Uluslararası Tarım Araştırmalarında Yenilikçi Yaklaşımlar Dergisi
International Journal of Innovative Approaches in Agricultural Research 2020, Vol. 4 (1), 78-88
https://doi.org/10.29329/ijiaar.2020.238.9

Original article

Comparison of Different Fertilization Variants on Camelina Sativa Yield, Plant Height and Oil Content

Peter Hozlár [a, *], Katarína Matúšková [a], Petra Ondrejíčková [b],
Elena Hájeková [c] & Ľudmila Joríková [d]

[a] The National Agricultural and Food Centre, Research Institute of Plant Production, Research and Breeding Station Vígľaš-Pstruša, 962 12 Detva, Slovakia
[b] Association Energy 21, 920 41 Leopoldov, Slovakia
[c] Slovak University of Technology in Bratislava, Faculty of Chemical and Food Technology, 812 37 Bratislava, Slovakia
[d] VÚRUP a.s., 820 03 Bratislava, Slovakia

Abstract

Oilseed plant *Camelina sativa*, the member of mustard (*Brassicaceae*) family, represents re-emerging low input oilseed energy crop with sustainable agronomic characteristics and environmental attractiveness. Camelina is a short-season crop adapted to the cool temperate regions of Europe, Asia, and North America. Although no original Slovak varieties are known to be preserved, Camelina recently attracts interest of Slovak agronomists and biofuel producers as it possesses many traits that make it an ideal candidate for the crop rotation schemes even on marginal lands and subsequent utilization for oil production. As a potential feedstock for the production of bio-components to fuels Camelina can contribute to achieve the increase of GHG savings. Main focus of this study was aimed to examine the effect of different fertilization conditions on Camelina sativa yield, plant height and oil content in Slovak region. Additionally, comparison study of two available varieties Zuzana (Czech variety) and Smilowska (Polish variety) was performed. Field trials evaluating 12 fertilization variants were conducted on spring 2018 and 2019 (as part of a long-term stationary experiment, founded in 1957), at the Research and Breeding Station Vígľaš-Pstruša, Slovakia. Nitrogen doses varied from 0, 40, 80, 120 to 150 kg/ha and were split into one to four dosages with or without P and K fertilizers. If fertilized with P and K, these were applied once prior to the seeding. The evaluated factors were: (A) – fertilization (12 fertilization variants), (B) – Camelina varieties (Zuzana, Smilowska) and (C) – year of study (2018, 2019). The influence of all factors on the yield, the height of plant and the oil content were assessed through multi-factor ANOVA. The study showed that fertilization with nitrogen and phosphorous has positive impact on seed yield, which is in accordance to the literature. Fertilization with nitrogen has positive effect on plant height. The growing conditions of individual year/season have largely influenced the seed yield as well as the height of the plants. It has been observed that oil yield is strongly related to temperature and precipitation conditions in individual year as well as the presence of fertilizers and type of Camelina variety.

Keywords: *Camelina sativa* (false flax), Fertilization, Seed yield, Oil content.

Received: 16 October 2019 * **Accepted:** 23 November 2019 * **DOI:** https://doi.org/10.29329/ijiaar.2020.238.9

* **Corresponding author:**

Peter Hozlár, The National Agricultural and Food Centre, Research Institute of Plant Production, Research and Breeding Station Vígľaš-Pstruša, 962 12 Detva, Slovakia
Email: peter.hozlar@nppc.sk

INTRODUCTION

False flax (*Camelina sativa*) is an annual plant that belongs to the *Brassicaceae* family. It occurs as winter form and also as a spring form. The height of the plants is between 30 - 90 centimetres. Leaves are mostly clenched, 2-8 centimetres long, usually without stems. Flowers are small of pale yellow colour. Seeds are tiny, yellowish - brown, generally 2 till 3 millimetres long. (Putnam et al., 1993, Francis and Warwick, 2009). The oil content of seeds is usually 38 - 43 % and contains 27 - 32 % of proteins (Gugel and Falk, 2006). Published literary sources state that content of oil in false flax seeds could be higher that 42 % with prevalent high content of unsaturated fatty acids. (Zubr and Matthäus, 2002; Abramovič and Abram, 2005; Berti et al., 2011).

False flax is not demanding to location and it is suitable for all production areas. It belongs to the earliest crops with a short vegetation time of about 3.5 months on average. It is possible to cultivate it as an alternative crop. The resistance to diseases and pests is high requiring only simple agro-technology (Strašil, 2008).

The growing of false flax in our territory is mainly intended for use in the non-food industry. False flax oil potential use is for the biofuels production, biofuel additives, for the pet food, aqua feed, animal nutrition markets as well as nutraceutical and personal care markets.

