute of Horticulture of the Lithuanian Research Centre for Agriculture and Forestry (IH-LRCAF) in 2009–2011. Soil type: Calc(ar) i-Epihypogleyic Luvisol (LVg-p-w-cc) (Buivydaitė et al. 2001).

Four dill cvs Moravan (Czech Republic), Szmaragd (Netherlands), Common (Netherlands), Mammoth (Netherlands), two even-leaved parsley cvs Festival (Czech Republic) and Gigant d'Italia (Italy) and two cvs curly parsley Moss Curled (United Kingdom), and Astra (Czech Republic) were investigated. Dill and parsley were sown in the first decade of May. Seeds of plants were sown with the manual sowing machine (EarthWay® Model 1001-B; Earthway Products Inc., Bristol, USA) in two rows with 70 cm inter-rows, on flat surface. Dill was harvested in the second decade of July, when plants attained the height determined by the accepted method. This occurred after 50–60 days of sowing. Parsley was harvested in the third decade of September, when plants were 100–120 days old. The harvest was carried out by cutting plants 1.5–2.0 cm above the soil.

For productivity estimation the plants were harvested from the plots of 2.8 m^2. Investigation was carried out in four replications. Ten samples of dill and parsley were used for the measurement and biochemical analyses. The amount of carotenoids and chlorophylls were established spectrophotometrically (Genesys 10 UV; Thermo Fisher Scientific Inc., Barrington, USA) according to Scott (2001).

Biochemical parameters were established in fresh weight (f.w.) of dill and parsley at the Laboratory of Biochemistry and Technology of LRCAF Institute of Horticulture, Babtai. The amount of total sugar was determined by the Bertrand's method, dry soluble solids by a numeric refractometer (ATAGO PR-32; Atago Co., Ltd., Tokyo, Japan) (AOAC 1990). Ascorbic acid content was determined by the titrimetric method using 2.6-dichlorphenolindophenol sodium salt solution (AOAC 1990). Essential oils were prepared from dried plant material by the Clevenger distillation (USP XXII, NFXVII, 1990) on a laboratory scale (Fisons Instruments Inc., Rodano, Italy), and the amount of essential oils was calculated per dry weight. Dry solids (DS) content was determined by the air oven method after drying at 105°C in Universal Oven ULE 500 (Memmert GmbH+Co. KG, Schwabach, Germany) to a constant weight (Food analysis 1986).

The data of biochemical properties and yield of dill and parsley were statistically processed by the ANOVA method according to the Fisher's and Duncan's multiple range test for mean separation at 5% level and the analysis of principle coordinates (SPSS for Windows 11.5.; SPSS Inc., Chicago, USA).

Weather conditions. Dryer and cooler weather prevailed (Table 1) in May 2009. Germination of dill and parsley seeds was longer and productivity in this year was the lowest during all three-year period of investigation. In May 2010 and 2011 the average temperature was similar, therefore dill and parsley germinated well. June 2010 was not warm – the temperature reached 14.6°C and was 1.3°C lower than the long-term average. Therefore, productivity of dill and parsley in this year was lower compared with 2011, but the productivity was higher compared with 2009. The average temperature in June–July 2011 varied from 17.9 to 19.3°C and it was 2.0°C higher than long-term average. June 2011 was not wet (the amount of precipitation was only 48 mm), there was much more precipitation in July (the amount of precipitation reached 203.6 mm), and thus leaves of dill

Table 1. Meteorological conditions during dill and parsley vegetation

Month	Air temperature (°C)				Total precipitation (mm)			
	2009	2010	2011	multi-year average	2009	2010	2011	multi-year average
May	9.8	13.5	14.4	12.3	43.0	71.4	51.6	50.7
June	13.2	14.6	17.9	15.9	96.0	72.6	48.0	71.2
July	17.2	19.9	19.3	17.3	96.2	119.2	203.6	75.3
August	14.6	17.8	17.1	16.4	48.3	105.4	135.2	75.8
September	11.2	9.9	13.3	12.0	43.2	51.0	75.8	30.0

data of the iMETOS®sm forecasting model 2009–2011, Babtai

started to turn yellow faster. August and September 2009 were dry and warmer than average in Lithuania, while in August 2010 and 2011 the amount of precipitation was higher; it created favourable conditions for a better yield formation of parsley.

