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YIELD RESPONSE OF TWO *Camelina sativa* VARIETIES UNDER DIFFERENT FERTILIZATION IN WESTERN PART OF ROMANIA

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Abstract

Due to the recent changes of the climatic conditions, new crops emerged and were taken into consideration by farmers all around the world. One such crop is Camelina sativa from the Brassicaceae botanical family which gained its attention due to the high oil content and balanced fatty acid ratio. In Romania, being a non-traditional crop, Camelina lacks a specific cultivation technology adapted to local pedo-climatic conditions. Although Camelina is not a pretentious crop, the yield response to fertilization is significant and that's what this paper covers. The experimental field was situated in the western part of Romania and we followed the yield response of two Camelina varieties under different fertilization schemes. The obtained results ensure the statistical significance of the positive yield variation of Camelina under different fertilization.

Key words: *camelina, crop, fertilization, technology.*

INTRODUCTION

For the last decades, *Camelina sativa* is in the spotlight of the science community, and can be considered an emerging crop worldwide due to high interest in its oil (Zanetti et al., 2021; Carciumaru, 2007; Laurentiu et al., 2018; Zubr, 1997; Séguin-Swartz et al., 2009). The fatty acid composition of camelina oil ensures both industrial and feed utilization of its seeds. (Imbrea et al., 2017). Camelina oil is high on linoleic and α-linolenic acid and it has an almost 1:1:1 ratio of omega-3, omega-6 and omega-9 fatty acids (Angelini et al., 2020; Imbrea et al., 2011; Gesch et al., 2011; Malhi et al., 2014; Zubr, 2003; Meunier et al., 2016) thus showing antimicrobial properties (Batrina et al., 2021). Furthermore, camelina also has a good ratio of essential and non-essential amino acids (Batrina et al., 2020). Camelina has little economic importance but it can be a good alternative to the commonly grown oilseed rape (Jarecky, 2021) due to the possibility of growing it on low performance lands and marginal lands with a minimum of fertilisation inputs (Von Cossel et al., 2019; Wittenberg et al., 2019; Wysocky et al., 2013) and almost no pesticides due to its natural resistance to pathogens (Jiang et al., 2016).

This study aims to point out the influence of fertilization schemes on Camelina seed.

MATERIALS AND METHODS

The experiment set was bifactorial one, with three repetitions, with the following graduation of the experimental factors:

1. Factor A - Camelina variety/hybrid

a1 - Madalina

a2 - Calena

2. Factor B - Fertilization

b1 - $N_{45}P_{45}K_{45}$

b2 - $N_{66}P_{57}K_{45}$ + 24SO_3 + 7CaO + 2Mg + 0.1 B +0.15 Zn

b3 - $N_{101}P_{78}K_{45}$ + 48SO_3 + 14CaO + 4Mg + 0.2 B +0.3 Zn

The soil on which the camelina experiment was placed is a molic preluvosol, a soil characteristic of the studied area, having the largest share in the agricultural land of Bocsig Administrative Territorial Unit.

