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STRAWBERRY CULTIVAR SELECTION FOR NORTHWEST CLIMATE AND EVALUATION OF SOME FERTILIZERS

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ABSTRACT

The aim of this research was to evaluate the performance of newly introduced strawberry cultivars in Latvia on open field conditions and to evaluate the effectiveness of nano and bio fertilizers. Eight cultivars: 'Selvik', 'Markat', 'Elsariusz', 'Granda Rosa', 'Panon', 'Paladyn', 'Suitene' and 'Honeoye' were included in the investigation. The fertilization scheme with application of fertilizers: Nano ELEMENT™ (microelement fertilizer) and Bio ELEMENT™ (contains microorganisms) was tested. The evaluation was done for two seasons. According to obtained results 'Selvik' and 'Panon' were selected as the most promising for growing in Latvia climatic conditions. They characterized by appropriate winter hardiness and good productivity. In total, the application of fertilizers Nano ELEMENT™ and Bio ELEMENT™ had no statistically significant impact on strawberry phenological development, productivity and fruit quality during two production seasons, while some difference in response among cultivars was observed.

Keywords: Fragaria × ananassa Duch., yield, fruit quality, resistance to pests and diseases, Latvia.

INTRODUCTION

Strawberry is the one of the most widely grown commercial berry crops in Latvia. In 2018, the area of strawberries was about 542 ha with increase for 11 % during last five years [1]. Strawberries are popular thanks to their good taste qualities, rich source of plant-derived compounds that promote human health, early beginning of production, plasticity in growing a. o. Due to high costs of growing in high tunnels and greenhouses farmers are still mainly growing strawberry on open field. It demands careful choice of cultivars adapted to local agroclimatic conditions. Latvia climate is characterized by warm summers and fairly severe winters. Climate is influenced by Baltic Sea and warm Goalph stream. Long term observation data show that climate changes are happening in Latvia as well [2]. There are observed higher fluctuations of temperature and rainfalls. The increased import of planting material succeeds the introduction of new foreign cultivars that not always are appropriate for growing in local conditions. The evaluation of newly introduced cultivars is performed at the Institute of Horticulture (LatHort). Some evaluation is done also on farms.

Proper plant nutrition is also very important for obtaining of good strawberry yield with high quality fruits [3]. Nanotechnology is a new area of technology in agricultural fields that recently has emerged and could be very useful in designing the new generation of fertilizers with higher efficiency of nutrient use [4]. Nanofertilizers are being studied as a way to increase nutrient efficiency and improve plant nutrition, compared with traditional fertilizers on different crops [4–6]. However there is still less information on their effectiveness, including strawberry. Alongside the new generation of fertilizers, biological fertilizers are also the centre of consideration. Biofertilizers play a very significant role in improving soil fertility by fixing atmospheric nitrogen, both, in association with plant roots and without it, solubilise insoluble soil phosphates and produces plant growth substances in the soil [7].

These studies summarize the research results on evaluation of 8 strawberry cultivars and the effect of two fertilizers: Nano ELEMENT™ (Nano microelement fertilizer) and Bio ELEMENT™ (bacteria fertilizer).

MATERIALS AND METHODS

The experiment was carried out at the Institute of Horticulture (LatHort) in Pūre, Tukums region, Latvia (57°02′ N and 22°52′ E). The experimental site was situated on a sandy loam soil with dolomite mother rock, pH_{KCl} 6.2, K_2O – 80 mg kg^{-1}; P_2O_5 – 220; Mg – 243; Ca – 1100 mg kg^{-1}.

Polish cultivars 'Selvik', 'Markat', 'Elsariusz', 'Granda Rosa', 'Panon', 'Paladyn' were included in the investigation. Local cultivar 'Suitene' (late ripening) and USA cultivar 'Honeoye' (early ripening) were used as controls. Plants were planted in the beginning of June, 2015 in rows with a planting distance 1.0 m between rows and 0.3 m between plants in rows. No irrigation was used, except at planting. Mineral fertilizers were applied each year as top dressings according to soil analysis results. Weeds were controlled mechanically and by hand weeding.

Cultivars were planted in randomly located plots in four replicates with 30 plants per plot. Plots were split in two parts, where fertilizers: Nano ELEMENT™ (microelement fertilizer, contains Mg, Zn, Fe, Mn, Cu, Co, No, Se, Nd) and Bio ELEMENT™ (contains microorganisms *Azotobacter chroococcum, Bacillus megaterium, Bacillus subtilis*) were applied in one part of plots. Fertilizers were applied two times per season every year during spring – summer time. The Bio ELEMENT™ was applied on April 5 and May 16 in 2016 and on April 7 and May 23 in 2017 with dose 1 L ha^{-1} by watering soil around plants. The Nano ELEMENT™ was applied on May 13 and June 6 in 2016 and on May 19 and June 15 in 2017 with dose 1 ml 100 m^{-2} by spraying on leaves.

