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Camelina sativa: A new source of vegetal oils

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Abstract

Camelina sativa is a re-discovered crop with multiple uses. Original from the Middle East, the plant – named camelina, false flax, German sesame, gold-of-pleasure, linseed dodder, Siberian oilseed or wild flax – belongs to the Family Cruciferae (Brassicaceae), genus Camelina and it includes several species. For the production of oil, only two species of camelina are used – Camelina sativa (with spring and autumn forms) and Camelina silvestris (sowed in autumn). The seeds are used for the extraction of oil (used in medicine or as bio fuel) or directly as animal feed due to its lower content of glucosinolates.

Camelina oil has the consistency of a clear, transparent, and oily liquid, with a small amount of sediments on the bottom of the recipient.

The particular value of camelina oil is given by its content in polyunsaturated fatty acids (50-60%), by its content in omega 3 (35-40%), and by its content in omega 6 (15-20%). Due to these properties, camelina oil is one of the richest vegetal sources of omega 3.

The study focused on the influence of the level of mineral fertilisers and of the sowing density on the level of production in spring camelina. We have also monitored the influence of technological elements on oil content and yield in spring camelina cultivated on the cambic chernozem of the Didactic Station of the Banat University of Agricultural Science and Veterinary Medicine (BUASVM) in Timişoara.

Measurements were done in the Laboratory for the Testing of the Quality of Seed and Seeding Material of the Department of Agricultural Cultivation Technologies of the Faculty of Agriculture.

On the whole, the yields oscillated between 932 kg/ha in the control variant (no fertilisers) and 1,813 kg/ha (in the variant fertilised with $N_{100}P_{60}$*).*

Results show that this species can be cultivated in the area, and oil amount and quality motivate its expansion as a crop.

Key words: Camelina sativa, Camelina silvestris, oil content, oil yield

Introduction

Camelina, though cultivated for over 2,000 years in the area for its seeds containing 30-45% oil, used as food, in the dye industry, in the soap industry, and, more recently, as bio fuel, is little known at present in Romania, though soil and climate conditions are favourable[2].

The oil from camelina seeds, a golden liquid, contains over 50% polyunsaturated essential fatty acids, and particularly linoleic and alpha-linoleic acids. Camelina oil is 10 times richer in these acids than many other vegetal oils[1,6,7].

The particular value of the camelina oil is given by its high content in natural tocopherols (vitamin E), which makes it very stable from an oxidative point of view [9].

Camelina oil also helps cell regeneration and skin elasticity and slenderness recovery [8].

The specificity of camelina oil is due to its basic properties, i.e.:

- exceptional taste and aroma;
- colour;
- physical and chemical composition;
- long preservation period (up to 2 years).

Table 1. Fatty acids composition of camelina oil (experimental field in the Constanta County, 2009)

Fatty acids	Oil content %	Fatty acids	Oil content %
Myristic acid C14: 0	0.10	Linolenic acid C18: 3n-6	35.58
Palmitic acid C16: 0	6.51	Conjugated linoleic acid C18: 2	1.06
Palmitoleic acid C16: 1	0.18	α Linolenic acid C18: 3n-3	11.59
Stearic acid C18: 0	2.15	Arachidonic acid C20: 4n-6	1.11
Oleic acid C18: 1n- 9	16.27	Erucic acid C22: 1n-9	1.6
Linoleic acid C18: 2n-6	20.99	Docosadienoic acid C22: 2n-3	2.24
Other fatty acids	0.61		

Table 1 shows high content in polyunsaturated acids of camelina oil, especially linolenic acid C18: 3n-6 (about 35.58%) and also α Linolenic acid (11.59%) oleic acid (16.27%) and linoleic acid (20.99%); a small content of erucic acid (1.6%) is observed, so this type of oil can be used for food [10].

The grits after oil cold extraction contains, in general, 10%-12% oil (about 5% omega-3 fatty acids) and 40% proteins, which recommends its use as human food, due to its low content of glucosinolates[3,5].

