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Fatty acid composition of sunflower hybrids influenced by year and biostimulators

Vplyv ročníka a biostimulátorov na obsah mastných kyselín v hybridoch slnečnice ročnej

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ABSTRACT

Sunflower (*Helianthus annuus* L.) is grown in Slovak growing conditions for edible oil of high quality, its composition of unsaturated fatty acids affects the human health positively. Influence of year, hybrids (Marbelia CS and Reasun DS-5) and biostimulating preparations (Florone and Fertisiline) on yield, oil content, and amount of selected fatty acids (oleic, linoleic, palmitic, and stearic acids) was find out in this study. Also evaluate the relationship within the achieved yield and oil content with the obtained amount of selected fatty acids. Field small-plot experiments were established by randomized split plot method during the growing years of 2018 and 2019. The experimental field is situated in a warm maize production area, while the course of weather conditions during individual growing seasons was different. On an average for experimental period of 2018-2019, more favorable course of temperatures and precipitation was recorded in 2018. Significantly higher achene yield (3.29±0.35 t/ha) and a higher amount of selected fatty acids (oleic acid 62.11±4.33%; linoleic acid 45.32±4.62%; palmitic acid 5.26±0.33%; stearic acid 4.21±0.20%) were found in Reasun DS-5 hybrid. Both biostimulating preparations had a significant effect on the yield and oleic acid content, when both biostimulators were applied in BBCH 15 and BBCH 55. The amount of linoleic acid decreased by both biostimulating applications in BBCH 15 (Florone 33.88±10.57%; Fertilisine 34.11±13.37%) and BBCH 15, 55 ((Florone 34.08±12.34%; Fertisiline 34.26±13.40%) compared by control treatments (38.43±6.01%). The contents of linoleic acid on treated variants by both preparations in BBCH 55 (Florone 38.26±9.47%; Fertisiline 39.03±8.95%) were statistically non-significant with comparison to untreated control. The height of yield was negatively correlated (r= -0.310; P<0.01) with the oil content in the average of 2018 and 2019. A significant positive correlation was found in the relationships between the yield and palmitic acid (r=0.35; P<0.01), linoleic acid and palmitic acid, and stearic acid (r=0.51; P<0.01) (r=0.86; P<0.01), palmitic acid and stearic acid (r=0.45; P<0.01).

Keywords: biological material, biostimulating preparations, linoleic acid, oil content, oleic acid, yield