The prerequisites for expanding the false flax in our territory will be effective management of seed production and processing. It is important to develop the right cultivation technology and recommend it for cultivation practice according to Slovak climate conditions.

Material and Methods

Material

Two varieties of *Camelina sativa* were used in the experiment, namely Zuzana variety (Czech variety) and Smilowska variety (Polish variety).

Zuzana variety is a spring form of *Camelina sativa*, unpretentious for growing technologies and nutrition. It has been registered in year 2013. It is suitable for cultivation on all types of land except acidic and wet soils. It is characterized by rapid initial development and is therefore suitable competitor to weeds in the early stages. The advantage of this variety is a short growing time with good resistance to diseases and pests. It is moderately resistant to blue mold (*Albugo candida*). The variety is self-pollinating but responds very well to pollination. Oil content reaches 35 – 40 %. Its quality is comparable to linseed oil, but it contains more unconventional fatty acids such as myristic acid.

Smilowska variety is an early spring Camelina variety, native to Poland, registered and legally protected since year 2012. It is highly productive oilseed, not demanding on climatic and soil conditions.

Field trials

Camelina spring varieties Zuzana and Smilowska were grown in trial fields at National Agricultural and Food centre, Research and Breeding Station at Vígľaš – Pstruša, Slovakia (48°33'20"N 19°17'41"W) as part of a long-term stationary experiment, founded in 1957. The study was conducted for two growing seasons, year 2018 and year 2019, in Slovak cultivation conditions. The plots were 1.25 m wide and 6 m long, the acreage of 7.5 m^2, with two replicates of each variant, the plot field testing selected fertilizer and a subplot representing its variety. Number of rows per plot were 10, with seeding rate 10 kg/ha.

Camelina was investigated under 12 different fertilizer inputs variants with respect to its yield performance. The trials evaluating 12 fertilization variants are listed in Table 1. Nitrogen doses varied from 0, 40, 80, 120 to 150 kg/ha with and without P and K combinations. P and K combinations are applied once in the spring prior to the seeding. N fertilization is divided into basic fertilization, regenerative fertilization, production and quality.

Camelina has been sown in mid-April 2018 and in almost March 2019 with Ojord seedling machine. Camelina seeds were harvested in almost/mid-July by a combine harvester. The moisture content was analysed and recalculated to 15 % humidity. Comparison of an agronomic characteristics and impact of fertilizers on the seed yield (t/ha), height of plants (cm), oil content (%) has been evaluated.

Table 1. Fertilization variants

Fertilization variants	**Doses and form of mineral nutrition (kg.ha^{-1})**		
	N	**P**	**K**
011*	0	0	0
012	0	60	60
013	40	60	60
014	80	60	60
015	120	60	60
016	150	60	60
021	0	0	0
022	120	0	0
023	40	0	0
024	80	0	0
025	80	60	0
026	80	0	60

* Variant 011 tested on field where manure has been applied once per 4 years at dosage 10 t/ha

Analysis of oil content

The cold pressing of Camelina seeds for further analyses was performed on Farmet Farmer 10 1FM pressing unit. The oil content was determined on samples of year 2018 and 2019 by extraction method with n-hexane and with gravimetric analysis.

Calculations and statistical evaluation

The observed parameters of crop, height and oil content were evaluated in two experimental years (2018, 2019) and in two repetitions at 12 levels of mineral nutrition.

The results were evaluated by a multi-factor analysis of variance (ANOVA), where the fertilizer variant, variety and year were considered as sources of variability. Tukey's HSD multiple comparison test at significance level $\alpha = 0.05$ was used to determine statistically significant differences between groups.

The statistical package STATGRAPHICS plus 5.1 was used for mathematical-statistical data processing using multi-factor analysis ANOVA.

Results

Influence of fertilization, Camelina variety and year of cultivation on seed yield

Investigated fertilization variants had differed significantly (statistically $P < 0.01$) (Table 2). Statistically, nitrogen fertilization has the most significant effect on the seed yield variability. The NPK (120-0-0), NPK (120-60-60) and NPK (80-0-60) variants proved to be the most optimal fertilization variants. From the results it is clear that P and K fertilizers are effective only in combination with N fertilizers. Already with application of 40 kg of N/ha (NPK 40-60-60) there was an increase in seed yield in both varieties (Figure 1, Figure 2), which represented an increase in seed yield of 36.2 % compared to the fertilization variant (NPK 0 -60-60).

The varieties of false flax have reacted differently to N fertilization. However, the effect of the variety on the seed yield of both years was not statistically significant. Interesting results were observed in the NPK (120-0-0) fertilized variant compared to the variant with additional phosphorus and potassium NPK (120-60-60). The Zuzana variety reacted very sensitively and the seed yield decreased by 20 % by adding phosphorus and potassium in 2019. In the Smilowska variety we have seen this phenomenon in both years. In 2018, the seed yield was reduced by 16.4 %, but in 2019 only 4 % (Figure 1, Figure 2).

