THE INFLUENCE OF FERTILIZATION AND SEEDING DENSITY ON FLAX OIL PRODUCTION QUALITY

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Abstract: *Due to the oil quality which conteins omega 3 and omega 9 fatty acids and the pleasant taste, flax oil, in addition to traditional uses, increasingly finds new uses in areas where until recently there were no data on the use of this culture. Among the new areas of use, areas where there is a growing demand for raw materials, we can specify: medicine, food industry (pastry and bakery), cosmetics. This paper presents the values of seed production and physical indices (mass of 1000 grains and hectoliter weight) obtained in five varieties of flax oil approved in Romania, under the influence of some foliar fertilization products and different densities, in order to determine whether these values depend on applied products and the influence on production quality. The biological material used consists of linseed varieties Lirina, Alexin, Floriana, Florinda and Iunia 96 sown at different densities of 600 germinable seeds/m², 800 germinable seeds/m² and 1000 germinable seeds/m². Fertilization was performed on following agrofunds: N_0P_0, $N_{64}P_{48}$, $N_{96}P_{64}$, $N_{64}P_{48}$ + foliar fertilizer combination Fertileader Viti + Corona K, $N_{96}P_{64}$ + foliar fertilizer combination Fertileader Magical + Corona K. The best yields were obtained from Florinda variety fertilized with $N_{96}P_{64}$ + foliar fertilizer combination Fertileader Magical + Corona K, 800 germinable seeds/m² seeding density, density that ensures adequate nutritional space for flax oil plants. Good results were also obtained at the other varieties, where official production values were exceeded. Regarding the analyzed physical indices, mass of 1000 grains and hectoliter weight, no major deviations were observed from the official descriptions of studied linseed varieties. The only differences occurred regarding the mass of 1000 grains at two varieties (Iunia 96 and Alexin) where the index registered a slight increase. The results obtained by Mr. I. Neştian during the experiments conducted to develop the PhD thesis with the title "Research on the influence of some ecological, biological and technological factors on production and seed quality of linseed (Linum usitatissimum L.), in order to diversify areas of use", once again reinforce the results from the literature according to which, fertilization, as input to the culture of flax oil, is fully justified economic. The author concluded that, regardless of environmental conditions during the three years of experiment, mineral fertilization always produced very significant increases in production (Neştian I., 2007).*

Key words: *flax oil, fertilization, production quality, varieties*

INTRODUCTION

Oil flax (*Linum usitatissimum* L.) is one of the most important oil plants with uses in more and more new areas where, until recently, there were no data on the use of this culture.

Due to its oil-rich seeds (37-46%) with an iodine value of 168-192 employing the oil obtained from those seeds in the group of drying oils (Gh. Bîlteanu, 2001), the main use of flax oil was as raw material for varnish, paints, linoleum and oilcloth industry, printing inks, leather and soap manufacture (V. Tabără, 2005).

According to recent research, the latest trends for the use of flax oil in industrialized countries (USA, Canada, Germany, Australia) and even some Eastern European countries (Czech Republic, Poland, Hungary) are: in human consumption in various sectors of the food industry, especially in bakery; in medical purposes in the prevention and treatment of

cardiovascular disease (coronary thrombosis, multiple sclerosis, hypertension) and malignant (cancer of the colon and breast) (Thompson, 1987, 1994, Maja Seid, 1994 quoted by Ionescu Niculina, 2005); in animal feed giving great nutritional value to milk, meat, eggs, with a beneficial role for the human body; in the textile industry by using flax fibres (woven textiles), in the wood industry for the manufacture of particle board and other industries (paper, insulation materials used in construction, cellulose).

Linolenic acid gives the flax oil siccative level dependent on variety, climatic conditions, technological conditions (density, fertilization).

In steppe conditions with higher humidity, the unsaturated fatty acids accumulation period is extended and the siccative oil level increases.

In steppe areas as in drought conditions, the iodine value decreases reducing the level of siccative oil. Early sowing increases this level because of the longer period of seed filling.

Content and level of siccative flax oil are influenced by day length, density and fertilization. The high density of plants reduces the level of siccative oil and heavy fertilization with nitrogen, reduces the iodine value.

Flax seed benefits have been demonstrated by several studies, including studies regarding lowering total cholesterol or LDL cholesterol ("bad" cholesterol), where flax has given remarkable results.

Flax oil can be used in cosmetics and dermatology to treat skin ulcers, burns, wounds, eczema, abscesses, boils.