The evaluations were performed for two growing seasons: 2016 and 2017. Strawberry flowering and fruit ripening time was registered. The winter damage, total yield, marketable yield, amount of Extra (>25 mm Ø), Class I and Class II (>18 mm Ø) fruits, unmarketable fruits, average fruit weight, susceptibility to diseases and pests were recorded during the both seasons. The sorting of fruits was done according to EC Regulation 543/2011/EU [8]. Winter damage was evaluated visually at the beginning of vegetation, using a scale 1–9 (where 1 = no visual winter injury, and 9 = totally injured/dead plants). Strawberry blossom weevil (*Anthonomus rubi*) damage was recorded as a percent of damaged flower buds from total for one meter of row in every plot. The susceptibility to leaf diseases – the common leaf spot (*Mycosphaerella fragariae* Tul., Lindau.) and leaf scorch (*Diplocarpon earlianum* Ellis & Everh), root and crown diseases (causal agent was not detected) and strawberry mite (*Tarsonemus pallidus*) were evaluated visually after finishing of fruit harvesting using a scale 1–9 (where 1 = no visual damages, and 9 = totally injured all plants). The sensory evaluation of fruits was performed where appearance, flavour and firmness on a scale of 1–9 (1 = the lowest positive evaluation, 9 = the highest positive evaluation) were evaluated.

Descriptive statistics, analysis of variance, followed by LSD test ($p \leq 0.05$) were used for data analysis.

RESULTS AND DISCUSSION

Flowering and fruit ripening time. Significant difference between evaluated cultivars regarding to flowering and fruit ripening time was stated. Usually it is important to get higher early and very late yield in season for higher income. In the trial, none of the evaluated polish cultivars had earlier beginning of flowering and fruit ripening as control cultivar 'Honeoye'. Some of evaluated cultivars had later beginning of harvesting than late ripening control cultivar 'Suitene', while the end of harvesting was similar. 'Paladyn' was the latest regarding to flowering and ripening time (table 1). Late fruit ripening time was observed also for 'Granda Rosa' and 'Panon'.

Table 1. **Strawberry flowering and fruit harvesting time for cultivars and fertilizer treatments, average of two years (2016–2017)**

Cultivar, treatment	Beginning of flowering, day of the year	Fruit harvesting		
		beginning, day of the year	end, day of the year	duration, days
Cultivar				
Selvik	143	172	200	27
Markat	140	173	199	26
Elsariusz	143	172	196	25
Granda Rosa	142	175	202	28
Panon	145	175	204	29
Paladyn	146	176	203	27
Honeoye (st.)	139	170	194	24
Suitene (st.)	142	173	204	31

End of table 1

Cultivar, treatment	Beginning of flowering, day of the year	Fruit harvesting		
		beginning, day of the year	end, day of the year	duration, days
Cultivar				
$LSD_{0.05}$	1.1	1.7	1.9	2.6
p value	0.000	0.000	0.000	0.000
Treatment				
Without additional fertilizing	140	173	200	27
With additional fertilizing	140	173	200	27
$LSD_{0.05}$	0.4	0.8	1.2	1.6
p value	0.720	0.846	0.362	0.450

'Honeoye' had the shortest harvesting period, whereas the longest harvesting period was observed for 'Suitene'. The application of "Nano ELEMENT" and "Bio ELEMENT" fertilizers significantly did not influence strawberry flowering and harvesting season.

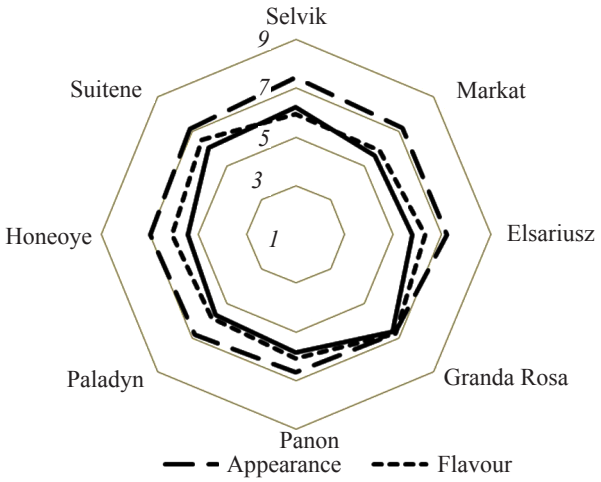
Yield and fruit quality. During growing seasons plants suffered from unfavourable weather conditions: from cold in winter and from draught (in 2016) and wet (in 2017). As well as spring frosts during flowering were observed in 2017. By these reasons, the obtained yield in trial was low. The significant differences among cultivars regarding to yield and quality were observed. In average of two years, the highest total and marketable yield was harvested from 'Panon' and 'Selvik' (table 2). They gave significantly higher total yield than both control cultivars. The lowest yield was harvested from 'Granda Rosa' which strongly suffered during winter.

