

Comparison of biological characteristics and productivity of introduced cultivars of asparagus (*Asparagus officinalis* L.)

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Abstract. There is no wide range of cultivars of asparagus (*Asparagus officinalis* L.) in Lithuania. Only two of them – ‘Mary Washington’ and ‘D’Argenteuili hative’ – have been investigated and are recommended for cultivation, however they do not meet the modern requirements for the cultivars. Therefore these cultivars must be renewed or replaced by the newly developed and more productive cultivars.

The investigations of biomorphological characteristics of introduced cultivars of asparagus were carried out in the period from 2003-06 by the Department of Horticulture of the LUA.

The biological characteristics of standard cultivars of asparagus ‘Mary Washington’ (control) and introduced cultivars ‘D’Argenteuil Primaticcio’, ‘Schwetzinger Meisterschub’, ‘Eposs’, ‘Schneekopf’, ‘Rambo’, ‘Gartner Saat’ and male cultivars ‘Ravel’, ‘Ramos’, ‘Ramada’, ‘Rally’, ‘Ranger’ were investigated. Harvest period, productivity, and chemical composition were established and the indicators of shoot quality were evaluated.

The results of the research showed that vegetation of bushes of the male cultivars start later but their harvest period is longer (lasting 20 – 24 days on average). In 2004, the highest yield of shoots was formed by the bushes of the male cultivars ‘Ramos’ and ‘Ranger’, and in 2005, the highest yield was received from the bushes of standard cultivars such as ‘D’Argenteuil Primaticcio’, ‘Schwetzinger Meisterschub’, and ‘Eposs’. The highest yield of shoots of the cultivars under investigation was received in 2006 (third harvest year), ‘Ramos’ and ‘Ranger’; the bushes of standard cultivars ‘Schwetzinger Meistersschub’, ‘Rambo’ and male cultivars ‘Ravel’, ‘Ramos’ were the most productive. According to the average results of investigations, the most productive cultivars in the group of standard cultivars were ‘Schwetzinger Meisterschub’ and ‘Eposs’, and in the group of male cultivars – ‘Ravel’, ‘Ramos’ and ‘Ranger’. Shoot quality indicators (length, diameter, average mass) were in compliance with the standard quality requirements.

Key words: Asparagus, cultivars, shoots, yield, quality.

INTRODUCTION

Asparagus is grown in many countries as a delicious vegetable, however, it is mostly planted in flower gardens in our country since their sprays are suitable for bouquets (Svetika & Kmitienė, 1989; Kmitiene & Kmitas, 1999).

Young asparagus shoots are a tasteful, nutritious, vitamin-rich vegetable. Their nutritional characteristics are still underestimated in our country. There is no doubt that demand and consumption of this vegetable will gradually increase and areas of cultivation of asparagus will expand in the future. While cultivating asparagus, it is very important to select productive cultivars to develop planting material of high quality and to ensure the quality of yield and shoots (Deputy, 1999).

Morphological characteristics and productivity parameters of asparagus depend on characteristics of breed, cultivar and different conditions of growing. Since asparagus is not widespread in Lithuania, it is difficult to find proper cultivars. The most popular cultivar whose seeds are for sale is 'Mary Washington'. This cultivar originates from the USA and has been cultivated in Lithuania since 1953 (Galvydis, 1994), however it is old and does not meet the modern requirements for asparagus cultivars. The cultivars must be renewed and replaced by newly developed and more productive varieties. Many new cultivars have been developed in France, Germany, and USA: for instance, a very early American hybrid 'Atlas F₁', cultivar 'Dolce Verde', Dutch 'Limburgia', German cultivars 'Schwetzinger Meisterschub-15' and 'Schwetzinger 253/55'; unfortunately they are not imported into Lithuania (Knaflewski, 1995; Deputy, 1999).

Asparagus cultivars may be standard, male and tetraploid hybrid. Asparagus is a dioecious plant, i.e. they have male and female flowers on separate plants. A crop of dioecious cultivars contains an almost equal number of male and female plants (Cantaluppi, 1994; Kmitiene et al. 2004, 2005).