The seed yield has been highly influenced by the year of cultivation (statistically $p < 0.01$). The yield potential of the Czech Zuzana variety was 26 % higher in 2018 compared to 2019. In 2018, the yield potential of the Polish variety Smilowska was up 36 % higher than in 2019 (Figure 1, Figure 2).

Table 2. Average values of seed yield, plant height and oil content in investigated years in individual fertilization variants

Fertilization variants	Seed yield (t.ha^{-1})	Height plants (cm)	Oil content (%)
011 (NPK 0-0-0)	0.54^{ab}	72.1^{ab}	38.17^{b}
012 (NPK 0-60-60)	0.58^{abc}	71.5^{ab}	34.82^{ab}
013 (NPK 40-60-60)	0.79^{bcd}	82.4^{cd}	36.46^{ab}
014 (NPK 80-60-60)	0.83^{cd}	86.2^{cd}	33.54^{ab}
015 (NPK 120-60-60)	0.88^{d}	88.7^{d}	33.65^{ab}
016 (NPK 150-60-60)	0.76^{bcd}	87.9^{d}	31.17^{a}
021 (NPK 0-0-0)	0.45^{a}	68.8^{a}	35.15^{ab}
022 (NPK 120-0-0)	0.89^{d}	80.1^{bcd}	33.19^{ab}
023 (NPK 40-0-0)	0.72^{abcd}	79.7^{bcd}	34.41^{ab}
024 (NPK 80-0-0)	0.69^{abcd}	76.2^{abc}	34.65^{ab}
025 (NPK 80-60-0)	0.85^{cd}	82.7^{cd}	34.48^{ab}
026 (NPK 80-0-60)	0.87^{d}	82.6^{cd}	33.72^{ab}
x	0.74	79.9	34.45

Averages within the column with different coefficients (a, b, c, d) are statistically significantly different at significance level $\alpha = 0.01$.

Effect of fertilization, variety and year on plant height

Fertilization variants in our experiment had a statistically highly significant effect ($p < 0.01$) also on plant height (Table 2). Both varieties in the experiment have grown within two years average with the highest stem obtained when the highest fertilization rates N in combination with P and K (120-60-60; 150-60-60) were applied (Table 2, Figures 3, 4). Naturally, the fertilizer variations with the lowest rates of NPK (0-0-0), NPK (0-60-60) had the lowest impact on the height of the false flax. The effect of variety and year on the plant height was not statistically significant.