Table 2. **Strawberry yield and quality for cultivars and fertilizer treatments, average of two years (2016–2017)**

Cultivar, treatment	Total yield, g plant^{-1}	Marketable yield, g plant^{-1}	In % from total yield			Average fruit weight, g
			Extra and Class I	rotted	other unmarketable	
Cultivar						
Selvik	231	148	42	1.4	35	9.7
Markat	105	58	32	9.8	38	11.4
Elsariusz	124	57	23	4.8	50	10.4
Granda Rosa	66	40	41	6.3	35	11.3
Panon	232	141	38	3.9	36	9.5
Paladyn	168	69	19	6.1	53	9.3
Honeoye (st.)	82	55	44	1.7	32	8.5
Suitene (st.)	152	113	51	2.6	24	7.9
$LSD_{0.05}$	43	32	6	3.3	3	1.1
p value	0.000	0.000	0.000	0.000	0.000	0.000
Treatment						
Without additional fertilizing	148	87	35	4.8	47	9.9
With additional fertilizing	142	83	37	4.4	47	9.6
$LSD_{0.05}$	21	13	2	1.0	3	0.5
p value	0.571	0.555	0.217	0.401	0.658	0.337

All polish cultivars had lower percentage of Extra and Class I fruit yield and higher percentage of unmarketable fruits than control cultivars. 'Suitene' had the highest percentage of Extra and Class I fruit yield and the lowest percentage of unmarketable fruits. The highest percentage of unmarketable fruits was observed for 'Paladyn' that exceeded more than 50 %. The most of them were misshaped.

The application of additional fertilizing statistically significantly ($p < 0.05$) did not influence strawberry yield and amount of Extra and Class I and unmarketable fruits, while there was observed different response of cultivars. In the treatment with application of additional fertilizers, the significant reduction of marketable yield was observed for cultivar 'Panon' (reduction 33 %). Whereas some cultivars had increase in the marketable yield, however it was not significant: 'Markat' had increase for 20 %, 'Elsariusz' – 19, 'Suitene' – 13 %.



Strawberry fruit appearance, flavour and firmness evaluation, scores 1–9, average of two years (2016–2017)

The harvesting season of 2017 characterized by wet weather that succeeded the developing of fruit rots. According to previous research the main causal agent of strawberry fruit rotting in Latvia strawberry plantations is *Botrytis cinerea* Pers. [9]. In 2017, the amount of damaged fruits was in average 7.4 %, while in 2016, it was only 1.9 %. In average of two years, the highest relative amount of rotted fruits was observed for 'Markat', while the lowest it was for 'Selvik'. The application of additional fertilizing statistically significantly ($p < 0.05$) did not influence the relative amount of rotted fruits, while it was slightly lower in the treatment with additional fertilizing.

All evaluated polish cultivars had larger fruits than control cultivars. 'Markat', 'Granda Rosa' and 'Elsariusz' had the largest fruits, while 'Suitene' had the lowest fruit weight. The application of additional fertilizing significantly did not influence fruit size.

In the fruit sensory evaluation, 'Selvik' got the highest score for fruit appearance (see figure). The highest fruit firmness was marked for 'Granda Rosa' whereas 'Honeoye' had the softest fruits.

Only 'Granda Rosa' get higher score for fruit flavor than control cultivar 'Suitene', whereas 'Markat' and 'Paladyn' had the lowest evaluation. The good fruit quality of 'Granda Rosa' is also mentioned by A. Masny and E. Žurawicz [10].

Winter damage and spreading of pests and diseases. In Latvia, winter hardiness is the one of the most important factors limiting the possibilities of growing different strawberry cultivars. In average of two testing years, polish cultivars 'Selvik', 'Panon' and 'Paladyn' had the lowest winter damage that was lower than for control cultivars (table 3). 'Granda Rosa' was the most damaged during winters.

