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INFLUENCE OF N, P CHEMICAL FERTILIZERS, ROW DISTANCE AND SEEDING RATE ON CAMELINA CROP

Paul DOBRE[1], Ştefana JURCOANE[2], Stelica CRISTEA[1], Florentina MATEI[1], Andra Cecilia MORARU[2], Liviu DINCĂ[1]

[1]University of Agronomic Sciences and Veterinary Medecine, 59 Marasti Blvd, 011460, District 1 Bucuresti, Romania, Phone +40 (21)3182266, Emails: pauldobre532@yahoo.com; stelicacristea@yahoo.com; flore_radoi@hotmail.com; dinca_liviu84@yahoo.com
[2]BIOTEHGEN, 59 Marasti Blvd, District 1, Bucuresti, Romania, Phone +40 (21)0212242893, Emails: stefana.jurcoane.biotehgen.eu; andrutza_moraru@yahoo.com

Corresponding author email: pauldobre532@yahoo.com

Abstract

Camelina sativa is considered to be a second generation crop used for advanced biofuel production. In Romania research is being done regarding the agronomic factors which influence camelina yield potential. The objective of this study was to identify the technological elements that are most suitable for camelina cultivation. Therefore, different concentrations of nitrogen and phosphorus based fertilizers, as well as various row distances and seeding rates were studied. The experiments were conducted at Moara Domneasca (Ilfov county) in 2013. The experiments were placed in subdivided plots, in three replicates. The results showed that the highest yield potential was obtained when N_{60} P_{50} fertilization scheme was applied. Consequently, the application of large amounts of fertilizers is not necessary. The row distance of 12.5 cm prevented weed infestation and the crop developed well. The data obtained can be useful for more extensive studies regarding the agro-technical aspects of camelina crop.

Keywords: *agro-technical aspects, camelina cultivation, camelina yield, Camelina sativa.*

INTRODUCTION

Camelina sativa (L.) Crantz (false flax, gold-of-pleasure, linseed dodder, German sesame, Siberian oilseed) is an annual oilseed crop of the Brassicaceae (mustard, rapeseed) family (Putnam et al., 1993; Zubr, 1997). Camelina oil has an unusual fatty acid composition with high levels of alpha-linolenic acid and linoleic acid (Budinet et al., 1995; Zubr and Matthäus, 2005; Abramovič and Abram, 2005; Vollman et al., 2007; Imbrea et al., 2011; Ciubota-Rosie et al., 2013; Toncea et al., 2013). In comparison with rapeseed, sunflower, soybean camelina cultivation has low agricultural inputs requirements (Putnam et al., 1993; Zubr, 1997; Dobre and Jurcoane, 2011 and it is more resistant to several pests and diseases (Berti et al., 2011; Pavlista et al., 2012).
The application of nitrogen fertilizers increases camelina yield potential (Agegenehu and Honermeier, 1997; Bugnarug and Borcean, 2000; Imbrea et al., 2011; Johnson and Gesch, 2013; Solis et al., 2013; Wysocki et al., 2013). The objective of this study was to identify the technological elements that are most suitable for camelina cultivation.
Therefore, different concentrations of nitrogen and phosphorus based fertilizers, as well as various row distances and seeding rates were studied.

MATERIALS AND METHODS

The experiment took place in 2013 at Moara Domneasca, Ilfov. The didactic farm Moara Domneasca belongs to SDE Belciugatele - University of Agronomic Sciences and Veterinary Medicine of Bucharest. The soil type is reddish preluvosoil, having loam-clay texture. Four *Camelina sativa* varieties were tested: *GP 202*, *GP 204, Camelia* (Toncea et al., 2013) and *Calena*. The fertilizers applied were represented by urea (46% N) and superphosphate (20% P_2O_5). Seeding rates were calculated before camelina sowing.