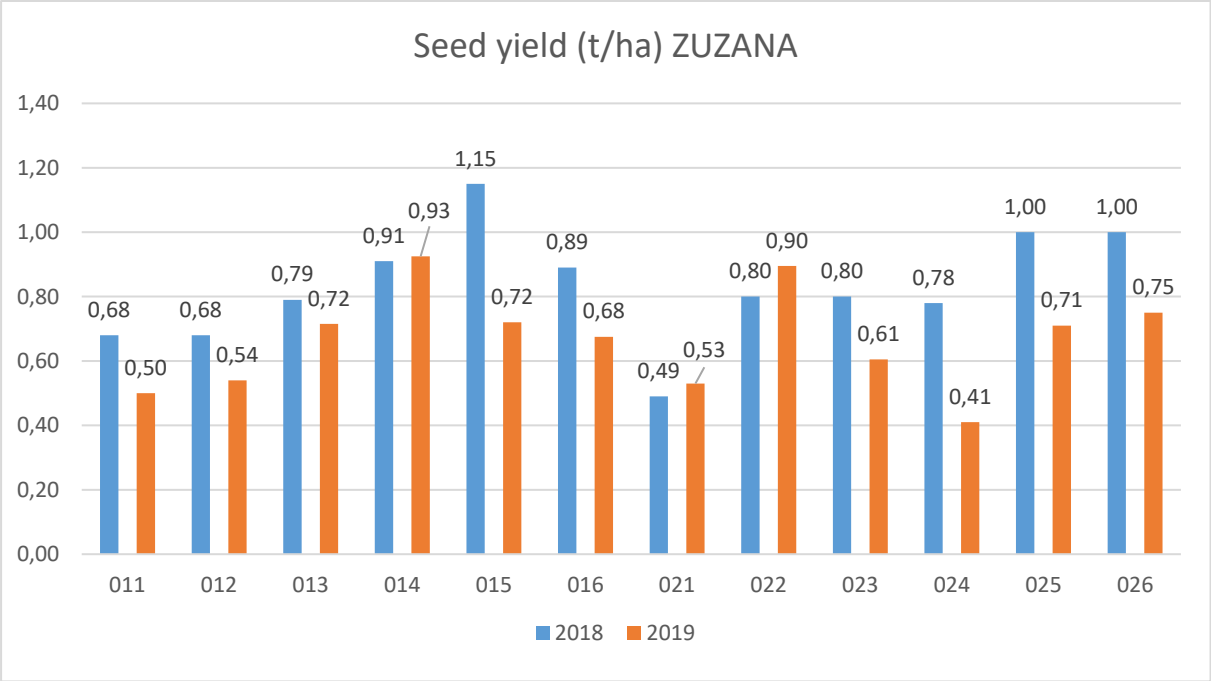

Figure 1. Seed yield of the variety Zuzana during the years 2018, 2019

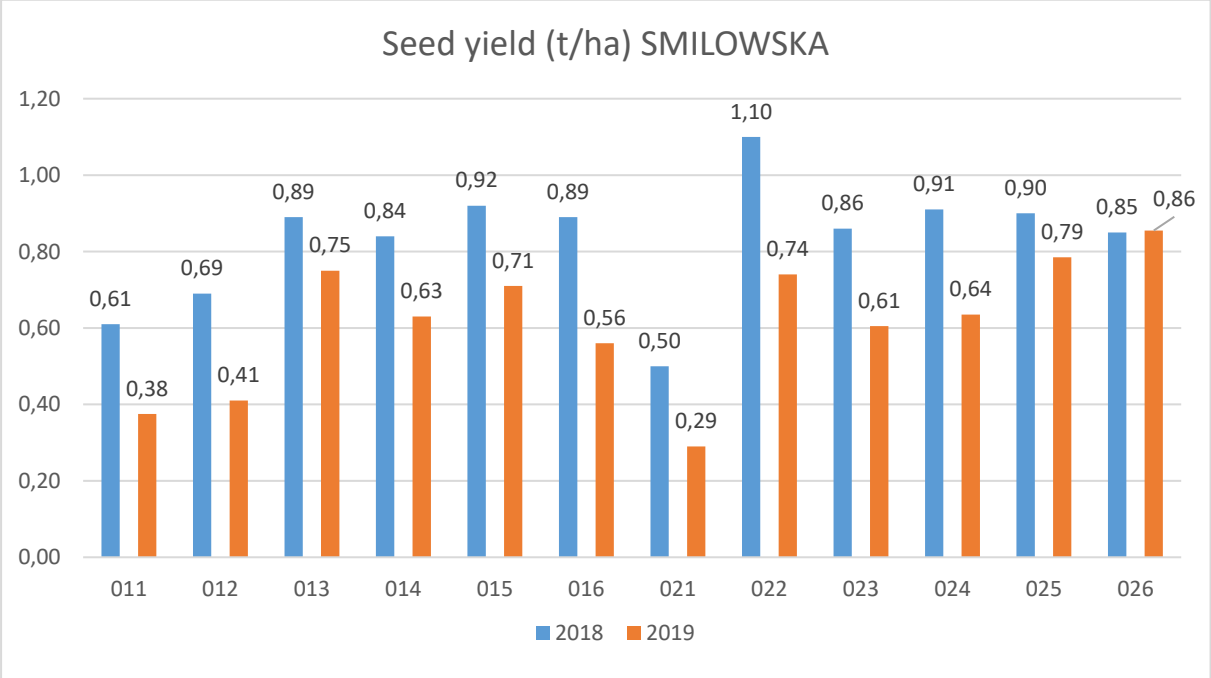

Figure 2. Seed yield of the variety Smilowska during the years 2018, 2019

Influence of fertilization, variety and year on oil content

Fertilization variants had statistically high significant effect (P <0.01) on the oil content. Nitrogen fertilization as well as phosphorous application reduced the oil content. This negative correlation is known for cereals and *Brassicaceae* family plants such as rapeseed. The application of nitrogen

enhances the growth of the stem and increases the protein content in the seed and decreases the oil content in the seed. Phosphorous application causes increased production of phospholipids, that are not extracted into the oil, influencing overall oil yield.