Material and Research Method

Research concerning the fertilisation of the crop was carried out on a cambic, moist phreatic (poorly gleyed), decarbonated chernozem developed on loessoid deposits.

The experiment was of the bifactorial type, with three replicates, set after the sub-divided plot method, with the following graduations of the factors:

- factor A - doze of phosphorus (a_1 - P_0; a_2 - 40 kg/ha P_2O_5; a_3 - 60 kg/ha P_2O_5);
- factor B – dose of nitrogen (b_1 - N_0; b_2 - N_{50}; b_3 - N_{100});

Sowing technology in camelina is not enough clear; therefore, we designed a bifactorial experiment organised after the subdivided plot method, with three replicates.

The experimental factors were as follows:

- factor A – level of fertilisation with two graduations: - a_1 – not treated and a_2 - N_{100} $P_2O_5 60 K_2O 60$;
- factor B – row distance: b_1 – 12.5 cm; b_2 - 25 cm; b_3 - 50 cm.

Sowing was done 1-2 cm in the soil, with 8 kg/ha of seed. The biological material was a local population of the BUASVM.

Winter wheat was the pre-emergent crop.

Soil works consisted in summer till 20-23 cm in the soil, with a plough aggregated with a star harrow, done right after wheat harvesting and straw removal from the field.

Phosphorus fertilizers applied as superphosphate and potassium fertilizers applied as potassium salts were incorporated under the summer till, while nitrogen fertilizers applied as ammonia nitrate was incorporated in spring, upon preparation of the germination bed, with a combinator.

Sowing was done in all three experimental years in the third decade of March.

Maintenance works consisted of harrowing after sprouting and weeding when the plants were 7-10 cm tall.

In the variant with 50 cm row distance we performed two weeding between the rows.

During vegetation there was no need to treat the crop to control diseases or pests.

Harvesting was done upon maturity, with a Hege experimental combine.

The crop from each variant was cleaned from silicules, weighed and reported per ha. Crop assessment was done when moisture reached 11.

Calculus of crop data was done according to the experiment setting method in the field.

On medium samples from the three replicates the content of oil was measured for each experimental variant.

The oil production per ha was calculated based on oil content and seed production.

Results

Yield results depending on fertilisation on the cambic chernozem in Timişoara are shown in Table 2. On the whole, yields oscillated between 932 kg/ha in the control variant (no fertilisers) and 1,813 kg/ha in the variant treated with $N_{100}P_{60}$.

Table 2. Crop results in *Camelina sativa* L. registered in Timişoara

A Factor Phosphorus dose	B Factor - Nitrogen doses			A Factorial Averages			
	N_0	N_{50}	N_{100}	Crop (kg/ha)	%	Difference (kg/ha)	Significance
P_0	932	1244	1405	1194	100	Control	-
P_{40}	1032	1394	1629	1352	113	158	xx
P_{60}	1166	1618	1813	1532	128	388	xxx

DL 5% = 73 kg/ha; DL 1% = 121 kg/ha; DL 0.1% = 227 kg/ha

B Factorial Averages

Crop ((*kg/ha*)	1043	1418	1615
%	100	136	155
Difference (*kg/ha*)	Mt.	375	572
Significance	-	xxx	xxx

DL 5% = 43 kg/ha; DL 1% = 55 kg/ha; DL 0.1% = 72 kg/ha

On the average for the three levels of nitrogen, by applying phosphorus dose of 40 kg/ha, an increase in yield of 13% was obtained, which corresponds to a difference compared to the control variant of 158 kg/ha, a difference statistically ensured as distinctly significant. Increasing the dose of phosphorus fertilizer from 60 kg/ha of P_2O_5 lead to an increase in yield of 28%, i.e. a very significant difference of 388 kg/ha.