Table 1. Research on camelina varieties time seeding and thickness

		Repetition I-			Repetition II			Repetition III			
2.625	b_1- GP 202	Thickness1		b_1- GP 202	Thickness1		b_1- GP 202	Thickness1		10.5 m	42 m
2.625		Thickness 2			Thickness 2			Thickness 2			
2.625		Thickness3			Thickness3			Thickness3			
2.625		Thickness 4			Thickness 4			Thickness 4			
2.625	b_2- Camelia	Thickness2		b_2- Camelia	Thickness2		b_2- Camelia	Thickness2		10.5 m	
2.625		Thickness 3			Thickness 3			Thickness 3			
2.625		Thickness4			Thickness4			Thickness4			
2.625		Thickness 1			Thickness 1			Thickness 1			
2.625	b_3 - Calena	Thickness3		b_3 - Calena	Thickness3		b_3 - Calena	Thickness3		10.5 m	
2.625		Thickness 4			Thickness 4			Thickness 4			
2.625		Thickness1			Thickness1			Thickness1			
2.625		Thickness 2			Thickness 2			Thickness 2			
2.625	b_4 - GP 204	Thickness4		b_4 - GP 204	Thickness4		b_4 - GP 204	Thickness4		10.5 m	
2.625		Thickness 1			Thickness 1			Thickness 1			
2.625		Thickness2			Thickness2			Thickness2			
2.625		Thickness 3			Thickness 3			Thickness 3			
	2	9.5 m	2		9.5 m	2		9.5 m	2		

Experimental factors: Factor A– The time of seeding: a_1 – sowing in spring, Factor B – The variety (cultivar) b_1 – GP 202; b_2 – Camelia; b_3 – Calena; b_4 – GP 204; Factor C– The thickness seeding

Table 2. Chemical fertilization research on camelina

	2m	9m	2	9m	2	9m	2	9m	2	2.62m		
Repetition I		N_0		N_0P_{50}		N_0P_{100}		N_0P_{150}		2.62	10.50 m	36.75 m
		N_{60}		$N_{60}P_{50}$		$N_{60}P_{100}$		$N_{60}P_{150}$		2.62		
		N_{120}		$N_{120}P_{50}$		$N_{120}P_{100}$		$N_{120}P_{150}$		2.62		
		N_{180}		$N_{180}P_{50}$		$N_{180}P_{100}$		$N_{180}P1_{50}$		2.62		
RepetitionII		N_0		N_0P_{50}		N_0P_{100}		N_0P_{150}		2.62	10.50 m	
		N_{60}		$N_{60}P_{50}$		$N_{60}P_{100}$		$N_{60}P_{150}$		2.62		
		N_{120}		$N_{120}P_{50}$		$N_{120}P_{100}$		$N_{120}P_{150}$		2.62		
		N_{180}		$N_{180}P_{50}$		$N_{180}P_{100}$		$N_{180}P_{150}$		2.62		
Repetition III		N_0		N_0P_{50}		N_0P_{100}		N_0P_{150}		2.62	10.50 m	
		N_{60}		$N_{60}P_{50}$		$N_{60}P_{100}$		$N_{60}P_{150}$		2.62		
		N_{120}		$N_{120}P_{50}$		$N_{120}P_{100}$		$N_{120}P_{150}$		2.62		
		N_{180}		$N_{180}P_{50}$		$N_{180}P_{100}$		$N_{180}P_{150}$		2.62		

Factor A– nitrogen fertilizer: a_1 – N0; a2 – N60; a3 – N_{120}; a_4 – N_{180}; Factor B– phosphorus fertilizer: b_1 – P_0; b_2 – P_{50}; b_3 – P_{100}; b_4 – P_{150}

Table 3. Row distance in camelina technology

			2m	R I	2m	R II	2m	R III	2m	2.625m
10.5 m	**a_1** 12.5 cm	b_1		4 kg/ha		4 kg/ha		4 kg/ha		31.5 m
		b_2		8 kg/ha		8 kg/ha		8 kg/ha		
		b_3		12 kg/ha		12 kg/ha		12 kg/ha		
		b_4		16 kg/ha		16 kg/ha		16 kg/ha		
10.5 m	**a_2** 25 cm	b_1		4 kg/ha		4 kg/ha		4 kg/ha		
		b_2		8 kg/ha		8 kg/ha		8 kg/ha		
		b_3		12 kg/ha		12 kg/ha		12 kg/ha		
		b_4		16 kg/ha		16 kg/ha		16 kg/ha		
10.5 m	**a_3** 37.5 cm	b_1		4 kg/ha		4 kg/ha		4 kg/ha		
		b_2		8 kg/ha		8 kg/ha		8 kg/ha		
		b_3		12 kg/ha		12 kg/ha		12 kg/ha		
		b_4		16 kg/ha		16 kg/ha		16 kg/ha		
				9 m		9 m		9 m		2.625m

Factor A – Row distance: a_1 – 12.5 cm; a_2 – 25 cm; a_3 – 37.5 cm; Factor B–Seed quantity: b_1 – 4 kg/ha; b_2 – 8 kg/ha; b_3 – 12 kg/ha; b_4 – 16 kg/ha.