Flax oil contains omega 3 and omega 6 acids which eliminates scaly skin and make skin more supple. Also, omega 3 fatty acid strengthens membranes around the cells and helps, in this way, to obtain a moisturized, soft, smooth and healthy skin.

Considering all these aspects regarding the benefits of flax seed oil, benefits that are not used to their full potential especially in our country, appears as appropriate the need to study some linseed varieties approved in Romania and the influence of some ecological and technological factors on flax oli quality.

MATERIAL AND METHODS

In the experience, the following varieties of the species *Linum usitatissimum* L. were used: Lirina, Floriana, Florinda, Iunia 96 and Alexin.

The studied experimental factors were the following:

A factor – variety

a_1 = Lirina
a_2 = Floriana
a_3 = Florinda
a_4 = Iunia 96
a_5 = Alexin

B factor – seeding density

b_1 = 600 g.s. / m²
b_2 = 800 g.s. / m²
b_3 = 1000 g.s. / m²

C factor – fertilizer dose

$c_1 = N_0P_0$
$c_2 = N_{64}P_{48}$
$c_3 = N_{96}P_{64}$
$c_4 = N_{64}P_{48}$ + foliar fertilizer
$c_5 = N_{96}P_{64}$ + foliar fertilizer

The preceding crop for the experimental field was potato. The soil was prepared by autumn plowing to 20-22 cm and disking; the seedbed was prepared with the combinator with a single pass. The seeding was done in the first decade of April. Before seeding, the seed was treated with: Dithane M-45 (mancozeb 80 %) and Lider 70 WG (imidacloprid 70 %).

The spacing beetwen the rows was of 25 cm and the seeding depth was 3-4 cm. Fertilization was performed on following agrofunds:

N_0P_0

$N_{64}P_{48}$: 300 kg/ha of 16:16:16 complex fertilizer + 50 kg/ha nitrogen

$N_{96}P_{64}$: 400 kg/ha of 16:16:16 complex fertilizer + 100 kg/ha nitrogen

$N_{64}P_{48}$ + foliar fertilizer: 300 kg/ha of 16:16:16 complex fertilizer + 50 kg/ha nitrogen + foliar fertilizer combination Fertileader Viti + Corona K

$N_{96}P_{64}$ + foliar fertilizer: 400 kg/ha of 16:16:16 complex fertilizer + 100 kg/ha nitrogen + foliar fertilizer combination Fertileader Magical + Corona K

Weed control was performed with the following products: Pantera 40 EC (40 g/l quizalofop-p-tefuryl) and Lontrel 300 (300 g/l clopiralid).

After harvesting and sampling, the following laboratory analysis were carried out: seed production , oil content, the mass of 1000 seeds and hectolitric weight.

The oil content of the studied varieties was determined by extraction with a SOXTHERM extraction unit. The extraction process is performed in 5 programmable steps which ensures complete extraction of the samples:

- **Stage 1 (Hot extraction) -** The sample is immersed in boiling solvent and the extractable material is liberated from the sample. An equilibrium is set up between the extract in solution and that still on the sample surface.
- **Stage 2 (Evaporation A) -** The level of the solvent is lowered below the extraction thimble. The excess solvent is collected in the rear solvent recovery tank .
- **Stage 3 (Rinsing time) -** The material is extracted by the refluxed, condensed solvent and is collected in the solvent, below in the extraction beaker.
- **Stage 4 (Evaporation B) -** The bulk of the solvent is distilled over into the rear storage tank for later recovery.
- **Stage 5 (Evaporation C) -** The extraction beakers are lifted from the hotplate automatically. Some of the residual solvent may be removed via convection heating. Cooling water and heating are switched off when the extraction is finished after the fifth stage.

RESULTS AND DISCUSSIONS

The data were processed according to the variance analysis method and test F which shows that fertilization and seeding density has significant effects upon the seed production.

The influence of variety, seeding density and fertilization on seed production is shown in tables 1, 2 and 3.

Table 1

The influence of variety on seed production

No.	Variety	Average production (kg/ha)	%	Difference (kg/ha)	Signification
1.	LIRINA	1322	100		
2.	FLORIANA	1633	123	311	xxx
3.	FLORINDA	1680	127	358	xxx
4.	IUNIA96	1597	120	275	xxx
5.	ALEXIN	1547	117	225	xxx

DL 5% = 14 kg/ha; DL 1% = 26 kg/ha; DL 0,1% = 58 kg/ha

Table 2

The influence of seeding density on seed production

No.	Seeding density	Average production (kg/ha)	%	Difference (kg/ha)	Signification
1.	600 g.s./m²	1516	100		
2.	800 g.s./m²	1578	104	62	xxx
3.	1000 g.s./m²	1565	103	49	xxx