Nitrogen fertilisers were well valorised, increasing the yield with 36% for a dose of N_{50} and with 55% for a dose of N_{100}. The differences in yield of 375 kg/ha (for a dose of N_{50}) and of 572 kg/ha (for a dose of N_{100}) are statistically ensured as very significant.

Results in spring camelina depending on row distance and soil are shown in Table 3.

Table 3. Crop results depending on row distance and fertilization registered in the Timişoara area

A Factor Fertilization level	B Factor - Row distance (cm)			A Factorial Averages			
	12.5	25	50	Crop (kg/ha)	%	Difference (kg/ha)	Significance
$N_0P_0 K_0$	912	980	906	932	100	Mt.	-
$N_{100}P_{60} K_{60}$	1680	1816	1720	1738	186	806	xxx

DL 5% = 81 kg/ha; DL 1% = 109 kg/ha; DL 0.1% = 139 kg/ha

B Factorial Averages

Crop (kg/ha)	1286	1398	1313
%	100	109	102
Difference (kg/ha)	Mt.	112	27
Significance		xx	

DL 5% = 65 kg/ha; DL 1% = 92 kg/ha; DL 0.1% = 163 kg/ha

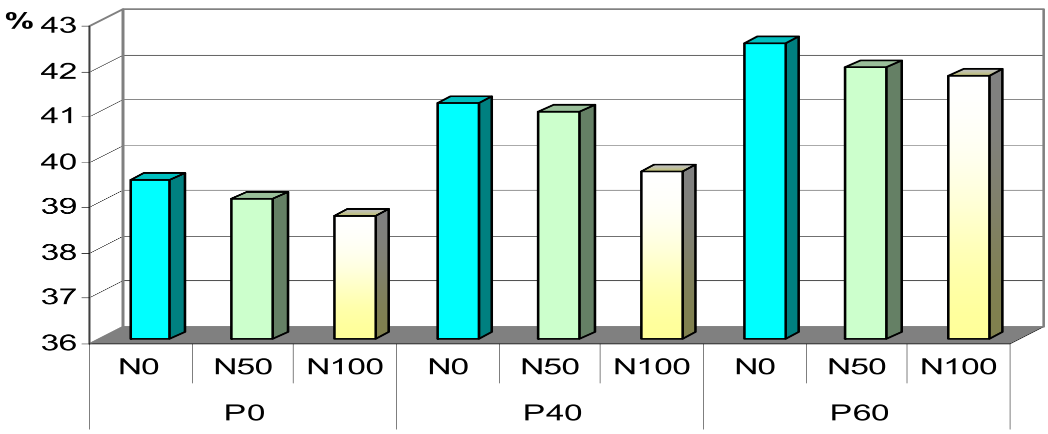
At the level of experimental factors under study the level of crop yields was within 906 kg/ha in the control variant (not treated) sowed at 50 cm row distance, and 1816 kg/ha in the variant sowed at 25 cm row distance on a soil fertilized with $N_{100}P_{60}K_{60}$.

On the average for the three row distances on the fertilized soil, the yield was 86% higher than that on the soil not treated. The difference in yield of about 806 kg/ha is statistically ensured as very significant.

By increasing row distance from 12.5 to 25 cm, an increase in yield of 9% was obtained, i.e. 112 kg/ha.

In the variant sowed at 50 cm row distance, the yield was practically equal to that obtained in the control variant, i.e. the variant sowed at a 12.5 cm row distance.

The variation of the oil content depending on fertilization at the BUASVM in Timişoara is shown in Figure 1.



P_0			P_{40}			P_{60}		
N_0	N_{50}	N_{100}	N_0	N_{50}	N_{100}	N_0	N_{50}	N_{100}
39.5	39.1	38.7	41.2	41.0	39.7	42.5	42.0	41.8

Freedom degree	DL	5%	1%	0.1%
	Phosphorus	1.3	1.7	2.9
	Nitrogen	0.9	1.6	3.1

Figure 1. Oil content variation registered at the BUASVM in Timisoara

In the research area, oil content ranged between 38.7% in the variant treated with $N_{100}P_0$ and 42.5% in the variant fertilised with N_0P_{60}.

