Research concerning the influence of fertilization on the yield quantity and quality of flax seeds

SUMMARY OF Ph.D. THESIS

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INTRODUCTION

To cope with the new conditions generated by climate change, one of the technological changes is the use of natural fertilization systems with positive effects on the stability of agro-ecosystems, biodiversity conservation, pollution limitation, sustainable use of natural resources, increasing productivity and quality of agricultural products. human consumption - important objectives for current agriculture (CĂMĂŞOIU CAMELIA, 1994; LIXANDRU, 2006).

In this context, I elaborated the doctoral thesis ′ ′ Research on the influence of fertilization on the production and quality of flax seeds ′ ′ with the main purpose of studying the effect of using natural fertilization with green manure in the cultivation of flax for oil as an alternative or decrease in the amount of mineral fertilizers. Our research responds to the new requirements and trends of agricultural, environmental, soil and water conservation systems.

According to BERCA, 2011, "A green manure is improperly said, because it brings to the soil much more than an act of nutrition; seen as an enhancer, it reacts with the "soil life" it stimulates by achieving an optimization of biochemical and physical properties, followed by an optimized manifestation of the relationship between crop plants - soil - atmosphere - better use of vegetation factors, water, CO2, nutrients and in full correlation with the consumption curves of crops ".

Flax (Linum usitatissimum L.), considered one of the oldest crops, in addition to traditional uses (fibers, seeds, or oil) is now used more and more in food, on the one hand for its pleasant taste, and on the other hand for its therapeutic effect with multiple benefits on human health (BABITA CHAUDHARY, 2016).

Flax seeds are the richest vegetable source of Omega 3-ALA, Omega 6, and 9 fatty acids while providing an important supply of lignans, quality proteins, fiber, vitamins (especially those from the B complex), minerals, and antioxidants (GOYAL, 2014). Various chemical and epidemiological studies (PRIYANKA KAJLA et al., 2015) revealed that the components of flaxseed offer therapeutic and risk prevention benefits for cardiovascular, neurological, diabetes and obesity, autoimmune diseases, gastrointestinal, skin diseases. and some hormone-sensitive cancers.

In the last two decades, flax seeds have aroused the interest of researchers, scientists, and industries, their use being extended from a functional food (flax seeds provide a model for recognizing the nutritional value of cereals, seeds, and whole foods), to various nutraceuticals and therapeutic attributes, thus helping to improve the availability of healthy food choices. Modern techniques such as micro-fluidization, spray granulation, ultrasound or nano-encapsulation can open new approaches in the stabilization and processing of flax seeds and oil (GOYAL, 2014).The research presented in this paper took place between 2017-2019, the experimental fields being located on the lands under the administration of ISTIS Bucharest, at the CTS Sibiu center.

1. The structure of the doctoral thesis

The doctoral thesis ''Research on the influence of fertilization on the production and quality of flax seeds'' is structured in two parts comprising a total of 8 chapters, 139 pages, 26 tables, 60 figures and 177 bibliographic titles.

Part I - The current state of knowledge, has 2 chapters, subchapters in which are presented information from the international and national literature on: the origin and evolution of flax cultivation for oil, the nutritional and therapeutic value of flax seeds, bio-ecological features and technology of flaxseed oil cultivation, the need and role of fertilization applied to the crop.

Part II - Personal contribution, contains 6 chapters, structured that present the objectives pursued, the particularities of the natural environment in which the research was conducted, the research material and method, the results obtained and discussions, conclusions and recommendations based on results and originality and innovative contributions of the thesis.

2. Research objectives

The focus on sustainable agriculture is a major challenge and importance of today's modern agriculture. Using a nutrient balance, a requirement of good agricultural practices of each agricultural producer is the use of different types of fertilizers (chemical and organic) thus optimizing the ratio between fertilizer costs and yields, in conditions of soil protection of the water and the environment (Code of Good agricultural practices, 2005, https://www.icpa.ro).