DL 5% = 7 kg/ha; DL 1% = 13 kg/ha; DL 0,1% = 30 kg/ha

Table 3

The influence of fertilization on seed production

No.	Fertilization	Average production (kg/ha)	%	Difference (kg/ha)	Signification
1.	N0P0	1256	100		
2.	N64P48	1370	109	114	xx
3.	N96P64	1508	120	252	xx
4.	N64P48 + foliar fertilizer	1730	138	474	xxx
5.	N96P64 + foliar fertilizer	1916	153	660	xxx

DL 5% = 7 kg/ha; DL 1% = 37 kg/ha; DL 0,1% = 375 kg/ha

Analysing the data from Table 1 regarding the influence of variety on seed production in flax we can see that all of the studied varieties showed differences of 311 kg/ha (Floriana), 358 kg/ha (Florinda), 275 kg/ha (Iunia 96) and 225 kg/ha (Alexin) compared to the reference variety, differences appreciated statistically as very significant.

Data from Table 2 on the average production obtained under the influence of seeding density, show that at the seeding density of 800 g.s./m² there was a difference of 62 kg/ha compared to the reference variety, difference appreciated statistically as very significant.

Regarding the influence of fertilization on seed production in flax, the data presented in Table 3 indicates that on two agrofunds ($N_{64}P_{48}$ and $N_{96}P_{64}$) there were differences of 114 kg/ha respectively 252 kg/ha compared to the reference variety, differences assessed statistically as distinct significant and on two other agrofunds ($N_{64}P_{48}$ + foliar fertilizer and $N_{96}P_{64}$ + foliar fertilizer) there were differences of 474 kg/ha respectively 660 kg/ha, differences appreciated statistically as very significant.

It can be noticed that increased production was achieved proportionally with increasing doses of nitrogen. The fertilization variant $N_{64}P_{48}$ brought a production plus of 9% compared with unfertilized variant while in the case of $N_{96}P_{64}$ fertilization variant, the increase was of 20%. Moreover, applying foliar fertilization in addition to fertilization with complex fertilizers, production growth was even higher. The fertilizer variant $N_{64}P_{48}$ + foliar fertilization has brought an increase in production of 38% compared to the unfertilized variant and of 26% compared with the $N_{64}P_{48}$ version while in the case of fertilization variant $N_{96}P_{64}$ + foliar fertilizer the difference was of 53% compared to the unfertilized variant and of 27% compared with the $N_{96}P_{64}$ version.

Tables 4, 5 and 6 present the influence of variety, seeding density and fertilization on oil content.

Table 4

The influence of variety on oil content

No.	Variety	Oil content (%)	%	Difference (%)	Signification
1.	LIRINA	37,42	100		
2.	FLORIANA	38,08	101	0,66	xxx
3.	FLORINDA	38,33	102	0,91	xxx
4.	IUNIA96	37,95	101	0,53	xxx

5.	ALEXIN	37,54	100	0,12	xx

DL 5% = 0,04%; DL 1% = 0,08%; DL 0,1% = 0,18%

Table 5

The influence of seeding density on oil content

No.	Seeding density	Oil content (%)	%	Difference (%)	Signification
1.	600 g.s./m²	37,46	100		
2.	800 g.s./m²	38,22	102	0,76	xx
3.	1000 g.s./m²	37,92	101	0,46	x

DL 5% = 0,13%; DL 1% = 0,68%; DL 0,1% = 6,80%

Table 6

The influence of fertilization on oil content

No.	Fertilization	Oil content (%)	%	Difference (%)	Signification
1.	N0P0	37,66	100		
2.	N64P48	37,77	100	0,11	xx
3.	N96P64	37,91	101	0,25	xxx
4.	N64P48 + foliar fertilizer	37,99	101	0,33	xxx
5.	N96P64 + foliar fertilizer	37,99	101	0,33	xxx

DL 5% = 0,04%; DL 1% = 0,07%; DL 0,1% = 0,16%

Analysing Table 4 regarding the influence of variety on oil content, we can see that three of the studied varieties showed positive differences (0,66%, 0,91% and 0,53%), assessed statistically as very significant compared to the reference variety, while one variety (Alexin) showed a difference of just 0,12% compared to Lirina variety, difference assessed statistically as distinct significant.

Influence of seeding density on the oil content is shown in Table 5. The data presented show that the best results were obtained at a density of 800 g.s./m² where there was a difference of 0,76% compared to the reference variety, difference statistically estimated as distinct significant and at the density of 1000 g.s./m² there was a difference of 0,46% compared to the reference variety, difference statistically appreciated as significant.