The analyses were performed in the Agrochemistry laboratory of USAMVBT and

the results indicated humus content between 1.52-3.54% showing an average supply of organic matter; the values being specific to a molic preluvosol.
The soil reaction was moderately acidic to neutral with pH values ranging from 5.57 in the A horizon to 7.16 in the B/C horizon. The nitrogen index varies between 2.04 and 3.08, being closely dependent on the humus content. The supply of mobile phosphorus is low with values ranging between 2.6-13 ppm, thus explaining the need to apply phosphorus fertilizers. The soil under study has a medium supply of mobile potassium with values ranging between 128-184 ppm. The degree of saturation of bases (V%) is high, especially in the lower horizons and oscillates within the range 84.3-91.8%.
In conclusion, the soil identified on which the experiment was carried out has a series of favourable chemical properties, like having a medium fertility so in order to achieve the full potential of production, it requires a series of agrochemical and agrotechnical measures to positively modify the physical and chemical properties.
The climatic conditions analysis of the studied area was made based on the interpretation of the data recorded at the Arad Meteorological Station within INMH Bucharest network.
The territory of Bocsig village can be characterized by a moderate- temperate continental climate, with shorter and milder winters, the value of average annual temperatures is over 10ºC with the passage of the average temperature through the threshold of 5ºC (which is the biological threshold for most crops) between March 12-18.
The soil works consisted of performing plowing in the autumn at a depth of 30-35 cm, and the preparation of the germination bed was done with a milling cutter, thus fulfilling an essential condition for the establishment of the camelina culture; that of having prepared a gardenly germination bed. The sowing was done as fast as possible in the the spring, in order to get the best yields (Righini et al., 2019) in close rows: with the distance between the rows at 12.5 cm, with an "Accord" seed drill.
The basic fertilization was done with 300 $kg \cdot ha^{-1} N_{45}P_{45}K_{45}$ before sowing alongsidethe preparation of the germination bed. The next fertilization was done when the plants reached the rosette stage and consisted in the application of Eurofertil NPS complex fertilizer produced by Timac Agro in a dose of $100 kg \cdot ha^{-1}$ and $200 kg \cdot ha^{-1}$ respectively, so that the variants are fertilized according to the field sketch.
NPS 56 fertilizer produced by Timac Agro is a complex fertilizer with an active substance content of $21N + 12P_2O_5 + 24SO_3 + 7CaO + 2Mg + 0.1 B + 0.15 Zn$.

RESULTS AND DISCUSSIONS

The results from the experimental cycle 2018-2020, from Bocsig (Table 1) shows that both, the variety and the fertilization treatments, respectively the interaction of these two factors had a considerable influence, statistically assured, on camelina yield. Climatic conditions also had the highest contribution to production variability (39.99%).
The combinations of macroelements and microelements had a significant contribution to the variability of production (30.78%), superior to the effect of the variety (21.27%). Also, the combined effect of the two factors showed a significant influence (0.96%), but considerably less than their separate effects.
At the experience level, the results obtained were influenced to a small extent (3.91%) by other sources of variation not included in the experimental device.

Table 1. Variance analysis for the effect of variety and fertilization on camelina yield at Bocsig during 2018-2020

Source of variation	SP	GL	S2	Test F
The total	2229235	53		
Repetition	820	2	410	0.51
Years	435867	2	217933	271.73 **
Error years	32087	4	802	
Variety	238722	1	238722	144.51 **
Years x Varieties	38540	2	19270	11.66 **
Variety error	9912	6	1652	
Fertilization	1275581	2	637791	209.14 **
Years x Fertilizers	68621	4	17155	5.63 **
Varieties x Fertilizers	39912	2	19956	6.54 **
Years x Varieties x Fertilizers	44862	4	11216	3.68 *
Fertilization error	73189	24	3050	

Comparing the suitability of agricultural years for camelina cultivation (Table 2), it can be observed that the highest yield was registered in 2019 compared to 2018, corresponding to a significant increase in yield value of 87 kg·ha^{-1}, equivalent to 4.34%. In 2020 there was a negative increase in production compared to the previous year and the first year of experience.

Table 2. The yearly average yields for camelina recorded at Bocsig in 2018

Years	Yield (kg ha^{-1})		Percent (%)	Difference/ meaning
2019-2018	2093	2006	104.34	87 ***
2020-2018	1874	2006	93.42	-132000
2020-2019	1874	2093	89.54	-219000

DL5% = 26 kg·ha^{-1} DL1% = 44 kg·ha^{-1} DL0.1% = 81 kg·ha^{-1}

The behavior of the tested varieties (Table 3) shows that during this period, at the level of the whole experience, the Madalina variety achieved a significantly higher yield by 133 kg·ha^{-1}, associated with an increase of 6.91% compared to the Calena variety whose average yield was of 1924 kg·ha^{-1}.

Table 3. The average yields for camelina varieties studied at Bocsig during 2018-2020

Variety	Yield (kg ha^{-1})		Percent (%)	Difference/ meaning
Madalina-Calena	2057	1924	106.91	133 ***

The yield results of camelina under the effect of different combinations of macroelements and microelements (Table 4) showed an amplitude of 372 kg·ha^{-1}, withlimits from 1788 kg·ha^{-1} in the case of the$N_{45}P_{45}K_{45}$ variant and up to 2160kg·ha^{-1} for the $N_{101}P_{78}K_{45}$ variant supplemented with microelements.