To increase the yield of shoots, only male plants should be planted. The harvest time of male plants starts earlier, resulting in higher yield of shoots. According to the professor William J., 50 male plants produce 17.28 kg of shoots on the average, while female plants produce only 11.57 kg (Macus & Gonzales, 1991). Asparagus sex may be identified only in the second year after planting when plants start to flower, therefore it is better to implant two-year sprouts in the field. According to Cantaluppi & Precheur, male plants produce more shoots, however the shoots of male bushes are larger and thicker (Cantaluppi & Precheur, 1993) Hybrids dominated only by male plants are already available abroad. The price of these hybrids is 40-50 times higher than the price of standard cultivars (Knaflewski, 1995; Motes, 1989).

Male cultivars produce only male plants. Cultivars are very productive, resistant to diseases, wilting and mechanical damage. Their plants produce fruits longer than those of standard cultivars and they do not produce seeds. The American cultivars such as 'Jersey Giant', 'Jersey King', 'Jersey Prince', 'Greenwich', Dutch cultivar 'Franklin', French hybrid 'Cito F₁', etc. are very productive. Tetraploid hybrids are mostly rareripe, productive, resistant to fusarium and asparagus corrosion – 'Apollo F₁' (German selections), etc. (Bielka, 1989; Cantaluppi, 1994; Knaflewski, 1995; Uno et al, 2002).

Asparagus plants may be grown in one place for 10-20 years. Some authors recommend cultivating asparagus for 20–30 years (Macus & Gonzales, 1991; Motes,

1989), however, according to the researches of Knaflewski M., Kmitienė L. et al., the most productive are the plants of 9–10 years; the yield of shoots decreases beyond that time frame. Harvesting of asparagus yield is started in the second or third year after planting (Knaflewski, 1995; Kmitienė & Kmitas, 1999).

To increase the yield of high quality shoots, the recommendations must be scientifically reasoned. Although literature about vegetable growth exists, it lacks practical knowledge about biological characteristics of asparagus cultivars, agricultural engineering, and nutritional value.

The aim of the investigation was to investigate biological characteristics and productivity of introduced cultivars of asparagus as well as the influence of plant age on the yield and quality of shoots, to compare productivity, intensity of yield formation and yield quality, to establish shoot quality and chemical composition, and to select more productive cultivars for propagation *in vitro*.

MATERIALS AND METHODS

The investigations of biomorphological characteristics and productivity of introduced cultivars of asparagus were carried out in the period from 2003-06 by the Department of Horticulture of the LUA. The standard cultivars such as ‘Mary Washington’ (control) (USA); ‘D’Argenteuil Primaticcio’ (France); ‘Schwetzinger Meisterschub’, ‘Eposs’, ‘Schneekopf’, ‘Rambo’, ‘Gartner Saat’ and male cultivars ‘Ravel’, ‘Ramos’, ‘Ramada’, ‘Rally’, ‘Ranger’ (German selections) were investigated. The asparagus cultivar ‘Mary Washington’ was chosen as control, since it has been investigated in Lithuania and it is possible to purchase its seeds. The seeds of asparagus cultivars selected in Germany were received from the German company “SUDVESTAAT”.

Soil in the research field is limnoglacial loam on till in deeper layers *Calc(ar)ipihypogleyic Luvisols* (Idg4-k). Agrochemical indicators of soil in 0-25 cm layer were the following: pH_{KCl} - 6.7–6.9; humus - 2.55–2.90 %; active P_2O_5 - 125–150 mg kg^{-1} , active K_2O - 108–117 mg kg^{-1} , total N - 0.150–0.160 %.

The asparagus precrop was green vegetables with short vegetation. Having harvested the precrop, the soil was scraped and 80 t ha^{-1} of organic fertilizers, 80 kg ha^{-1} of P_2O_5 and 200 kg ha^{-1} of K_2O were used during ploughing. The soil was tilled with the plough with a dredger. In spring, the nitrogen fertilizers (90 kg ha^{-1}) were spread. Rotation is not applied in this field, since asparagus may be cultivated in one place for 10–15 years.