For camelina crop a conventional tillage was used consisting of soil ploughing carried out in autumn at a depth of 20-25 cm and disc harrowing. Bed preparation was made in spring using a combinatory and leveling equipment before and after sowing. For the experiment with chemical fertilizers application the previous crop was maize, and for the rest, the previous crop was wheat. The seed rate calculation formula was: Seed rate (kg/ha) = N = $\frac{D\ x\ MMB}{P\ x\ G}$ x 100 [kg/ha], where D- the planned plant population value (germinable seeds/m^2); TKW- the mass of 1000 seeds; P-purity, G-germination. The following seed rates were used: 4 kg/ha (350 seeds/m^2), 8 kg/ha (700 seeds/m^2), 12 kg/ha (1050 seeds/m^2), 16 kg/ha (1400 seeds/m^2). The planned plant population value had a deviation of +/- 18-20 seeds/m^2. The row distances of 12.5 cm, 25 cm; 37.5 cm were tested. The experiments were placed in subdivided plots, in three replicates, as shown in Tables 1, 2 and 3.

In March 2013 the climatic conditions were non-favourable for sowing the camelina trials. At the beginning of April 2013 a high amount of rainfall was recorded. Consequently, the sowing was done in mid-April. The sowing took place on 15-16 April 2013. The period from sowing to cotyledons emergence lasted 7-9 days. On 29 April 2013 the plants had two visible pairs of leaves. The plants started flowering in mid-May. On 10 June 2013 they still had flowers and 70% of their silicules were already formed. Their phytosanitary condition was good – the plants had not been attacked by diseases and pests. No treatments were applied. The harvest took place on 12-16 July 2013, when the plants reached maturity. The yield obtained was sieved in order to remove impurities (the sieve's holes diameter = 1.2 mm).

The observations and measurements made for camelina crop were: emergence date, flowering period, pests and diseases monitoring, plant population/m^2; silicules formation; plant height; number of branches per plant; number of silicules per plant; number of seeds per silicule; the mass of 1000 grains weighed after camelina harvest.

Table 4. Results on camelina varieties time seeding and thickness

Camelina sativa cultivar	Calculated seed rate (kg/ha)	Plant population /m^2	Plant height (cm)	Branches / plant	Silicules / plant	Seed / silicule	TKW (g)	Estimative yield (kg/ha)	Yield obtained (kg/ha)
GP 202	4	332	56	1.6	60	8	1	1593	1351
GP 202	8	512	52	3	45	11	0.9	1274	1084
GP 202	12	576	50	1.1	26	12	1	1797	1523
GP 202	16	736	63	1.5	34	11	0.9	2477	2101
Camelia	4	312	57	2.3	45	9	1	1263	1076
Camelia	8	376	57	3	50	11	0.9	1861	1584
Camelia	12	428	60	2.3	40	11	1	1883	1599
Camelia	16	448	61	1.1	33	11	0.9	1463	1239
Calena	4	392	57	2.8	40	9	0.9	1270	1075
Calena	8	400	58	1.3	37	10	0.8	1184	1009
Calena	12	436	58	2.2	35	12	0.8	1465	1248
Calena	16	452	57	2.6	32	9	0.9	1171	997
GP 204	4	384	58	1.6	29	11	0.9	1102	934
GP 204	8	400	58	2.9	27	11	1	1069	905
GP 204	12	472	60	2.8	25	11	0.9	1168	994
GP 204	16	520	50	1.40	25	11	0.9	1287	1098

The biometrical measurements were done when the plants reached maturity. The plants were randomly chosen from each replicate. Estimative yield = (plant population per. m^2* number of silicula per plant*number of seed per silicula*1000 seeds mass). The values in the Tables 4, 5 and 6 for both estimative and obtained yield are the average of the values obtained for the three replicates. The harvest was done using a combine designed for demonstrative trials. After harvesting, the obtained yield quantity and the mass of 1000 grains were calculated.

RESULTS AND DISCUSSIONS

Regarding the experimental plan with various seeding rate, the results showed that at a higher seeding rate (12 kg/ha and 16 kg/ha), the final plant population obtained at harvest was lower (Table 4). This was due to poor seedbed preparation (as a consequence of heavy rains recorded in early April 2013).

Between the estimated and obtained yield were differences of about 15% due to losses at harvest.