RESULTS AND DISCUSSIONS

Results of dill height and productivity showed that cv. Common was the most productive. Average height of cv. Common reached 62.3 cm (Fig. 1a), and yield of fresh dill was 29.1 t/ha (Fig. 2a). Dill cv. Mammoth was sufficiently high and productive while cv. Szmaragd was distinguished by high productivity but medium height of plants. These results agree with the earlier investigations done at the Institute of LRCAF Horticulture where dill cvs Common and Mammoth were distinguished by the productivity as well (Dambrauskiene et al. 2006). According to the results of Kawecka, Dyduch (2006a) the yield of cv. Szmaragd reached to 18.16 t/ha and the height of plant was 24.5 cm, when the vegetation period lasted on average 27–35 days. The results of our investigation showed that cv. Szmaragd yield was 67% and its height was 56% higher than when the vegetation period lasted 50–60 days. Based on the results obtained in our work and Polish researcher's investigation it is possible to conclude that dill height and productivity are determined by different meteorological conditions and time of sowing and harvesting.

According to the data of literature (Kmiecik et al. 2005) the leaf blade of dill is the most useful part for using fresh and in processing technology. Our and other researchers' investigations determined that the highest yield was obtained from the cultivars which formed the plants with the highest leaf (Udagawa 1995).

Analysis of biochemical components showed that during the three experimental years dill accumulated carotenoids up to 10.6 mg%, chlorophyll up to 2.04 mg/g and essential oils up to 0.18%. The amount of ascorbic acid in dill varied from 55.1 to 66.3 mg/100 g. Dry matter average 13.55% was determined in all investigated dill cultivars. Similar results according to this parameter were reported by other authors. Witkowska et al. (1996) stated that dry matter content in dill varied from 8.07 to 14.09 mg/100 g. It was established that dill cv. Szmaragd produced significantly the highest amount of dry matter and total sugar – 14.7% and 3.07%,

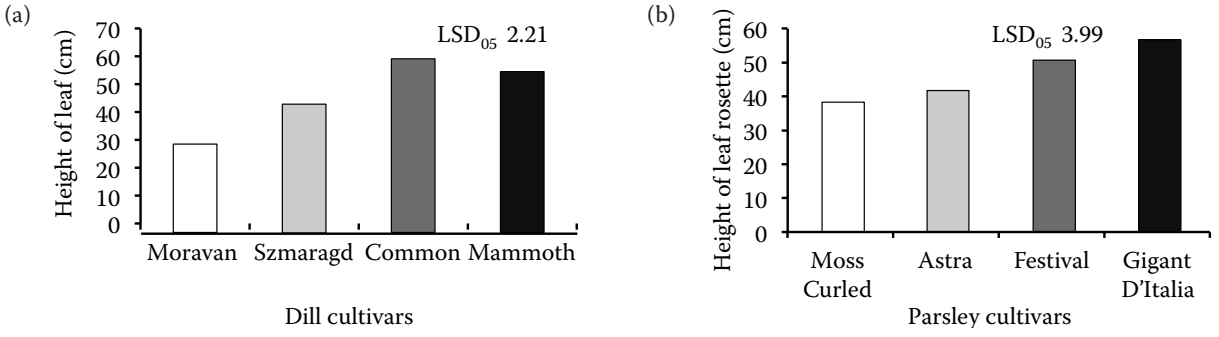

Fig. 1. Leaf height of dill (a) and parsley (b) in 2009–2011

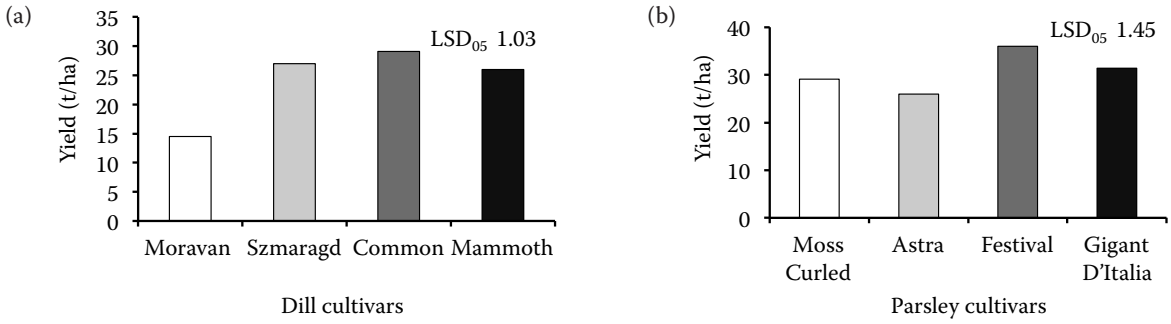

Fig. 2. Yield of dill (a) and parsley (b) in 2009–2011

respectively (Table 2). Cvs Moravan and Mammoth were distinguished by the highest amount of ascorbic acid – 64.0 and 66.3 mg/100 g in fresh herb, respectively.