The experiment was designed with 3 repetitions. The size of the sample field was 4.2 m^2 (6,0 x 0,7 m). The same methodology of the field experiment was applied to all asparagus cultivars.

The annual asparagus seedlings were planted at the beginning of May 2003, when early coltsfoot flowered. Distances of 70 cm were left among the rows and among the plants. When asparagus plants started to grow, they were hilled up. In the second and the third year, the plants were hilled up after harvesting and staked up in order to prevent slashes. Every year, the asparagus stalks were cut, bushes were mulched with peat, and inter-row spacings with muck before the first freeze-up periods.

Harvesting of asparagus shoots started on the 26 April 2004, the last shoots were harvested on 21 May; the harvest time in 2005 was from 10-31 May; and the harvest time in 2006 was from May 5-24.

Standard shoots (of 15–20 cm) were cut each 2nd or 3rd day early in the morning. After harvesting of the yield, shoots were sorted and weighed; total and standard yields have been established. The morphometric measurements were performed to establish the following indicators of shoot quality: average length, diameter, mass of a shoot, average number of shoots per bush. Reliability of investigational results ($LSD_{0.5}$) was assessed in terms of statistics by performing analysis of variance with software program ANOVA (Tarakanovas & Raudonius, 2003).

RESULTS AND DISCUSSION

Evaluation of Comparative Timing and Duration of Asparagus Harvest

The asparagus seedlings were planted in the field on 5 May 2003. The sprouts of standard cultivars 'Eposs', 'Shneekopf' and 'Gartner Saat' were the first ones to establish and start to grow. The asparagus sprouts of the control cultivar grew equally until the beginning of June; intensive growth of plants started in July. The duration of this growth was affected every year by the different meteorological conditions.

The yield of asparagus shoots may be harvested in the third year after planting (Knaflewski, 1995; Kmitienė & Kmitas, 1989).

The bushes of the cultivars under investigation seemed to be strong, therefore the yield of shoots was harvested before the third year after planting. The bushes of different asparagus cultivars raised their shoots at different times. Harvesting of the standard cultivars 'Mary Washington', 'D'Argenteuil Primaticcio', 'Rambo' was started earlier (on 26 April), however the harvest time of the bushes of male cultivars was longer (Table 1).

In 2005 harvesting of the shoots of cultivars under investigation was started on 10 May. The shortest harvest time was that of 'Mary Washington' bushes – 14 days. The harvest time of other cultivars was 20 - 21 days. Vegetation of the male cultivars started later, and the duration of harvest period was longer (20 - 24 days on the average).

In 2006, the asparagus plants of the cultivars under investigation started to grow earlier than in 2005, therefore the first yield of shoots was harvested 5 days earlier than previously (on 5 May). The harvest period of all cultivars was similar to the average harvest period, i.e. 19 days. The last yield of shoots was harvested on 24 May. When the air temperature rose, the shoots started to grow rapidly and formed the stalks.

According to Knaflewski M. and other authors, the shoots of young asparagus plants (1 - 3 years) may be harvested at 3 - 4 weeks. Starting from the fourth year after planting, the harvest time is extended up to 6 - 8 weeks (Knaflewski, 1995). During our investigation, the bushes of introduced cultivars produced shoots from 18 - 24 days.