The best yields obtained were:

- for GP 202 cultivar - 2101 kg/ha which corresponds to a seeding rate of 16 kg seed/ha, i.e. 736 harvested plants/m^2.
- for Camelia cultivar - 1599 kg/ha, which corresponds to a seeding rate of 12 kg seed/ha, i.e. a plant population of 428 harvested plants/m^2;
- for Calena cultivar - 1248 kg/ha which corresponds to a seeding rate of 12 kg seed/ha, i.e. a plant population of 436 harvested plants/m^2;
- for GP 204 cultivar - 1098 kg/ha which corresponds to a seeding rate of 12 kg seed/ha, i.e. a plant population of 520 harvested plants/m^2;

Data analysis from Table 5, regarding the results of chemical fertilizers applied on camelina crop, showed that the $N_{60}P_{50}$ fertilization scheme was the best (2338 kg/ha of conditioned seeds were obtained).

Table 5. Results regarding chemical fertilizers applied on camelina crop

Camelina sativa cultivar	Factors		Plant population /m^2	Silicules/ plant	Seed/ silicula	TKW(g)	Estimative yield (kg/ha)	Yield obtained (kg/ha)
Camelia	a_1b_1	$N_0 P_0$	360	32	12	0.9	1244	1057
Camelia	$a_2 b_1$	$N_{60} P_0$	264	82	11	0.9	2143	1825
Camelia	$a_3 b_1$	$N_{120} P_0$	640	42	9	0.9	2177	1846
Camelia	$a_4 b_1$	$N_{180} P_0$	224	116	11	0.9	2572	2183
Camelia	a_1b_2	N_0P_{50}	356	78	10	0.9	2499	2119
Camelia	$a_2 b_2$	$N_{60} P_{50}$	316	88	11	0.9	2753	2338
Camelia	$a_3 b_2$	$N_{120}P_{50}$	392	64	11	0.9	2484	2109
Camelia	$a_4 b_2$	$N_{180} P_{50}$	337	91	11	0.8	2699	2289
Camelia	a_1b_3	N_0P_{100}	252	36	9	0.8	653	557
Camelia	$a_2 b_3$	$N_{60}P_{100}$	216	78	12	0.8	1617	1377
Camelia	$a_3 b_3$	$N_{120}P_{100}$	345	76	10	0.9	2360	2009
Camelia	$a_4 b_3$	$N_{180}P_{100}$	248	29	11	0.8	1962	1669
Camelia	a_1b_4	N_0P_{150}	444	56	9	0.9	2014	1707
Camelia	$a_2 b_4$	$N_{60}P_{150}$	320	96	9	0.9	2488	2110
Camelia	$a_3 b_4$	$N_{120}P_{150}$	400	63	12	0.9	2722	2309
Camelia	$a_4 b_4$	$N_{180}P_{150}$	412	47	11	0.8	1704	1452

Table 6. Results regarding row distance

***Camelina sativa* cultivar**		Row distance (cm)	Seed rate kg/ha	Plant population /m^2	Silicula/ plant	Seed/ silicula	TKW (g)	Estimative yield (kg/ha)	Yield obtained (kg/ha)
Factor a	Factor b								
Camelia a_1	b_1	12.5	4	235	63	12	1	1777	1502
	b_2	12.5	8	272	62	10	1	1686	1437
	b_3	12.5	12	324	46	8	0.8	954	806
	b_4	12.5	16	460	32	9	0.9	1192	1015
Camelia a_2	b_1	25	4	246	44	10	0.9	974	830
	b_2	25	8	268	61	10	1	1635	1387
	b_3	25	12	158	75	11	1	1303	1103
	b_4	25	16	302	31	9	0.8	843	713
Camelia a_3	b_1	37.5	4	62	66	10	0.8	327	279
	b_2	37.5	8	88	74	8	0.8	416	349
	b_3	37.5	12	112	31	9	0.9	281	233
	b_4	37.5	16	128	32	9	0.8	294	251

Data analysis presented in Table 6 showed that the best results were obtained for a_1b_2. For this experimental trial the yield obtained was of 1437 kg/ha conditioned seeds.

CONCLUSIONS

The plants' height varied with their plant population. Thus, the plants with low plant population were taller - and vice versa. The tallest plant belongs to *GP 202* reaching 63 cm. The results showed that the optimal plant population is 400 plants/m^2.

The best estimated yield was obtained for *GP 202 cultivar* (2101 kg/ha).

Nitrogen application positively influenced the vegetative growth of the plants and of the yield. The $N_{60}P_{50}$ fertilization scheme was the best (2338 kg/ha of conditioned seeds were obtained).

The best yield potential was of 1437 kg at the row distance of 12.5 cm and the seed rate of 8 kg/ha. Also, good results were obtained for the seed rate of 8 kg/ha. The row distance of 37.5 cm is not recommended because it causes weed infestation.

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