Thus, for an evaluation of the potential effect of green manure on flax seeds with a high degree of certainty, it is ideal to use both types of fertilizers: mineral and green manure.

Based on these considerations, an important objective of the present research can be the accumulation of new knowledge, which will contribute to the scientific and practical substantiation of the use in culture of the most efficient fertilization variants, which, correlated with the productive capacity of some varieties of flax. to lead to the quantitative and qualitative increase of production, within the limits of environmental protection and economic efficiency.

The main specific objectives can be deduced from the general objective:

1. The study of the effect that different fertilizers have, as type and dose, on the morphology of plants and productivity elements (height, number of capsules, production, MMB) of flax for oil.

2. The study of the effect that different fertilizers have, as type and dose, on the quality (oil and protein content) of flax seeds.

3. Expanding the cultivation of flax for oil by increasing the confidence of growers based on the results obtained.

Based on the conclusions of the research, further action can be taken to optimize and adapt crop technologies and their distribution in production, in order to reduce the polluting effect of excessive and unilateral fertilization with mineral fertilizers.

3. Material and method of conducting experiments

Biological material. To carry out the experiments and achieve the objectives set in the study of this paper, the biological material used is represented by 6 flax varieties for oil-genotype factor and phacelia (Phacelia tanacetifolia) and black mustard (Brassica nigra) used to produce green manure (fertilization factor), all the biological material being zoned in this culture area.

Method of performing the experiment. The field experience is bifactorial, the factors studied being the year, fertilization and variety.

- ✓ Factor A - year of experimentation (2017, 2018, 2019)
- ✓ Factor B - fertilization with 4 graduations:

B1 - unfertilized

B2 - fertilized with green phacelia fertilizer

B3 - fertilized with double the amount of green manure (facelia + black mustard)

B4 - complex mineral fertilizers-250 kg / ha N.P.K. (20.20.0) respectively 50.50.0.kg/ha N.P.K. active substance (s.a.)

- ✓ Factor C - genotype (variety) with 6 graduations:

C1 - Alexin

C2 - Geria

C3 - Lirina

C4 - Cristina

C5 - Fluin

C6 - Elan FD

The experience has rectangular plots equal in size, arranged in blocks located in natural conditions as close as possible, in order to eliminate the unevenness of the land and the influence of environmental factors. Each variant is arranged randomly placed in 3 repetitions to reduce qualitative and quantitative fluctuations (experimental errors). The experimental variants have a length = 12 m and a width = 1 m, at a density of 800 germinating grains per sqm.

As one of the graduations of fertilization being organic fertilization with green manure, since 2016 has been cultivated facelia and black mustard in pure culture established in spring on the land intended for organizing experiments with flax in 2017, in 2017 were cultivated plots of green manure for fertilization for 2018 and in 2018 for 2019. For the establishment of crops with plants (facelia and mustard) used for the fertilized version with green manures as well as those with flax for oil, the applied crop technology was specific to the related crops.

4. Results and discussions

4.1. Results obtained on the influence of fertilization on quantitative characteristics of flax for oil

Plant height

The height of the plants registers the highest values when applying the mineral fertilizer, but for the organic fertilization with phacelia and mustard, the values are significantly close. Even in the situation of non-fertilization, but sown in a black field,

the differences in height compared to mineral fertilization are not more than 5 cm (fig.4.1.). The height of the flax plants is not very much influenced by the fertilization variant, the studied cultivars behave well even in non-fertilized conditions, but probably the growth rate in unfertilized is more diminished which reduces the competitiveness of plants in weed control, especially in the early stages. vegetation when plants are sensitive to weeding due to the slow rate of growth.