Considering the multiple comparisons between the treatments in terms of seed yield , it can be observed that the variant, $N_{101}P_{78}K_{45}$ supplemented with microelements had a significantly higher efficiency than the other two combinations, materialized with an increases between 6.72% compared to the variant $N_{66}P_{57}K_{45}$ and 20.81 % compared to $N_{45}P_{45}K_{45}$ without microelements. Also, the application of the $N_{66}P_{57}K_{45}$variant with microelements showed an increase of seed yield by 13.20% compared to the simple fertilisation variant $N_{45}P_{45}K_{45}$.

Table 4. Average yields for fertilization treatments studied at Bocsig during 2018-2020

Fertilization	Yield (kg ha^{-1})		Percent (%)	Difference / Significance
B2-B1	2024	1788	113.20	236 ***
B3-B1	2160	1788	120.81	372 ***
B3-B2	2160	2024	106.72	136 ***

DL5% = 38 kg·ha^{-1} DL1% = 52 kg·ha^{-1} DL0.1% = 69 kg·ha^{-1}
B1 -$N_{45}P_{45}K_{45}$;
B2 - N66P57K45 + 24SO_3 + 7CaO + 2Mg + 0.1 B +0.15 Zn;
B3 - $N_{101}P_{78}K_{45}$ + 48SO_3 + 14CaO + 4Mg + 0.2 B +0.3 Zn

Comparing the suitability of the experimental years 2018 - 2020 in terms of climate and variety on the yield of camelina seeds at Bocsig (Table 5, Figure 1) it is observed that in the case of the year 2020 the smallest difference between the 2 varieties was insignificant, while in the rest of the years the difference between the varieties is higher.

Table 5. The effect of camelina variety on yield at Bocsig during 2018-2020

Years	Variety			
	Calena	**Madalina**	$\bar{x} \pm s_{\bar{x}}$	S%
2018	y1950± 110 b	x2062± 130 b	2006 + 87	18.32
2019	y2000± 102 a	x2185± 122 a	2093 + 89	18.16
2020	y1823± 94 c	x1925± 106 c	1874 + 73	16.55
$\bar{x} \pm s_{\bar{x}}$	1924 + 64	2057 + 78	1991 + 53	
S%	17.22	19.81	18.67	

Year DL5%=37 kg·ha^{-1} DL 1%=53 kg·ha^{-1} DL 0.1% = 76 kg·ha^{-1}(a,b,c)
Varieties DL5%=47 kg·ha^{-1} DL 1%=71 kg·ha^{-1} DL 0.1%=114 kg·ha^{-1} (x,y)

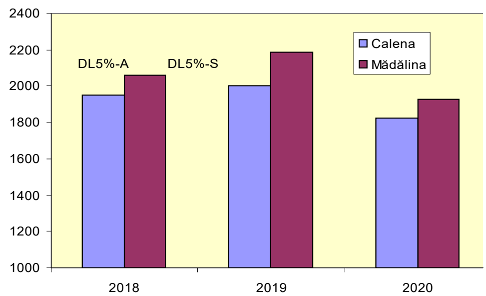

Figure 1. The yearly yield of camelina varieties recorded at Bocsig during 2018-2020

Given the combined effect of the agricultural year and the level of fertilization on camelina yieldat Bocsig in the period 2018-2020 (Table 6, Figure2) it is observed that the production differences between the agricultural year 2018 and 2020 related to the level of fertilization B1 are significant.

A significantly difference inyield increase was also recorded in 2019. For the higher levels of fertilization, there are significant differences of yield between years, the highest being in 2019 for both fertilization variants.