Table 1. The harvest time of asparagus shoots of introduced cultivars. LUA, 2004 – 2006

Years	Beginning of vegetation	Harvest time		Duration of fruiting, days
		Beginning	Completion	
Standard cultivars				
2004	04.19-22	04.26	05.17-19	18-23
2005	05.02-07	05.10	05.23-31	14-21
2006	04.28-30	05.05	05.24	19
Male cultivars				
2004	04.22	04.26-30	05.20-21	20-24
2005	05.04-07	05.10	05.31	21
2006	04.28-30	05.05	05.24	19

Evaluation of Asparagus Productivity

The plants of the cultivars under investigation produced different yields of shoots. The maximum yield in 2004 was formed by male cultivars ‘Ramos’ and ‘Ranger’ respectively: total yield – 814.7 and 812.0, while the yield of standard shoots was 789.0 and 664.0 kg ha⁻¹ (Table 2). The more productive cultivars among standard cultivars were ‘Rambo’ and ‘D’Argenteuil Primaticcio’: total yield of shoots was respectively 582.7 and 537.6 kg ha⁻¹, while the yield of standard shoots was 542.4 and 485.1 kg ha⁻¹.

In 2005, the quality of the yield was negatively affected by disadvantageous ecological conditions – non-standard shoots comprised 30% of the whole production. Most of the non-standard yield consisted of curved, diseased and pest-damaged shoots. The cultivars ‘Mary Washington’ and ‘Gartner Sast’ produced especially small yield (total yield was only 118.2 and 250.9 kg ha⁻¹, standard yield – 100.0 and 219.1 kg ha⁻¹). The most productive male cultivars were ‘Ravel’ and ‘Ranger’. It might be assumed that in the second year after planting (2004) the bushes of some cultivars weakened due to harvesting of shoots: they raised fewer stalks, therefore they could not store enough nutrients for production of the next year’s yield. The results of investigations confirmed the statement of other scientists that it is purposeful to harvest asparagus shoots only in the third year after planting (Bielka, 1989; Knaflewski, 1995).

Table 2. The productivity of asparagus shoots of introduced cultivars. LUA, 2004-2006

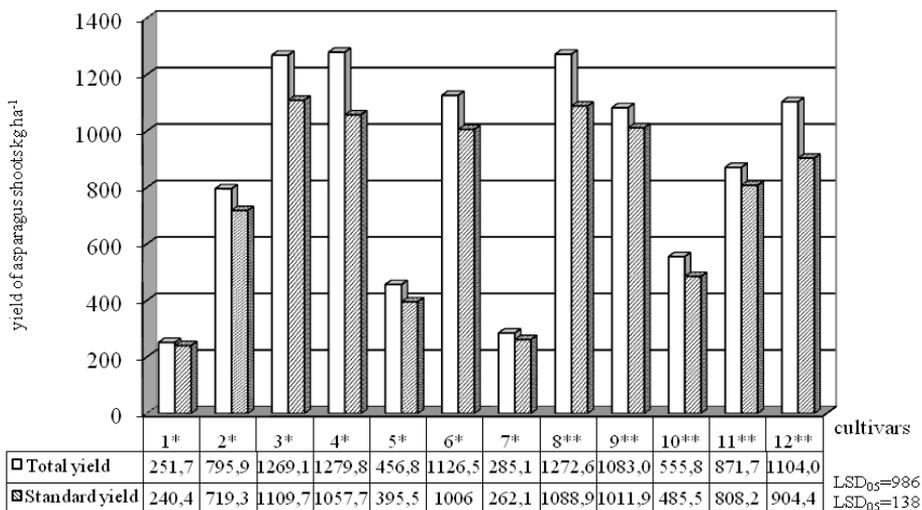
Cultivars	2004		2005		2006	
	Total shoots yield kg ha ⁻¹	Standard shoots yield kg ha ⁻¹	Total shoots yield kg ha ⁻¹	Standard shoots yield kg ha ⁻¹	Total shoots yield kg ha ⁻¹	Standard shoots yield kg ha ⁻¹
Standard cultivars						
‘Mary Washington’-control	347.3	331.5	118.2	100.0	289.7	289.7
‘D’Argenteuil Primaticcio’	537.6	485.1	644.1	505.6	1206.2	1167.3
‘Schwetzinger Meistershub’	357.5	326.7	1345.2	910.4	2185.7	2092.0
‘Eposs’	479.8	450.5	1597.0	1087.0	1762.5	1620.5
‘Schneekopf’	435.4	413.4	288.0	218.2	646.9	554.8
‘Rambo’	582.7	542.4	993.0	748.0	1803.9	1727.7
‘Gartner Saat’	409.6	359.2	250.9	219.1	239.7	208.0
Male cultivars						
‘Ravel’	479.1	448.4	1175.3	961.1	2163.3	1857.1
‘Ramos’	814.7	789.0	764.7	662.7	1669.7	1584.0
‘Ramada’	271.3	252.5	456.3	354.0	939.8	850.1
‘Rally’	263.7	553.0	621.2	527.0	1430.2	1344.5
‘Ranger’	812.0	664.0	1088.1	768.2	1412.0	1281.0
<i>LSD</i> ₀₅	6.30	92.82	6.99	5.79	170.51	221.63