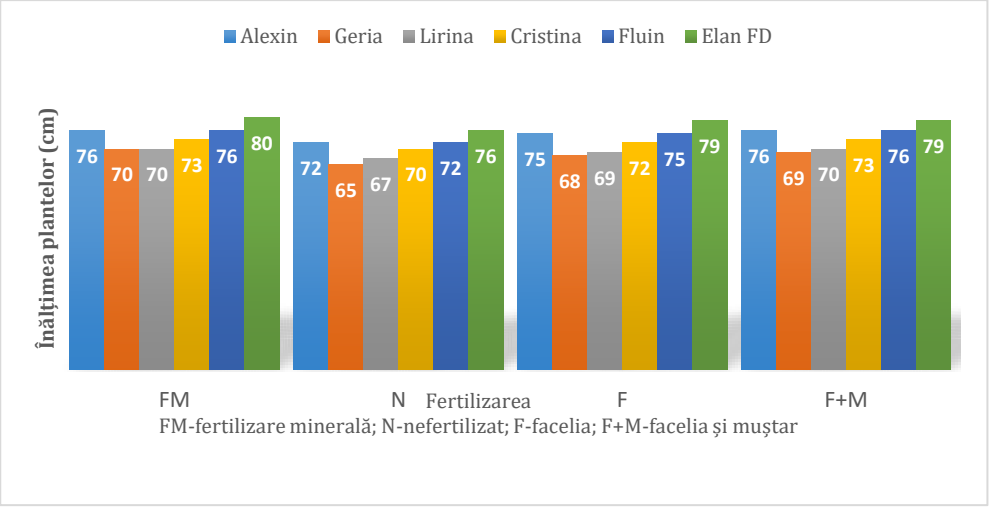

Fig. 4.1. The behavior of varieties for the four types of fertilization

Number of capsules

Flaxseed production is correlated with a number of quantitative morphological characters, such as: number of branches/plant, number of capsules/plant, seed/capsule and plant weight, the mass of 1000 berries. The expression of these features is closely related to the genetic factor but can be influenced in one way or another by pedo-climatic conditions and technological links, the dynamics of these influences are closely correlated with the genetic determinism of each character.

Figure 4.2. very suggestively shows the variation of the average number of capsules formed in the four fertilization systems under the influence of climatic conditions and genetic factor. The fluctuation range of the average number of capsules in the three years very clearly reflects the favorability of 2018 in the formation of productivity elements in flax. Due to the excess water, there was additional sprouting and, implicitly, an increased number of capsules.

In 2019, the number of capsules, in four of the six varieties, was slightly lower compared to 2017, but in general, it could be said that there were no significant fluctuations between the two years. This observation is not, however, valid if we compare the results of 2017 and 2019 with those of 2018, the differences being much more eloquent. Although the average number of capsules in each genotype varied from year to year, the range of variation of these traits is much wider between genotypes, suggesting, in a suggestive way, that this trait is very closely related to hereditary factor. Therefore, we can say that in the formation of the number of capsules per flax and even production, we must pay special attention to the choice of cultivar and then the climatic

conditions prevailing in the area, conditions that can potentiate, within limited limits, the number of capsules per flax.

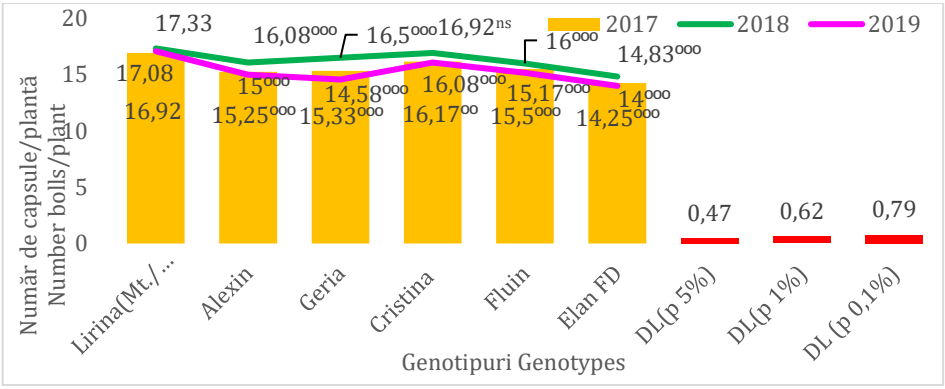

Fig. 4.2. The average number of capsules of the six flax varieties in the three years (Sibiu 2017-2019)