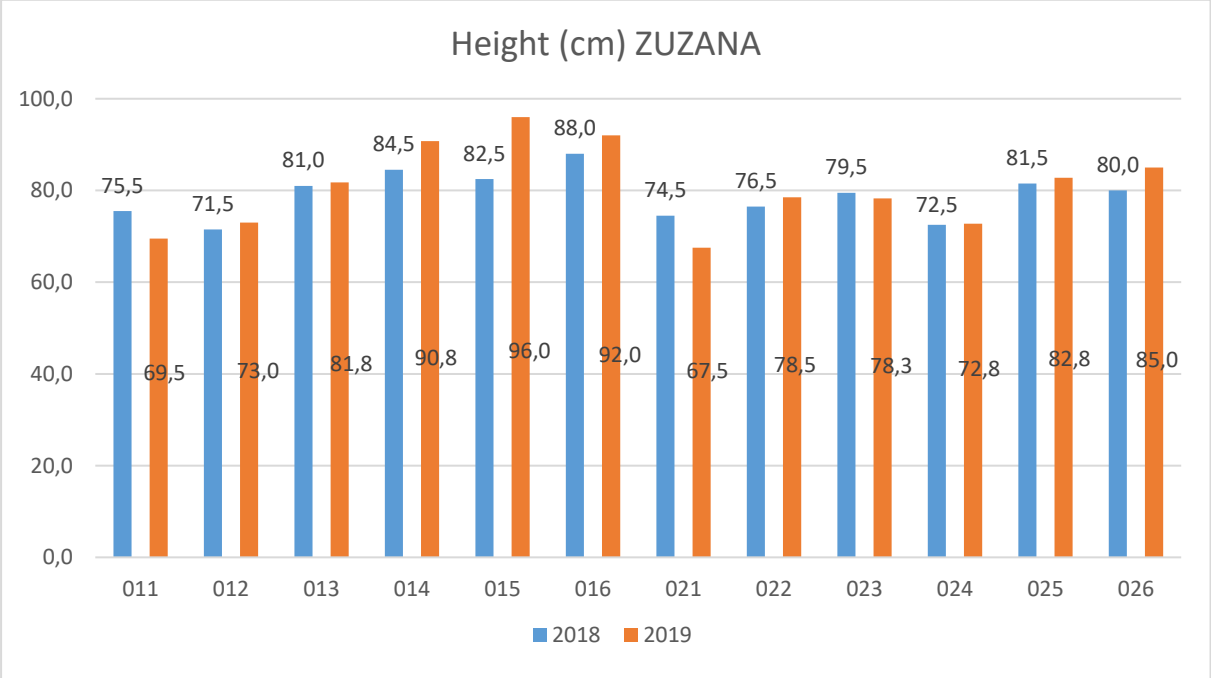

Figure 3. The height of plants, variety Zuzana during the years 2018, 2019

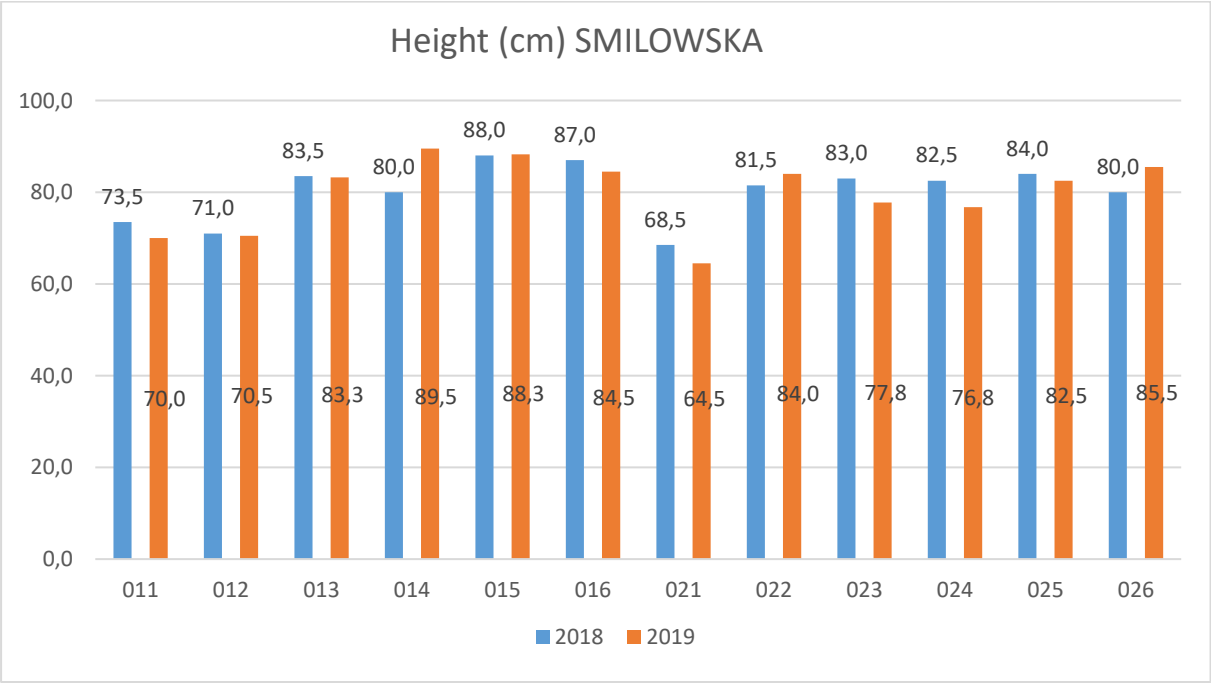

Figure 4. The height of plants, variety Smilowska during the years 2018, 2019

Values of obtained oil yields varied over an average of two years of testing from 38.17 % to 31.17 % (Table 2). The highest oil content in the seeds of the false flax was recorded for the variety Zuzana at the NPK (0-0-0) variant when manure has been applied once per 4 years at dosage 10 t/ha in 2018. On the other hand, the lowest oil content was detected for the variety Zuzana, but at the NPK (150-60-60) variant (Figure 5, 6).