The maximum yield of shoots was obtained in 2006 (the third harvesting year). The most productive cultivars were the following: ‘Schwetzinger Meistershub’, ‘Rambo’ (among standard cultivars) and ‘Ravel’ as well as ‘Ramos’ (among male cultivars). The yield of standard shoots was respectively 2090.0 and 1727.7 kg ha⁻¹, and 1857.1 and 1584.0 kg ha⁻¹. The results of the performed investigations allow the assumption that the larger yield of shoots is produced by older, more mature plants.

In summary, the average results of investigations allow concluding that the most productive cultivars in the group of standard cultivars were ‘Schwetzinger Meistershub’, ‘Eposs’ and ‘Rambo’, and in the group of male cultivars – ‘Ravel’, ‘Ramos’ and ‘Ranger’ (Fig. 1).

While comparing the parameters of shoot quality (average length, diameter, average mass) of different cultivars, it was found that the average length of shoots produced by standard cultivars differed significantly (Fig. 2). In 2004, the longest shoots were produced by ‘Mary Washington’ and ‘D’Argenteuil Primaticcio’ bushes, respectively – 21.9 and 22.4 cm. It is worth noting that the length of asparagus shoots of all categories must be 12-22 cm (Autko, 2001; Lill & Borst, 2001). The length of the shoots of male cultivars, which differed significantly, amounted to 19.2 - 20.7 cm. In 2005, the asparagus bushes of the introduced cultivars produced shorter (17.2 - 19.8

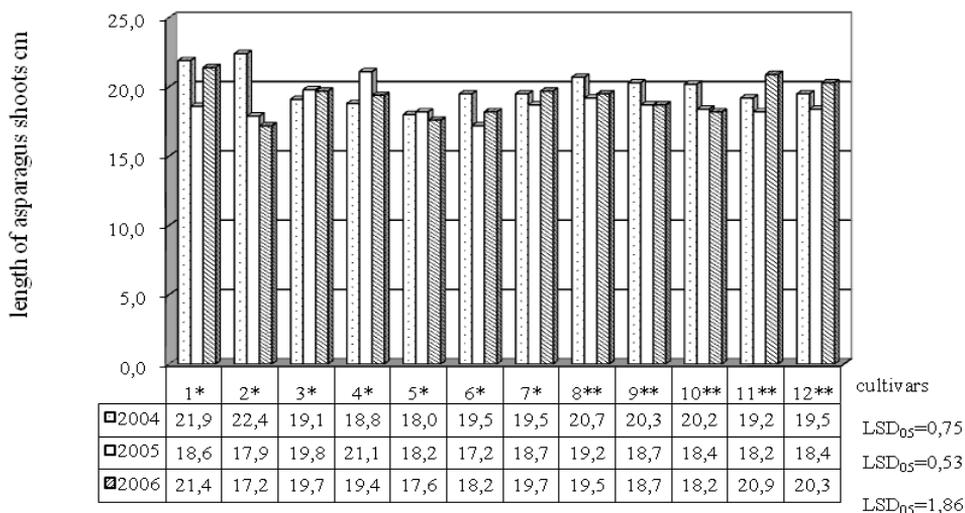
cm) shoots, only ‘Eposs’ formed longer shoots (21.1 cm on the average). In 2006, the shoots of ‘Mary Washington’ grew most rapidly, reaching reached 21.4 cm in length. In the group of male cultivars, the longest shoots were produced by ‘Rally’ and ‘Ranger’ bushes (respectively, 20.9 and 20.3 cm); the shoot length of other cultivars differed significantly from that of the control cultivar ‘Mary Washington’, however it was in compliance with the standards of quality requirements.