TKW

The weight of 1000 seeds is a feature that directly reflects the weight of the seeds and indirectly their size, therefore this feature is also an indicator in terms of seed quality, usually being directly related to seed production. Within the biological material analyzed there are remarkable differences, differences that were not canceled by fertilization or climatic conditions. The four fertilization systems also contributed very significantly to the variation of TKW, indicating that through the applied technology we can control in -some extent the variation of the accumulation of reserve substances in the seeds.

Both mineral and organic fertilization failed to restore the differences in grain weight between the control Lirina and the other varieties, in all three fertilization systems as well as unfertilized, the control was significantly exceeded by all cultivars (Fig. 4.3.).

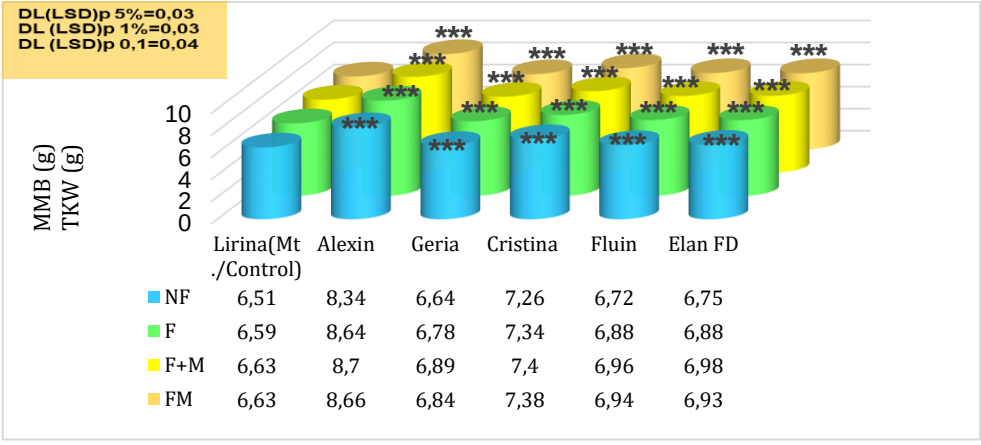

Fig. 4.3. Average MMB values for the six flax crops in the four fertilization systems (Sibiu 2017-2019)

Even in non-fertilization conditions, all cultivars achieved higher MMB values compared to Lirina in the three fertilization systems. The only cultivar that recorded values close to the control Lirina is Geria, which achieved 6.64 g unfertilized, a value close to that of the Lirina variety, from fertilization with phacelia + mustard and mineral fertilization of 6.63 g (fig.). All cultivars except the control reacted most favorably to organic fertilization with phacelia and mustard addition, the average values of MMB in the three years of this fertilization system being higher even than in mineral fertilization.

Seed production

The biological factor remains a central pillar in the formation of production around it gravitating technological factors and, in our case, fertilization. In the three experimental years, (fig. 4.4.) The control variety Lirina was surpassed in productive aspect only by the Cristina variety, the differences being very significant.