ABSTRAKT

Slnečnica ročná (*Helianthus annuus* L.) je v našich podmienkach pestovaná hlavne pre získavanie vysoko kvalitného jedlého oleja, ktorého zloženie nenasýtených mastných kyselín pozitívne vplýva na zdravie človeka. V tejto štúdii bolo cieľom zistiť vplyv ročníka, hybridov (Marbelia CS a Reasun DS-5) a biostimulačných prípravkov (Florone a Fertisiline) na úrodu, obsah oleja a množstvo vybraných mastných kyselín (kyselina olejová, linolová, palmitová a steárová). Taktiež zhodnotiť vzťah v rámci dosiahnutej úrody a obsahu oleja so získaným množstvom vybraných mastných kyselín. Poľné maloparcelové experimenty boli založené metódou kolmo delených blokov a v náhodnom usporiadaní počas pestovateľských rokov 2018 a 2019. Pokusné stanovište je situované v teplej kukuričnej výrobnej oblasti, pričom priebeh poveternostných podmienok počas jednotlivých pestovateľských období bol rozdielny. V priemere za sledované obdobie bol štatisticky preukazne vhodnejší priebeh teplôt a zrážok zaznamenaný v roku 2018. V priemere štatisticky preukazne vyššia úroda nažiek (3,29±0,35 $t.ha^{-1}$) a vyšší obsah vybraných mastných kyselín (kyselina olejová 62,11±4,33 %; kyselina linolová 45,32±4,62 %; kyselina palmitová 5,26±0,33 %; kyselina steárová 4,21±0,20 %) boli zistené pri hybride Reasun DS-5. Použitím biostimulačných prípravkov bola úroda v priemere za sledované obdobie ovplyvnená štatisticky preukazne, pri aplikácii oboch prípravkov (Florone a Fertisiline) v rastovej fáze BBCH 15 aj BBCH 55 (fáza 6-8 listov a fáza kvitnutia), rovnako tak aj množstvo kyseliny olejovej. Obsah kyseliny linolovej klesol po aplikácii oboch prípravkov v rastovej fáze BBCH 15 (Florone 33,88±10,57 %; Fertilisine 34,11±13,37 %) a BBCH 15, 55 (Florone 34,08±12,34 %; Fertisiline 34,26±13,40 %) v porovnaní s kontrolným variantom (38,43±6,01 %). Obsahy získanej kyseliny linolovej na variantoch ošetrených vo fáze BBCH 55 (Florone 38,26±9,47 %; Fertisiline 39,03±8,95 %) boli štatisticky nepreukazné v porovnaní s kontrolou. Výška úrody negatívne korelovala (r= -0,310; P<0,01) s obsahom získaného oleja v priemere rokov 2018 a 2019. Významná pozitívna korelácia bola zistená pri vzťahoch úroda a kyselina palmitová (r=0.35; P<0.01), kyselina linolová a kyselina palmitová, a steárová (r=0.51; P<0.01) (r=0.86; P<0.01), kyselina palmitová a kyselina steárová (r=0.45; P<0.01).

Kľúčové slová: biologický materiál, biostimulačné prípravky, úroda, obsah oleja, kyselina olejová, kyselina linolová