The results of our investigation showed that on average 1.86 mg/g of chlorophyll was accumulated in dill (Table 3). Three dill cultivars were significantly different according to this parameter. Chlorophyll accumulation of cvs Moravan and Common was similar and reached 2.04–2.02 mg/g. Dill cv. Szmaragd accumulated significantly lowest content of carotenoids (9.7 mg%) and cv. Common accumulated low amount of essential oils (0.11%).

The obtained results of parsley height and productivity showed that the most significantly productive was cv. Festival while the yield reached to 36 t/ha (Fig. 1b). Cv. Gigant d'Italia was distinguished by the highest rosette of leaves, up to 56.7 cm (Fig. 2b).

The evaluation of biochemical composition showed high amount of dry matter – up to 19.4%, total sugar up to 3.34% and ascorbic acid up to 162.8 mg/100 g in parsley. Significantly the highest amount of dry mater was determined in leaves of parsley cvs Festival and Moss Curled, 19.2 and 19.4%, respectively (Table 4). A significant difference in ascorbic acid amount was obtained in parsley leaves; cvs Festival and Gigant d'Italia were distinguished by significantly higher amount of total sugar, 3.63 and 4.13%, respectively. Novac (2011) recorded higher amount of chlorophyll and carotenoids when curly parsley was grown in greenhouses. Significant differences were obtained between investigated parsley cultivars when the content of

Table 2. Biochemical composition of dill cultivars (2009–2011)

Cultivar	Dry matter (%)	Total sugar (%)	Ascorbic acid (mg/100 g)
Moravan	13.3^{b}	2.95^{b}	64.0^{c}
Szmaragd	14.7^{d}	3.07^{d}	58.0^{ab}
Common	12.2^{a}	2.72^{a}	55.1^{a}
Mammoth	14.0^{c}	3.0^{bcd}	66.3^{cd}
Average	13.55	2.94	60.85

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

Table 3. The content of pigments and essential oils of dill cultivars (2009–2011)

Cultivar	Chlorophylls (mg/g)	Carotenoids (mg%)	Essential oils (%)
Moravan	2.04^{c}	10.3^{b}	0.15^{b}
Szmaragd	1.60^{a}	9.7^{a}	0.17^{bcd}
Common	2.02^{c}	10.6^{d}	0.11^{a}
Mammoth	1.77^{b}	10.5^{bcd}	0.18^{d}
Average	1.86	10.27	0.15

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

Table 4. Biochemical composition of leaf parsley cultivars (2009–2011)

Cultivar	Dry matter (%)	Total sugar (%)	Ascorbic acid (mg/100 g)
Moss Curled	19.4[c]	3.35[a]	162.8[c]
Astra	17.8[a]	3.34[a]	138.4[a]
Festival	19.2[c]	3.63[b]	154.3[b]
GigantD'italia	18.3[b]	4.13[c]	138.5[a]
Average	18.68	3.61	148.86

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

Table 5. Content of pigments and essential oils of leaf parsley cultivars (2009–2011)

Cultivar	Chlorophylls (mg/g)	Carotenoids (mg%)	Essential oils (%)
Moss Curled	1.15[a]	5.4b[c]	0.08[abc]
Astra	1.44[d]	5.2a[b]	0.10[c]
Festival	1.32[c]	5.3[b]	0.04[a]
Gigant D'italia	1.25[b]	5.1[a]	0.03[a]
Average	1.29	5.25	0.06

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

chlorophyll was estimated (Table 5). The amount of carotenoids in parsley varied from 5.1 to 5.4 mg%, but the obtained differences were not significant. Cv. Astra accumu-lated significantly highest amount of essential oils (0.10%). Pokluda (2003) distinguished the influence of root parsley genotype to the productivity, accumulation of biochemical components and the development of morphological traits.

The principal coordinate analysis (PCA) showed different ability of all investigated cultivars for biochemical elements and yield formation. Dill cv. Mammoth was distinguished by the high possibility to form yield and to accumulate biochemical elements and dispersed in the scatter plot area with the highest positive value (Fig. 3a). PCA results of the amount of pigments and essential oils are shown in Fig. 3b. Cv. Mammoth is located in the PCA scatter plot with high positive value, while the rest of is located in front side of the scatter plot.