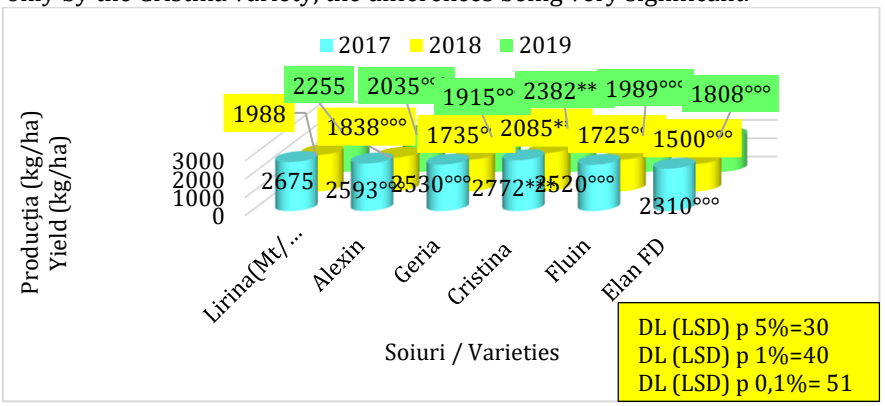

Fig. 4.4. The effects of the interaction between climatic conditions and varieties on flax production (Sibiu 2017-2019)

The other four varieties, Alexin, Geria, Fluin, and Elan recorded productions below the performance of the control, in all three years, the differences being very significant. Therefore, the Cristina variety can be considered the best performing genotype in the analyzed group, regardless of the climatic conditions of the three years, the yields did not fall below the level of 2000 kg/ha, which somewhat suggests the stability of yields for this variety, an important requirement of cultivars in the current climatic conditions and especially in their variation from one year to another.

4.2. Results obtained regarding the influence of fertilization on some qualitative characters in linseed oil

Seed protein content

Among the experimental factors analyzed, the year (climatic conditions) most significantly influenced the protein content. The values of the variance attributed to fertilization indicate a very important contribution of this technological element to the oscillations of the protein content. There are very significant differences between genotypes regarding the potential for protein accumulation in seeds. The interactions

between the factors also marked very significantly the variation of the protein content (Table 4.5.).

Table 4.1.

Variations in protein content (%) in the four fertilization variants for the six flax varieties (SIBIU 2017, 2018, 2019)

Nr. crt	Varianta		Protein	%	Diff.	Semnif	Fertilizarea	Semnific.
	Varieties	Fertilization						
1	**ALEXIN**	*FM*	24,56	100	0,00	Mt.	*NF*	Mt.
2		*NF*	22,94	93	-1,62	000	*F*	***
3		*F*	24,48	99	-0,08	-	*F+M*	***
4		*F+M*	24,95	102	0,38	***	*FM*	***
5	**GERIA**	*FM*	26,32	100	0,00	Mt.	*NF*	Mt.
6		*NF*	24,14	92	-2,18	000	*F*	***
7		*F*	24,72	94	-1,60	000	*F+M*	***
8		*F+M*	25,85	98	-0,48	000	*FM*	***
9	**LIRINA**	*FM*	24,42	100	0,00	Mt.	*NF*	Mt.
10		*NF*	22,38	92	-2,03	000	*F*	***
11		*F*	23,42	96	-0,99	000	*F+M*	***
12		*F+M*	24,47	100	0,06	-	*FM*	***
13	**CRISTINA**	*FM*	24,96	100	0,00	Mt.	*NF*	Mt.
14		*NF*	22,74	91	-2,21	000	*F*	***
15		*F*	23,25	93	-1,70	000	*F+M*	***
16		*F+M*	23,57	94	-1,39	000	*FM*	***
17	**FLUIN**	*FM*	24,24	100	0,00	Mt.	*NF*	Mt.
18		*NF*	22,80	94	-1,44	000	*F*	***
19		*F*	23,86	98	-0,38	00	*F+M*	***
20		*F+M*	23,97	99	-0,27	0	*FM*	***
21	**ELAN FD**	*FM*	24,13	100	0,00	Mt.	*NF*	Mt.
22		*NF*	23,05	96	-1,09	000	*F*	***
23		*F*	24,34	101	0,21	-	*F+M*	***
24		*F+M*	23,98	99	-0,16	-	*FM*	***
DL(LSD) p 5% 0,22; DL(LSD) p 1% 0,29; DL(LSD) p 0,1% 0,38;								

The oil content of flax seeds

Flaxseed oil is becoming more and more popular for its nutritional and pharmaceutical values. The most important implications in the variation of the oil content have fertilization followed by the genetic factor and the climatic conditions. The meanings of sample F, record the very significant involvement of fertilization and biological factor in the control of the amount of oil and only significant climatic factor. The interaction between the year and fertilization does not have a significant impact on the variability of the oil content (fig.4.5, 4.6).