DETAILNÝ ABSTRAKT

Slnečnica ročná je z hľadiska využiteľnosti všestrannou plodinou. V prevažnej miere je pestovaná za účelom získavania vysoko kvalitného oleja s adekvátnym pomerom nenasýtených mastných kyselín, prednostne kyseliny olejovej a linolovej a nízkym pomerom nasýtených mastných kyselín. Cieľom príspevku bolo zhodnotiť vplyv ročníka, hybridov (Marbelia CS a Reasun DS-5) a biostimulačných prípravkov (Florone a Fertisiline) na úrodu, obsah oleja a množstvo vybraných mastných kyselín (Kyselina olejová, linolová, palmitová a steárová) v získanom oleji. Poľné polyfaktorové pokusy boli situované na experimentálnej báze Dolná Malanta v rokoch 2018 a 2019. Pokusné stanovište spadá do kukuričnej výrobnej oblasti, agroklimatickej podoblasti veľmi teplej a veľmi suchej (TS > 10 °C; suma priemerných teplôt za hlavné vegetačné obdobie 3000 °C a viac; priemerný úhrn zrážok za IV. – IX. mesiac 320,3 mm). Pôda experimentálnej oblasti je klasifikovaná ako hnedozem kultizemná. Predplodinou bola pšenica letná f. ozimná (*Triticum aestivum* L.). Pokusy boli založené formou kolmo delených blokov v náhodnom usporiadaní v troch opakovaniach a v súlade so zásadami konvenčnej technológie pestovania slnečnice ročnej. Sejba bola realizovaná do pestovateľského sponu 0,70 x 0,22 m. V rámci pokusu boli použité hybridy Marbelia CS a Reasun DS-5 stredne vysoké hybridy pestované Clearfield technológiou. Použité prípravky v rámci pokusných variantov boli Florone (vyrobený z hydrolyzovaných rastlinných bielkovín, formulované s NPK v množstve celkového N 1,0 %; P vo forme P_2O_5 10,0 %; K vo forme K_2O 10,0 % a mikroprvkov B 0,25 % a Mo 0,20 % aplikovaný v dávke 0,2 $l.ha^{-1}$) a Fertisiline (listové hnojivo obsahujúce kyselinu ortokremičitú s obsahom Si 2,5 %; s mikroelementami B 0,3 %; Cu 1,0 %; Mo 0,2 %; Zn 0,6 % aplikovaný v dávke 0,6 $l.ha^{-1}$) v rastových fázach BBCH 15 (6 – 8 pravých listov), BBCH 55 (kvitnutie) a BBCH 15, 55 (v oboch rastových fázach). Poveternostné podmienky experimentálnych období 2018 a 2019 boli rozdielne. V priemere za sledované obdobie bol štatisticky preukazne vhodnejší priebeh teplôt a zrážok zaznamenaný v roku 2018. V priemere štatisticky preukazne vyššia úroda nažiek (3,29±0,35 $t.ha^{-1}$) a vyšší obsah vybraných mastných kyselín (kyselina olejová 62,11±4,33 %; kyselina linolová 45,32±4,62 %; kyselina palmitová 5,26±0,33 %; kyselina steárová 4,21±0,20 %) boli zistené pri hybride Reasun DS-5. Použitím biostimulačných prípravkov bola úroda v priemere za sledované obdobie ovplyvnená štatisticky preukazne, pri aplikácii oboch prípravkov (Florone a Fertisiline) v rastovej fáze BBCH 15 aj BBCH 55 (fáza 6-8 listov a fáza kvitnutia), rovnako tak aj množstvo kyseliny olejovej. Obsah kyseliny linolovej klesol po aplikácii oboch prípravkov v rastovej fáze BBCH 15 (Florone 33,88±10,57 %; Fertilisine 34,11±13,37 %) a BBCH 15, 55 (Florone 34,08±12,34 %; Fertisiline 34,26±13,40 %) v porovnaní s kontrolným variantom (38,43±6,01 %). Obsahy získanej kyseliny linolovej na variantoch ošetrených vo fáze BBCH 55 (Florone 38,26±9,47 %; Fertisiline 39,03±8,95 %) boli nepreukazné v porovnaní s kontrolou. Výška úrody negatívne korelovala (r= -0,310; P<0,01) s obsahom získaného oleja v priemere rokov 2018 a 2019. Vo vzťahu ku kyseline olejovej boli zaznamenané významné negatívne korelácie s kyselinou linolovou, palmitovou a steárovou. Významná pozitívna korelácia bola zistená pri vzťahoch úroda a kyselina palmitová (r=0.35; P<0.01), kyselina linolová a kyselina palmitová, a steárová (r=0.51; P<0.01) (r=0.86; P<0.01), kyselina palmitová a kyselina steárová (r=0.45; P<0.01).

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a crop that is widely used in various fields, not only in industry, but also in medicine (Bashir et al., 2015). The most important goal of sunflower production is a high crop yield and high oil content. To achieve this effect, it is necessary to plant hybrids with high production potential and use optimal cultivation practices (Kolomaznik et al., 2012). The successful mastering of the sunflower cultivation technology is also based on the application of growth stimulators, the use of which is supposed to support rooting, improve post-stress regeneration, and positively affect the production and final quality of achenes (Černý et al., 2011). The application of different types of plant growth preparations under different regimes and at different growth phases of cultivated plants, especially in the initial stage, has been shown to be very effective in reducing the adverse impacts of negative factors (Ashraf et al., 2008).