Table 6. Effect of fertilization treatment on camelina yield at Bocsig during 2018-2020

Years	Fertilization				
	B1	B2	B3	$\bar{x} \pm s_{\bar{x}}$	S%
2018	z1805± 30 b	y1996± 64 b	x2217± 60 a	2006 + 87	18.32
2019	z1878± 74 a	y2149± 78 a	x2251± 104 a	2093 + 89	18.16
2020	z1682± 36 c	y1927± 64 c	x2013± 42 b	1874 + 73	16.55
$\bar{x} \pm s_{\bar{x}}$	1788 + 48	2024 + 58	2160 + 64	1991 + 53	
S%	11.36	12.26	12.70	18.67	

Year DL5%=57 kg·ha^{-1} DL 1%=77 kg·ha^{-1} DL 0.1%=102 kg·ha^{-1}(a,b,c)
Fertilization DL5%=66 kg·ha^{-1}DL 1% = 89 kg·ha^{-1} DL 0.1%=120 kg·ha^{-1} (x,y,z)

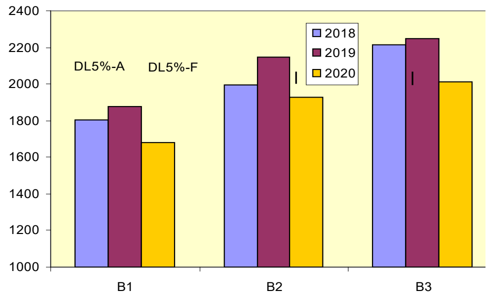

Figure 2. Yearly yield of fertilization treatments recorded at Bocsig during 2018-2020

Analyzing the cross effect of fertilizer and variety in the period 2018-2020 at Bocsig on the yield of camelina seeds (Table 7, Figure 3) it is observed that in the case of fertilization with $N_{45}P_{45}K_{45}$ the smallest difference betweenvarieties was registered while on the background of application of microelements supplemented treatments the difference between the yield potential of the varieties was more obvious, being higher for the Madalina variety.

Table 7. The effect of variety and fertilization on camelina yield at Bocsig during 2018-2020

Variety	Fertilization				
	B1	B2	B3	$\bar{x} \pm s_{\bar{x}}$	S%
Calena	z1741 + 48 b	y1948 + 60 b	x2084 + 58 b	1924 + 64	17.22
Madalina	z1836 + 68 a	y2100 + 70 a	x2237 + 92 a	2057 + 78	19.81
$\bar{x} \pm s_{\bar{x}}$	1788 + 48	2024 + 58	2160 + 64	1991 + 53	
S%	11.36	12.26	12.70	18.67	

Varieties DL5%=49 kg·ha^{-1} DL 1%=66 kg·ha^{-1} DL 0.1%=87 kg·ha^{-1} (a,b)
Fertilization DL5%=54 kg·ha^{-1} DL 1%=73 kg·ha^{-1} DL 0.1%=98 kg·ha^{-1} (x,y,z)

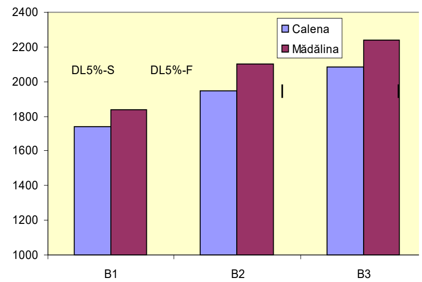

Figure 3. Yields of camelina varieties under different fertilization schemes at Bocsig during 2018-2020

CONCLUSIONS

The results from the experimental cycle 2018-2020 obtained in the experimental field at Bocsig, show that both variety and fertilization schemes, respectively the interaction of these two factors had considerable influences, statistically assured on the yield of camelina seeds.
Climatic conditions also had a high contribution to the yield variability of 39.99%.
The combinations of macroelements and microelements had a significant contributionof 30.78% to the yield, higher than the effect of the variety of 21.27%.
The combined effect of the two factors also showed a considerably lower influence than their separate effects on the level of camelina yield.
The highest seed yield was obtained in the $N_{101}P_{78}K_{45}$ supplemented with microelements variant, with a 6.72% increase compared to the $N_{66}P_{57}K_{45}$ variant and 20.81% compared to the $N_{45}P_{45}K_{45}$ variant without microelements.
The combined effect of fertilization and variety on camelina seed yield highlights that in the case of the $N_{45}P_{45}K_{45}$variant the smallest difference between the varieties was registered, while on the background of the application of some treatments supplemented with microelements, the difference between the yield potential of the varieties was more obvious, being higher for the Madalina variety.

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