standard cultivars: 1-‘Mary Washington’, 2*-‘D’Argenteuil Primaticcio’, 3*-‘Schwetzinger Meistershub’, 4*- ‘Eposs’, 5*-‘Schneekopf’, 6*- ‘Rambo’, 7*- ‘Gartner Saat’, ** male cultivars - 8**-'Ravel', 9**-'Ramos', 10**-'Ramada', 11**-'Rally', 12**-'Ranger'

Fig. 1. The average means of yield of asparagus shoots of introduced cultivars (kg ha⁻¹).
LUA, 2004 – 2006

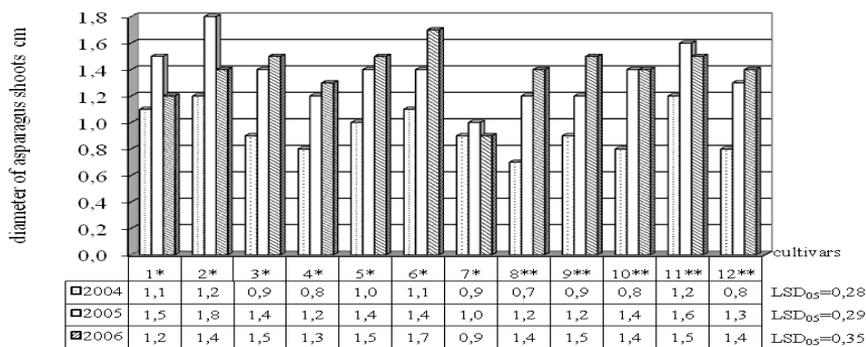
In 2004, the standards for diameter of asparagus shoots were met by the standard cultivars ‘Mary Washington’, ‘D’Argenteuil Primaticcio’ and ‘Rambo’ (1.1-1.2 cm), and among male cultivars only by ‘Rally’ – 1.2 cm (Fig. 3).



standard cultivars: 1-'Mary Washington', 2*-'D'Argenteuil Primaticcio', 3*-'Schwetzinger Meistershub', 4*-'Eposs', 5*-'Schneekopf', 6*-'Rambo', 7*-'Gartner Saat', ** male cultivars - 8**-'Ravel', 9**-'Ramos', 10**-'Ramada', 11**-'Rally', 12**-'Ranger'

Fig. 2. Length of asparagus shoots of introduced cultivars (cm). LUA, 2004-2006

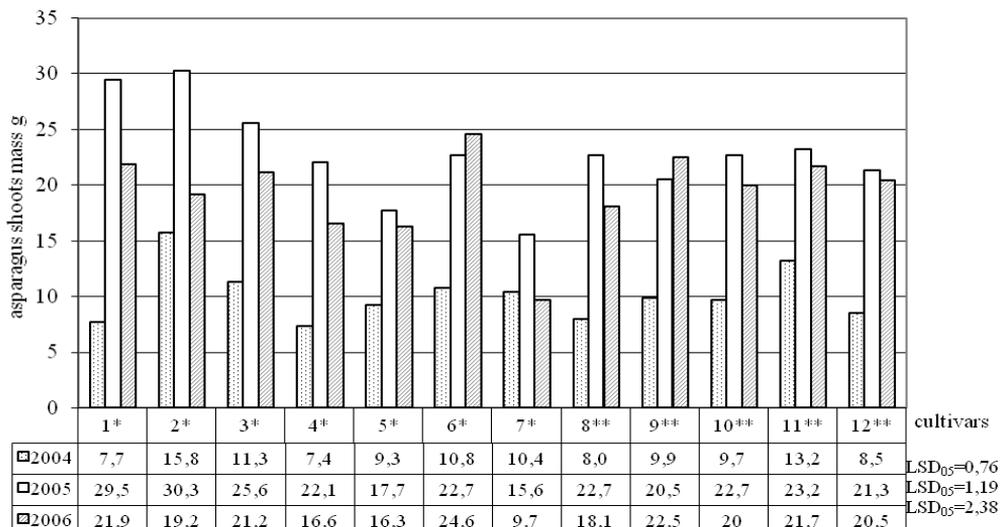
In 2005, the asparagus shoots produced thicker shoots (1.0 - 1.8 cm) and only the bushes of standard cultivar 'Gartner Saat' produced the shoots with an average diameter less than 1.0 cm. The shoots diameter of all cultivars met the standard requirements (1.0 - 2.0 cm). In 2006, the shoots diameter of all asparagus cultivars was smaller (0.9 - 1.7 cm).