Table 3. **Winter damage and damage by pests and diseases for strawberry cultivars and fertilizer treatments, average of two years (2016–2017)**

Cultivar, tratment	Winter damage*	Leaf scorch*	Common leaf spots*	Root and crown diseases*	Strawberry blossom weevil damaged buds, % from total	Strawberry mite*
Cultivar						
Selvik	4.4	2.5	4.0	2.0	2.6	2.3
Markat	6.0	2.3	4.1	1.7	4.1	2.2
Elsariusz	5.6	1.6	4.7	3.0	4.7	3.1
Granda Rosa	6.7	1.8	4.3	2.6	2.5	1.2
Panon	4.4	1.4	6.1	2.1	2.1	3.0
Paladyn	4.4	2.2	5.0	2.4	1.5	2.4
Honeoye (st.)	4.8	2.0	3.8	2.6	0.4	1.7
Suitene (st.)	4.9	1.4	4.2	1.4	2.7	2.8
$LSD_{0.05}$	0.7	0.8	0.8	0.7	3.7	0.6
p value	0.000	0.057	0.000	0.002	0.356	0.000

End of table 3

Cultivar, tratment	Winter damage*	Leaf scorch*	Common leaf spots*	Root and crown diseases*	Strawberry blossom weevil damaged buds, % from total	Strawberry mite*
Treatment						
Without additional fertilizing	5.1	2.0	4.4	2.3	3.1	2.1
With additional fertilizing	5.2	1.8	4.6	2.2	2.0	2.5
$LSD_{0.05}$	0.1	0.2	0.3	0.3	1.4	0.3
p value	0.268	0.096	0.293	0.545	0.122	0.015

* Evaluation given in scores 1–9, where 1 = no damage observed; 9 = all plants fully damaged.

Leaf (leaf spots) and root and crown diseases were observed in the trial (see table 3). Leaf scorch damage severity during investigation years was very low. Common leaf spot disease was spread more than leaf scorch. All evaluated cultivars had lower resistance to common leaf spot disease than control 'Honeoye'. The highest damage was observed for 'Panon'. The application of additional fertilizing significantly did not influence strawberry damage severity by diseases.

The damage by root and crown diseases was comparatively low in the trial and it slightly increased with the age of plantation. In average of two years, the highest root and crown disease damage was observed for 'Elsariusz', while 'Suitene' was the most resistant.

Strawberry mite and strawberry bud weevil are the major pests for strawberries in Latvia [11]. They were observed in our trial too, though the damage was low. In average of two years, the relative amount of damaged buds by strawberry bud weevil did not differ significantly among evaluated cultivars and treatments. 'Honeoye' had the lowest damage, while 'Elsariusz' was the most damaged.

The damage by strawberry mite increased with the age of plantation. In average of two years, the lowest damage by strawberry mite was observed for 'Granda Rosa' and 'Honeoye', while the highest it was for 'Elsariusz' and 'Panon'. It was observed, that in the treatment with application of fertilizers, the damage severity by mites was significantly higher than without additional fertilizing.

CONCLUSIONS

1. According to obtained results 'Selvik' and 'Panon' were selected as the most promising for growing in Latvia from the evaluated newly introduced polish cultivars. They characterized by appropriate winter hardiness and good productivity. More investigations on selected cultivars are necessary in different growing regions of Latvia.

2. Very good fruit quality was observed for cultivar 'Granda Rosa', however it had low winter hardiness and therefore is not recommended for growing in northern climate conditions.

3. The application of Nano ELEMENT™ and Bio ELEMENT™ fertilizers in tested doses significantly did not influence strawberry flowering and harvesting season, productivity, fruit quality and spreading of diseases, while it increased damage by strawberry mite. Different response of cultivars to application of fertilizers was observed.

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ВЫБОР СОРТОВ ЗЕМЛЯНИКИ ДЛЯ СЕВЕРО-ЗАПАДНОГО КЛИМАТА И ОЦЕНКА НЕКОТОРЫХ УДОБРЕНИЙ

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АННОТАЦИЯ

В работе представлены результаты изучения новых сортов земляники в латвийских условиях в открытом грунте и эффективность нано- и биоудобрений. Объектами исследований являлись восемь сортов земляники: Selvik, Markat, Elsariusz, Granda Rosa, Panon, Paladyn, Suitene, Honeoye. В испытании использовали два удобрения: Nano ELEMENT™ (содержит микроэлементы) и Bio ELEMENT™ (содержит микроорганизмы). Оценку проводили два сезона (2016–2017 гг.). Из новых сортов наилучшие результаты показали Selvik и Panon, которые были выделены как перспективные для выращивания в латвийских климатических условиях. Эти сорта характеризировались хорошей зимостойкостью и урожайностью. В среднем использование удобрений Nano ELEMENT™ и Bio ELEMENT™ не повлияло на фенологическое развитие, урожайность и качество земляники, однако отмечены некоторые различия между сортами по отношению к удобрениям.

Ключевые слова: *Fragaria* × *ananassa* Duch., урожайность, качество ягод, восприимчивость к болезням и вредителям, Латвия.

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