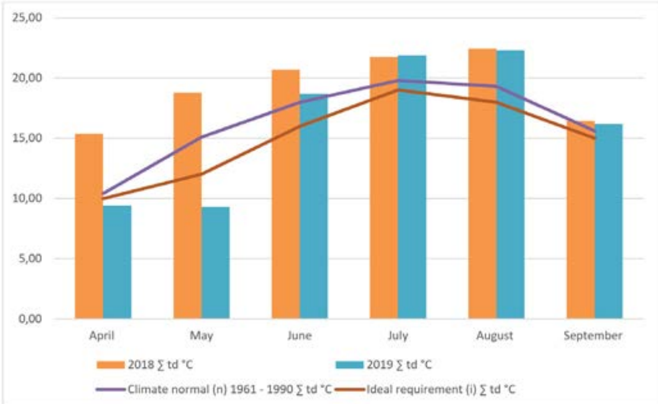
The economic importance of sunflower is oriented to obtaining edible oil, the composition of which consists of a high content of unsaturated fatty acids, namely linoleic acid at the level of 48-74% and oleic acid at 14-40%. The proportion of unsaturated fatty acids in sunflower oil is more than 85%, and the content of saturated fatty acids should not exceed 15% of the total content of fatty acids (Firestone, 1997; White, 2000). According to Kostik et al. (2013), the composition of fatty acids in vegetable oils is one of the most important factors that affect the quality of the oil, its stability and usability in the field of human nutrition. According to Harun (2019), the quality of sunflower oil is generally related with the relative concentration of oleic and linoleic acids. Oil with high oleic acid content has several benefits regarding human health. High consumption of saturated fats (palmitic and stearic acids) correlates with an increased risk of cardiovascular disease. Oils with a high oleic acid content are better and longer stored and have a positive effect on human health.

Therefore, the aim of the study was to evaluate the fatty acid content of sunflower hybrids affected by application of biostimulating preparations in 2018 and 2019.

MATERIAL AND METHODS

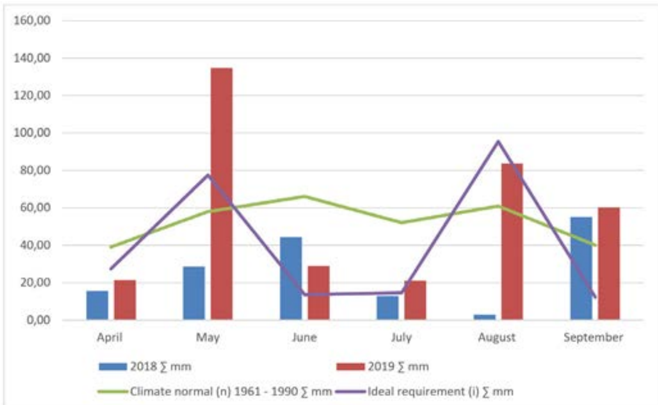
Experimental area

Field small-plot experiments were carried out at the Dolná Malanta (48° 19' 0" North, 18° 9' 0" East) research-experimental base, located approx. 5,000 m from the Slovak University of Agriculture in Nitra in 2018 and 2019. The very warm and dry experimental area is characterized by the sum of average air temperatures (TS >10 °C) for the main growing season of 3,000 °C and more. The agroclimatic subregion is very dry with an irrigation indicator in the summer months ($K_{VI-VIII}$ =150 mm). The soil of the experimental field is Haplic Luvisol silt loam according to the FAO classification (FAO, 2014; Šimanský and Kováčik, 2015). The course of weather conditions of the experimental years is defined in Figures 1 and 2.



∑ td °C – sum of mean daily temperature

Figure 1. Mean daily air temperatures (°C) of sunflower growth seasons in 2018 and 2019



∑ mm – sum of precipitation

Figure 2. Sum of daily precipitation (mm) of sunflower growth seasons in 2018-2019