The oil content of seeds varied depending on the year. In our experiment, the year had a statistically highly significant impact ($P<0.01$) on the oil content (Figure 5, 6). The lowest percentage of oil in seeds was recorded for both varieties in year 2019, when the weather during the ripening period (June, July) was very warm and dry (+ 3.85 ° C; -37.9 mm from long-term normal). The oil content in this year reached an average 32.15 % for both varieties, which is 4.6 % less than in year 2018.

The variety had a statistically significant effect ($p <0.05$) on the oil content. Higher oil contents in the seeds of the false flax have been observed for two years in the Czech variety Zuzana (Figure 5, 6).

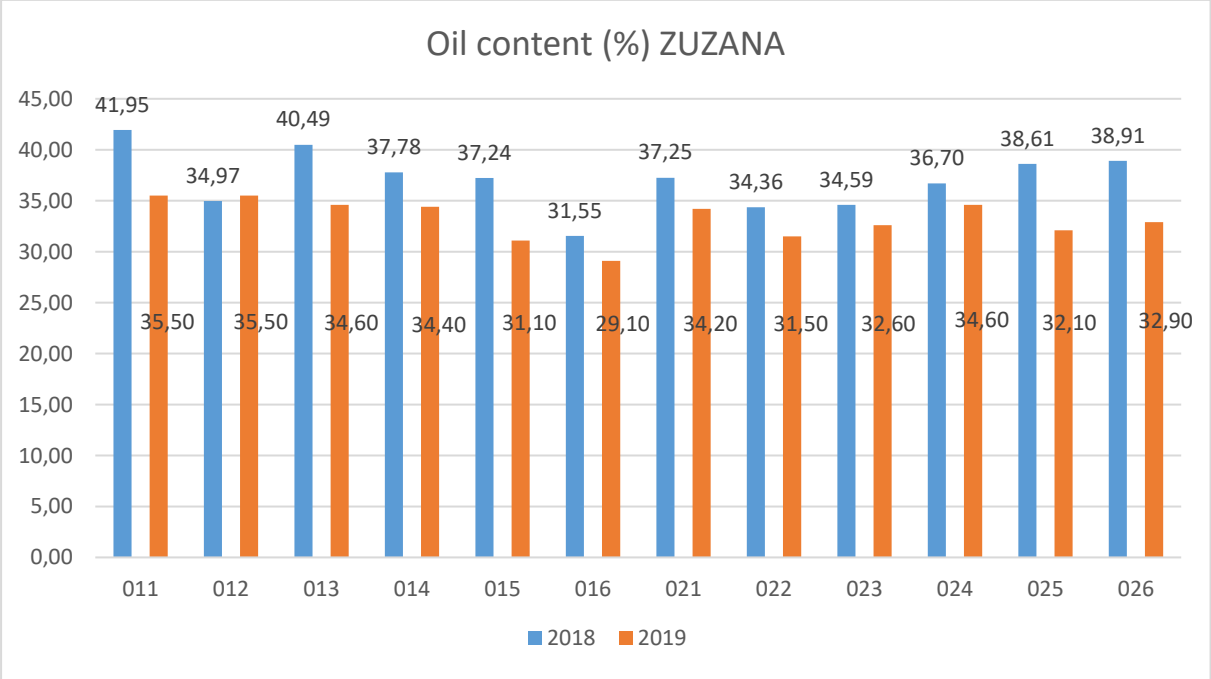

Figure 5. Oil content, variety Zuzana during the years 2018, 2019

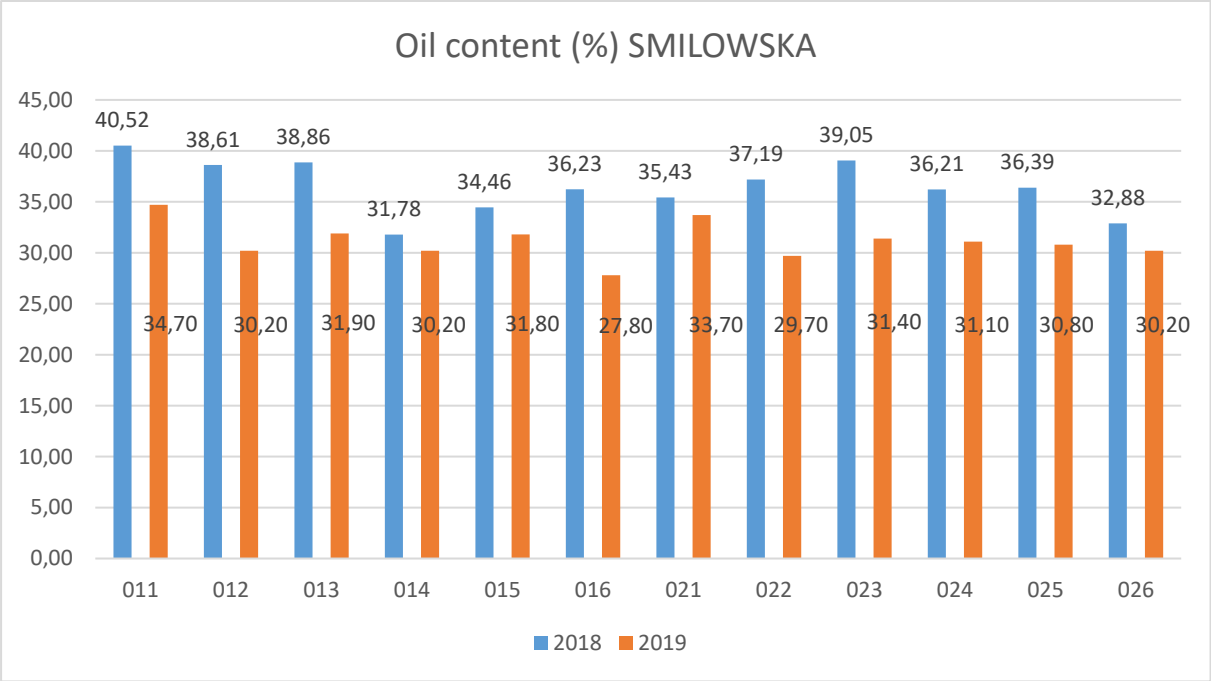

Figure 6. Oil content, variety Smilowska during the years 2018, 2019

Discussion

Our experiment suggests that nitrogen is the most important nutrient to increase the yield of the seed of the false flax. Increasing doses of N fertilization had a positive effect on the increase in seed yield. The positive effect of higher doses of nitrogen on the seed yield was also confirmed in studies by other authors (Jiang et al., 2013; Jiang et al., 2014; Sintim et al., 2015). The optimum dose of nitrogen for false flax was determined by Jiang et al. (2013) at 120 to 160 kg/ha. Research carried out in Germany confirms that the highest seed yield (2.28 t/ha) of spring form of false flax has been achieved with a combination of fertilizers with a dose of 80 kg/ha at sowing 400 seeds per m^2 (Agegnehu, Honermeier, 1996). This was also confirmed in our experiment, where we have recorded the highest yields on average of two years and both varieties in NPK (120-0-0), NPK (120-60-60) and NPK (80-0-60) fertilizer variants. Karčauskiene et al. (2014) also confirm the highest seed yield achieved at dose of N 90 kg/ha in summer form of false flax. Thus, we can conclude that higher doses of nitrogen (over 120 kg/ha) in summer form of false flax have no significance effect for further increase of seed yield. In our experiment with the fertilization variant NPK (150-60-60) no higher seed yield was achieved in any of the studied varieties.