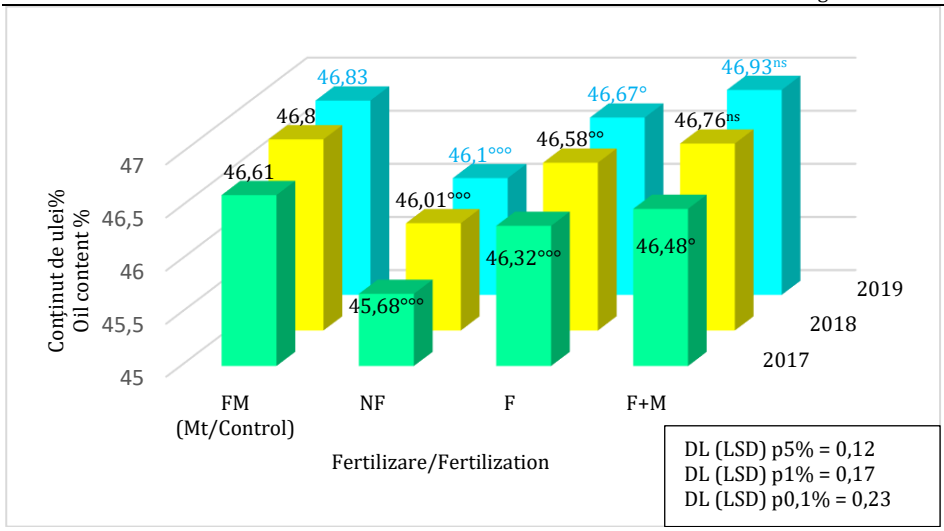

Fig. 4.5. The effects of the interaction between fertilization and years on the oil content

Fertilization with green manure can be a viable alternative for obtaining large quantities of oils, without any chemical residues. Obviously, in non-fertilization conditions, the percentage of oil is decreased in a very significant way, in all the years in this system, the lowest values of the oil were obtained.

Figure 4.6., Shows the behavior of the six flax crops in the three years of experimentation, regarding the deposits of fatty substances in the seeds. The performer of the oil content in the three experimental years is the Cristina variety, the increases compared to the control being distinctly significant (2017, 2019) or very significant (2018). At the opposite pole, with the lowest performance is the Fluin variety, the differences from the control being negative and very significant in all years of experimentation. For the other varieties, the oil content varies from year to year, the differences compared to the Cristina variety being sometimes negatively statistically assured at different thresholds, sometimes insignificant. The oil content is a qualitative component in close interdependence with the variations of the thermal and precipitation regimes.