The PCA of different leaf parsley varieties according to their biochemical composition and yield results (Fig. 4a) showed that two cultivars, Moss curled and Festival, dispersed in one side of the scatter plot with high positive value not far away from

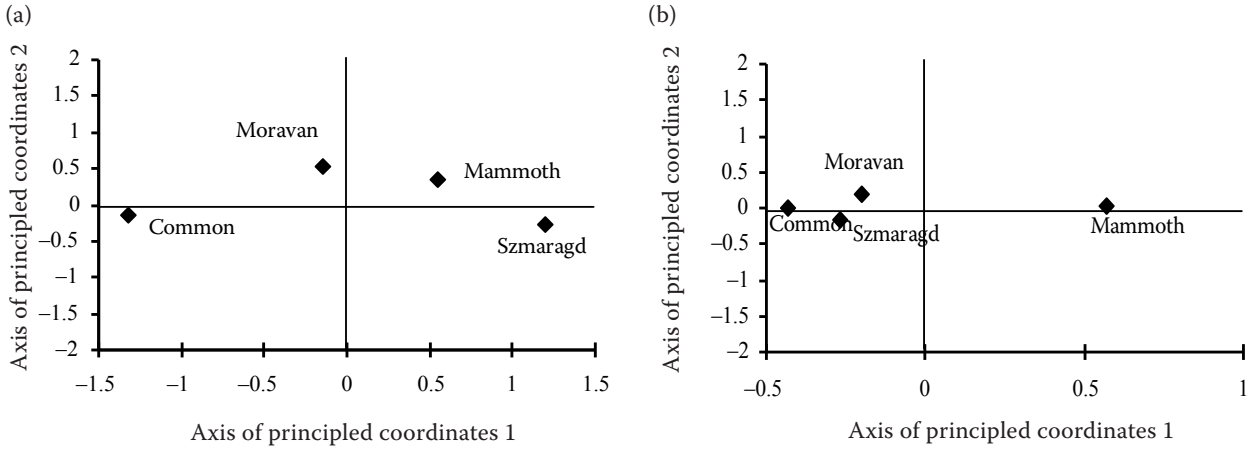

Fig. 3. Scatter plot of different dill cultivars according to the results of principal coordinate analysis (PCA) of yield and biochemical composition (a) and analysis of pigments and essential oils (b)

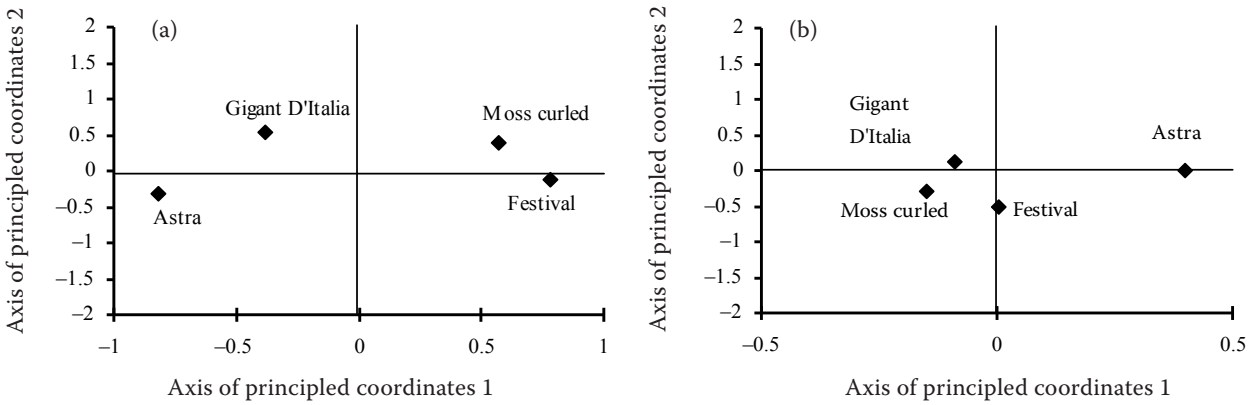

Fig. 4. Scatter plot of different parsley cultivars according to the results of PCA analysis of yield and biochemical composition (a) and analysis of pigments and essential oils (b)
PCA – principal coordinate analysis

each other. Cv. Astra was distinguished by the ability for pigments and essential oils accumulation and was dispersed in the scatter plot area with the highest positive value (Fig. 4b).

CONCLUSION

Results obtained in our investigation showed that our climatic and soil conditions are favourable for dill and parsley growing. It was determined that cultivar is one of the most important factors that affect productivity and biochemical compounds of dill and parsley.

Dill cultivar Common formed the highest rosette of leaves and was distinguished by the productivity and high chlorophyll accumulation. Cv. Szmaragd produced significantly highest amount of dry matter and total sugar, whereas cvs Moravan and Mammoth gave the highest amount of ascorbic acid.

Parsley cv. Gigant d'Italia was distinguished by the highest rosette of leaves and total sugar accumulation, whereas cv. Festival was the most productive. Cv. Astra was distinguished by the best accumulation of chlorophylls and essential oils.

In conclusion, our results show that Lithuania can be a potential competitor for countries which traditionally grow and supply dried dill and parsley to the market of the European Union.

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