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Experimental material

Sunflower hybrids Marbelia CS and Reasun DS-5 (Saatbau) grown by Clearfield technology were used in the experiment. The medium-early and medium-tall hybrid Marbelia CS is characterized by high plasticity, resistance to pathogens such as *Sclerotinia sclerotiorum*, *Peronospora halstedii*, *Phomopsis helianthi*, *Verticilium*, and *Phoma*. The medium-tall hybrid Reasun DS-5 is characterized by high oil production and good resistance to diseases such as *Phomopsis helianthi*, *Sclerotinia*. Within the experiments, the biostimulating preparations Florone (made from hydrolyzed plant proteins, formulated with NPK in the amount of total N 1.0%; P in the form of P_2O_5 10.0%; K in the form of K_2O 10.0% and microelements B 0.25% and Mo 0.20%; Atlántica Agrícola Spain) was applied in a dose of 0.2 l/ha. Fertisilin (foliar fertilizer containing orthosilicic acid with a Si content of 2.5%; with microelements B 0.3%; Cu 1.0%; Mo 0.2%; Zn 0.6%; Innvigo Poland) was used in dose of 0.6 l/ha. Experimental treatments of the applied preparations were divided into a control variant (without treatment), and according to the date of application in the growth phase BBCH 15 – phase 6-8 leaves; BBCH 55 – beginning of flowering; in both growth phases BBCH 15 and BBCH 55. Basic and pre-sowing fertilization was carried out based on the results of the agrochemical analysis. The soil samples were taken in autumn and spring for the expected sunflower yield of 3 tons per hectare (Table 1). The winter wheat (*Triticum aestivum* L.) was used as a forecrop.

Experimental methods

Field experiments were established by split plot (60 m^2) method in three replications. Tillage (subsoil, autumn deep plowing) and sowing (0.70 m between rows, and 0.22 m was distance in the row) were carried out according to the principle of conventional cultivation technology for sunflower. Industrial fertilizers NPK (20-20-15) and urea (46% of N) were used. Doses (NPK 200 kg in 2018; urea 215 kg in 2019) were calculated on the base of agrochemical soil analysis results and nutrient requirements of sunflower on expected yield 3.0 tons per hectare. The determination methods for individual nutrients and results are listed in Table 1. The oil content in the samples of sunflower hybrid seeds (weight of sample 200g) was determined by the extraction method (%) using a Soxhlet extraction apparatus. The contents of selected amino acids were determined by gas chromatography with a flame ionization detector (FID) expressed as a

Table 1. Autumn and spring agrochemical soil analysis

	Autumn	
Nutrient and determination method	2017	2018
P (mg/kg) – colorimetrically by Mehlich III	23.8	63.75
K (mg/kg) - flame photometry by Mehlich III	255	425
Mg (mg/kg) – AAS by Mehlich III	813.1	331.6
pH – by KCl (0.2 mol/dm^3 KCl) (pH units)	6.98	6.49
	Spring	
Nutrient and determination method	2018	2019
IN (mg/kg) – sum of ammonium and nitrate nitrogen	18.55	14.8
NO_3^- -N (mg/kg) – colorimetrically by phenol 2,4 - disulfonic acid	8.8	7.8
NH^{4+}-N (mg/kg) – colorimetrically by Nessler's reagent	9.75	7.0

IN – inorganic nitrogen; AAS - atomic absorption spectrophotometer percentage of crude fat (Christie, 1993) on a machine Agilent 6890A GC (Agilent Technologies, USA).

Statistical analysis

The data were statistically evaluated by standard methods using the Statgraphics plus 5.1 statistical software (Rockville, USA). A multifactor ANOVA was used for the individual treatment comparison at P=0.05, with separation of the means by the LSD multiple-range test. For correlation analysis was selected simple regression, where was used simple correlation coefficient according to Pearson.

RESULTS

Yield of achenes

The influence of the cultivation year on the yield of achenes was statistically significant on an average for the observed period of years 2018 and 2019. The year 2018 seemed to be more favorable in course of weather conditions, where the yield was statistically significantly higher 4.09 t/ha (Table 2). As well a significant effect of hybrid on yield of achenes was recorded, where in mean higher yield 3.92 t/ha was obtained with Reasun DS-5 in comparison with Marbelia CS 3.77 t/ha (Table 2). From evaluation of foliar applied preparations follows, that after application of both biostimulators in both growth stages (BBCH 15 and BBCH 55) were found the higher yields in comparison with control treatment in mean of monitored experimental years. The highest yield of achenes 4.16 t/ha was recorded by Florone application in both growth stages and the lowest yield 3.60 t/ha on untreated control in mean for monitored growing seasons (Table 2).