In the experiment, we have also observed a phenomenon where, at the N level of 120 kg/ha, the addition of phosphorus and potassium leads to a decrease in the yield. Solisa et al. (2013), also observed in their study the impact of nitrogen with phosphorus (P at 0, 50, 100 kg/ha) on seed yield in various combinations. The maximum seed yield was at 0 kg/ha addition of P.

The height of the plants was clearly influenced by the fertilization variant. In both varieties, the average height of the plants was increased by approximately 19 cm due to the effect of mineral nutrition over two years of testing. The results are also confirmed by a team of Urbaniak (2008), who claim that plant height, seed yield, oil content and protein content are nitrogen-dependent. Even in our experiment, both varieties reached the highest height at the highest fertilization rate in the NPK combination on average for years of testing.

Many authors (Agegneh, Honermeier, 1996; Malhi et al., 2014) reported that nitrogen fertilization reduced the oil content of the seeds of the false flax. This was confirmed in our experiment. It can be stated that in both varieties, in tested period the higher doses of nitrogen N (40-150 kg/ha) reduced the oil content compared to the dose N (0 kg/ha) by 7 % (Table 2). In publication by Strašil (2008), it is mentioned that the warm and dry weather has negative effect causing the reduction of oil content in seeds of false flax. We can conclude that even in our trial in 2019 such weather had a negative impact on the oil content. Toncea et al. (2013), also stated that the oil content in the seeds of the false flax is strongly dependent on the weather conditions of the year.