Phosphorus fertilisers had a positive impact on oil content, which increased from 39.1% on the average for the three nitrogen levels on the soil not treated with phosphorus, to 42.1% on the average for the three nitrogen levels on the soil treated with 60 kg/ha of P_2O_5.

Nitrogen fertilisers had a negative impact on oil content.

Oil yield, depending on fertilisation, is shown in Table 4. We see that, on the average for all experimental variants, phosphorus fertilisers resulted in an increase with 18% of oil yield in the variant treated with P_{40} and 25% in the variant treated with P_{60}, both differences in yield being statistically ensured as very significant.

Table 4. Oil yield in correlation with fertilization level

Factor A Phosphorus dose	Factor B - Nitrogen rate			A Factorial Averages			
	N_0	N_{50}	N_{100}	Oil yield kg/ha	Difference kg/ha	%	Significance
P_0	368	486	543	466	0 (Control)	100	
P_{40}	425	571	648	548	82	118	xxx
P_{60}	495	679	758	584	118	125	xxx

DL 5% = 24.8; DL 1% = 35.3; DL 0.1% = 48.8

B Factorial Averages

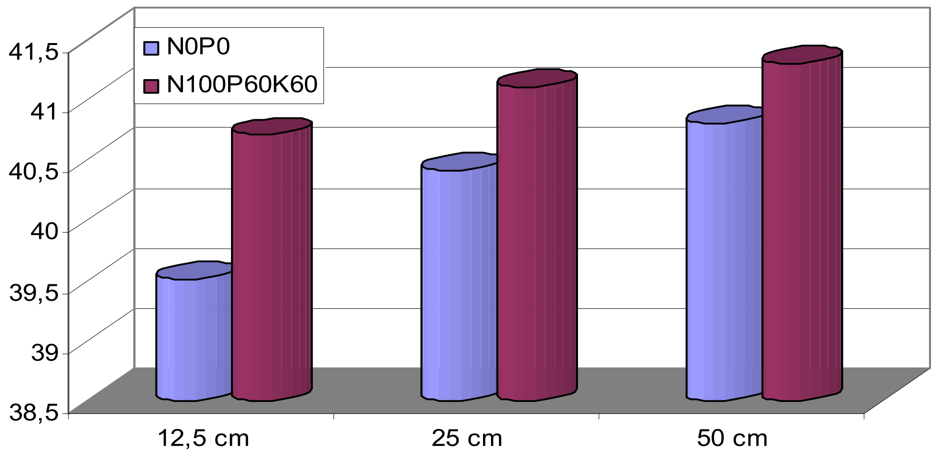
Yield kg/ha	429	577	650
%	100	134	151
Difference kg/ha		148	221
Significance		xxx	xxx

DL 5% = 12.7; DL 1% = 17.9; DL 0.1% = 26.1

Nitrogen fertilisers resulted in an increase in yield because oil content was lower in the variants fertilised with N_{50} and N_{100}.

The variation of oil content depending on row distance and on fertilisation level is presented in Figure 2.

At the level of experimental factors, oil content ranged between 39.5% (variant sowed at 12.5 cm row distance, on a not treated soil) and 41.3% (in the variant sowed at 50 cm row distance on a not treated soil). Oil content on the average for the three row distances tested was 0.8% higher on the fertilized variant compared to the oil content obtained on the unfertilised variant.



Specification	Row distance (cm)		
	12.5	25	50
N_0P_0	39.50	40.40	40.80
$N_{100}P_{60}K_{60}$	40.70	41.10	41.30
X	40.10	40.70	41.05
Sx	0.82	0.43	0.35
S%	6.88	8.54	7.80

Figure 2. Oil content variation from *Camelina sativa* L. seeds

The variation of oil yield (kg/ha) depending on row distance and on level of fertilisation is shown in Table 5.