Oil content

The influence of cultivation year on oil content was significant in mean for experimental period 2018 and 2019, where higher oil content 46.47% was found out in 2019 in comparison with year 2018 44.60% (Table 2). No statistically significant differences were found between oil content 45.54% in hybrid Reasun DS-5 and hybrid Marbelia CS 45.52% in mean for two experimental years. Statistically significantly differences were recorded between variants treated and control in mean for monitored cultivation periods. Highest oil content 46.84% was signed on variant treated by Florone in growth stage BBCH 15 and the lowest 44.89% on variant, where was applied Florone in BBCH 55 (Table 2).

Fatty acid composition

Year 2018 was favorable for amount of oleic and palmitic acid, and on the contrary year 2019 was more suitable in terms of achieved amount of linoleic and stearic acid. Significantly more productive was hybrid Reasun DS-5 within the amount of achieved selected fatty acids (Table 2). The treatment had statistically significant impact on amount of oleic acid in mean 2018 and 2019. Significantly higher oleic acid contents were recorded by treatment of both preparations in growth stages BBCH 15, and BBCH 15, 55. On the contrary the decreasing tendency of linoleic acid content was detected by foliar treatment in comparison with control variant in mean for years 2018 and 2019. Comparable values with the control variant in the amount of linoleic acid were recorded on treated variant by both biostimulators in BBCH 55, but they were statistically non-significant in comparison with other treated variants (in BBCH 15 and BBCH 15, 55) (Table 2). Significantly lower contents of linoleic acids were found on variants by treated by both biostimulating preparations in BBCH 15 and BBCH 15, 55. As well a statistically significant decrease of palmitic acid content was signed by application both biostimulators (Table 2). The influence by biostimulating preparations on stearic acid amount had rather decreasing tendency, but it was not in statistically clear result (Table 2).

Negative correlation in relationship yields and oil content was significant (Figure 3). In relation to oleic acid, significant negative correlations were recorded with linoleic, palmitic, and stearic acids. Significant positive correlation was found in relationship yield and palmitic acid (r=0.35; P<0.01), linoleic acid and palmitic, and stearic acid (r=0.51; P<0.01) (r=0.86; P<0.01), palmitic acid and stearic acid (r=0.45; P<0.01) (Table 3).

Table 2. Multi-factor ANOVA of data of production parameters and fatty acids of sunflower

		Yield (t/ha) Úroda (t/ha)	Oil content (%) Obsah oleja (%)	Oleic acid (%) Kyselina olejová (%)	Linoleic acid (%) Kyselina linolová (%)	Palmitic acid (%) Kyselina palmitová (%)	Stearic acid (%) Kyselina steárová (%)
Year Rok	2018	4.09±0.39^{b}	44.60±1.33^{a}	55.29±10.26^{b}	32.81±9.49^{a}	5.21±0.48^{b}	3.89±0.19^{a}
	2019	3.59±0.22^{a}	46.47±1.65^{b}	49.97±11.43^{a}	39.20±11.01^{b}	4.78±0.33^{a}	4.01±0.40^{b}
Hybrid	Marbelia CS	3.78±0.35^{a}	45.52±1.75^{a}	43.16±6.91^{a}	26.70±5.77^{a}	4.74±0.44^{a}	3.70±0.16^{a}
	Reasun DS-5	3.92±0.43^{b}	45.54±1.79^{a}	62.11±4.33^{b}	45.32±4.62^{b}	5.26±0.33^{b}	4.21±0.20^{b}
Treatment Ošetrenie	Control/Kontrola	3.60±0.24^{a}	45.42±1.05^{a}	50.14±6.20^{a}	38.43±6.01^{b}	5.30±0.42^{c}	3.99±0.27^{c}
	Florone 15	3.80±0.27^{bc}	46.84±2.17^{b}	55.14±10.74^{b}	33.88±10.57^{a}	4.93±0.34^{ab}	3.91±0.30^{abc}
	Florone 55	3.89±0.25^{c}	44.89±0.90^{a}	50.14±9.88^{a}	38.26±9.47^{b}	5.29±0.43^{bc}	4.13±0.28^{d}
	Florone 15, 55	4.17±0.31^{d}	45.70±1.97^{ab}	54.84±12.80^{b}	34.08±12.34^{a}	4.93±0.44^{a}	4.00±0.38^{c}
	Fertisiline 15	3.67±0.26^{ab}	45.52±1.52^{a}	54.98±13.91^{b}	34.11±13.37^{a}	4.84±0.58^{a}	3.85±0.34^{ab}
	Fertisiline 55	3.71±0.46^{abc}	45.15±1.91^{a}	48.30±8.65^{a}	39.03±8.95^{b}	4.98±0.35^{ab}	3.95±0.29^{bc}
	Fertisiline 15, 55	4.11±0.54^{d}	45.21±2.09^{a}	54.91±13.84^{b}	34.26±13.40^{a}	0.49±0.55^{a}	3.80±0.29^{a}