Conclusion

False flax is a suitable crop for growing in our growing conditions at low inputs into the production process. Based on the results of our work, we can recommend a dose of nitrogen fertilization at the level of 80-120 kg/ha for the cultivation of summer form of false flax. At higher doses of N fertilization, the false flax plants have reached the highest growth of the plants, but this led to subsequent lodging of the plants, and seed yield losses. The oil content was influenced mainly by the weather during the year and in part by the variety. By increasing amount of N fertilization the oil content has decreased.

Acknowledgements

This work was supported by the Slovak Research and Development Agency under the contract No. APVV-16-0097 and contract No. APVV-16-0051.

REFERENCES

Abramovič, H. and V. Abram (2005). Physico-chemical properties, composition and oxidative stability of Camelina sativa oil. Food Techn. Biotech, 43 (1), 63–70.

Agegnehu, M. and B. Honermeier (1996). Effects of seeding rates and nitrogen fertilization on seed yield, seed quality and yield components of false flax (Camelina sativa Crtz.). Die Bodenkultur, 48 (1), 2–20.

Berti, M., R. Wilckens, S. Fisher, A. Solis and B. Johnson (2011). Seeding date influence on camelina seed yield, yield components, and oil content in Chile. Ind. Crop. Prod., 34, 1358–1365.

Francis, A. and S. I. Warwick (2009). The biology of Canadian weeds. 142. Camelina alyssum (Mill.) Thell.; C. microcarpa Andrz. ex DC.; C. sativa (L.) Crantz. Can. J. Plant Sci., 89, 791–810.

Gugel, R. K. and K. C. Falk (2006). Agronomic and seed quality evaluation of Camelina sativa in western Canada. Can. J. Plant Sci., 86, 1047–1058.

Jiang, Y., C. D. Caldwell and K. C. Falk (2014). Camelina seed quality in response to applied nitrogen, genotype and environment. Can. J. Plant Sci., 94, 971-980.

Jiang, Y., C. D. Caldwell, K. C. Falk, R. R. Lada and D. MacDonald (2013). Camelina yield and quality response to combined nitrogen and sulfur. Agron. J., 105, 1847-1852.

Karčauskiené, D., E. Sendžikiené, V. Makarevičiené, Akareviečiené, E. Zaleckas, Aleckas, R. Repšiené and D. Ambrazaitiené (2014). False flax (Camelina sativa L.) as an alternative source for biodiesel production. Zemdirbyste-Agriculture, 101 (2), 161–168.

Malhi, S.S., E. N. Johnson, L. M. Hall, W. E. May, S. Phelps and B. Nybo (2014). Effect of nitrogen fertilizer application on seed yield, N uptake, and seed quality of Camelina sativa. Can. J. Soil Sci., 94 (1), 35–47.

Putnam, D. H., J. T. Budin, L. A. Field and W. M. Breene (1993). Camelina: A promising low-input oilseed. New Crops. Wiley, New York, NY: 314-322.

Sintim, H. Y., V. D. Zheljazkov, A. K. Obour, A. G. Garcia and T. K. Foulke (2015). Influence of nitrogen and sulfur application on Camelina performance under dryland conditions. Ind. Crop. Prod., 70, 253-259.

Solisa, A., I. Vidala, L. P. Burton, L. Johnson and M. T. Berti (2013). Camelina seed yield response to nitrogen, sulfur, and phosphorus fertilizer in South Central Chile. Ind. Crop. Prod., 44, 132-138.

Strašil, Z., (2008). Základy pěstování a možnosti využití lničky seté. Metodika pro praxi. Výzkumný ústav rostlinné výroby, v.v.i., Praha 6 – Ruzyně.

Toncea, I., D. Necseriu, T. Prisecaru, L.-N. Balint, M.-I. Ghilvacs, M. Popa (2013). The seed's and oil composition of Camelia – first romanian cultivar of camelina (Camelina sativa, L. Crantz). Rom. Biotech. Lett., 18 (5), 8594-8602

Urbaniak, S., C. Caldwell, V. Zheljazkov, R. Lada and L. Luan (2008). The effect of cultivar and applied nitrogen on the performance of Camelina sativa L. in the Maritime Provinces of Canada. Can. J. Plant Sci., 88 (1), 111–119.

Zubr, J. and B. Matthäus (2002). Effects of growth conditions on fatty acids and tocopherols in Camelina sativa oil. Ind. Crops Prod., 15, 155-162.