Table 6 presents the influence of fertilization on oil content. From the data presented we can conclude that one of the agrofunds ($N_{64}P_{48}$) showed a difference of just 0,11% compared to the reference variety, difference assessed statistically as distinct significant and three other agrofunds ($N_{96}P_{64}$, $N_{64}P_{48}$ + foliar fertilizer and $N_{96}P_{64}$ + foliar fertilizer) had differences of 0,25% respectively 0,33% compared to the reference variety, differences assessed statistically as very significant.

The mass of 1000 grains of the studied flax varieties varies between 5.77 g at Lirina variety and 8.42 g at Alexin variety, data represented in Figure 1.

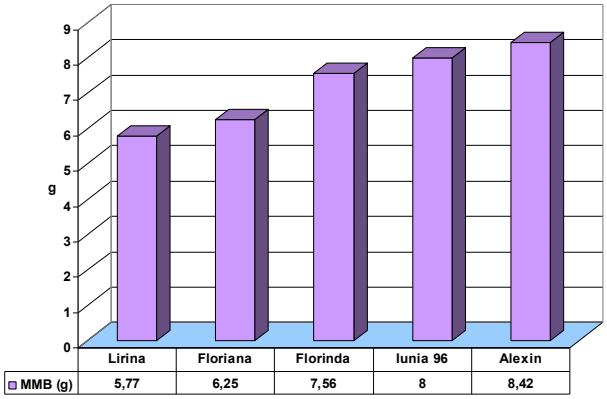

Fig. 1 - Mass of 1000 grains of the studied flax varieties

The seeding density does not affect in any way the mass of 1000 grains from any of the studied varieties. Regarding the influence of fertilization on the mass of 1000 grains, in general, there were no major differences compared to the reference variety except the variety Florinda in which on $N_{64}P_{48}$ agrofund there was a difference of 0.13 g compared to the reference variety, difference evaluated statistically as very significant. At the same variety, differences of 0.11 to 0.12 g were recorded on other agrofunds ($N_{96}P_{64}$, $N_{64}P_{48}$ + foliar fertilizer respectively $N_{96}P_{64}$ + foliar fertilizer) differences appreciated statistically as distinct significant.

Hectoliter weight of the studied flax varieties have values between 67.06 kg/hl and 68.38 kg/hl, data represented in Figure 2.

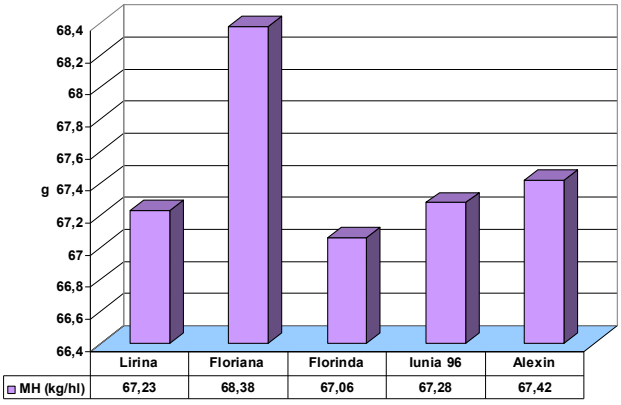

Fig. 2 - Hectoliter weight of the studied flax varieties

Seeding density and fertilization did not affect in any way the hectoliter weight of any of the studied varieties.

CONCLUSIONS

The studied flax varieties have a good degree of adaptability to climatic conditions in the western part of the country.

The production capacity of the studied varieties is a good one ranging between 1322 - 1680 kg/ha.

In the climatic conditions of 2011, the highest yield was recorded in Florinda variety.

Applying fertilizers with foliar fertilizers added to the five studied flax varieties increases seed production. The fertilizer variant $N_{64}P_{48}$ + foliar fertilization has brought an increase in production of 38% compared to the unfertilized variant while in the case of fertilization variant $N_{96}P_{64}$ + foliar fertilizer the difference was of 53% compared to the unfertilized variant.

The seeding density influence the production level.

In terms of seeding density, the best results are obtained for flax at 800 g.s. / m².

Mass of 1000 grains and hectoliter weight depends on variety with values ranging between 5,77 g – 8,42 g respective 67,06 kg/hl – 68,38 kg/hl.

Seed production obtained in 2011 has an oil content with values ranging from 37,42% in Lirina variety to 38,33% in Florinda variety.

Fertilization does not produce substantial changes in seed oil content.

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