Same small letters indicate non-significant differences (LSD test, α=0.05) between production seasons, hybrids, and biostimulation preparations. Number at the biostimulator indicates the growth phase, when the biostimulator was applied

Table 3. Correlation coefficients of production parameters and fatty acids of sunflower hybrids affected by biostimulation preparations

	1	2	3	4	5	6
Yield (t/ha) (1)	1					
Oil (%) (2)	-0.31**	1				
Oleic acid (3)	0.10N	-0.14N	1			
Linoleic acid (4)	-0.08N	0.19N	-0.98**	1		
Palmitic acid (5)	0.35**	-0.24N	-0.54**	0.51**	1	
Stearic acid (6)	0.01N	0.08N	-0.84**	0.86**	0.45**	1

N – non-significant difference; ** significant difference at level <0.01

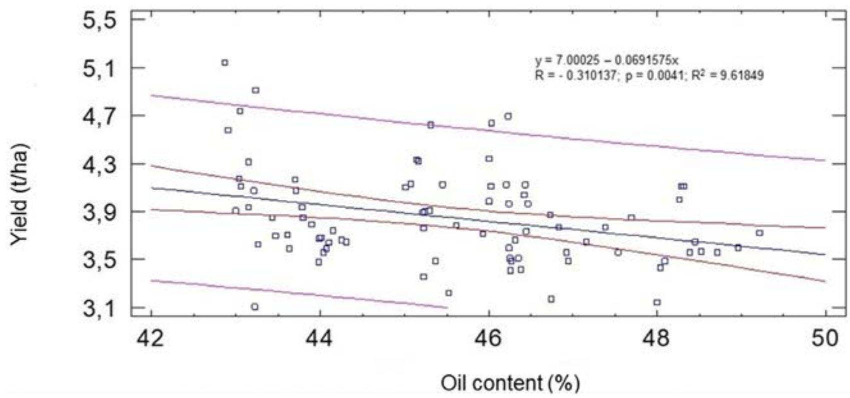

Figure 3. Negativ correlation relationship between yield and oil content of sunflower

DISCUSSION

Yield of achenes

According to the Kolomaznik et al. (2012) the main goal of sunflower cultivation is a high yield and a high oil content in the achenes. For this purpose, it is necessary to choose the suitable hybrid and follow the correct growing practices that are in accordance with the requirements of the cultivated crop. One of the measures to achieve optimal conditions for growth is the use of biostimulating preparations, the task of which is not only to increase resistance but also to reduce stress caused by adverse environmental influences. The results of Matyás et al. (2014) confirm the results of two-year experiments that the weather conditions of the growing year significantly influence the achieved yield of sunflower. In the same way, the farmer can by the correctly chosen biological material, that is high production hybrid, final yield, and quality of achenes. Kaya and Atakisi (2004) emphasize the validity of the sunflower hybrid choice. Compared to ordinary crossbred varieties, hybrids have more stable and higher yields. As reported by Arshad et al. (2007) knowledge of the properties of genetic material is a fundamental factor leading to the improvement of breeding programs. Demir (2019) and Ebeed et al. (2019) evaluated the effect of hybrids on sunflower seed yield as statistically significant, which is in line with our experimental results. Effect of biostimulation on the height of the harvest of sunflower seeds was recorded by Arif et al. (2016) together with Ullah et al. (2017), which is consistent with the obtained results of the study.