Table 5. Oil yield depending on row distance and fertilization level

A Factor Agroessence	B Factor - Row distance (cm)			A Factorial Averages			
	12,5	25	50	Yield (kg/ha)	Difference (kg/ha)	%	Significance
$N_0P_0K_0$	360	396	370	375	0 (Control)	100	
$N_{100}P_{60}K_{60}$	684	744	710	713	338	190	xxx

DL 5% = 69; DL 1% = 131; DL 0.1 = 205

B Factorial Averages

Yield kg/ha	522	570	540
%	100	109	103
Difference kg/ha		48	18
Significance		x	

DL 5% = 36; DL 1% = 70; DL 0.1 = 109

The span of oil yield at the level of the studied factors ranged between 360 kg/ha (cultivated at a 12.5 cm row distance on a variant unferetilised) and 744 kg/ha (cultivated at a 25 cm row distance on a fertilized variant).

On the average for the three row distances the differences were relatively low.

Thus, by increasing row distance from 12.5 cm to 25 cm oil yield increased with 48 kg/ha.

By increasing row distance to 50 cm, oil yield decreased compared to that obtained in the variant sowed at 25 cm, but it was only 18 kg/ha higher than that obtained when sowed at 112.5 cm.

On the soil fertilized with $N_{100}P_{60}K_{60}$, on the average for the three row distances, oil yield was 338 kg/ha higher than that obtained from the variant unferetilised.

Conclusions

The need for alimentary oil is increasing worldwide; therefore, besides the development of new cultivars and hybrids, and besides the ongoing improvement of the cultivation technologies of oil plants, we also need to introduce new species into cultivation that can accumulate fats (oils) as reserve substances.

Analysing technological elements with direct impact on crop level in camelina, we can draw the following conclusions:

1. Nitrogen and phosphorus fertilisation have a positive impact on the level of yield in spring camelina on the cambic chernozem in Timişoara.
2. Phosphorus fertilisers applied in doses of P_{40}-P_{60} increased the yield from13% (P_{40}) to 28% (P_{60}), while nitrogen fertilisers increased the yield from 36% (N_{50}) to 55% (N_{100}).
3. Optimal row distance is 25 cm on both types of soil. By increasing row distance from 12.5 to 25 cm, we obtained an increase in yield of 9%. Increasing row distance to 50 cm is not justified, since the increase in yield is only 4% on the cambic chernozem.
4. Oil content on the average for the experimental cycle 2008-2010 on the cambic chernozem in Timişoara ranged between 38.7% in the variant $N_{100}P_0$ and 42.5% in the variant N_0P_{60}.
5. Phosphorus fertilisers, at the level of experimental doses (P_{40}-P_{60}) resulted in an increase of oil content.
6. Phosphorus fertilisers, on the average for the levels fertilised with nitrogen, resulted in an increase of 18% of the oil yield on the soil fertilised with P_{40} and of 25% on the soil fertilised with P_{60}.
7. Nitrogen fertilisers, though decreasing oil content, resulted in an increase of the oil yield due to the positive impact of nitrogen on seed yield; on the average for the three phosphorus fertilisation levels, it increased with 34% for a dose of N_{50} and with 51% for a dose of N_{100}.
8. Row distance in the studied field had no impact on oil content: it was 40.1% in the variant sowed at 12.5 cm row distance, 40.7% in the variant sowed at 25 cm row distance, and 41.05% in the variant sowed at 50 cm row distance. In this context, oil yield was 522 kg/ha in the variant sowed at 12.5 cm, 570 kg/ha in the variant sowed at 25 cm and 540 kg/ha in the variant sowed at 50 cm.

In this context, results obtained in seed yield, oil content, oil yield in spring camelina and its multiple uses allow us to promote its expansion into cultivation.

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