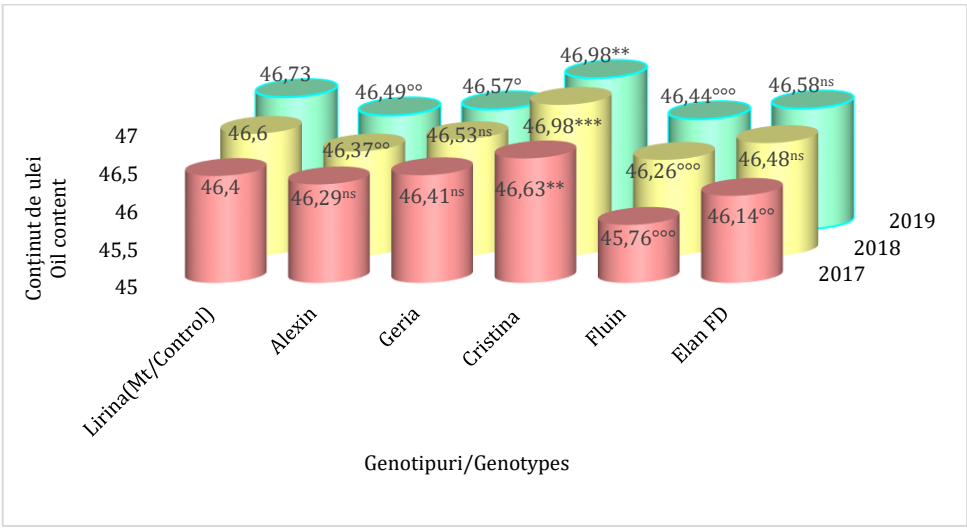

Fig. 4.6. Effects of the interaction between cultivation and years on oil content

Conclusions and recommendations

- The green mass production obtained was significantly influenced by climatic conditions, especially by rainfall during the vegetation period.
- The amount of biomass obtained was 60 t / ha phacelia and 65 t/ha black mustard in 2016, 70 t/ha phacelia, and 56 t/ha black mustard in 2017 (on the background of 218, 1 mm -2016, 129, 4 mm-2017 of precipitation from April-May) and only 50 t/ha phacelia or 42 t/ha black mustard obtained in 2018 due to the deficient precipitation regime of 79.5 mm (April-May).
- The action of incorporating green manures in the soil was materialized by increasing every year the content of nutrients (N-0.6-0.92%, P-24-64 ppm, K-50-148 ppm) and humus up to 0-40 cm deep.
- The height of the plants in the six cultivations has a pronounced genetic determinism, but it can be influenced, to a certain extent, by the climatic conditions and the studied technological link, namely the fertilization.
- concluding the behavior of the six cultivars regarding the average number of capsules made in the four fertilization systems, in the three years, on the first place is the Lirina variety followed by the Cristina cultivar, and on the three places the Alexin, Geria and Fluin varieties the differences between them being insignificant, the last being the Elan FD variety. Compared to the control, all varieties in the experiment formed a smaller number of capsules, the differences being very significant.
- In all the fertilization systems experienced the MMB values are over 7 g, more precisely between 7.04, in non-fertilization conditions, and 7.26, in the facelia + black mustard fertilization system. Organic fertilization, especially the use of large amounts of green manure, can supplement mineral fertilization and even provide increases in terms of MMB, obtaining flax seeds for quality "bio" nutraceuticals, is fully possible.

- Between the six varieties of flax for oil, there are significant differences in terms of production potential, the most productive being the Cristina variety, which surpassed the control (Lirina) ranked second with very significant increases. The other genotypes, Alexin, Geria, Fluin, and Elan recorded productions below the performance of the witness, in all three years, the differences being very significant. Therefore, the Cristina variety can be considered the best performing genotype, regardless of the climatic conditions of the three years, the yields did not fall below the level of 2000 kg/ha, which suggests somewhat the stability of production in the case of this variety, an important requirement of cultivars in the current climatic conditions and especially in their variation from one year to another
- The statement that there is a negative correlation between production and protein is also confirmed in the present situation, the most productive cultivars, namely Lirina (23.67%) and Cristina (23.63%) have the lowest average value in the three years of protein content. The Geria variety (25.26%), which is less productive, ranks first in the top protein content, followed by significant differences by the varieties Alexin (24.23%), Elan FD (23.88%), and Fluin (23.72%)
- The behavior of the six flax cultivations in the three years of experimentation, regarding the deposits of fatty substances in the seeds, highlights the increased oil accumulation capacity of the Cristina variety (46.87%) which exceeded the control Lirina (46.58%), the increases compared to the control being distinctly significant (2017, 2019) or very significant (2018). In the other varieties, the values of the oil content show a decreasing tendency, the differences being ensured statistically as very significant except for the Geria variety (46.50%) for which no meanings are registered, with the lowest performance is the Fluin variety (46, 15%).