Oil content

Gonzáles et al. (2013), García-Lopez et al. (2016), Sinha et al. (2017) state that the weather conditions of the growing season have a decisive influence on the sunflower production process (yield and oil content in the achenes), which is identical to the achieved results. Statistically highly significant results of the effect of the hybrid on the oil content of sunflower seeds reported by Demir (2019), Ebeed et al. (2019) and Serheed and Hussein (2019) agree with achieved results in this experiment. The statistically highly significant influence of biostimulators was confirmed not only on the yield, but also on the oil content, what agrees by the results of this study, and by the findings of Heideri and Karami (2014) and Koutoubasa et al. (2014). Mourad and Teileb (2019) noted a statistically non-significant effect of biostimulators precisely on the oil content, which contradicts not only the results of the study, but also the findings of Kovár et al. (2016) and Rehman et al. (2018). According to Anandhan et al. (2010), the oil content was positively correlated with the yield of achenes, which was also confirmed by Suzer (1998) and Teklewold et al. (1999), but this tendency does not agree with the results of this study.

Fatty acid composition

Petcu et al. (2010) states that the most important factor defining the composition of fatty acids in sunflower is its genotype. Popa et al. (2017) agrees with above, that the genotype is the decisive factor influencing the variability in the fatty acid composition of sunflower. The influence of the hybrid on the content of fatty acids depends on the cultivated hybrid (Petcu et al., 2001; Ebeed et al., 2019). There is an inverse relationship between the content of oleic acid and linoleic acid (Petcu et al., 2001), which corresponds to our obtained results. An increase of saturated fatty acid palmitic and stearic and polyunsaturated fatty acid linoleic due to the application of growth biostimulators is also declared in study of Rehman et al. (2018), which was not confirmed in our experiment, whereas the contents of linoleic and palmitic acid decreased statistically significantly on treatments treated by biopreparations. According to Lamas et al. (2014) the important part of high-quality sunflower oil is the content of linoleic acid, what does not match with experimental results. Hussain et al. (2018) describes the positive effects of silicon application in sunflower, what was statistically significant confirmed only by increase of oleic acid. Correlation relationships between fatty acids were described by Petakov et al. (2014), where negative correlations were found between the content of oleic acid and other fatty acids within a 32-member composition of sunflower hybrids, which confirms the results achieved.

CONCLUSIONS

The results of field polyfactorial experiments in years 2018 and 2019 showed, that more suitable was year 2018. Hybrid Reasun DS-5 affected positively the yield 3.92±0.35 t/ha, and fatty acid content (oleic acid 62.11±4.33%, linoleic acid 45.32±4.62%, palmitic acid 5.26±0.33%, stearic acid 4.21±0.20%). Application of both biostimulating preparation decrease amount of linoleic acid used in growth stages BBCH 15 and BBCH 15, 55.

Increasing the yield negatively affected the oil content in the achenes. The application of biostimulating preparations (Florone and Fertilisine) had a positive effect on the content of oleic acid, which the increasing content negatively affected the content of linoleic (r= -0.98; P<0.01), palmitic (r= -0.54; P<0.01) and stearic (r= -0.84; P<0.01) acid. A significant positive correlation was found for yield and palmitic acid (r=0.35; P<0.01), linoleic acid and palmitic acid, and stearic acid (r=0.51; P<0.01) (r=0.86; P<0.01), palmitic acid and stearic acid (r=0.45; P<0.01)

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