standard cultivars: 1-'Mary Washington', 2*-'D'Argenteuil Primaticcio', 3*-'Schwetzinger Meistershub', 4*-'Eposs', 5*-'Schneekopf', 6*-'Rambo', 7*-'Gartner Saat', ** male cultivars - 8**-'Ravel', 9**-'Ramos', 10**-'Ramada', 11**-'Rally', 12**-'Ranger'

Fig. 3. Diameter of asparagus shoots of introduced cultivars (cm). LUA, 2004-2006

The average mass of the asparagus cultivars under investigation was the smallest in the first harvesting year (2004) and was 7.4 - 15.8 g on the average (Fig. 4). In 2005, the shoots of all cultivars under investigation were bigger and their mass was significantly larger.



standard cultivars: 1-'Mary Washington', 2*-'D'Argenteuil Primaticcio', 3*-'Schwetzinger Meistershub', 4*-'Eposs', 5*-'Schneekopf', 6*-'Rambo', 7*-'Gartner Saat', ** male cultivars - 8**-'Ravel', 9**-'Ramos', 10**-'Ramada', 11**-'Rally', 12**-'Ranger'

Fig. 4. The average of shoots mass of asparagus of introduced cultivars (g). LUA, 2004 – 2006

The average mass of standard cultivars varied from 15.6 - 30.3 g; the shoots of the maximum mass were produced by 'D'Argenteuil Primaticcio' (30.3 g). 'Rally' distinguished among other male cultivars – the average mass of its shoots was 23.2 g and thus it differed significantly from other cultivars. In 2006 (in the third harvesting year), the mass of shoots of the standard cultivars was smaller (9.7 - 24.6 g). The average shoot mass of male cultivars differed insignificantly, however it was smaller than that of 'Mary Washington'.

CONCLUSIONS

Asparagus bushes of different cultivars raise shoots at different times. The standard cultivars 'Mary Washington', 'D'Argenteuil Primaticcio' and 'Rambo' start to produce shoots earlier than the male cultivars, however the duration of harvest period of male cultivars was longer (20-24 days on average).

The most productive cultivars in the group of standard cultivars were 'Schwetzinger Meistershub' (respectively: total yield -1269,1 kg ha⁻¹, standard – 1109,7 kg ha⁻¹ on the average) and 'Eposs' (respectively: total yield – 1279,8 kg ha⁻¹, standard – 1057,7 kg ha⁻¹ on the average) and in the group of male cultivars – 'Ravel'

(respectively: total yield -1272,6 kg ha⁻¹, standard – 1088,9 kg ha⁻¹ on the average), ‘Ramos’ respectively: total yield – 1083,0 kg ha⁻¹, standard – 1011,9 kg ha⁻¹ on the average) and ‘Ranger’ respectively: total yield – 1104,0 kg ha⁻¹, standard – 904,4 kg ha⁻¹ on the average). These cultivars may be recommended for propagation *in vitro*.

The length and width of the shoots of standard and male cultivars under investigation (respectively 19.2 – 20.7 cm and 1.0-1.8 cm on the average) were in compliance with the standard requirements.

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